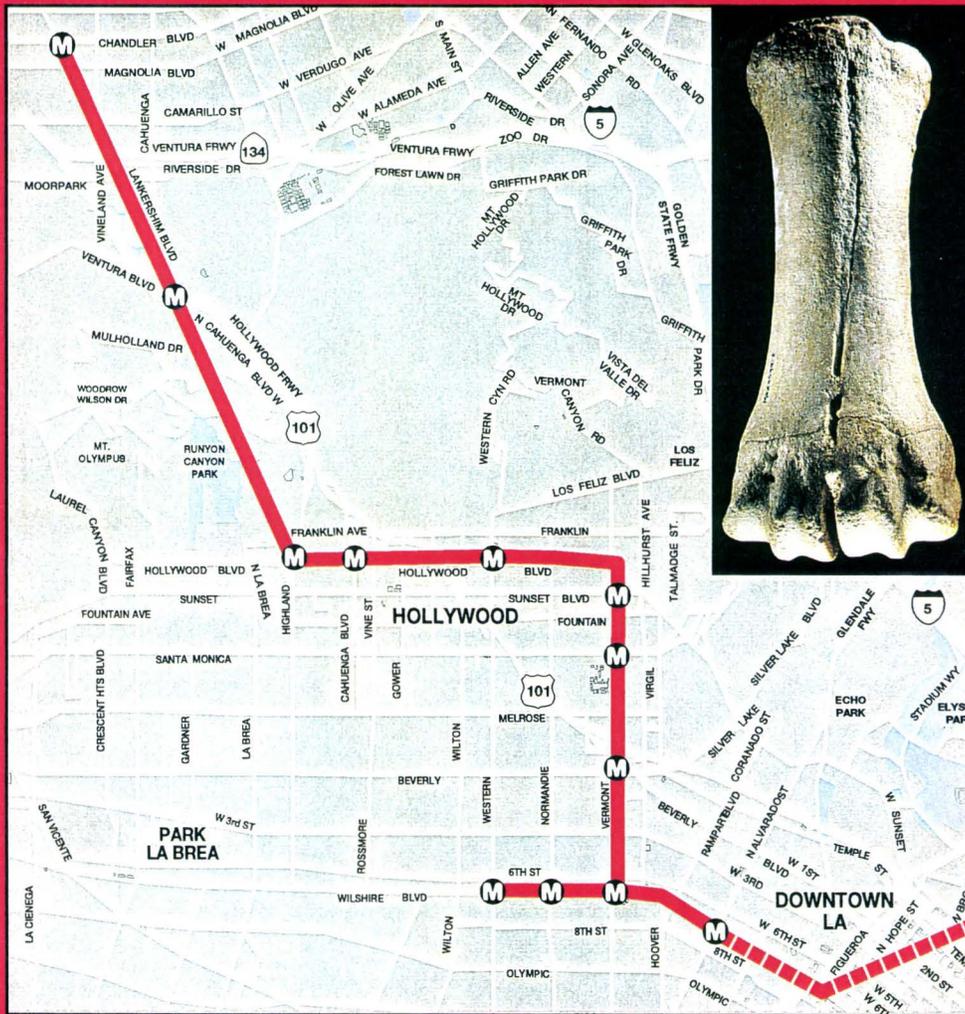


# LOS ANGELES METRO RED LINE PROJECT SEGMENTS 2 AND 3

## Paleontologic Resource Impact Mitigation Program Final Technical Report of Findings



*Submitted to*

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Metropolitan Transportation Authority  
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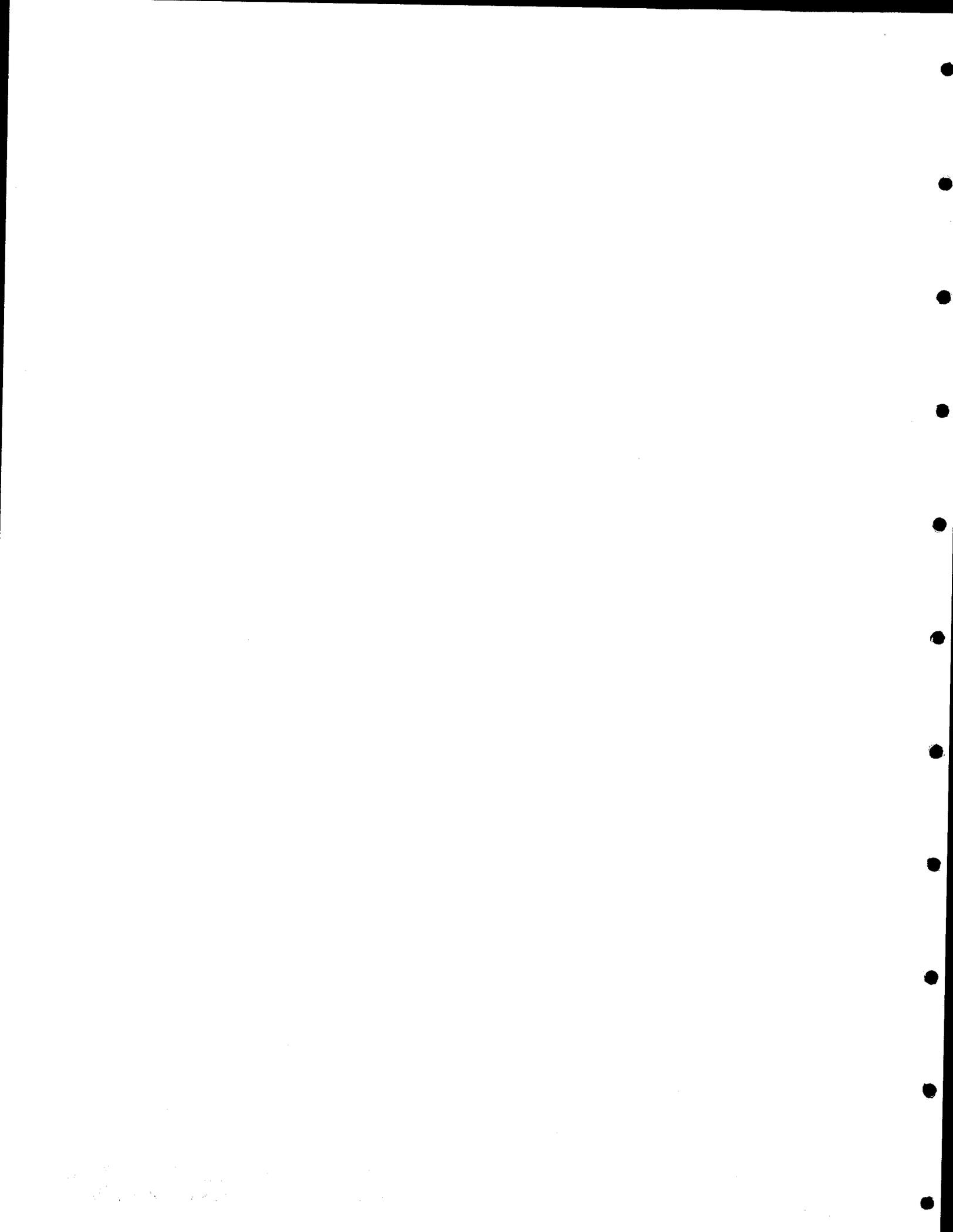
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SEGMENTS 2 AND 3  
PALEONTOLOGIC RESOURCE  
IMPACT MITIGATION PROGRAM  
FINAL TECHNICAL REPORT OF FINDINGS—  
PART 1: INTRODUCTION**

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This final technical report of findings presents the results of the paleontologic resource impact mitigation program conducted from October 1991 to February 1999 by Paleo Environmental Associates, Inc. (PEAI), personnel during and in support of earth moving associated with construction of Segments 2 and 3 of the Los Angeles Metro Red Line, Los Angeles, California (results and findings of PEA I impact mitigation program conducted in support of construction of Segment 1 are presented in earlier final technical reports). The mitigation program was required because of the moderate to high potential for scientifically highly important fossil remains being uncovered by earth moving, particularly cut-and-cover excavation for stations, in the Red Line construction zone.

The mitigation program was implemented at each construction site to ensure NEPA/CEQA compliance with mitigation measures developed during the environmental impact review process for the project and with Southern California Rapid Transit District/ Los Angeles County Transportation Commission/ Los Angeles County Metropolitan Transportation Authority Specifications Section 01170. The mitigation program was conducted in compliance with these measures and with Society of Vertebrate Paleontology standard measures to reduce the potential adverse environmental impacts of construction on the paleontologic resources of the Red Line construction zone to an insignificant level by allowing for the recovery of fossil remains and the

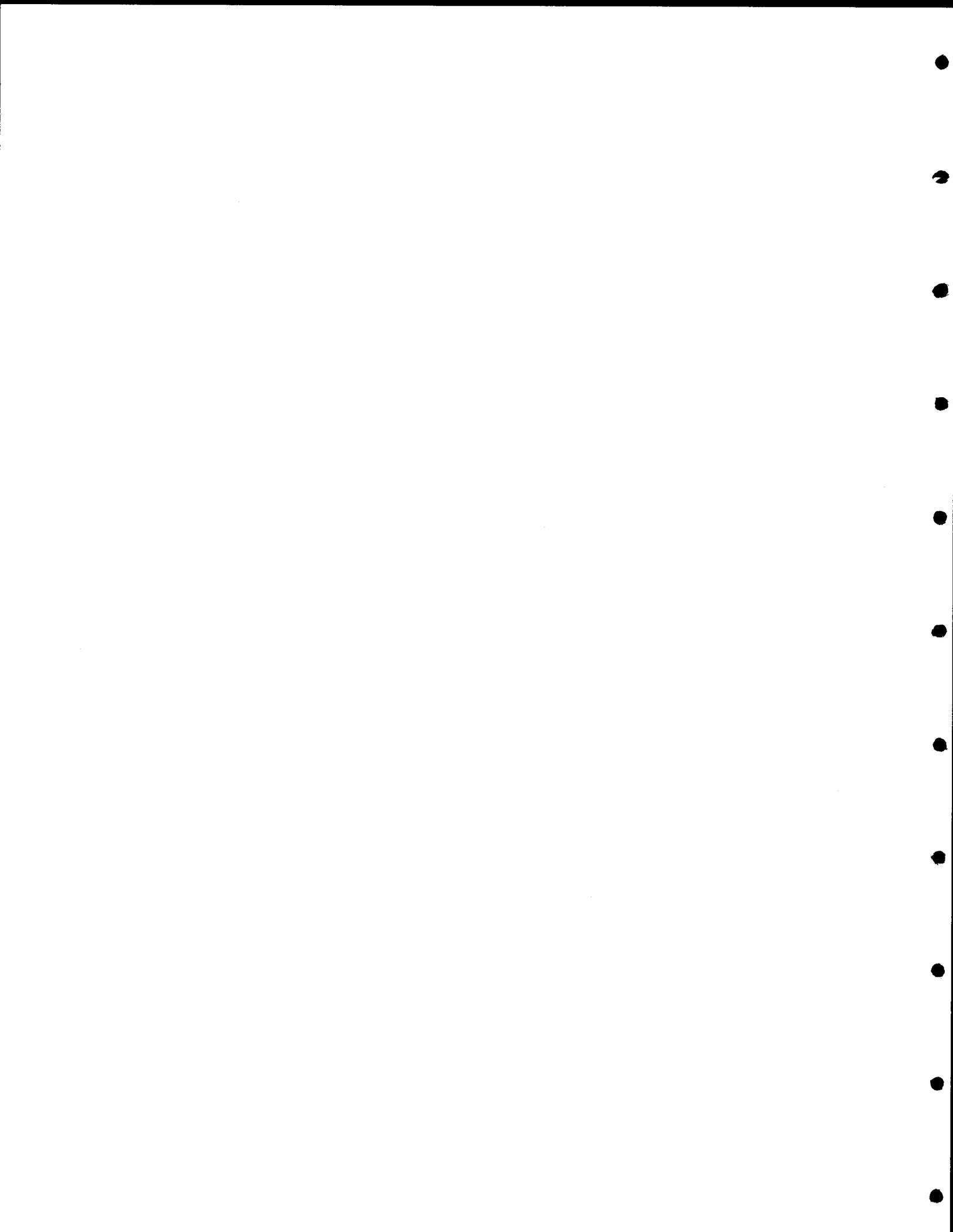
recording of associated specimen data and corresponding geologic and geographic site data that otherwise would have been lost to earth moving and to unauthorized fossil collecting by construction personnel, and for preservation of the fossil remains and archiving of associated data in recognized museum repositories, where they will be retrievable and available for future study by qualified investigators. Moreover, with the mitigation program, construction resulted in beneficial effects, including the recovery of scientifically highly important fossil remains and associated data that would not even have been uncovered without construction-related earth moving and, therefore, would not have been available for recovery.

Submission of this report to the MTA signifies completion of the Los Angeles Metro Red Line paleontologic resource impact mitigation program and will assist the MTA in meeting its mitigation monitoring compliance and reporting responsibilities under California Public Resources Code Section 21081.6.

Parts 2 and 3 of this final report presents the results of paleontologic construction monitoring conducted as part of the PEA I paleontologic resource impact mitigation program implemented during and in support of earth moving associated with construction of Segments 2 and 3, respectively. Appendices are contained in Part 4.



**LOS ANGELES METRO RED LINE PROJECT  
PALEONTOLOGIC RESOURCE  
IMPACT MITIGATION PROGRAM  
FINAL TECHNICAL REPORT OF FINDINGS—  
PART 2: SEGMENT 2**

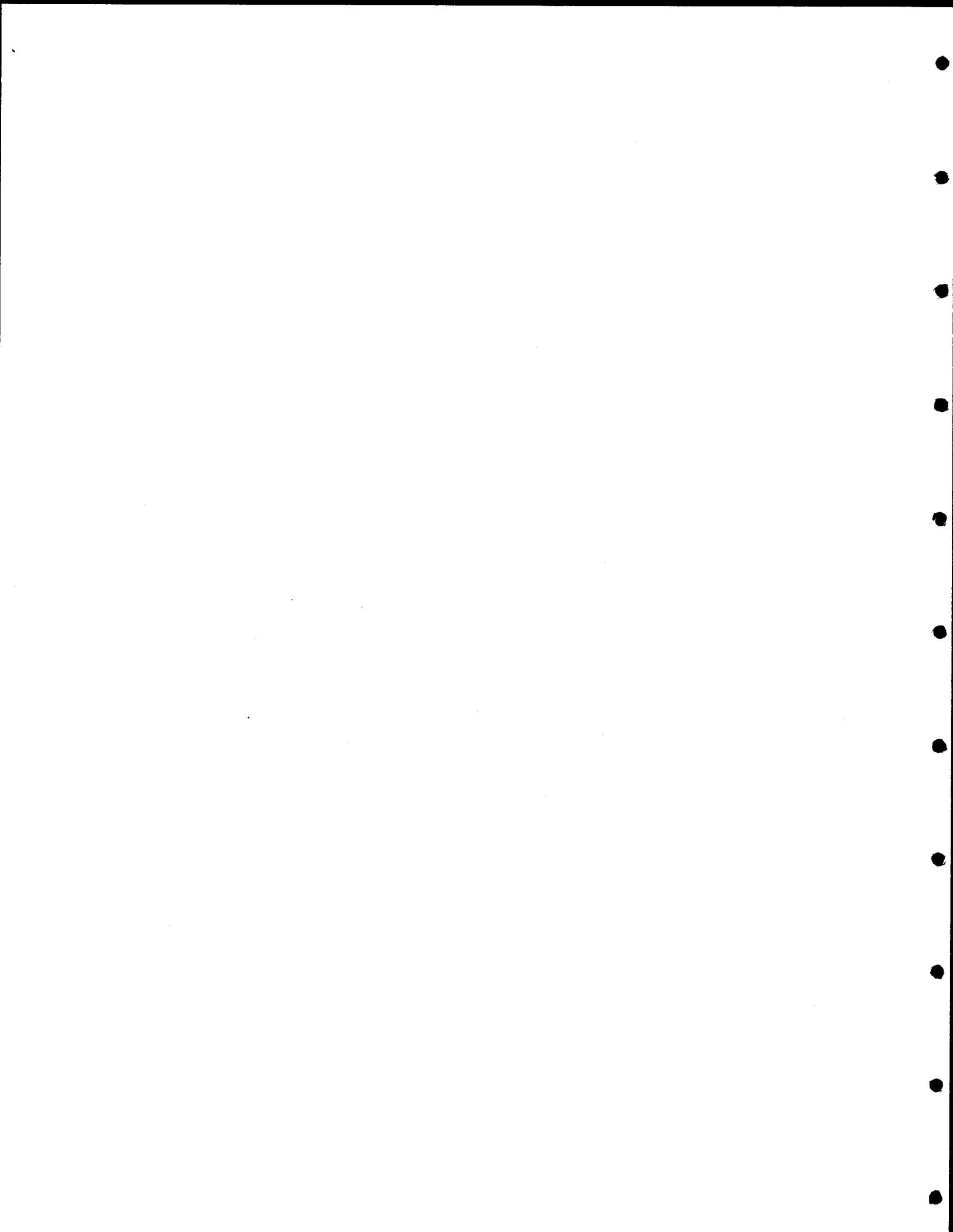


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SECTION 1

SUMMARY

This final technical report of findings presents the results of the paleontologic resource impact mitigation program conducted by Paleo Environmental Associates, Inc. (PEAI), personnel during and in support of earth moving associated with construction of the Los Angeles Metro Red Line Segment 2 MacArthur Lake pocket track structure (contract B-201); Wilshire/Vermont, Wilshire/Normandie, Wilshire/Western, Vermont/Beverly, Vermont/Santa Monica, Vermont/Sunset, Hollywood/Western, and Hollywood/Vine stations (contracts B-211, -221, -231, -241, -252, -261, -271, -281, respectively); cross passage 19 (contract B-251); Barnsdall Art Park tunnel access shaft (contract B-251); and the intervening tunnel segments (contracts B-201, -251), Los Angeles, California. The mitigation program was required because of the moderate to high potential for scientifically highly important fossil remains being uncovered by earth moving, particularly cut-and-cover excavation, in the Segment 2 construction zone, and was implemented to ensure NEPA/CEQA compliance with mitigation measures developed during the environmental impact review process and with Southern California Rapid Transit District (SCRTD)/Los Angeles County Transportation Commission (LACTC)/Los Angeles County Metropolitan Transportation Authority (MTA) Specifications Section 01170. The mitigation program was conducted in compliance with these measures and with Society of Vertebrate Paleontology (SVP) standard measures to reduce the potential adverse environmental impacts of construction on the paleontologic resources of the Segment 2 construction zone to an insignificant level.

The mitigation program substantially reduced the adverse environmental impacts of earth moving on the paleontologic resources of the Segment 2 construction zone to an insignificant level by allowing for the recovery of more than 2,200 fossil specimens at 19 newly recorded PEAi fossil sites (fragmentary remains discovered, but not recovered at 2 additional PEAi fossil sites) and the recording of associated specimen data and corresponding geologic and geographic site data that otherwise would have been lost to earth moving and to unauthorized fossil collecting by construction personnel, and for preservation of the fossil remains and archiving of associated data in recognized museum repositories, where they will be retrievable and available for future study by qualified investigators. Moreover, with the

mitigation program, construction resulted in beneficial effects by exposing and allowing for the recovery of scientifically highly important fossil remains and associated specimen data and corresponding site data that would not even have been uncovered without construction-related earth moving and, therefore, would not have been available for recovery.

The Segment 2 construction zone encountered, in order of increasing geologic age and depth, historic artificial fill, Holocene younger alluvium, late Pleistocene older alluvium, the middle to late Pleistocene marine San Pedro Sand, and an unnamed late Miocene marine shale that probably is laterally equivalent to strata in the Santa Monica Mountains assigned to the upper member of the Modelo Formation by some workers.

Fossil remains, including more than 100 marine invertebrate specimens, approximately 2,090 marine fish specimens, 1 whale specimen, roughly 25 noncalcareous intertidal benthic marine algal (seaweed) specimens, an undetermined number of marine microfossil specimens, and 3 land plant specimens, were recovered at 14 newly discovered PEAi fossil sites in unit Tps1 (upper, but not uppermost unit) of the unnamed marine shale and recorded under 26 new museum fossil site numbers, treated (prepared, identified, curated, catalogued, as appropriate), and analyzed as a result of the Segment 2 mitigation program, most of the fossil specimens having been recovered at the Wilshire/Vermont station site. Prior to analysis of these specimens, the fossil record of the marine shale in the downtown Los Angeles/Hollywood area was very poorly known. The specimens are scientifically highly important because they represent a taxonomically very large and highly diverse assemblage of associated marine microfossil and algal, land plant, and marine invertebrate and vertebrate species, such an association being comparatively rare in the fossil record.

Marine calcareous nannoplankton species represented in one of two Segment 2 microfossil samples indicate the fossil-bearing level in unit Tps1 of the marine shale at the Wilshire/Vermont station site is approximately 7.2 million to 8.6 million years (early late Miocene) in age, and the benthic (bottom-dwelling) marine foraminifer species suggest a very-deep-water marine (upper middle bathyal = upper

middle slope) environment and ocean depths roughly 1,500 to 4,700 feet below sea level. At least 65 marine microfossil species are represented in the sample. Marine calcareous nannoplankton species represented in a microfossil sample from the Metro Red Line Segment 1 Tom Bradley/Civic Center station site indicate the fossil-bearing level in overlying unit Tpds (uppermost unit) of the marine shale is approximately 5.0 million to 5.3 million years (earliest Pliocene) in age.

The fossil marine invertebrate specimens, primarily mollusk (snail, clam) shells, from the marine shale represent species comprising an assemblage of limited taxonomic diversity. The fauna consists of five species of clams and one species each of snail, barnacle, starfish, and sea urchin, of which the clam and sea urchin species all are extinct. None of these species has been reported previously from the marine shale in the downtown Los Angeles/Hollywood area. With the exception of one species of clam and the barnacle and starfish species, their occurrences in the marine shale are among the oldest fossil records of these species, which have been reported previously as occurring in the Miocene fossil record only in the Sycamore Canyon Formation in the Puente Hills. The specimens are scientifically highly important because they appear to represent chronologic range extensions for their respective species downward from the early Pliocene Epoch into the early late Miocene Epoch. The starfish specimens are of particular scientific importance because such occurrences are very rare in the fossil record. Although some of the deeper-water marine invertebrate species presumably occurred down to ocean depths at least as great as about 2,300 feet below sea level, specimens of the shallower-water marine invertebrate species might have been transported downward from shallower depths and into the Segment 2 construction zone by submarine sediment or debris (turbidity) flows.

The fossil marine fish specimens, primarily skeletons, scales, and otoliths (ear ossicles), from the marine shale are assignable to 36 families, of which 1 family is extinct, 57 genera, and 66 (1 extant, 64 extinct) species, of which 39 of the extinct species are new, not having been reported previously in the scientific literature. Most of the other species are rare. Many of the specimens are scientifically highly important because they represent chronologic and/or geographic range extensions, including the first, first North American, and oldest occurrences of their respective families and genera reported from the fossil record, and some specimens represent the first reported fossil occurrences of otoliths and/or the first reported

association of otoliths with skeletal remains for their respective families and genera. The species these specimens represent also are highly important scientifically because they comprise the taxonomically largest and most diverse fish fauna ever reported from the late Miocene fossil record of California. The Segment 2 lanternfish assemblage, which contains fifteen genera and sixteen species of lanternfishes, is taxonomically the largest and most diverse lanternfish assemblage reported from the fossil record. The Segment 2 fish fauna, which consists mostly of comparatively rare deeper-water marine (upper bathypelagic) species, such as netdevils, lanternfishes, blackchins, lightfishes, and viperfishes, is unusual because it also contains shallow-water marine (epipelagic and benthic [bottom-dwelling]) species, such as flounders, herrings, sardines, mackerels, and sea basses/groupers, as well as two very-deep-water marine (middle bathypelagic) species (dreamers, fangtooths) that have not been reported from any other fossil marine fish fauna. The presence of very-deep-water marine species, whose modern representatives live at ocean depths greater than roughly 2,000 to 3,300 feet (0.4 to 0.6 mile), at the Wilshire/Vermont station site suggests the sea floor at this site might have been at least 0.6 mile below sea level during deposition of the sediments comprising the marine shale and deeper than at any other known southern California marine fossil site during the late Miocene Epoch. However, the well-preserved nature of the delicate fossil fish, seaweed and land plant specimens suggests the sea floor was within or below an anoxic or oxygen-minimum zone, which was between roughly 5,000 and 10,000 feet (1.0 and 2.0 miles) below sea level during the late Miocene Epoch and would have prevented decay or disruption of the fish skeletons, seaweed remains, and land plant leaves by bottom-dwelling organisms. This conclusion is corroborated by the apparent absence of any evidence indicating bioturbation of the fossil-bearing strata, but not by the presence of benthic foraminifer or mollusk remains, although these remains might have been transported to greater depths by turbidity flows. On the other hand, these sediment flows presumably would have disrupted the well-preserved seaweed remains, land plant leaves, and articulated fish skeletons. Conflicting lines of evidence have made it difficult to reconstruct the depositional environment of the Segment 1 and 2 construction zones. Nevertheless, the presence of very-deep-water marine fish species only at the Wilshire/Vermont station site, along with sedimentologic (geologic) data, suggests the sea floor in the construction zones sloped to the south during the late Miocene Epoch. Alternatively, the greater

depth represented by the fish assemblage at the Wilshire/Vermont station site, which appears to lie stratigraphically above many of the other station sites and, therefore, to be composed of younger strata, also might reflect progressive subsidence of the sea floor as a result of regional extension of the southern California continental margin during deposition of the sediments comprising the marine shale.

The noncalcareous intertidal benthic marine algal specimens represent one species of red alga and three genera and four species (including one new genus and two new species) of brown algae. The algal remains are of particular scientific importance because such occurrences are comparatively rare in the fossil record and have not been reported previously as occurring in the marine shale in the downtown Los Angeles/Hollywood area.

The leaves of land plants represent aspen, buckthorn, and a land plant resembling an oak (beech family) or a member of the laurel family. The leaves are of particular scientific importance because such occurrences are very rare in the marine fossil record and have not been reported previously as definitely occurring in the marine shale in the downtown Los Angeles/Hollywood area. The presence of land plant remains and their association with the remains of intertidal benthic marine algal species and shallow-water benthic marine fish species (sanddab, turbot) suggest the sediments comprising the marine shale were deposited in a near-shore marine environment.

Paleoenvironmental preferences of some of the species comprising the composite Segment 2 fossil assemblage, particularly the Wilshire/Vermont station assemblage, suggest these species lived at ocean depths roughly 3,300 to 4,700 feet below sea level during the early late Miocene Epoch, approximately 7.2 million to 8.6 million years ago. These preferences, in conjunction with taphonomic (paleontologic) and geologic (sedimentologic) data from the marine shale, suggest the sediments comprising the marine shale were deposited by turbidity flows that originated in a near-shore shallow-water marine environment and traveled offshore in a southerly direction down a large submarine fan (Tarzana fan) that developed as these sediments accumulated along the northern margin of a deep submarine basin (central Los Angeles basin) that once existed along the former coastline, which lay much farther inland during the late Miocene Epoch. The presence of middle bathypelagic fish species only at the Wilshire/Vermont station site suggests the

surface of the Tarzana fan (sea floor) sloped in a southerly direction. The presence of upper middle bathyal benthic marine foraminifer species indicates the station site, which now lies at an elevation approximately 250 feet above sea level, has been uplifted nearly 5,000 feet in the last 7.2 million years, although other topographic data suggest the station site has been uplifted at least 5,250 feet (1.0 mile).

The tusk of an extinct Ice Age elephant, possibly a Colombian mammoth, was recovered from the older alluvium at the Wilshire/Western station site, and the bones and teeth of extinct American mastodont (elephant), western horse, western camel, and ancient bison were recovered from the older alluvium at four newly discovered PEAI fossil sites in the westbound (northern) Hollywood Boulevard tunnel segment just west of the Hollywood/Western station site. These remains are scientifically highly important because land mammal remains are comparatively rare in the fossil record and, particularly with regard to the bison specimen, corroborate a middle? to late Pleistocene (Rancholabrean; 10,750 to 130,000- or 280,000-year) age assignment and nonmarine origin for the older alluvium. The species represented by the remains also occur in the older alluvium at the La Brea tar pits, and probably are indicative of a savanna woodland habitat.

PEAI personnel assisted in establishing paleontologic exhibits regarding some of the fossil remains recovered from the Segment 2 construction zone as a result of the Segment 2 mitigation program. One exhibit is on display in the MTA headquarters library. Another exhibit is a traveling display to be used by MTA Public Affairs personnel. Other exhibits are being developed for the stations. PEAI personnel also assisted MTA Media Relations personnel by reviewing press releases; conducting newspaper, magazine, television, and film interviews; and in developing an MTA web site regarding the Segment 2 fossil remains and the beneficial effects of the mitigation program on paleontology. Some of the fossil marine fish and land mammal specimens received wide media coverage from 1994 to 1997.

Submission of this report to the MTA signifies completion of the Los Angeles Metro Red Line Segment 2 paleontologic resource impact mitigation program and will assist the MTA in meeting its mitigation monitoring compliance and reporting responsibilities under California Public Resources Code Section 21081.6.

## SECTION 2

### INTRODUCTION

This final technical report of findings presents the results of the paleontologic resource impact mitigation program conducted by PEA personnel during and in support of earth moving associated with construction of the Los Angeles Metro Red Line Segment 2 MacArthur Lake pocket track structure (contract B-201); Wilshire/Vermont, Wilshire/Normandie, Wilshire/Western, Vermont/Beverly, Vermont/Santa Monica, Vermont/Sunset, Hollywood/Western, and Hollywood/Vine stations (contracts B-211, -221, -231, -241, -252, -261, -271, -281, respectively); cross passage 19 (contract B-251); Barnsdall Art Park tunnel access shaft (contract B-251); and the intervening tunnel segments (contracts B-201, -251), Los Angeles, California. Topographic map coverage of the Segment 2 route is provided by the U.S. Geological Survey Hollywood Quadrangle, 7.5 Minute Series (Topographic). A map of the Segment 2 construction zone and vicinity is presented in Figure 1. Appendices are contained in Part 4.

#### 2.1 BACKGROUND

Paleontologic resources, including fossil remains, associated specimen data and corresponding geologic and geographic site data, fossil sites, and the fossil-bearing rock units, are a limited, nonrenewable, and very sensitive scientific and educational resource and, particularly with regard to fossil sites, are afforded protection under the following federal and state environmental legislation (California Office of Historic Preservation, 1983; Reynolds, 1990).

National Environmental Policy Act of 1969 (NEPA) (P.L. 91-190; 31 Stat. 852, 42 U.S.C. 4321-4327).—Requires that important natural aspects of our national heritage be considered in assessing the environmental consequences of a proposed project.

Archaeological and Historic Data Preservation Act of 1974 (P.L. 86-253, as amended by P.L. 93-291; 88 Stat. 174, U.S.C. 469).—Provides for the survey, recovery, and preservation of significant paleontologic data when such data might be destroyed or lost due to a federal, federally licensed, or federally funded project.

California Environmental Quality Act of 1970 (CEQA) (13 Public Resources Code: 21000 et

seq.).—Requires that public agencies and private interests identify the environmental consequences of their proposed projects on any object or site of significance to the scientific annals of California (Division I, Public Resources Code: 5020.1 [b]).

Guidelines for the Implementation of CEQA, as amended May 10, 1980 (14 California Administrative Code: 15000 et seq.).—Define procedures, types of activities, persons, and public agencies required to comply with CEQA, and include definitions of significant impacts on a fossil site (Section 15023, Appendix G [j]).

Public Resources Code, Section 5097.5 (Stats. 1965, c. 1136, p. 2792).—Defines any unauthorized disturbance or removal of a fossil site or remains on public land as a misdemeanor.

Public Resources Code, Section 30244.—Requires reasonable mitigation of adverse environmental impacts that result from development of public land and affect paleontologic resources.

In response to these acts, the U.S. Department of Transportation Urban Mass Transportation Administration (UMTA) and the SCRTPD, the initial federal (NEPA) and California (CEQA) lead agencies, respectively, for Metro Red Line construction, required completion of several tasks prior to Red Line construction because of the potential for paleontologic resources being adversely affected by construction-related earth moving for the Red Line. These tasks included compilation of baseline paleontologic resource inventories, preparation of paleontologic resource and impact assessments, and, based on the results of these assessments, formulation and implementation of mitigation measures to reduce, to an insignificant level, the adverse environmental impacts that would result from cut-and-cover excavation associated with construction of the Red Line stations. These impacts would affect the paleontologic resources of the construction zone. Subsequently, paleontologic resource inventory/assessment technical reports presenting site-specific paleontologic resource impact mitigation measures for Red Line Segments 1 and 2 were prepared by Lander (1987), the UMTA and SCRTPD (1983, 1987), and WESTEC Services, Inc. (1983). These measures were incorporated into the

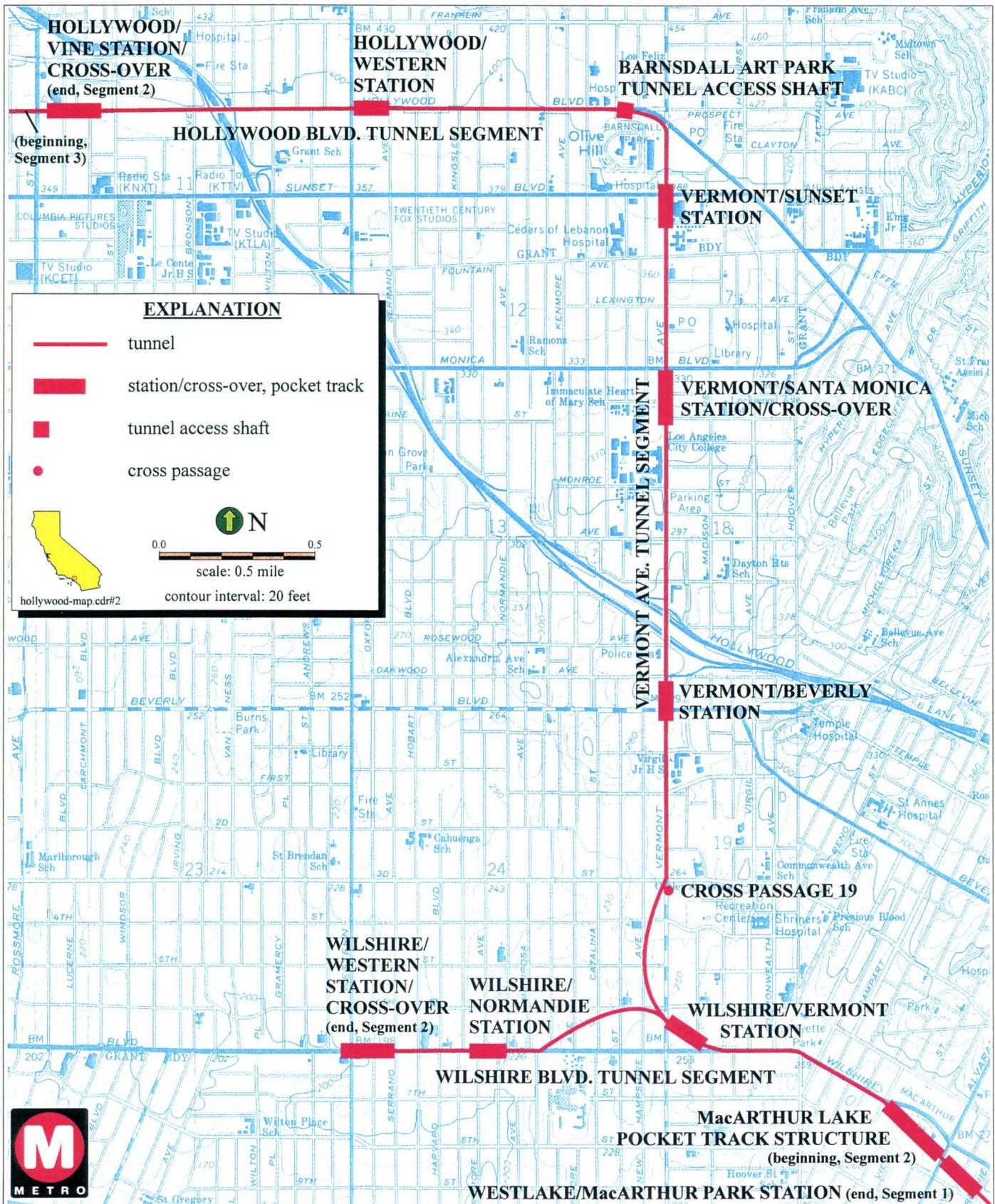
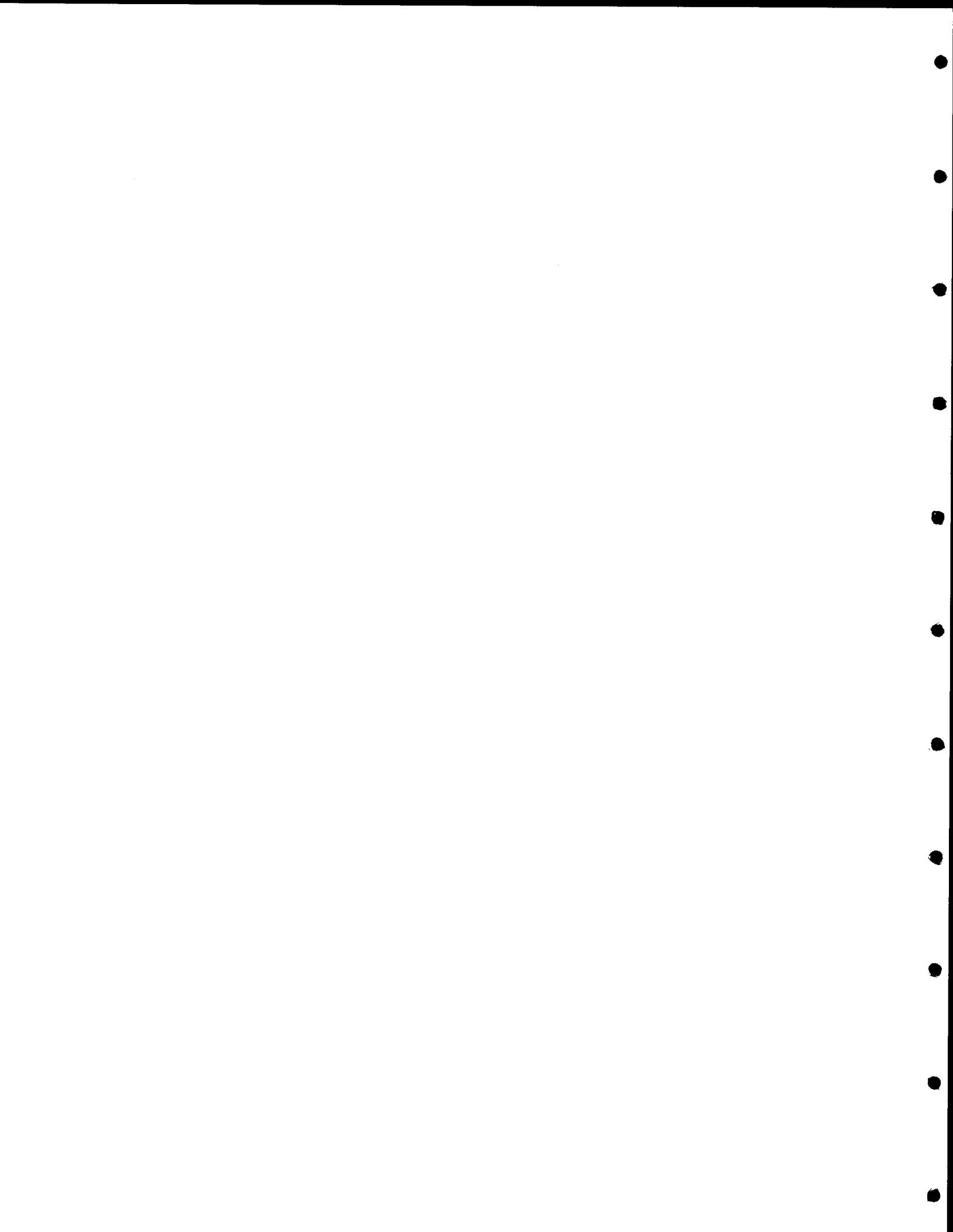
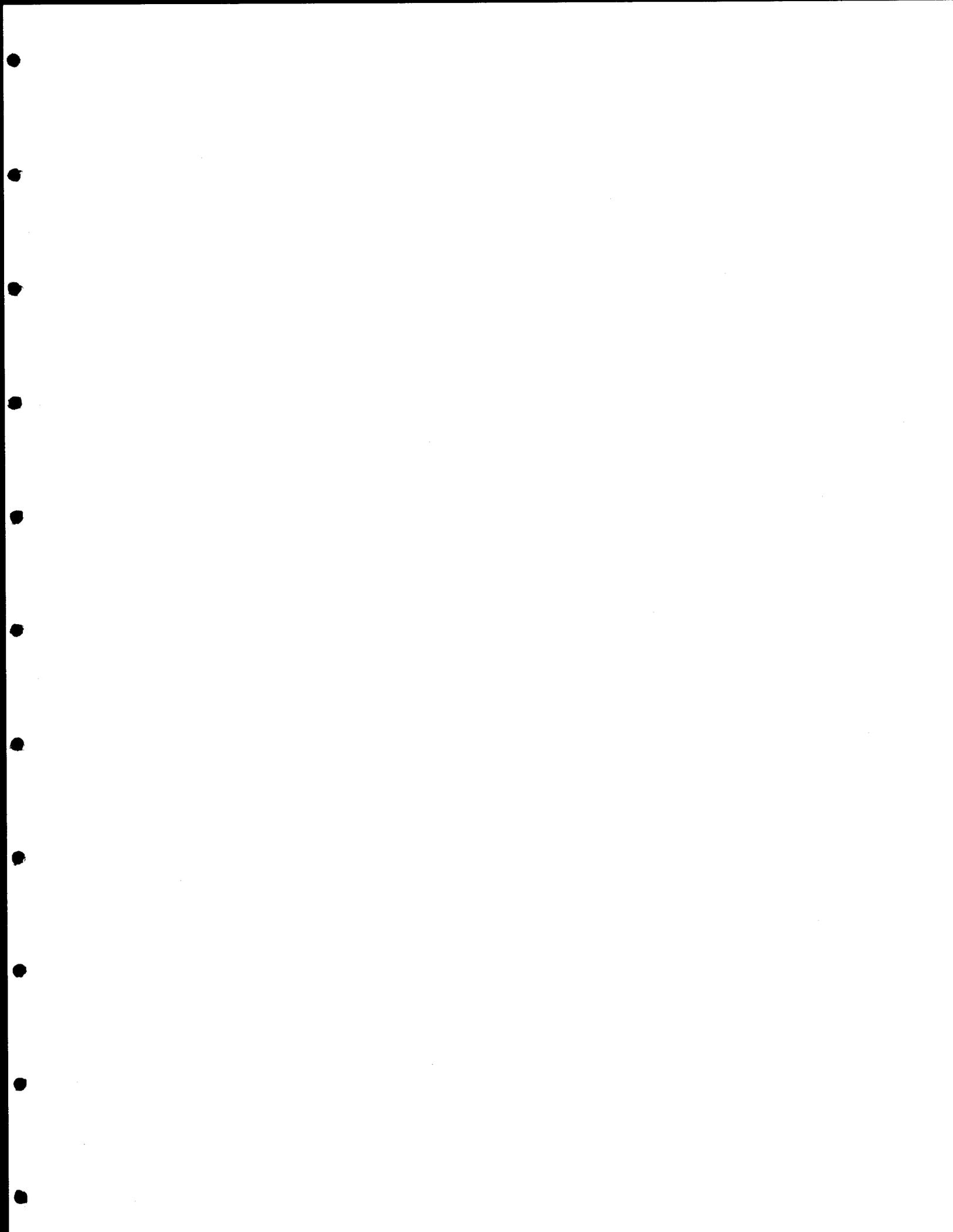


Figure 1.—Map of Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. Base map: U.S. Geological Survey Hollywood 7.5-minute Quadrangle.





standard paleontologic resource impact mitigation procedures (Specifications Section 01170; see Appendix A) for the Red Line by the SCRDT and, subsequently, the LACTC and its successor, the MTA, which currently has responsibility for the Metro Red Line.

Prior to construction, the Segment 2 construction zone was underlain by rock units with a moderate to high potential for yielding scientifically important fossil remains at previously unrecorded fossil sites during construction-related cut-and-cover excavation, particularly for the stations (Lander, 1987; UMTA and SCRDT, 1983, 1987; WESTEC Services, Inc., 1983). This paleontologic potential was indicated by surficial geologic mapping of the Segment 2 route and vicinity by Converse Ward Davis Dixon and others (CWDD and others, 1981), Dibblee (1991a), and Lamar (1970); documentation of a number of previously recorded fossil sites in the same area, most having been uncovered during excavation for other construction projects (Jefferson, 1991; Lamar, 1970; Lander, 1987; Miller, 1971; Reynolds, 1987; WESTEC Services, Inc., 1983); recognition of the fossil-bearing rock units at and near the surface in the Segment 2 construction zone (Lander, 1987; UMTA and SCRDT, 1983, 1987; WESTEC Services, Inc., 1983); fossiliferous bore hole samples obtained from these rock units in the Red Line construction zone (Lander, 1987; UMTA and SCRDT, 1983, 1987; WESTEC Services, Inc., 1983); and the occurrence of fossil remains recovered from the same rock units during cut-and-cover excavation in the Metro Red Line Segment 1 construction zone (most as result of Segment 1 paleontologic resource impact mitigation program; Lander, 1990b).

The mitigation measures developed for Segment 2 (Lander, 1987; UMTA and SCRDT, 1983, 1987; WESTEC Services, Inc., 1983; SCRDT/LACTC/MTA Specifications Section 01170; see Appendices A, D) were designed to substantially reduce the adverse environmental impacts of cut-and-cover excavation on the paleontologic resources at each station site to an insignificant level. These measures would ensure some of the fossil remains that might be uncovered by excavation and other construction-related earth-moving activities (trenching for utility lines, augering for piles) associated with construction of the station boxes/appendages (entrances, fresh-air intakes, blast relief shafts), and cross-overs were recovered. These measures also would ensure all potentially identifiable specimens recovered were fully treated (prepared to point of identification, identified to lowest taxonomic level possible, curated,

catalogued). The specimens then would be permanently stored and maintained, and associated specimen data and corresponding geologic and geographic site data archived at recognized museum repositories, including the Vertebrate Paleontology (VP) and Invertebrate Paleontology Sections (IP) of the Natural History Museum of Los Angeles County (LACM), and the University of California Museum of Paleontology (UCMP), Berkeley, where they would be retrievable and made available for future study by qualified investigators. Without these measures, the remains and associated specimen and site data would have been lost to earth moving and to unauthorized fossil collecting by construction personnel. Similar losses would have resulted from earth moving associated with construction of the tunnels, pocket track structures, tunnel access shafts, and cross passages. These losses would have been a significant adverse environmental impact. On the other hand, with appropriate mitigation measures, such as paleontologic construction monitoring of earth moving, Segment 2 construction would have resulted in beneficial effects by exposing and allowing for the recovery of scientifically highly important fossil remains and associated specimen and site data that would not even have been uncovered without construction-related earth moving and, therefore, would not have been available for recovery. Moreover, recovery of fossil remains and associated data conducted as part of a mitigation program would have been allowed under CEQA Appendix G (j).

Any identifiable fossil remains recovered in the Segment 2 construction zone would be considered scientifically highly important if they represented a new or rare species; a new geographic or chronologic (geologic) record; an age-diagnostic species or a specimen whose age could be determined using carbon-14 dating analysis; an environmentally sensitive species; or a specimen more complete than, or a skeletal element different from those previously available for the species. Moreover, the recovery of remains representing an age-diagnostic species would be critical in confirming, refining, or correcting previous age estimates for the fossil-bearing strata. The recovery of remains representing an environmentally sensitive species would be critical in reconstructing the paleoenvironments and paleoclimates represented by the strata and in confirming, refining, or correcting previous reconstructions. Finally, the remains would contribute to a more comprehensive documentation of the diversity of plant and animal life that existed in the area crossed by the Red Line route and to a more accurate reconstruction of the geologic history of the

area, particularly with regard to major paleoenvironmental and paleoclimatic changes resulting from uplift of the area and its subsequent emergence above sea level.

The Segment 2 paleontologic resource impact mitigation program, begun under LACTC Contract Number 4344, Amendments 7 and 8, and completed under MTA Contract EN025, Work Order 11, included paleontologic construction monitoring of cut-and-cover excavation to allow for the discovery and subsequent recovery of fossil remains uncovered by excavation. Monitoring, which began in September 1991 and ended in February 1998, covered excavation (and other earth-moving activities, including trenching for utility lines, augering for piles) associated with construction of the station boxes, accompanying appendages (entrances, fresh-air intakes, blast relief shafts), and cross-overs for the Wilshire/Vermont, Wilshire/Normandie, Wilshire/Western, Vermont/Beverly, Vermont/Santa Monica, Vermont/Sunset, Hollywood/Western, and Hollywood/Vine stations. Because of the potential for encountering fossil remains at other Segment 2 construction sites and with LACTC and MTA approval, the monitoring task was expanded to include cut-and-cover excavation associated with construction of the MacArthur Lake pocket track structure, cross passage 19, and the Barnsdall Art Park tunnel access shaft, as well as the conveyance of tunneling debris at the MacArthur Lake pocket track structure and Wilshire/Vermont station sites. The mitigation program also included the appropriate treatment and disposition of any recovered fossil remains and the recording and archiving of associated specimen data and corresponding site data. Submission of this final technical report of results and findings to the current CEQA lead agency, the MTA, signifies completion of the Segment 2 mitigation program. The results of the mitigation program conducted during excavation for the Wilshire/Normandie and Wilshire/Western stations (B-221, -231, respectively) and cross passage 19 have been presented in previous final reports (Lander, 1993a, -b, 1994a, -c), although the present report includes results of the mitigation program at the Wilshire/Normandie station site not included in the respective final reports.

The mitigation program, particularly with regard to construction monitoring; recovery, treatment, and permanent museum storage and maintenance of fossil remains uncovered by cut-and-cover excavation; recovery and archiving of associated specimen and site data; and reporting of results and findings, was

conducted in compliance with SVP (1991, 1995, 1996) standard measures (see Appendices B, C) for mitigating adverse construction-related environmental impacts on paleontologic resources, mitigation measures developed during the Segment 2 environmental impact review process (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983), and with SCRTD/LACTC/MTA Specifications Section 01170 (see Appendix A), which originally was developed for Segment 1. Moreover, submission of this final technical report of findings to the MTA will ensure compliance by the MTA with California Public Resources Code Section 21081.6 (mitigation monitoring compliance and reporting), which requires a California (CEQA) lead agency demonstrate project compliance with mitigation measures developed during the environmental impact review process.

The paleontologic construction monitors were experienced in archaeological monitoring and would spot check for cultural resources, including archaeological artifacts, deposits, features, and structural remains, during earth moving at the shallowest depths at each construction site. Any cultural resource recovered and treated as part of the cultural resource impact mitigation program are discussed in final reports by Greenwood and Associates (G&A).

## 2.2 PERSONNEL

Initially, G&A was contracted by the LACTC, successor to the SCRTD, to manage and conduct the first phase of the Metro Red Line Segment 2 cultural resource impact mitigation program and to supervise the paleontologic resource impact mitigation program under LACTC Contract Number 4344, Amendments 7 and 8. PEAI was retained by G&A to manage and conduct the paleontologic mitigation program. Subsequently, G&A was contracted by Parsons Engineering Science, Inc. (PES), who in turn was contracted by the MTA, to manage and conduct the second phase of the Segment 2 cultural mitigation program and to supervise the paleontologic mitigation program under LACTC/MTA Contract Number EN025, Work Order 11. Again, PEAI was retained by G&A to manage and conduct the paleontologic mitigation program. Treatment of recovered fossil remains was covered by both contracts.

This final technical report of results and findings was prepared by Dr. E. Bruce Lander, a senior vertebrate paleontologist with PEAI and principal investigator for the Segment 2 paleontologic resource impact

mitigation program. Dr. Lander has a Ph.D. degree in paleontology and was certified by the State of California as a registered environmental assessor (REA-01290) during Red Line construction. He has prepared paleontologic resource assessments in support of environmental impact review documents for major earth-moving projects, including Segment 2, Red Line Segments 1 and 3, and the Red Line Eastern Extension, and served as principal investigator for paleontologic resource impact mitigation programs conducted in support of construction for Segments 1 and 3 and other major earth-moving projects in the western United States (Lander, 1987, 1990a to -c, 1991, 1993a, -b, 1994a to -c, 1999). Dr. Lander also assisted with MTA media relations and in establishing MTA exhibits and an MTA web site regarding the Segment 2 fossil remains and mitigation program.

Mr. Mark A. Roeder (MAR), a senior vertebrate paleontologist with PEAI, served as field supervisor for the Segment 2 mitigation program. Mr. Roeder also has served as field supervisor for the mitigation programs conducted during construction of Segments 1 and 3.

Paleontologic construction monitoring of cut-and-cover excavation and other construction-related earth-moving activities, as well as recovery of fossil specimens uncovered by these activities, were conducted by M.W. Morris, T.L. Stubbs, G.T. Takeuchi (GTT), and R.D. Turner, PEAI paleontologic construction monitors and technicians, with the assistance of K.J. Bartenstein, T.T. Connors, and R.L. Palmer, former PEAI monitors. Preparation and curation of the specimens were conducted by Mr. Takeuchi and Ms. Turner, and Mr. Takeuchi was responsible for entry of specimen and corresponding geologic and geographic site data into the LACMVP fossil specimen catalog and corresponding computerized data bases. Mr. Takeuchi also conducted the initial (field) processing of a fossiliferous sediment sample.

Mr. Richard W. Huddleston, a PEAI senior vertebrate paleontologist, identified and analyzed the fossil fish remains recovered as a result of the mitigation program, and Mr. Lindsey T. Groves, a PEAI senior invertebrate paleontologist, identified and analyzed

the fossil marine invertebrate remains. Mr. Howard E. Schorn, a paleobotanist and museum scientist emeritus with the UCMP, and Dr. Lanny H. Fisk, a paleobotanist with F & F GeoResource Associates, Inc. (F&F), identified and analyzed the fossil algal and land plant remains. Ms. Shelley M. Cox and, in particular, Mr. Christopher A. Shaw of the George C. Page Museum, and Mr. Eric G. Scott of the San Bernardino County Museum Division of Earth Sciences assisted in identifying the land mammal remains. The microfossil samples were processed and the recovered microfossils identified and analyzed by Micropaleo Consultants, Inc.

Accessioning into the LACMVP fossil collection of the vertebrate fossil specimens recovered as a result of the mitigation program was conducted by Dr. Samuel A. McLeod, collections manager of the LACMVP; accessioning of the invertebrate fossil specimens into the LACMIP fossil collection was conducted by Mr. Lindsey T. Groves, collections manager of the LACMIP; and accessioning of the fossil plant specimens into the UCMP paleobotanic fossil collection was conducted by Dr. Diane M. Erwin and Mr. Howard E. Schorn, museum scientists with the UCMP. Accessioning included archiving of associated data (entry of specimen and corresponding site data into respective museum fossil site catalogs and/or computerized data bases).

R. Radwonski and R. Veatch of Parsons-Dillingham (PD), R. Tack of Tutor-Saliba/Perini (TSP), and M. Guinther of Shea/Kiewit/Kenny (SKK) recovered fossil specimens from the tunnels.

Mr. James L. Sowell, Manager, MTA Construction Division Environmental Compliance Department, and Roberta S. Greenwood, G&A principal investigator, supervised the mitigation program and ensured project personnel fulfilled their responsibilities under the mitigation program.

Dr. David P. Whistler, a PEAI senior vertebrate paleontologist and curator of vertebrate paleontology at the LACMVP, assisted with MTA media relations and in establishing MTA exhibits and an MTA web site regarding the Segment 2 fossil remains and mitigation program.

## SECTION 3

### STRATIGRAPHY

Surficial geologic mapping of the Los Angeles Metro Red Line Segment 2 construction zone and vicinity is presented at a scale of 1:24,000 by CWDD and others (1981), Dibblee (1991a), and Lamar (1970), and regional mapping of the downtown Los Angeles/Hollywood area is provided by Jennings and Strand (1969) at a scale of 1:250,000. Subsurface geologic bore-hole data for the Segment 2 construction zone are presented by CWDD and others (1981), Lander (1987), the Rail Construction Corporation and others (RCC and others, 1991a to -d, 1992, 1993a to -c, 1994a, -b), the UMTA and SCRTD (1983, 1987), and WESTEC Services, Inc. (1983). A surficial geologic map by Dibblee (1991a) of the Segment 2 construction zone and vicinity is presented in Figure 2. A generalized composite stratigraphic columnar section of the Segment 2 construction zone is presented in Figure 3 and summarized in Table 1. The distribution of each surficial and subsurface rock unit is tabulated in Table 2 and depicted in Figure 4 by Segment 2 construction site.

#### 3.1 ROCK UNITS

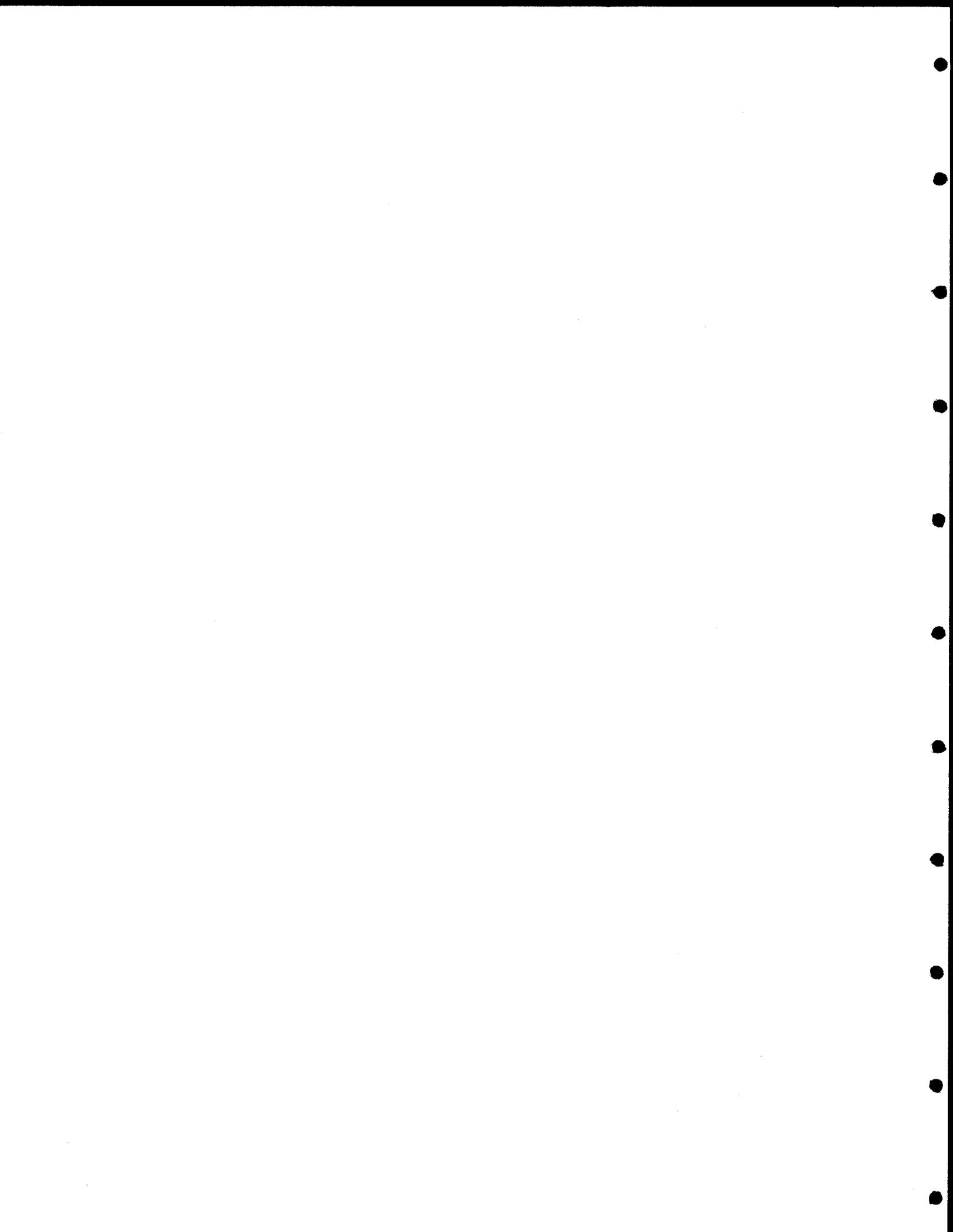
Surficial geologic mapping and geologic bore-hole data indicate that excavation in the Segment 2 construction zone would encounter, in order of increasing geologic age and depth (or in descending stratigraphic order), historic artificial fill (not mapped), Holocene younger alluvium, late Pleistocene older alluvium, the middle to late Pleistocene marine San Pedro Sand, and an unnamed late Miocene marine shale.

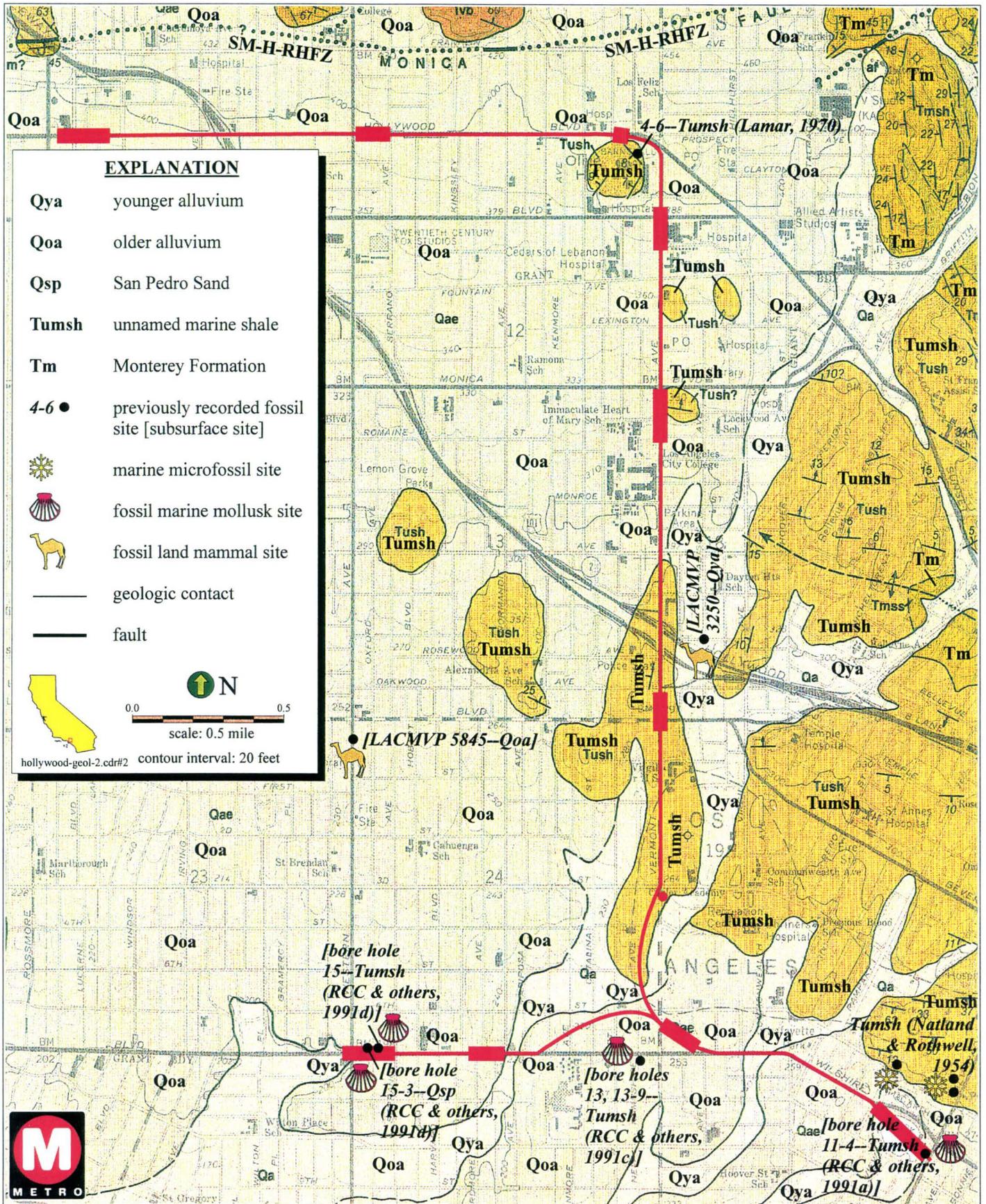
Although not encountered in the Segment 2 construction zone, the Mohnian (late middle to early late? Miocene) marine Monterey Formation (= lower part of Puente Formation and much of underlying early? to middle Miocene marine Topanga Formation of Lamar, 1970) occurs in the Segment 2 vicinity, where it immediately underlies the unnamed marine shale (Dibblee, 1989a, 1991a). The Repettian and Wheelerian (early Pliocene to middle Pleistocene) Repetto Member of the marine Fernando Formation, which immediately overlies the marine shale in the Red Line Segment 1 construction zone (Lander, 1990b, -c), also does not occur in the Segment 2 construction zone, having been removed by erosion prior to deposition of the San Pedro Sand. Although the Repetto Member was encountered by excavation near the northwestern end of the Westlake/MacArthur

Park station site at the southwestern end of the Segment 1 construction zone (Lander, 1990c), the rock unit was not encountered by excavation at, and is not recorded in any bore log, including bore logs 11-1 and -2, from the southeastern end of the MacArthur Lake pocket track structure (see RCC and others, 1991a) at the adjacent southeastern end of the Segment 2 construction zone.

The Segment 2 route and the downtown Los Angeles/Hollywood area occupy an area that once was the northern (shelf) portion of the central Los Angeles basin, a deep submarine basin that previously existed along the former coastline and was bounded on the north by the Santa Monica-Hollywood-Raymond Hill Fault Zone (SM-H-RHFZ) (Blake, 1991; Wright, 1991), which (Santa Monica Fault segment) now roughly parallels and lies less than 0.25 mile north of the Hollywood Boulevard tunnel segment (see Figure 2). The central Los Angeles basin was part of a larger fault-bounded submarine basin (Los Angeles basin) that developed along the southern California continental margin (borderland) as a result of regional extension of the margin during the Miocene and Pliocene Epochs (Rumelhart and Ingersoll, 1997; Wright, 1991). The SM-H-RHFZ separates the central Los Angeles basin, which includes the area now occupied by the northwestern corner of the Peninsular Ranges Province, from the northwestern Los Angeles basin, which includes the area now occupied by the south-central Transverse Ranges Province (including Santa Monica Mountains and San Fernando Valley) to the north (see Dibblee, 1989a, 1991a). In the Peninsular Ranges Province, geographic features and the underlying geologic structures are oriented in a northwest-southeast direction, but are oriented in an east-west direction in the Transverse Ranges Province.

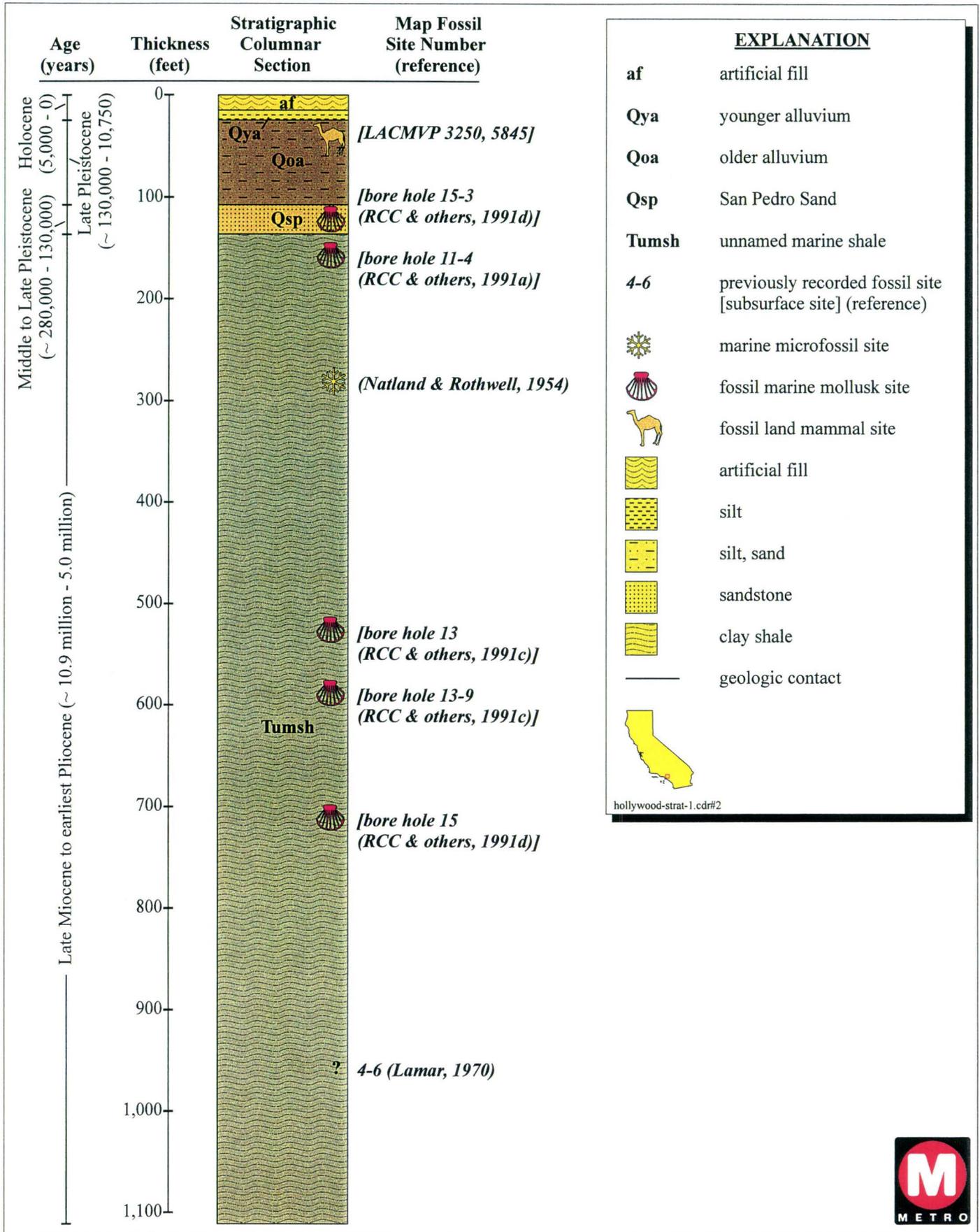
Most of the Segment 2 construction zone is flat and, with the exception of artificial fill, immediately underlain by older alluvium (CWDD and others, 1981; Dibblee, 1991a; Lamar, 1970). The overlying younger alluvium occurs as fill in shallow drainages incised into the older alluvium along Wilshire Boulevard and along Vermont Avenue between Wilshire and Beverly Boulevards. The unnamed late Miocene marine shale occurs in the subsurface throughout most of the Segment 2 construction zone, but is exposed at the surface as erosional remnants only along Vermont Avenue, particularly between





**Figure 2.**—Surficial geology and distribution of fossil taxa by rock unit and previously recorded fossil site, Los Angeles Metro Red Line Segment 2 construction zone and vicinity, Los Angeles, California. Base map: U.S. Geological Survey Hollywood 7.5-minute Quadrangle. Geology after Dibblee (1991a). Fossil site locations after CWDD and others (1981), Lamar (1970), Lander (1995), Natland and Rothwell (1954), RCC and others (1991a, c, d), and Reynolds (1987). See Figure 1. LACMVP: Natural History Museum of Los Angeles County Vertebrate Paleontology Section; SM-H-RHFZ: Santa Monica-Hollywood-Raymond Hill Fault Zone.





**Figure 3.**—Generalized composite stratigraphic columnar section and distribution of fossil taxa by rock unit and previously recorded fossil site, Los Angeles Metro Red Line Segment 2 construction zone and immediate vicinity, Los Angeles, California. Rock units and corresponding lithologies after Dibblee (1991a), Lamar (1970), and RCC and others (1991a to d, 1992, 1993a to c, 1994a, b). Ages of rock units after Berggren and others (1995), Blake (1991), Jefferson (1991), Lander (1999), and Micropaleo Consultants, Inc. (1993, 1998). Stratigraphic levels of fossil sites approximate. Fossil site locations and taxa after CWDD and others (1981), Lamar (1970), Lander (1995), Natland and Rothwell (1954), RCC and others (1991a, c, d), and Reynolds (1987). See Table 1, Figure 2. LACMVP: Natural History Museum of Los Angeles County Vertebrate Paleontology Section.





**Table 1.**—Composite stratigraphic columnar section summary, surficial (exposed) and subsurface rock units, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. Rock units and corresponding lithologies after CWDD and others (1981), Dibblee (1991a), Lamar (1970), RCC and others (1991a to -d, 1992, 1993a to -c, 1994a, -b), and WESTEC Services, Inc. (1983). Ages of rock units after Berggren and others (1995), Blake (1991), Dibblee (1989b, 1991a), Jefferson (1991), Lander (1999), Micropaleo Consultants, Inc. (1993, 1998), and Stock and Harris (1992). See Figures 1 to 3.

Rock Unit	Age (years before present)	Lithology	Environment	Fossil Taxon <sup>a</sup>
artificial fill	historic (< 130)	disturbed sediment, debris	urban	(unfossiliferous)
younger alluvium	middle to late Holocene (5,000 to 130)	unconsolidated gravel, sand, silt, clay	alluvial, fluvial	— <sup>b</sup>
older alluvium	middle? and late Pleistocene to early Holocene? (~ 280,000 and/or 130,000 to 10,750 or < 6,000)	semiconsolidated gravel, sand, silt, clay	alluvial fan	land mammals <sup>c</sup>
San Pedro Sand	middle to late Pleistocene (~ 280,000 to 130,000)	quartz-rich gray sand, pebbly sand	shallow-water marine	marine mollusks <sup>d</sup>
Fernando Formation, Repetto Member <sup>e</sup>	early Pliocene to middle Pleistocene (~ 5,000,000 to ~ 280,000)	poorly bedded to massive, gray to greenish-gray siltstone, mudstone	deep-water marine	— <sup>b</sup>
unnamed marine shale, unit Tpd <sup>e</sup>	earliest Pliocene (~ 5,300,000 to ~ 5,000,000)	white diatomaceous shale	deep-water marine	— <sup>b,f</sup>
unnamed marine shale, unit Tpsl	late Miocene (~ 10,900,000 to ~ 5,300,000)	thinly bedded, light gray to light brown, fine-grained sandstone, siltstone, silty clay shale	deep-water marine	marine microfossils, snails, clams, barnacles, star fishes, sea urchins, fishes, whales, algae, land plants <sup>c,g</sup>
Monterey Formation <sup>e</sup>	late middle to early late? Miocene (~ 12,700,000 to ~ 10,900,000)	white siliceous shale, tan to light gray sandstone	deep-water marine	—

<sup>a</sup>Occurrence in Segment 2 construction zone.

<sup>b</sup>Rock unit fossiliferous, but no fossil remains recovered in Segment 2 construction zone.

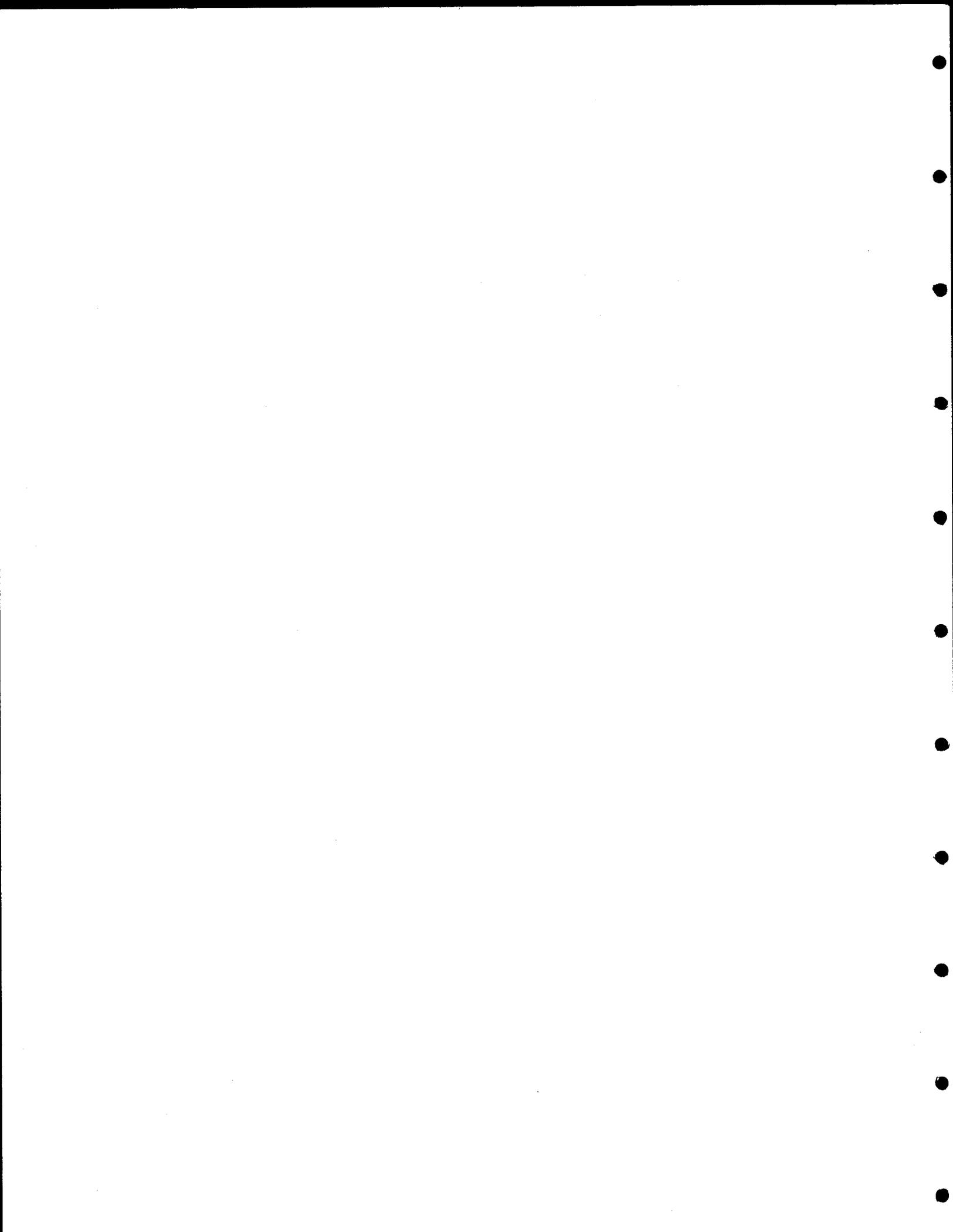
<sup>c</sup>This report.

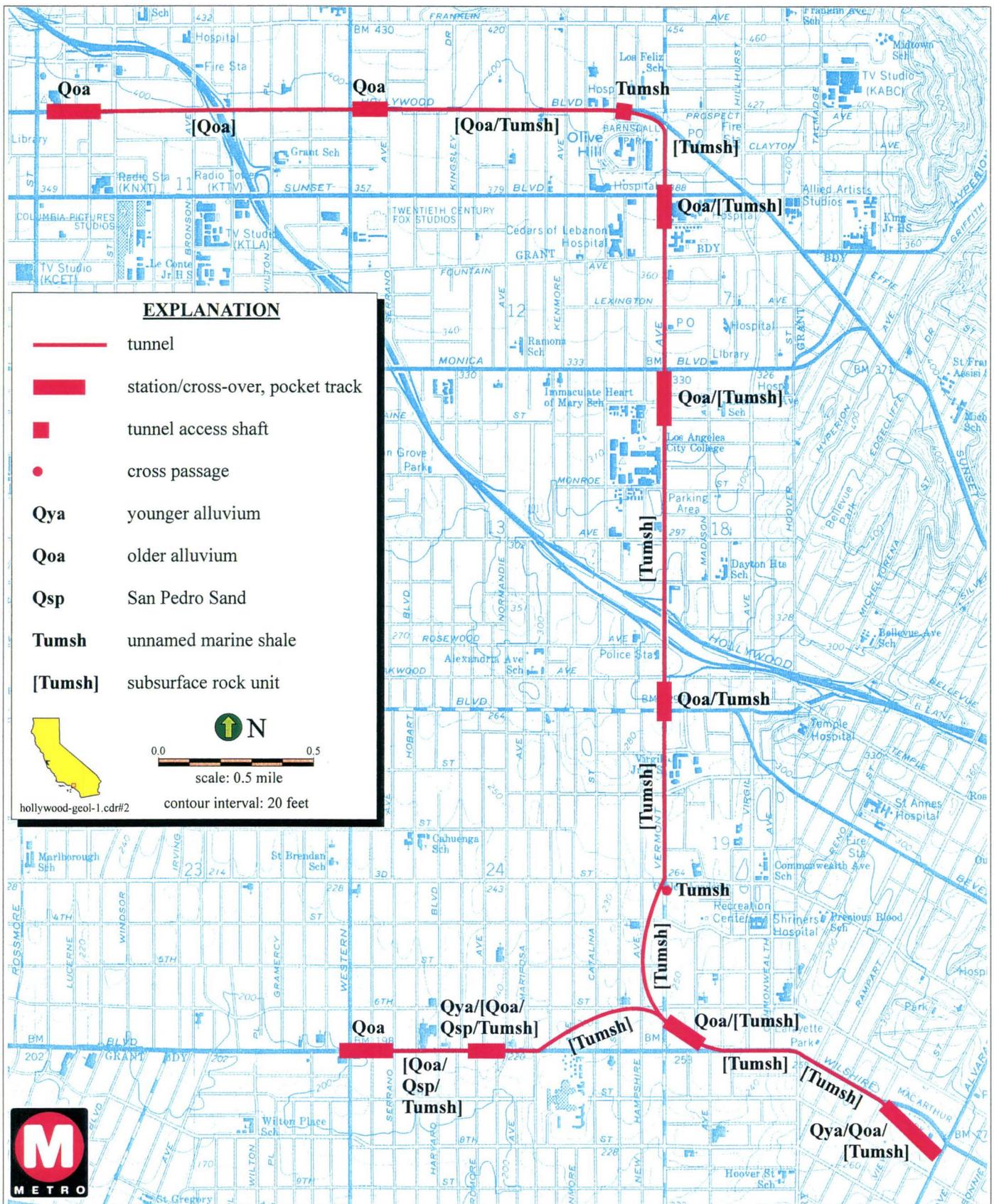
<sup>d</sup>RCC and others (1991c) reported fossil mollusk shells from San Pedro Sand.

<sup>e</sup>Does not occur in Segment 2 construction zone.

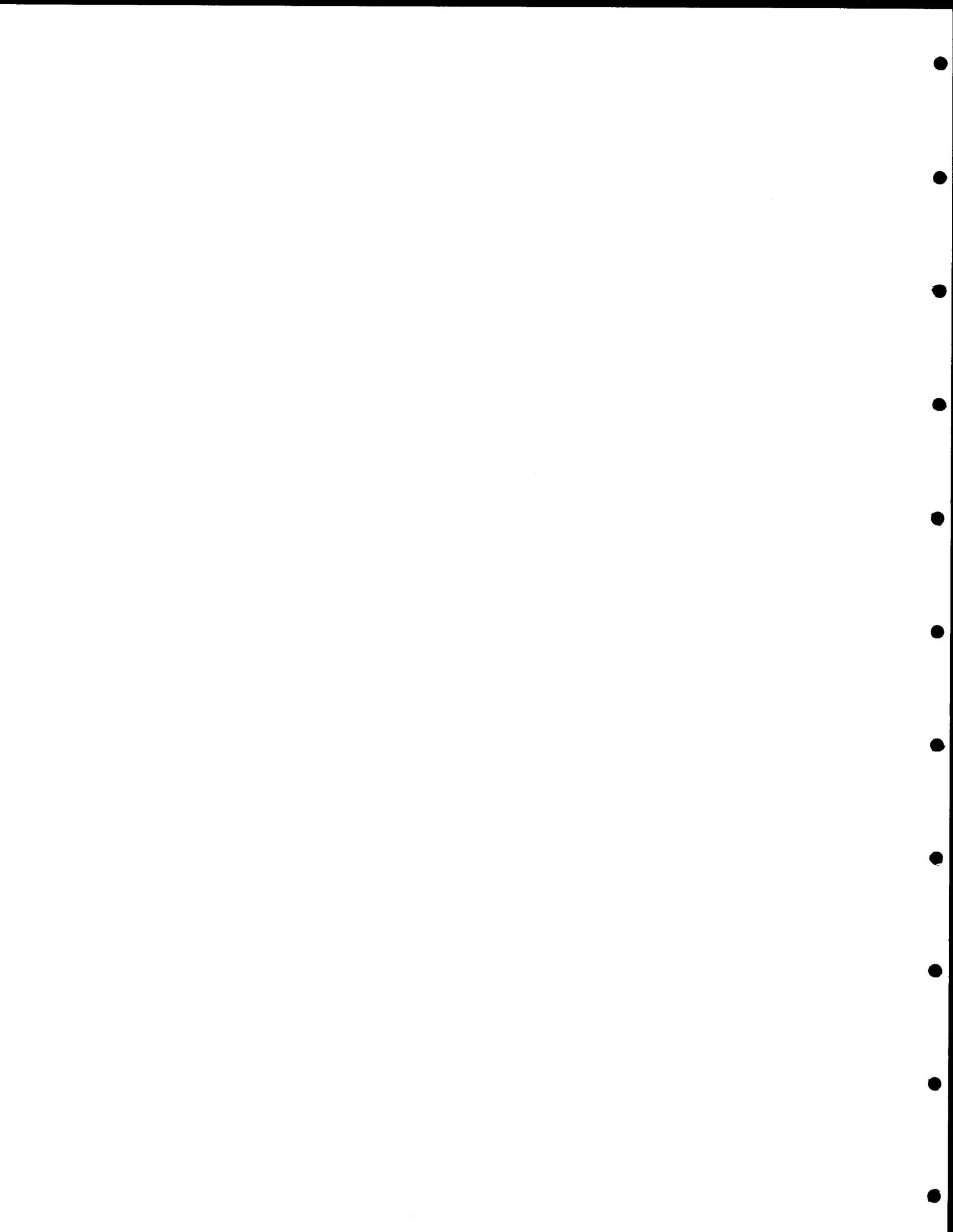
<sup>f</sup>Lander (1990b) reported fossil fish remains from unit Tpd<sup>s</sup> of unnamed marine shale in Red Line Segment 1 construction zone.

<sup>g</sup>RCC and others (1991a, -c, -d) reported fossil clam shells from unit Tpsl of unnamed marine shale.





**Figure 4.**—Distribution of surficial and subsurface rock units by construction site, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. Artificial fill not shown. Base map: U.S. Geological Survey Hollywood 7.5-minute Quadrangle. Geology after CWDD and others (1981), Dibblee (1991a), Lamar (1970), RCC and others (1991a to d, 1992, 1993a to c, 1994a, b), and WESTEC Services, Inc. (1983). See Tables 1, 2, Figures 1 to 3.



**Table 2.**—Distribution of rock units by construction site, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. After CWDD and others (1981), Dibblee (1991a), Lamar (1970), RCC and others (1991a to -d, 1992, 1993a to -c, 1994a, -b), and WESTEC Services, Inc. (1983). See Table 1, Figures 1 to 4.

Construction Site	Rock Unit (Map Symbol <sup>a</sup> )				
	unnamed marine shale (Tumsh)	San Pedro Formation (Qsp)	older alluvium (Qoa)	younger alluvium (Qya)	artificial fill — <sup>b</sup>
MacArthur Lake pocket track structure	[X] <sup>c</sup>		X	X	X
Wilshire/Vermont station	[X]		X		X
Wilshire/Normandie station	[X]	[X]	[X]	X	X
Wilshire/Western station/cross-over			X		X
Wilshire Boulevard tunnel segment	[X]	[X]	[X]		
cross passage 19	X				X
Vermont/Beverly station	X		X		X
Vermont/Santa Monica station/cross-over	[X]		X		X
Vermont/Sunset station	[X]		X		X
Barnsdall Art Park tunnel access shaft	X				
Vermont Avenue tunnel segment	[X]				
Hollywood/Western station			X		X
Hollywood/Vine station/cross-over			X		X
Hollywood Boulevard tunnel segment	[X]		[X]		

<sup>a</sup>Map symbol in Figures 2 to 6.  
<sup>b</sup>Rock unit not mapped in Figures 2 to 6.  
<sup>c</sup>X: surficial rock unit;  
[X]: subsurface rock unit.

Wilshire and Santa Monica Boulevards, and in Barnsdall Art Park, near the intersection of Vermont Avenue and Hollywood Boulevard, where the marine shale usually forms prominences surrounded by older and/or younger alluvium.

**3.1.1 Unnamed Late Miocene Marine Shale**

In the downtown Los Angeles/Hollywood area, the unnamed marine shale previously has been assigned to the upper part (unit Tpsl of Lamar, 1970, and overlying unit Tpbs at top; unit Tush of Dibblee, 1991a) of the Puente Formation by Lamar (1970), and to the Yorba (Shale) Member of Puente/Monterey Formation by Dibblee (1989b) and some other workers. Unit Tpsl consists of thinly bedded, light gray to light brown, silty clay shale, siltstone, and fine-grained sandstone layers (Dibblee, 1989b, 1991a; Lamar, 1970). However, Dibblee (1995) now considers the marine shale laterally equivalent to the Sycamore Canyon Formation (= Sycamore Canyon [uppermost] Member of Puente Formation of some

workers; immediately overlies Yorba [Shale] Member of Monterey Formation). The Sycamore Canyon Formation is based on distinctive marine strata in the Puente Hills, which now occupy the western portion of the northeastern Los Angeles basin (Blake, 1991).

In the Santa Monica Mountains, which lie immediately north of the Segment 2 route and the SM-H-RHFZ (see Figure 2), the marine shale (= upper member of Modelo Formation of some workers) is assigned to the Sisquoc Formation by Fritsche (1993), who restricts the Modelo Formation to the lower member of the Modelo Formation of other workers. Dibblee (1989a, -b, 1991a, 1992, 1995) considers the marine shale of the Los Angeles basin laterally equivalent to the Sisquoc Formation of the Ventura basin, although the Sisquoc Formation is based on distinctive marine strata in the Santa Maria basin.

Strata assigned to the marine shale are similar to those assigned to the Sisquoc and Sycamore Canyon

Formations and the upper member of the Modelo Formation in terms of lithology, marine origin, and geologic age (see Blake, 1991; Fritsche, 1993; Dibblee, 1991a, 1995; Sullwold, 1960). Unlike the conformably underlying Monterey Formation (units Tpsh, Tpss, Tpun in lower part of Puente Formation of Lamar, 1970, in downtown Los Angeles/Hollywood area), the unnamed marine shale and its lateral equivalents lack siliceous shale layers (Dibblee, 1995; Lamar, 1970). However, strata comprising the marine shale and Sycamore Canyon Formation, unlike those comprising the Sisquoc Formation in the Santa Maria basin, were deposited in adjacent parts of the Los Angeles basin. Therefore, the marine shale cannot be assigned to the Sisquoc Formation. Moreover, strata comprising the marine shale in the central Los Angeles basin presumably once were continuous across the SM-H-RHFZ with strata comprising the upper member of the Modelo Formation in the northwestern Los Angeles basin (see Wright, 1991). Strata in both areas are composed of sediments derived from a more westerly source in the San Gabriel Mountains than the sediments comprising the Sycamore Canyon Formation and were deposited to form a large deep-water submarine fan (Tarzana fan) lying west of the fan (Puente fan) formed by the sediments comprising the Sycamore Canyon Formation (Rumelhart and Ingersoll, 1997; Sullwold, 1960; Wright, 1991), although, contrary to most workers, Lamar (1970) did not consider strata comprising the marine shale (unit Tpsl) part of the Tarzana fan. Therefore, the unnamed marine shale cannot be assigned to the Sycamore Canyon Formation, either.

Unfortunately, the Modelo Formation is based on distinctive marine strata in the eastern Ventura basin, strata comprising this rock unit being composed of sediments derived from a more westerly source in the San Gabriel Mountains than the sediments comprising the marine shale and the upper member of the Modelo Formation in the Los Angeles basin, the sediments in the Ventura basin being deposited to form a submarine fan (Piru fan) lying northwest of the Tarzana fan (Rumelhart and Ingersoll, 1997). Therefore, neither the marine shale nor the upper member of the Modelo Formation can be assigned to the Modelo Formation. A new formational name must be proposed for the marine shale and the upper member of the Modelo Formation. Strata comprising the underlying Monterey Formation in the downtown Los Angeles/Hollywood area (units Tm/Tmsh, Tmss of Dibblee, 1991a; unit Tpsh, Tpss of Lamar, 1970) and the Santa Monica Mountains (lower member, Modelo Formation), considered part of the Tarzana

fan by some workers (Lamar, 1970; Rumelhart and Ingersoll, 1997; Sullwold, 1960; Wright, 1991), were considered part of the Elysian fan by Dibblee (1989b, 1991a).

Based on geologic (sedimentologic) evidence (Blake, 1991; Lamar, 1970; Rumelhart and Ingersoll, 1997; Sullwold, 1960; Wright, 1991), strata comprising the Tarzana fan are composed of sediments derived from a continental source area in the central San Gabriel Mountains and transported by submarine sediment or debris (turbidity) flows into deep-water marine (bathyal) environments that existed in deeper portions of the Los Angeles basin during the upper Mohnian and lower "Delmontian" Benthic Foraminiferal Stages (late Miocene Epoch). These debris flows traveled offshore (basinward) in a southerly direction from a point near the former coastline, which lay much farther inland (along base of San Gabriel Mountains) during the late Miocene Epoch; down a submarine canyon incised into the northern shelf and adjacent upper slope of the northwestern Los Angeles basin; and into channels and onto the adjacent interchannel divides on the lower slope and adjacent subsiding floor of the northwestern and central Los Angeles basin, where the debris flows finally slowed, dissipated, and deposited their sediment loads to produce successive layers of sediments that accumulated over time to form a large cone-shaped deep-water submarine fan (Tarzana fan) (Rumelhart and Ingersoll, 1997; Sullwold, 1960). In the northern portion of the central Los Angeles basin, sediments comprising upper Mohnian strata in the lowermost part of the marine shale appear to have been transported in a southwesterly direction (Lamar, 1970).

The Tarzana fan began below the mouth of the submarine canyon near the northeastern margin of the northwestern Los Angeles basin (area now occupied by northeastern San Fernando Valley) and progressively built upward and outward in a southerly direction across the area now occupied by the southwestern San Fernando Valley and Santa Monica Mountains and into the northern (shelf) portion and, ultimately, the central (trough) portion of the central Los Angeles basin, where the distal portions of the Tarzana and Puente fans merge (Blake, 1991; Lamar, 1970; Rumelhart and Ingersoll, 1997; Sullwold, 1960; Wright, 1991). Since development of the Tarzana fan, strata comprising the marine shale in the downtown Los Angeles/Hollywood area have been offset in an easterly direction from laterally equivalent strata in the Santa Monica Mountains by approximately 9 miles of left-lateral displacement

along the SM-H-RHFZ (Wright, 1991; see Figure 2). Excavation in the Segment 2 construction zone encountered only the upper 800 to 1,000 feet of unit Tpsl (upper, but not uppermost unit) of the marine shale, which is approximately 2,400 feet thick in the downtown Los Angeles/Hollywood area (see Lamar, 1970). However, excavation under Alvarado Street at the southeastern end of the MacArthur Lake pocket track structure site apparently did not encounter unit Tpds (uppermost unit) of the marine shale (see Lamar, 1970; RCC, 1991a, bore holes 11-1, -2). Unit Tpds, roughly 200 feet thick, consists of white diatomite and diatomaceous shale layers that immediately underlie the Fernando Formation at the Red Line Segment 1 Tom Bradley/Civic Center station site (see Lamar, 1970). With the exception of the Hollywood/Western and Hollywood/Vine station sites and the Hollywood Boulevard tunnel segment west of Alexandria Avenue, the marine shale was encountered by cut-and-cover excavation and tunneling throughout the entire Segment 2 construction zone (see Figure 4).

In the Segment 2 construction zone, the Repetto Member of the Fernando Formation is absent, having been removed by erosion prior to deposition of the sediments comprising the San Pedro Sand, and the marine shale is separated from the unconformably overlying San Pedro Sand and older alluvium by a pronounced angular discordance with high topographic relief.

### **3.1.2 San Pedro Sand**

The San Pedro Sand, which consists of quartz-rich sandstone and pebbly sandstone layers of shallow-water marine and beach origin (WESTEC Services, Inc., 1983), is not exposed at the surface in the Segment 2 construction zone or its immediate vicinity. The San Pedro Sand was encountered by cut-and-cover excavation and tunneling only at the Wilshire/Normandie station site, where the rock unit is up to 30 feet thick (RCC and others, 1991c; see Figure 4).

### **3.1.3 Older Alluvium**

The older alluvium (unit Qae of Dibblee, 1991a; includes alluvial fan deposits [unit Qf] of CWDD and others, 1981) consists of dissected semiconsolidated clay, silt, sand, and gravel layers of alluvial fan origin (Dibblee, 1991a; Lamar, 1970). Successive layers of sediments derived from canyons incised into the southern side of the Santa Monica Mountains accumulated to form the Hollywood (alluvial) fan,

which developed on the coastal floodplain below the mouths of the canyons and built progressively southward toward the coastline during the late Pleistocene Epoch (Shaw and Quinn, 1986; Stock and Harris, 1992).

With the exception of the Wilshire Boulevard tunnel segment east of the Wilshire/Normandie station site, cross passage 19, the Vermont Avenue tunnel segment, Barnsdall Art Park tunnel access shaft, and the Hollywood Boulevard tunnel segment east of Edgemont Street, the older alluvium was encountered by cut-and-cover excavation and tunneling throughout the entire Segment 2 construction zone, where the rock unit is up to 85 feet thick (RCC and others, 1991c; see Figure 4).

### **3.1.4 Younger Alluvium**

The younger alluvium (unit Qa of Dibblee, 1991a) consists of undissected, flat-lying, poorly bedded, unconsolidated, tan to brown clay, silt, sand, and gravel layers of floodplain origin (Dibblee, 1991a; Lamar, 1970). The younger alluvium was encountered by shallow earth moving only at the MacArthur Lake pocket track structure and Wilshire/Normandie station sites, where the rock unit is up to 10 feet thick (RCC and others, 1991c; see Figure 4).

### **3.1.5 Artificial Fill**

Artificial fill is not mapped in the Segment 2 construction zone, but was encountered by shallow earth moving at every Segment 2 construction site, except at the Barnsdall Art Park tunnel access shaft site and in the tunnel segments. Artificial fill consists of historic unconsolidated sediments and debris deposited and substantially disturbed by human activity, and is up to 15 feet thick in the construction zone (RCC and others, 1991d).

### **3.1.6 Summary**

The Monterey Formation, unnamed late Miocene marine shale, and the lower part of the Repetto Member of the Fernando Formation record the development and progressive deepening of the northern portion of central Los Angeles basin during the middle Miocene to early Pliocene Epochs. Development of the Tarzana fan ended with uplift of the Santa Monica Mountains along the SM-H-RHFZ (Wright, 1991). Paleontologic (benthic marine foraminifer) data suggest the basin floor in the area now occupied by downtown Los Angeles and Hollywood, at least 2,000 feet below sea level during

the middle Miocene Epoch and deposition of the sediments comprising the Monterey Formation and over 4,000 feet below sea level during the late Miocene Epoch and deposition of the sediments comprising the marine shale, may have subsided to roughly 6,000 feet below sea level during the early Pliocene Epoch and deposition of the sediments comprising the Repetto Member (Lamar, 1970; Natland, 1957; Yerkes and others, 1965). The upper part of the Repetto Member and the overlying San Pedro Sand record filling of the Los Angeles basin and/or uplift of the sea floor and final disruption of the basin during the late Pliocene and early to middle Pleistocene Epochs, while the older and younger alluvium record the final uplift of the sea floor above sea level during the late Pleistocene and Holocene Epochs (Natland, 1957; Wright, 1991; Yerkes and others, 1965).

### **3.2 STRATIGRAPHY BY CONSTRUCTION SITE**

Except where noted, the surficial geology at each Segment 2 construction site is based on surficial geologic mapping presented by CWDD and others (1981), Dibblee (1991a), and Lamar (1970), while the subsurface geology is based on bore-hole data provided by CWDD and others (1981), Lander (1987), the RCC and others (1991a to -d, 1992, 1993a to -c, 1994a, -b), the UMTA and SCRTD (1983, 1987), and WESTEC Services, Inc. (1983). The stratigraphy of each construction site is described below. The distribution of each surficial and subsurface rock unit is tabulated in Table 2 and depicted in Figure 4 by construction site.

#### **3.2.1 MacArthur Lake Pocket Track Structure**

Cut-and-cover excavation for the MacArthur Lake pocket track structure encountered 1.0 to 5.0 feet of artificial fill; younger alluvium, which extends downward from the base of the artificial fill to depths 9.0 to 22 feet below grade; older alluvium, which extends from the base of the artificial fill or, where present, younger alluvium downward to depths 8.5 to 28 feet below grade near the southeastern end of the pocket track structure excavation; and the unnamed marine shale, which extends downward from the base of the younger or older alluvium to an undetermined depth below the bottom of the excavation, 30 to 60 feet below grade (RCC and others, 1991a, bore holes 11-1, -2, -7 to -9, -11). Excavation of the marine shale apparently encountered only unit Tps1 (upper, but not uppermost unit), excavation at the southeastern end of the construction zone under Alvarado Street probably

not encountering unit Tpds (uppermost unit) (see RCC and others, 1991a, bore holes 11-1, -2).

#### **3.2.2 Wilshire/Vermont Station**

Cut-and-cover excavation for the Wilshire/Vermont station encountered 3.0 to 5.0 feet of artificial fill; older alluvium, which extends downward from the base of the artificial fill to depths 30 to 35 feet below grade; and the unnamed marine shale, which extends downward from the base of the older alluvium to an undetermined depth below the bottom of the station box excavation, 105 feet below grade (RCC and others, 1991b, bore holes PII-1, -3, -5).

#### **3.2.3 Wilshire/Normandie Station**

Cut-and-cover excavation for the Vermont/Normandie station encountered 1.0 to 2.5 feet of artificial fill; younger alluvium, which extends downward from the base of the artificial fill to depths 1.0 to 9.0 feet below grade; older alluvium, which extends downward from the base of the younger alluvium to a depth 23 feet below grade near the eastern end of the station box excavation and to a depth below the bottom of the excavation, 70 feet below grade, at the western end of the excavation; the San Pedro Sand, which extends downward from the base of the older alluvium at 23 feet below grade to a depth 38 feet below grade near the eastern end of the excavation, the upper and lower contacts of the formation sloping to the west until the upper contact extends below the bottom of the excavation approximately three quarters of the distance to the western end of the excavation; and the unnamed marine shale, which extends downward from the base of the San Pedro Sand at 38 feet below grade to an undetermined depth below the bottom of the excavation at the eastern end of the excavation, the upper contact sloping to the west until the contact extends below the bottom of the excavation near the middle of the excavation (Lander, 1993a; RCC and others, 1991c, bore holes 14-1 to -5).

#### **3.2.4 Wilshire/Western Station/Cross-Over**

Cut-and-cover excavation for the Wilshire/Western station/cross-over encountered 2.0 to 14 feet of artificial fill, and older alluvium, which extends from the base of the artificial fill to a depth below the bottom of the station box excavation, 60 feet below grade (Lander, 1993b; RCC and others, 1991c, -d, bore holes 15-1 to -5).

#### **3.2.5 Wilshire Boulevard Tunnel Segment**

Between the northwestern end of the MacArthur Lake pocket track structure site and the eastern end of the Wilshire/Vermont station site, tunneling for the eastern Wilshire Boulevard tunnel segment encountered only the unnamed marine shale (RCC and others, 1991a). Between the eastern end of the Wilshire/Vermont station site and the eastern end of the Wilshire/Normandie station site, tunneling for this part of the western Wilshire Boulevard tunnel segment also encountered only the unnamed marine shale (RCC and others, 1991b, -c). Between the eastern and the western ends of the Wilshire/Normandie station site, tunneling for this part of the western tunnel segment successively encountered the marine shale, San Pedro Sand, and the older alluvium (RCC and others, 1991c). Between the western end of the Wilshire/Normandie station site and the western end of the Wilshire/Western station/cross-over site, only the older alluvium was encountered by tunneling for this part of the western tunnel segment (RCC and others, 1991d).

### **3.2.6 Cross Passage 19**

Cut-and-cover excavation for cross passage 19 encountered 3.0 feet of artificial fill, and the unnamed marine shale, which extends downward from the base of the artificial fill to a depth below the bottom of the cross passage excavation, 85 feet below grade (Lander, 1994c; RCC and others, 1992, bore hole PII-12).

### **3.2.7 Vermont/Beverly Station**

Cut-and-cover excavation for the Vermont/Beverly station encountered 2.5 to 5.0 feet of artificial fill; older alluvium, which, where present, extends downward from the base of the artificial fill to depths 7.5 to 9.0 feet below grade; and the unnamed marine shale, which extends downward from the base of the artificial fill or, where present, older alluvium to an undetermined depth below the bottom of the station excavation, 60 feet below grade (RCC and others, 1992, 1993a, bore holes PII-20 to -22).

### **3.2.8 Vermont/Santa Monica Station/Cross-Over**

Cut-and-cover excavation for the Vermont/Santa Monica station/cross-over encountered 1.0 to 9.5 feet of artificial fill; older alluvium, which extends downward from the base of the artificial fill to depths 9.0 to 35 feet below grade; and the unnamed marine shale, which extends downward from the base of the older alluvium to an undetermined depth below the bottom of the station excavation, 70 feet below grade

(RCC and others, 1992, 1993b, bore holes PII-34, -36, -38 to -40).

### **3.2.9 Vermont/Sunset Station**

Cut-and-cover excavation for the Vermont/Sunset station encountered 1.0 to 5.0 feet of artificial fill; older alluvium, which extends downward from the base of the artificial fill to depths 5.5 to 58 feet below grade near the northern and southern ends of the station excavation, respectively; and the unnamed marine shale, which extends downward from the base of the older alluvium to an undetermined depth below the bottom of the excavation, 85 feet below grade (RCC and others, 1992, 1994a, bore holes PII-46, -49B, -51 VS-4, -5, -7).

### **3.2.10 Barnsdall Art Park Tunnel Access Shaft**

Cut-and-cover excavation for the Barnsdall Art Park tunnel access shaft encountered the unnamed marine shale, which extends downward from the surface to an undetermined depth below the bottom of the tunnel access shaft excavation, approximately 125 feet below grade (RCC and others, 1992, bore hole PII-58A).

### **3.2.11 Vermont Avenue Tunnel Segment**

Between the northwestern end of the Wilshire/Vermont station site and the Barnsdall Art Park tunnel access shaft, tunneling for the Vermont Avenue tunnel segment encountered only the unnamed marine shale (RCC and others, 1992).

### **3.2.12 Hollywood/Western Station**

Cut-and-cover excavation for the Hollywood/Western station encountered 3.0 to 5.0 feet of artificial fill, and older alluvium, which extends downward from the base of the artificial fill to an undetermined depth below the bottom of the station excavation, 70 feet below grade (RCC and others, 1991c, 1994b, bore holes PII-68 to -72). The older alluvium as mapped by Dibblee (1991a) previously was mapped as alluvial fan deposits by CWDD and others (1981).

### **3.2.13 Hollywood/Vine Station/Cross-Over**

Cut-and-cover excavation for the Hollywood/Vine station/cross-over encountered 3.0 to 5.0 feet of artificial fill, and older alluvium, which extends downward from the base of the artificial fill to an undetermined depth below the bottom of the station excavation, 70 feet below grade (RCC and others,

1992, 1993c, bore holes HV-1 to -6, PII-85, -88, -89). The older alluvium as mapped by Dibblee (1991a) previously was mapped as alluvial fan deposits by CWDD and others (1981).

**3.2.14 Hollywood Boulevard Tunnel Segment**

Between the Barnsdall Art Park tunnel access shaft and eastern end of the Hollywood/Western station site, tunneling for the Hollywood Boulevard tunnel segment successively encountered the unnamed

marine shale and, between Edgemont Street and Alexandria Avenue, the older alluvium (RCC and others, 1992). Between the eastern end of the Hollywood/Western station site and the western end of the Hollywood/Vine station/cross-over site, tunneling for this segment encountered only the older alluvium (RCC and others, 1992). The older alluvium as mapped by Dibblee (1991a) previously was mapped as alluvial fan deposits by CWDD and others (1981).

SECTION 4

PREVIOUS PALEONTOLOGIC RESOURCE INVESTIGATIONS IN AREA

The results of previous scientific investigations regarding the paleontologic resources of each rock unit in the Los Angeles Metro Red Line Segment 2 construction zone are presented below by rock unit, beginning with the oldest rock unit (see Table 1, Figures 2, 3).

With the exception of the artificial fill, all of the rock units in the Segment 2 construction zone have yielded fossil remains at previously recorded fossil sites in and near the construction zone. These fossil remains have been critical in refining previous age estimates for their respective fossil-bearing rock units, reconstructing the paleoenvironments and paleoclimates represented by their sediments, and in documenting the geologic history of the area crossed by the Red Line route.

4.1 UNNAMED LATE MIOCENE MARINE SHALE

The Segment 2 route crossed only unit Tps1 (upper, but not uppermost unit) of the unnamed late Miocene marine shale. Otherwise unidentified marine bivalve remains (clam shells) were encountered in samples from bore hole 11-4, which was drilled at or near the MacArthur Lake pocket track structure site; bore holes 13 and 13-9, which were drilled at or near the Wilshire/Vermont station site; and bore hole 15, which was drilled at or near the Wilshire/Western station site (CWDD and others, 1981; Lander, 1987; RCC and others, 1991a, -c, -d; UMTA and SCRDT, 1983, 1987; WESTEC Services, Inc., 1983; see Figures 2, 3).

Natland and Rothwell (1954) reported the occurrence of "Delmontian" benthic (bottom-dwelling) marine foraminifer (microfossil) assemblages throughout the entire rock unit at numerous previously recorded fossil sites in the downtown Los Angeles/Hollywood area, several sites occurring in the immediate vicinity of the MacArthur Lake pocket track structure site (see Figures 2, 3). However, Dibblee (1989a) and Lamar (1970) reported the occurrence of upper Mohnian and lower "Delmontian" benthic foraminifer assemblages in this rock unit at a number of previously recorded fossil sites near the Segment 2 route, upper Mohnian assemblages occurring only in the lower 250 feet of the rock unit (see Lamar, 1970). These assemblages suggest the floor of the Los Angeles basin was at least 2,000 feet below sea level during the upper Mohnian

Benthic Foraminiferal Stage and over 4,000 feet below sea level in the area now occupied by downtown Los Angeles during the succeeding lower "Delmontian" Stage (Lamar, 1970; Natland, 1957). The assemblages also indicate the marine shale is early late to latest Miocene (roughly 10.9 million to 5.3 million years) in age, although Blake (1991) considered the microfossil assemblages from the top of the marine shale earliest Pliocene (5.3 million to 5.0 million years) in age (see Berggren and others, 1995; Micropaleo Consultants, Inc., 1993).

Lamar (1970) reported the occurrence of fossil marine fish remains representing the family Sciaenidae (croaker *Lompoquia*) at his fossil site 27-10, approximately 4 miles northeast of Union Station in east Los Angeles near Alhambra and South Pasadena. This record is the first reported fossil occurrence of the family from the marine shale in the central Los Angeles basin. Two other fossil sites (6, 26-17) are in the same area and a fourth site (4-6) is in Barnsdall Art Park, immediately adjacent to the tunnel access shaft site (Lamar, 1970; see Figures 2, 3). Although the types of fossil remains recovered at the latter three sites were not reported by Lamar (1970), fossil site 6 in Alhambra almost certainly is the source for the "Delmontian" microfossil sample reported by Lamar (1970).

More recently, a number of fossil fish skeletons were recovered from the marine shale at a then newly recorded PEAI fossil site (LACMVP 5961) in the Red Line Segment 1 construction zone as a result of the paleontologic resource impact mitigation program conducted by PEAI personnel during cut-and-cover excavation for the Tom Bradley/Civic Center station (Lander, 1990b; Huddleston, 1997; Stewart, 1990; see Appendix J). LACMVP fossil site 5961 is in unit Tps1 (uppermost unit) of the marine shale and stratigraphically immediately above unit Tps1 (see Lamar, 1970). The specimens represent five marine fish families, including the Argentinidae? (herring smelts), Clupeidae (herring *?Xyne grex*), Gonostomatidae (bristlemouth *Cyclothone*), Bathylagidae (deepsea smelts), and Myctophidae (lanternfishes; two genera). With the exception of the Argentinidae, these fossil records are the first reported occurrences of the families from the marine shale in the central Los Angeles basin and, with the exception of the shallower-water marine Clupeidae, represent moderately deep-water (mesopelagic)

marine species. Microfossils, algal (seaweed) remains, and sea urchin spines, all of marine species, also were recovered at this fossil site (Lander, 1990b). Lamar (1970) reported the occurrence of otherwise unidentified fish scales in unit Tpd.

The occurrence of fossil mollusk shells in bore samples from the Segment 2 construction zone, as well as the fossil fish occurrences reported by Lamar (1970), indicated a moderate to high potential for similar remains being uncovered at previously unrecorded fossil sites in the marine shale during cut-and-cover excavation for the Wilshire/Vermont, Wilshire/Normandie, Vermont/Beverly, Vermont/Santa Monica, and Vermont/Sunset stations (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983), MacArthur Lake pocket track structure, and the Barnsdall Art Park tunnel access shaft.

Paleontologic data derived from a study of the marine microfossil and fish remains from the unnamed marine shale, in conjunction with sedimentologic (geologic) evidence, have been critical in documenting the deep-water (bathyal) submarine fan origin and predominantly late Miocene age of the rock unit (see Dibblee, 1989a, 1991a; Lamar, 1970; WESTEC Services, Inc., 1983).

#### 4.2 SAN PEDRO SAND

With the exception of otherwise unidentified marine mollusk remains (shells) encountered in samples from bore holes 15 and 15-3, which were drilled at or near the Wilshire/Western station/cross-over site (CWDD and others, 1981; RCC and others, 1991c, -d; see Table 1, Figures 2, 3), no fossil remains are recorded from the San Pedro Sand in the immediate vicinity of the Segment 2 route. However, unlike the other rock units in the Segment 2 construction zone, this rock unit is not exposed at the surface in the Segment 2 route vicinity. Dibblee (1991a) reported the occurrence of fossil marine mollusk shells in this rock unit approximately 5.5 miles southwest of the Wilshire/Western station site in the Baldwin Hills. Woodard and Marcus (1973) reported a marine benthic foraminifer assemblage as occurring in this rock unit in the subsurface south of Hancock Park, which lies 2.6 to 2.7 miles west of the Wilshire/Western station site.

In the Palos Verdes Hills and the adjacent San Pedro area approximately 15 to 20 miles south of the Segment 2 route, the San Pedro Sand has yielded fossilized remains representing Pleistocene marine

invertebrate and vertebrate species and Rancholabrean land mammal species, including the oldest reported occurrence of bison (*Bison*) in the Los Angeles basin (Jefferson, 1991; Kennedy, 1975; Langenwarter, 1975; Miller, 1971; Woodring and others, 1946). The beginning of the Rancholabrean North American Land Mammal Age (NALMA) is defined by the first local appearance of bison, which immigrated to North America from Asia over the Bering land bridge at least 130,000 years ago, during the late Illinoian Glacial Stage sea-level lowstand (Jefferson, 1991; Lundelius and others, 1987; Miller, 1971). However, in the Mojave Desert, the first record of bison has been estimated to be approximately 280,000 years (middle Pleistocene) in age (Jefferson, 1992; see Berggren and others, 1995). Bison are not recorded from the preceding early to middle Pleistocene Irvingtonian NALMA. South of Hancock Park, the San Pedro Sand is immediately overlain by the Palos Verdes Sand, which is assignable to oxygen-18 (isotope) zone 5e and approximately 130,000 to 120,000 years (late Pleistocene) in age (Jefferson, 1991; Kennedy and others, 1987; see Berggren and others, 1995). Presumably, the San Pedro Sand is roughly 280,000 to 130,000 years and middle to late Pleistocene in age, and the beginning of the Rancholabrean NALMA also is about 280,000 years in age. Moreover, the sea floor along the western Wilshire Boulevard tunnel segment probably was not uplifted above sea level until as recently as about 130,000 years ago.

The marine vertebrate and invertebrate fossil occurrences indicated that there was no more than a moderate potential for marine vertebrate and invertebrate fossil remains being uncovered at previously unrecorded fossil sites in the San Pedro Sand during cut-and-cover excavation for the Wilshire/Normandie station (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983).

Paleontologic data derived from a study of the fossil marine mollusk and land mammal remains from the San Pedro Sand, in conjunction with geologic (sedimentologic) evidence, have been critical in documenting the near-shore shallow-water marine origin and middle to late Pleistocene (Rancholabrean) age of the rock unit (Jefferson, 1991; Dibblee, 1989a, 1991a; Miller, 1971; WESTEC Services, Inc., 1983).

#### 4.3 OLDER ALLUVIUM

Jefferson (1991), Lander (1987, 1994b), Miller

(1971), Reynolds (1987), and WESTEC Services, Inc. (1983), reported the occurrence of fossilized remains representing extinct Rancholabrean land mammal species at numerous previously recorded fossil sites in the Los Angeles area, including the immediate vicinity of the Segment 2 route, most of the sites having been uncovered by excavation for other construction projects. Some of these sites are in areas immediately underlain by younger alluvium (see Dibblee, 1989a, 1991a; Lamar, 1970), but occurred at depths possibly sufficient to have been in the stratigraphically underlying older alluvium. LACMVP fossil site 3250, less than 0.2 mile east of the Segment 2 route along Vermont Avenue, yielded mammoth remains at a depth only 8 feet below grade (see Figures 2, 3). Another fossil site (LACMVP 1755), 0.6 mile south of the Red Line Segment 1 Metro Center (7<sup>th</sup>/Figueroa) station, yielded horse remains. More recently, part of a bison limb bone was uncovered at a depth roughly 35 to 55 feet below grade during excavation of the Segment 1 tunnel at a then newly recorded (but uncatalogued) fossil site just west of Union Station (Lander, 1993a, -b, 1994b). Carbon-14 dating analyses conducted on three fossil wood specimens recovered at a stratigraphic level very near the base of the younger alluvium at the Segment 3 Universal City station site in the San Fernando Valley have yielded early Holocene radiometric age determinations of  $7,860 \pm 80$ ,  $8,880 \pm 60$ , and  $10,500 \pm 25$  years (average:  $9,080 \pm 70$  years) (Lander, 1999). These age determinations suggest that the land mammal remains actually are from the underlying older alluvium and are Rancholabrean and at least 10,500 years in age (Lander, 1999).

The remainder of the sites that yielded Rancholabrean land mammal remains are in the older alluvium (see Dibblee, 1991a; Lamar, 1970). Included with these sites is the La Brea tar pits area of Hancock Park, which lies 2.6 to 2.7 miles west of the Wilshire/Western station site and produced the extinct land mammal fauna that is the basis for the Rancholabrean NALMA (Lundelius and others, 1987; Shaw and Quinn, 1986; Stock and Harris, 1992; Woodburne, 1987). On the basis of radiometric (including carbon-14) dating analyses, the Rancholabrean fossil land mammal remains from the La Brea tar pits and vicinity have been determined to be more than 46,500 to approximately 11,000 years (late Pleistocene) in age (Marcus and Berger, 1984; Stock and Harris, 1992; see Berggren and others, 1995). South of Hancock Park, the older alluvium (upper part of unit B; overlying unit C of Woodard and Marcus, 1973) is immediately underlain by the late Pleistocene marine

Palos Verdes Sand (lower part of unit B), which is interbedded with the lower part of the older alluvium and has yielded marine mollusk shells in the Hancock Park area (Shaw and Quinn, 1986; WESTEC Services, Inc., 1983; Woodard and Marcus, 1973). The Palos Verdes Sand is assignable to oxygen-18 (isotope) zone 5e and approximately 130,000 to 120,000 years (late Pleistocene) in age (Jefferson, 1991; Kennedy and others, 1987; see Berggren and others, 1995). Presumably, the sea floor in the Hancock Park area was not uplifted above sea level until as recently as about 120,000 years ago. These data suggest the base of the older alluvium is as old as 130,000 years in age, at least at the Wilshire/Normandie and Wilshire/Western station sites, where the older alluvium unconformably overlies the San Pedro Sand and where the lower part of the older alluvium probably is laterally equivalent to the Palos Verdes Sand in the Hancock Park area. However, the base of the older alluvium might be as old as about 280,000 years and middle Pleistocene in age elsewhere in the Segment 2 construction zone, where the older alluvium immediately overlies the unnamed late Miocene marine shale and where the lower part of the older alluvium possibly is laterally equivalent to the San Pedro Sand.

The end of the Pleistocene Epoch (and Rancholabrean NALMA), probably about 10,750 years in age (Lander, 1999), is marked by a worldwide extinction event that involved most large land mammal species and occurred as a result of 1) overkill arising from intense hunting by prehistoric humans and/or 2) the severe climatic changes that followed the end of the last Ice Age and the accompanying alterations of habitat and vegetation that lead to present conditions (Lander, 1988; Lundelius and others, 1987; Stock and Harris, 1992). However, possibly unreliable carbon-14 dating analyses suggest the top of the older alluvium is early Holocene and younger than 6,000 years in age, but no younger than the overlying younger alluvium, the base of which is approximately 5,000 years and middle Holocene in age at Union Station (Beta Analytic Inc., 1996; Lander, 1999; Stock and Harris, 1992; E.B. Lander, PEAI, unpublished data; see below).

A previously recorded fossil site (LACMVP 5845) approximately 1.0 mile west of the Vermont/Beverly station site yielded Rancholabrean mastodont (elephant) remains at a depth only 5 to 6 feet below grade (Lander, 1995; see Figures 2, 3).

The occurrences of Rancholabrean fossil land

mammal remains in the older alluvium at previously recorded fossil sites other than those at and in the immediate vicinity of Hancock Park indicated that there was only a moderate potential for similar remains being uncovered at previously unrecorded fossil sites in the older alluvium during cut-and-cover excavation for the Wilshire/Vermont, Wilshire/Normandie, Wilshire/Western, Vermont/Santa Monica, Vermont/Sunset, Hollywood/Western, and Hollywood/Vine stations (Lander, 1987; UMTA and SCRTRD, 1983, 1987; WESTEC Services, Inc., 1983), MacArthur Lake pocket track structure, and the Barnsdall Art Park tunnel access shaft.

Paleontologic data derived from a study of the fossil land mammal remains from the older alluvium, in conjunction with geologic (sedimentologic) evidence, have been critical in documenting the continental or nonmarine (coastal alluvial floodplain) origin and late Pleistocene (Rancholabrean) and possibly early Holocene age of the rock unit (Jefferson, 1991; Dibblee, 1989a, 1991a; Miller, 1971; WESTEC Services, Inc., 1983).

#### **4.4 YOUNGER ALLUVIUM**

Until recently, no fossil remains were reported definitely as having been recovered from the younger alluvium in the vicinity of the Segment 2 route and, because of its presumed comparatively recent (Holocene) age, there was considered to have been only a low potential for any remains or previously unrecorded fossil site being uncovered in this rock unit during cut-and-cover excavation for the MacArthur Lake pocket track structure (see Lander, 1987; UMTA and SCRTRD, 1983, 1987; WESTEC Services, Inc., 1983).

Recently, however, fossilized wood, pollen, and spores of land plants were recovered at a previously unrecorded fossil site approximately 5 feet above the base of the younger alluvium as a result of a paleontologic resource impact mitigation program conducted by PEAI personnel during and in support of earth moving associated with construction at Union Station, 0.2 mile south of the Red Line Segment 1 tunnel (E.B. Lander, PEAI, unpublished data). Carbon-14 dating analysis conducted on a fossil wood fragment from this fossil site indicates the specimen is  $5,020 \pm 80$  years (middle to late Holocene) in age (Beta Analytic Inc., 1996; E.B. Lander, PEAI, unpublished data). This radiometric age determination indicates the base of the younger alluvium probably is about 5,000 years and middle Holocene in age (Lander, 1999).

Paleontologic data derived from a study of the fossil land plant remains from the younger alluvium, in conjunction with geologic (sedimentologic) evidence, have been critical in documenting the continental or nonmarine (fluvial or stream channel) origin and Holocene age of the rock unit (Dibblee, 1989a, 1991a; WESTEC Services, Inc., 1983).

#### **4.5 ARTIFICIAL FILL**

Artificial fill consists of historic sediment and debris substantially disturbed by human activity. Any fossil remains encountered in the artificial fill would have lacked any original geologic or geographic context. For this reason, there was no potential for any scientifically important fossil remains or previously unrecorded fossil site being uncovered in this rock unit during cut-and-cover excavation at any construction site.

## SECTION 5

### METHODS

The Los Angeles Metro Red Line Segment 2 paleontologic resource impact mitigation program required by the LACTC and MTA was conducted by PEAI personnel during and in support of cut-and-cover excavation and other earth-moving activities (trenching, augering, tunneling) associated with construction of the MacArthur Lake pocket track structure; Wilshire/Vermont, Wilshire/Normandie, Wilshire/Western, Vermont/Beverly, Vermont/Santa Monica, and Vermont/Sunset station boxes/appendages (entrances, fresh-air intakes, blast relief shafts), and cross-overs; cross passage 19; Barnsdall Art Park tunnel access shaft; and the intervening tunnel segments. The mitigation program, particularly with regard to paleontologic construction monitoring of earth moving; recovery, treatment, and permanent museum storage and maintenance of fossil remains uncovered by cut-and-cover excavation; recording and archiving of associated specimen data and corresponding geologic and geographic site data; and reporting of results and findings, has been in compliance with SVP standard measures for mitigating adverse construction-related environmental impacts on paleontologic resources (SVP, 1991, 1995, 1996; see Appendices B, C), mitigation measures developed during the Segment 2 environmental impact review process (Lander, 1987; UMTA and SCRTRD, 1983, 1987; WESTEC Services, Inc., 1983), and mitigation measures, including those measures presented in SCRTRD/LACTC/MTA Specifications Section 01170 (see Appendix A), developed for Metro Red Line Segment 1 (Greenwood, 1987).

#### 5.1 MUSEUM REPOSITORY STORAGE AND MAINTENANCE AGREEMENTS

The LACMVP and LACMIP are the designated museum repositories for the fossil vertebrate and invertebrate specimens, respectively, and associated specimen data and corresponding geologic and geographic site data recovered as a result of the Metro Red Line Segment 2 paleontologic resource impact mitigation program, and the UCMP is the designated museum repository for the recovered fossil plant specimens and associated specimen and site data. The PEAI mitigation program principal investigator developed formal agreements with the LACMIP, LACMVP, and UCMP regarding final disposition and permanent storage and maintenance of the Segment 2 fossil invertebrate, vertebrate, and

plant collections and associated specimen and site data (see Appendices E, F, G). As necessary, each agreement covered, but was not necessarily limited to, museum or section requirements regarding storage and maintenance fees; level of treatment (specimen preparation to point of identification, identification to lowest taxonomic level possible, curation [assigning and labeling specimens with repository specimen and corresponding site numbers, placing specimens in specimen trays and vials with completed specimen data cards], cataloguing [entering specimen and site numbers and corresponding data into appropriate catalogs and computerized data bases of designated museum repositories]) of the appropriate part of the collection before that part of the collection would be accepted by the respective museum repository; and the purchase of specimen storage cabinets and drawers, as well as specimen trays and vials and other curation supplies. Unless some or all of these requirements were fulfilled, the LACMIP, LACMVP, or UCMP could have refused to accept the respective part of the Segment 2 fossil collection and, under SVP (1991, 1995, 1996; see Appendices B, C) guidelines, adverse construction-related environmental impacts on paleontologic resources of the Segment 2 construction zone would not have been considered mitigated to an insignificant level.

#### 5.2 DISCOVERY CLAUSE AND TREATMENT PLAN

The PEAI principal investigator developed discovery clauses and treatment plans for the Metro Red Line Segment 2 paleontologic resource impact mitigation program (see Appendix D). A discovery clause for a particular construction site specified procedures to be conducted and personnel to be contacted if an unusually large or productive fossil occurrence were uncovered by earth moving and could not be recovered without significantly diverting the paleontologic construction monitor from the routine monitoring task or diverting earth moving around the fossil site for an extended period of time, or if a fossil occurrence were uncovered when the monitor was not on site.

A treatment plan, when approved by the LACTC or MTA and implemented following the discovery of an unusually large or productive fossil occurrence, allowed for the additional manpower and tasks (recovery, processing, preparation, identification,

curation, cataloguing, data entry, purchasing equipment/supplies, permanent museum storage and maintenance, as appropriate) required to treat the occurrence.

### **5.3 PRECONSTRUCTION MEETINGS**

As specified in SCRTRD/LACTC/MTA Specifications Section 01170 (see Appendix A), a preconstruction meeting between PEAI paleontologic mitigation program (principal investigator, field supervisor, paleontologic construction monitors), LACTC/MTA (Environmental Compliance Section manager), environmental controls (PES), construction management (PD), and appropriate construction contractor (Kiewit/Shea, SKK, TSP) staff was held prior to any earth-moving activity at a particular Metro Red Line Segment 2 construction site to ensure construction management and contractor staff were advised of 1) the potential for fossil remains being uncovered by earth moving; 2) mitigation measures to be implemented as part of the Segment 2 paleontologic resource impact mitigation program during earth moving, particularly if fossil remains were uncovered by this activity; and 3) construction worker responsibilities and lines of communication if fossil remains were uncovered by earth moving, especially when a monitor was not on site.

The principal investigator briefed the other meeting attendees on the following items.

Routine mitigation measures (primarily paleontologic monitoring to allow for discovery and recovery of fossil remains) to be employed by a monitor during any earth-moving activity, particularly cut-and-cover excavation, at the construction site, and the responsibility of the monitor in ensuring earth moving was not delayed.

The potential for fossil remains being uncovered by cut-and-cover excavation at specific depths and the need to implement specific actions and additional mitigation measures (as specified in discovery clause/treatment plan) if a fossil occurrence were uncovered by excavation.

Functions and responsibilities of the monitor (as specified in discovery clause/treatment plan) if fossil remains were uncovered by earth moving and could be recovered without diverting the monitor from monitoring (divert earth moving temporarily around fossil site until remains evaluated and recovered, and earth moving

allowed to proceed through fossil site by monitor; enlist assistance of earth-moving equipment and operator to expedite recovery of remains, reduce any potential construction delay, and obviate need for additional recovery personnel).

Functions and responsibilities of the monitor (as specified in discovery clause/treatment plan) if an unusually large fossil specimen or a concentration of small fossil specimens was uncovered by earth moving and could not be recovered without diverting the monitor from monitoring (flag fossil site; advise earth-moving equipment operator and other appropriate construction contractor staff of need to have earth moving avoid site until further notice; call principal investigator or field supervisor to construction site).

Functions and responsibilities of the principal investigator or field supervisor (as specified in discovery clause/treatment plan) if notified by the monitor that an unusually large fossil specimen or a concentration of small fossil specimens had been uncovered by earth moving (evaluate occurrence to determine if recovery warranted; if warranted, notify appropriate construction management and construction contractor staff and MTA Environmental Compliance Section manager of fossil occurrence, necessity of having earth moving avoid fossil site for extended period, implementing additional mitigation measures specified in discovery clause/treatment plan, initiating full-time monitoring, if appropriate and not already in effect, to allow for recovery of large fossil remains, and assigning additional personnel to mitigation program; within 24 hours after MTA approval, mobilize recovery crew to recover remains or fossiliferous rock sample containing concentration of small fossil remains; supervise recovery of remains or rock sample and its transport off site; if warranted, enlist assistance of earth-moving equipment and operator to expedite recovery of remains or sample, reduce any potential construction delay, and obviate need for additional recovery personnel; after recovering remains or sample, allow earth moving to proceed through fossil site).

Responsibilities of the construction management and construction contractor staff, particularly earth-moving equipment operators, if large fossil

remains were uncovered by excavation, especially when a monitor was not on site when the remains were encountered (avoid disturbance of fossil site by earth moving; call monitor, principal investigator, or field supervisor to construction site; if requested by mitigation program personnel, provide earth-moving equipment and operator to assist in recovery of remains, reduce any potential construction delay, and obviate need for additional recovery personnel).

Responsibilities of the construction management and construction contractor staff, particularly tunneling-machine operators, if fossil remains were uncovered by tunneling (avoid disturbance of occurrence by tunneling; recover remains; record associated specimen [fossil type] and corresponding geologic [rock unit, rock type] and geographic [location; elevation or depth] site data; retain remains and associated specimen and site data on site; call monitor, field supervisor, or principal investigator to construction site to retrieve remains and associated data).

Legislation prohibiting unauthorized fossil collecting by construction management and construction contractor staff, and of LACTC/MTA worker incentive program developed to encourage staff to submit fossil remains to paleontologic mitigation program personnel.

Lines of communication to be followed if fossil remains were discovered, especially when a monitor was not on site when the remains were uncovered by earth moving.

When warranted, the field supervisor and a monitor gave a similar on-site presentation to construction contractor earth-moving equipment operators at one of their earliest safety meetings. The operators were briefed on recognizing fossil remains at the construction site; shown examples of fossil specimens similar to those that might be encountered at the site; informed of their responsibilities if they observed fossil remains, particularly when the monitor was not on site (avoid disturbance of remains by earth moving; have construction contractor staff call monitor, field supervisor, or principal investigator to construction site; assist in recovering remains, if requested; if necessary, recover remains and record associated specimen data and corresponding site data and retain for retrieval by paleontologic mitigation program personnel); advised that their unauthorized collecting of fossil remains was illegal; and told of

the LACTC/MTA worker incentive program.

#### 5.4 PALEONTOLOGIC CONSTRUCTION MONITORING AND LARGER FOSSIL SPECIMEN RECOVERY

In compliance with SCRTRD/LACTC/MTA Specifications Section 01170 (see Appendix A) and mitigation measures developed during the Metro Red Line environmental impact review process (Lander, 1987; UMTA and SCRTRD, 1983, 1987; WESTEC Services, Inc., 1983), paleontologic construction monitoring of earth moving was conducted by PEAI paleontologic construction monitors as part of the Segment 2 paleontologic resource impact mitigation program from September 1991 to February 1999 at the Red Line Segment 2 MacArthur Lake pocket track structure, Wilshire/Vermont, Wilshire/Normandie, Wilshire/Western, Vermont/Beverly, Vermont/Santa Monica, Vermont/Sunset, Hollywood/Western, and Hollywood/Vine station, cross passage 19, and Barnsdall Art Park tunnel access shaft sites. Monitoring was conducted in areas underlain by sedimentary rock units (older alluvium, San Pedro Sand, unnamed late Miocene marine shale) with a moderate to high potential for containing larger fossil remains, and allowed for the discovery and subsequent recovery of any remains and associated specimen data and corresponding geologic and geographic site data uncovered by cut-and-cover excavation and any other earth-moving activity (augering for piles, trenching for utility lines; conveyance of earth-moving debris) in the Segment 2 construction zone. Monitoring ensured any potential construction delay would be avoided or kept to a minimum because a monitor usually was on site when remains most likely would be uncovered by these earth-moving activities.

Monitoring consisted of visually inspecting previously undisturbed sedimentary rock exposed by earth moving, as well as the debris generated by earth moving. When a larger fossil specimen was found, the specimen was recovered by the monitor. Hand equipment was used, if required. If necessary, an unusually large specimen would have been covered with a protective plaster-impregnated jacket prior to recovery. As stipulated by SCRTRD/LACTC/MTA Specifications Section 01170, the monitor had the authority to divert earth moving temporarily around the fossil site until the remains had been recovered and earth moving allowed to proceed through the site by the monitor. If warranted, the fossil site could have been flagged with colored survey ribbon to divert earth moving around the site, thereby ensuring the

site would not be disturbed by earth moving. If necessary to ensure the monitor would not be diverted from the monitoring task and to reduce the potential for any construction delay, additional PEAI personnel (paleontologic field technicians) with hand equipment could have been assigned to the recovery effort to expedite recovery of the specimen and its transport to a laboratory facility for treatment. Under SCRTD/LACTC/MTA Specifications Section 01170, earth-moving equipment and an operator could have been enlisted to assist in and expedite recovery of the specimen, thereby obviating the need for additional recovery personnel and further reducing the potential for any construction delay. A temporary field number was assigned to each specimen; the field number, associated specimen data (preliminary field identification of taxon, element), and corresponding geologic (rock unit) and geographic (location; elevation or depth) site data recorded in daily monitoring logs or field notes; and the field number recorded and the site location plotted on a map of the construction site.

Augering was monitored to allow for the early determination of the location and depth of any fossil site in the subsurface prior to cut-and-cover excavation for a station, pocket track structure, or tunnel access shaft to ensure the monitor would be present to relocate the site and recover additional fossil remains when and where it was most likely the site would be encountered during excavation, and to ensure monitoring of excavation would be conducted at an appropriate level of effort.

Tunneling and the excavation of cross passages were not monitored because of the confined working spaces, although tunneling debris was inspected at the MacArthur Lake and Wilshire/Vermont conveyance sites and excavation debris from cross passage 19 was inspected on site. Tunneling debris conveyed from the Barnsdall Art Park tunnel access shaft was not inspected because debris from as many as four tunnel segments was being conveyed at the same time, and the original location of the fossil site yielding a fossil specimen retrieved from the debris could not have been determined. However, as part of a worker incentive program developed by the LACTC and subsequently adopted by the MTA, construction management and construction contractor personnel were encouraged to recover fossil specimens and record associated specimen data and corresponding geologic and geographic site data from the tunnels and submit them to paleontologic mitigation program personnel.

Initially, monitoring was conducted on a part-time basis in areas underlain by the older alluvium, San Pedro Sand, and unnamed marine shale because cut-and-cover excavation was considered to have only a moderate to high potential for uncovering fossil remains in these rock units, based on the comparatively low density (or local absence) of previously recorded fossil sites in these rock units in the Segment 2 vicinity (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983). Part-time monitoring allowed one monitor to be present at more than one construction site on a daily basis. Monitoring was conducted at a higher rate when and where excavation encountered the marine shale because of the demonstrated potential for fossil remains being uncovered by excavation of this rock unit in the Segment 2 construction zone (Lander, 1990b). However, following the initial discovery of numerous fossilized fish remains at a previously unrecorded fossil site in the marine shale during cut-and-cover excavation for the Wilshire/Vermont station, and with LACTC approval, the monitoring rate was increased to full time at the construction site because of the high potential for additional similar fossil remains being uncovered by excavation of this rock unit. Similarly, following the initial discovery of fossilized land mammal remains at previously unrecorded fossil sites in the older alluvium during tunneling for the Hollywood Boulevard tunnel segment, and with MTA approval, the monitoring rate was increased at the Hollywood/Western station site because of the high potential for additional fossil remains being uncovered by excavation of this rock unit. Monitoring was not conducted in areas immediately underlain by younger alluvium because cut-and-cover excavation was considered to have only a low potential for uncovering fossil remains in this rock unit.

#### 5.5 FOSSILIFEROUS ROCK SAMPLE PROCESSING AND SMALLER FOSSIL SPECIMEN RECOVERY

As part of the Metro Red Line Segment 2 paleontologic resource impact mitigation program, sedimentary rock samples were recovered from selected rock units at several Segment 2 construction sites by a PEAI paleontologic field technician to allow for the recovery of smaller fossil remains. Such remains normally are too small to be observed by a paleontologic construction monitor while monitoring earth moving at a construction site, unless the monitor routinely dry test screens rock samples as part of the monitoring effort.

### 5.5.1 Smaller Vertebrate Fossil Specimen Recovery

Periodically, as part of the monitoring task, small (25-pound) rock samples from the older alluvium were dry test screened by the monitor to allow for the documentation of fossil sites suitable for recovering large fossiliferous rock samples that could be processed to allow for the recovery of smaller vertebrate fossil remains. The recovery and processing of fossiliferous rock samples are recommended under SVP (1991, 1995; see Appendix B) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources.

Because it contained organic debris, a 50-pound test sample was recovered from the older alluvium at the Wilshire/Vermont station site. Initial (field) processing of the sample was conducted by a paleontologic field technician to determine if smaller vertebrate fossil remains had been uncovered at the sampling site by cut-and-cover excavation. Initial processing of the sample consisted of wet screening or sieving the sediment comprising the sample through a 20-mesh box screen immersed in a tub of water to remove the smaller (clay, silt) sedimentary particles from the larger (sand, rock) particles and, if present, any smaller fossil remains, resulting in volume and weight reductions of approximately 90 to 95 per cent. However, no fossil remains were observed during a cursory laboratory examination by the PEAI senior vertebrate paleontologist of the concentrate generated by initial processing. Therefore, the entire sample was discarded and all work at the sampling site was suspended because the strata at the site were not considered sufficiently productive to warrant any additional processing.

### 5.5.2 Microfossil Specimen Recovery

Two microfossil-bearing rock samples were recovered from unit Tps1 of the unnamed late Miocene marine shale at the Wilshire/Vermont and Vermont/Sunset station sites to process for microfossils, and a third sample was recovered from overlying unit Tpds (uppermost unit) of the marine shale at the Red Line Segment 1 Tom Bradley/Civic Center station site. Microfossil recovery requires a specialized processing technique substantially different from the technique required for recovering small vertebrate fossil remains.

### 5.5.3 Smaller Invertebrate Fossil Specimen Recovery

No sample was processed to allow for the recovery of smaller invertebrate remains because no rock unit in the Segment 2 construction zone was considered suitable for the preservation or recovery of such remains.

## 5.6 LABORATORY TREATMENT

In the laboratory, larger fossil remains recovered in the Metro Red Line Segment 2 construction zone as part of the Segment 2 paleontologic resource impact mitigation program were prepared by PEAI paleontologic laboratory technicians. Preparation of a fossil specimen included removal of much of the rock containing the specimen. Preparation sufficient to allow identification of the specimen to the lowest taxonomic level possible (and reduce storage space) is recommended under SVP (1991, 1995, 1996; see Appendices B, C) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources. Identification of many of the specimens would not have been possible without preparation.

After preparation, all (larger and smaller) specimens were identified to the lowest taxonomic level possible and analyzed by knowledgeable PEAI senior paleontologists or, as appropriate, other paleontologists (F&F; Micropaleo Consultants, Inc.). Fossil specimen identification is recommended under SVP (1991, 1995, 1996; see Appendices B, C) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources, and now is required before a fossil collection will be accepted by most museum repositories, particularly the LACMVP (see Appendices E to G). Moreover, the scientific importance of a fossil specimen cannot be evaluated until the specimen has been identified to the lowest taxonomic level possible.

Microfossil-bearing rock samples were submitted to Micropaleo Consultants, Inc., for processing and the subsequent recovery, identification, and analysis of any microfossil remains.

## 5.7 MUSEUM TREATMENT

After initial (field and laboratory) treatment, the fossil vertebrate, invertebrate, and plant specimens recovered in the Metro Red Line Segment 2 construction zone as part of the Segment 2 paleontologic resource impact mitigation program were accessioned into the fossil collections of the appropriate designated museum repositories (LACMIP, LACMVP, UCMP), and associated

specimen data and corresponding geologic and geographic site data were archived at the same repositories. The fossil specimens were curated (assigned and labeled with appropriate repository specimen and site numbers; placed in specimen vials, if required, and trays with completed specimen data cards) and catalogued (specimen and site numbers and associated specimen data and corresponding geologic and geographic site data entered into appropriate catalogs and computerized data bases of designated repositories) by a PEAI paleontologic laboratory technician or a museum curator, only the vertebrate specimens receiving specimen numbers. Fossil specimen curation and archiving of associated data, recommended under SVP (1991, 1995, 1996; see Appendices B, C) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources, now are required before a fossil collection will be accepted by most museum repositories, particularly the LACMVP (see Appendix F).

At the designated museum repositories, the fossil specimens were placed in specimen storage cabinets and drawers for permanent storage and maintenance, and, along with associated data, will be retrievable and available for future study by qualified investigators. Under SVP (1991, 1995, 1996; see Appendices B, C) guidelines, adverse construction-related environmental impacts on paleontologic resources are not considered mitigated to an insignificant level until a fossil collection and associated data are accessioned into a museum repository and the repository archives, respectively, and made available by retrieval for later study.

### **5.8 SITE INSPECTIONS**

Periodic inspections of each Metro Red Line Segment 2 construction site and the laboratory facility were conducted on a monthly basis as part of the Segment 2 paleontologic resource impact mitigation program by the PEAI principal investigator and, as appropriate, on a monthly or semimonthly basis by the PEAI field supervisor to document the progress of cut-and-cover excavation and any other earth-moving activity at the site, and of initial treatment of any recovered fossil remains, as well as to ensure the appropriate monitoring rate was being employed at the site, based on the amount of excavation being conducted and the paleontologic productivity of the rock unit being excavated. As appropriate and with LACTC/MTA approval, the monitoring rate at a particular construction site was maintained at the specified level, increased, or decreased, or monitoring

was suspended. As necessary, the field supervisor conducted periodic Cal/OSHA-mandated safety meetings for PEAI paleontologic construction monitors and field/laboratory technicians during his site inspections.

### **5.9 REPORTING**

Monthly and quarterly progress reports were prepared by the PEAI principal investigator and forwarded to G&A for submission to PES and the LACTC/MTA. The reports, which covered each Metro Red Line Segment 2 construction site and corresponding paleontologic resource impact mitigation program task, were based on monthly inspections by the principal investigator and PEAI field supervisor, and on verbal or written information received periodically from other PEAI paleontologic mitigation program personnel (senior vertebrate and invertebrate paleontologists, paleontologic construction monitors, field/laboratory technicians) and other paleontologists (Micropaleo Consultants, Inc.). The reports noted the progress of cut-and-cover excavation and of any work conducted by mitigation program personnel during the reporting period; results of paleontologic construction monitoring and of initial treatment of any fossil specimen or fossiliferous rock sample recovered as a result of monitoring; tentative identification of any fossil specimen recovered as a result of monitoring or sample processing; any problem encountered; measures implemented to resolve the problem; and the effectiveness of the measures.

This final technical report of results and findings for the Segment 2 paleontologic resource impact mitigation program complies with SVP (1991, 1995; see Appendix B) standard measures for mitigating adverse construction-related environmental impacts on paleontologic resources. The guidelines recommend preparation of a final report that describes project area geology/stratigraphy, summarizes field and laboratory methods used, includes a faunal list and an inventory of curated/catalogued fossil specimens, evaluates the scientific importance of the specimens, and discusses the relationship of any newly recorded fossil site in the project area to relevant fossil sites previously recorded from other areas. The report is prepared after the recovered specimens have been accessioned into a museum collection. Under SVP (1991, 1995, 1996; see Appendices B, C) guidelines, adverse construction-related impacts on paleontologic resources are not considered mitigated to an insignificant level and the mitigation program

completed until the final report has been filed with the lead agency and the museum repository.

Submission of this report to the MTA signifies completion of the Los Angeles Metro Red Line Segment 2 paleontologic resource impact mitigation program and will assist the MTA in meeting its mitigation monitoring compliance and reporting responsibilities under California Public Resources Code Section 21081.6.

**5.10 ADDITIONAL TASKS**

PEAI personnel, with the assistance of Dr. David P. Whistler of PEA I and the LACMVP, assisted in

establishing exhibits regarding some of the fossil remains recovered in the Segment 2 construction zone as part of the Segment 2 paleontologic resource impact mitigation program. One exhibit is on display in the MTA headquarters library. Another exhibit is a traveling display to be used by MTA Public Affairs personnel. Other exhibits are being developed for the stations. PEA I personnel also assisted MTA Media Relations personnel by reviewing press releases; conducting newspaper, magazine, television, and film interviews; and in developing an MTA web site regarding the Segment 2 fossil remains and the beneficial effects of the mitigation program on paleontology.

## SECTION 6

### RESULTS

The results of the Los Angeles Metro Red Line Segment 2 paleontologic resource impact mitigation program are presented below. The locations of newly recorded fossil sites discovered as a result of the mitigation program, the fossil-bearing rock units present at these sites, and the fossil taxa recovered from each rock unit at a site are presented in Table 3 and Figures 5 and 6. Approximately 2,200 fossil specimens representing land mammal and plant species and marine invertebrate, vertebrate, and algal species, as well as an undetermined number of microfossil specimens, were recovered at 19 newly recorded PEAI fossil sites, which were catalogued under 10 LACMIP, 18 LACMVP, and 3 UCMP fossil site numbers (Table 3, Figures 5, 6, Appendices L, M, N) as a result of the mitigation program. The vertebrate specimens subsequently were catalogued with LACMVP fossil specimen numbers (Appendix O). Unidentifiable fragmentary fossil marine mollusk and land mammal remains were found, although not recovered at three additional newly recorded, but otherwise uncatalogued PEAI fossil sites (Table 3, Figures 5, 6).

The mitigation program substantially reduced the adverse environmental impacts of construction-related excavation on the paleontologic resources of the Segment 2 construction zone to an insignificant level by allowing for the recovery of scientifically highly important fossil remains and the recording of associated specimen data and corresponding geologic and geographic site data that otherwise would have been lost to excavation and unauthorized fossil collecting, and by ensuring preservation of the fossil remains and archiving of associated data in museum repositories, where they will be retrievable and available for future study by qualified investigators. The invertebrate, vertebrate, and plant remains were accessioned into the fossil collections of the LACMIP, LACMVP, and UCMP, respectively, and associated specimen data and corresponding site data were archived at the appropriate museum repositories. The MTA agreement (deed of gift) transferring the Segment 2 invertebrate and vertebrate fossil collections to the LACM is presented in Appendix P.

With the mitigation program, Segment 2 construction resulted in beneficial effects by exposing and allowing for the recovery of scientifically highly important fossil remains and the recording of

associated specimen data and corresponding site data that would not even have been uncovered without construction-related excavation and, therefore, would not have been available for recovery.

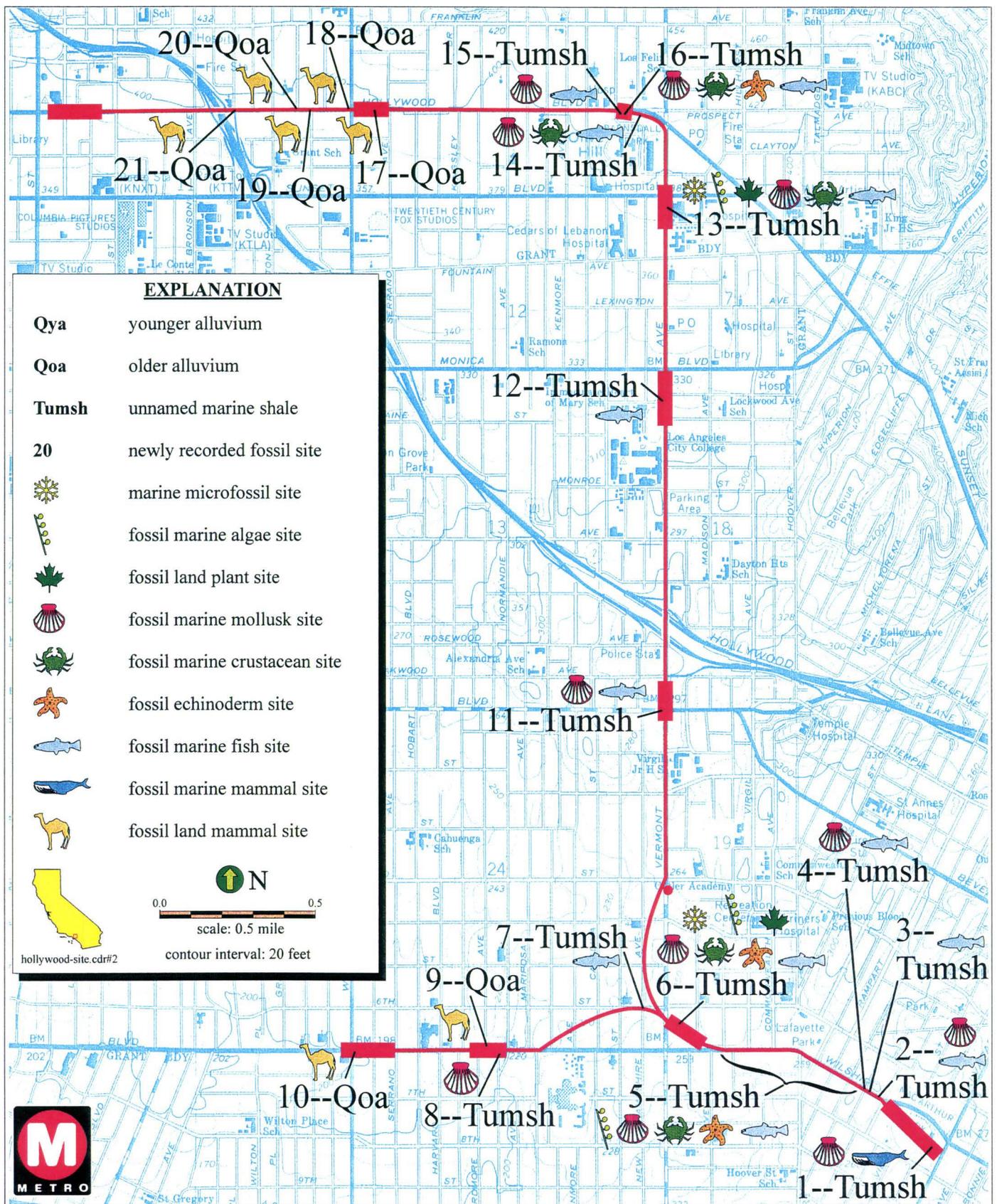
#### 6.1 UNNAMED LATE MIOCENE MARINE SHALE

Fossil remains, including more than 100 marine invertebrate specimens, approximately 2,090 marine fish specimens, 1 whale specimen, approximately 25 noncalcareous intertidal benthic marine algal (seaweed) specimens, an undetermined number of marine microfossil specimens, and 3 land plant specimens, were recovered at 14 newly discovered PEAI fossil sites in unit Tps1 (upper, but not uppermost unit) of the unnamed late Miocene marine shale as a result of the Segment 2 mitigation program (Table 3, Figures 5, 6). These sites were catalogued under 10 LACMIP, 13 LACMVP, and 3 UCMP fossil site numbers (Appendices L, M, N). Prior to analysis of these specimens, the fossil record of the marine shale in the central Los Angeles basin was very poorly known (see above). No fossil remains were recovered from unit Tpd5 (uppermost unit).

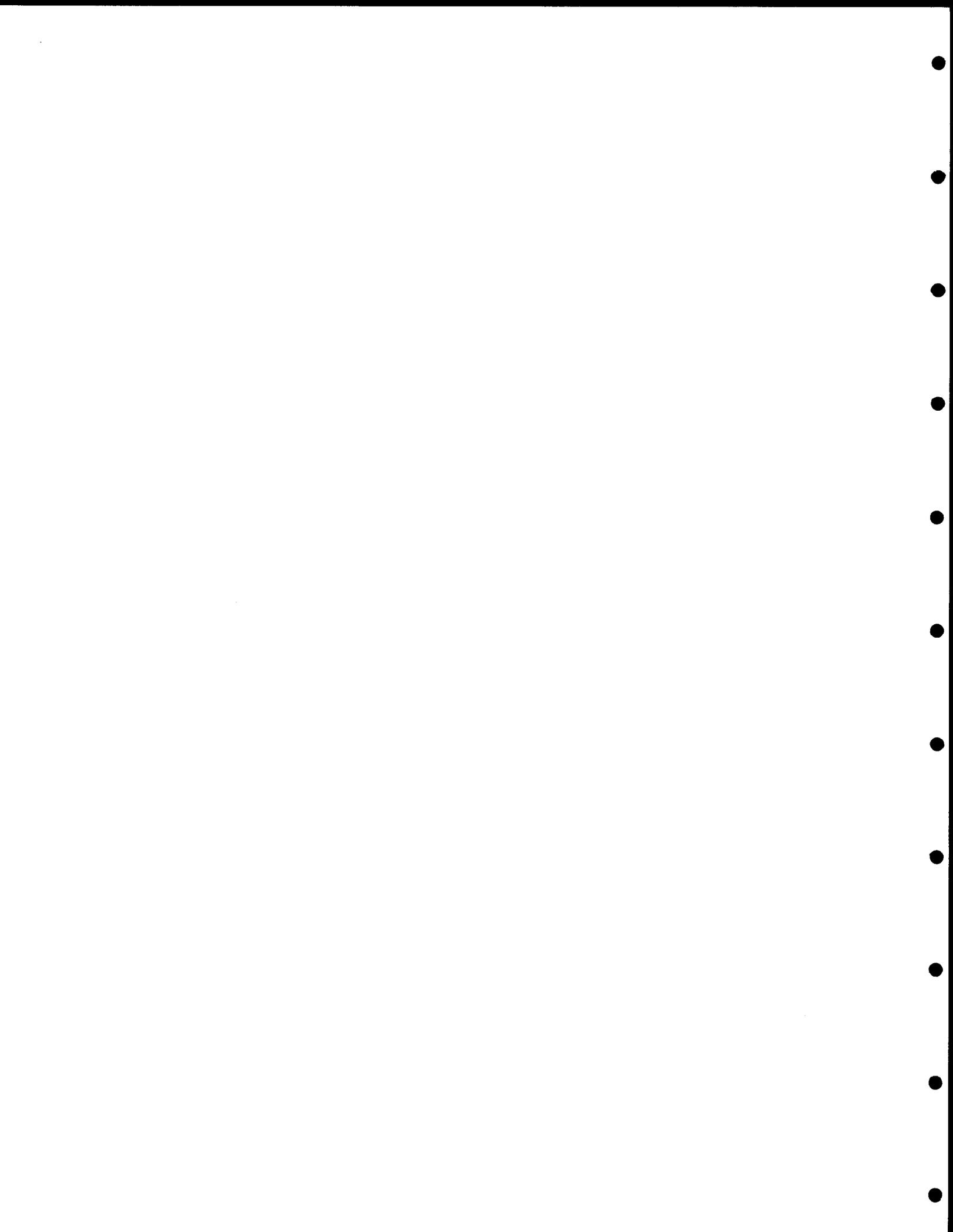
##### 6.1.1 Microfossils

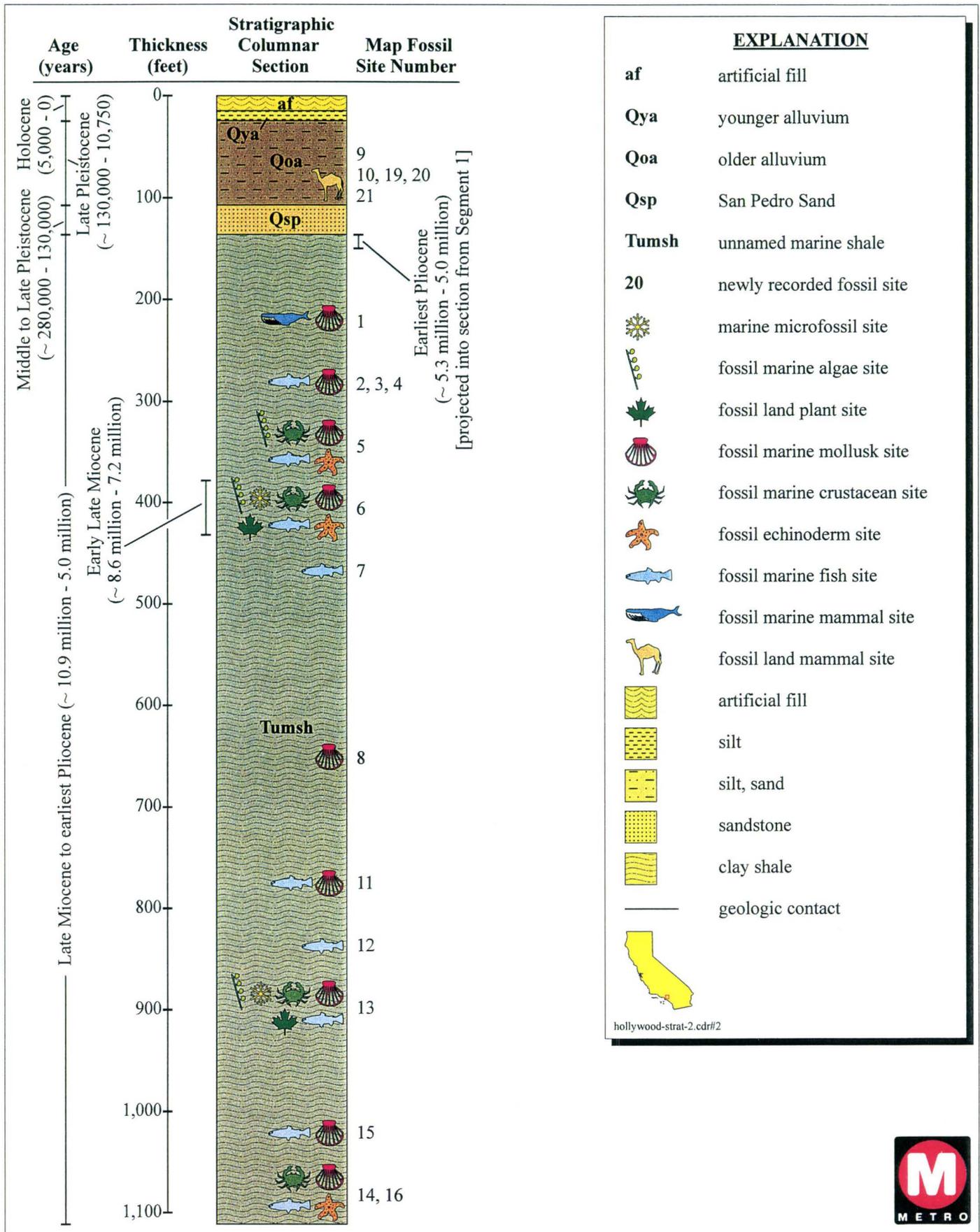
Two microfossil-bearing samples of the marine shale were recovered as part of the Segment 2 mitigation program conducted during excavation for the Wilshire/Vermont station and the Vermont/Sunset station (PEAI fossil site/sample GTT 9510135), and a third sample (PEAI fossil site/sample MAR 435) was acquired from strata containing fossil fish skeletons recovered from unit Tpd5 of the marine shale at LACMVP fossil site 5961 during excavation for the Red Line Segment 1 Tom Bradley/Civic Center station site. The samples subsequently were submitted to Micropaleo Consultants, Inc., to process for the recovery, identification, and analysis of age-diagnostic and depth-sensitive microfossil specimens.

The samples recovered from the Wilshire/Vermont and Vermont/Sunset station sites yielded microfossils representing at least 68 marine foraminifer (shelled amoeba), calcareous nannoplankton, and siliceous microfossil (including diatom) species, 65 of these species being represented in the microfossil assemblage from the Wilshire/Vermont station site (Micropaleo Consultants, Inc., 1993, 1998; see Table



**Figure 5.**—Fossil-bearing rock units and distribution of fossil taxa by rock unit and newly recorded fossil site, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. Base map: U.S. Geological Survey Hollywood 7.5-minute Quadrangle. Geology after CWDD and others (1981), Dibblee (1991a), Lamar (1970), RCC and others (1991a to d, 1992, 1993a to c, 1994a, b), and WESTEC Services, Inc. (1983). See Table 3, Figure 6, Appendices L, M, N.





**Figure 6.**—Generalized composite stratigraphic columnar section and distribution of fossil taxa by rock unit and newly recorded fossil site, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. Rock units and corresponding lithologies after Dibblee (1991a), Lamar (1970), and RCC and others (1991a to d, 1992, 1993a to c, 1994a, b). Ages of rock units after Berggren and others (1995), Blake (1991), Jefferson (1991), Lander (1999), and Micropaleo Consultants, Inc. (1993, 1998). Stratigraphic levels of fossil sites approximate. See Tables 1, 3, Figure 5, Appendices H, S.





**Table 3.**—Newly recorded fossil sites, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. See Tables 2, 4 to 8, Figures 1, 5, 6, Appendices L, M, N.

Map Fossil Site Number <sup>a</sup>	Museum Fossil Site Number	Fossil Site Location	Rock Unit	Fossil Taxon
1	LACMVP <sup>b</sup> 6254, uncatalogued invertebrate fossil site	MacArthur Lake pocket track structure, 10 feet above base at an elevation of 225 feet	unnamed marine shale	marine mollusk (clam; remains fragmentary, not recovered), mammal (whale)
2	LACMIP 16840, LACMVP 6198	eastern segment, Wilshire Boulevard tunnel segment, 400 feet NW of MacArthur Lake pocket track structure, 60 feet below grade at elevation of 210 feet	unnamed marine shale	marine mollusks (clams), fish
3	LACMVP 6199	eastern segment, Wilshire Boulevard tunnel segment, 577 feet NW of MacArthur Lake pocket track structure, 60 feet below grade at elevation of 210 feet	unnamed marine shale	marine fish
4	LACMIP 16841, LACMVP 6200	eastern segment, Wilshire Boulevard tunnel segment, 650 feet NW of MacArthur Lake pocket track structure, 60 feet below grade at elevation of 210 feet	unnamed marine shale	marine mollusk (clam), fishes
5	LACMIP 16842, LACMVP 6201, UCMP PA-722	eastern segment, Wilshire Boulevard tunnel segment, unspecified distances between MacArthur Lake pocket track structure and Wilshire/Vermont station, and at elevations between 215 and 237 feet	unnamed marine shale	marine algae (seaweed), mollusk (clam), crustacean (barnacle), echinoderm (sea urchin), fishes
6	LACMIP 16843, LACMVP 6202, UCMP PA-723, uncatalogued microfossil site	Wilshire/Vermont station, approximately 50 to 105 feet below grade at elevations between 155 and 210 feet	unnamed marine shale	marine algae (seaweed), microfossils (foraminifers, calcareous nannofossils, diatoms), mollusks (clams, snail), crustacean (barnacle), echinoderm (starfish), fishes; land plant
7	LACMVP 6203	western segment, Wilshire Boulevard tunnel segment, 502 feet W of Wilshire/Vermont station, 80 feet below grade at elevation of 170 feet	unnamed marine shale	marine fishes
8	LACMIP 16844	Wilshire/Normandie station, 60 feet below grade at elevation of 162 feet	unnamed marine shale	marine mollusks (clams)
9	uncatalogued vertebrate fossil site	Wilshire/Normandie station, 30 feet below grade at elevation of 132 feet	older alluvium	land mammal (fragmentary/unidentifiable, not recovered)
10	LACMVP 6204	Wilshire/Western station, 65 feet below grade at elevation of 140 feet	older alluvium	land mammal (mammoth?)

11	LACMIP 17137, LACMVP 6946	Vermont/Beverly station	unnamed marine shale	marine mollusks (clam), fishes
12	LACMVP 6947	Vermont/Santa Monica station	unnamed marine shale	marine fishes
13	LACMIP 17138, LACMVP 6948, UCMP PB-99003, uncatalogued microfossil site (PEAI GTT 9510135)	Vermont/Sunset station	unnamed marine shale	marine microfossils, algae (seaweed), mollusks (clam), crustacean (barnacle), fishes; land plants
14	LACMIP 16845, LACMVP 6205	Vermont Avenue tunnel segment, 0 to 176 feet southeast of Barnsdall Art Park tunnel access shaft, 91 feet below grade at elevation of 328 feet	unnamed marine shale	marine mollusks (clams), crustacean (barnacle), fishes
15	LACMIP 16846, LACMVP 6206	Barnsdall Art Park tunnel access shaft (conveyor shaft), 0 to 62.5 feet below grade at elevations between 350 and 412.5 feet	unnamed marine shale	marine mollusks (clams), fishes
16	LACMIP 16847, LACMVP 6207	Barnsdall Art Park tunnel access shaft (conveyor shaft), 62.5 to 116.5 feet below grade at elevations of 296 to 350 feet	unnamed marine shale	marine mollusk (clam), crustacean (barnacle), echinoderm (starfish), fishes
17	uncatalogued vertebrate fossil site	Hollywood/Western station, 60 feet below grade at elevation of 335 feet	older alluvium	land mammal (fragmentary/unidentifiable, not recovered)
18	LACMVP 6297	Hollywood Boulevard tunnel segment, 160 feet W of Hollywood/Western station, 47 feet below grade at elevation of 344 feet	older alluvium	land mammal (horse)
19	LACMVP 6298	Hollywood Boulevard tunnel segment, 725 feet W of Hollywood/Western station, 60 feet below grade at elevation of 328 feet	older alluvium	land mammal (mastodont)
20	LACMVP 6299	Hollywood Boulevard tunnel segment, 975 feet W of Hollywood/Western station, 60 feet below grade at elevation of 330 feet	older alluvium	land mammal (bison)
21	LACMVP 6300	Hollywood Boulevard tunnel segment, 2,075 feet W of Hollywood/Western station, approximately 80 feet below grade at elevation of 316 feet <sup>c</sup>	older alluvium	land mammal (camel)

<sup>a</sup>Map fossil site number in Figures 5, 6.

<sup>b</sup>GTT: Gary T. Takeuchi, PEA;I;

LACMIP: Natural History Museum of Los Angeles County Invertebrate Paleontology Section;

LACMVP: Natural History Museum of Los Angeles County Vertebrate Paleontology Section;

PEAI: Paleo Environmental Associates, Inc.;

UCMP: University of California Museum of Paleontology.

<sup>c</sup>Fossil site stated to be at a depth 65 feet below grade. However, field data indicate site is approximately 4 feet below top of tunnel, which is at a depth 76 feet below grade. Presumably, site is at a depth about 80 feet below grade.

**Table 4.**—Microfossil list, unnamed late Miocene marine shale, Los Angeles Metro Red Line Segment 2 construction zone, Wilshire/Vermont and Vermont/Sunset station sites, and Red Line Segment 1 construction zone, Tom Bradley/Civic Center station site, Los Angeles, California. After Boettcher, R.S.; Kling, S.A., in Micropaleo Consultants, Inc. (1993, 1998). See Table 3, Figures 1, 5, 6, Appendices H, S.

Genus, Species	Map Fossil Site Number <sup>a</sup>			Genus, Species	Map Fossil Site Number		
	6 <sup>b</sup>	13	— <sup>c</sup>		6	13	—
<b><u>Foraminifers</u></b>				<b><u>Calcareous Nannoplankton</u></b>			
<i>Baggina</i> sp. undet. <sup>d</sup>	X			<i>Braarudosphaera bigelowi</i>	X	X	
<i>Bolivina bramlettei</i> ?	X			<i>Calcidiscus macintyreii</i>	X		
<i>Bolivina granti</i>	X			<i>Coccolithus pelagicus</i>	X	X	
<i>Bolivina hughesi</i> ?	X			<i>Discoaster brouweri</i>	X		
<i>Bolivina pseudospissa</i>	X			<i>Discoaster intercalaris</i>	X		
<i>Bolivina tongi</i>	X			<i>Discoaster loeblichii</i>	X		
<i>Bolivina vaughani</i>	X			<i>Discoaster surculus</i>	X		
<i>Bolivina woodringi</i>	X			<i>Dictyococcites antarcticus</i>	X	X	
<i>Bolivina</i> sp. undet.		X		<i>Dictyococcites minutus</i>	X	X	
<i>Bulimina inflata</i>	X			<i>Reticulofenestra pseudoumbilica</i>	X	X	
<i>Buliminella subfusiformis</i>	X			<i>Sphenolithus moriformis</i>	X		
<i>Cassidulina crassa</i> ?	X			<b><u>Siliceous Microfossils</u></b>			
<i>Cassidulina delicata</i>	X			<i>Actinocyclus curvatulus</i>			X
<i>Epistominella subperuviana</i>	X	X		<i>Actinocyclus ehrenbergii</i>	X		
<i>Eponides multicameratus</i>	X			<i>Actinocyclus ingens</i>	X		
<i>Eponides rosaformis</i>	X			<i>Actinocyclus oculatus</i> ?			X
<i>Globigerina bulloides</i>	X			<i>Actinoptychus senarius</i>	X		X
<i>Globigerina</i> sp. undet.		X		<i>Actinoptychus spendens</i>	X		
<i>Gyroidina rotundimargo</i> ?	X			<i>Ammodochium rectangulare</i>	X		
<i>Nonion goudkoffi</i>	X			<i>Campyloneis grevillei</i>	X		
<i>Nonion</i> sp. undet.		X		<i>Coscinodiscus asteromphalus</i>	X		
<i>Turborotalia scitula</i>	X			<i>Coscinodiscus marginatus</i>	X		X
<i>Uvigerina hootsi</i>		X		<i>Coscinodiscus nodulifera</i>	X		
<i>Uvigerinella</i> sp. undet.		X					
<i>Valvulineria araucana araucana</i>		X					

<i>Coscinodiscus vetustissimus</i>		X	<i>Navicula lyra</i>	X	
<i>Delphineis sachalinensis</i>	X		<i>Navicula pennata</i>	X	
<i>Delphineis surirella</i>	X		<i>Nitzschia fossilis</i>	X	
<i>Denticulopsis hustedtii</i>	X		<i>Nitzschia reinholdii</i>		X
<i>Denticulopsis hyalina?</i>	X		<i>Nitzschia rolandii</i>		X
<i>Dictyocha aspera</i>	X		<i>Opephora schwartzii</i>	X	
<i>Dictyocha fibula</i>	X		<i>Rhizosolenia barboi</i>		X
<i>Dictyocha subclinata</i>	X		<i>Rhizosolenia styliformis</i>		X
<i>Diploneis smithii</i>	X		<i>Stephanopyxis appendiculata</i>	X	
<i>Diploneis sp. undet.</i>	X		<i>Stephanopyxis turris</i>	X	
<i>Distephanus boliviensis</i>	X	X	<i>Stictodiscus californicus</i>	X	
<i>Distephanus jimligii</i>	X	X	<i>Thalassionema nitzschioides</i>	X	X
<i>Distephanus speculum</i>	X		<i>Thalassiosira lineata</i>	X	
<i>Endictya oceanica</i>	X		<i>Thalassiosira antiqua</i>		X
<i>Grammatophora sp. undet.</i>	X		<i>Thalassiosira oestrupii</i>		X
<i>Hemidiscus cuneiformis</i>	X		<i>Thalassiosira praeoestrupii</i>		X
<i>Melosira sulcata</i>	X		<i>Thalassiosira sp. undet.</i>	X	
<i>Navicula praetexta</i>	X		<i>Thalassiothrix longissima</i>	X	

<sup>a</sup>Map fossil site number in Figures 5, 6.

<sup>b</sup>PEAI fossil site/sample GTT 9510135.

<sup>c</sup>Segment 1 Tom Bradley/Civic Center station construction zone (PEAI fossil site/sample MAR 435).

<sup>d</sup>sp.: species;

undet.: undetermined.

4, Appendices H, S). These microfossils are scientifically highly important because the species they represent allow paleoenvironmental reconstruction of the downtown Los Angeles/Hollywood area during the late Miocene Epoch (and earliest Pliocene Epoch; see below) and deposition of the sediments comprising the marine shale, and provide refined estimates of the age of the marine shale. The benthic (bottom-dwelling) foraminifer species indicate the microfossil assemblage from the Wilshire/Vermont station site is assignable to the upper Mohnian Stage, the association of the calcareous nannoplankton species *Discoaster surculus* and *Discoaster loeblichii* indicate assignment to zone CN9A; and the siliceous microfossil species *Nitzschia fossilis* indicates the assemblage is no older than the uppermost part of the *Denticulopsis hustedtii* Zone (Boettcher, R.S.; Kling, S.A., in Micropaleo Consultants, Inc., 1993). Assignment to these biostratigraphic zones suggests the entire fossil assemblage from the Wilshire/Vermont station site is early late Miocene and, based on recent revisions of the paleomagnetic polarity time scale, approximately 7.2 million to 8.6 million years in age (see Berggren and others, 1995; Blake, 1991; Micropaleo Consultants, Inc., 1993).

The benthic foraminifer species indicate the microfossil assemblages from the Wilshire/Vermont and Vermont/Sunset station sites represent an upper middle bathyal (= upper middle continental slope; very-deep-water marine) environment and ocean depths roughly 1,500 to 4,700 feet below sea level (Boettcher, R.S., in Micropaleo Consultants, Inc., 1993, 1998). The paleoenvironmental reconstruction allowed by these species is similar to those based on the species in other microfossil samples from the marine shale in the downtown Los Angeles area and presented by Lamar (1970) and Natland (1957). The species represented in the microfossil sample from the Wilshire/Vermont station site, which now lies at an elevation approximately 250 feet above sea level, indicate the station site has been uplifted nearly 5,000 feet (1.0 mile) in the last 7.2 million years, although other topographic data (elevations of exposures of marine shale on hills adjacent to Segment 2 construction zone) suggest the station site has been uplifted at least 5,250 feet (1.0 mile).

Lamar (1970) considered only the lower 250 feet of unit Tps1 assignable to the upper Mohnian Stage, the remainder of the unit, possibly to the succeeding lower "Delmontian" Stage. Natland and Rothwell (1954), on the other hand, assigned the entire rock unit to the "Delmontian" Stage. However, the upper

Mohnian microfossil sample from the Wilshire/Vermont station site is from a stratigraphic level near the top of unit Tps1 and much higher than that of the "Delmontian" microfossil sample from fossil site 6 of Lamar (1970) in Alhambra, the latter fossil site lying near the base of unit Tps1 (see Lamar, 1970).

The association of the siliceous microfossil species *Thalassiosira oestrupii* and *Thalassiosira praeoestrupii* in the sample recovered from the Tom Bradley/Civic Center station site indicates the microfossil assemblage from unit Tps1 at the top of the marine shale is assignable to the lower part of the *Thalassiosira oestrupii* Zone and earliest Pliocene in age (Kling, S.A., in Micropaleo Consultants, Inc., 1998; see Blake, 1991), and, based on recent revisions of the paleomagnetic polarity time scale, approximately 5.0 million to 5.3 million years in age (see Berggren and others, 1995; Micropaleo Consultants, Inc., 1993).

#### **6.1.2 Invertebrates**

More than 100 fossil invertebrate specimens, primarily mollusk (snail, clam) shells representing a fossil marine invertebrate assemblage of limited taxonomic diversity, were recovered at 10 newly recorded LACMIP fossil sites in the marine shale as a result of the Segment 2 mitigation program (fragmentary remains discovered, but not recovered at additional fossil site) (Groves, 1997a; see Tables 3, 5, Figures 5, 6, Appendices I, L). The fauna consists of five species of clams and one species each of snail, barnacle, starfish, and sea urchin; the clam and sea urchin species all are extinct. None of these species has been reported previously as occurring in the marine shale in the Los Angeles basin. The starfish specimens from the marine shale are of particular scientific importance because such occurrences are very rare in the fossil record. Photographs of a starfish specimen and several clam specimens are presented in Figure 7.

The starfish and other Segment 2 invertebrate specimens are scientifically highly important because the species they represent allow paleoenvironmental reconstruction of the downtown Los Angeles/Hollywood area during the late Miocene Epoch and deposition of the sediments comprising the marine shale. Although modern species of the clams *Corbula* and *Periploma* are never or only rarely found at ocean depths greater than 330 and 1,300 feet, respectively, below sea level, starfish species of the family Zoroasteridae are common at depths greater than 300 feet and species of the sea urchin

**Table 5.**—Invertebrate faunal list by fossil site, unnamed late Miocene marine shale, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. After Groves (1997a). See Table 3, Figures 1, 5, 6, Appendices I, L.

Phylum	Class	Genus, Species	Common Name	LACMIP <sup>a</sup> Fossil Site Number (Map Fossil Site Number <sup>b</sup> )										
				16840 (2)	16841 (4)	16842 (5)	16843 (6)	16844 (8)	16845 (14)	16846 (15)	16847 (16)	17137 (11)	17138 (13)	
Mollusca			chitons, tusk shells, snails, nautiloids, clams											
	Bivalvia		clams											
		<i>Acesta hamlini</i> ? <sup>c</sup>	Hamlin's fileclam	X				X	X	X				
		<i>Corbula binominata</i> ? <sup>c</sup>	Corbula clam				X		X					
		<i>Delectopecten vancouverensis fernandoensis</i> ? <sup>c,d</sup>	mudpecten				X							
		<i>Delectopecten peckhami</i> ? <sup>c,d</sup>	mudpecten	X	X	X	X	X	X	X	X			
		<i>Delectopecten</i> sp. undet. <sup>c</sup>	mudpecten									X	X	
		<i>Periploma cryphia</i> ? <sup>c</sup>	spoonclam				X							
	Gastropoda		snails											
		<i>Mitrella permodesta</i>	dove-snail				X							
Arthropoda			trilobites, centipedes, spiders, crabs, insects, crabs, barnacles											
	Crustacea		barnacle			X	X		X		X		X	
		<i>Lepas?</i> sp. indet.	sand dollars, starfishes, sea lilies											
Echinodermata			sand dollars, sea urchins											
	Echinoidea		sand dollars, sea urchins											
		<i>Paleopneustes holmani</i> ? <sup>c</sup>	sea urchin			X								
	Asteroidea		starfishes											
		Zoroasteridae?, gen. & sp. indet.	sea star				X				X			

<sup>a</sup>Natural History Museum of Los Angeles County Invertebrate Paleontology Section.

<sup>b</sup>Map fossil site number in Figures 5, 6.

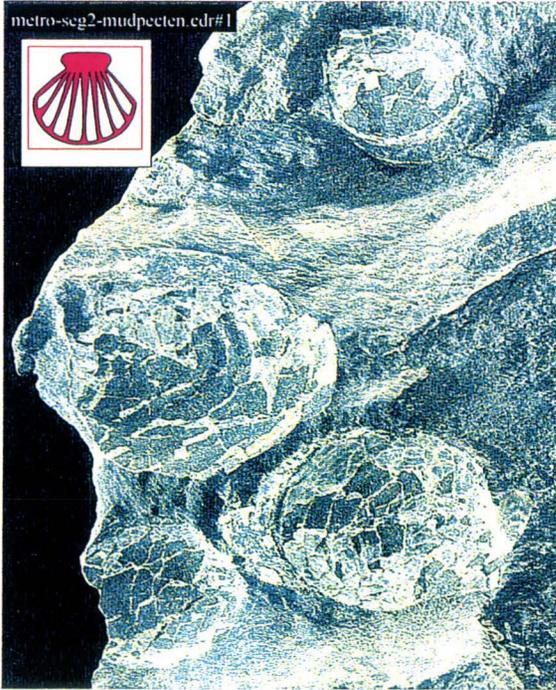
<sup>c</sup>Extinct species.

<sup>d</sup>*Delectopecten* sp. undet. also observed at MacArthur Lake pocket track structure site.

<sup>d</sup>gen.: genus;

sp.: species;

indet.: indeterminate.



A

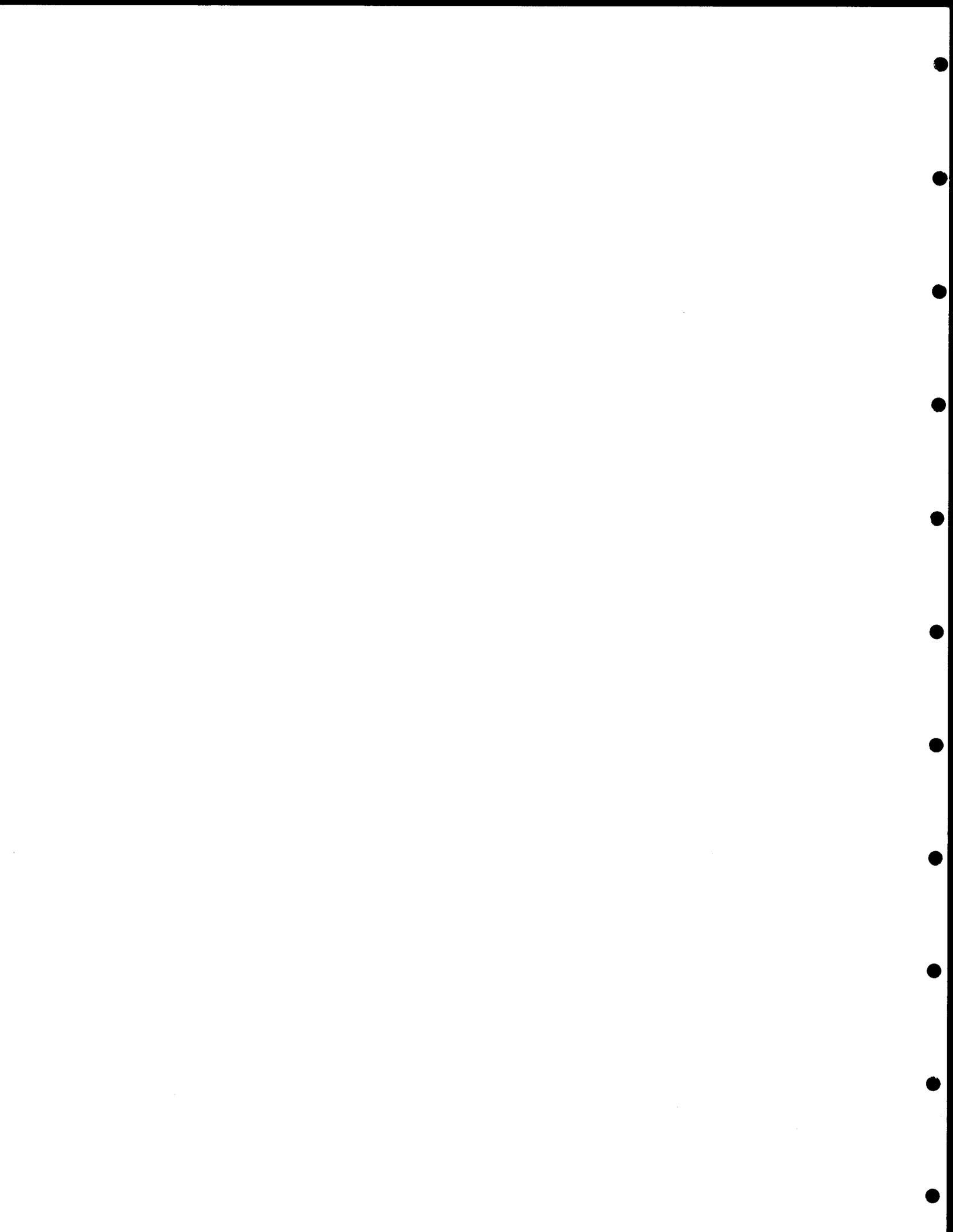


B

**Figure 7.**—Fossil invertebrate specimens, unnamed late Miocene marine shale. See Appendix L.

**A.**—Mudpecten, *Delectopecten peckhami*, Barnsdall Art Park tunnel access shaft site (LACMIP fossil site 16847). Lateral view of valves. Natural size.

**B.**—Sea star, Zoroasteridae?, genus and species undetermined, Wilshire/Vermont station site (LACMIP fossil site 16843). Ventral view of interior dorsal



*Paleopneustes* are found at depths of roughly 600 feet (Grant and Hertlein, 1938; Groves, 1997a, -b). However, living examples of the snail *Mitrella permodesta* and modern species of the clams *Delectopecten* and *Acesta* and the barnacle *Lepas* are found at depths greater than about 1,650 feet (Groves, 1997a, -b).

Hickman (1984) described six types of Cenozoic deep-water marine mollusk communities that are based on paleobathymetric (depth) ranges and paleoecological criteria. Two of these community types, the *Acesta* and Mud Pecten Communities, occur in the Segment 2 construction zone, and are represented by *Acesta* and *Delectopecten*, respectively (Groves, 1997a). Based on depth preferences of the modern species of these genera, these communities ranged from 1,935 to 2,310 feet (*Acesta* Communities) and from 65 to 2,300 feet (Mud Pecten Communities) below sea level, although *Delectopecten* now occurs at depths down to 6,600 feet (Hickman, 1984). Both communities were dominated by epifaunal suspension feeders and are preserved in laminated and/or massive siltstone strata (Hickman, 1984). The fossil communities are very similar to modern mollusk communities living off the southern and central California coast (Groves, 1997a).

The late Miocene species of these invertebrate genera lived on the sea floor or buried in the sediments then comprising the sea floor and now comprising the marine shale. The depth preferences of some of the genera comprising the composite fossil marine invertebrate assemblage from the marine shale suggests the sea floor was at depths 1,935 to 2,310 feet below sea level during deposition of the sediments comprising the marine shale, remains of shallower-water marine species presumably having been transported into deeper water by turbidity currents (Groves, 1997a; see Appendix I).

The Segment 2 invertebrate specimens also are scientifically highly important because the species they represent provide an estimate of the age of the marine shale. *Acesta hamlini*, *Corbula binominata*, *Delectopecten peckhami*, *Periploma cryphia*, and *Paleopneustes holmani* have been reported previously as occurring in the early Pliocene "Repetto" Formation (= Repetto [lower] Member of Fernando Formation, which immediately overlies marine shale; see Table 1) of earlier workers in the Los Angeles basin (Grant and Hertlein, 1938; Groves, 1997a, -b; Woodring, 1938), and *Acesta hamlini*, *Corbula binominata*, and *Delectopecten peckhami*

also have been reported as occurring in the Repetto Member in the downtown Los Angeles area in the immediate vicinity of the Red Line Segment 1 Pershing Square (Fifth/Hill) station (Soper and Grant, 1932). *Mitrella permodesta* also is from the "Repetto" Formation in the Los Angeles basin, and *Delectopecten vancouverensis fernandoensis?* is from the "Repetto" Formation (= Towsley Formation) in northern Los Angeles County (Eldridge and Arnold, 1907; Groves, 1997a; Moore, 1984). With the exception of *Delectopecten peckhami*, their occurrences in the unnamed late Miocene marine shale are the oldest records of these species, which have been reported previously as occurring in the Miocene fossil record only in the Sycamore Canyon Formation of the Puente Hills (Groves, 1997a, -b; Lander, 1997), and are scientifically highly important because they represent chronologic range extensions from the early Pliocene Epoch downward into the early late Miocene Epoch. *Delectopecten peckhami* is known from rock units of Eocene to early Pliocene age in central and southern California (Groves, 1997a; Moore, 1984). The fossil invertebrate assemblage from the marine shale is very similar to the early Pliocene faunas reported by Woodring (1938) as occurring in the "Repetto" Formation in the Los Angeles basin (Groves, 1997a) and the fauna reported by Soper and Grant (1932) as occurring in the Repetto Member of the Fernando Formation in the downtown Los Angeles area, but, with the exception of some geologically wide ranging species such as *Delectopecten peckhami*, bears little resemblance to other late Miocene marine invertebrate faunas from the southern California fossil record.

### 6.1.3 Fishes

Over 5,000 fossil fish specimens representing a taxonomically very large and highly diverse fossil marine fish assemblage were recovered at 13 newly recorded LACMVP fossil sites in the marine shale as a result of the Segment 2 mitigation program (Huddleston, 1997; see Tables 6, 7, Appendices J, M, O). Each specimen was evaluated and over 3,000 specimens were discarded because they were determined too incomplete or poorly preserved to be identifiable, even if subjected to additional study. The remaining specimens, which consist of complete and partial skeletons, scales, and otoliths (ear ossicles), were identified and catalogued under approximately 2,090 LACMVP fossil specimen numbers (Appendix O). Approximately 235 otherwise unidentified fish specimens were assigned to the Teleostei (advanced bony fishes; Table 6, Appendix O) because they were

**Table 6.**—Vertebrate faunal list by fossil site, unnamed late Miocene marine shale, Natural History Museum of Los Angeles County Vertebrate Paleontology Section fossil sites 6198 to 6207, 6254, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. After Huddleston (1997). See Table 3, Figures 1, 5, 6, Appendices J, M, O.

Class, Family	Genus, Species	Common Name	LACMVP <sup>a</sup> Fossil Site Number (Map Fossil Site Number <sup>b</sup> )									
			6198 (2)	6199 (3)	6200 (4)	6201 (5)	6202 (6)	6203 (7)	6205 (14)	6206 (15)	6207 (16)	6254 (1)
<u>Osteichthyes</u>		bony fishes										
undetermined	Congroidei, gen. undet., n. sp. <sup>c</sup>	eel						X	X			
Clupeidae	<i>Ganolytes cameo</i>	cameo sardine						X		X	X	
	<i>Xyne grex</i>	herring						X		X		
Argentiniidae?	Argentiniidae?, gen. undet., n. sp.	herring smelt						X		X		
Bathylagidae	<i>Bathylagus</i> sp.	deepsea smelt			X			X				
	<i>Leuroglossus</i> sp.	smoothtongue						X				
	Bathylagidae, gen. & sp. undet.	deepsea smelt							X			
Opisthoproctidae	Opisthoproctidae, gen. undet., n. sp.	barreleye/spookfish						X				
Alepocephalidae	Alepocephalinae, gen. undet. A, n. sp.	slickhead				X		X		X		
Platyroctidae	Platyroctidae, gen. undet., n. sp.	tubeshoulder						X				
Gonostomatidae	<i>Cyclothone</i> sp.	bristlemouth				X		X		X	X	
Sternoptychidae	<i>Argyropelecus</i> sp. A	silver hatchetfish						X				
	<i>Argyropelecus</i> sp. B	silver hatchetfish						X				
	<i>Danaphos</i> , n. sp.	bottlelight							X			
Photichthyidae	<i>Vinciguerria</i> ?, n. sp.	lightfish						X				
Stomiidae	<i>Stomias</i> , n. sp.	scaly dragonfish						X				
	Stomiini, gen. A, n. sp.?	scaly dragonfish						X				
Chauliodontidae	<i>Chauliodus eximius</i>	viperfish						X				
Myctophidae	<i>Benthoosema</i> ?, n. sp.	lanternfish						X				
	<i>Centrobranchus</i> ?, n. sp.	lanternfish						X				
	<i>Ceratoscopelus</i> , n. sp.	dogtooth lampfish						X				
	<i>Diogenichthys</i> ?, n. sp.	Diogenes lanternfish						X				
	<i>Diaphus</i> sp.	headlightfish						X			X	
	<i>Hygophum</i> , n. sp. A	lanternfish						X				
	<i>Hygophum</i> , n. sp. B	lanternfish						X				
	<i>Lampanyctus</i> sp.	broadfin lampfish						X				
	<i>Notoscopelus</i> ? sp.	lampfish						X				
	<i>Myctophum</i> sp.	lanternfish						X				
	<i>Stenobranchius</i> , n. sp.	northern lampfish						X				
	<i>Symbolophorus</i> , n. sp.	lanternfish						X				
	<i>Taaningichthys</i> , n. sp.	lanternfish						X				
	<i>Tarletonbeania</i> , n. sp.	lanternfish						X				
	<i>Triphoturus</i> sp.	Mexican lampfish						X				
	Myctophidae, gen. & sp. undet.	lanternfish				X			X	X		



**Table 7.**—Vertebrate faunal list (fishes; Class Osteichthyes) by fossil site, unnamed late Miocene marine shale, Natural History Museum of Los Angeles County Vertebrate Paleontology Section fossil sites 6946 to 6948, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. After Huddleston (1997). See Table 3, Figures 1, 5, 6, Appendices J, M, O.

Family	Genus, Species	Common Name	LACMVP <sup>a</sup> Fossil Site Number (Map Fossil Site Number <sup>b</sup> )		
			6946 (11)	6947 (12)	6948 (13)
Nemichthyidae	<i>Nemichthys?</i> , n. sp. <sup>c</sup>	snipe eel			X
Clupeidae	<i>Ganolytes</i> sp. A	sardine		X	X
	<i>Xyne grex?</i>	herring	X		X
Argentiniidae?	<i>Argentina</i> sp.	herring smelt			X
Bathylagidae	<i>Bathylagus</i> sp.	deepsea smelt	X		
	Bathylagidae, gen. & sp. undet.	deepsea smelt			X
Alepocephalidae	Alepocephalinae, gen. undet. B, n. sp.	slickhead			X
Gonostomatidae	<i>Cyclothone</i> sp.	bristlemouth	X	X	X
Sternoptychidae	<i>Argyropelecus</i> sp.	silver hatchetfish			X
Chauliodontidae	<i>Chauliodus eximius?</i>	viperfish			X
Neoscopelidae	<i>Scopelengys?</i> , n. sp.	blackchin			X
Myctophidae	Myctophidae, gen. & sp. undet.	lanternfish	X		X
Moridae	Moridae, gen. undet., n. sp.	deepsea cod			X
Serranidae	<i>Paralabrax</i> , n. sp.?	sand bass			X
Carangidae	<i>Decapterus</i> sp.	Mexican scad			X
Sparidae	<i>Plectrites classeni?</i>	porgy/seabream			X
Sciaenidae	<i>Lompoquia</i> sp.	croaker			X
	<i>Genyonemus</i> sp.	white croaker			X
	Sciaenidae, gen. & sp. undet.	corvina/sea trout		X	
Zaphlegidae <sup>d</sup>	<i>Thysocles</i> sp.	false mackerel			X
Scombridae	<i>Sarda</i> sp.	bonito			X
	<i>Scomber?</i> sp.	mackerel			X
	Scombridae, gen. & sp. undet.	mackerel	X		

<sup>a</sup>Natural History Museum of Los Angeles County Vertebrate Paleontology Section.  
<sup>b</sup>Map fossil site number in Figures 5, 6.  
<sup>c</sup>gen.: genus;  
n.: new;  
sp.: species;  
undet.: undetermined.  
<sup>d</sup>Extinct family.

determined potentially identifiable to a lower taxonomic level only with additional study. The approximately 1,855 specimens remaining were identified to the lowest possible taxonomic level (family, genus, species) (Tables 6, 7, Appendix O). The latter specimens are assignable to 36 families, of which 1 family is extinct, 57 genera, and 66 species (1 extant, 64 extinct), of which 39 of the extinct species are new, not having been reported previously in the scientific literature (Huddleston, 1997; Tables 6, 7). Most of the other species are rare. The Segment 2 fish fauna is scientifically highly important because

it is taxonomically the largest and most diverse fossil marine fish assemblage reported from the late Miocene fossil record of southern California and many of the new species represent deep-water marine forms. Moreover, the Wilshire/Vermont station lanternfish assemblage, which contains fifteen genera and sixteen species of lanternfishes, is taxonomically the largest and most diverse lanternfish assemblage reported from the fossil record (Huddleston, 1997).

Of the families and genera represented in the Segment 2 fish fauna, only *Cyclothone* (Gonostomatidae;

bristlemouth), *Lompoquia* (Sciaenidae; croaker), the Bathylagidae (deepsea smelts), Clupeidae (herrings, sardines), and Myctophidae (lanternfishes) have been reported previously as occurring in the marine shale in the central Los Angeles basin, including in earliest Pliocene unit Tpd's at the top of the marine shale at the Red Line Segment 1 Tom Bradley/Civic Center station site (Lamar, 1970; Lander, 1990b; Stewart, 1990). However, nine genera and two species of fishes (*Argyropelecus*, *Chauliodus*, *Cyclothone*, *Decapterus*, *Ganolytes cameo*, *Lampanyctus*, *Lompoquia*, *Scomber*, *Xyne grex*) represented in the Segment 2 fish fauna and also reported earlier by David (1943) as occurring in the upper member of the Modelo Formation at previously recorded California Institute of Technology (CIT) fossil sites in the Santa Monica Mountains (northwestern Los Angeles basin) are from the marine shale (see Dibblee, 1991b). Some of these and other taxa (*Bathylagus*, *Ganolytes cameo*, *Lampanyctus*, *Myctophum*) represented in the Segment 2 fish fauna also had been reported even earlier by David (1941) as occurring in the "Modelo" Formation (possibly including upper part of "Puente" Formation of Dibblee, 1995) at two previously recorded CIT and U.S. National Museum fossil sites in the western shelf area of the southwestern Los Angeles basin near Torrance (see Blake, 1991; Wright, 1991), and could be from strata laterally equivalent to the marine shale.

The following discussion is after Huddleston (1997; see Appendix J). At least 41 Segment 2 fish species are represented, at least in part, by otoliths and comprise taxonomically the largest and most diverse late Miocene fossil fish otolith assemblage ever reported from the southern California fossil record. Seventeen of these species are represented only by otoliths. With the exception of one previously recorded late Miocene fossil fish site (Chalk Hill) in the Puente Hills of the northeastern Los Angeles basin, otoliths rarely are preserved with their respective skeletal remains. The Chalk Hill fossil site, which occurs in the Yorba (upper) Member of the marine Monterey Formation (Puente Formation of earlier workers), has yielded five or six marine fish species represented by associated otoliths and skeletal remains. However, at least 25 Segment 2 fish species identified from the marine shale are represented by associated otoliths and skeletal remains. This very rare association of otoliths and identifiable skeletal remains in the marine shale is scientifically highly important because it is possible to document, in some cases for the first time, that particular fish species based on otoliths are the same as particular species based on skeletal remains. Moreover, the taxonomic

diversity of these otoliths and associated skeletal remains provides an opportunity to compare the Segment 2 fish fauna with other late Miocene marine fish faunas and with middle Miocene and Pliocene marine fish assemblages in the southern California fossil record, thereby making it possible to identify the fish species comprising these other faunas and to resolve many of the taxonomic problems that resulted from the last major study of these faunas by David (1943).

Some of the Segment 2 fossil fish specimens are scientifically highly important in part because they represent very rare fossil occurrences for their respective genera and families, and, based on Huddleston (1997), include the

first reported fossil occurrences of the Anoplogasteridae (fangtooths), Coryphaenidae (dolphinfishes), Neoscopelidae (blackchins), Oneirodidae (dreamers), Opisthoproctidae (barreleyes, spookfishes), and Platyroctidae (tubeshoulders), and of *Centrobranchus?* and *Taaningichthys* (Myctophidae; lanternfishes);

second reported fossil occurrences of the Linophrynidae (netdevils) and of *Bolinichthys?* and *Diogenichthys?* (Myctophidae; lanternfishes);

third reported fossil occurrence of *Leuroglossus* (Bathylagidae; smoothtongue);

oldest reported fossil occurrences of *Genyonemus* (Sciaenidae; white croaker), *Leuroglossus* (Bathylagidae; smoothtongue), *Ceratoscopelus*, *Stenobranchius*, *Tarletonbeania*, *Triphoturus* (Myctophidae; lanternfishes), *Paralabrax* (Serranidae; sand bass), and *Scopelogadus* (Melamphaeidae; bigscale; additional fossil occurrence, reported as occurring in late Miocene [upper Mohnian] Yorba Member, Monterey Formation, Orange County [Rigby and Albi, 1996], probably from early Pliocene lower member, Fernando Formation; lower member, not Yorba Member, immediately underlies older alluvium at LACMIP fossil site 15677; see Schoellhamer and others, 1981);

oldest reported North American fossil occurrences of *Argentina* (Argentinidae; argentines), *Benthoosema?* (Myctophidae; lanternfish), and *Physiculus* (Moridae; codling/mora; additional fossil occurrence, reported as

occurring in late Miocene [upper Mohnian] Yorba Member, Monterey Formation, Orange County [Rigby and Albi, 1996], probably from early Pliocene lower member, Fernando Formation; lower member, not Yorba Member, immediately underlies older alluvium at LACMIP fossil site 15677; see Schoellhamer and others, 1981);

oldest reported American fossil occurrence of *Symbolophorus* (Myctophidae; lanternfish);

first reported North American fossil occurrences of the Alepocephalidae (slickheads), Photichthyidae (lightfishes), and Trichiuridae (cutlassfishes, scabbardfishes), and of *Bolinichthys?* and *Diogenichthys?* (Myctophidae; lanternfishes), *Stomias* and genus A (Stomiidae; scaly dragonfishes), one member (genus A) of the Melamphaeidae (big scales), and possibly of *Nemichthys?* (Nemichthyidae; snipe eel);

first reported fossil occurrences of otoliths of the Alepocephalidae (slickheads), Gempylidae? (snake mackerels, escolars, oilfishes), and Nemichthyidae (snipe eels);

first reported fossil occurrences of otoliths preserved with skeletal remains of the Alepocephalidae (slickheads), Anoplogasteridae (fangtooths), Bathylagidae (deepsea smelts), Coryphaenidae (dolphinfishes), Gempylidae? (snake mackerels, escolars, oilfishes), Neoscopelidae (blackchins), Oneirodidae (dreamers), Paralichthyidae (sanddabs), and Serranidae (sea basses, groupers), and for *Genyonemus* (Sciaenidae; white croaker), *Physiculus* (Moridae; codling/mora), *Pleuronichthys* (Pleuronectidae; turbot), and *Scopelogadus* (Melamphaeidae; bigscale);

second reported fossil occurrence of otoliths preserved with skeletal remains of the Moridae (deepsea cods/moras);

first reported North American fossil occurrences of otoliths preserved with skeletal remains of the Cynoglossidae? (tonguefishes) and Platyroctidae (tubeshoulders);

and the first reported fossil occurrences of otoliths preserved in a coprolite and as stomach contents of the Myctophidae (lanternfishes) and Bathylagidae (deepsea smelts), respectively.

Photographs of modern representatives of some of these and other fish genera and families (snipe eel, fangtooth, viperfish, marine hatchetfish, deepsea anglerfish, needlefish, rockfish, dolphin) are presented by Dorfman and others (1995) and Paxton and Eschmeyer (1995). Illustrations of these and other modern representatives are provided by Eschmeyer and others (1983). Photographs of several Segment 2 fish specimens representing a herring, lanternfish, and a needlefish are presented in Figures 8 and 9. Photographs of Miocene, Pliocene, and Pleistocene otoliths from the southern California fossil record and representing lanternfish genera that also occur in the Segment 2 fish fauna are provided by Fitch (1969).

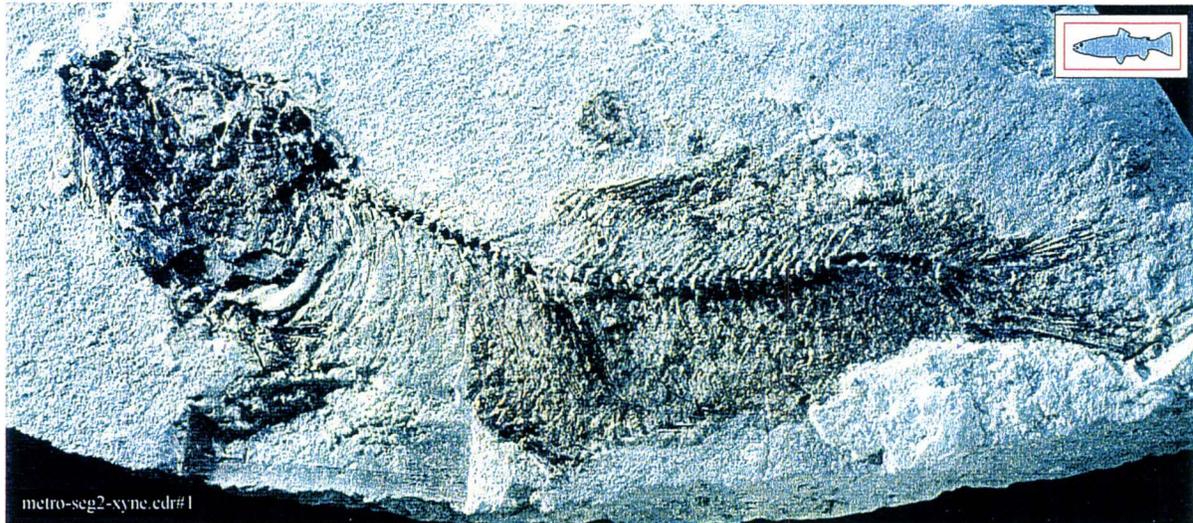
The Segment 2 fossil fish specimens also are scientifically highly important because the specimens, along with the species they represent, allow paleoenvironmental reconstruction of the downtown Los Angeles/Hollywood area during the late Miocene Epoch and deposition of the sediments comprising the marine shale. Unlike other fossil marine fish faunas of similar age from southern California, the Segment 2 fish assemblage from the Wilshire/Vermont station site is the only assemblage reported to contain the very-deep-water marine (middle bathypelagic) fish genera *Anoplogaster* (Anoplogasteridae; fangtooth) and *Oneirodes* (Oneirodidae; dreamer) in addition to the deep-water (upper bathypelagic) and moderately deep-water marine (mesopelagic) species comprising the other assemblages, including the Chalk Hill fish fauna (Huddleston, 1997). The latter fauna and the fish assemblages from the other Red Line fossil sites lack these two bathypelagic fish genera and presumably represent slightly shallower-water marine (upper bathypelagic) fish assemblages than the fish assemblage from the Wilshire/Vermont station site (Huddleston, 1997). Although the fossil fish assemblage from the Wilshire/Vermont station site is represented by the most species and fossil specimens, the faunal differences observed between this assemblage and the fish assemblages from the other Red Line fossil sites do not appear to represent a collecting or sampling bias because the other fossil sites (particularly Vermont/Sunset station site) have yielded fossil fish specimens representing species not recorded from the Wilshire/Vermont station site (Tables 6, 7).

Because modern representatives of fangtooths, deepsea anglerfishes, tubeshoulders, and bigscales live at ocean depths at least 2,000 or 2,600, 2,600, 3,000, and 3,300 feet (0.4 to 0.6 mile), respectively,

**Figure 8.**—Fossil fish specimens, unnamed late Miocene marine shale, Wilshire/Vermont station site (LACMVP fossil site 6202). Anterior to left. See Appendices M, O.

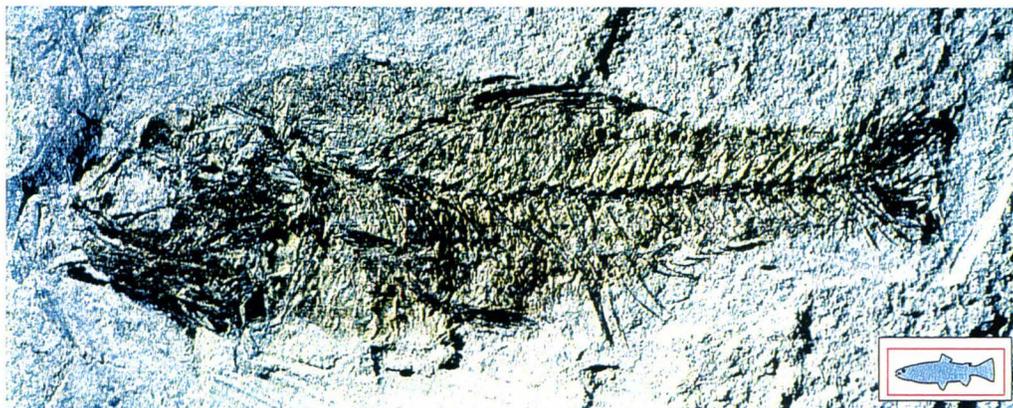
**A.**—Herring *Xyne grex*. Left lateral view of skeleton (LACMVP fossil specimen 138192). Natural size.

**B.**—Lanternfish, Myctophidae, genus and species undetermined. Left lateral view of skeleton (LACMVP fossil specimen 137134). Three times natural size.



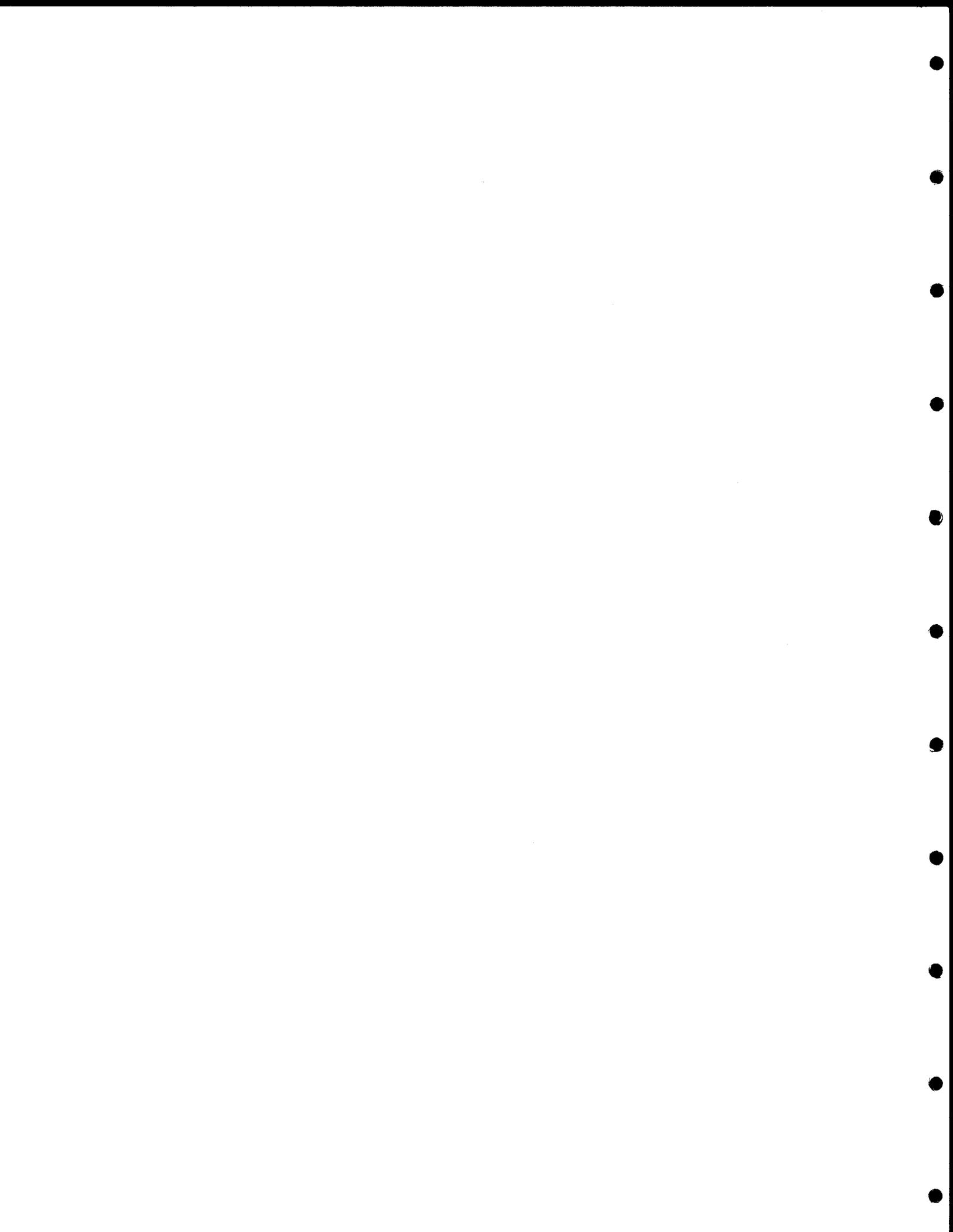
**A**

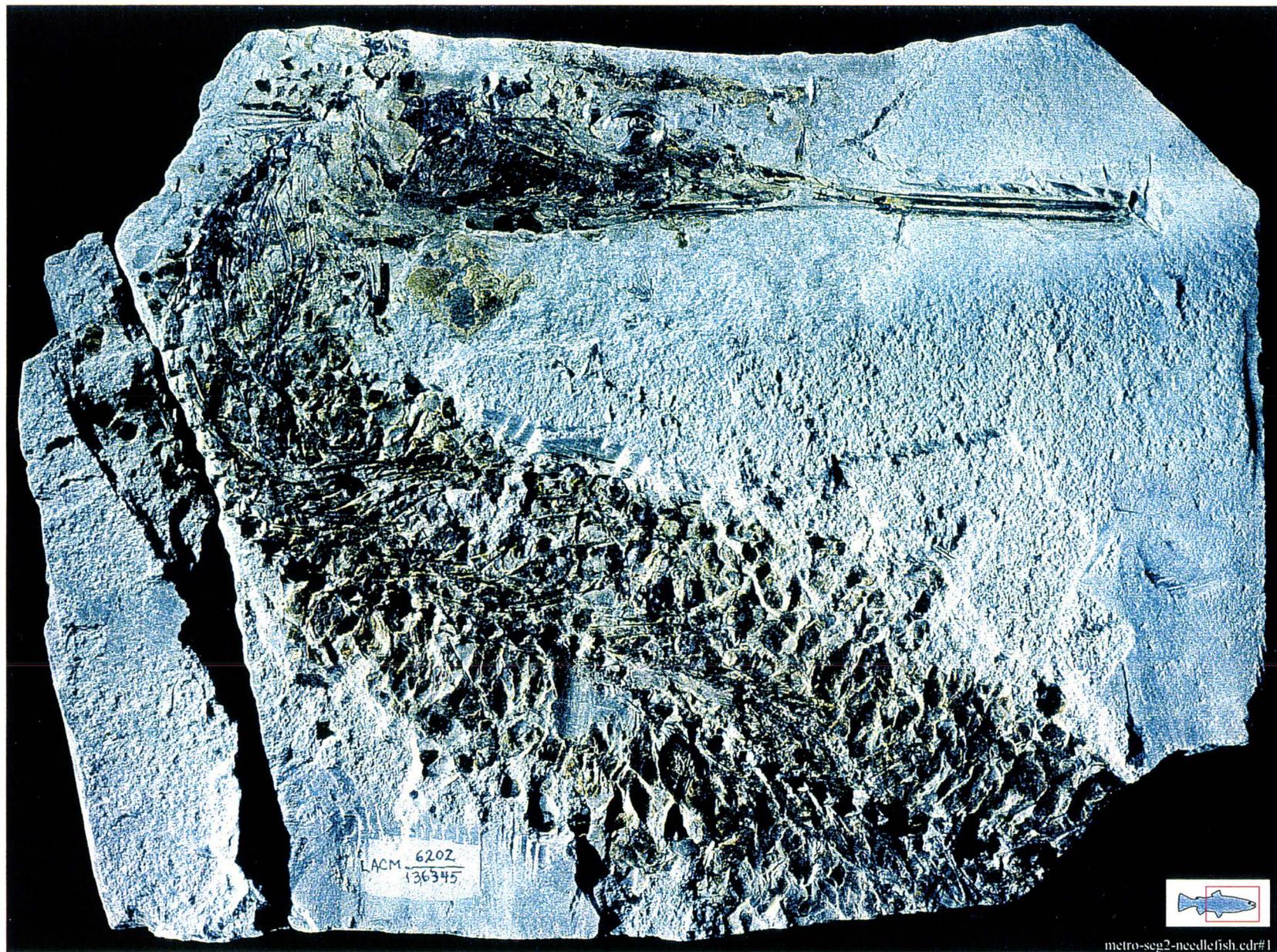
**B**



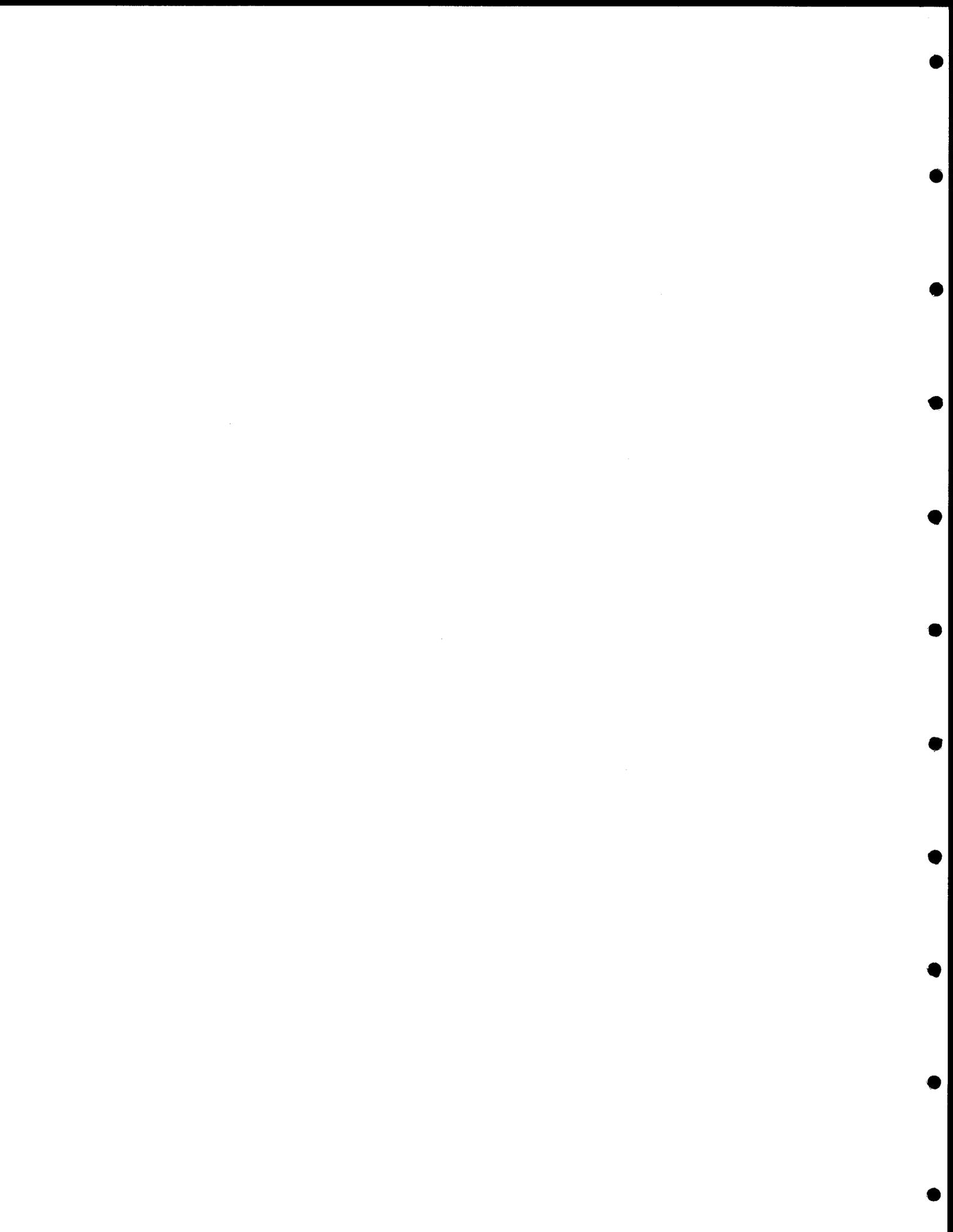
below sea level (Dorfman and others, 1995; Eschmeyer and others, 1983, Paxton, 1995), the presence of fossil forms of these species in the assemblage from the Wilshire/Vermont station site suggests the sea floor at the station site might have been at least 3,300 feet below sea level during deposition of the sediments comprising the marine shale, while the absence of these comparatively deep-water marine species and the possible presence of the fish genus *Scopelengys* (Neoscopelidae; porgy) in the Segment 2 fish assemblage from the Vermont/Sunset

station site suggests the sea floor at this station site was at least 2,300 feet below sea level, but probably not as deep as at the Wilshire/Vermont station site. The Wilshire/Vermont station site presumably was deeper than any other known southern California marine fossil site during the late Miocene Epoch. Moreover, modern deepsea anglerfishes live at ocean depths down to nearly 10,000 feet below sea level (Dorfman and others, 1995). However, the comparatively well-preserved, complete, and articulated nature of the delicate bathypelagic and





**Figure 9.**--Needlefish, *Strongylura* sp., unnamed late Miocene marine shale, Wilshire/Vermont station site (LACMVP fossil site 6202). Dorsal (below) and right lateral views (left) of anterior portion of postcranial skeleton, and right lateral view of skull and lower jaws (above; anterior to right) (LACMVP fossil specimen 136345). Natural size. See Appendices M, O.



mesopelagic fish specimens suggests the sea floor was in or below an anoxic or oxygen-minimum zone, which is believed to have been between roughly 5,000 and 10,000 feet (1 and 2 miles) below sea level during the late Miocene Epoch and would have prevented decay or disruption of the fish skeletons by bottom-dwelling organisms (Huddleston, 1997). On the other hand, the presence of shallow-water benthic marine fish species (turbot *Pleuronichthys*, possibly sanddab *Citharichthys*) at the Wilshire/Vermont station site indicate the sediments comprising the marine shale in the Segment 2 construction zone probably were deposited in a near-shore marine environment (Huddleston, 1997).

Documenting the taxonomic differences between the marine fish faunas of southern California and establishing their respective paleoenvironmental (depth) preferences will make it possible to relate these differences to the major geologically induced sea-level changes and accompanying coastline transgressions that occurred in southern California, particularly the Los Angeles basin, during the Miocene Epoch.

#### **6.1.4 Marine Mammals**

The proximal end of a rib (LACMVP fossil specimen 136303) from an otherwise unidentifiable species of whale was recovered from the marine shale as a result of the Segment 2 mitigation program conducted during excavation for the MacArthur Lake pocket track structure at newly recorded LACMVP fossil site 6254 (see Table 6, Appendices M, O). This specimen is scientifically highly important because the remains of marine mammals are comparatively rare in the fossil record and have not been reported previously as occurring in the marine shale in the central Los Angeles basin.

#### **6.1.5 Algae**

Approximately 25 identifiable noncalcareous intertidal benthic marine algal (seaweed) specimens were recovered at three newly recorded UCMP plant fossil sites (PA-722, -723, PB-99003) in the marine shale as a result of the Segment 2 mitigation program conducted during excavation for the Wilshire/Vermont and Vermont/Sunset stations and tunneling for the eastern Wilshire Boulevard tunnel segment (Fisk, 1999; Schorn, 1995; see Appendices K, N, BB). One of the specimens represents the red algal species *Chondrides flexilis* and the remaining specimens represent the brown algal species *Paleocystophora plumosa*, *Paleohalidrys californica*,

*Paleohalidrys liguliformis*, a new species of *Paleohalidrys*, and a new genus and species of brown alga. These specimens are scientifically highly important because marine algal remains are comparatively rare in the fossil record and have not been reported previously as occurring in the marine shale in the central Los Angeles basin, although some of the remains of these species reported by Parker and Dawson (1965) as occurring in the Monterey Formation at previously recorded fossil sites in the northern Santa Monica Mountains (northwestern Los Angeles basin) also are from the marine shale (see Dibblee, 1991b, 1992). The presence of well-preserved intertidal benthic marine algal specimens in the marine shale indicates the sediments comprising the marine shale probably were deposited in a near-shore deep-water marine environment (Fisk, 1999; Parker and Dawson, 1965).

#### **6.1.6 Land Plants**

Three fossil land plant leaf specimens were recovered from the marine shale as a result of the Segment 2 mitigation program conducted during excavation for the Wilshire/Vermont and Vermont/Sunset stations at two newly recorded UCMP plant fossil sites (PA-723, PB-99003) (Fisk, 1999; Schorn, 1995; see Appendices K, N, BB). One leaf resembles the oak *Quercus* (beech family) and members of the laurel family (Schorn, 1995). The other two specimens represent *Populus pliotremuloides* (aspen) and *Rhamnus precalifornica* (buckthorn) (Fisk, 1999). These specimens are scientifically highly important because the leaves of land plants are very rare in the marine fossil record and, with one possible exception, have not been reported previously as occurring in the marine shale in the central Los Angeles basin. The fossil leaf reported by Soper and Grant (1941) as occurring in the downtown Los Angeles area is from the marine shale or the underlying Monterey Formation. The presence of well-preserved fossil leaves of land plants in the marine shale suggests the sediments comprising the marine shale were deposited in a near-shore deep-water marine environment (Fisk, 1999).

#### **6.1.7 Summary**

The Segment 2 fossil specimens from unit Tps1 of the unnamed marine shale are scientifically highly important because they represent a taxonomically very large and highly diverse assemblage of associated marine microfossil and algal, land plant, and marine invertebrate and vertebrate species, and, along with sedimentologic (geologic) data (see

Lamar, 1970), have been critical in documenting and refining estimates of the age of the marine shale and in reconstructing the depositional paleoenvironment represented by its sediments (see Fisk, 1999; Groves, 1997a; Huddleston, 1997; Micropaleo Consultants, Inc., 1993, 1998; Schorn, 1995). Such an association is very rare in the fossil record. Moreover, some of the invertebrate and many of the fish specimens represent the first, first North American, and/or oldest reported occurrences of their respective species (or even genera and families) in the fossil record, and many of these species, particularly with regard to most of the fish species, are new and/or only rarely recorded in the fossil record.

Although the microfossil and some of the fish species (particularly herring *Xyne grex*, although Huddleston, 1997, reports questionable occurrence of this species in earliest Pliocene unit Tpds at Red Line Segment 1 Tom Bradley/Civic Center station site; see Appendix J) indicate unit Tps1 of the marine shale is late Miocene in age, the invertebrate species suggest unit Tps1 is early Pliocene age. However, late Miocene marine invertebrate assemblages from the Los Angeles basin and vicinity are very rare and, therefore, poorly known because rock units of this age usually represent deep-water marine sedimentary deposits, which generally contain few age-diagnostic invertebrate remains. Presumably, the Segment 2 invertebrate species from the marine shale represent downward chronologic range extensions. Microfossil species indicate overlying unit Tpds at the top of the marine shale is earliest Pliocene in age.

The paleoenvironmental preferences of the deeper-water marine mollusk species, mesopelagic and bathypelagic fish species, and upper middle bathyal benthic marine foraminifer species comprising the composite Segment 2 assemblage, particularly the Wilshire/Vermont station assemblage, suggest these species lived at ocean depths roughly 3,300 to 4,700 feet below sea level during the early late Miocene Epoch, approximately 7.2 million to 8.6 million years ago, the Wilshire/Vermont station fish assemblage having lived at ocean depths greater than those occupied by any other fish assemblage known from the southern California late Miocene marine fossil record. These conclusions are corroborated by the presence of possible lower "Delmontian" benthic marine foraminifer species in the marine shale at a fossil site (fossil site 6 of Lamar, 1970) in Alhambra (east to northeast of Segment 2 fossil sites), these species suggesting that the sea floor at this fossil site was over 4,000 feet below sea level during the late Miocene Epoch (Lamar, 1970; Natland, 1957). The

Segment 2 epipelagic fish species presumably are represented by individuals that, like the intertidal benthic marine algal and land plant remains, sank to the sea floor from shallower depths in the water column, or, along with the comparatively poorly preserved, incomplete, and disarticulated specimens of the shallow-water benthic marine fish species and specimens of the shallower-water marine invertebrate species, might have been transported downward from shallower depths and into the Segment 2 construction zone by turbidity flows. However, the comparatively well-preserved, complete, and articulated nature of the delicate specimens representing the bathypelagic and mesopelagic fish species, as well as the well-preserved nature of the delicate plant remains, suggests these specimens were not transported and that the sea floor was within or below an anoxic or oxygen-minimum zone, which was between roughly 5,000 and 10,000 feet below sea level during the late Miocene Epoch and would have prevented decay or disruption of the fish skeletons and plant remains by bottom-dwelling organisms. The latter conclusion is corroborated by the apparent absence of any evidence indicating bioturbation of the fossil-bearing strata, but contradicted by the presence of benthic foraminifer and invertebrate remains, unless these remains, like the shallow-water benthic marine fish remains, were transported downward from shallower depths by turbidity flows. On the other hand, these turbidity flows presumably would have disrupted the plant and articulated fish skeletons.

The presence of remains representing shallow-water benthic marine fish species (sanddab, turbot) suggests the sediments comprising the marine shale were deposited in a near-shore marine environment, a conclusion corroborated by the association of the remains of these and the other fish species with the remains of intertidal benthic marine algae and the leaves of land plants.

Paleoenvironmental preferences of the species comprising the composite Segment 2 fossil assemblage, in conjunction with taphonomic (paleontologic) data from the marine shale, do not conflict with geologic (sedimentologic) data, which suggest the sediments comprising the unnamed marine shale were deposited by turbidity flows that traveled in a southerly direction down the Tarzana fan. The presence of middle bathypelagic fish species only at the Wilshire/Vermont station site suggests the surface of the Tarzana fan (sea floor) in the northern portion of the central Los Angeles basin sloped in a southerly direction. Alternatively, the greater depth represented by the fish assemblage at the Wilshire/

Vermont station site, which, with the possible exceptions of the MacArthur Lake pocket track structure and Wilshire Boulevard tunnel segment fossil sites, appears to lie stratigraphically above the other Segment 2 fossil sites in the marine shale (see CWDD and others, 1981; Dibblee, 1991a; Lamar, 1970), and, therefore, to be composed of younger strata, also might reflect progressive but rapid subsidence of the northern edge of the basin floor along the SM-H-RHFZ during the late Miocene Epoch and deposition of the sediments comprising the marine shale. The presence of upper middle bathyal benthic marine foraminifer species at the Wilshire/Vermont station site, which now lies at an elevation approximately 250 feet above sea level, indicates the station site has been uplifted nearly 5,000 feet in the last 7.2 million years. However, areas adjacent the Segment 2 route and underlain by the marine shale now lie at elevations in excess of 550 feet (see Dibblee, 1991a), suggesting the Segment 2 construction zone and vicinity have been uplifted over 5,250 feet (1.0 mile).

The Segment 2 fossil marine invertebrate and fish specimens received extensive media coverage during 1996 and 1997.

## **6.2 SAN PEDRO SAND**

No fossil remains were observed in the San Pedro Sand as a result of the Segment 2 mitigation program conducted during excavation for the Wilshire/Normandie station and, therefore, no remains were recovered by the PEA paleontologic construction monitor (Lander, 1993a).

## **6.3 OLDER ALLUVIUM**

Five fossil land mammal specimens were recovered at five newly recorded LACMVP fossil sites in the older alluvium as a result of the Segment 2 mitigation program (fragmentary remains discovered, but not recovered at 2 additional fossil sites) (Table 3, Figures 5, 6, Appendix M). The five fossil specimens from these fossil sites subsequently were catalogued under six LACMVP fossil specimen numbers (Table 8, Appendix O).

A fossilized tusk fragment of an extinct elephant, probably the late Pleistocene Columbian mammoth *Mammuthus columbi* but possibly the American mastodont (LACMVP fossil specimen 137902), was recovered from the older alluvium at a depth approximately 65 feet below grade during excavation for the Wilshire/Western station at newly recorded

LACMVP fossil site 6204 (Lander, 1993b, 1994b; see Table 8, Figures 5, 6, Appendices M, O). The specimen, originally about 3 feet in length, was heavily damaged by earth-moving equipment before being recovered by a construction worker.

The fossilized bones and teeth of a number of extinct Ice Age land mammal species, including the American mastodont *Mammuthus americanus* (elephant) (LACMVP fossil specimen 140856), the zebra-like western horse *Equus "occidentalis"* (LACMVP fossil specimen 140855), the large western camel *Camelops hesternus* (LACMVP fossil specimens 140858, 140859, which represent same individual), and the ancient bison *Bison antiquus* (LACMVP fossil specimen 140857) were recovered from the older alluvium at depths 47 to approximately 80 feet below grade during excavation of the westbound (northern) Hollywood Boulevard tunnel segment between the Hollywood/Western station site and the Hollywood Freeway (newly recorded LACMVP fossil sites 6297 to 6300, respectively) (Lander, 1994d, -e, -f; see Table 8, Figures 5, 6, 10, 11, Appendices, M, O). These specimens subsequently received extensive media coverage from 1994 to 1997.

The length of the bison metacarpal (225 millimeters) is within the observed metacarpal size range (212 to 233 millimeters) for *Bison antiquus* from the older alluvium at the La Brea tar pits, but is decidedly less than that for the larger longhorn bison *Bison latifrons* (244 to 255 millimeters), which also occurs in the older alluvium at the La Brea tar pits (see Gust, undated; Miller, 1971; Miller and Brotherson, 1979; however, see Gust, 1993, regarding incorrect assignment of *Bison antiquus* specimens from La Brea tar pits to *Bison latifrons* by Miller, 1971, and Miller and Brotherson, 1979).

The fossil land mammal remains from the older alluvium are scientifically highly important because they corroborate the nonmarine or continental origin of the older alluvium in the Segment 2 construction zone and vicinity. Moreover, such remains are comparatively rare in the fossil record. The bison remains, in particular, are scientifically highly important because they corroborate a late Pleistocene (Rancholabrean) age rather than an early to middle Pleistocene (Irvingtonian) or Holocene age for the older alluvium. Like *Bison antiquus*, the other species represented by remains recovered in the Segment 2 construction zone also occur in the older alluvium at the La Brea tar pits and became extinct at the end of the Pleistocene Epoch and the Rancholabrean

**Table 8.**—Dimensions of fossil land mammal specimens, older alluvium, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. See Table 3, Figures 5, 6, 10, 11, Appendices, M, O.

Genus, Species	Common Name	LACMVP <sup>a</sup> Fossil Site/ Specimen Number	Element <sup>b</sup>	Dimensions (millimeters)
<i>Mammut americanum</i>	American mastodont	6298/140856	L m2	length: 72.8 width: 76.0
? <i>Mammuthus columbi</i>	Columbian mammoth?	6204/137902	tusk fragment	—
<i>Equus "occidentalis"</i>	western horse	6297/140855	R 1 <sup>st</sup> phalanx III	length: 98.0
<i>Camelops hesternus</i>	western camel	6300/140858 <sup>c</sup>	L M1	length: 36.2 width: 32.0
		6300/140859 <sup>c</sup>	R M1	length: 36.2 width: 32.7
<i>Bison antiquus</i>	ancient bison	6299/140857	L metacarpal	length: 225.0

<sup>a</sup>LACMVP: Natural History Museum of Los Angeles County Vertebrate Paleontology Section.  
<sup>b</sup>L: left;  
M: upper molar;  
m: lower molar;  
R: right.  
<sup>c</sup>LACMVP fossil specimens 140858 and 140859 represent same individual and stated to be from a depth 65 feet below grade. However, field data indicate specimens are from approximately 4 feet below top of tunnel, which is at a depth 76 feet below grade. Presumably, specimen is from a depth approximately 80 feet below grade.

NALMA, approximately 10,750 years ago (Lander, 1999; Jefferson, 1991; Lundelius and others, 1987; Stock and Harris, 1992; see above).

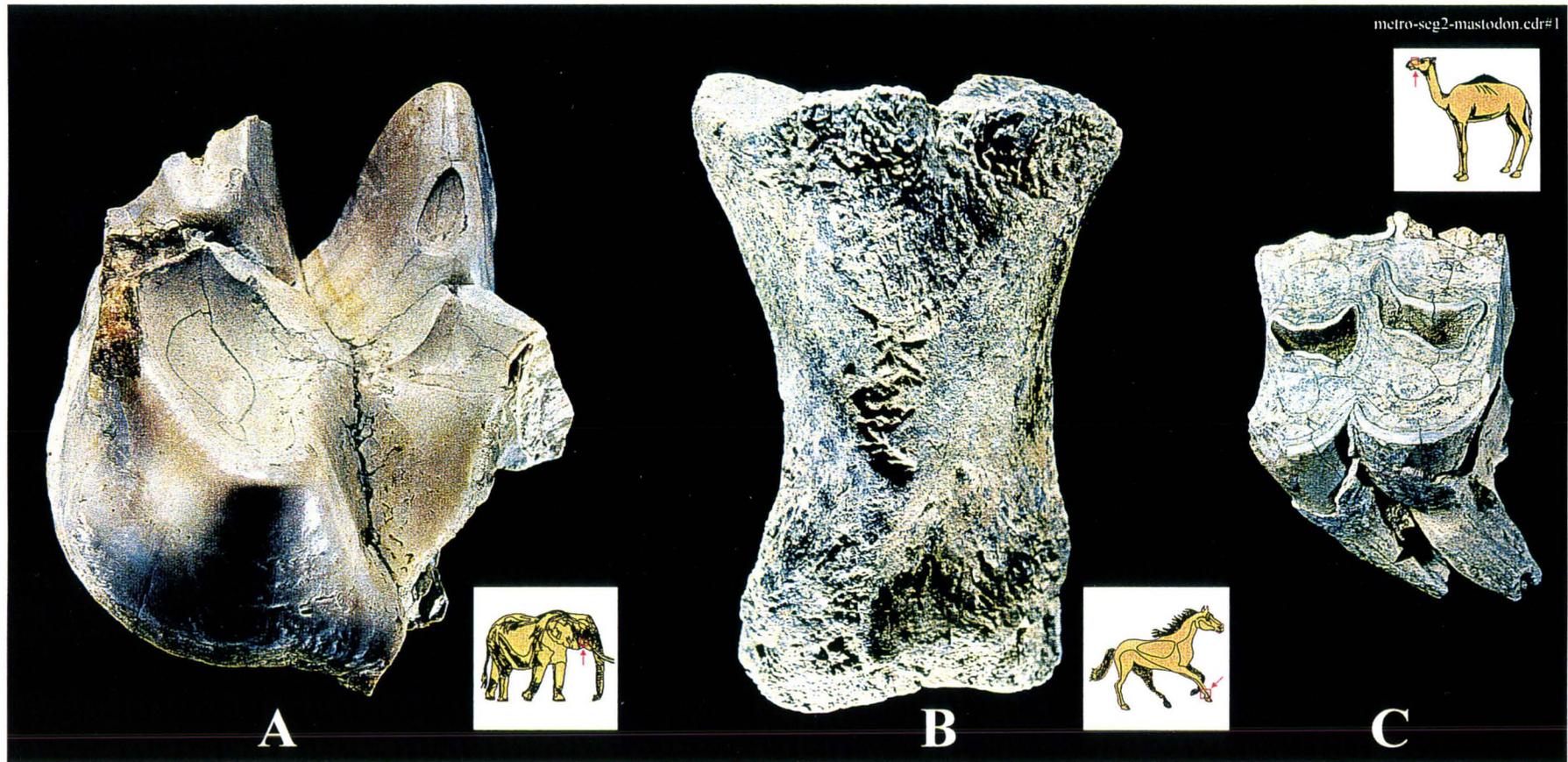
The presence of grazing (grass-eating) herbivores, including horse, bison, and possibly mammoth, suggests the Segment 2 construction zone and vicinity was mostly grassland habitat during the late Pleistocene Epoch, although the occurrence of a mastodont, a browsing (leaf-eating) herbivore, suggests some woodland habitat also was present (see Edwards, 1996; Koch and Hoppe, 1996; Miller, 1971; Stock and Harris, 1992). Contrary to Miller (1971), *Camelops hesternus* was not a grazer and, therefore, is not indicative of a grassland habitat, but instead was an intermediate feeder that ate both grass and leaves, and presumably is indicative of an open

savanna woodland habitat (Dompierre and Churcher, 1996).

Fragmentary and otherwise unidentifiable land mammal remains were recovered from the older alluvium at a depth about 30 feet below grade as a result of the mitigation program conducted during excavation for the Wilshire/Normandie station (Lander, 1993a), and at a depth roughly 60 feet below grade during excavation for the Hollywood/Western station.

**6.4 YOUNGER ALLUVIUM**

No fossil remains were recovered from the younger alluvium as a result of the Segment 2 mitigation program conducted during excavation for the

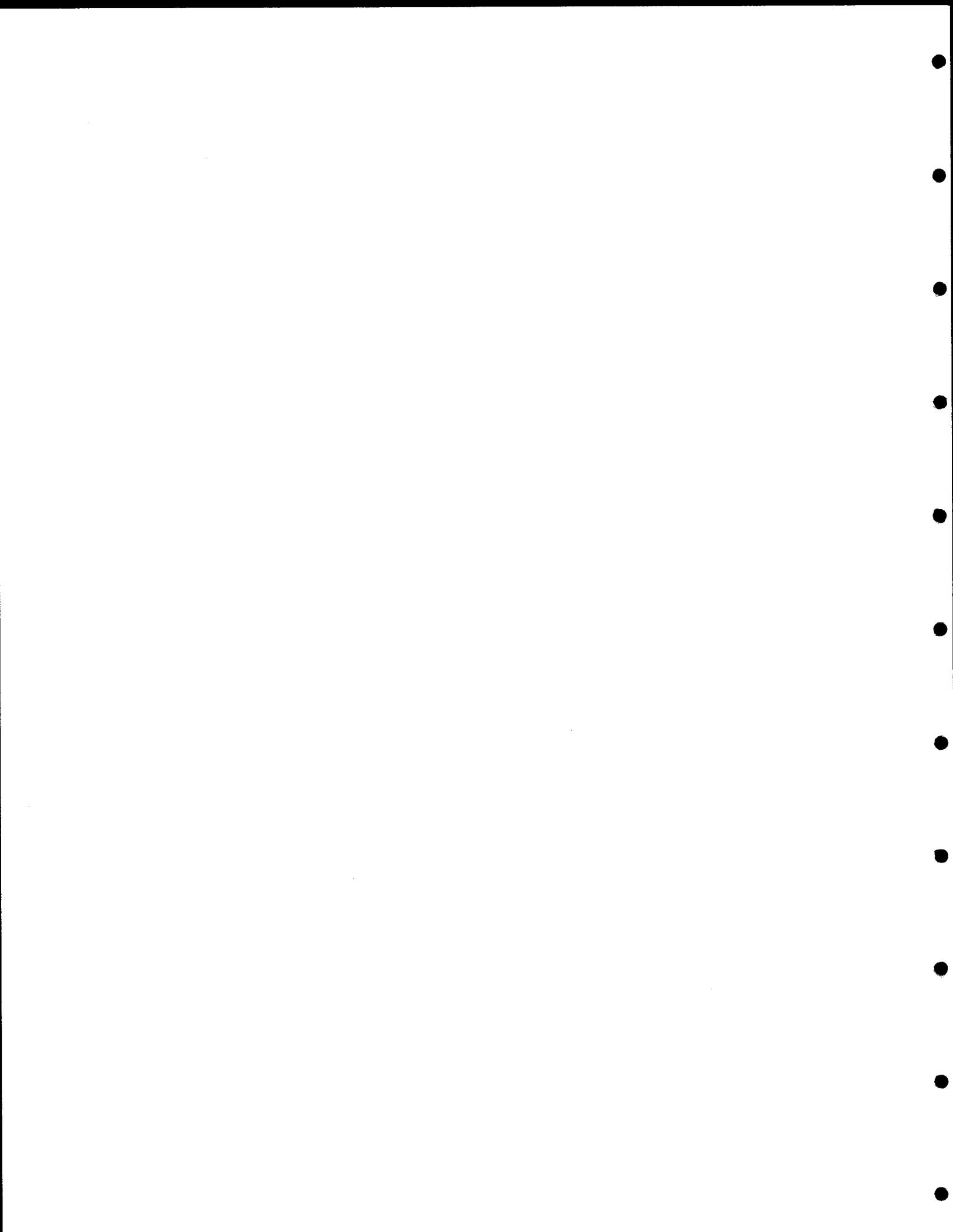


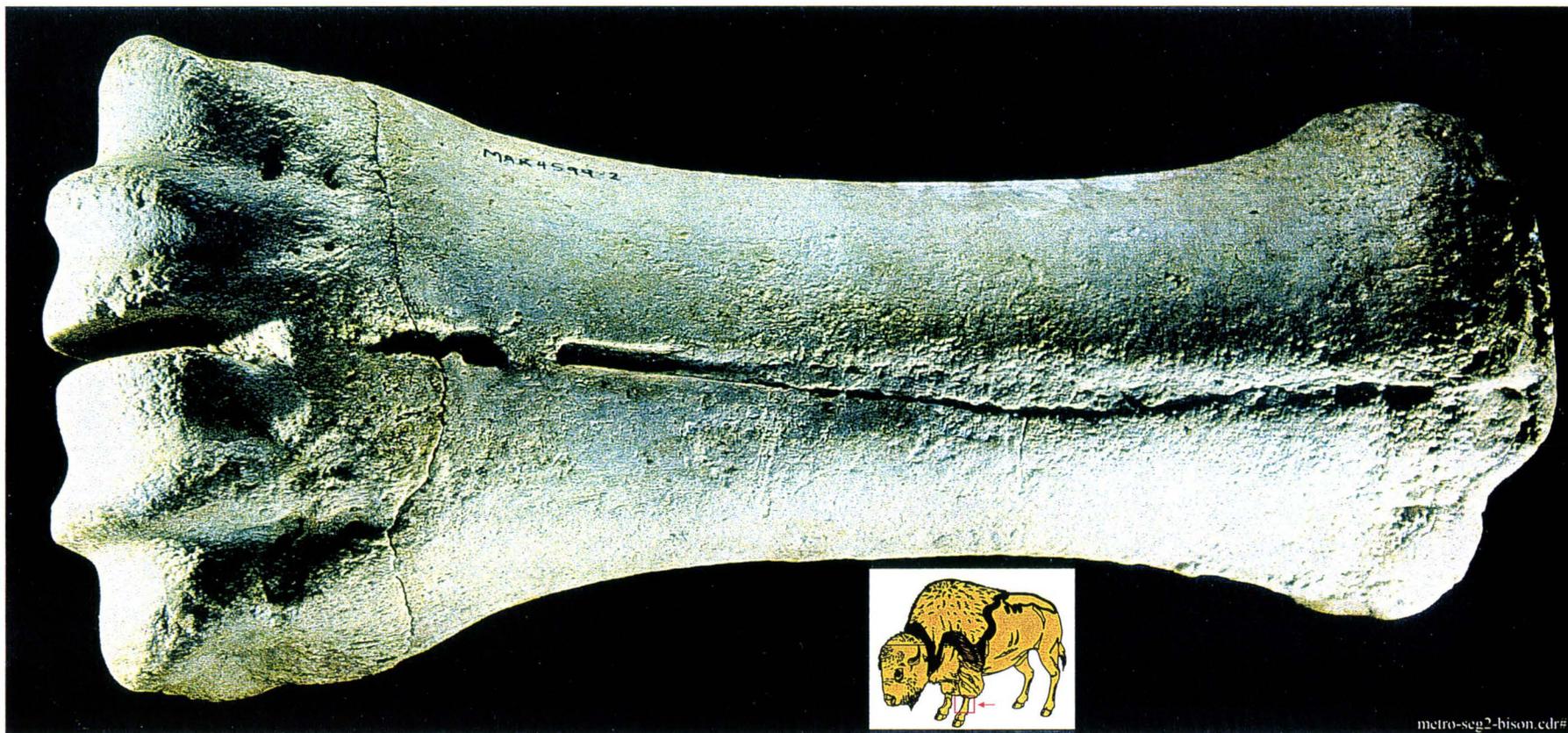
**Figure 10.**—Fossil land mammal specimens, older alluvium, Hollywood Boulevard tunnel segment. Natural size. See Table 8, Appendices M, O.

**A.**—American mastodont, *Mammot americanum*, LACMVP fossil site 6298. Occlusal oblique view of lower left second molar (LACMVP fossil specimen 140856). Anterior to left.

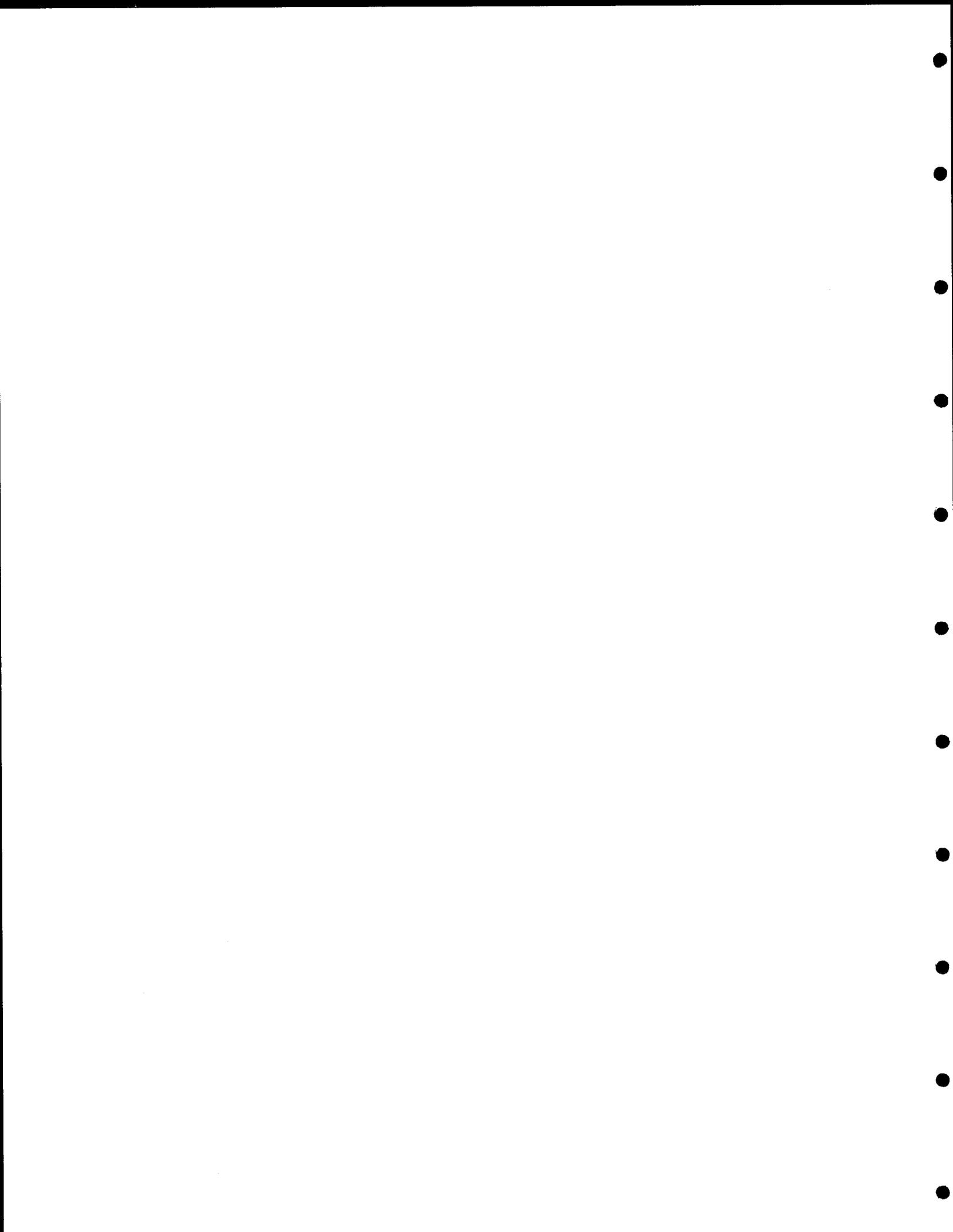
**B.**—Western horse, *Equus occidentalis*, LACMVP fossil site 6297. Anterior view of first phalanx of third digit (LACMVP fossil specimen 140855). Proximal above.

**C.**—Western camel, *Camelops hesternus*, LACMVP fossil site 6300. Occlusal oblique view of upper left first molar (LACMVP fossil specimen 140858). Anterior to left.





**Figure 11.**—Ancient bison, *Bison antiquus*, older alluvium, Hollywood Boulevard tunnel segment (LACMVP fossil site 6298). Anterior view of left metacarpal (LACMVP fossil specimen 140857). Proximal to right. Natural size. See Tables 4 to 8, Appendices M, O.



MacArthur Lake pocket track structure or the Wilshire/Normandie station because no remains were observed by the PEAI paleontologic construction monitor.

**6.5 ARTIFICIAL FILL**

No fossil remains were recovered from the artificial

fill as a result of the Segment 2 mitigation program because this rock unit probably is unfossiliferous. Moreover, any fossil remains in this rock unit would have lacked any original geologic or geographic context. Therefore, excavation of the rock unit was not monitored by a PEAI paleontologic construction monitor as part of the mitigation program.

SECTION 7

ACRONYMS AND ABBREVIATIONS

CEQA	California Environmental Quality Act
CIT	California Institute of Technology
CWDD	Converse Ward Davis Dixon
F&F	F & F GeoResource Associates, Inc.
gen.	genus
GTT	Gary T. Takeuchi, PEAI
G&A	Greenwood and Associates
indet.	indeterminate
LACM	Natural History Museum of Los Angeles County, Los Angeles
LACMIP	LACM Invertebrate Paleontology Section
LACMVP	LACM Vertebrate Paleontology Section
LACTC	Los Angeles County Transportation Commission
MAR	Mark A. Roeder, PEAI
MTA	Los Angeles County Metropolitan Transportation Authority
n.	new
NALMA	North American land mammal age
NEPA	National Environmental Policy Act
PD	Parsons-Dillingham
PEAI	Paleo Environmental Associates, Inc.
PES	Parsons Engineering Science, Inc.
RCC	LACTC Rail Construction Corporation
SCRTD	Southern California Rapid Transit District
SKK	Shea/Kiewit/Kenny
SM-H-RHFZ	Santa Monica-Hollywood-Raymond Hill Fault Zone
sp.	species
SVP	Society of Vertebrate Paleontology
TSP	Tutor-Saliba/Perini
UCMP	University of California Museum of Paleontology, Berkeley
UMTA	U.S. Department of Transportation Urban Mass Transportation Administration
undet.	undetermined

SECTION 8

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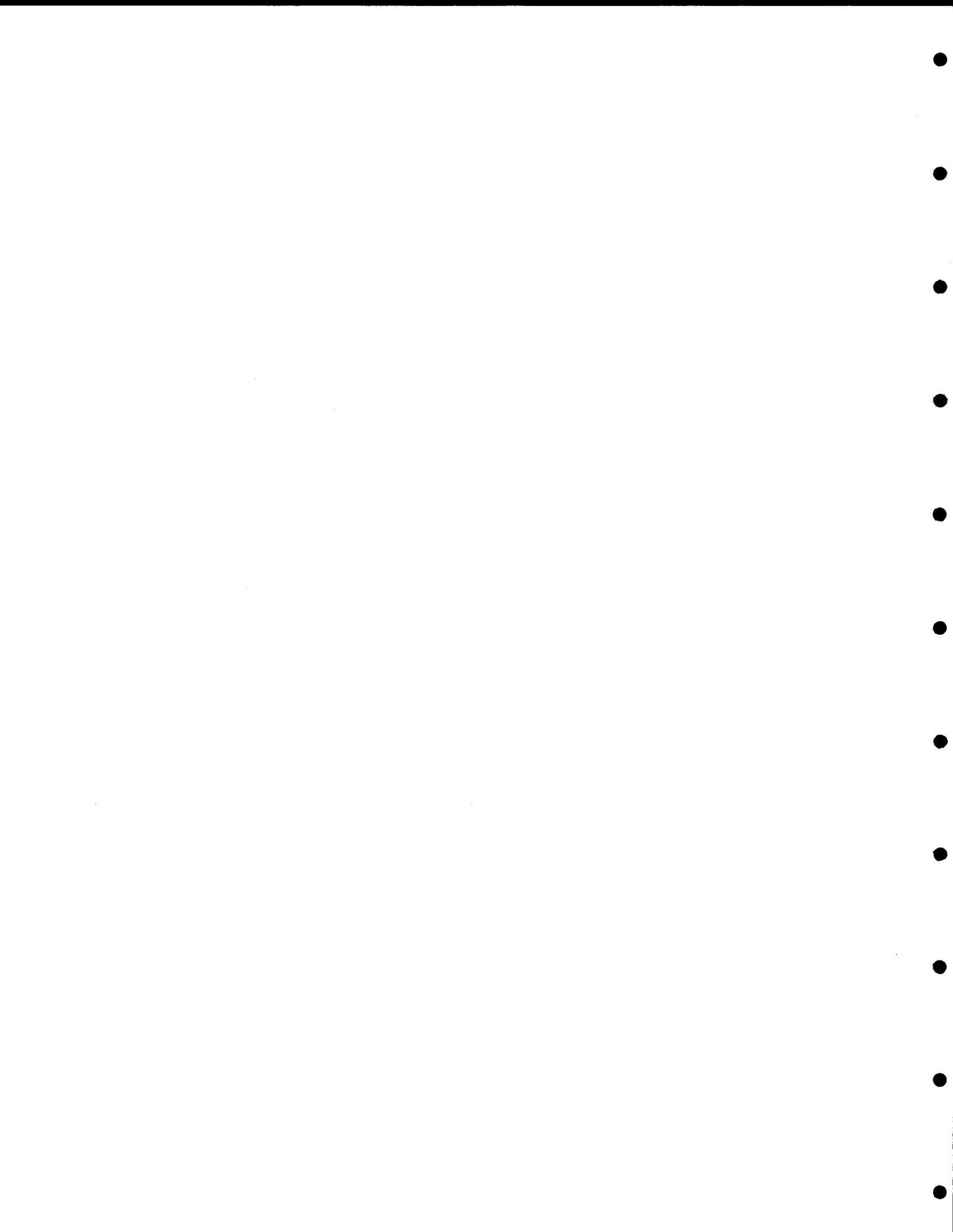
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**LOS ANGELES METRO RED LINE PROJECT  
PALEONTOLOGIC RESOURCE  
IMPACT MITIGATION PROGRAM  
FINAL TECHNICAL REPORT OF FINDINGS—  
PART 3: SEGMENT 3**

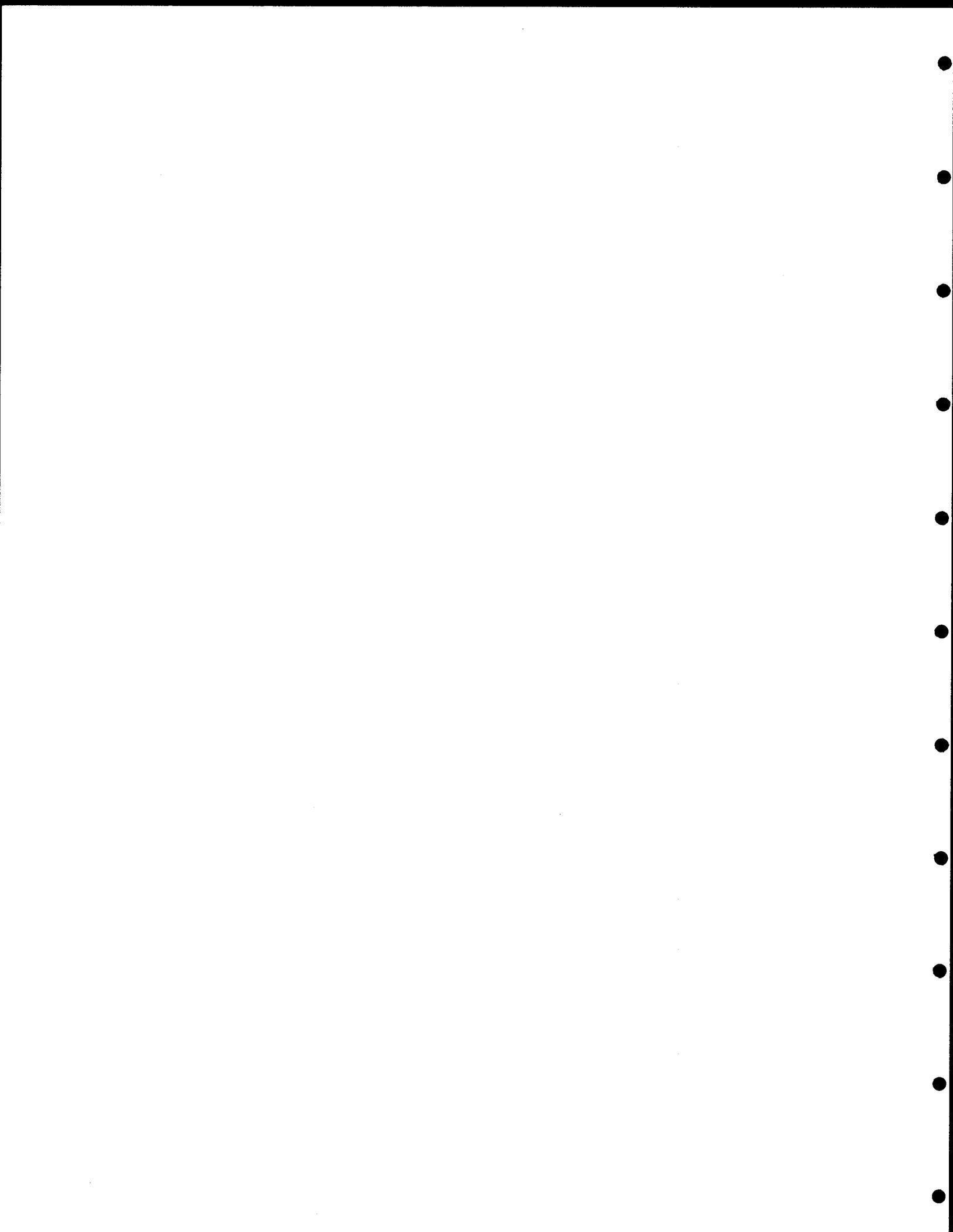


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## SECTION 1

### SUMMARY

This final technical report of findings presents the results of the paleontologic resource impact mitigation program conducted by Paleo environmental Associates, Inc. (PEAI), personnel during and in support of earth moving associated with construction of the Los Angeles Metro Red Line Segment 3 Hollywood/Highland, Universal City, and North Hollywood stations (contracts C-301, -321, -351, respectively); Universal City cross-over (contract C-311); southern and northern Santa Monica Mountains tunnel access shafts (contracts C-301, -311, respectively); and the intervening Hollywood, Santa Monica Mountains, and San Fernando Valley tunnel segments (contracts C-301, -311, -331), Los Angeles, California. The mitigation program was required because of the moderate to high potential for scientifically highly important fossil remains being uncovered by earth moving, particularly cut-and-cover excavation for stations, in the Segment 3 construction zone, and were implemented to ensure NEPA/CEQA compliance with mitigation measures developed during the environmental impact review process and with Southern California Rapid Transit District (SCRTD)/ Los Angeles County Transportation Commission (LACTC)/Los Angeles County Metropolitan Transportation Authority (MTA) Specifications Section 01170. The mitigation program was conducted in compliance with these measures and with Society of Vertebrate Paleontology (SVP) standard measures to reduce the potential adverse environmental impacts of construction on the paleontologic resources of the Segment 3 construction zone to an insignificant level.

The mitigation program substantially reduced the adverse environmental impacts of earth moving on the paleontologic resources of the Segment 3 construction zone to an insignificant level by allowing for the recovery of numerous fossil specimens and the recording of associated specimen data and corresponding geologic and geographic site data that otherwise would have been lost to earth moving and to unauthorized fossil collecting by construction personnel, and for preservation of the fossil remains and archiving of associated data in recognized museum repositories, where they will be retrievable and available for future study by qualified investigators. Moreover, with the mitigation program, construction resulted in beneficial effects by exposing and allowing for the recovery of scientifically highly

important fossil remains and associated specimen data and corresponding site data that would not even have been uncovered without construction-related earth moving and, therefore, would not have been available for recovery.

Earth moving in the Segment 3 construction zone encountered, in order of increasing geologic age and depth, historic artificial fill, Holocene younger alluvium, middle to late Pleistocene older alluvium, the early to middle Miocene marine Lower, Middle?, and Upper Topanga Formation and an associated unnamed submarine volcanic rock unit; the Paleocene marine and nonmarine? Santa Susana Formation (including Simi Conglomerate Member), an unnamed late Cretaceous marine rock unit, possibly a late Cretaceous nonmarine rock unit, and an unnamed early Cretaceous quartz diorite.

Fossil marine clam shell fragments questionably assignable to the Lucinidae were recovered from a dark gray sandstone layer at a newly recorded PEA I fossil site in the Santa Monica Mountains tunnel segment as a result of the Segment 3 mitigation program. The remains are scientifically highly important because they indicate that strata interbedded with the unnamed middle Miocene submarine volcanic rock unit and assignable to the Middle Topanga Formation occur in the tunnel segment.

Thirty-three marine fish specimens, one land plant specimen, and undetermined number of marine microfossil specimens were recovered at three newly discovered PEA I fossil sites in the Upper Topanga Formation (fish specimens recorded under one new museum fossil site number), treated (prepared, identified, curated, catalogued, as appropriate), and analyzed as a result of the Segment 3 mitigation program, these fossil specimens having been recovered at the northern Santa Monica Mountains tunnel access shaft and starter tunnel sites and the Universal City station/cross-over site, and in the San Fernando Valley tunnel segment. Prior to analysis of these specimens, the fossil record of the Upper Topanga Formation in the northwestern Los Angeles basin was very poorly known.

The Segment 3 fossil specimens from the Upper Topanga Formation are scientifically highly important because they represent a taxonomically

moderately large and diverse assemblage of associated marine microfossil and fish species and a land plant species, and have been critical in documenting and refining estimates of the age of the rock unit and in reconstructing the depositional paleoenvironment and marine paleoclimate represented by its sediments.

The benthic (bottom-dwelling) marine foraminifer remains are scientifically highly important because the species they represent indicate the microfossil assemblage from the station site probably is early middle Miocene (approximately 12.7 million to 16.4 million years) in age and represents a lower middle bathyal (very-deep-water marine) environment and ocean depths roughly 4,700 to 6,250 feet below sea level, but possibly closer to 4,700 feet. However, the presence of the fossilized wood of a land plant suggests the sediments comprising this rock unit were deposited in a near-shore marine environment. At least 13 marine microfossil (including calcareous nannoplankton) species are represented in the sample.

The fossil marine fish specimens, primarily skeletons, and scales, from the Upper Topanga Formation are assignable to 8 families, at least 12 and possibly as many as 14 genera, and 14 extinct species, of which most of the species are new, not having been reported previously in the scientific literature. Most of the other species are rare. Many of the specimens are scientifically highly important because they represent chronologic and/or geographic range extensions, including the first, first North American, and oldest North American occurrences of their respective families and genera reported from the fossil record. The Segment 3 fish fauna is unusual because, unlike other marine fish faunas in the southern California fossil record, it contains comparatively rare species representing herrings and boarfishes and possibly codlets, bigeyes and sardinellas. Modern representatives of these species do not occur off the southern California coast today, but rather occur far to the south in warmer tropical and subtropical marine waters, suggesting that marine waters of coastal southern California were unusually warm during the middle Miocene Epoch and warmer than today.

Although all lines of evidence are not entirely consistent, paleoenvironmental preferences of the species comprising the composite Segment 3 fossil assemblage, in conjunction with sedimentologic data from the Upper Topanga Formation, suggest the sediments comprising this rock unit were deposited by turbidity flows. Presumably, these flows originated

in a near-shore shallow-marine environment; traveled offshore (basinward) in a southwesterly direction and downslope along the sea floor under the influence of gravity; and finally slowed, dissipated, and deposited their sediment loads to form a large submarine fan on the subsiding floor and adjacent northeastern (landward) lower slopes of the deep, steep-walled submarine basin (ancestral northwestern Los Angeles basin) that once existed very near and parallel to the former coastline, which lay much farther inland during the middle Miocene Epoch. The basin probably was bounded to the south by the Santa Monica-Hollywood-Raymond Hill Fault Zone (SM-H-RHFZ), which now roughly parallels and lies less than 0.25 mile north of the Hollywood tunnel segment, and to the northeast by the San Gabriel Mountains and the San Gabriel Fault. To the south, the ancestral north-central Los Angeles basin is bounded to the north by the SM-H-RHFZ, lacks strata laterally equivalent to the Upper Topanga Formation and older sedimentary rock units, and presumably was emergent and subjected to erosion during the earlier part of the Luisian Stage and middle Miocene Epoch and deposition of the sediments comprising the Upper Topanga Formation in the northwestern Los Angeles basin.

Although the alluvium is not differentiated in the San Fernando Valley, fossil land mammal remains and carbon-14 radiometric age determinations on fossilized wood recovered from the alluvium as a result of the Segment 3 mitigation program suggest that, in the subsurface, the alluvium consists of two stratigraphically superposed rock units: an older rock unit (older alluvium), middle to late Pleistocene and at least 46,340 years in age below, and a younger rock unit (younger alluvium), Holocene and no older than 10,500 years in age above. The oldest carbon-14 age determination (10,500 years) for the fossilized wood specimens from the younger alluvium at the Universal City station site and the youngest, presumably reliable age determinations (11,130, 10,940 years) for late Pleistocene land mammal remains from the older alluvium at the La Brea tar pits suggest the Pleistocene-Holocene Epoch boundary is approximately 10,750 years in age. Moreover, the middle to late Pleistocene Segment 3 fossil assemblages from the older alluvium in the San Fernando Valley tunnel segment and at the North Hollywood station site are at least 35,840 years older than the assemblage from the younger alluvium.

The bones and teeth of extinct Harlan's ground sloth, otherwise unidentifiable elephant, western camel, and ancient and longhorn bison, and the wood and pollen

of land plants, including incense cedar and coast redwood, were recovered from the older alluvium in the San Fernando Valley tunnel segment and at the North Hollywood station site. These remains are scientifically highly important because land mammal remains are comparatively rare in the fossil record and, particularly with regard to the bison specimens, corroborate a middle to late Pleistocene (Rancholabrean; 10,750- to 280,000-year) age assignment and nonmarine origin for the older alluvium. The species represented by the remains also occur in the older alluvium at the La Brea tar pits and probably are indicative of a savanna woodland habitat. Carbon-14 dating analyses of fossilized wood specimens from the older alluvium in the San Fernando Valley tunnel segment and at the North Hollywood station site and the La Brea tar pits and vicinity indicate the Segment 3 fossil assemblage is similar in age to the assemblages from near the base of the older alluvium in the tar pits vicinity.

Environmental preferences of the modern descendants of the species represented by the land plant remains, particularly those of the coast redwood and the incense cedar *Calocedrus*, from the older alluvium suggest the middle to late Pleistocene maritime climate that characterized the Los Angeles basin at least 46,350 years ago was cooler, moister, and less seasonal or more equable than the modern climate of the region, and was similar to climates occurring at higher elevations and/or higher latitudes in California today. However, the common occurrence of *Calocedrus* in the San Fernando Valley and its absence at the La Brea tar pits suggest that, like today, a more maritime climate existed along the coastal plain than in the San Fernando Valley during the middle to late Pleistocene Epoch.

The Segment 3 fossil specimens from the older alluvium are scientifically highly important because they represent a taxonomically moderately large and diverse assemblage of associated land plant and mammal species, and have been critical in documenting and refining estimates of the age of the rock unit and in reconstructing the depositional paleoenvironments and paleoclimates represented by its sediments. Moreover, such an association is comparatively rare in the fossil record.

Fossilized nonmarine mollusk shells, fresh-water ostracod (bivalved crustacean) valves, continental vertebrate bones and teeth, and the wood and pollen of land plants were recovered from the lower 5 to 10 feet of the younger alluvium at depths approximately 45 to 60 feet below grade at the Universal City

station/cross-over site as a result of the Segment 3 mitigation program.

The mollusk shells recovered from the younger alluvium represent six species of fresh-water snails and clams and one species of land snail (first reported fossil occurrence of waxy tightcoil snail *Pristiloma gabrielinum*). The vertebrate remains represent fresh-water sticklebacks, tree and pond frogs, alligator and side-blotched lizards, garter and black-headed snakes, birds, shrews, cottontails, pocket gophers, pocket mice, kangaroo rats, voles, and deer mice. The wood specimens represent *Populus* (probably cottonwood) and occurred as logs up to 11 feet in length. The logs were oriented in a southwesterly direction, presumably as a result of a major flood along the ancestral Los Angeles River, and their ends subsequently were truncated by a later flood.

The composite assemblage from the younger alluvium is dominated by fresh-water species whose modern descendants inhabit permanent fresh-water streams and ponds in southern California, and by terrestrial species whose modern descendants inhabit moister terrestrial environments along the margins of these streams and ponds. Moreover, the fossil-bearing sediments, fine grained and organic rich, appear to represent stream and pond deposits. The Universal City station site, only 0.25 mile south of the modern Los Angeles River channel, might have been in and/or immediately adjacent to the river channel during the early Holocene Epoch.

However, the occurrence of *Ephedra nevadensis?* in the younger alluvium suggests the early Holocene climate of the Los Angeles basin approximately 7,850 to 10,500 years ago was considerably dryer and more extreme, with hotter summers and colder winters, than the Mediterranean climate that characterizes the region today and especially the maritime climate that characterized the region during the middle to late Pleistocene Epoch, and might have been similar to the modern climate of the Mojave Desert and the adjacent lower slopes of the northern San Gabriel and San Bernardino Mountains, where *Ephedra nevadensis* (Mormon tea) occurs today.

The Segment 3 fossil specimens from the younger alluvium are scientifically highly important because they represent a taxonomically moderately large and diverse assemblage of associated land plant and continental vertebrate species, and have been critical in documenting and refining estimates of the age of the rock unit and in reconstructing the depositional paleoenvironments and paleoclimates represented by

its sediments. Moreover, such an association is comparatively rare in the fossil record and probably represents the first reported fossil occurrence of a diverse early Holocene plant and animal assemblage from the Los Angeles basin and vicinity (including San Fernando Valley).

PEAI personnel assisted in establishing paleontologic exhibits regarding some of the fossil remains recovered from the Segment 3 construction zone as a result of the mitigation program. One exhibit is on display in the MTA headquarters library. Another exhibit is a traveling display to be used by MTA Public Affairs personnel. Other exhibits are being developed for the stations. PEA I personnel also assisted MTA Media Relations personnel by

reviewing press releases; conducting newspaper, magazine, television, and film interviews; and in developing an MTA web site regarding the Segment 3 fossil remains and the beneficial effects of the mitigation program on paleontology. Some of the fossil wood and land mammal specimens from the alluvium received wide media coverage during 1996 and 1997.

Submission of this report to the MTA signifies completion of the Los Angeles Metro Red Line Segment 3 paleontologic resource impact mitigation program and will assist the MTA in meeting its mitigation monitoring compliance and reporting responsibilities under California Public Resources Code Section 21081.6.

## SECTION 2

### INTRODUCTION

This final technical report of findings presents the results of the paleontologic resource impact mitigation program conducted by PEA I personnel during and in support of earth moving associated with construction of the Los Angeles Metro Red Line Segment 3 Hollywood Highland, Universal City, and North Hollywood stations (contracts C-301, -311/-321, -351, respectively); Santa Monica Mountains southern and northern starter tunnels and tunnel access shafts (contract C-311); San Fernando Valley tunnel segment mid-line vent structure (contract C-331); and the intervening Hollywood, Santa Monica Mountains, and San Fernando Valley tunnel segments (contracts C-301, -311, -331), Los Angeles, California. Topographic map coverage of the Segment 3 route is provided by the U.S. Geological Survey Burbank, Hollywood, and Van Nuys Quadrangles, 7.5 Minute Series (Topographic). A map of the Segment 3 construction zone and vicinity is presented in Figure 1. Appendices are contained in Part 4.

#### 2.1 BACKGROUND

Paleontologic resources, including fossil remains, associated specimen data and corresponding geologic and geographic site data, fossil sites, and the fossil-bearing rock units, are a limited, nonrenewable, and very sensitive scientific and educational resource and, particularly with regard to fossil sites, are afforded protection under the following federal and state environmental legislation (California Office of Historic Preservation, 1983; Reynolds, 1990).

National Environmental Policy Act of 1969 (NEPA) (P.L. 91-190; 31 Stat. 852, 42 U.S.C. 4321-4327).—Requires that important natural aspects of our national heritage be considered in assessing the environmental consequences of a proposed project.

Archaeological and Historic Data Preservation Act of 1974 (P.L. 86-253, as amended by P.L. 93-291; 88 Stat. 174, U.S.C. 469).—Provides for the survey, recovery, and preservation of significant paleontologic data when such data might be destroyed or lost due to a federal, federally licensed, or federally funded project.

California Environmental Quality Act of 1970 (CEQA) (13 Public Resources Code: 21000 et

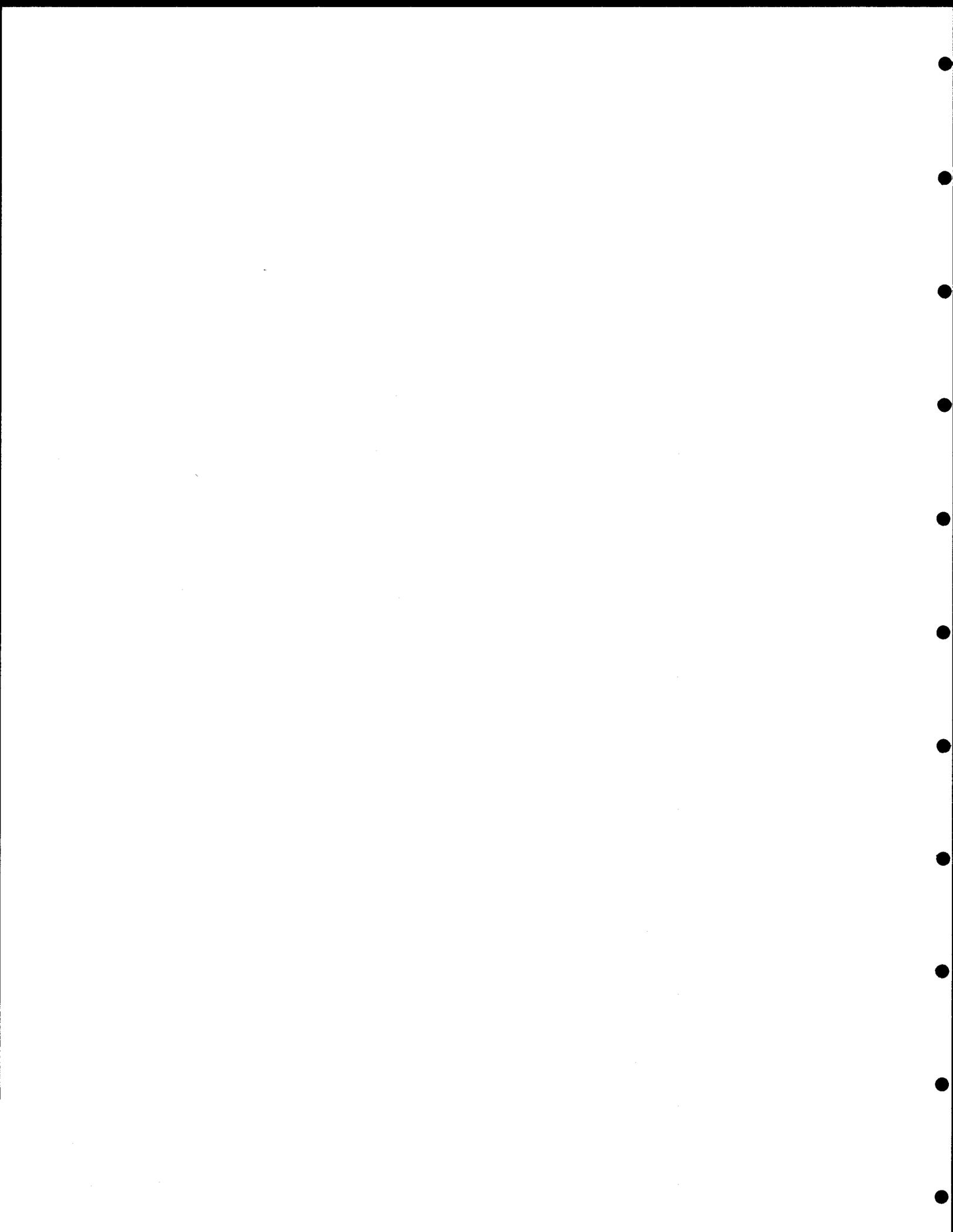
seq.).—Requires that public agencies and private interests identify the environmental consequences of their proposed projects on any object or site of significance to the scientific annals of California (Division I, Public Resources Code: 5020.1 [b]).

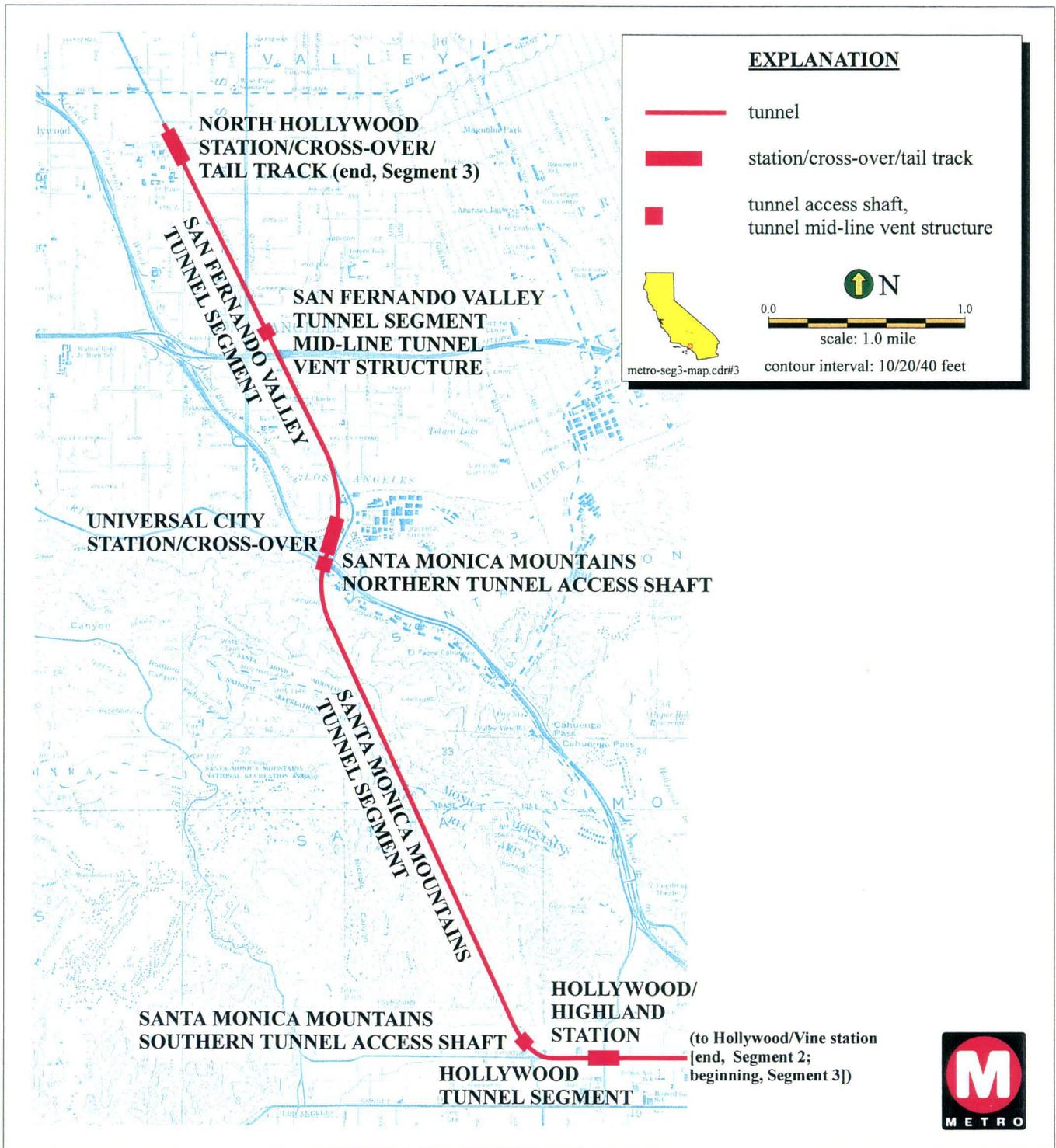
Guidelines for the Implementation of CEQA, as amended May 10, 1980 (14 California Administrative Code: 15000 et seq.).—Define procedures, types of activities, persons, and public agencies required to comply with CEQA, and include definitions of significant impacts on a fossil site (Section 15023, Appendix G [j]).

Public Resources Code, Section 5097.5 (Stats. 1965, c. 1136, p. 2792).—Defines any unauthorized disturbance or removal of a fossil site or remains on public land as a misdemeanor.

Public Resources Code, Section 30244.—Requires reasonable mitigation of adverse environmental impacts that result from development of public land and affect paleontologic resources.

In response to these acts, the U.S. Department of Transportation Urban Mass Transportation Administration (UMTA) and the SCRTD, the initial federal (NEPA) and California (CEQA) lead agencies, respectively, for Metro Red Line construction, required completion of several tasks prior to Red Line construction because of the potential for paleontologic resources being adversely affected by construction-related earth moving for the Red Line. These tasks included compilation of baseline paleontologic resource inventories, preparation of paleontologic resource and impact assessments, and, based on the results of these assessments, formulation and implementation of mitigation measures to reduce, to an insignificant level, the adverse environmental impacts that would result from cut-and-cover excavation associated with construction of the Red Line stations. These impacts would affect the paleontologic resources of the construction zone. Subsequently, paleontologic resource inventory/assessment technical reports presenting site-specific paleontologic resource impact mitigation measures for Red Line Segment 3 were prepared by Lander (1987), the UMTA and SCRTD (1983, 1987), and WESTEC Services, Inc. (1983). These measures were incorporated into the standard



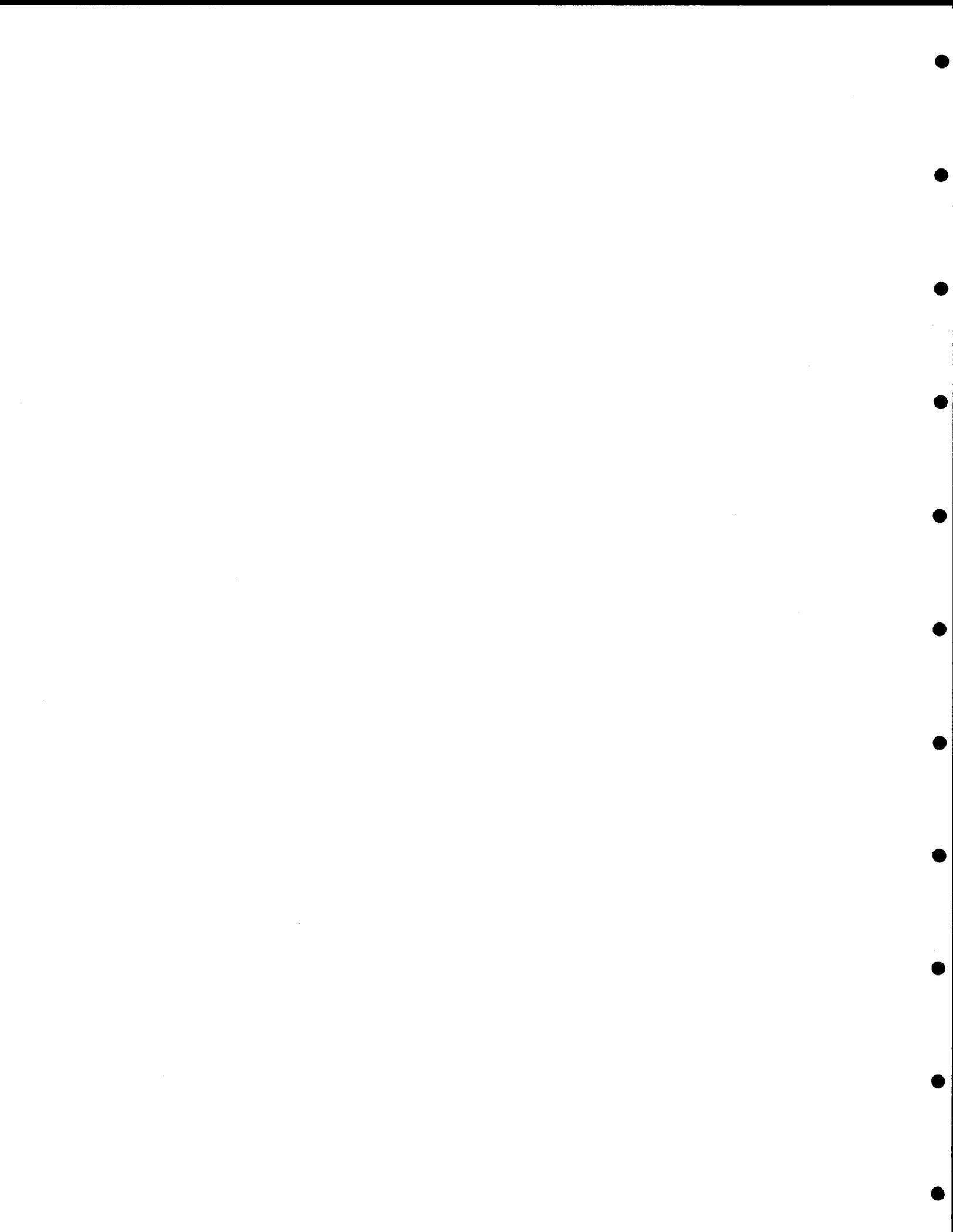


**Figure 1.**—Map of Los Angeles Metro Red Line Segment 3 construction zone, Los Angeles, California. Base maps: U.S. Geological Survey Beverly Hills, Burbank, Hollywood, and Van Nuys 7.5-minute Quadrangles.

paleontologic resource impact mitigation procedures (Specifications Section 01170; see Appendix A) for the Red Line by the SCR TD and, subsequently, the LACTC and its successor, the MTA.

Prior to construction, the Segment 3 construction zone was underlain in part by rock units with a moderate potential for yielding scientifically

important fossil remains at previously unrecorded fossil sites during construction-related cut-and-cover excavation, particularly for the stations (Lander, 1987; UMTA and SCR TD, 1983, 1987; WESTEC Services, Inc., 1983). This paleontologic potential was indicated by surficial geologic mapping of the Segment 3 route and vicinity by Converse Ward Davis Dixon and others (1981) and Dibblee (1991a,



-b); documentation of a number of previously recorded fossil sites in the same area, most having been uncovered during excavation for other construction projects (Hoots, 1931; Jefferson, 1991b; Lander, 1987; Miller, 1971; Reynolds, 1987; WESTEC Services, Inc., 1983); recognition of the fossil-bearing rock units at and near the surface in the Segment 3 construction zone (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983); and the occurrence of fossil remains recovered from some of the same rock units during cut-and-cover excavation in the Segment 2 construction zone as a result of one of the corresponding paleontologic resource impact mitigation program (Lander, 1999).

The mitigation measures developed for Segment 3 (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983; SCRTD/LACTC/MTA Specifications Section 01170; see Appendices A, D) were designed to substantially reduce the adverse environmental impacts of cut-and-cover excavation on the paleontologic resources of each station site to an insignificant level. These measures would ensure some of the fossil remains that might be uncovered by excavation and other construction-related earth-moving activities (trenching for utility lines, augering for piles) associated with construction of the station boxes/appendages (entrances, fresh-air intakes, blast relief shafts) and cross-overs were recovered. These measures also would ensure all potentially identifiable specimens recovered were fully treated (prepared to point of identification, identified to lowest taxonomic level possible, curated, catalogued). The specimens then would be permanently stored and maintained, and associated specimen data and corresponding geologic and geographic site data archived at recognized museum repositories, including the Vertebrate Paleontology (VP) and Invertebrate Paleontology Sections (IP) of the Natural History Museum of Los Angeles County (LACM), and the University of California Museum of Paleontology (UCMP), Berkeley, where they would be retrievable and made available for future study by qualified investigators. Without these measures, the remains and associated specimen and site data would have been lost to earth moving and to unauthorized fossil collecting by construction personnel. Similar losses would have resulted from earth moving associated with construction of the tunnels, tail tracks, tunnel access shafts, and tunnel mid-line vent structures. These losses would have been a significant adverse environmental impact. On the other hand, with appropriate mitigation measures, such as paleontologic construction monitoring of earth moving, Segment 3 construction would have resulted

in beneficial effects by exposing and allowing for the recovery of scientifically highly important fossil remains and associated specimen and site data that would not even have been uncovered without construction-related earth moving and, therefore, would not have been available for recovery. Moreover, recovery of fossil remains and associated data conducted as part of a mitigation program would have been allowed under CEQA Appendix G (j).

Any identifiable fossil remains recovered in the Segment 3 construction zone would be considered scientifically highly important if they represented a new or rare species; a new geographic or chronologic (geologic) record; an age-diagnostic species or a specimen whose age could be determined using carbon-14 dating analysis; an environmentally sensitive species; or a specimen more complete than, or a skeletal element different from those previously available for the species. Moreover, the recovery of remains representing an age-diagnostic species would be critical in confirming, refining, or correcting previous age estimates for the fossil-bearing strata. The recovery of remains representing an environmentally sensitive species would be critical in reconstructing the paleoenvironments and paleoclimates represented by the strata and in confirming, refining, or correcting previous reconstructions. Finally, the remains would contribute to a more comprehensive documentation of the diversity of plant and animal life that existed in the area crossed by the Red Line route and to a more accurate reconstruction of the geologic history of the area, particularly with regard to major paleoenvironmental and paleoclimatic changes resulting from uplift of the area and its subsequent emergence above sea level.

The Segment 3 paleontologic resource impact mitigation program, conducted under MTA Contract EN025, Work Order 12, included paleontologic construction monitoring of cut-and-cover excavation to allow for the discovery and subsequent recovery of fossil remains uncovered by excavation. Monitoring, which began in April 1994 and ended in December 1997, covered excavation (and other earth-moving activities, including trenching for utility lines, augering for piles) associated with construction of the station boxes, accompanying station appendages (entrances, fresh-air intakes, blast relief shafts), and cross-overs and tail tracks for the Hollywood/Highland, Universal City, and North Hollywood stations. Because of the potential for encountering fossil remains at other Segment 3 construction sites and with MTA approval, the monitoring task was

expanded to include cut-and-cover excavation associated with construction of the Santa Monica Mountains northern and southern tunnel access shafts and northern starter tunnels, and the San Fernando Valley tunnel segment mid-line vent structure, as well as the conveyance of tunneling debris at the Universal City and North Hollywood station sites. The mitigation program also included the appropriate treatment and disposition of any recovered fossil remains and the recording and archiving of associated specimen data and corresponding site data. Submission of this final technical report of results and findings to the CEQA lead agency, the MTA, signifies completion of the Segment 3 mitigation program.

The mitigation program, particularly with regard to construction monitoring; recovery, treatment, and permanent museum storage and maintenance of fossil remains uncovered by cut-and-cover excavation; recovery and archiving of associated specimen and site data; and reporting of results and findings, was conducted in compliance with SVP (1991, 1995, 1996) guidelines (see Appendices B, C) for mitigating adverse construction-related environmental impacts on paleontologic resources, mitigation measures developed during the Segment 3 environmental impact review process (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983), and with SCRTD/LACTC/MTA Specifications Section 01170 (see Appendix A), which originally was developed for Red Line Segment 1. Moreover, submission of this final technical report of findings to the MTA will ensure compliance by the MTA with California Public Resources Code Section 21081.6 (mitigation monitoring compliance and reporting), which requires a California (CEQA) lead agency demonstrate project compliance with mitigation measures developed during the environmental impact review process.

The paleontologic construction monitors were experienced in archaeological monitoring and would spot check for cultural resources, including archaeological artifacts, deposits, features, and structural remains, during earth moving at the shallowest depths at each construction site. Any cultural resource recovered and treated as part of the cultural resource impact mitigation program are discussed in final reports by Greenwood and Associates (G&A).

## **2.2 PERSONNEL**

G&A was contracted by Parsons Engineering

Science, Inc. (PES), who in turn was contracted by the MTA, to manage and conduct the Metro Red Line Segment 3 cultural resource impact mitigation program and to supervise the paleontologic resource impact mitigation program under MTA Contract Number EN025, Work Order 12. PEAI was retained by G&A to manage and conduct the paleontologic mitigation program.

This final technical report of results and findings was prepared by Dr. E. Bruce Lander, a senior vertebrate paleontologist with PEAI and principal investigator for the Segment 3 paleontologic resource impact mitigation program. Dr. Lander has a Ph.D. degree in paleontology and was certified by the State of California as a registered environmental assessor (REA-01290) during Red Line construction. He has prepared paleontologic resource assessments in support of environmental impact review documents for major earth-moving projects, including Segment 3, Red Line Segments 1 and 2, and the Red Line Eastern Extension, and served as principal investigator for paleontologic resource impact mitigation programs conducted in support of construction for Segments 1 and 2 and other major earth-moving projects in the western United States (Lander, 1987, 1990a to -c, 1991, 1993a, -b, 1994a to -c, 1999). Dr. Lander also assisted with MTA media relations and in establishing exhibits and an MTA web site regarding the Segment 3 fossil remains and mitigation program.

Paleontologic construction monitoring of cut-and-cover excavation and other construction-related earth-moving activities, as well as recovery of fossil specimens uncovered by these activities, were conducted by M.W. Morris (MM), T.L. Stubbs (TLS), G.T. Takeuchi (GTT), and R.D. Turner (RDT), PEAI paleontologic construction monitors and technicians. Mr. Takeuchi also was responsible for preparation and curation of the specimens, entry of specimen and corresponding geologic and geographic site data into the LACMVP fossil specimen catalog and corresponding computerized data bases, and initial (field) processing of fossiliferous rock samples.

Mr. Richard W. Huddleston, a PEAI senior vertebrate paleontologist, identified and analyzed the fossil fish remains recovered as a result of the mitigation program. Dr. David P. Whistler (DPW), another PEAI senior vertebrate paleontologist and a curator of vertebrate paleontology at the LACMVP, identified and analyzed the small continental vertebrate remains, conducted the final (laboratory)

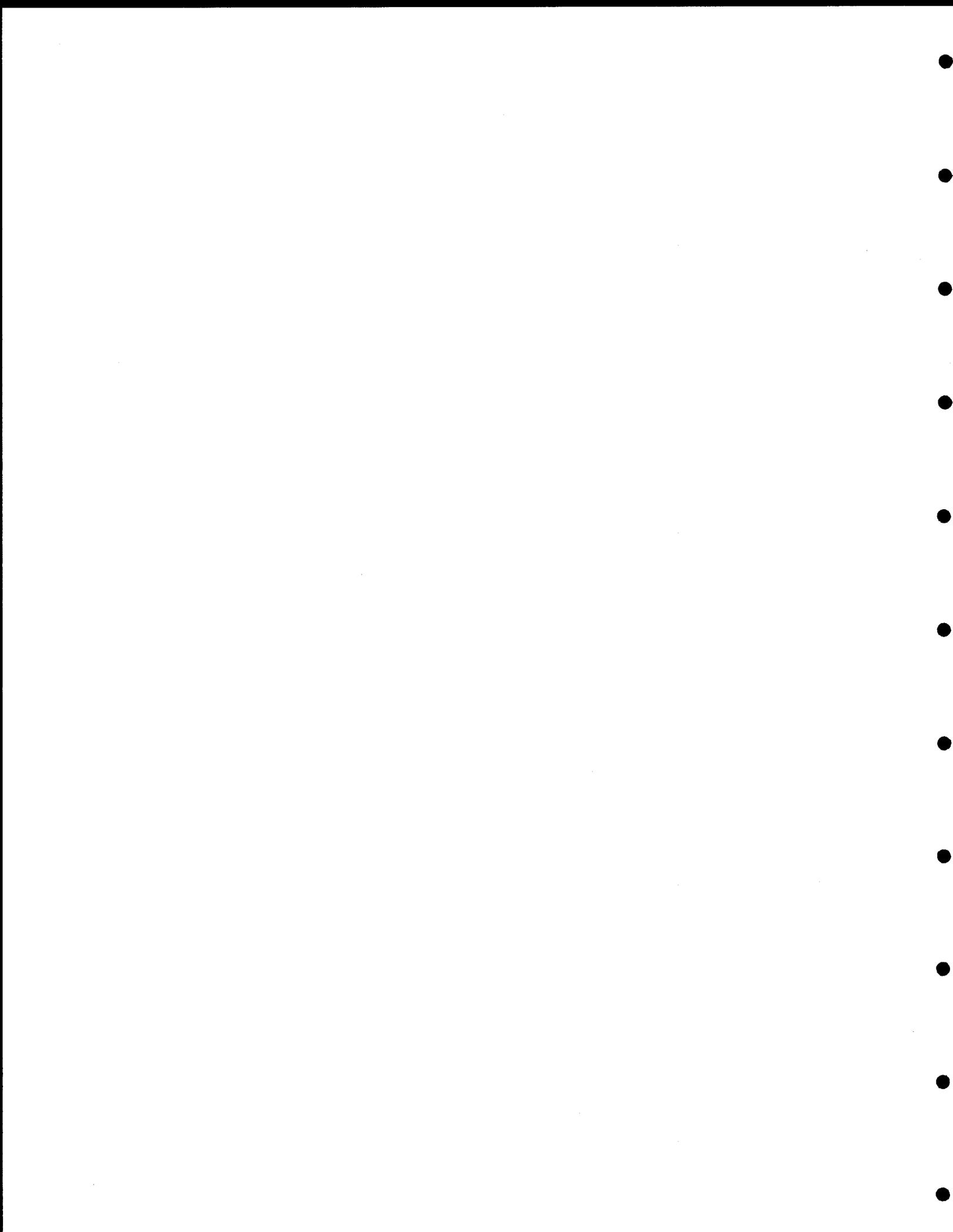
processing of fossiliferous rock samples and identified the recovered vertebrate fossil remains, and assisted with MTA media relations and in establishing MTA exhibits and an MTA web site regarding the Segment 3 fossil remains and mitigation program. Mr. Lindsey T. Groves, a PEAI senior invertebrate paleontologist, identified and analyzed the fossil marine and continental invertebrate remains. Dr. Lanny H. Fisk, a paleobotanist with F & F GeoResource Associates, Inc. (F&F), prepared and identified the fossil land plant remains (wood) and analyzed the wood and land plant pollen. Ms. Shelley M. Cox, Mr. Theodore T. Connors, and, in particular, Mr. Christopher A. Shaw of the George C. Page Museum assisted in identifying the large land mammal remains. The microfossil samples were processed and the recovered microfossils (including pollen) identified and analyzed by Micropaleo Consultants, Inc. Carbon-14 dating analysis of the fossil land plant remains was conducted by Beta Analytic Inc.

Accessioning into the LACMVP fossil collection of the vertebrate fossil specimens recovered during the

mitigation program was conducted by Dr. Samuel A. McLeod, collections manager of the LACMVP; accessioning of the invertebrate fossil specimens into the LACMIP fossil collection was conducted by Mr. Lindsey T. Groves, collections manager of the LACMIP; and accessioning of the fossil plant specimens into the UCMP paleobotanic fossil collection was conducted by Dr. Diane M. Erwin, a museum scientists with the UCMP. Accessioning included archiving of associated data (entry of specimen and corresponding site data into respective museum fossil site catalogs and/or computerized data bases).

R. Veatch of Parsons-Dillingham (PD) recovered fossil specimens from the San Fernando Valley tunnel segment.

Mr. James L. Sowell, Manager, MTA Construction Division Environmental Compliance Department, and Roberta S. Greenwood, G&A principal investigator, supervised the mitigation program and ensured project personnel fulfilled their responsibilities under the mitigation program.



## SECTION 3

### STRATIGRAPHY

Surficial geologic mapping of the Los Angeles Metro Red Line Segment 3 construction zone and vicinity is presented at a scale of 1:24,000 by CWDD and others (1981) and Dibblee (1991a, -b), and regional mapping of the north-central and northwestern Los Angeles basins is provided by Jennings and Strand (1969) at a scale of 1:250,000. Subsurface geologic bore-hole data for the Segment 3 construction zone are presented by CWDD and others (1981), Lander (1987), the MTA and others (1995a to -c), the Rail Construction Corporation and others (RCC and others, 1993a, -b), the UMTA and SCRTRD (1983, 1987), and WESTEC Services, Inc. (1983). A surficial geologic map by Dibblee (1991a) of the Segment 3 construction zone and vicinity is presented in Figure 2. Generalized composite stratigraphic columnar sections of the Segment 3 construction zone are presented in Figures 3 to 5 and summarized in Table 1. The distribution of each surficial and subsurface rock unit is tabulated in Table 2 and depicted in Figure 6 by Segment 3 construction site.

#### **3.1 ROCK UNITS**

Surficial geologic mapping and geologic bore-hole data indicate that earth moving in the Segment 3 construction zone encountered, in order of increasing geologic age and depth (or in descending stratigraphic order), historic artificial fill (not mapped); Holocene younger alluvium; the middle to late Pleistocene older alluvium; early to middle Miocene marine Lower, Middle?, and Upper Topanga Formation and an associated unnamed submarine volcanic rock unit; the Paleocene marine and nonmarine? Santa Susana Formation (including Simi Conglomerate Member), an unnamed late Cretaceous marine rock unit, possibly a late Cretaceous nonmarine rock unit, and an unnamed early Cretaceous quartz diorite (Dibblee, 1991a, -b; Hoots, 1931; MTA and others; 1995a to -c; RCC and others, 1993a, -b).

The quartz diorite occurs only in the southern third of the Santa Monica Mountains tunnel segment lying immediately north of the Hollywood Fault segment of the SM-H-RHFZ, the unnamed late Cretaceous rock unit(s), Santa Susana Formation (including Simi Conglomerate Member and unnamed upper member), and the Lower and possibly the Middle Topanga Formation and the associated volcanic rock unit are present only in the middle third of the tunnel segment,

where they occur in ascending stratigraphic order in successively more northerly intervals of the tunnel segment (RCC and others, 1993a). The Upper Topanga Formation occurs in the northern third of the Santa Monica Mountains tunnel segment and at the southern end of the San Fernando Valley tunnel segment, and only in the subsurface at the Santa Monica Mountains northern tunnel access shaft and starter tunnel sites and the Universal City station/cross-over site (MTA and others; 1995c; RCC and others, 1993a, -b).

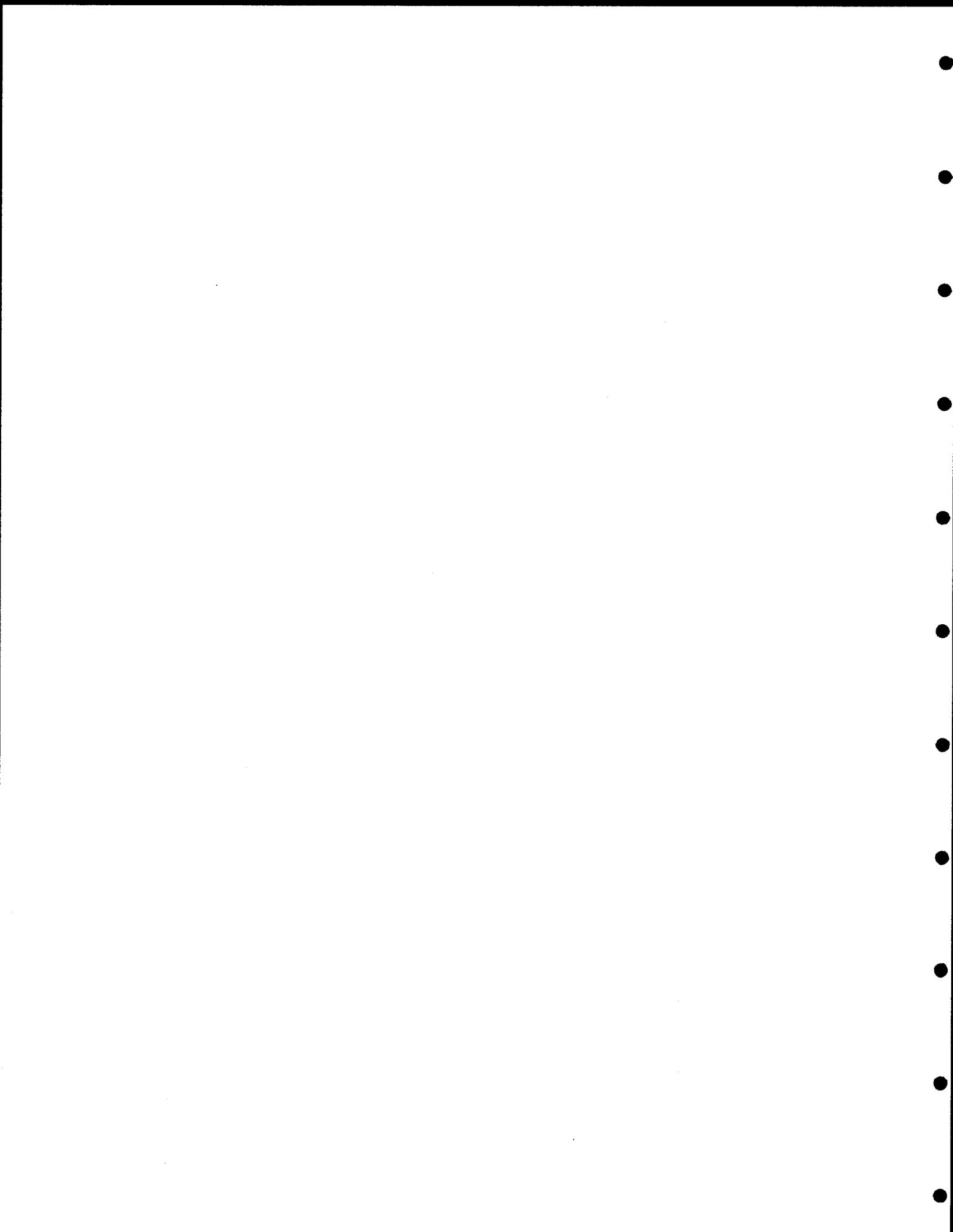
With the exception of the Santa Monica Mountains tunnel segment north of the Hollywood Fault segment, most of the Segment 3 construction zone is flat and, with the exception of artificial fill, immediately underlain by alluvium, older alluvium underlying the Hollywood portion of the construction zone and younger alluvium underlying the San Fernando Valley portion (CWDD and others, 1981; Dibblee, 1991a, -b; MTA and others; 1995a to -c; RCC and others, 1993a, -b), where the older alluvium probably underlies the younger alluvium in the subsurface of the construction zone (Lander, 1987; UMTA and SCRTRD, 1983, 1987; WESTEC Services, Inc., 1983).

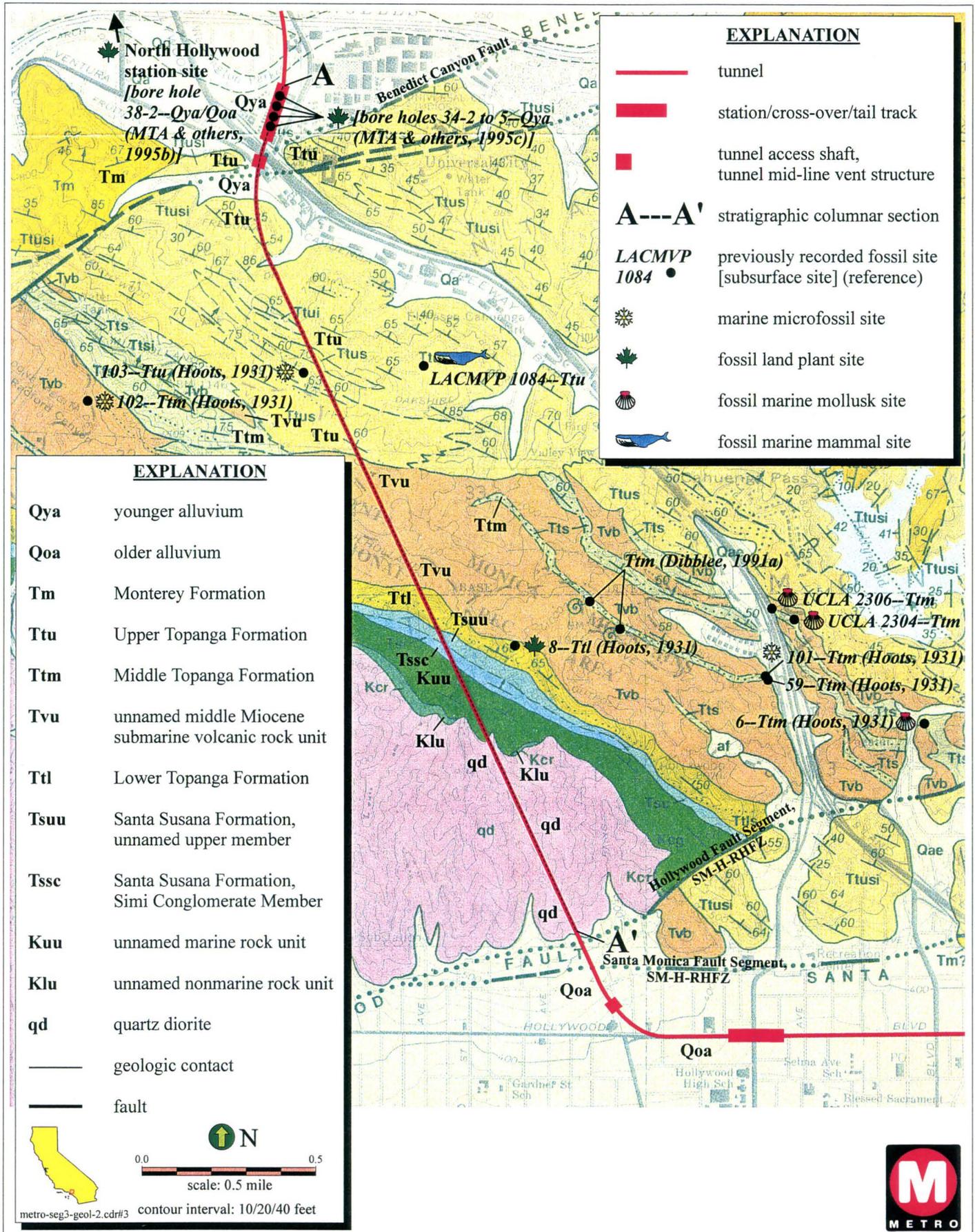
#### **3.1.1 Unnamed Early Cretaceous Quartz Diorite**

A granitic rock unit was encountered by earth moving only in the southern third of the Santa Monica Mountains tunnel segment north of the Hollywood Fault segment of the SM-H-RHFZ (see RCC and others, 1993a). This rock unit is a light gray quartz diorite determined to be 102 million years (latest early Cretaceous) in age and, to the south, is in fault contact with the older alluvium (Dibblee, 1991a, -b; RCC and others, 1993a).

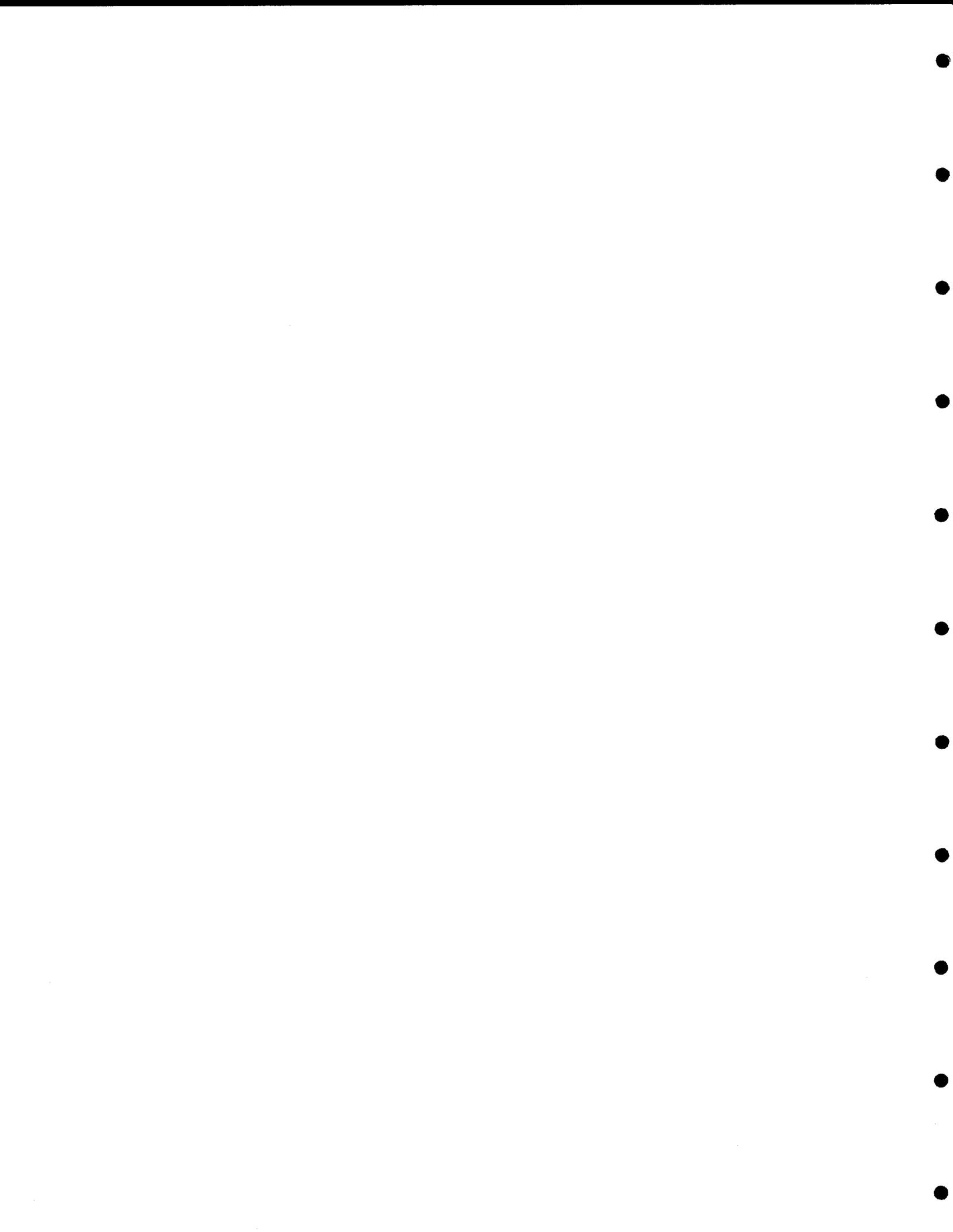
#### **3.1.2 Unnamed Late Cretaceous Nonmarine Rock Unit**

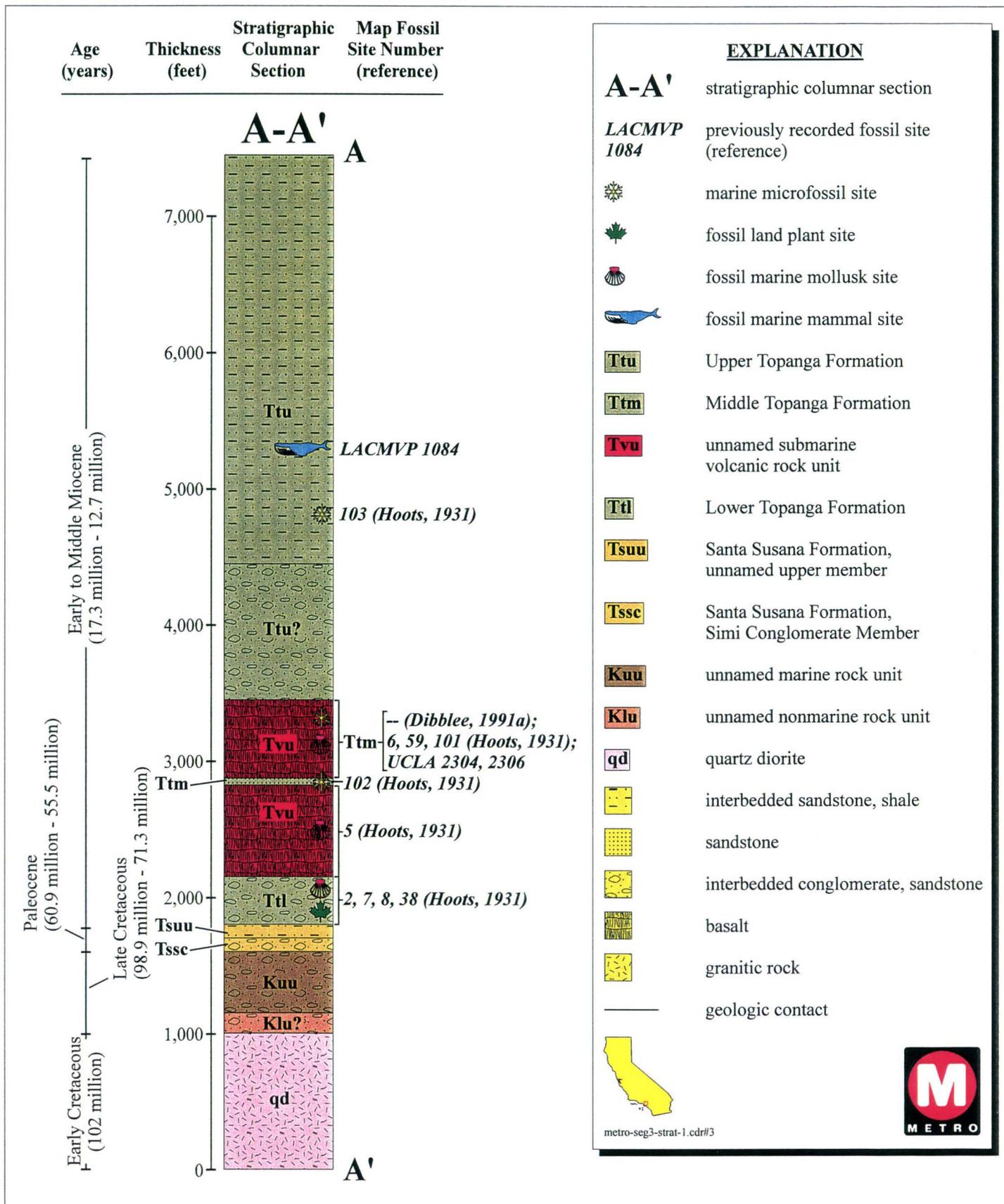
As described by Hoots (1931), the unnamed late Cretaceous nonmarine rock unit, which was assigned to the lower member of the Chico Formation and is separated from the underlying quartz diorite by a major unconformity, consists of interbedded red conglomerate and sandstone of nonmarine origin. According to Dibblee (1991a, -b), the rock unit consists of poorly bedded, reddish-brown conglomerate that contains cobbles and pebbles of



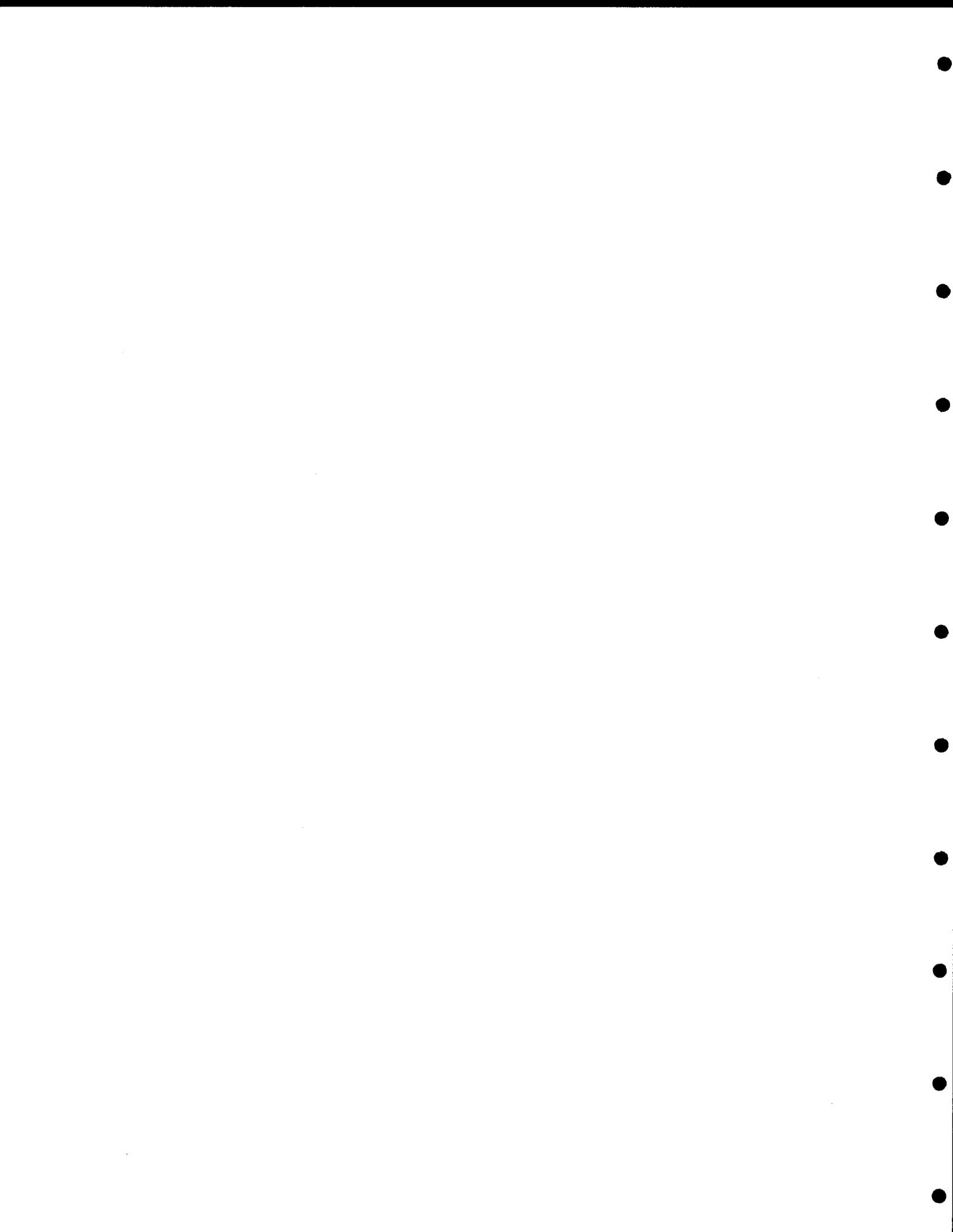


**Figure 2.**—Surficial geology and distribution of fossil taxa by rock unit and previously recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone and vicinity, Los Angeles, California. Base maps: U.S. Geological Survey Beverly Hills, Burbank, Hollywood, and Van Nuys 7.5-minute Quadrangles. Geology after Dibblee (1991a). Fossil site locations after Dibblee (1991a), Hoots (1931), MTA and others (1995b, -c), Neuerburg (1953), and RCC and others (1993b). See Figure 1. LACMVP: Natural History Museum of Los Angeles County Vertebrate Paleontology Section; SM-H-RHFZ: Santa Monica-Hollywood-Raymond Hill Fault Zone; UCLA: University of California, Los Angeles.





**Figure 3.**—Generalized stratigraphic columnar section and distribution of fossil taxa by rock unit and previously recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone and immediate vicinity, Santa Monica Mountains tunnel segment, Los Angeles, California. Rock units and corresponding lithologies after Dibblee (1991a) and RCC and others (1993a). Ages of rock units after Alderson (1988), Berggren and others (1995), Blake (1991), Dibblee (1991a), Gradstein and others (1995), Jefferson (1991b), Lander (1999), Micropaleo Consultants, Inc. (1993, 1998), Saul (1983), Turner (1970), Yerkes and Campbell (1979), and Zinsmeister (1983). Stratigraphic levels of fossil sites approximate. Fossil site locations and taxa after Dibblee (1991a), Hoots (1931), and Neuerburg (1953). See Table 1, Figure 2. LACMVP: Natural History Museum of Los Angeles County Vertebrate Paleontology Section; UCLA: University of California, Los Angeles.



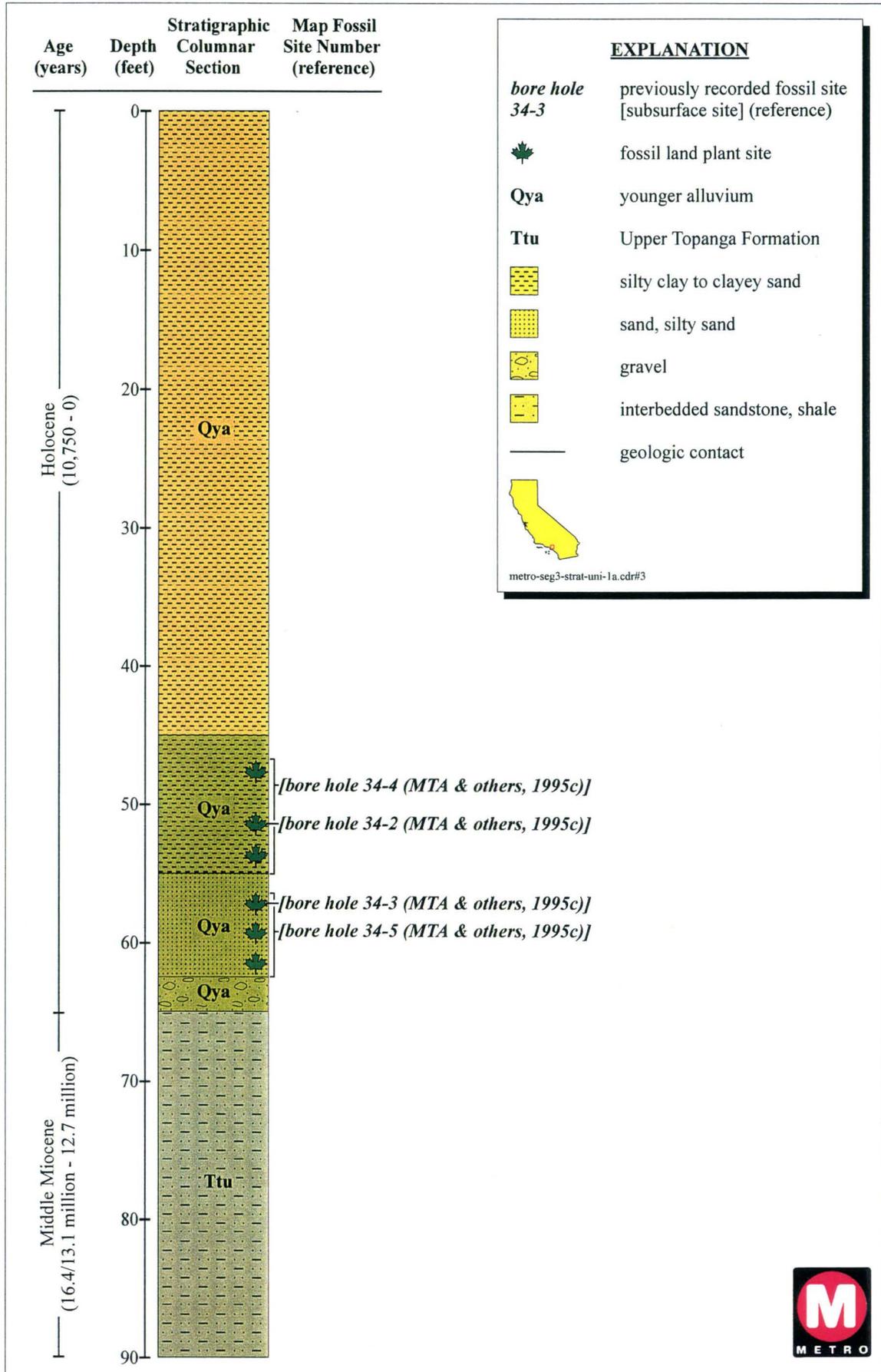
**Table 1.**—Stratigraphic columnar section summary, surficial (exposed) and subsurface rock units, Los Angeles Metro Red Line Segment 3 construction zone, Los Angeles, California. After CWDD and others (1981), Dibblee (1991a, -b), Hoots (1931), MTA and others (1995a to -c), Neuerburg (1953), RCC and others (1993a, -b), and WESTEC Services, Inc. (1983). Ages of rock units after Alderson (1988), Berggren and others (1995), Beta Analytic Inc. (1995, 1996a-c, 1997), Blake (1991), Dibblee (1991a), Gradstein and others (1995), Jefferson (1991b), Lander (1999), Micropaleo Consultants, Inc. (1993, 1998), Saul (1983), Turner (1970), Turner and Campbell (1979), Yerkes and Campbell (1979), and Zinsmeister (1983). See Table 2, Figures 1 to 6.

Rock Unit	Age (years before present)	Lithology	Environment	Fossil Taxon <sup>a</sup>
artificial fill	historic	disturbed sediment, debris	urban	(unfossiliferous)
younger alluvium <sup>b</sup> (San Fernando Valley)	Holocene ( $\leq 10,750$ )	unconsolidated clay, sand, gravel	alluvial, fluvial	land plants; nonmarine snails, clams, ostracods; continental vertebrates <sup>c,d</sup>
younger alluvium (Hollywood)	Holocene ( $\leq 5,000$ )	unconsolidated clay, sand, gravel	alluvial, fluvial	— <sup>e</sup>
older alluvium <sup>b</sup> (San Fernando Valley)	middle to late Pleistocene (~ 280,000 or 130,000 to 10,750)	semiconsolidated clay, sand, gravel	alluvial	land plants, mammals <sup>e</sup>
older alluvium (Hollywood)	middle? to late Pleistocene to early Holocene? (~ 280,000 or 130,000 to 10,750 or < 6,000)	semiconsolidated clay, sand, gravel	alluvial	— <sup>e</sup>
Upper Topanga Formation	early middle to late middle Miocene (Luisian) (~ 16.4 million or 13.4 million to ~ 12.7 million)	interbedded sandstone, shale overlying interbedded sandstone, conglomerate	shallow-water marine	marine microfossils, fishes <sup>c</sup>
Middle Topanga Formation <sup>f</sup>	late early to late middle Miocene (16.6 million to 13.4 million)	sandstone	shallow-water marine	marine clam <sup>c,g</sup>
unnamed submarine volcanic rock unit	late early to late middle Miocene (16.6 million to 13.4 million)	basalt	marine	(unfossiliferous <sup>g</sup> )
Lower Topanga Formation	late early Miocene (Relizian) (~ 17.3 million to 16.6 million)	interbedded sandstone, conglomerate overlying basal conglomerate	shallow-water marine	— <sup>e</sup>

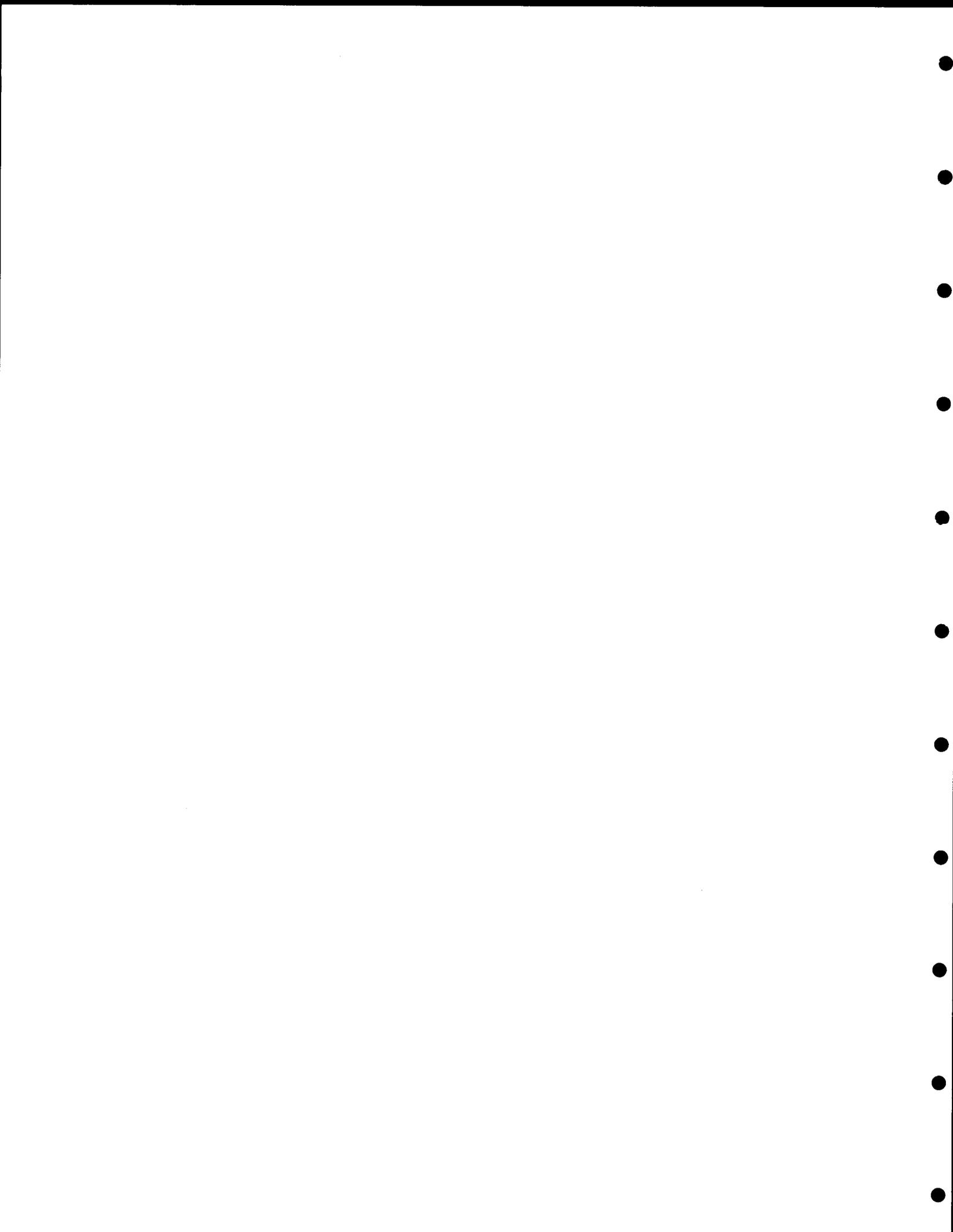
Santa Susana Formation, unnamed upper member	late Paleocene (< 60.9 million to ~ 55.5 million)	shale overlying sandstone	shallow-water marine	— <sup>e</sup>
Santa Susana Formation, Simi Conglomerate Member	late Paleocene (~ 60.9 million to > 55.5 million)	interbedded conglomerate, sandstone	shallow-water marine, nonmarine?	— <sup>e</sup>
unnamed marine rock unit	late Cretaceous (Turonian to Campanian) (93.5 million to 71.3 million)	interbedded conglomerate, sandstone	shallow-water marine	— <sup>e</sup>
unnamed nonmarine rock unit <sup>f</sup>	late Cretaceous (98.9 million to 93.5 million)	interbedded red conglomerate, sandstone	fluvial, alluvial fan	—
unnamed quartz diorite	latest early Cretaceous (Albian) (102 million)	quartz diorite	plutonic	(unfossiliferous)

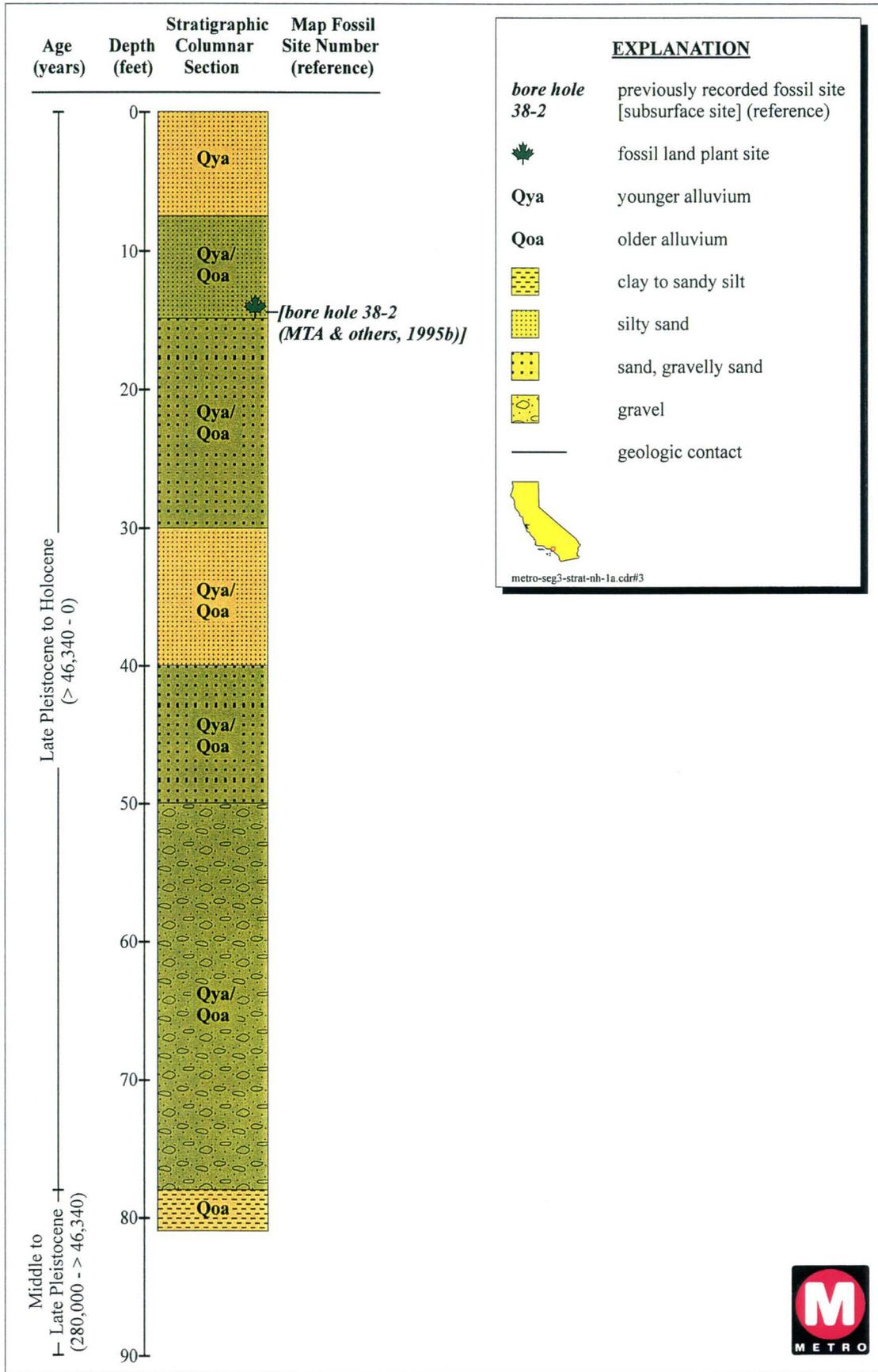
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<sup>a</sup>Occurrence in Segment 3 construction zone.  
<sup>b</sup>Older and younger alluvium not differentiated in San Fernando Valley.  
<sup>c</sup>This report.  
<sup>d</sup>MTA and others (1995b, -c) and RCC (1993b) reported fossil wood from (younger) alluvium.  
<sup>e</sup>Rock unit fossiliferous, but no fossil remains recovered in Segment 3 construction zone.  
<sup>f</sup>Rock unit may not occur in Segment 3 construction zone (see Dibble, 1991a; Figure 4).  
<sup>g</sup>Fossil marine clam fossil remains recovered in Santa Monica Mountains tunnel Segment at newly recorded LACMIP fossil site 17099, probably from interbed of Middle Topanga Formation mapped by Hoots (1931) as occurring within unnamed submarine volcanic rock unit (see RCC, 1993a).

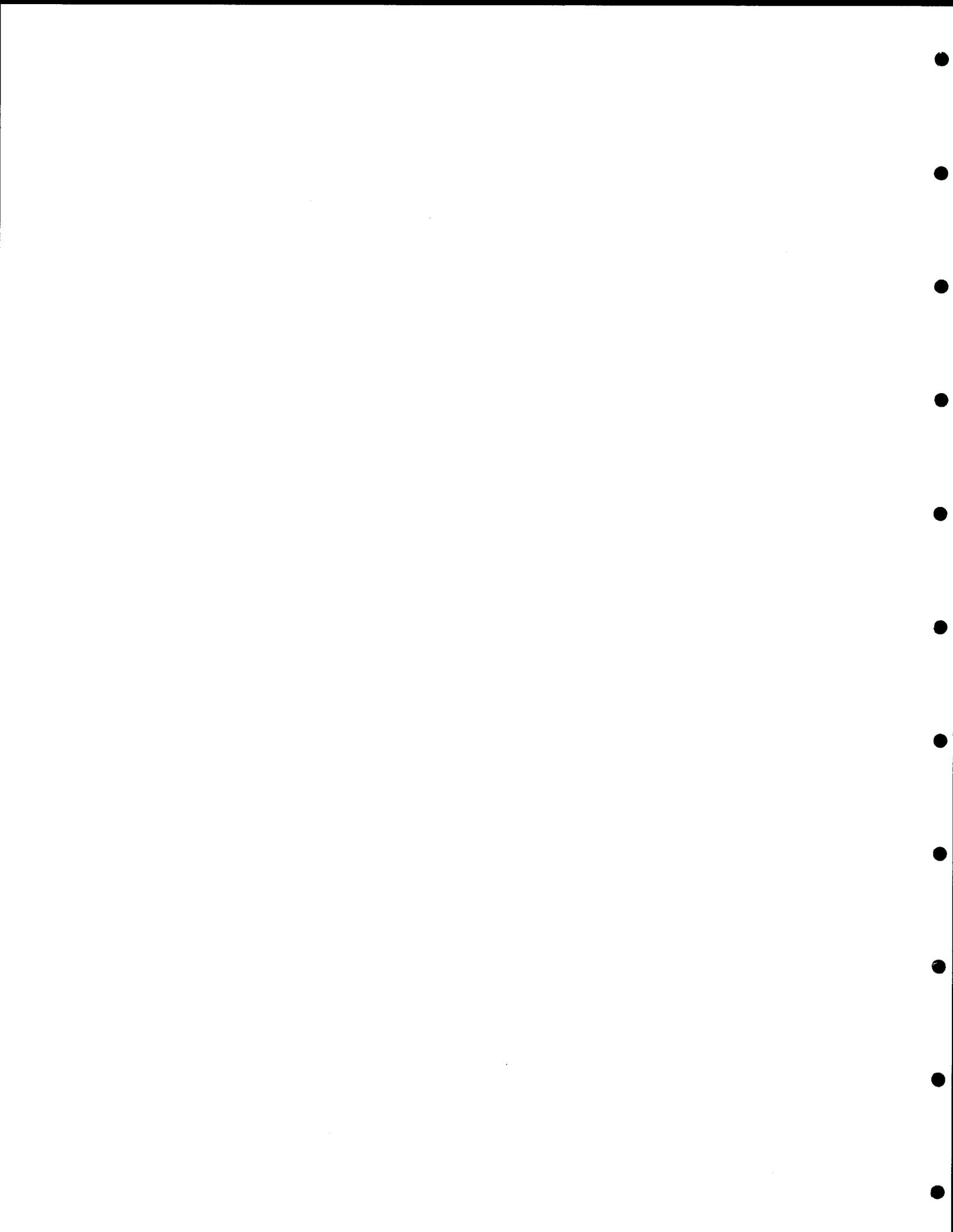


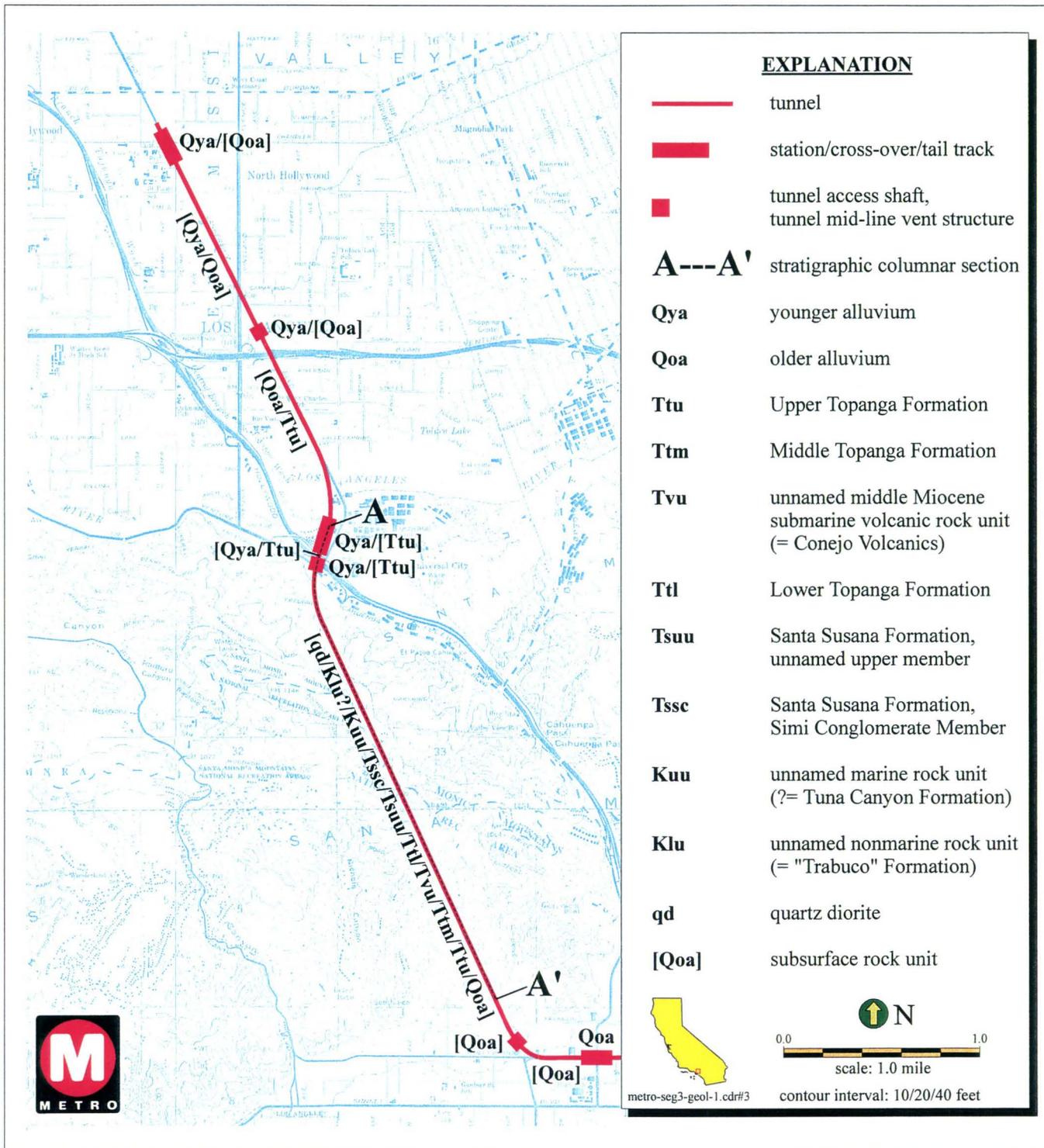
**Figure 4.**—Generalized stratigraphic columnar section and distribution of fossil taxa by rock unit and previously recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone, Universal City station site, Los Angeles, California. Rock units and corresponding lithologies after MTA and others (1995c) and RCC and others (1993b). Ages of rock units after Berggren and others (1995), Dibblee (1991a), Jefferson (1991b), Lander (1999), Micropaleo Consultants, Inc. (1993, 1998), and Turner (1970). Stratigraphic levels of fossil sites approximate. Fossil site locations and taxa after MTA and others (1995c) and RCC and others (1993b). See Table 1, Figure 2.





**Figure 5.**—Generalized stratigraphic columnar section and distribution of fossil taxa by rock unit and previously recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone, North Hollywood station site, Los Angeles, California. Rock units and corresponding lithologies after MTA and others (1995b) and RCC and others (1993b). Ages of rock units after Berggren and others (1995), Jefferson (1991b), and Lander (1999). Stratigraphic level of fossil site approximate. Fossil site location and taxon after MTA and others (1995b) and RCC and others (1993b). See Table 1, Figure 2.



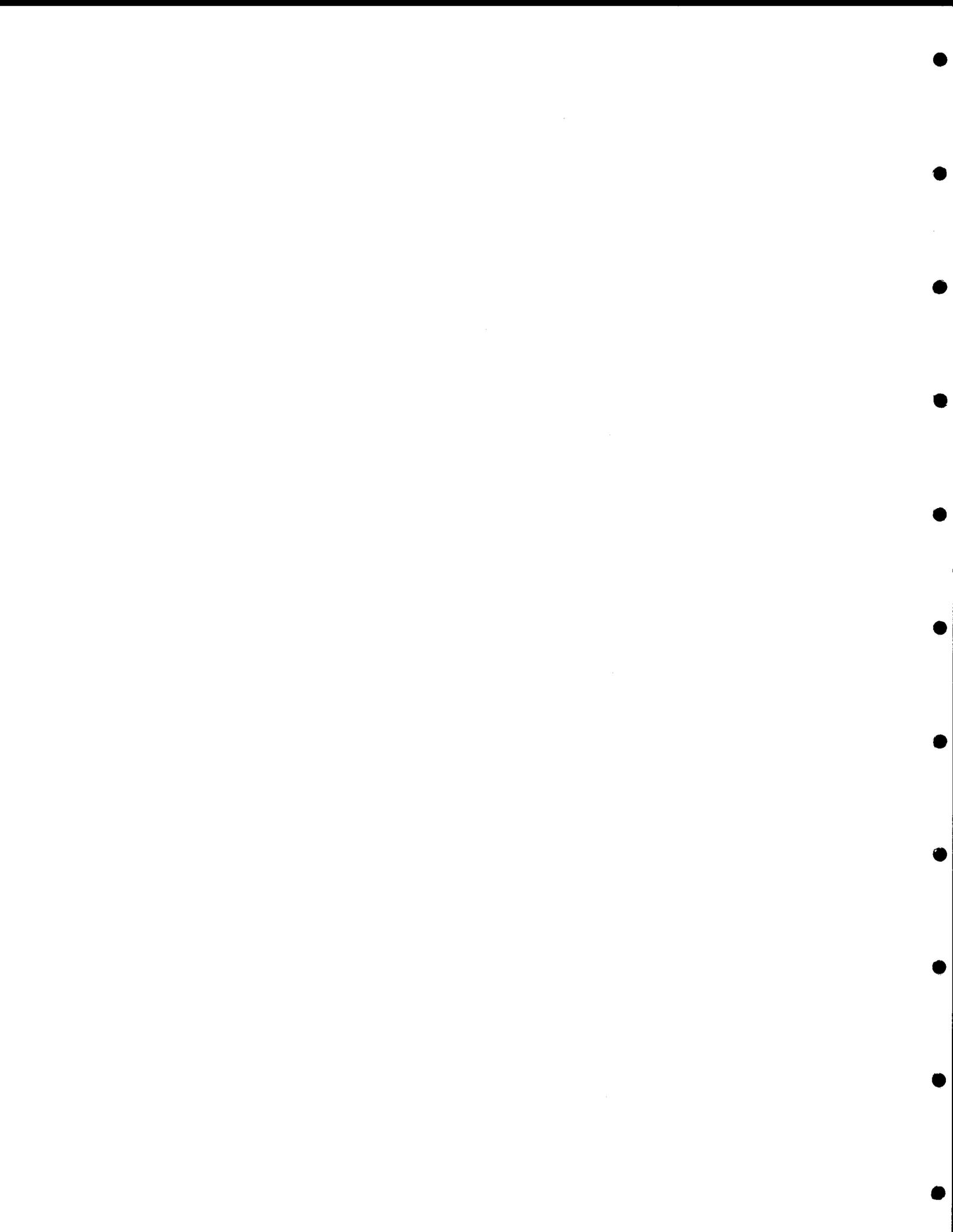


**Figure 6.**—Distribution of surficial and subsurface rock units by construction site, Los Angeles Metro Red Line Segment 3 construction zone, Los Angeles, California. Artificial fill not shown. Base map: U.S. Geological Survey Beverly Hills, Burbank, Hollywood, and Van Nuys 7.5-minute Quadrangles. Geology after CWDD and others (1981), Dibblee (1991a, -b), MTA and others (1995a to -c), RCC and others (1993a, -b), and WESTEC Services, Inc. (1983). See Tables 1, 2, Figures 1 to 5.

granitic and metavolcanic rocks and quartzite in a brown sandstone matrix, and is interbedded with reddish sandstone and claystone. This rock unit is equivalent to the nonmarine "Trabuco" Formation, which occurs west of the Segment 3 route in the eastern and central Santa Monica Mountains between Cahuenga Pass and Topanga Canyon, and is of fluvial

and alluvial fan origin (Dibblee, 1991a, -b; 1992). The Trabuco Formation is based on lithologically similar late Cretaceous nonmarine strata in the Santa Ana Mountains.

The unnamed nonmarine rock unit, which occurs adjacent to the middle third of the Santa Monica



**Table 2.**—Distribution of rock units by construction site, Los Angeles Metro Red Line Segment 3 construction zone, Los Angeles, California. After CWDD and others (1981), Dibblee (1991a, -b), MTA and others (1995a to -c), RCC and others (1993a, -b), and WESTEC Services, Inc. (1983). See Table 1, Figures 1 to 6.

CONSTRUCTION SITE	Rock Unit (Map Symbol <sup>a</sup> )				
	rock units underlying Upper Topanga Formation — <sup>b</sup>	Upper Topanga Formation (Ttu)	older alluvium (Qoa)	older and younger alluvium, undifferentiated (Qya, Qoa)	artificial fill —
Hollywood/Highland station			X <sup>c</sup>		X
Hollywood tunnel segment			[X]		
Santa Monica Mountains southern tunnel access shaft			X		X
Santa Monica Mountains southern starter tunnel			X		
Santa Monica Mountains tunnel segment	[X]	[X]			
Santa Monica Mountains northern tunnel access shaft		[X]		X <sup>d</sup>	X
Santa Monica Mountains northern starter tunnel		[X]		X <sup>d</sup>	
Universal City station		[X]		X <sup>d</sup>	X
San Fernando Valley tunnel segment		[X]		[X]	
San Fernando Valley tunnel segment mid-line vent structure				[X]	X
North Hollywood station				[X]	X

<sup>a</sup>Map symbol in Figures 2 to 11.  
<sup>b</sup>Unnamed Cretaceous quartz diorite (qd); unnamed late Cretaceous nonmarine (Klu) and marine (Kuu) rock units; Simi Conglomerate Member (Tssc) and unnamed upper member (Tsuu), Santa Susana Formation; Lower Topanga Formation (Tl); unnamed middle Miocene submarine volcanic rock unit (Tvu); Middle Topanga Formation (Tm).  
<sup>c</sup>X: surficial rock unit;  
[X]: subsurface rock unit.  
<sup>d</sup>Younger alluvium.

Mountains tunnel segment, might not have been encountered by earth moving in the tunnel segment (see Dibblee, 1991a; Figure 2).

**3.1.3 Unnamed Late Cretaceous Marine Rock Unit**

As described by Hoots (1931) and the RCC and others (1993a), the unnamed late Cretaceous marine rock unit, which was assigned to the Chico Formation by the RCC and others (1993a) and to the upper member of the Chico Formation by Hoots (1931), consists of interbedded conglomerate, sandstone, and shale. According to Dibblee (1991a, -b, 1992), this rock unit consists of poorly bedded, gray to brown conglomerate with cobbles and pebbles of granitic and metavolcanic rocks and quartzite in a brown sandstone matrix, and possibly is equivalent to the marine Tuna Canyon Formation west of the Segment 3 route in the central Santa Monica Mountains west

of Topanga Canyon.

The unnamed marine rock unit was encountered by earth moving only in the middle third of the Santa Monica Mountains tunnel segment (see RCC and others, 1993a).

**3.1.4 Santa Susana Formation, Simi Conglomerate Member**

The Santa Susana Formation, which includes the marine and nonmarine? Simi Conglomerate (lower) Member at its base and an unnamed upper member (Dibblee, 1991a, -b), was encountered by earth moving only in the middle third of the Santa Monica Mountains tunnel segment (see RCC and others, 1993a).

As described by the RCC and others (1993a), the Simi Conglomerate Member consists of interbedded

conglomerate and sandstone, the lower part of the member primarily consisting of quartzite cobbles. According to Dibblee (1991a, -b), the member, which is separated from the underlying unnamed late Cretaceous marine rock unit by an unconformity, consists of poorly bedded, gray to brown conglomerate that contains cobbles and pebbles of granitic and metavolcanic rocks and quartzite in a sandstone matrix, and is interbedded with reddish sandstone and claystone.

### **3.1.5 Santa Susana Formation, Unnamed Upper Member**

As described by Hoots (1931), the unnamed marine upper member of the Santa Susana Formation, which was assigned to the Martinez Formation by Hoots (1931) and the Las Virgenes Sandstone by the RCC and others (1993a), consists of brown and gray shale. As described by the RCC and others (1993a), the member consists of sandstone that is interbedded with shale in the upper part of the member. According to Dibblee (1991a, -b, 1992), the rock unit consists of fine-grained, light gray to tan sandstone interbedded with poorly bedded, micaceous silty claystone, and possibly is equivalent to the marine Coal Canyon Formation west of the Segment 3 route in the central Santa Monica Mountains west of Topanga Canyon.

### **3.1.6 Lower Topanga Formation**

The Topanga Formation (Topanga Group of some workers; lowermost part of formation includes Vaqueros Formation of some workers west of Segment 3 route in central Santa Monica Mountains west of Topanga Canyon) is the oldest rock unit representing marine deposition in the ancestral Los Angeles basin, which developed during the early Miocene Epoch (Lander, 1999; Rumelhart and Ingersoll, 1997).

As described by the RCC and others (1993a), the marine Lower Topanga Formation, which is separated from the underlying unnamed upper member of the Santa Susana Formation by an unconformity, consists of sandstone that is interbedded with conglomerate at the base of the rock unit (as mapped by Hoots, 1931, Lower Topanga Formation incorrectly includes only Cretaceous rock units and Santa Susana Formation; see Dibblee, 1991a). According to (Dibblee, 1991a, -b), the rock unit consists of moderately hard, thickly bedded, tan arkosic sandstone, and (Dibblee, 1992, 1995) is equivalent to the marine Saddle Peak (lower) and Cold Creek (upper) Members of the Topanga Canyon Formation of the Topanga Group west of the

tunnel segment in the central Santa Monica Mountains west of Topanga Canyon. This rock unit is composed of sediments derived from a source area to the northeast (presumably San Gabriel Mountains) and deposited to form a submarine fan (Dibblee, 1989b).

The Lower Topanga Formation was encountered by earth moving only in the middle third of the Santa Monica Mountains tunnel segment (see RCC and others, 1993a).

### **3.1.7 Unnamed Middle Miocene Submarine Volcanic Rock Unit**

An unnamed sequence of submarine lava flows that immediately overlies the Lower Topanga Formation was assigned to the Middle Topanga Formation (unit Ttv) by the RCC and others (1993a). This sequence was encountered by earth moving only in the middle third of the Santa Monica Mountains tunnel segment (see RCC and others, 1993a). According to Dibblee (1989b, 1991a, -b), the rock unit consists of dark gray to black, submarine andesitic and basaltic lava flows, and is a correlative of the Conejo Volcanics west of the Segment 3 route in the Topanga Canyon area of the central Santa Monica Mountains. The Conejo Volcanics have been determined to be 13.4 to 16.6 million years (latest early to late middle Miocene) in age (Turner, 1970; Turner and Campbell, 1979; see Berggren and others, 1995; age determinations corrected using conversion factors presented by Dalrymple, 1979).

### **3.1.8 Middle Topanga Formation**

According to by the RCC and others (1993a), the marine Middle Topanga Formation (unit Tts) is interbedded with the unnamed middle Miocene submarine volcanic rock unit and consists of sandstone. According to Dibblee (1991a, -b), this rock unit consists of moderately hard, light gray to tan, locally pebbly sandstone (unit Tts of Dibblee, 1991a, -b) that is interbedded with the volcanic rock unit and, where the Middle Topanga Formation overlies the volcanic rock unit, with semi-friable tan sandstone containing gray micaceous clay shale and claystone interbeds and local lenses of pebbly sandstone and pebble to cobble conglomerate (unit Ttsi of Dibblee, 1991a, -b). As mapped by Dibblee (1991a), the Santa Monica Mountains tunnel segment does not pass under any exposure of this rock unit (see Figure 4). However, as mapped by Hoots (1931), the middle third of the tunnel segment passes under an exposure of the Middle Topanga Formation where

an interbed of the rock unit occurs within the unnamed submarine volcanic rock unit (see RCC, 1993a).

The Middle Topanga Formation, if not crossed by the middle third of the tunnel segment, would not have been encountered by earth moving in the tunnel segment (see RCC and others, 1993a).

### **3.1.9 Upper Topanga Formation**

As described by the RCC and others (1993a), the marine Upper Topanga Formation consists of a lower unit (unit Ttu [ss+cgl]) that contains interbedded sandstone and conglomerate and overlies the unnamed middle Miocene submarine volcanic rock unit, and an upper unit (unit Ttu [ss+sh]) containing interbedded sandstone and shale. According to Dibblee (1991a, -b), the rock unit consists of moderately hard, well-bedded, light gray to tan, locally pebbly sandstone (unit Ttus of Dibblee, 1991a, -b) that underlies and is interbedded with gray micaceous clay shale and claystone with semi-friable, gray to tan sandstone interbeds (unit Ttusi of Dibblee, 1991a, -b) that in turn are interbedded with thinly bedded, platy, semi-siliceous shale (unit Ttui of Dibblee, 1991a, -b). However, Hoots (1931) assigned the lower part of this rock unit west of Cahuenga Pass to the Middle Topanga Formation. The Upper Topanga Formation is equivalent to the marine Calabasas Formation of the Topanga Group west of the Segment 3 route in the central Santa Monica Mountains west of Topanga Canyon (Dibblee, 1989b, 1991a, -b, 1992, 1995). The rock unit is composed of sediments derived from a source area to the northeast (presumably San Gabriel Mountains) and deposited to form a submarine fan (Dibblee, 1989b).

The Upper Topanga Formation was encountered by earth moving in the northern third of the Santa Monica Mountains tunnel segment; at the northern tunnel access shaft and starter tunnel sites; Universal City station/cross-over site; and in the southern part of the San Fernando Valley tunnel segment south of Valley Spring Lane, just north of the Los Angeles River (see MTA and others, 1995c; RCC and others, 1993a, -b). Intense folding of the rock unit at the Universal City station site probably resulted from offset along the Benedict Canyon Fault, which lies immediately south of the station site at the base of the Santa Monica Mountains (see Dibblee, 1991a). The late middle to early late? Miocene marine Monterey Formation, which consists of siliceous shale, overlies the Upper Topanga Formation just west of the Universal City station site (see Dibblee, 1991a;

Figure 2).

### **3.1.10 Older Alluvium**

In the Hollywood area, the older alluvium (unit Qae of Dibblee, 1991a; includes alluvial fan deposits [unit Qf] of CWDD and others, 1981) is bounded to the north by the Hollywood Fault segment of the SM-H-RHFZ and consists of dissected semiconsolidated clay, sand, and gravel of alluvial fan origin (Dibblee, 1991a, -b). Successive layers of sediments derived from canyons incised into the southern side of the eastern Santa Monica Mountains accumulated to form the Hollywood (alluvial) fan, which developed on the coastal floodplain below the mouths of the canyons and built progressively southward toward the coastline during the middle? to late Pleistocene Epoch (Shaw and Quinn, 1986; Stock and Harris, 1992).

The older alluvium was encountered by earth moving at the Hollywood/Highland station site, Santa Monica Mountains southern tunnel access shaft and starter tunnel sites, and at the southern end of the Santa Monica Mountains tunnel segment immediately south of the Hollywood Fault segment of the SM-H-RHFZ (see MTA and others, 1995a; RCC and others, 1993a).

### **3.1.11 Older and Younger Alluvium, Undifferentiated**

In the San Fernando Valley, the younger alluvium (unit Qa of Dibblee, 1991a, -b) consists of undissected, unconsolidated, alluvial clay, sand, and gravel derived from the Santa Monica Mountains, as well as fluvial sand and gravel (Dibblee, 1991a, -b). Unfortunately, the older and younger alluvium were not differentiated in the subsurface of the San Fernando Valley by the MTA and others (1995b, -c) or the RCC and others (1993b), although Lander (1987), the UMTA and SCR TD (1983, 1987), and WESTEC Services, Inc. (1983), reported the older alluvium as occurring immediately below the younger alluvium, which was reported to extend from the surface downward to a depth 50 to 80 feet below grade in the construction zone.

The undifferentiated alluvium was encountered by earth moving at the Santa Monica Mountains northern tunnel access shaft, Universal City station/cross-over, and North Hollywood station/cross-over/tail track sites; in the Santa Monica Mountains northern starter tunnel; in the San Fernando Valley tunnel segment between the Los Angeles River and the North

Hollywood station site; and at the San Fernando Valley tunnel segment mid-line vent structure (see MTA and others, 1995b, -c; RCC and others, 1993b). In the Santa Monica Mountains northern starter tunnel, at the Universal City station/cross-over site, and in the San Fernando Valley tunnel segment south of Acama Street, the alluvium is separated from the unconformably underlying Upper Topanga Formation by a pronounced angular discordance of comparatively high topographic relief.

### **3.1.12 Artificial Fill**

Artificial fill is not mapped in the Segment 3 construction zone, but was encountered by shallow earth moving at every Segment 3 construction site, except in the tunnels and at the San Fernando Valley tunnel segment mid-line vent structure, North Hollywood station/cross-over/tail track, and starter tunnel sites (see MTA and others; 1995a to -c; RCC and others, 1993b). Artificial fill consists of unconsolidated historic sediments and debris deposited and then substantially disturbed by human activity, as well as pavement, and is up to 8 feet thick in the construction zone (MTA and others, 1995c).

### **3.1.13 Summary**

The sedimentary rock units present in the Segment 3 construction zone represent several episodes of marine and nonmarine deposition along the southern California continental margin during the last 100 million years, and include nonmarine and overlying marine strata of late Cretaceous and late Paleocene age, marine strata and lava flows of early to middle Miocene age, and nonmarine strata of middle to late Pleistocene and Holocene age. The transitions from nonmarine to marine and from marine to nonmarine conditions probably reflect subsidence and uplift, respectively, of the western edge of the North American (continental) plate in response to the interaction of the North American plate margin and the eastern margin of the adjacent Pacific plate to the west.

## **3.2 STRATIGRAPHY BY CONSTRUCTION SITE**

Except where noted, the surficial geology of each Segment 3 construction site is based on surficial geologic mapping presented by CWDD and others (1981) and Dibblee (1991a, -b), while the subsurface geology is based on bore-hole data provided by CWDD and others (1981), the MTA and others (1995a to -c), the RCC and others (1993a, -b), the

UMTA and SCRTD (1983, 1987), and WESTEC Services, Inc. (1983). The stratigraphy of each construction site is described below. The distribution of each surficial and subsurface rock unit is tabulated in Table 2 and depicted in Figure 6 by construction site.

### **3.2.1 Hollywood/Highland Station**

Cut-and-cover excavation for the Hollywood/Highland station encountered artificial fill, which extends from the surface downward to a depth 2.5 feet below grade, and older alluvium, which extends from the base of the artificial fill downward to an undetermined depth below the bottom of the station excavation, 75 feet below grade, and primarily consists of brown sandy clay and silt and clayey and silty sand (MTA and others, 1995a, bore holes HH-4 to -7).

### **3.2.2 Hollywood Tunnel Segment**

Between the Hollywood/Highland station site and the Santa Monica Mountains southern tunnel access shaft sites, tunneling for the Hollywood tunnel segment encountered only the older alluvium (MTA and others, 1995a).

### **3.2.3 Santa Monica Mountains Southern Tunnel Access Shafts**

Cut-and-cover excavation for the Santa Monica Mountains southern tunnel access shafts encountered artificial fill, which extends from the surface downward to a depth several feet below grade, and older alluvium, which extends from the base of the artificial fill downward to an undetermined depth below the bottom of the access shaft excavations, 90 feet below grade. The older alluvium primarily consists of poorly consolidated brown silty sand.

### **3.2.4 Santa Monica Mountains Southern Starter Tunnels**

Excavation for the Santa Monica Mountains southern starter tunnels encountered only older alluvium.

### **3.2.5 Santa Monica Mountains Tunnel Segment**

Tunneling for the southern end of the Santa Monica Mountains tunnel segment south of the Hollywood Fault segment of the SM-H-RHFZ encountered only older alluvium. Between the Hollywood Fault segment and the Santa Monica Mountains northern starter tunnel sites, tunneling encountered (from south

to north) the unnamed early Cretaceous quartz diorite and the successively overlying unnamed late Cretaceous nonmarine? and marine rock units, Santa Susana Formation (including Simi Conglomerate Member at base and overlying unnamed upper member), and the Lower, Middle?, and Upper Topanga Formation and the associated unnamed middle Miocene submarine volcanic rock unit (RCC and others, 1993a; see Dibblee, 1991a; Hoots, 1931; see Figures 2, 3).

### **3.2.6 Santa Monica Mountains Northern Tunnel Access Shaft**

Cut-and-cover excavation for the Santa Monica Mountains northern tunnel access shaft encountered artificial fill, which extends from the surface downward to a depth 8 feet below grade; younger alluvium, which extends from the base of the artificial fill downward to a depth 56 feet below grade; and the Upper Topanga Formation, which extends from the base of the younger alluvium downward to an undetermined depth below the bottom of the access shaft excavation, 100 feet below grade (MTA and others, 1995c, bore hole 34-A).

### **3.2.7 Santa Monica Mountains Northern Starter Tunnels**

Excavation for the Santa Monica Mountains northern starter tunnels encountered undifferentiated older and younger alluvium and the Upper Topanga Formation (MTA and others, 1995c). As at the Universal City station/cross-over site, the entire sequence of undifferentiated alluvium probably represents younger alluvium.

### **3.2.8 Universal City Station/Cross-Over**

Cut-and-cover excavation for the Universal City station/cross-over encountered artificial fill, which, where present, extends from the surface downward to a depth 2.5 feet below grade; undifferentiated older and younger alluvium, which extends from the surface or the base of the artificial fill downward to depths 50.0 to 68.0 feet below grade; and the Upper Topanga Formation, which extends from the base of the alluvium to an undetermined depth below the bottom of the station/cross-over excavation, 75 feet below grade (MTA and others, 1995c, bore holes 34-1 to -5; see Figure 4). The entire sequence of undifferentiated alluvium consists of semiconsolidated strata probably representing younger alluvium. These strata in turn mostly consist of brown and dark yellowish-brown sand, clayey sand

and silt, and sandy and silty clay above, and greenish-gray sand, sandy and silty sand, sandy silt, and sandy and silty clay below, a greenish-gray sand with gravel lenses occurring at the base of the sequence. The Upper Topanga Formation is highly folded and separated from the overlying alluvium by a pronounced angular discordance of comparatively high topographic relief.

### **3.2.9 San Fernando Valley Tunnel Segment**

Tunneling for the San Fernando Valley tunnel segment encountered (from south to north) the Upper Topanga Formation, which extends from the Universal City station/cross-over site to a point between Acama Street and Valley Spring Lane, just north of the Los Angeles River; and undifferentiated older and younger alluvium, which extends from a point very near the Los Angeles River to the North Hollywood station/cross-over/tail track site (RCC and others, 1993b, bore holes 34-6 to 38A). The older alluvium probably extends northward to a point between the San Fernando Valley tunnel segment mid-line vent structure site and the North Hollywood station site (but also was encountered in deeper auger hole borings below the base of the station excavation), the overlying younger alluvium probably extending southward at least to the mid-line vent structure site.

### **3.2.10 San Fernando Valley Tunnel Segment Mid-Line Vent Structure**

Cut-and-cover excavation for the San Fernando Valley tunnel segment mid-line vent structure encountered only undifferentiated older and younger alluvium, which extends from the surface downward to an undetermined depth below the bottom of the vent structure excavation, 90 feet below grade (RCC and others, 1993b, bore hole 36-C). However, a lithologic change at a depth 60 feet below grade from gray sand with interbedded gravel above, to brown to brownish-gray sand, silty sand, sandy silt, and clayey silt below (see RCC and others, 1993b, bore hole 36-C), possibly represents the contact between the younger alluvium and the underlying older alluvium (see below).

### **3.2.11 North Hollywood Station/Cross-Over/Tail Track**

Cut-and-cover excavation for the North Hollywood station/cross-over/tail track encountered only undifferentiated older and younger alluvium, which is at least 201 feet thick and extends from the surface

downward at least 135 feet to an undetermined depth below the bottom of the station/cross-over excavation, 65 feet below grade (MTA and others, 1995b; RCC and others, 1993b, bore hole CEG 38). However, a pronounced lithologic change in the alluvium was encountered by augering for soldier piles at a depth approximately 78 feet below grade.

This change corresponds to a shift from light brownish-gray sandy gravel above (see MTA and others, 1995b; RCC and others, 1993b, bore hole 38-4; see Figure 5), to tan silty sand and greenish-gray clay below, and possibly represents the contact between the younger alluvium and the underlying older alluvium.

SECTION 4

PREVIOUS PALEONTOLOGIC RESOURCE INVESTIGATIONS IN AREA

The results of previous scientific investigations regarding the paleontologic resources of each rock unit in the Los Angeles Metro Red Line Segment 3 construction zone are presented below by rock unit, beginning with the oldest rock unit (see Table 1, Figures 2 to 5).

With the exception of the unnamed early Cretaceous quartz diorite and the artificial fill, all of the rock units in the Segment 3 construction zone have yielded fossil remains at previously recorded fossil sites in and near the construction zone. These fossil remains have been critical in refining previous age estimates for their respective fossil-bearing rock units, reconstructing the paleoenvironments and paleoclimates represented by their sediments, and in documenting the geologic history of the area crossed by the Red Line route.

4.1 UNNAMED EARLY CRETACEOUS QUARTZ DIORITE

The unnamed early Cretaceous quartz diorite formed by the crystallization of molten rock deep within the earth's crust (plutonic environment). Because of its mode of origin, this rock unit is unfossiliferous. For this reason, there was no potential for any fossil remains or previously unrecorded fossil site being encountered in the quartz diorite as a result of tunneling for the Santa Monica Mountains tunnel segment.

4.2 UNNAMED LATE CRETACEOUS NONMARINE ROCK UNIT

The unnamed late Cretaceous nonmarine rock unit is equivalent to the "Trabuco" Formation west of the Santa Monica Mountains tunnel segment in the central Santa Monica Mountains east of Topanga Canyon (Dibblee, 1991a, -b). Neither rock unit has yielded any reported fossil remains in the Santa Monica Mountains. For this reason, there probably would be no more than a low potential for any fossil remains or previously unrecorded fossil site being encountered in the unnamed nonmarine rock unit as a result of tunneling for the Santa Monica Mountains tunnel segment, if this rock unit were encountered by tunneling.

4.3 UNNAMED LATE CRETACEOUS MARINE ROCK UNIT

The unnamed late Cretaceous marine rock unit may be equivalent to the Tuna Canyon Formation west of the Santa Monica Mountains tunnel segment in the central Santa Monica Mountains west of Topanga Canyon (Dibblee, 1991a, -b, 1992). In the eastern and central Santa Monica Mountains between Sepulveda and Topanga Canyons, the latter rock unit has yielded the remains of Turonian to Campanian marine mollusks, including ammonites, and Campanian or Maestrichtian foraminifers (Alderson, 1988; Yerkes and Campbell, 1979).

Hoots (1931) reported the occurrence of fossil remains representing late Cretaceous marine snails, clams, nautiloids, and ammonites from the Chico Formation (= unnamed marine rock unit) at 12 previously recorded fossil sites in the eastern Santa Monica Mountains west of Sepulveda Canyon. Based on these fossil occurrences, there probably was at least a moderate potential for similar fossil remains being encountered at previously unrecorded fossil sites in the unnamed marine rock unit as a result of tunneling for the Santa Monica Mountains tunnel segment.

4.4 SANTA SUSANA FORMATION, SIMI CONGLOMERATE MEMBER

The Santa Susana Formation includes the marine and nonmarine? Simi Conglomerate (lower) Member at its base. The Simi Conglomerate Member has yielded the very rare remains of Martinez Stage (late Paleocene) marine mollusks in the Simi Hills (Lander, 1988b; Zinsmeister, 1983). Based on these fossil occurrences, there probably was only a low potential for similar fossil remains being encountered at previously unrecorded fossil sites in the Simi Conglomerate Member as a result of tunneling for the Santa Monica Mountains tunnel segment.

4.5 SANTA SUSANA FORMATION, UNNAMED UPPER MEMBER

The unnamed upper member of the Santa Susana Formation may be equivalent to the Coal Canyon Formation west of the Santa Monica Mountains tunnel segment in the central Santa Monica Mountains west of Topanga Canyon (Dibblee, 1991a, -b, 1992), where the latter rock unit also has yielded the remains of Martinez Stage marine mollusks (Yerkes and Campbell, 1979). However, unlike the

Coal Canyon Formation (see Yerkes and Campbell, 1979), the Santa Susana Formation in the eastern Santa Monica Mountains has not yielded the remains of Domengine Stage (early to early middle Eocene) marine mollusks.

Hoots (1931) reported the occurrence of fossil remains representing Martinez Stage marine snails, clams, and heart urchins from the Martinez (= Santa Susana) Formation at 11 previously recorded fossil sites in the eastern Santa Monica Mountains west of Sepulveda Canyon. Dibblee (1991b) mapped two fossil sites in the eastern Santa Monica Mountains between Cahuenga Pass and Sepulveda Canyon. Based on these fossil occurrences, there probably was at least a moderate potential for similar fossil remains being encountered at previously unrecorded fossil sites in the Santa Susana Formation as a result of tunneling for the Santa Monica Mountains tunnel segment.

#### **4.6 LOWER TOPANGA FORMATION**

The Lower Topanga Formation is equivalent to the Saddle Peak (lower) and Cold Creek (upper) Members of the Topanga Canyon Formation of the Topanga Group west of the Santa Monica Mountains tunnel segment in the central Santa Monica Mountains west of Topanga Canyon (Dibblee, 1992), where the latter rock unit underlies the Conejo Volcanics and has yielded the remains of Temblor Stage (middle Miocene) marine mollusks (Yerkes and Campbell, 1979). The Topanga Canyon Formation also has yielded Relizian (late early to early middle? Miocene) marine benthic foraminifers (Blake, 1991; see Berggren and others, 1995; Micropaleo Consultants, Inc., 1993).

Hoots (1931) reported the occurrence of fossil remains representing Temblor Stage marine snails and clams and the leaf of the land plant *Salix* (willow) from the Lower Topanga Formation (as mapped by Dibblee, 1991a) at four previously recorded fossil sites (2, 7, 8, 38) in the eastern Santa Monica Mountains between Cahuenga Pass and Sepulveda Canyon (see Figures 2, 3). Based on these and other fossil occurrences, there was considered to be a moderate potential for similar fossil remains being encountered at previously unrecorded fossil sites in the Lower Topanga Formation as a result of tunneling for the Santa Monica Mountains tunnel segment (Lander, 1987; UMTA and SCR TD, 1983, 1987; WESTEC Services, Inc., 1983).

#### **4.7 UNNAMED MIDDLE MIOCENE SUBMARINE VOLCANIC ROCK UNIT**

Because of its mode of origin as a sequence of lava flows, the unnamed middle Miocene submarine volcanic rock unit is unfossiliferous. For this reason, there was no potential for any fossil remains or previously unrecorded fossil site being encountered in this rock unit as a result of tunneling for the Santa Monica Mountains tunnel segment (Lander, 1987), although the UMTA and SCR TD (1983, 1987) and WESTEC Services, Inc. (1983), considered there to be a low potential.

#### **4.8 MIDDLE TOPANGA FORMATION**

Hoots (1931) reported the occurrence of marine microfossil remains and fossil remains representing clams from the Middle Topanga Formation (as mapped by Dibblee, 1991a) at four previously recorded fossil sites (5, 6, 101, 102; fossil remains not recorded from a fifth fossil site, 59) in the eastern Santa Monica Mountains, all but one of the sites lying west of Cahuenga Pass, the remaining site lying just east of the pass (see Figures 2, 3). Neuerburg (1953) reported the remains of additional clams as occurring at two University of California, Los Angeles (UCLA) fossil sites (UCLA 2304, 2306) just east of Cahuenga Pass, and Dibblee (1991a) mapped two additional fossil sites just west of the pass and two more east of the pass (see Figures 2, 3). All of these fossil sites occur in sedimentary strata interbedded with the unnamed submarine volcanic rock unit. Based on these fossil occurrences, there would be at least a moderate potential for similar fossil remains and previously unrecorded fossil sites being encountered at previously unrecorded fossil sites in the Middle Topanga Formation as a result of tunneling for the Santa Monica Mountains tunnel segment, if this rock unit were encountered by tunneling.

#### **4.9 UPPER TOPANGA FORMATION**

The Upper Topanga Formation may be equivalent to the Calabazas Formation of the Topanga Group west of the Santa Monica Mountains tunnel segment in the central Santa Monica Mountains west of Topanga Canyon (Dibblee, 1991a, -b, 1992), where the latter rock unit overlies the Conejo Volcanics and has yielded the remains of fishes and Temblor Stage (middle Miocene) mollusks and Luisian (early middle Miocene) marine benthic foraminifers (Blake, 1991; Yerkes and Campbell, 1979; see Berggren and others,

1995; Micropaleo Consultants, Inc., 1993).

Hoots (1931) reported the occurrence of fossil remains representing marine microfossils from the Upper Topanga Formation (as mapped by Dibblee, 1991a; mapped as upper part of Middle Topanga Formation by Hoots, 1931) at a previously recorded fossil site (103) in the eastern Santa Monica Mountains just west of Cahuenga Pass (see Figures 2, 3). The remains of a marine mammal (desmostylid *Palaeoparadoxia*) were recovered in the same area at LACMVP fossil site 1084 (see Figures 2, 3). Based on these and other fossil occurrences, there was considered to be a moderate potential for similar fossil remains being encountered at previously unrecorded fossil sites in the Lower Topanga Formation as a result of tunneling for the Santa Monica Mountains and San Fernando Valley tunnel segments, excavation of the Santa Monica Mountains northern starter tunnels, and of cut-and-cover excavation for the Santa Monica Mountains northern tunnel access shaft and the Universal City station/cross-over (Lander, 1987; UMTA and SCRTRD, 1983, 1987; WESTEC Services, Inc., 1983).

#### **4.10 OLDER ALLUVIUM**

Jefferson (1991a, -b), Lander (1987, 1994b, 1999), Miller (1971), Reynolds (1987), and WESTEC Services, Inc. (1983), reported the occurrence of fossil remains representing extinct Pleistocene (Ice Age) land mammal and other continental vertebrate species at numerous previously recorded fossil sites in the Los Angeles area, including the immediate vicinity of the Hollywood/Highland station site, many of the fossil sites having been uncovered by excavation for other construction projects. Most of the fossil sites that yielded Pleistocene land mammal remains are in the older alluvium (see Dibblee, 1991a). Included in these sites is the La Brea tar pits area of Hancock Park, which lies 2.4 miles south-southwest of the Hollywood/Highland station site and produced the extinct land mammal fauna that is the basis for the Rancholabrean North American Land Mammal Age (NALMA) (Lundelius and others, 1987; Shaw and Quinn, 1986; Stock and Harris, 1992; Woodburne, 1987). On the basis of radiometric (carbon-14) dating analyses, fossilized wood and Rancholabrean land mammal remains from the La Brea tar pits have been determined to be more than 40,000 (wood) to approximately 11,000 years (bone) and late Pleistocene in age (disparate and, therefore, presumably unreliable age determinations not included) (Marcus and Berger, 1984; Stock and Harris, 1992; see Berggren and others, 1995).

Fossilized wood from 0.7 mile east-southeast of the tar pits at LACMVP fossil site 1814 has been determined to be more than 46,500 years in age (Marcus and Berger, 1984).

The beginning of the Rancholabrean NALMA is defined by the first local appearance of bison (*Bison*), which immigrated to North America from Asia over the Bering land bridge at least 130,000 years ago, during the late Illinoian Glacial Stage sea-level lowstand (Jefferson, 1991b; Lundelius and others, 1987; Miller, 1971). Bison are not recorded from the preceding early to middle Pleistocene Irvingtonian NALMA. South of Hancock Park, the older alluvium (upper part, unit B; overlying unit C of Woodard and Marcus, 1973) is immediately underlain by the Pleistocene marine Palos Verdes Sand (lower part, unit B), which is interbedded with the lower part of the older alluvium and has yielded marine mollusk shells in the Hancock Park area (WESTEC Services, Inc., 1983; Woodward and Marcus, 1973). The Palos Verdes Sand is assignable to oxygen-18 (isotope) zone 5e and approximately 130,000 to 120,000 years (late Pleistocene) in age (Jefferson, 1991b; Kennedy and others, 1987; see Berggren and others, 1995). In the Palos Verdes Hills and the adjacent San Pedro area approximately 20 to 25 miles south of the Segment 3 route, the San Pedro Sand, which unconformably underlies the Palos Verdes Sand, has yielded fossilized remains representing Pleistocene marine invertebrate and vertebrate species and Rancholabrean land mammal species, including the oldest reported occurrence of bison in the Los Angeles basin (Jefferson, 1991b; Kennedy, 1975; Langenwaller, 1975; Miller, 1971; Woodring and others, 1946). However, in most of the Los Angeles Metro Red Line Segment 3 construction zone, the older alluvium unconformably overlies an unnamed late Miocene marine shale (Lander, 1999) or the middle Miocene marine Upper Topanga Formation. Moreover, in the Mojave Desert, the first fossil record of bison has been estimated to be approximately 280,000 years (middle Pleistocene) in age (Jefferson, 1992; see Berggren and others, 1995). These data suggest the base of the older alluvium might be as old as about 280,000 years and middle Pleistocene in age in the Segment 3 construction zone, where the older alluvium probably overlies the unnamed marine shale and possibly is laterally equivalent to the San Pedro Sand. Presumably, the beginning of the Rancholabrean NALMA also is about 280,000 years in age.

The end of the Pleistocene Epoch (and Rancholabrean NALMA), probably about 10,750

years in age (Lander, 1999; see below), is marked by a world-wide extinction event that involved most large land mammal species and occurred as a result of 1) overkill arising from intense hunting by prehistoric humans and/or 2) the severe climatic changes that followed the end of the last Ice Age and the accompanying alterations of habitat and vegetation that lead to present conditions (Lander, 1988a; Lundelius and others, 1987; Stock and Harris, 1992). However, younger carbon-14 age determinations, although nearly always disparate and, therefore, probably unreliable, suggest the top of the older alluvium is early Holocene and younger than 6,000 years in age, but probably no younger than the overlying younger alluvium, the base of which has been determined to be approximately 5,000 years and middle Holocene in age, based on carbon-14 dating analysis of a fossil wood specimen recovered from approximately 5 feet above the base of the younger alluvium at Union Station (Beta Analytic Inc., 1996c; Lander, 1999; Stock and Harris, 1992; E.B. Lander, PEAI, unpublished data; see below).

Two LACMVP fossil sites (2034 = 3261; 3371), approximately 1.9 to 2.3 miles southwest of the Hollywood/Highland station site, yielded mastodon (elephant), mammoth (elephant), and, at a depth 12 feet below grade, bison remains (Jefferson, 1991b; Miller, 1971). Another LACMVP fossil site (5845), approximately 2.5 miles southeast of the station site, yielded mastodon remains at a depth only 5 to 6 feet below grade (Lander, 1999).

Based on the occurrences of fossil land mammal remains in the older alluvium at previously recorded fossil sites (other than those at and in immediate vicinity of Hancock Park) in the Hollywood area, there was considered to be only a moderate potential for similar remains being uncovered at previously unrecorded fossil sites in the older alluvium during cut-and-cover excavation for the Hollywood/Highland station (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983).

Recently, four LACMVP fossil sites (6297 to 6300), approximately 1.2 to 1.6 miles east of the Hollywood/Highland station site, yielded mastodon, horse, camel, and bison remains during tunneling of the Segment 2 Hollywood Boulevard tunnel segment between the Hollywood/Western station site and the Hollywood Freeway, and LACMVP fossil site 6204 yielded mammoth? remains during cut-and-cover excavation at the Wilshire/Western station site, 3.2 miles southeast of the Hollywood/Highland station site (Lander, 1999).

Paleontologic data derived from a study of the fossil land mammal remains from the older alluvium, in conjunction with geologic (sedimentologic) evidence, have been critical in documenting the continental or nonmarine (coastal alluvial floodplain) origin and middle? to late Pleistocene (Rancholabrean) age of the rock unit (see Jefferson, 1991b; Dibblee, 1989a, 1991a; Miller, 1971; WESTEC Services, Inc., 1983).

#### **4.11 OLDER AND YOUNGER ALLUVIUM, UNDIFFERENTIATED**

Until recently, no fossil remains definitely were known to have been recovered from the younger alluvium in the vicinity of the Segment 3 route and, because of its comparatively recent (presumably Holocene) age, there was considered to be only a low potential for any remains or previously unrecorded fossil site being uncovered in this rock unit during cut-and-cover excavation for the Universal City and North Hollywood stations (see Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983). However, Holocene fossil plant remains recently were recovered from the younger alluvium at newly recorded PEAI fossil sites at Union Station, 0.2 mile south of the Metro Red Line Segment 1 tunnel in the downtown Los Angeles area (Lander, 1999; E.B. Lander, PEAI, unpublished data).

In the San Fernando Valley, a number of fossil sites that yielded Rancholabrean land mammal remains are in areas immediately underlain by younger alluvium (see Dibblee, 1991a, -b), but occurred at depths possibly sufficient to have been in the underlying older alluvium. LACMVP fossil sites 3263, 3822, and 6208, 4.3 to 4.9 miles west of the North Hollywood station site, yielded horse and bison remains at depths 14, 20, and 75 to 100 feet below grade (Jefferson, 1991b; Reynolds, 1987).

Based on the occurrences of Rancholabrean land mammal remains in the undifferentiated older and younger alluvium at previously recorded fossil sites in the San Fernando Valley, there was considered to be only a moderate potential for similar remains being uncovered at previously unrecorded fossil sites in this rock unit during cut-and-cover excavation for the Universal City and North Hollywood stations (Lander, 1987; UMTA and SCRTD, 1987).

Paleontologic data derived from a study of the fossil land mammal remains from the older alluvium, in conjunction with geologic (sedimentologic) evidence, have been critical in documenting the continental or nonmarine (fluvial or stream channel) origin and

middle to late Pleistocene (Rancholabrean) age of the rock unit (see Jefferson, 1991b; Dibblee, 1991a, -b).

The undifferentiated older and younger alluvium yielded fossilized wood fragments of otherwise unidentified land plant species at a depth 16 feet below grade at the North Hollywood station site (bore hole 38-2; MTA, 1995b; RCC, 1993b; see Figures 2, 5). The greenish-gray (lower, but not lowermost) lithologic unit of the undifferentiated alluvium yielded additional fossilized wood fragments at depths 44 to 62 feet below grade at the Universal City station site (bore holes 34-2 to -5; MTA, 1995c;

RCC, 1993b; see Figures 2, 4).

#### **4.12 ARTIFICIAL FILL**

Artificial fill consists of historic sediment and debris substantially disturbed by human activity. Any fossil remains encountered in the artificial fill would have lacked any original geologic or geographic context. For this reason, there was no potential for any scientifically important fossil remains or previously unrecorded fossil site being uncovered in this rock unit during cut-and-cover excavation at any construction site.



## SECTION 5

### METHODS

The Los Angeles Metro Red Line Segment 3 paleontologic resource impact mitigation program required by the LACTC and MTA was conducted by PEAI personnel during and in support of cut-and-cover excavation and other earth-moving activities (trenching, augering, tunneling) associated with construction of the Hollywood/Highland, Universal City, and North Hollywood stations; Universal City cross-over; southern and northern Santa Monica Mountains tunnel access shafts; and the intervening Hollywood, Santa Monica Mountains, and San Fernando Valley tunnel segments. The mitigation program, particularly with regard to paleontologic construction monitoring of earth moving; recovery, treatment, and permanent museum storage and maintenance of fossil remains uncovered by cut-and-cover excavation; recording and archiving of associated specimen data and corresponding geologic and geographic site data; and reporting of results and findings, has been in compliance with SVP guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources (SVP, 1991, 1995, 1996; see Appendices B, C), mitigation measures developed during the Segment 3 environmental impact review process (Lander, 1987; UMTA and SCRTRD, 1983, 1987; WESTEC Services, Inc., 1983), and mitigation measures developed for Metro Red Line Segment 1 (Greenwood, 1987), including SCRTRD/LACTC/MTA Specifications Section 01170 (see Appendix A).

#### 5.1 MUSEUM REPOSITORY STORAGE AND MAINTENANCE AGREEMENTS

The LACMVP and LACMIP are the designated museum repositories for the fossil vertebrate and invertebrate specimens, respectively, and associated specimen data and corresponding geologic and geographic site data recovered as a result of the Metro Red Line Segment 3 paleontologic resource impact mitigation program, and the UCMP is the designated museum repository for the recovered fossil plant specimens and associated specimen and site data. The PEAI mitigation program principal investigator developed formal agreements with the LACMIP, LACMVP, and UCMP regarding final disposition and permanent storage and maintenance of the Segment 2 fossil invertebrate, vertebrate, and plant collections and associated specimen and site data (see Appendices E, F, G). As necessary, each agreement covered, but was not necessarily limited

to, museum or section requirements regarding storage and maintenance fees; level of treatment (specimen preparation to point of identification, identification to lowest taxonomic level possible, curation [assigning and labeling specimens with repository specimen and corresponding site numbers, placing specimens in specimen trays and vials with completed specimen data cards], cataloguing [entering specimen and site numbers and corresponding data into appropriate catalogs and computerized data bases of designated museum repositories]) of the appropriate part of the collection before that part of the collection would be accepted by the respective museum repository; and the purchase of specimen storage cabinets and drawers, as well as specimen trays and vials and other curation supplies. These agreements subsequently were extended to cover the Segment 3 fossil collection (see deed of gift, Appendix P). Unless some or all of these requirements were fulfilled, the LACMIP, LACMVP, or UCMP could have refused to accept the respective part of the Segment 3 collection and, under SVP (1991, 1995, 1996; see Appendices B, C) guidelines, adverse construction-related environmental impacts on paleontologic resources of the Segment 3 construction zone would not have been considered mitigated to an insignificant level.

#### 5.2 DISCOVERY CLAUSE AND TREATMENT PLAN

The PEAI principal investigator developed discovery clauses and treatment plans for the Metro Red Line Segment 2 paleontologic resource impact mitigation program (see Appendix D). A discovery clause for a particular construction site specified procedures to be conducted and personnel to be contacted if an unusually large or productive fossil occurrence were uncovered by earth moving and could not be recovered without significantly diverting the paleontologic construction monitor from the routine monitoring task or diverting earth moving around the fossil site for an extended period of time, or if a fossil occurrence were uncovered when the monitor was not on site. The lists of personnel to be contacted if a fossil occurrence were uncovered by earth moving subsequently were updated for each Segment 3 construction site to allow the discovery clause and treatment plan for the Segment 2 Wilshire/Vermont station site to be adopted for the Segment 3 mitigation program.

The treatment plan, previously approved by the MTA and subsequently implemented following the discovery of an unusually large or productive fossil occurrence in the Segment 3 construction zone, allowed for the additional manpower and tasks (recovery, processing, preparation, identification, curation, cataloguing, data entry, purchasing equipment/supplies, permanent museum storage and maintenance, as appropriate) required to treat the occurrence.

### 5.3 PRECONSTRUCTION MEETINGS

As specified in SCRTRD/LACTC/MTA Specifications Section 01170 (see Appendix A), a preconstruction meeting between PEAI paleontologic mitigation program (principal investigator, paleontologic construction monitors), MTA (Environmental Compliance Section manager), environmental controls (PES), and appropriate construction management (PD, Jacobs Engineering Group, Inc./Mott McDonald Hatch/A.G.C. Environmental) and construction contractor (Kajima/Ray Wilson, Obayashi Corporation, Traylor Brothers/Frontier-Kemper, Tutor-Saliba/Perini) staff was held prior to any earth-moving activity at a particular Metro Red Line Segment 3 construction site to ensure construction management and contractor staff were advised of 1) the potential for fossil remains being uncovered by earth moving; 2) mitigation measures to be implemented as part of the Segment 3 paleontologic resource impact mitigation program during earth moving, particularly if fossil remains were uncovered by this activity; and 3) construction worker responsibilities and lines of communication if fossil remains were uncovered by earth moving, especially when a monitor was not on site.

The principal investigator briefed the other meeting attendees on the following items.

Routine mitigation measures (primarily paleontologic monitoring to allow for discovery and recovery of fossil remains) to be employed by a monitor during any earth-moving activity, particularly cut-and-cover excavation, at the construction site, and the responsibility of the monitor in ensuring earth moving was not delayed.

The potential for fossil remains being uncovered by cut-and-cover excavation at specific depths and the need to implement specific actions and additional mitigation measures (as specified in discovery clause/treatment plan) if a fossil

occurrence were uncovered by excavation.

Functions and responsibilities of the monitor (as specified in discovery clause/treatment plan) if fossil remains were uncovered by earth moving and could be recovered without diverting the monitor from monitoring (divert earth moving temporarily around fossil site until remains evaluated and recovered, and earth moving allowed to proceed through fossil site by monitor; enlist assistance of earth-moving equipment and operator to expedite recovery of remains, reduce any potential construction delay, and obviate need for additional recovery personnel).

Functions and responsibilities of the monitor (as specified in discovery clause/treatment plan) if an unusually large fossil specimen or a concentration of small fossil specimens was uncovered by earth moving and could not be recovered without diverting the monitor from monitoring (flag fossil site; advise earth-moving equipment operator and other appropriate construction contractor staff of need to have earth moving avoid site until further notice; call principal investigator to construction site).

Functions and responsibilities of the principal investigator (as specified in discovery clause/treatment plan) if notified by the monitor that an unusually large fossil specimen or a concentration of small fossil specimens had been uncovered by earth moving (evaluate occurrence to determine if recovery warranted; if warranted, notify appropriate construction management and construction contractor staff and MTA Environmental Compliance Section manager of fossil occurrence, necessity of having earth moving avoid fossil site for extended period, implementing additional mitigation measures specified in discovery clause/treatment plan, initiating full-time monitoring, if appropriate and not already in effect, to allow for recovery of large fossil remains, and assigning additional personnel to mitigation program; within 24 hours after MTA approval, mobilize recovery crew to recover remains or fossiliferous rock sample containing concentration of small fossil remains; supervise recovery of remains or rock sample and its transport offsite; if warranted, enlist assistance of earth-moving equipment and operator to expedite recovery of remains or sample, reduce any potential construction delay, and obviate need for additional recovery

personnel; after recovery of remains or sample, allow earth moving to proceed through fossil site).

Responsibilities of the construction management and construction contractor staff, particularly earth-moving equipment operators, if large fossil remains were uncovered by excavation, especially when a monitor was not on site when the remains were encountered (avoid disturbance of fossil site by earth moving; call monitor or principal investigator to construction site; if requested by mitigation program personnel, provide earth-moving equipment and operator to assist in recovery of remains, reduce any potential construction delay, and obviate need for additional recovery personnel).

Responsibilities of the construction management and construction contractor staff, particularly tunneling-machine operators, if fossil remains were uncovered by tunneling (avoid disturbance of occurrence by tunneling; recover remains; record associated specimen (fossil type) and corresponding geologic (rock unit, rock type) and geographic (location; elevation or depth) site data; retain remains and associated specimen and site data on site; call monitor or principal investigator to construction site to retrieve remains and associated data).

Legislation prohibiting unauthorized fossil collecting by construction management and construction contractor staff, and of MTA worker incentive program developed to encourage staff to submit fossil remains to paleontologic mitigation program personnel.

Lines of communication to be followed if fossil remains were uncovered by earth moving, especially when a monitor was not on site when the remains were encountered.

When warranted, a monitor gave a similar on-site presentation to construction contractor earth-moving equipment operators at one of their earliest safety meetings. The operators were briefed on recognizing fossil remains at the construction site; shown examples of fossil specimens similar to those that might be encountered at the site; informed of their responsibilities if they observed fossil remains, particularly when the monitor was not on site (avoid disturbance of remains by earth moving; have construction contractor staff call monitor or principal investigator to construction site; assist in recovery of

remains, if requested; if necessary, recover remains and associated specimen data and corresponding site data and retain for retrieval by paleontologic mitigation program personnel); advised that their unauthorized collecting of fossil remains was illegal; and told of the MTA worker incentive program.

#### 5.4 PALEONTOLOGIC CONSTRUCTION MONITORING AND LARGER FOSSIL SPECIMEN RECOVERY

In compliance with SCRTD/LACTC/MTA Specifications Section 01170 (see Appendix A) and mitigation measures developed during the Metro Red Line environmental impact review process (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983), paleontologic construction monitoring of earth moving was conducted by PEAI paleontologic construction monitors as part of the Segment 3 paleontologic resource impact mitigation program from April 1994 to December 1997 at the Red Line Segment 3 Hollywood/Highland, Universal City, and North Hollywood stations; Universal City cross-over; and the southern and northern Santa Monica Mountains tunnel access shafts. Monitoring was conducted in areas underlain by sedimentary rock units (Upper Topanga Formation, older and younger alluvium) with a moderate to high potential for containing larger fossil remains, and allowed for the discovery and subsequent recovery of any remains and associated specimen data and corresponding geologic and geographic site data uncovered by cut-and-cover excavation and any other earth-moving activity (augering for piles, trenching for utility lines; conveyance of earth-moving debris) in the Segment 3 construction zone. Monitoring ensured any potential construction delay would be avoided or kept to a minimum because a monitor usually was on site when remains were most likely to be uncovered by these earth-moving activities.

Monitoring consisted of visually inspecting previously undisturbed sedimentary rock exposed by earth moving, as well as the debris generated by earth moving. When a larger fossil specimen was found, the specimen was recovered by the monitor. Hand equipment was used when required. If necessary, an unusually large specimen would have been covered with a protective plaster-impregnated jacket prior to recovery. As stipulated by SCRTD/LACTC/MTA Specifications Section 01170, the monitor had the authority to divert earth moving temporarily around the fossil site until the remains had been recovered and earth moving allowed to proceed through the site by the monitor. If warranted, the fossil site could have

been flagged with colored survey ribbon to divert earth moving around the site, thereby ensuring the site would not be disturbed by earth moving. When necessary to ensure the monitor would not be diverted from the monitoring task and to reduce the potential for any construction delay, additional PEAI personnel (paleontologic field technicians) with hand equipment were assigned to the recovery effort to expedite recovery of the specimen and its transport to a laboratory facility for treatment. Following SCRTD/LACTC/MTA Specifications Section 01170, earth-moving equipment and an operator were enlisted to assist in and expedite recovery of some of the specimens, thereby obviating the need for additional recovery personnel and further reducing the potential for any construction delay. A temporary field number was assigned to each specimen; the field number, associated specimen data (preliminary field identification of taxon, element), and corresponding geologic (rock unit) and geographic (location; elevation or depth) site data recorded in daily monitoring logs or field notes; and the field number recorded and the site location plotted on a map of the construction site.

Augering was monitored to allow for the early determination of the location and depth of any fossil site in the subsurface prior to cut-and-cover excavation for a station, cross-over, or tunnel access shaft to ensure the monitor would be present to relocate the site and recover additional fossil remains when and where it was most likely the site would be encountered during excavation, and to ensure monitoring of excavation would be conducted at an appropriate level of effort.

Tunneling was not monitored because of the confined working space, although tunneling debris was inspected at the Universal City and North Hollywood station sites. However, as part of a worker incentive program developed by the LACTC and subsequently adopted by the MTA, construction management and construction contractor personnel were encouraged to recover fossil specimens and associated specimen data and corresponding geologic and geographic site data from the tunnels and tunneling debris and submit them to paleontologic mitigation program personnel.

Initially, monitoring was conducted on a part-time basis in areas underlain by the Upper Topanga Formation and older and younger alluvium because cut-and-cover excavation was considered to have only a moderate to high potential for uncovering fossil remains in these rock units, based on the comparatively low density (or local absence) of

previously recorded fossil sites in these rock units in the Segment 3 vicinity (Lander, 1987; UMTA and SCRTD, 1983, 1987; WESTEC Services, Inc., 1983). Part-time monitoring allowed one monitor to be present at more than one construction site on a daily basis. However, following the initial discovery of numerous fossilized logs and fish remains at previously unrecorded fossil sites in the younger alluvium and Upper Topanga Formation, respectively, during cut-and-cover excavation for the Universal City cross-over, and with MTA approval, the monitoring rate was increased at the construction site because of the high potential for additional similar fossil remains being uncovered by excavation of this rock unit.

#### 5.5 FOSSILIFEROUS ROCK SAMPLE PROCESSING AND SMALLER FOSSIL SPECIMEN RECOVERY

As part of the Metro Red Line Segment 3 paleontologic resource impact mitigation program, a number of sedimentary rock samples were recovered from selected rock units at several Segment 3 construction sites by a PEAI paleontologic field technician and/or other PEAI paleontologic mitigation program personnel to allow for the recovery of smaller fossil remains. Such remains normally are too small to be observed by a paleontologic construction monitor at a construction site, unless a monitor routinely dry test screens rock samples as part of the monitoring effort.

#### 5.5.1 Smaller Vertebrate Fossil Specimen Recovery

Periodically, as part of the monitoring task, small (25-pound) rock samples from the older and younger alluvium at the Hollywood/Highland, Universal City, and North Hollywood station sites, respectively, were dry test screened by a monitor to allow for the documentation of fossil sites suitable for recovering large fossiliferous rock samples that could be processed for the recovery of smaller vertebrate fossil remains. The recovery and processing of fossiliferous rock samples to allow for the recovery of smaller vertebrate fossil remains are recommended under SVP (1991, 1995; see Appendix B) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources. Under these guidelines, up to 6,000 pounds of fossiliferous rock from each fossil-bearing rock unit can be processed.

When fossil remains were observed in any rock sample dry test screened by the monitor, a

substantially larger sample of fossiliferous rock was recovered at the sampling site by the monitor, field technician, and/or other paleontologic mitigation program personnel for processing. Under SCRTD/LACTC/MTA Specifications Section 01170 (see Appendix A), mitigation program personnel had the authority to divert earth moving temporarily around the fossil site until the sample had been removed and earth moving allowed to proceed through the site by program personnel. If warranted, the fossil site could have been flagged with colored survey ribbon to divert earth moving around the site, thereby ensuring the site would not be disturbed by earth moving. When necessary to reduce the potential for any construction delay, additional PEAI mitigation program personnel, including field technicians with hand equipment, were assigned to the recovery effort to expedite recovery of the sample and its transport to another location for initial processing. Following SCRTD/LACTC/MTA Specifications Section 01170, earth-moving equipment and an operator were enlisted to assist in and expedite recovery of one sample, thereby obviating the need for additional PEAI mitigation program recovery personnel and further reducing the potential for any construction delay. A temporary field number was assigned to each sample; the field number, associated specimen data (preliminary field identification of taxon, elements), and corresponding geologic (rock unit) and geographic (location; elevation or depth) site data recorded in daily monitoring logs or field notes; and the field number recorded and the site location plotted on a map of the construction site.

Two rock samples weighing approximately 100 and 150 pounds each were recovered from the upper part of the older alluvium in the San Fernando Valley tunnel segment and at the North Hollywood station site, respectively, because this stratigraphic interval contained fossil remains and, at the North Hollywood station site, a carbonaceous layer.

Nine rock samples totaling nearly 7,000 pounds and including three test samples weighing from approximately 100 to 150 pounds each and six large samples weighing from approximately 1,000 to 1,600 pounds each were recovered from the lower 5 to 10 feet of the younger alluvium at the Universal City station site because this stratigraphic interval contained fossil remains and carbonaceous (organic-rich) layers.

Following sample recovery, the sample was transported to a processing site for initial (field) processing. Initial processing of the samples was

conducted by a paleontologic field technician to determine if smaller vertebrate fossil remains had been uncovered at the sampling site by cut-and-cover excavation. Initial processing of a sample consisted of wet screening or sieving the sediment comprising the sample through a 20-mesh box screen immersed in a tub of water to remove the smaller (clay, silt) sedimentary particles from the larger (sand, rock) particles and, if present, any smaller fossil remains, resulting in volume and weight reductions of approximately 90 to 95 per cent. If necessary, the sample would have been soaked in an environmentally safe dispersing agent (di-limonene or citrus oil) prior to wet screening to improve the separation of the clay particles from the rest of the sample during screening.

The concentrate generated by initial processing then was transported to a laboratory facility for final (laboratory) processing by a PEAI senior vertebrate paleontologist. The concentrate subsequently was examined by the paleontologist with a microscope and any fossil specimen removed by hand from the remaining sand and rock particles. Smaller fossil remains cannot be easily recovered without using the sophisticated sample processing technique described above.

If fossilized bones and teeth recovered from the concentrate had been determined to be sufficiently denser than the remaining sand and rock particles, a sophisticated separation/flotation technique employing an environmentally safe heavy liquid (sodium polytungstate) would have been used to separate the specimens from the remaining rock particles in the initial concentrate generated by field processing. When added to a separatory funnel filled with heavy liquid, the concentrate separates, the particles floating to the surface and the fossils sinking to the bottom, from where they are retrieved. This process can result in further volume and weight reductions in excess of 90 per cent (less than 1 per cent of original sample volume and weight). The final concentrate generated by heavy-liquid separation conducted as part of laboratory processing then would have been examined by the senior vertebrate paleontologist with a microscope and any fossil specimen removed by hand from the remaining sand and rock particles.

A test sample weighing from approximately 50 to 150 pounds was split from each larger rock sample weighing at least 1,000 pounds and then processed before the remainder of the sample was processed, or the test sample was recovered at a sampling site and

processed before additional rock was recovered at the site and processed. Final processing of a test sample and evaluation by the senior vertebrate paleontologist of the results of test processing before initial processing of the remainder of the sample or before recovering and processing additional rock had been undertaken made it possible to determine if the sample was sufficiently productive and the recovered fossil remains sufficiently well preserved, diagnostic, and taxonomically diverse to warrant processing of the remainder of the sample or recovering and processing more rock to allow for the recovery of additional remains. Processing of the remainder of the sample and any concentrate was completed or suspended, based on an evaluation by the senior vertebrate paleontologist of the results of final processing of the test samples. When processing was suspended, any remaining rock or concentrate was discarded.

#### **5.5.2 Smaller Invertebrate Fossil Specimen Recovery**

One of the 100-pound rock samples recovered from the lower 5 to 10 feet of the younger alluvium at the Universal City station site also contained mollusk shells, which were removed from the sample prior to processing for smaller vertebrate fossil remains. A second smaller rock sample also yielded mollusk shells.

#### **5.5.3 Microfossil Specimen Recovery**

Two 1-pound microfossil-bearing rock samples were recovered from the Upper Topanga Formation and younger alluvium at the Universal City station/cross-over site, and two 1-pound samples were recovered from the older alluvium at the North Hollywood station site and in the San Fernando Valley tunnel segment to process for the recovery of microfossils. Microfossil recovery requires a specialized processing technique substantially different from the technique required for recovering small vertebrate fossil remains..

#### **5.6 LABORATORY TREATMENT**

In the laboratory, larger fossil remains recovered in the Metro Red Line Segment 3 construction zone as part of the Segment 3 paleontologic resource impact mitigation program were prepared by a PEAI paleontologic laboratory technician. Preparation of a fossil specimen included removal of much of the rock containing the specimen. Preparation of fossil wood specimens also included sectioning by an F&F

paleobotanist to allow microscopic examination. Preparation sufficient to allow identification of a fossil specimen to the lowest taxonomic level possible (and reduce storage space) is recommended under SVP (1991, 1995, 1996; see Appendices B, C) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources. Identification of many of the specimens would not have been possible without preparation.

After preparation, all (larger and smaller) specimens were identified to the lowest taxonomic level possible and analyzed by knowledgeable PEAI senior paleontologists or, as appropriate, other paleontologists (F&F; Micropaleo Consultants, Inc.). Fossil specimen identification is recommended under SVP (1991, 1995, 1996; see Appendices B, C) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources, and now is required before a fossil collection will be accepted by most museum repositories, particularly the LACMVP (see Appendices E to G). Moreover, the scientific importance of a fossil specimen cannot be evaluated until the specimen has been identified to the lowest taxonomic level possible.

Microfossil-bearing rock samples were submitted to Micropaleo Consultants, Inc., for processing and the subsequent recovery, identification, and analysis of any microfossil remains.

Wood samples were submitted to F&F for preparation (including sectioning), identification, and analysis, and to Beta Analytic Inc. for carbon-14 dating analysis.

#### **5.7 MUSEUM TREATMENT**

After initial (field and laboratory) treatment, the fossil vertebrate, invertebrate, and plant specimens recovered in the Metro Red Line Segment 3 construction zone as part of the Segment 3 paleontologic resource impact mitigation program were accessioned into the fossil collections of the appropriate designated museum repositories (LACMIP, LACMVP, UCMP), and associated specimen data and corresponding geologic and geographic site data were archived at the same repositories. The fossil specimens were curated (assigned and labeled with appropriate repository specimen and site numbers; placed in specimen vials, if required, and trays with completed specimen data cards) and catalogued (specimen and site numbers and associated specimen data and corresponding geologic and geographic site data entered into

appropriate catalogs and computerized data bases of designated repositories) by a PEA I paleontologic laboratory technician or a museum curator, only the vertebrate specimens receiving specimen numbers. Fossil specimen curation and archiving of associated data are recommended under SVP (1991, 1995, 1996; see Appendices B, C) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources, and now are required before a fossil collection will be accepted by most museum repositories, particularly the LACMVP (see Appendix F).

At the designated museum repositories, the fossil specimens were placed in specimen storage cabinets and drawers for permanent storage and maintenance, and, along with associated data, will be retrievable and available for future study by qualified investigators. Under SVP (1991, 1995, 1996; see Appendices B, C) guidelines, adverse construction-related environmental impacts on paleontologic resources are not considered mitigated to an insignificant level until a fossil collection and associated data are accessioned into a museum repository and the repository archives, respectively, and made available by retrieval for later study.

### **5.8 SITE INSPECTIONS**

Periodic inspections of each Metro Red Line Segment 3 construction site and the laboratory facility were conducted on a monthly basis as part of the Segment 3 paleontologic resource impact mitigation program by the PEA I principal investigator to document the progress of cut-and-cover excavation and any other earth-moving activity at the site, and of initial treatment of any recovered fossil remains, as well as to ensure the appropriate monitoring rate was being employed at the site, based on the amount of excavation being conducted and the paleontologic productivity of the rock unit being excavated. As appropriate and with MTA approval, the monitoring rate at a particular construction site was maintained at the specified level, increased, or decreased, or monitoring was suspended.

### **5.9 REPORTING**

Monthly and quarterly progress reports were prepared by the PEA I principal investigator and forwarded to G&A for submission to PES and the MTA. The reports, which covered each Metro Red Line Segment 3 construction site and corresponding paleontologic resource impact mitigation program task, were based on monthly inspections by the principal investigator

and on verbal or written information received periodically from other PEA I paleontologic mitigation program personnel (senior vertebrate and invertebrate paleontologists, senior paleobotanist, paleontologic construction monitors, field/laboratory technicians), other paleontologists (F&F; Micropaleo Consultants, Inc.), and Beta Analytic Inc. The reports noted the progress of cut-and-cover excavation and of any work conducted by mitigation program personnel during the reporting period; results of paleontologic construction monitoring and of treatment and analysis of any fossil specimen or fossiliferous rock sample recovered as a result of monitoring; tentative identification of any fossil specimen recovered as a result of monitoring or sample processing; any problem encountered; measures implemented to resolve the problem; and the effectiveness of the measures.

This final technical report of results and findings for the Segment 3 paleontologic resource impact mitigation program complies with SVP (1991, 1995; see Appendix B) guidelines for mitigating adverse construction-related environmental impacts on paleontologic resources. The guidelines recommend preparation of a final report that describes project area geology/stratigraphy, summarizes field and laboratory methods used, includes a taxonomic list and an inventory of curated/catalogued fossil specimens, evaluates the scientific importance of the specimens, and discusses the relationship of any newly recorded fossil site in the project area to relevant fossil sites previously recorded from other areas. The report is prepared after the recovered specimens have been accessioned into a museum repository. Under SVP (1991, 1995, 1996; see Appendices B, C) guidelines, adverse construction-related impacts on paleontologic resources are not considered mitigated to an insignificant level and the mitigation program completed until the final report has been filed with the lead agency and the museum repository.

Submission of this report to the MTA signifies completion of the Los Angeles Metro Red Line Segment 3 paleontologic resource impact mitigation program and will assist the MTA in meeting its mitigation monitoring compliance and reporting responsibilities under California Public Resources Code Section 21081.6.

### **5.10 ADDITIONAL TASKS**

PEAI personnel, with the assistance of Dr. David P. Whistler of PEA I and the LACMVP, assisted in

establishing exhibits regarding some of the fossil remains recovered in the Segment 3 construction zone as part of the Segment 3 paleontologic resource impact mitigation program. One exhibit is on display in the MTA headquarters library. Another exhibit is a traveling display to be used by MTA Public Affairs personnel. Other exhibits are being developed for the

stations. PEAI personnel also assisted MTA Media Relations personnel by reviewing press releases; conducting newspaper, magazine, television, and film interviews; and in developing an MTA web site regarding the Segment 3 fossil remains and the beneficial effects of the mitigation program on paleontology.

SECTION 6

RESULTS

The results of the Los Angeles Metro Red Line Segment 3 paleontologic resource impact mitigation program are presented below. The locations of newly recorded PEA I fossil sites discovered as a result of the mitigation program, the fossil-bearing rock units present at these sites, and the fossil taxa recovered from each rock unit at a site are presented in Table 3 and Figures 7 to 11. Over 100 fossil vertebrate specimens, as well as numerous nonmarine mollusk, crustacean, and land plant specimens, and an undetermined number of microfossil specimens, were recovered at 54 newly recorded PEA I fossil sites subsequently catalogued under 3 LACMIP, 5 LACMVP, and 3 UCMP fossil site numbers (Table 3, Appendices L, M, N) as a result of the mitigation program. The vertebrate specimens subsequently were catalogued with LACMVP fossil specimen numbers (Appendix O).

The mitigation program reduced the adverse environmental impacts of construction-related excavation on the paleontologic resources of the Segment 3 construction zone to an insignificant level by allowing for the recovery of scientifically highly important fossil remains and the recording of associated specimen data and corresponding geologic and geographic site data that otherwise would have been lost to excavation and unauthorized fossil collecting, and by ensuring preservation of the fossil remains and archiving of associated data in museum repositories, where they will be retrievable and available for future study by qualified investigators. The invertebrate, vertebrate, and plant remains were accessioned into the fossil collections of the LACMIP, LACMVP, and UCMP, respectively, and associated specimen data and corresponding site data were archived at the appropriate museum repositories. The MTA deed of gift transferring the Segment 3 invertebrate and vertebrate fossil collections to the LACM is presented in Appendix P.

With the mitigation program, Segment 3 construction resulted in beneficial effects by exposing and allowing for the recovery of scientifically highly important fossil remains and the recording of associated specimen data and corresponding site data that would not even have been uncovered without construction-related excavation and, therefore, would not have been available for recovery.

6.1 UNNAMED EARLY CRETACEOUS QUARTZ DIORITE

No fossil remains were recovered from the early Cretaceous quartz diorite as a result of the Segment 3 mitigation program because this rock unit is unfossiliferous. Therefore, excavation of the rock unit was not monitored by a PEA I paleontologic construction monitor as part of the mitigation program.

6.2 UNNAMED LATE CRETACEOUS NONMARINE ROCK UNIT

No fossil remains were recovered from the unnamed late Cretaceous nonmarine rock unit as a result of the Segment 3 mitigation program because this rock unit was encountered by earth moving only in the Santa Monica Mountains tunnel segment, where paleontologic monitoring of earth moving was not conducted by a PEA I paleontologic construction monitor.

6.3 UNNAMED LATE CRETACEOUS MARINE ROCK UNIT

No fossil remains were recovered from the unnamed late Cretaceous marine rock unit as a result of the Segment 3 mitigation program because this rock unit was encountered by earth moving only in the Santa Monica Mountains tunnel segment, where paleontologic monitoring of earth moving was not conducted by a PEA I paleontologic construction monitor.

6.4 SANTA SUSANA FORMATION, SIMI CONGLOMERATE MEMBER

No fossil remains were recovered from the Simi Conglomerate Member of the Santa Susana Formation as a result of the Segment 3 mitigation program because this rock unit was encountered by earth moving only in the Santa Monica Mountains tunnel segment, where paleontologic monitoring of earth moving was not conducted by a PEA I paleontologic construction monitor.

6.5 SANTA SUSANA FORMATION, UNNAMED UPPER MEMBER

No fossil remains were recovered from the unnamed upper member of the Santa Susana Formation as a result of the Segment 3 mitigation program because this rock unit was encountered by earth moving only in the Santa Monica Mountains tunnel segment, where paleontologic monitoring of earth moving was not conducted by a PEAI paleontologic construction monitor.

#### **6.6 LOWER TOPANGA FORMATION**

No fossil remains were recovered from the Lower Topanga Formation as a result of the Segment 3 mitigation program because this rock unit was encountered by earth moving only in the Santa Monica Mountains tunnel segment, where paleontologic monitoring of earth moving was not conducted by a PEAI paleontologic construction monitor.

#### **6.7 UNNAMED MIDDLE MIOCENE SUBMARINE VOLCANIC ROCK UNIT**

No fossil remains were recovered from the early unnamed middle Miocene submarine volcanic rock unit as a result of the Segment 3 mitigation program because this rock unit is unfossiliferous. Therefore, excavation of the rock unit was not monitored by a PEAI paleontologic construction monitor as part of the mitigation program.

#### **6.8 MIDDLE TOPANGA FORMATION**

Fossil marine clam shell fragments questionably assignable to the Lucinidae were recovered from a dark gray sandstone at newly recorded LACMIP fossil site 17099 by a construction worker at a depth approximately 700 feet below grade in the southern part of the Santa Monica Mountains tunnel segment and 4,700 feet from the Santa Monica Mountains northern tunnel access shaft as a result of the Segment 3 mitigation program (Groves, 1997; see Table 3, Figures 7, 8, Appendix L). The remains are scientifically highly important because they indicate that strata interbedded with the unnamed middle Miocene submarine volcanic rock unit and assignable to the Middle Topanga Formation occur in the tunnel segment.

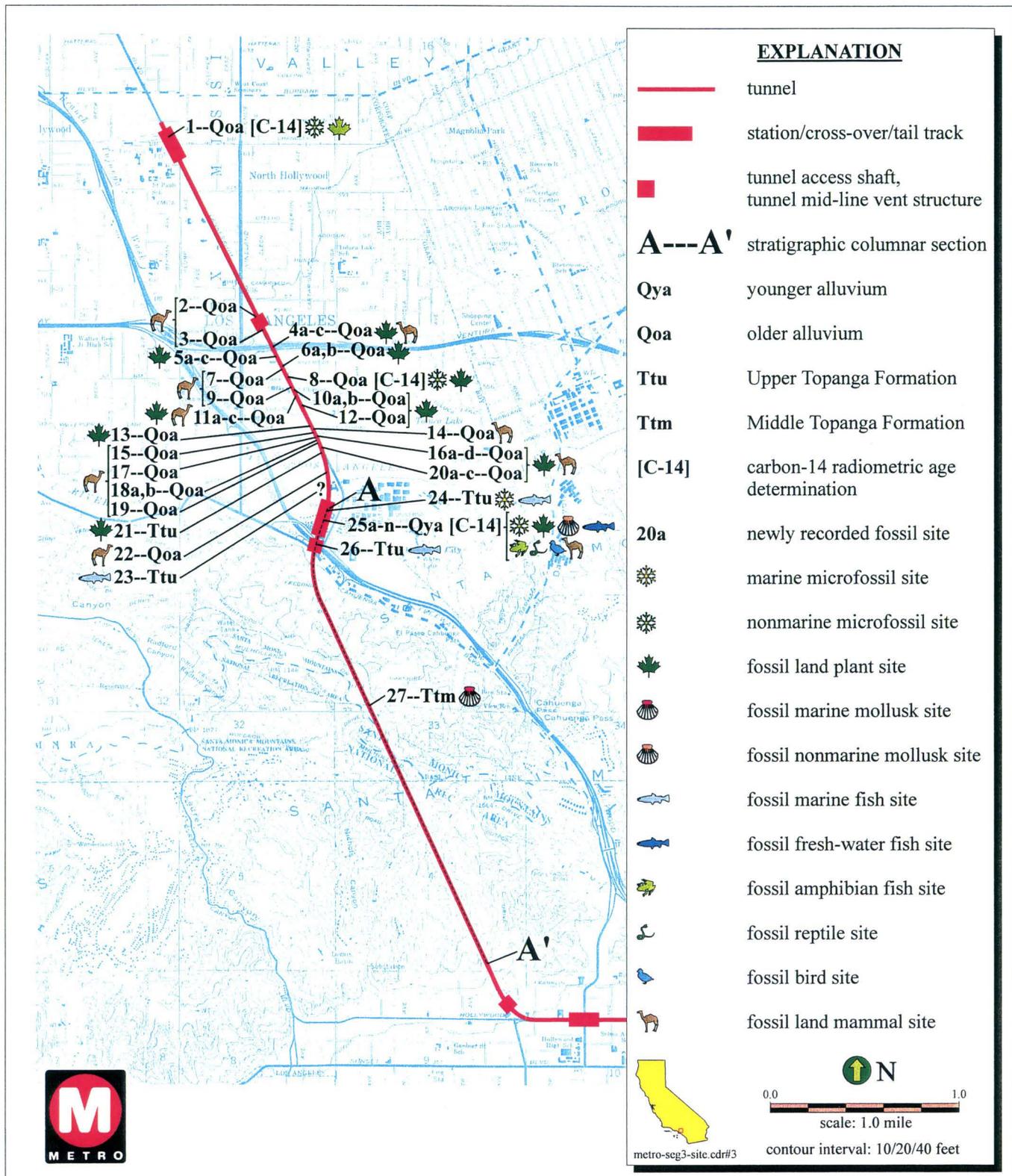
#### **6.9 UPPER TOPANGA FORMATION**

Nearly 35 identifiable marine fish specimens and one marine microfossil sample were recovered at newly recorded PEAI fossil sites at the Santa Monica Mountains northern tunnel access shaft and starter

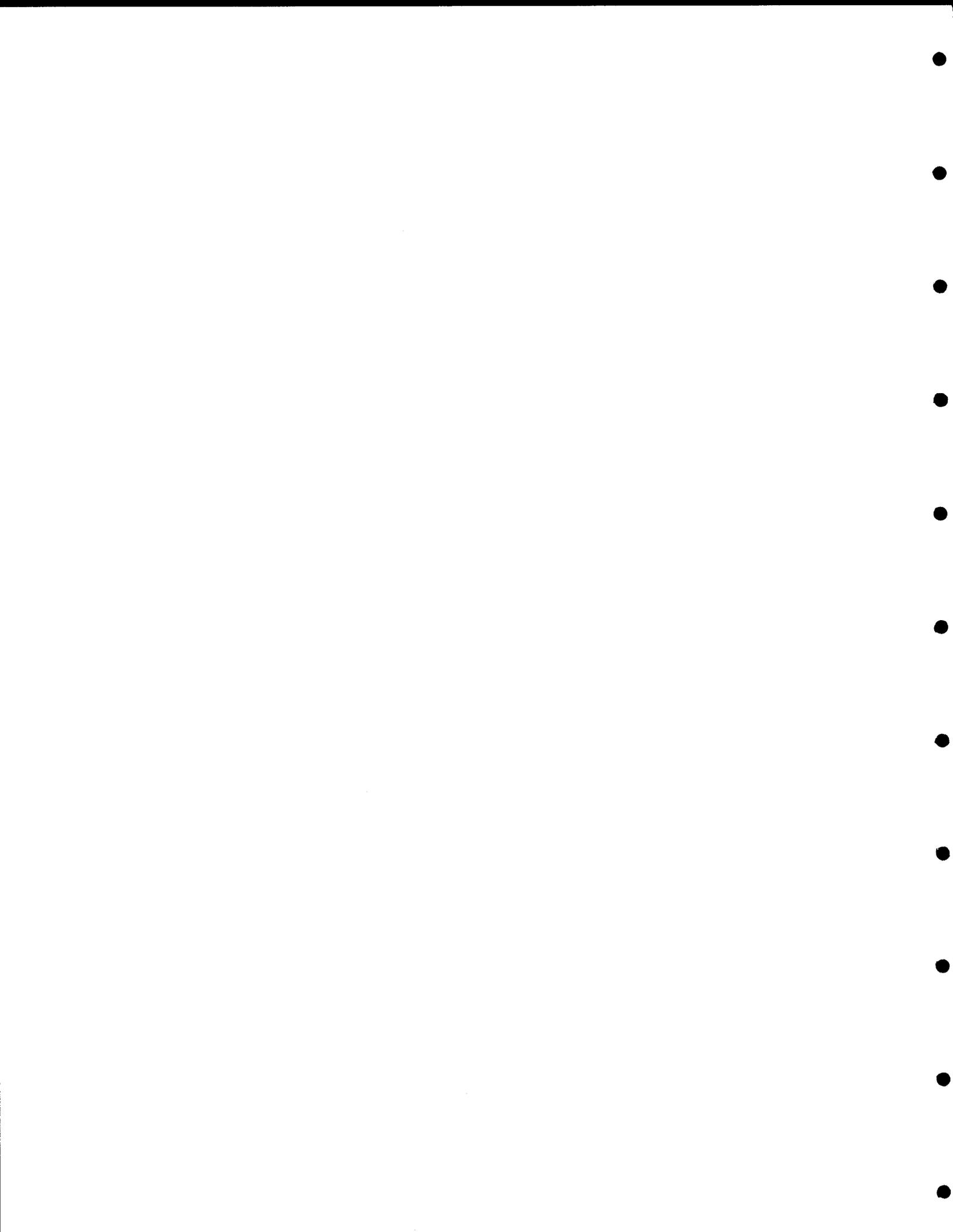
tunnel sites and the Universal City station/cross-over site, and in the southern part of the San Fernando Valley tunnel segment as a result of the Segment 3 mitigation program, all of the microfossil specimens and virtually all of the fossil fish specimens having been recovered from the station/cross-over site (see Table 3, Figures 7 to 10). The fossil fish sites were catalogued under LACMVP fossil site number 6969 (see Table 3, Appendix M). One small rock sample was submitted for palynological (pollen) analysis (see Tables 3, 4, Figures 7, 9). Prior to analysis of these specimens and the microfossil sample, the fossil record of the Upper Topanga Formation in the ancestral northwestern Los Angeles basin was very poorly known (see above).

#### **6.9.1 Microfossils**

A microfossil-bearing sample of the Upper Topanga Formation was recovered as part of the Segment 3 mitigation program conducted during excavation for the Universal City station (see Table 4). The sample subsequently was submitted to Micropaleo Consultants, Inc., to process for the recovery, identification, and analysis of age-diagnostic and depth-sensitive microfossil specimens. The sample yielded microfossils representing at least 13 marine foraminifer (shelled amoeba) and calcareous nannoplankton species (Micropaleo Consultants, Inc., 1998; see Table 5, Appendix S). These microfossils are scientifically highly important because the species they represent allow paleoenvironmental reconstruction of the southeastern San Fernando Valley and adjacent northeastern Santa Monica Mountains areas during the middle Miocene Epoch and deposition of the sediments comprising the Upper Topanga Formation, and provide an estimate of the age of the formation. The benthic (bottom-dwelling) foraminifer species indicate the microfossil assemblage from the station site probably is assignable to the Luisian Stage and represents a lower middle bathyal (very-deep-water marine) environment and ocean depths roughly 4,700 to 6,250 feet below sea level, but possibly closer to 4,700 feet (Boettcher, R.S., *in* Micropaleo Consultants, Inc., 1998). Assignment to the Luisian Stage suggests the entire fossil assemblage from the station site and vicinity is early (but not earliest?) middle to late (but not latest) middle Miocene and, based on recent revisions of the paleomagnetic polarity time scale, approximately 12.7 million to 16.4 million years in age (see Berggren and others, 1995; Blake, 1991; Micropaleo Consultants, Inc., 1993). The age determination and paleoenvironmental reconstruction provided by the Universal City station sample are similar to those



**Figure 7.**—Fossil-bearing rock units and distribution of fossil taxa by rock unit and newly recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone, Los Angeles, California. Base map: U.S. Geological Survey Beverly Hills, Burbank, Hollywood, and Van Nuys 7.5-minute Quadrangles. Geology after CWDD and others (1981), Dibblee (1991a, -b), MTA and others (1995a to -c), RCC and others (1993a, -b), and WESTEC Services, Inc. (1983). See Table 3, Figures 1, 8 to 11, Appendices L, M, N.



**Table 3.**—Newly recorded fossil sites, Los Angeles Metro Red Line Segment 3 construction zone, Los Angeles, California. See Figures 1, 6 to 11, Tables 1, 2, 4 to 12, Appendices L, M, N.

Map Fossil Site Number <sup>a</sup>	Museum Fossil Site Number	PEAI <sup>b</sup> Fossil Site Number	Fossil Site Location (Lithology)	Rock Unit	Fossil Taxon	Age (years)
1	UCMP <sup>c</sup> PB-98003, uncatalogued microfossil site	DPW <sup>d</sup> 2516	North Hollywood station, 80 feet below grade (tan clayey silt)	older alluvium	land plants (wood, pollen)	> 46,340
2	LACMVP 6970		south-bound San Fernando Valley tunnel segment, tunnel station 995 + 68, 120 feet north of tunnel mid-line vent structure, between Kling and Hortense Streets, 70 feet below grade	older alluvium	land mammal	
3	LACMVP 6970		south-bound San Fernando Valley tunnel segment, tunnel station 991 + 90, 170 feet south of tunnel mid-line vent structure, between Hortense Street and Ventura Freeway, 70 feet below grade	older alluvium	land mammal	
4a	LACMVP 6970		north-bound San Fernando Valley tunnel segment, tunnel station 986 + 67, below Ventura Freeway, 70 feet below grade	older alluvium	land mammal	
4b	uncatalogued fossil plant site		north-bound San Fernando Valley tunnel segment, tunnel station 986 + 63, below Ventura Freeway, 60 to 80 feet below grade	older alluvium	land plant (wood)	
4c	LACMVP 6970		north-bound San Fernando Valley tunnel segment, tunnel station 986 + 43, below Ventura Freeway, 71 feet below grade	older alluvium	land mammal	
5a	uncatalogued fossil plant site		north-bound San Fernando Valley tunnel segment, tunnel station 983 + 90, below Riverside Drive, 60 to 80 feet below grade	older alluvium	land plant (wood)	
5b	uncatalogued fossil plant site		north-bound San Fernando Valley tunnel segment, tunnel station 983 + 32, between Riverside Drive and Landale Street, 60 to 80 feet below grade	older alluvium	land plant (wood)	
5c	uncatalogued fossil plant site		north-bound San Fernando Valley tunnel segment, tunnel station 983 + 28, between Riverside Drive and Landale Street, 68 feet below grade	older alluvium	land plant (wood)	
6a	uncatalogued fossil plant site		north-bound San Fernando Valley tunnel segment, tunnel station 980 + 57, between Riverside Drive and Landale Street, 71 feet below grade	older alluvium	land plant (wood)	
6b	uncatalogued fossil plant site		north-bound San Fernando Valley tunnel segment, tunnel station 980 + 53, between Riverside Drive and Landale Street, 71 feet below grade	older alluvium	land plant (wood)	
7	LACMVP 6970		north-bound San Fernando Valley tunnel segment, tunnel station 979 + 52, between Landale and Moorpark Streets, 67 feet below grade	older alluvium	land mammal	
8	UCMP PB-98004	DPW 2565, 2566	north-bound San Fernando Valley tunnel segment, tunnel station 977 + 30, between Landale and Moorpark Streets, 67 feet below grade	older alluvium	land plants (wood, pollen)	> 48,620

9	LACMVP 6970	south-bound San Fernando Valley tunnel segment, tunnel station 974 + 56, between Moorpark and Bloomfield Streets, 67 feet below grade	older alluvium	land mammal
10a	uncatalogued fossil plant site	San Fernando Valley tunnel segment cross passage, tunnel station 973 + 61, between Moorpark and Bloomfield Streets, 72 feet below grade	older alluvium	land plant (wood)
10b	uncatalogued fossil plant site	north-bound San Fernando Valley tunnel segment, tunnel stations 973 + 53 to 65, between Moorpark and Bloomfield Streets, 60 to 80 feet below grade	older alluvium	land plant (wood)
11a	LACMVP 6970	north-bound San Fernando Valley tunnel segment, tunnel station 971 + 98, between Bloomfield and Woodbridge Streets, 65 feet below grade	older alluvium	land mammal
11b	LACMVP 6970, uncatalogued fossil plant site	north-bound San Fernando Valley tunnel segment, tunnel stations 971 + 48 to 60, between Bloomfield and Woodbridge Streets, 60 to 80 feet below grade	older alluvium	land plant (wood), land mammal
11c	uncatalogued fossil plant site	north-bound San Fernando Valley tunnel segment, tunnel station 971 + 37, between Bloomfield and Woodbridge Streets, 70 feet below grade	older alluvium	land plant (wood)
12	uncatalogued fossil plant site	north-bound San Fernando Valley tunnel segment, tunnel station 968 + 96, between Woodbridge and Whipple Streets, 60 to 80 feet below grade	older alluvium	land plant (wood)
13	uncatalogued fossil plant site	north-bound San Fernando Valley tunnel segment, tunnel station 962 + 30, between Whipple Street and Valley Spring Lane, 70 feet below grade	older alluvium	land plant (wood)
14	LACMVP 6970	south-bound San Fernando Valley tunnel segment, tunnel station 961 + 46, between Valley Spring Lane and Acama Street, 60 to 80 feet below grade	older alluvium	land mammal
15	LACMVP 6970	north-bound San Fernando Valley tunnel segment, tunnel station 960 + 20, between Valley Spring Lane and Acama Street, 60 to 80 feet below grade	older alluvium	land mammal
16a	uncatalogued fossil vertebrate site	north-bound San Fernando Valley tunnel segment, tunnel station 959 + 62, between Valley Spring Lane and Acama Street, 66 feet below grade	older alluvium	land mammal
16b	LACMVP 6970	north-bound San Fernando Valley tunnel segment, tunnel station 959 + 32, between Valley Spring Lane and Acama Street, 60 to 80 feet below grade	older alluvium	land mammal
16c	uncatalogued fossil plant site	north-bound San Fernando Valley tunnel segment, tunnel station 959 + 28, between Valley Spring Lane and Acama Street, 60 to 80 feet below grade	older alluvium	land plant (wood)
16d	LACMVP 6970	north-bound San Fernando Valley tunnel segment, tunnel station 959 + 9, between Valley Spring Lane and Acama Street, 60 to 80 feet below grade	older alluvium	land mammal
17	LACMVP 6970	south-bound San Fernando Valley tunnel segment, tunnel station 958 + 50, between Valley Spring Lane and Acama Street, 60 to 80 feet below grade	older alluvium	land mammal
18a	LACMVP 6970	south-bound San Fernando Valley tunnel segment, tunnel stations 957 + 55 to 958 + 10, under Acama Street or between Acama and Aqua Vista Streets, 60 to 80 feet below grade	older alluvium	land mammal

18b	LACMVP 6970		south-bound San Fernando Valley tunnel segment, tunnel station 957 + 80, between Acama and Aqua Vista Streets, 60 to 80 feet below grade	older alluvium	land mammal	
19	LACMVP 6970		north-bound San Fernando Valley tunnel segment, tunnel stations 956 + 44 to 957 + 02, between Acama and Aqua Vista Streets, 60 to 80 feet below grade	older alluvium	land mammal	
20a	LACMVP 6970		north-bound San Fernando Valley tunnel segment, tunnel stations 955 + 66 to 956 + 44, between Acama and Aqua Vista Streets, 60 to 80 feet below grade	older alluvium	land mammal	
20b	LACMVP 6970		north-bound San Fernando Valley tunnel segment, tunnel station 955 + 94, between Acama and Aqua Vista Streets, 71 feet below grade, 8 feet above Upper Topanga Formation	older alluvium	land mammal	
20c	LACMVP 6970		north-bound San Fernando Valley tunnel segment, tunnel station 955 + 66, between Acama and Aqua Vista Streets, 68 feet below grade, 3 feet above Upper Topanga Formation	older alluvium	land mammal	
21	UCMP PB-99030		south-bound San Fernando Valley tunnel segment, tunnel station 953 + 89, between Aqua Vista and Chiquita Streets, 68 to 80 feet below grade	Upper Topanga Formation	land plant (wood)	
22	LACMVP 6970		south-bound San Fernando Valley tunnel segment, tunnel station 949 + 32, below Los Angeles River	older alluvium	land mammal	
23	LACMVP 6969		San Fernando Valley tunnel segment, between tunnel station 958 + 39 and Universal City station, south of Acama Street	Upper Topanga Formation	marine fishes	
24	LACMVP 6969, uncatalogued microfossil site	MM 970225	Universal City station/cross-over, 50 to 90 feet below grade	Upper Topanga Formation	marine microfossils, fishes	
25a	uncatalogued plant fossil site		Universal City station/cross-over, 35 feet below grade	younger alluvium	land plant (wood)	
25b	uncatalogued vertebrate fossil site <sup>c</sup>		Universal City station/cross-over, 40 feet below grade	younger alluvium	land mammal <sup>c</sup>	
25c	uncatalogued fossil plant site		Universal City station/cross-over, 42 feet below grade	younger alluvium	land plant (wood)	
25d	UCMP PB-98002	RDT 961015	Universal City station/cross-over, piles E22 to E23, 45 feet below grade, 5 to 10 feet above Upper Topanga Formation (gray sandy silt)	younger alluvium	land plant (wood)	7,860 ± 80
25e	LACMVP 6386, UCMP PB-98002	RDT 96822	Universal City station/cross-over, piles W35 to W36, 45 feet below grade, 5 to 10 feet above Upper Topanga Formation	younger alluvium	land plant (wood), land mammal	10,500 ± 70
25f	LACMIP 16967, LACMVP 6385, uncatalogued fossil plant site	MM 961220, RDT 970205, 970212b	Universal City station/cross-over, pile E22, 40 or 45 to 50 or 55 feet below grade, 5 to 10 feet above Upper Topanga Formation; gray clay (silt, sandy silt, and sand)	younger alluvium	land plants (wood), nonmarine mollusks, continental vertebrates	

25g	LACMIP 16967, uncatalogued fossil plant site	MM 961024-1	Universal City station/cross-over, piles W11 to W14, 50 feet below grade	younger alluvium	land plant (wood), nonmarine mollusks	
25h	uncatalogued fossil plant site		Universal City station/cross-over, pile E52, 55 feet below grade, 5 feet above Upper Topanga Formation (gray clay and clayey sand)	younger alluvium	land plant (wood)	
25i	uncatalogued fossil plant site		Universal City station/cross-over, pile W44, 56 feet below grade, 3 to 4 feet above Upper Topanga Formation (gray clayey silt)	younger alluvium	land plant (wood)	
25j	uncatalogued fossil plant site		Universal City station/cross-over, pile W46, 58 feet below grade, 1 to 2 feet above Upper Topanga Formation (gray clay and silty sand)	younger alluvium	land plant (wood)	
25k	LACMVP 6306, UCMP PB-98002	DPW 2502, 2504, 2505, 2508, 2509, GTT 951025	Universal City station/cross-over, piles W2 to W4 and N48 to N50, 61 feet below grade, 3 feet above Upper Topanga Formation (gray sandy clay, sandy silt, and sand)	younger alluvium	land plants (wood, pollen), continental vertebrates	8,880 ± 60
25l	uncatalogued fossil plant site		Universal City station/cross-over, pile N8, 57 feet below grade, 0.5 feet above Upper Topanga Formation (gravel)	younger alluvium	land plant (wood)	
25m	uncatalogued fossil plant site	RDT 970212a	Universal City station/cross-over, piles E42 to E43, 40 feet below grade (gray gravel)	younger alluvium	land plant (wood)	
25n	LACMIP 16966		Universal City station/cross-over	younger alluvium	nonmarine snail	
26	LACMVP 6969		Santa Monica Mountains tunnel segment northern tunnel access shaft/starter tunnels, 50 to 90 feet below grade	Upper Topanga Formation	marine fishes	
27	LACMIP 17099		Santa Monica Mountains tunnel segment, tunnel station 710 + 88, 4,700 feet south of northern tunnel access shaft, 680 to 720 feet below grade (dark gray sandstone)	Middle Topanga Formation <sup>1</sup>	marine clam	

<sup>a</sup>Map fossil site number in Figures 7 to 11.

<sup>b</sup>PEAI: Paleo Environmental Associates, Inc.

<sup>c</sup>LACMIP: Natural History Museum of Los Angeles County Invertebrate Paleontology Section;

LACMVP: Natural History Museum of Los Angeles County Vertebrate Paleontology Section;

UCMP: University of California Museum of Paleontology Paleobotany Section.

<sup>d</sup>DPW: David P. Whistler, PEA I;

GTT: Gary T. Takeuchi, PEA I;

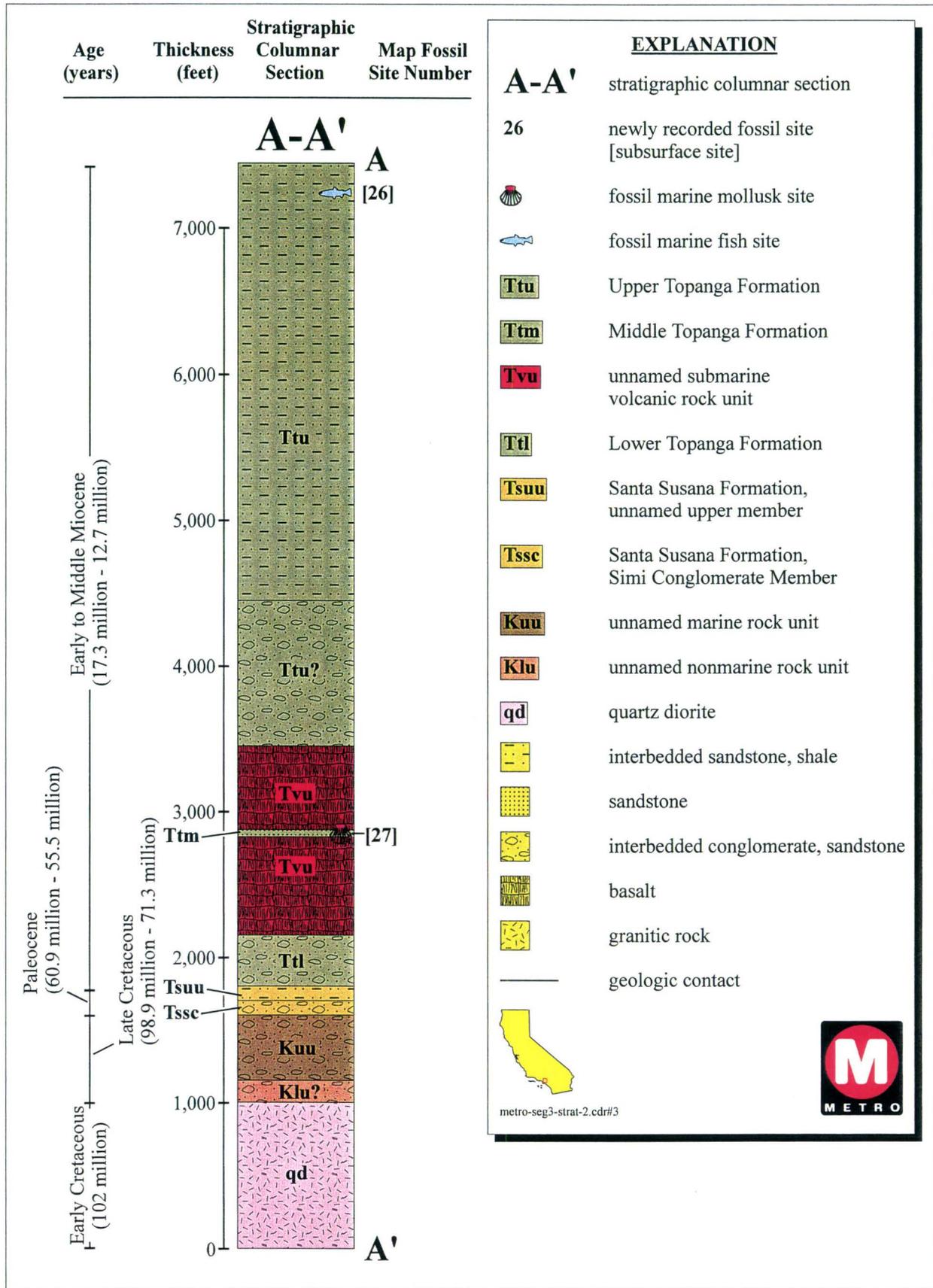
MM: Michael W. Morris, PEA I;

RDT: Robin D. Turner, PEA I;

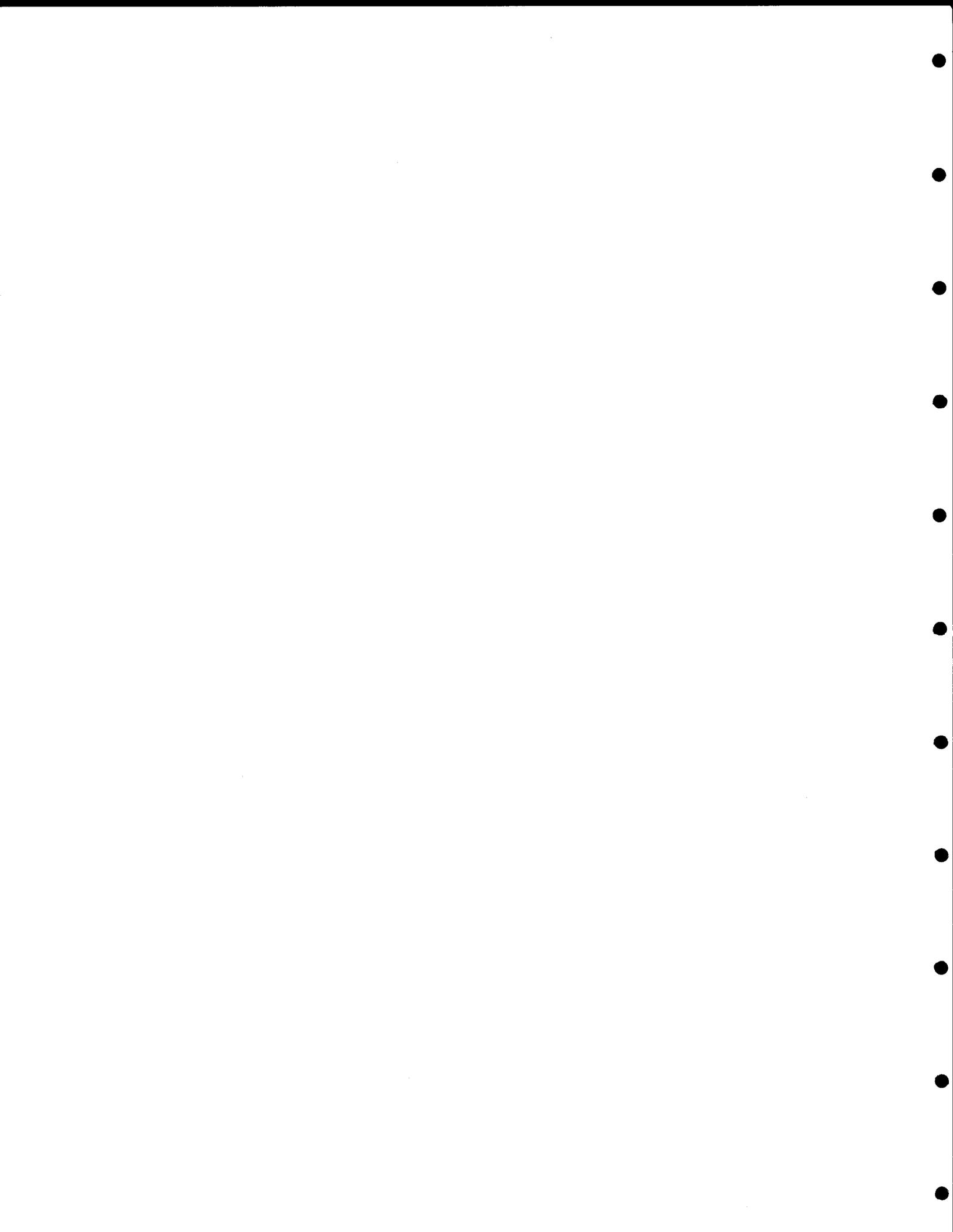
TLS: Trudy L. Stubbs, PEA I.

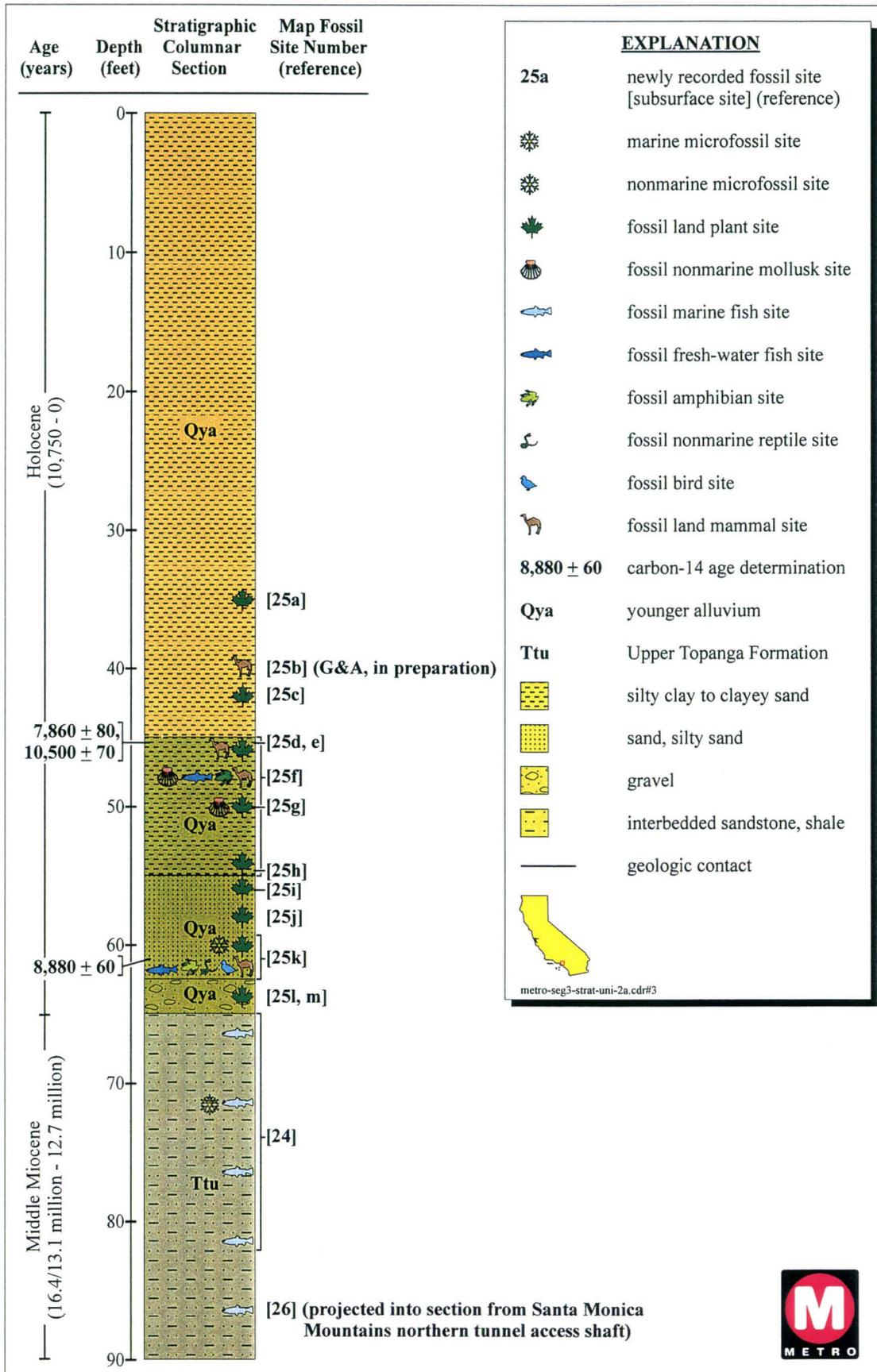
<sup>e</sup>See Greenwood and Associates (in preparation).

<sup>f</sup>Fossil site stated by construction worker to be in unnamed middle Miocene submarine volcanic unit. However, fossil remains enclosed by sandstone.

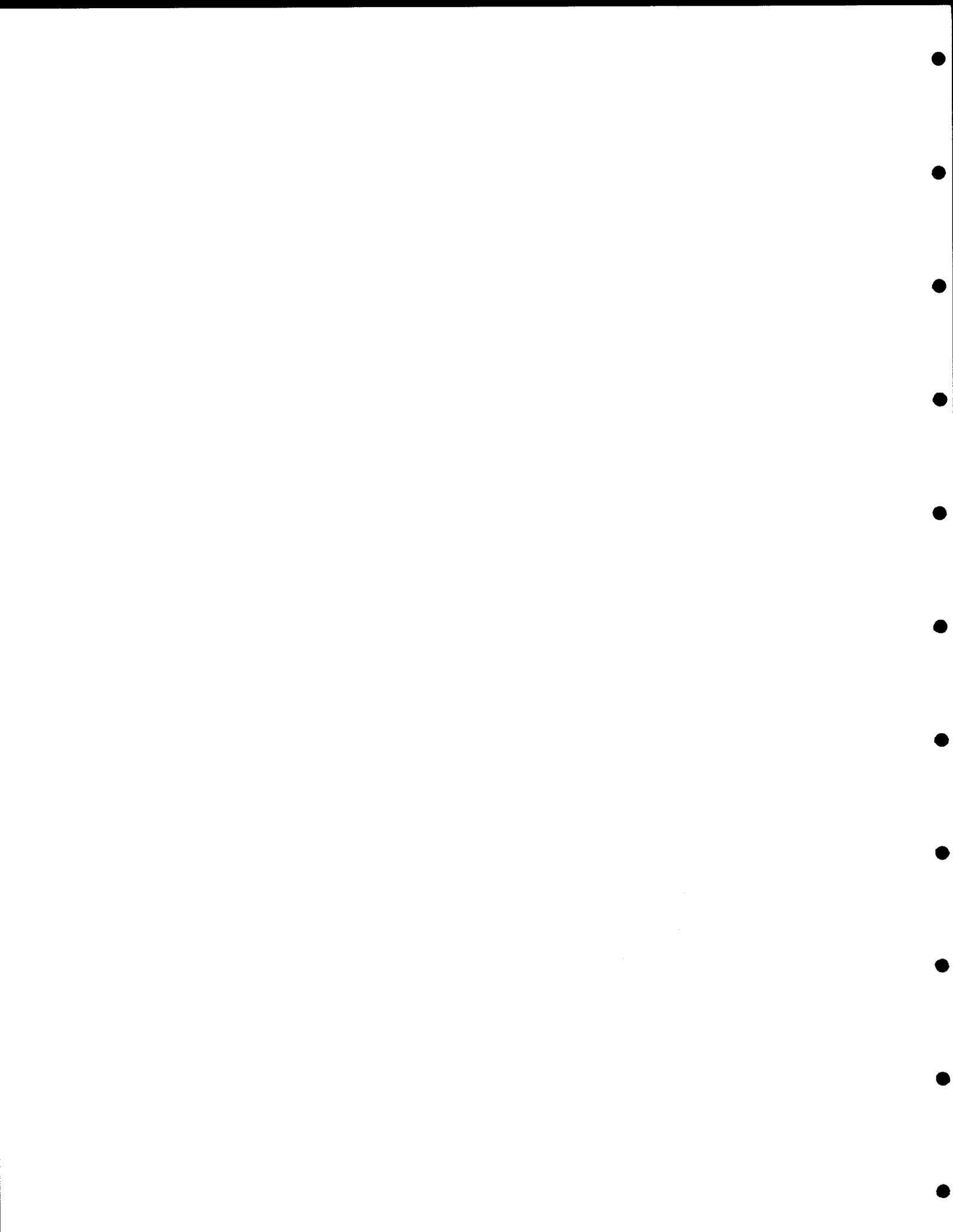


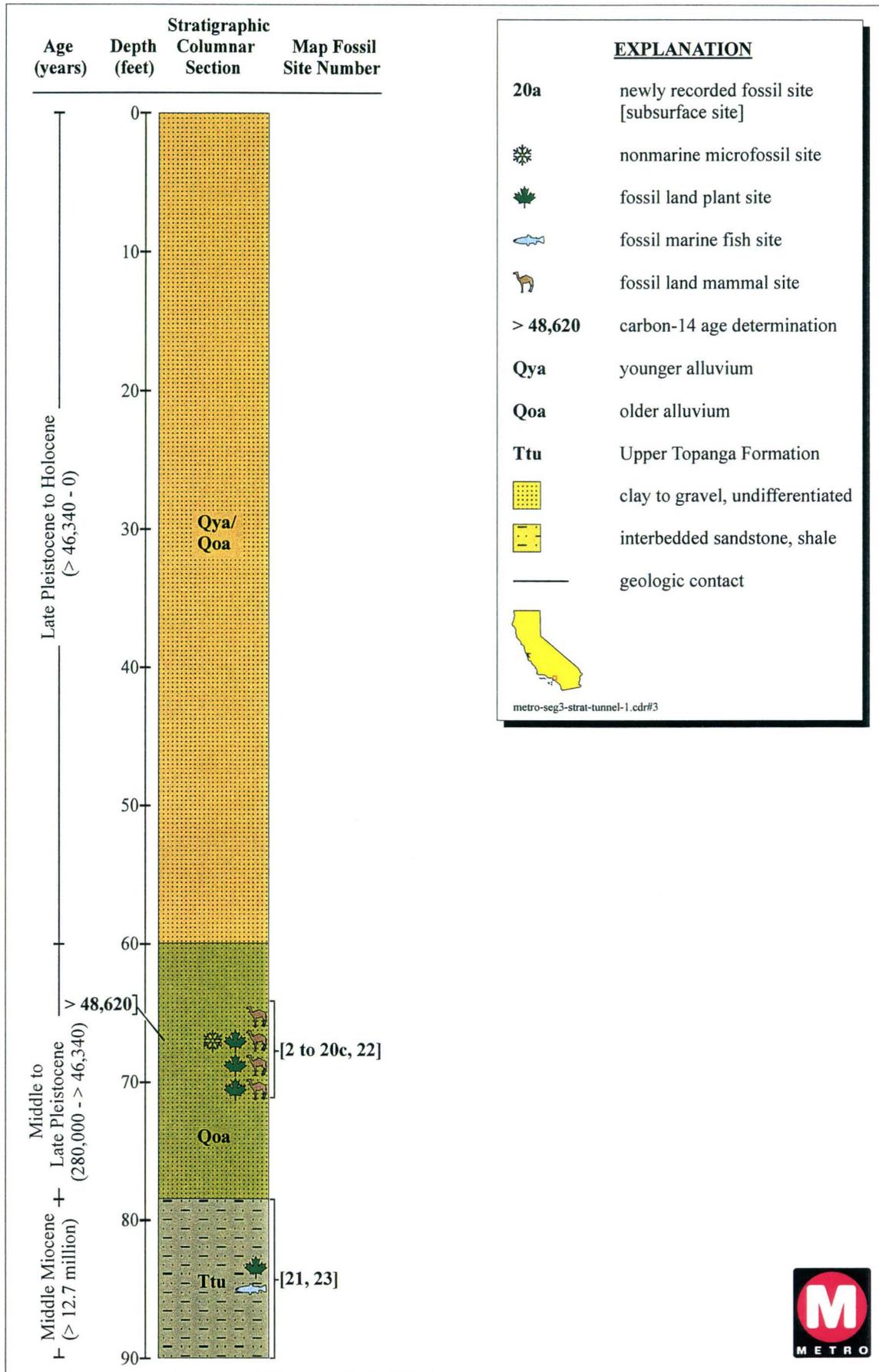
**Figure 8.**—Generalized stratigraphic columnar section and distribution of fossil taxa by rock unit and newly recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone, Santa Monica Mountains tunnel segment, Los Angeles, California. Rock units and corresponding lithologies after Dibblee (1991a) and RCC and others (1993a). Ages of rock units after Alderson (1988), Berggren and others (1995), Blake (1991), Dibblee (1991a), Gradstein and others (1995), Jefferson (1991b), Lander (1999), Micropaleo Consultants, Inc. (1993, 1998), Saul (1983), Turner (1970), Yerkes and Campbell (1979), and Zinsmeister (1983). Stratigraphic levels of fossil sites approximate. See Tables 1, 3, Figures 1, 7.



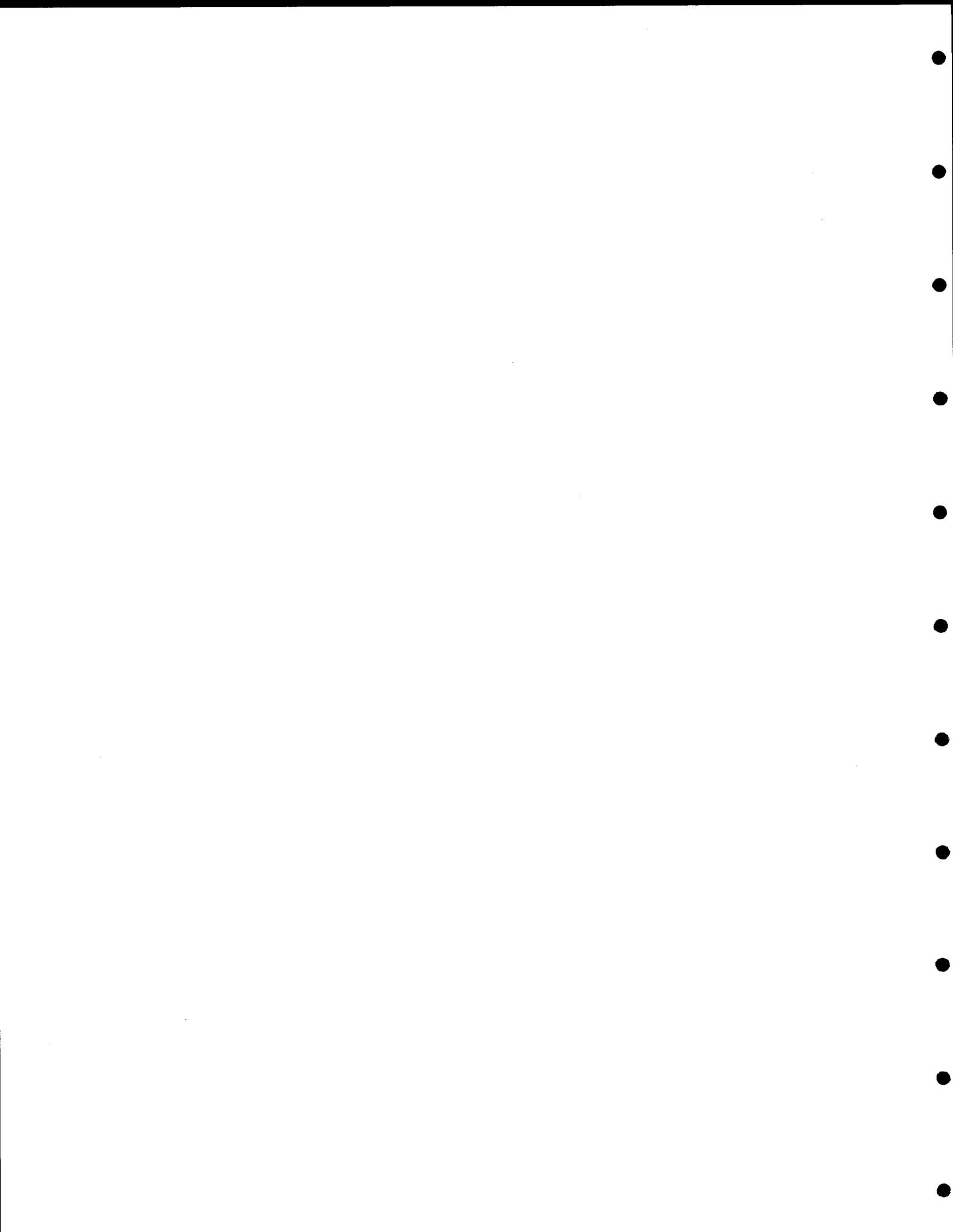


**Figure 9.**—Generalized stratigraphic columnar section and distribution of fossil taxa by rock unit and newly recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone, Universal City station site and immediate vicinity, Los Angeles, California. Rock units and corresponding lithologies after MTA and others (1995c) and RCC and others (1993b). Ages of rock units after Berggren and others (1995), Dibblee (1991a), Jefferson (1991b), Lander (1999), Micropaleo Consultants, Inc. (1993, 1998), and Turner (1970). Carbon-14 age determinations after Beta Analytic Inc. (1995, 1997). Stratigraphic levels of fossil sites approximate. See Tables 1, 3, Figures 1, 7, Appendices V, Y. G&A: Greenwood and Associates.





**Figure 10.**—Generalized stratigraphic columnar section and distribution of fossil taxa by rock unit and newly recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone, San Fernando Valley tunnel segment, Los Angeles, California. Rock units and corresponding lithologies after RCC and others (1993b). Ages of rock units after Berggren and others (1995), Jefferson (1991b), and Lander (1999). Carbon-14 age determination after Beta Analytic Inc. (1996b). Stratigraphic levels of fossil sites approximate. See Tables 1, 3, Figures 1, 7, Appendix X.



**Table 4.**—Status of wood, microfossil, pollen, and fossiliferous rock samples from newly recorded fossil sites, Upper Topanga Formation and undifferentiated older and younger alluvium, Los Angeles Metro Red Line Segment 3 construction zone, Universal City and North Hollywood station sites and San Fernando Valley tunnel segment, Los Angeles, California (see Table 3, Figures 1, 7, 9 to 11, Appendices L, M, N).

Map Fossil Site Number <sup>a</sup>	PEAI <sup>b</sup> Sample/ Fossil Site Number	Museum Fossil Site Number	Rock Sample Weight (pounds)	Rock Processed (pounds)	Fossil Type Recovered	Status of Fossil Remains
<b>Upper Topanga Formation, Universal City Station Site</b>						
24	MM 970225 <sup>c</sup>	—	—	—	foraminifers	identified/analyzed
<b>Older Alluvium, North Hollywood Station Site</b>						
1	DPW 2516	—	150	150	—	—
		UCMP <sup>d</sup> PB-98003	—	—	pollen wood	identified, analyzed dated, identified/analyzed, curated
		<b>Subtotal:</b>	<b>150</b>	<b>150</b>		
<b>Older Alluvium, San Fernando Valley Tunnel Segment</b>						
8	DPW 2565	UCMP PB-98004	—	—	wood	dated, identified/analyzed, curated
	DPW 2566	—	—	—	pollen	identified, analyzed
—	—	—	100	100	—	—
		<b>Subtotal:</b>	<b>100</b>	<b>100</b>		
<b>Younger Alluvium, Universal City Station Site</b>						
25d	RDT 961015	UCMP PB-98002	—	—	wood	dated, curated
25e	RDT 96822	LACMVP 6386	1,000	100 <sup>e</sup>	tooth	identified/catalogued
		UCMP PB-98002	—	—	wood	dated, curated
25f	MM 961220	LACMIP 16967	—	—	shells	identified/curated
		LACMVP 6385	100	100	bones	identified/catalogued
25g	MM 961024-1	LACMIP 16967	—	—	shells	identified/curated
25k	DPW 2502	LACMVP 6306	150	150	bones/teeth	identified/catalogued
		—	—	—	pollen, ostracods	identified/analyzed
	DPW 2505	UCMP PB-98002	—	—	wood	dated, identified/analyzed, curated
	DPW 2506	—	100	100	—	—
	DPW 2508	UCMP PB-98002	—	—	wood	curated
	DPW 2509	UCMP PB-98002	—	—	wood	identified/analyzed, curated
	GTT 951025	LACMVP 6306	1,600	1,600	bones/teeth	identified/catalogued
25m	RDT 970212a	—	1,000	0 <sup>e</sup>	—	—
25-	TLS 71696a	—	1,000	100 <sup>e</sup>	—	—
	TLS 71696b	—	1,000	50 <sup>e</sup>	—	—
	TLS 71696c	—	1,000	50 <sup>e</sup>	—	—
		<b>Subtotal:</b>	<b>6,950</b>	<b>2,250</b>		
		<b>TOTAL:</b>	<b>7,200</b>	<b>2,500</b>		

<sup>a</sup>Map fossil site number in Figures 7, 9 to 11.

<sup>b</sup>PEAI: Paleo Environmental Associates, Inc.

<sup>c</sup>DPW: David P. Whistler, PEAI;

GTT: Gary T. Takeuchi, PEAI;

MM: Michael W. Morris, PEAI;

RDT: Robin D. Turner, PEAI;

TLS: Trudy L. Stubbs, PEAI.

<sup>d</sup>LACMIP: Natural History Museum of Los Angeles County Invertebrate Paleontology Section;

LACMVP: Natural History Museum of Los Angeles County Vertebrate Paleontology Section;

UCMP: University of California Museum of Paleontology Paleobotany Section.

<sup>e</sup>Test sample unproductive. Processing of remainder of sample discontinued. Sample discarded.

**Table 5.**—Microfossil list, Upper Topanga Formation, Los Angeles Metro Red Line Segment 3 construction zone, Universal City station site, Los Angeles, California. After Boettcher, R.S.; Kling, S.A., in Micropaleo Consultants, Inc. (1998). See Tables 3, 4, Figures 1, 7, 9, Appendix S.

Genus, Species
<b><u>Foraminifers</u></b>
<i>Bolivina imbricata?</i>
<i>Buccella</i> sp. undet. <sup>a</sup>
<i>Buliminella curta</i>
<i>Buliminella subfusiformis</i>
<i>Elphidium crispum</i>
<i>Epistominella subperuviana</i>
<i>Planulina</i> sp. undet.
<i>Pullenia miocenica</i>
<i>Uvigerinella?</i> , sp. undet.
<i>Valvulinera californica obesa?</i>
<i>Valvulinera miocenica?</i>
<b><u>Calcareous Nannoplankton</u></b>
<i>Coccolithus pelagicus</i>
<i>Dictyococcites antarcticus</i>
<sup>a</sup> sp.: species; undet.: undetermined.

based on microfossil samples from the Calabasas Formation (= Upper Topanga Formation) in the Topanga Canyon area of the central Santa Monica Mountains area (see Blake, 1991). However, this age determination conflicts with that based on the age determination (13.4 million years) for the top of Conejo Volcanics that suggests the base of the Upper Topanga Formation is no older than late middle Miocene in age (see Berggren and others, 1995; Turner, 1970; Turner and Campbell, 1979; Table 1).

**6.9.2 Fishes**

Thirty-three identifiable fossil fish specimens representing a taxonomically small but comparatively diverse fossil marine fish assemblage were recovered at newly recorded LACMVP fossil site 6969 in the marine shale as a result of the Segment 3 mitigation program (Huddleston, 1998; see Table 6, Appendices

M, O, T). The specimens, which consist of scales and partial and complete skeletons, were identified to the lowest taxonomic level possible.

The following discussion regarding the fish specimens from the Upper Topanga Formation is after Huddleston (1998; see Appendix T). The Segment 3 fish fauna from the Upper Topanga Formation is scientifically highly important because taxonomically it is unlike any fish assemblage previously reported from the Miocene fossil record of southern California. The fauna is represented by 8 families, at least 12 and possibly as many as 14 genera, and 14 extinct species of marine fishes, most of the species being new, not having been reported previously in the scientific literature. A taxonomic list of the Segment 3 fish fauna is presented in Table 6.

Some of the Segment 3 fossil fish specimens are scientifically highly important in part because they represent new species and very rare fossil occurrences for their respective genera and families, and include the

first possible reported fossil occurrences of at least one and as many as three as-yet unidentified genera of the Clupeidae (herrings);

first reported North American fossil occurrences of the Caproidae (boarfishes) and possibly the Priacanthidae (bigeyes) and *Sardinella* (Clupeidae; sardinella);

first possible reported North American Pacific Coast fossil occurrence of the Bregmacerotidae (codlets);

and the oldest reported North American fossil occurrence of the Atherinidae (silversides) (Huddleston, 1998).

The Segment 3 fish fauna is highly unusual because of the diversity of clupeids (six species and at least four and possibly as many as six genera) represented in a taxonomically limited assemblage (Huddleston, 1998).

The fossil specimen assigned to the Atherinidae is unusual because it has fewer vertebrae than in previously recognized genera of the family and probably represents a new species and possibly a new genus (Huddleston, 1998).

A digestive mass from an otherwise unidentified species of fish contained a scale possibly assignable

to *Decapterus* (Carangidae; Mexican scad) (Huddleston, 1998).

The Segment 3 fossil marine fish specimens also are scientifically highly important because the specimens, along with the families, genera, and species they represent, allow paleoenvironmental reconstruction of the Santa Monica Mountains/San Fernando Valley area during the middle Miocene Epoch.

Unlike other fossil marine fish faunas from the Miocene fossil record of southern California, the Segment 3 fish fauna is the first reported to contain a diversity of tropical fish taxa, including two genera of the Caproidae (boarfishes), three species and at least one and possibly as many as three as-yet unidentified genera of the Clupeidae (herrings), and possibly the Bregmacerotidae (codlets) and Priacanthidae (bigeyes) and *Sardinella* (Clupeidae; sardinella) (Huddleston, 1998). Modern representatives of nearly all of these taxa do not occur off the southern California coast today, but rather occur far to the south in warmer tropical and subtropical marine waters.

The Segment 3 fish fauna is dominated by neritic (near-shore) epipelagic (shallow-water) forms whose modern representatives inhabit ocean depths less than 825 feet below sea level (Angel, 1997; Huddleston, 1998), deeper-water (mesopelagic, bathypelagic) marine species not being represented.

Documenting the taxonomic differences between the marine fish faunas of southern California and establishing their respective environmental (temperature) preferences will make it possible to relate these differences to the major climatic changes that occurred during the Miocene Epoch.

**6.9.3 Land Plants**

A fragment of fossilized wood from a land plant was recovered from the Upper Topanga Formation in the San Fernando Valley tunnel segment at newly recorded UCMP fossil site PB-99030 as a result of the Segment 3 mitigation program (see Table 3, Figures 7, 10, Appendix N). The specimen represents either a conifer or an angiosperm, but is poorly preserved and otherwise taxonomically indeterminate (Fisk, 1998; see Appendix U). This specimen is scientifically highly important because the wood of land plants is very rare in the marine fossil record and has not been reported previously from the Upper Topanga Formation in the Santa Monica Mountains (Fisk, 1998). The presence of fossilized wood in the

**Table 6.**—Taxonomic list, fishes, Upper Topanga Formation, Los Angeles Metro Red Line Segment 3 construction zone, Universal City station site and immediate vicinity, Los Angeles, California. After Huddleston (1998). See Table 3, Figures 1, 7 to 9, Appendices M, O, T.

Family	Genus, Species	Common Name
Clupeidae	<i>Ganolytes?</i> , sp. undet. <sup>a</sup>	sardine
	<i>Etringus</i> , sp. undet.	herring
	<i>Sardinella?</i> , n. sp.	sardinella
	gen. undet., n. sp.? A	herring
	gen. undet., n. sp.? B	herring
Bregmacerotidae?	gen. undet., n. sp.? C	herring
	gen. undet., n. sp.?	codlet?
Atherinidae	n. gen.? & sp.	silversides
Caproidae	gen. undet. A, n. sp.?	boarfish
	gen. undet. B, n. sp.?	boarfish
Priacanthidae?	gen. & sp. undet.	bigeye?
Carangidae	<i>Decapterus?</i> , sp. undet.	Mexican scad?
Sciaenidae?	gen. & sp. undet.	croaker
Scombridae	gen. & sp. undet.	mackerel

<sup>a</sup>gen.: genus;  
n.: new;  
sp.: species;  
undet.: undetermined.

Upper Topanga Formation suggests the sediments comprising this rock unit were deposited in a near-shore marine environment.

**6.9.4 Summary**

The presence of lower middle bathyal benthic foraminifer species indicates the microfossil assemblage from the Upper Topanga Formation at the Universal City station site probably is assignable to the Luisian Stage (middle Miocene Epoch) and represents a (very-deep-water marine) environment and ocean depths roughly 4,700 to 6,250 feet below sea level, but possibly closer to 4,700 feet (Boettcher, R.S., in Micropaleo Consultants, Inc., 1998). However, the presence of the fossilized wood of a land plant suggests the sediments comprising this rock unit were deposited in a near-shore marine environment.

The Segment 3 fossil specimens from the Upper Topanga Formation are scientifically highly important because they represent a taxonomically moderately large and diverse assemblage of associated marine microfossil and fish species and a

land plant species, and have been critical in documenting and refining estimates of the age of the rock unit and in reconstructing the depositional paleoenvironment and marine paleoclimate represented by its sediments (see Huddleston, 1998; Micropaleo Consultants, Inc., 1993, 1998). Such an association is very rare in the fossil record. Moreover, many of the of the fish specimens represent the first, first North American, and/or oldest reported occurrences of their respective species (or even genera and families) from the fossil record, and many of these species are new and/or only rarely recorded as fossils. Unlike other marine fish faunas from the Miocene fossil record of southern California, the Segment 3 fish fauna is the first reported to contain a diversity of tropical fish taxa, suggesting that marine waters of coastal southern California were unusually warm during the middle Miocene Epoch and warmer than today.

Although all lines of evidence are not entirely consistent, paleoenvironmental preferences of the species comprising the composite Segment 3 fossil assemblage, in conjunction with sedimentologic data from the Upper Topanga Formation, suggest the sediments comprising this rock unit were deposited by turbidity flows. Presumably, these flows originated in a near-shore shallow-marine environment; traveled offshore (basinward) in a southwesterly direction and downslope along the sea floor under the influence of gravity; and finally slowed, dissipated, and deposited their sediment loads to form a large submarine fan on the subsiding floor and adjacent northeastern (landward) lower slopes of the deep, steep-walled submarine basin (ancestral northwestern Los Angeles basin) that once existed very near and parallel to the former coastline, which lay much farther inland during the middle Miocene Epoch. The basin probably was bounded to the south by the SM-H-RHFZ, which now roughly parallels and lies less than 0.25 mile north of the Hollywood tunnel segment (see Dibblee, 1991a; Figure 2), and to the northeast by the San Gabriel Mountains and the San Gabriel Fault (Blake, 1991; Rumelhart and Ingersoll, 1997). To the south, the ancestral north-central Los Angeles basin is bounded to the north by the SM-H-RHFZ, lacks strata laterally equivalent to the Upper Topanga Formation and older sedimentary rock units (see Dibblee, 1989a), and presumably was emergent and subjected to erosion during the earlier part of the Luisian Stage and middle Miocene Epoch and deposition of the sediments comprising the Upper Topanga Formation in the northwestern Los Angeles basin.

## **6.10 OLDER ALLUVIUM**

No fossil remains were observed in the older alluvium in the Hollywood area as a result of the Segment 3 mitigation program and, therefore, no remains were recovered by the PEAI paleontologic construction monitor.

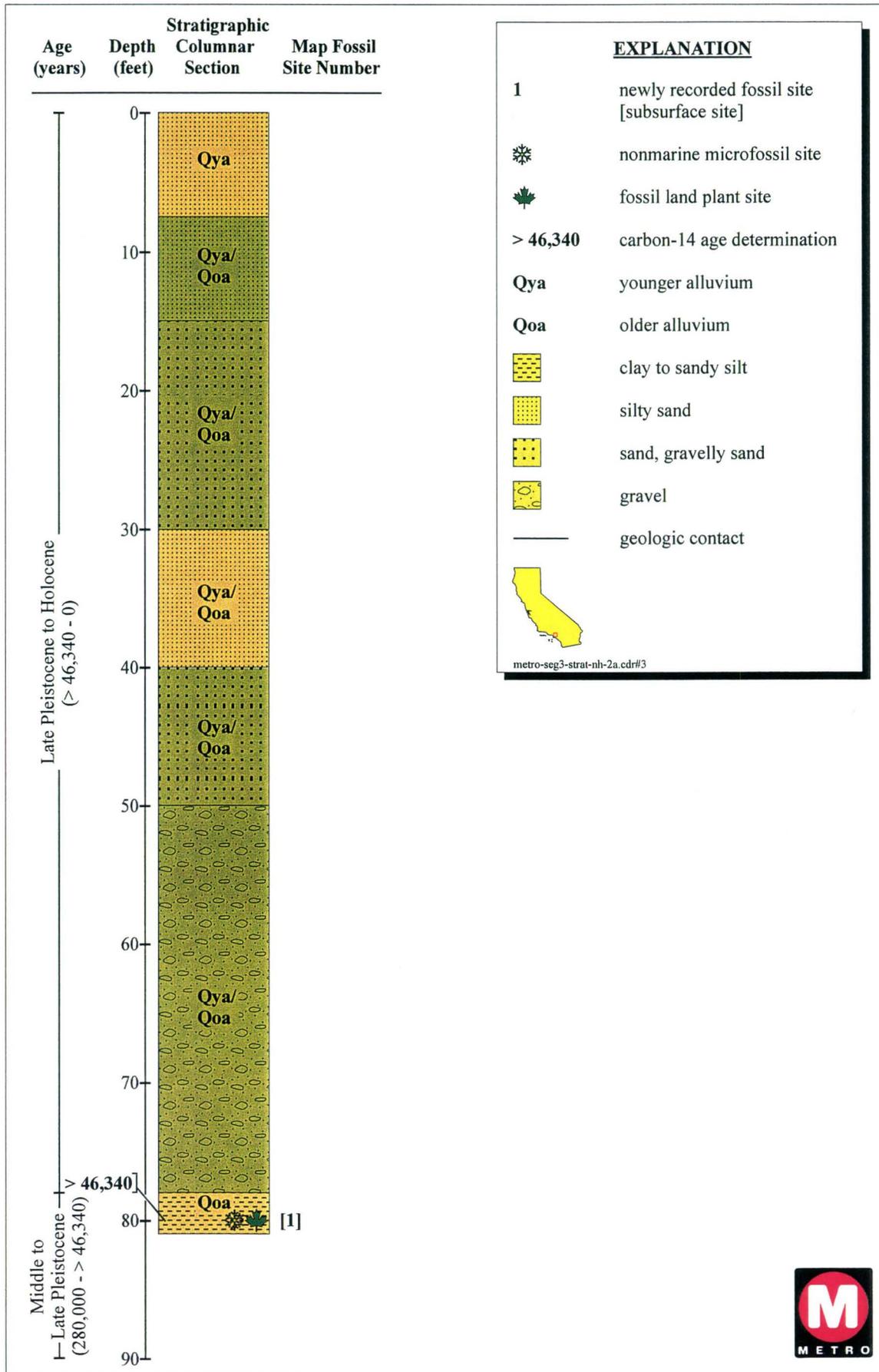
## **6.11 OLDER AND YOUNGER ALLUVIUM, UNDIFFERENTIATED**

Although the alluvium is not differentiated in the San Fernando Valley, fossil land mammal remains and carbon-14 radiometric age determinations on fossilized wood specimens recovered from the alluvium as a result of the Segment 3 mitigation program (see Table 7) suggest that, in the subsurface, the alluvium consists of two stratigraphically superposed rock units: an older rock unit (older alluvium) of middle to late Pleistocene (Rancholabrean) age below and a younger rock unit (younger alluvium) of Holocene age above (see below).

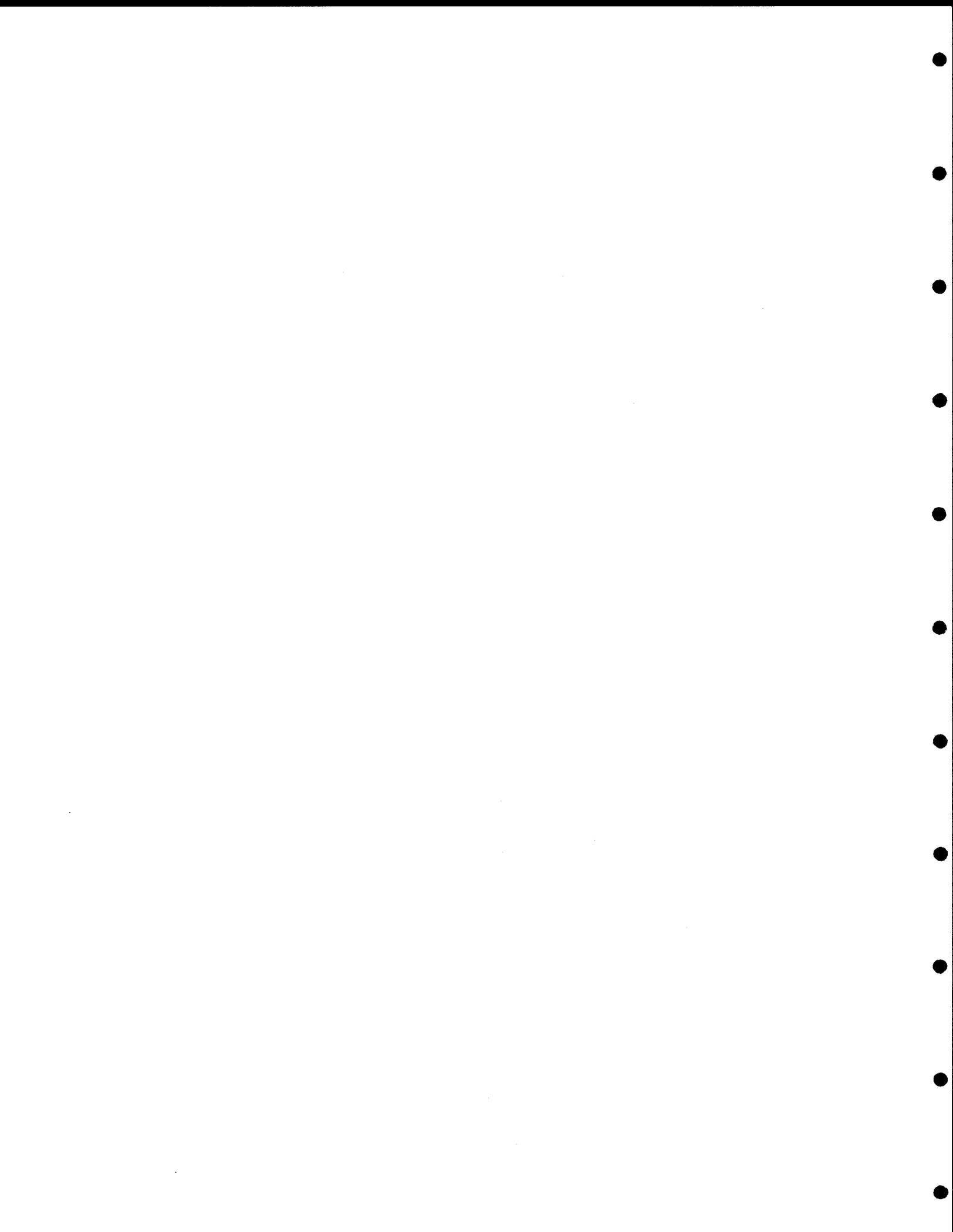
### **6.11.1 Older Alluvium**

The fossilized bones and teeth of land mammals and wood and pollen of land plants were recovered from the upper part of the older alluvium at depths approximately 60 to 80 feet below grade at the North Hollywood station site and at 33 newly recorded PEAI fossil sites in the San Fernando Valley tunnel segment as a result of the Segment 3 mitigation program (see Table 3, Figures 7, 10, 11). The fossil land mammal sites were catalogued under LACMVP fossil site number 6970 and the fossil land plant site under UCMP fossil site numbers PB-98003 and PB-98004 (see Table 3, Appendices M, N). Two rock samples weighing a total of approximately 250 pounds were processed to allow for the recovery of small vertebrate remains, two small rock samples were submitted for palynological (pollen) analysis, and two wood samples were submitted for carbon-14 dating analysis (see Tables 3, 4, Figures 7, 10, 11). Prior to analysis of these specimens and samples, the fossil record of the older alluvium in the San Fernando Valley was very poorly known (see above).

**6.11.1.A Carbon-14 Radiometric Age Determinations.**—Carbon-14 dating analyses yielded radiometric age determinations greater than 46,340 and 48,620 years (average: greater than 47,480 years) for two fossil wood specimens recovered from the older alluvium at depths 80 and 67 feet below grade at the North Hollywood station site and in the San Fernando Valley tunnel segment (map fossil site



**Figure 11.**—Generalized stratigraphic columnar section and occurrence of fossil taxa by rock unit and newly recorded fossil site, Los Angeles Metro Red Line Segment 3 construction zone, North Hollywood station site, Los Angeles, California. Rock units and corresponding lithologies after MTA and others (1995b) and RCC and others (1993b). Ages of rock units after Berggren and others (1995), Jefferson (1991b), and Lander (1999). Carbon-14 age determination after Beta Analytic Inc. (1996a). Stratigraphic level of fossil site approximate. See Tables 1, 3, Figures 1, 7, Appendix W.



**Table 7.**—Carbon-14 radiometric age determinations, fossil wood specimens, undifferentiated older and younger alluvium, Los Angeles Metro Red Line Segment 3 construction zone, Universal City and North Hollywood station sites and San Fernando Valley tunnel segment, Los Angeles, California. After Beta Analytic Inc. (1995, 1996a, -b, 1997). See Tables 3, 4, Figures 1, 7, 9, 10, 11 Appendices V, W, X, Y.

Rock Unit	Beta Analytic Inc. Sample Number	PEAI <sup>a</sup> Sample Number	Age (years before present <sup>b</sup> )	Reference
younger alluvium	Beta-102794	RDT <sup>c</sup> 961015	7,860 ± 80	Beta Analytic Inc. (1997)
	Beta-86689	DPW 2505	8,880 ± 60	Beta Analytic Inc. (1995)
	Beta-102795	RDT 96822	10,500 ± 70	Beta Analytic Inc. (1997)
older alluvium	Beta-90086	DPW 2516	> 46,340	Beta Analytic Inc. (1996a)
	Beta-099228	DPW 2565	> 48,620	Beta Analytic Inc. (1996b)

<sup>a</sup>Paleo Environmental Associates, Inc.  
<sup>b</sup>By convention, present is 1950 A.D.  
<sup>c</sup>DPW: David P. Whistler, PEAI;  
RDT: Robin D. Turner, PEAI.

numbers 1, 8; newly recorded UCMP fossil site numbers PB-98003, PB-98004), respectively, and, along with radiometric age determinations for fossil wood specimens from the overlying younger alluvium (see below), indicate that the fossil-bearing level in the upper part of the older alluvium is no younger than late Pleistocene in age (Lander, 1999; Fisk, 1998; Beta Analytic Inc., 1996a, -b; see Tables 3, 4, 7, Figures 7, 10, 11, Appendices N, U, W, X). Moreover, a radiometric age determination of greater than 46,500 years for a fossil wood specimen recovered 0.7 mile east-southeast of the La Brea tar pits at LACMVP fossil site 1814 (Marcus and Berger, 1984; Stock and Harris, 1992), is the oldest age determination for any fossil specimen from the older alluvium at and near the tar pits, and indicates that the upper part of the older alluvium in the San Fernando Valley tunnel segment and vicinity probably is similar in age to the base of the older alluvium in the tar pits vicinity.

**6.11.1.B Land Mammals.**—Although no remains of smaller continental vertebrate species were recovered as a result of processing rock samples, more than 20 fossil specimens representing at least five extinct species of larger Ice Age land mammals were recovered at 20 newly discovered PEAI fossil sites in the older alluvium as a result of the Segment 3

mitigation program (Tables 3, 8, Figures 7, 10). These sites subsequently were catalogued under LACMVP fossil site number 6970, and nine of the fossil specimens from these sites then were catalogued under LACMVP fossil specimen numbers (Appendices M, O). The specimens include the fossilized bones of Harlan's ground sloth *Paramylodon harlani* (LACMVP fossil specimen 145034; Table 9, Figure 12c), an otherwise unidentifiable proboscidean (elephant; LACMVP fossil specimen 145042), the large western camel *Camelops hesternus* (LACMVP fossil specimens 145039, 145040), and the large longhorn bison *Bison latifrons* (LACMVP fossil specimen 145038; Table 9, Figure 12a); the bones and teeth of the smaller ancient bison *Bison antiquus* (LACMVP fossil specimens 145035 to 145037; Table 9, Figure 12b); and the fragmentary and otherwise unidentifiable bones of these and other land mammal species. These specimens were recovered from the older alluvium at depths 64 to 71 feet below grade during excavation of the San Fernando Valley tunnel segment between the Universal City and North Hollywood station sites (map fossil site numbers 2 to 4, 7, 9, 11, 14 to 20, 22) (see Tables 3, 8, Figures 7, 10, Appendices M, O). The ground sloth and bison specimens, which were recovered by Segment 3 construction workers, subsequently received extensive media coverage in

**Table 8.**—Taxonomic list, mammals, older alluvium, Los Angeles Metro Red Line Segment 3 construction zone, San Fernando Valley tunnel segment, Los Angeles, California. See Table 3, Figures 1, 7, 10, Appendices M, O.

Map Fossil Site No. <sup>a</sup>	Genus, Species	Common Name
2	? <i>Bison antiquus</i>	ancient bison?
3	Proboscidea	elephant
4a	? <i>Bison antiquus</i>	ancient bison?
4b	<i>Bison antiquus</i>	ancient bison
7	Mammalia	land mammal
9	<i>Camelops hesternus</i>	western camel
11a	<i>Bison latifrons</i>	longhorn bison
11b	<i>Glossotherium harlani</i>	Harlan's ground sloth
	<i>Camelops hesternus</i>	western camel
14	Mammalia	land mammal
15	<i>Bison antiquus</i>	ancient bison
16a	Mammalia	land mammal
16b	? <i>Bison antiquus</i>	ancient bison?
16d	Mammalia	land mammal
17	<i>Bison antiquus</i>	ancient bison
18a	Proboscidea?	elephant?
18b	Proboscidea?	elephant?
19	Mammalia	land mammal
20a	<i>Camelops hesternus</i>	western camel
	<i>Bison antiquus</i>	ancient bison
20b	<i>Bison antiquus</i>	ancient bison
22	Mammalia	land mammal

<sup>a</sup>Map fossil site number in Figures 7, 10, 11.

1996 and 1997.

The distal width of the damaged bison metatarsal (≥ 64.0 millimeters) probably is within the observed metatarsal size range (67 to 78 millimeters) for *Bison antiquus* from the La Brea tar pits, but is decidedly less than that for *Bison latifrons* (83 to 87 millimeters), which also occurs in the older alluvium at the La Brea tar pits (see Miller, 1971; however, see Gust, 1993, regarding incorrect assignments of *Bison antiquus* remains from La Brea tar pits to *Bison latifrons* by Miller, 1971, and Miller and Brotherson, 1979). The distal width of the bison tibia (102.9

millimeters) is greater than the observed metatarsal size range (91 to 94 millimeters) for *Bison latifrons*, but is decidedly greater still than that for *Bison antiquus* (76 to 84 millimeters) from the tar pits (see Miller, 1971), and presumably represents a very large male individual of *Bison latifrons*.

The fossil land mammal remains from the older alluvium are scientifically highly important because they corroborate the nonmarine or continental origin of the older alluvium in the Segment 3 construction zone and vicinity. Moreover, such remains are comparatively rare in the fossil record. The bison remains, in particular, are scientifically highly important because they corroborate a middle to late Pleistocene (Rancholabrean) rather than an early to middle Pleistocene (Irvingtonian) or Holocene age for the older alluvium. Like *Bison*, the other species represented by remains recovered in the Segment 3 construction zone also occur in the older alluvium at the La Brea tar pits and became extinct at the end of the Pleistocene Epoch and the Rancholabrean NALMA, approximately 10,750 years ago (Jefferson, 1991b; Lander, 1999; Lundelius and others, 1987; Stock and Harris, 1992; see below). The presence of grazing (grass-eating) herbivores, including ground sloth and bison, suggests the Segment 3 construction zone and vicinity was mostly grassland habitat during the middle to late Pleistocene Epoch (see Miller, 1971). However, contrary to Miller (1971), *Camelops hesternus* was neither a grazer nor indicative of grassland habitat, but rather an intermediate feeder that ate both grass and leaves and probably indicative of open savanna woodland habitat (Dompierre and Churcher, 1996).

**6.11.1.C Land Plants.**—Numerous specimens of fossilized wood of trees were recovered from the older alluvium at 15 newly recorded PEAI fossil sites (map fossil site numbers 1, 4 to 6, 8, 10 to 13, 16; newly recorded UCMP plant fossil sites (PB-98003, PB-98004) at the North Hollywood station site and in the San Fernando Valley tunnel segment, as were the fossilized spores and pollen of other land plants (see Tables 3, 4, 10, Figures 7, 10, 11, Appendix N). The wood specimens, up to 6 feet in length, represent *Calocedrus* and are indistinguishable from modern *Calocedrus decurrens* (incense cedar) (Fisk, 1998; see Table 10, Appendix U). Some of the wood specimens, which were recovered by Segment 3 construction workers, subsequently received extensive media coverage in 1996 and 1997.

The following discussion regarding the *Calocedrus* specimens from the older alluvium is after Fisk

**Table 9.**—Dimensions of fossil land mammal specimens, older alluvium, Los Angeles Metro Red Line Segment 3 construction zone, San Fernando Valley tunnel segment, Los Angeles, California. See Table 3, Figures 1, 7, 10, 12, Appendices M, O.

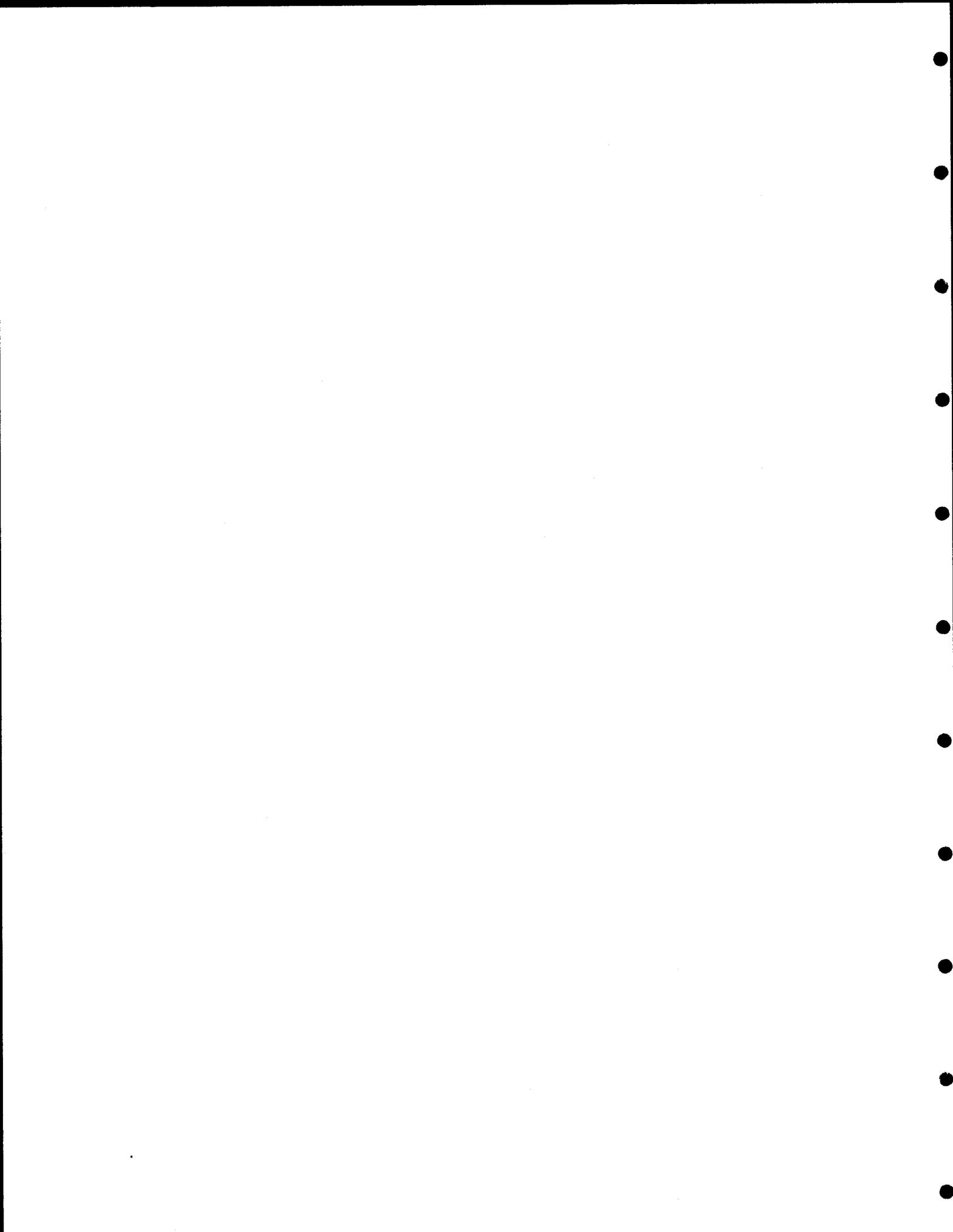
Genus, Species	Common Name	LACMVP <sup>a</sup> Fossil Specimen Number	Element <sup>b</sup>	Dimensions (millimeters)
<i>Paramylodon harlani</i>	Harlans's ground sloth	145034	caudal vertebra	centrum width: 75.3
<i>Bison antiquus</i>	ancient bison	145036	R p4 R m3	length: 21.8 length: 50.3
<i>Bison antiquus</i>	ancient bison	145035	distal L metatarsal	condylar width: $\geq$ 64.0
<i>Bison latifrons</i>	longhorn bison	145038	distal R tibia	width: 102.9

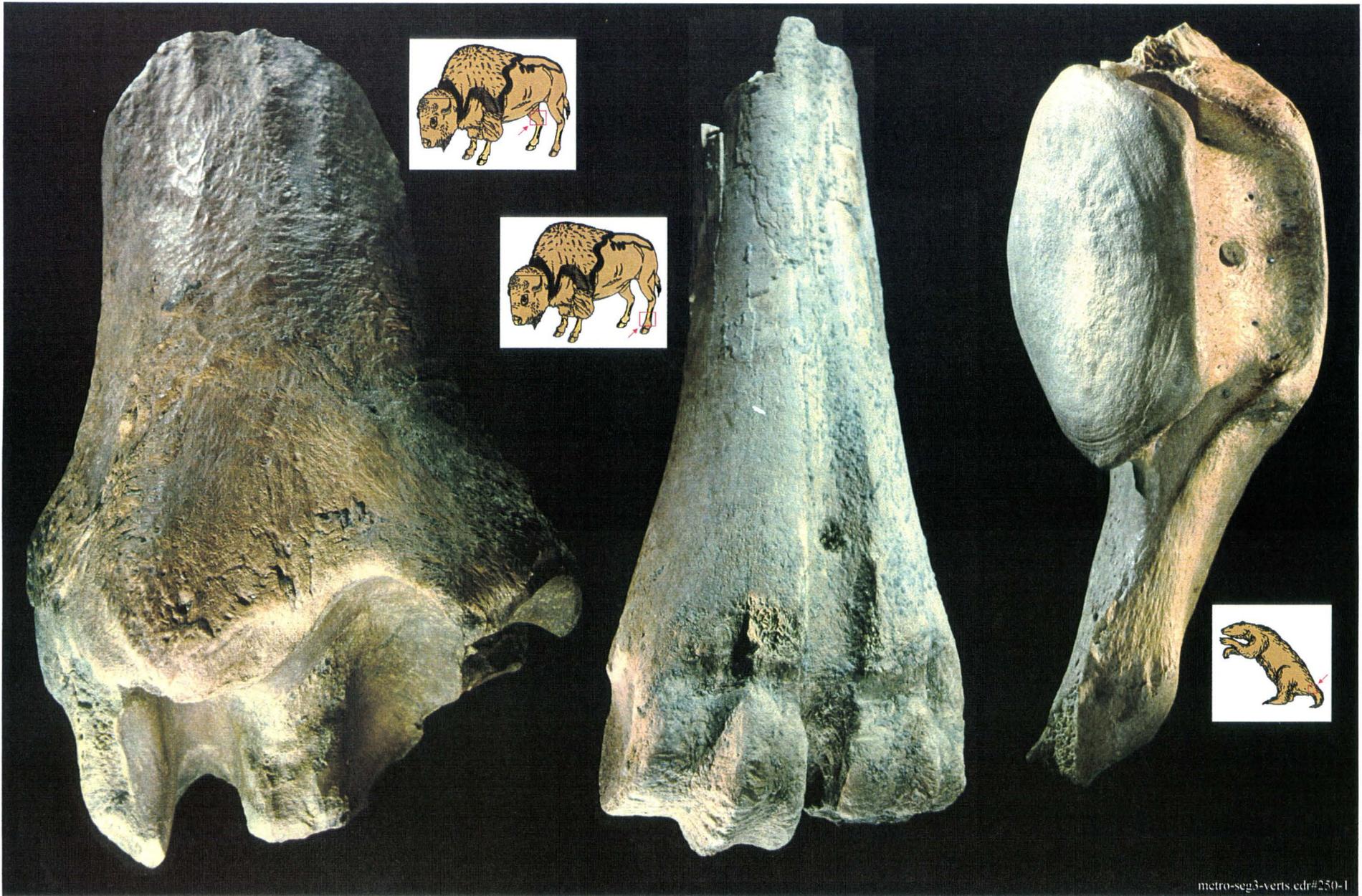
<sup>a</sup>LACMVP: LACM Vertebrate Paleontology Section.  
<sup>b</sup>L: left;  
m: lower molar;  
p: lower premolar;  
R: right.

(1998; see Table 10, Appendix U). Today, *Calocedrus* occurs in the mountains of southern California at elevations greater than 2,500 to 3,000 feet above sea level. The presence of *Calocedrus* in the older alluvium suggests that the middle to late Pleistocene climate of the San Fernando Valley at least 46,350 years ago was considerably wetter and probably cooler than now and comparable to climates found at higher elevations in southern California today. Moreover, uniform tracheid size throughout each growth ring and growth rings delineated by only a few smaller cells suggest an equable cool-wet climate with a relatively long uniform growing season and only a short period unfavorable for growth. However, narrow growth rings suggest that, although the climate was equable, it was not ideal for growth. A uniformly cool climate with a short cold winter and a relatively uniform seasonal distribution of rainfall is more likely. The climate that probably characterized the San Fernando Valley and the rest of the Los Angeles basin at least 46,350 years ago is in marked contrast to the strong seasonality characteristic of the Mediterranean climate, with its hot dry summers and warm wet winters, that exists in the region today, and

presumably was similar to climates found at higher elevations and/or higher latitudes in California today. The paleoclimatic reconstruction of the San Fernando Valley during the middle to late Pleistocene Epoch based on the occurrence of *Calocedrus* is consistent with palynological (pollen) data recovered from the older alluvium at the North Hollywood station site and in the San Fernando Valley tunnel segment (PEAI samples DPW 2516, 2566, respectively; see Haga, H., in Micropaleo Consultants, Inc., 1996a, -b; Tables 3, 4, 10, Figures 7, 10, 11, Appendices Q, R) and with paleoclimatic reconstructions based on pollen and other remains representing the same or similar species reported as occurring in the older alluvium at the La Brea tar pits (see Shaw and Quinn, 1986; Stock and Harris, 1992).

Buckwheat and ragweed pollen, which have been reported as occurring in the older alluvium at the La Brea tar pits (Shaw and Quinn, 1986; Stock and Harris, 1992), were recovered from the tunnel segment. Buckwheat and some other plant species, including some drought-tolerant species, grew on the Santa Monica coastal plain and comprise the coastal





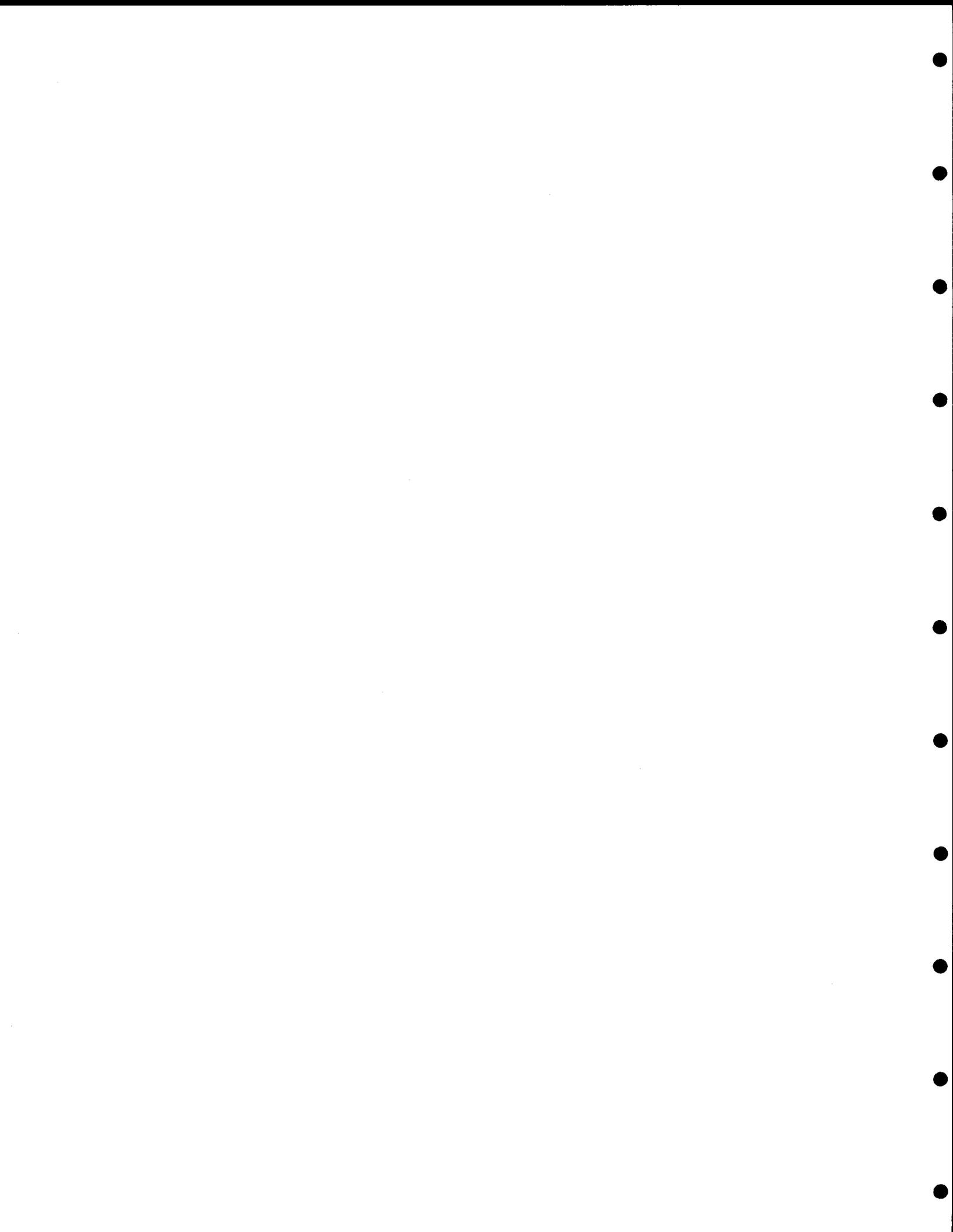
**Figure 12.**—Fossil land mammal specimens, older alluvium, San Fernando Valley tunnel segment. Natural size. See Tables 8, 9, Appendices M, O.

**A.**—Longhorn bison, *Bison latifrons*. Anterior/ventral view of distal right tibia (LACMVP fossil specimen 145035). Distal below.

**B.**—Ancient bison, *Bison antiquus*. Anterior view of distal left metatarsal (LACMVP fossil specimen 145035). Distal below.

**C.**—Harlans's ground sloth, *Paramylodon harlani*. Anterior/ventral view of vertebra (LACMVP fossil specimen 145034). Anterior to left.

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**Table 10.**—Composite floral list, undifferentiated older and younger alluvium, Los Angeles Metro Red Line Segment 3 construction zone, Universal City and North Hollywood station sites and San Fernando Valley tunnel segment, Los Angeles, California. After Fisk (1998) and Haga, H., in Micropaleo Consultants, Inc. (1996a, -b). See Tables 3, 4, Figures 1, 7, 9 to 11, Appendices Q, R, U.

Rock Unit	PEAI <sup>a</sup> Sample Number	Taxon	Common Name	Remains	Pollen/Spore Abundance <sup>b</sup>	Reference
older alluvium	DPW <sup>c</sup> 2516	<i>Alnus</i> sp. <sup>d</sup>	alder	pollen	R	Micropaleo Consultants, Inc. (1996a)
		<i>Selaginella?</i> sp.	clubmoss	spores	V	Micropaleo Consultants, Inc. (1996a)
	DPW 2566	Caryophyllaceae	pinks/carnations	pollen	R	Micropaleo Consultants, Inc. (1996b)
		Chenopodiaceae	goosefoots	pollen	V	Micropaleo Consultants, Inc. (1996b)
		Compositae ( <i>Ambrosia</i> -type)	ragweeds	pollen	C	Micropaleo Consultants, Inc. (1996b)
		Compositae ( <i>Helianthus</i> -type)	sunflowers	pollen	C	Micropaleo Consultants, Inc. (1996b)
		<i>Eriogonum</i> sp.	buckwheat	pollen	V	Micropaleo Consultants, Inc. (1996b)
		<i>Pinus</i> sp.	pine	pollen	A	Micropaleo Consultants, Inc. (1996b)
		<i>Selaginella sinuites</i>	clubmoss	spores	R	Micropaleo Consultants, Inc. (1996b)
		Taxodiaceae	redwoods/sequoias	pollen	R	Micropaleo Consultants, Inc. (1996b)
		<i>Diporites</i> sp.	fungus	spores	R	Micropaleo Consultants, Inc. (1996b)
		DPW 2516, 2565	<i>Calocedrus</i> sp.	incense cedar	wood	—
	younger alluvium	DPW 2502	Caryophyllaceae	pinks/carnations	pollen	R
Chenopodiaceae			goosefoots	pollen	V	Micropaleo Consultants, Inc. (1996a)
Compositae ( <i>Artemisia</i> sp.)			coastal sagebrush	pollen	C	Micropaleo Consultants, Inc. (1996a)
Compositae ( <i>Ambrosia</i> -type)			ragweeds	pollen	C	Micropaleo Consultants, Inc. (1996a)
Compositae ( <i>Helianthus</i> -type)			sunflowers	pollen	C	Micropaleo Consultants, Inc. (1996a)
Compositae ( <i>Taraxacum</i> -type)			dandelions	pollen	F	Micropaleo Consultants, Inc. (1996a)
<i>Ephedra nevadensis?</i>			Mormon tea	pollen	R	Micropaleo Consultants, Inc. (1996a)
<i>Eriogonum</i> sp.			buckwheat	pollen	F	Micropaleo Consultants, Inc. (1996a)
<i>Liquidambar?</i> sp. <sup>e</sup>			sweetgum?	pollen	R	Micropaleo Consultants, Inc. (1996a)
<i>Pinus</i> sp.			pine	pollen	V	Micropaleo Consultants, Inc. (1996a)
Polypodiaceae			ferns	spores	C	Micropaleo Consultants, Inc. (1996a)
<i>Selaginella</i> sp.			clubmoss	spores	F	Micropaleo Consultants, Inc. (1996a)
<i>Sphagnum</i> sp.			peat moss	spores	R	Micropaleo Consultants, Inc. (1996a)
DPW 2516, 2566			<i>Populus</i> sp.	cottonwood	wood	—

<sup>a</sup>Paleo Environmental Associates, Inc.

<sup>b</sup>Pollen/spore abundances (quantities): A: abundant (more than 30 specimens); C: common (16 to 30 specimens); F: frequent (6 to 15 specimens); R: rare (2 to 5 specimens); V: very rare (1 specimen).

<sup>c</sup>DPW: David P. Whistler, PEAI.

<sup>d</sup>sp.: species.

<sup>e</sup>Possible contaminant.

sage scrub plant association (Shaw and Quinn, 1986; Stock and Harris, 1992). The common occurrence of ragweed pollen in the tunnel segment (see Table 10) suggests the pollen was derived from plants growing on the San Fernando Valley floor.

Redwood/sequoia pollen presumably representing coast redwood, which also has been reported as occurring in the older alluvium at the La Brea tar pits (Shaw and Quinn, 1986; Stock and Harris, 1992), also was recovered from the tunnel segment. Redwoods, along with some other plant species, grew in the larger, deeper, and more protected canyons of the Santa Monica Mountains during the middle to late Pleistocene Epoch, this assemblage representing the southernmost reported occurrence of the deep canyon plant association (Shaw and Quinn, 1986; Stock and Harris, 1992).

Alder pollen, which also has been reported as occurring in the older alluvium at the La Brea tar pits (Shaw and Quinn, 1986; Stock and Harris, 1992), was recovered from the North Hollywood station site. Alders, along with some other plant species, grew along stream margins in the deep canyons of the Santa Monica Mountains during the middle to late Pleistocene Epoch, this assemblage representing the riparian plant association (Shaw and Quinn, 1986; Stock and Harris, 1992). Because alder pollen was not recovered nearer the Santa Monica Mountains in the San Fernando Valley tunnel segment and is not associated with any other type of pollen at the North Hollywood station site, it is likely the alder pollen was derived from trees growing along stream margins on the San Fernando Valley floor.

The composite floral assemblage from the older alluvium at the La Brea tar pits contains plant species whose modern descendants live along the coastal summer fog belt from San Luis Obispo north to Oregon and on the Channel Islands, or in the southern Sierra Nevada at elevations 4,000 to 6,000 feet above sea level, these modern occurrences (like those of *Calocedrus*) suggesting the maritime climate that characterized the La Brea tar pits area during the late Pleistocene Epoch was cooler, moister, and more equable or less seasonal than today (Shaw and Quinn, 1986). This paleoclimatic reconstruction is similar to that based on fossil plant remains from the older alluvium in the San Fernando Valley.

*Calocedrus* is not reported as occurring in the older alluvium at the La Brea tar pits. The common occurrence of this species in the San Fernando Valley

and its absence in the La Brea tar pits area could reflect the relative proximity of the latter and the surrounding Santa Monica coastal plain to the Pacific Ocean; their separation from the San Fernando Valley by the Santa Monica Mountains, which would have blocked the moderating influence of the Pacific Ocean on the climate of the San Fernando Valley; and, like today, a more maritime climate along the coastal plain compared to in the San Fernando Valley during the middle to late Pleistocene Epoch. On the other hand, the absence of *Calocedrus* also could reflect the development of a more maritime or less seasonal climate in the Los Angeles basin and vicinity (including San Fernando Valley) during the late Pleistocene Epoch between approximately 46,350 and 10,750 years ago, a time interval apparently not preserved in the geologic record of the Segment 3 construction zone in the San Fernando Valley.

The floral assemblage from the older alluvium at the North Hollywood station site and in the San Fernando Valley tunnel segment is scientifically highly important because it represents the first reported fossil occurrence of a middle to late Pleistocene floral assemblage from the San Fernando Valley and includes the first reported fossil occurrence of *Calocedrus* (Fisk, 1998). Moreover, the plant remains have been critical in paleoenvironmental reconstruction of the San Fernando Valley tunnel segment and North Hollywood station site and paleoclimatic reconstruction of the San Fernando Valley and vicinity during the middle to late Pleistocene Epoch, and, based on carbon-14 dating analysis, in documenting the middle to late Pleistocene age of the older alluvium.

**6.11.1.D Summary.**—Environmental preferences of the modern descendants of the species represented by the land plant remains from the older alluvium in the San Fernando Valley tunnel segment and at the North Hollywood station site suggest the middle to late Pleistocene maritime climate that characterized the Los Angeles basin at least 46,350 years ago was cooler, moister, and less seasonal or more equable than the modern climate of the region, and was similar to climates occurring at higher elevations and/or higher latitudes in California today.

Carbon-14 dating analyses of fossilized wood specimens from the older alluvium in the San Fernando Valley tunnel segment and at the North Hollywood station site and the La Brea tar pits and vicinity suggest the Segment 3 fossil assemblages probably are similar in age to the oldest fossil

assemblages from near the base of the older alluvium in the tar pits vicinity.

The Segment 3 fossil specimens from the older alluvium are scientifically highly important because they represent a taxonomically moderately large and diverse assemblage of associated land plant and mammal species, and have been critical in documenting and refining estimates of the age of the rock unit and in reconstructing the depositional paleoenvironments and paleoclimates represented by its sediments (see Beta Analytic Inc., 1996a, -b; Fisk, 1998; Micropaleo Consultants, Inc., 1996a, -b). Moreover, such an association is comparatively rare in the fossil record.

### **6.11.2 Younger Alluvium**

Fossilized nonmarine mollusk shells, fresh-water ostracod (bivalved crustacean) valves, continental vertebrate bones and teeth, and land plant wood and pollen were recovered from the lower 5 to 10 feet of the younger alluvium at depths approximately 45 to 60 feet below grade at the Universal City station/cross-over site as a result of the Segment 3 mitigation program (see Table 3, Figures 7, 9). The PEAI fossil continental vertebrate sites were catalogued under LACMVP fossil site numbers 6306, 6385, and 6386, the PEAI fossil nonmarine mollusk sites under LACMIP fossil site numbers 16966 and 16967, and the fossil land plant sites under UCMP fossil site number PB-98002 (see Table 3, Appendices L, M, N).

Nine rock samples weighing a total of approximately 6,950 pounds were recovered, of which approximately 2,250 pounds were processed to allow for the recovery of small vertebrate remains and one small rock sample was submitted for palynological (pollen) analysis, and three wood samples were submitted for carbon-14 dating analysis (see Tables 3, 4, Figures 7, 9).

Prior to analysis of these specimens and samples, the fossil record of the younger alluvium in the Los Angeles basin and vicinity was very poorly known, particularly with regard to the San Fernando Valley (see above).

**6.11.2.A Carbon-14 Radiometric Age Determinations.**—Carbon-14 dating analyses yielded radiometric age determinations of  $7,860 \pm 80$ ,  $8,880 \pm 60$ , and  $10,500 \pm 70$  years (average:  $9,080 \pm 70$  years) for three fossil wood specimens recovered from the younger alluvium and indicate that the lower

10 feet of the younger alluvium is early Holocene in age (Lander, 1999; Fisk, 1998; Beta Analytic Inc., 1995, 1997; see Tables 3, 4, 7, Figures 7, 9, Appendices N, U, V, Y). These age determinations and those for the wood specimens from the older alluvium suggest the top of the fossil-bearing level in the older alluvium might be at least 35,000 to 40,000 years older than the base of the younger alluvium in the San Fernando Valley tunnel segment vicinity. The younger alluvium possibly is similar in age to the youngest (Holocene) strata in the older alluvium at the La Brea tar pits (see Marcus and Berger, 1984; Stock and Harris, 1992), although the youngest age determinations for fossil remains from the La Brea tar pits probably are unreliable (see above).

**6.11.2.B Fresh-Water Ostracods.**—Fifteen valves representing 2 species of the fresh-water ostracod *Limnocythere* were recovered from the younger alluvium, fourteen specimens representing *Limnocythere staplini* and one specimen possibly representing *Limnocythere paraornata* (Finger, K.L., in Micropaleo Consultants, Inc., 1996a; Tables 3, 4, Figures 7, 9, Appendix Q). The common occurrence of *Limnocythere staplini*, which is tolerant of moderate to high salinities, suggests the fossil-bearing sediments were deposited in a pluvial lake or pond that had become saline or alkaline as a result of increased evaporation and decreased runoff, possibly during a period of warming climate, while the presence of disarticulated valves instead of complete carapaces, the lack of sorting by size, and the presence of juvenile specimens indicate a comparatively slow rate of deposition in a low-energy environment (Finger, K.L., in Micropaleo Consultants, Inc., 1996a; see Appendix Q).

The ostracod assemblage from the younger alluvium at the Universal City station site is scientifically highly important because it probably represents the first reported fossil occurrence of an early Holocene ostracod assemblage from the Los Angeles basin and vicinity (including San Fernando Valley). Moreover, the ostracod remains have been critical in paleoenvironmental reconstruction of the station site and paleoclimatic reconstruction of the San Fernando Valley and vicinity during the early Holocene Epoch.

**6.11.2.C Nonmarine Mollusks.**—Shells representing seven species of nonmarine mollusks were recovered from the younger alluvium at two newly recorded LACMIP fossil sites (Groves, 1998; see Tables 3, 4, 11, Figures 7, 9, Appendices I, L). All of the species are represented at LACMIP fossil site 16967, which yielded virtually all of the fossil specimens.

**Table 11.**—Taxonomic list, mollusks, younger alluvium, Los Angeles Metro Red Line Segment 3 construction zone, Universal City station site, Los Angeles, California. After Groves (1998). See Table 3, Figures 1, 7, 9, Appendices I, L.

Class	Genus, Species	Common Name	LACMIP <sup>a</sup> Fossil Site Number		Environment	
			16966	16967	FW <sup>b</sup>	T <sup>b</sup>
Bivalvia	<i>Anodonta</i> sp. <sup>c</sup>	floater clam				
	<i>Pisidium compressum</i>	ridged-beak peaclam		X	X	
Gastropoda	<i>Amnicola longinqua</i>	dusky snail		X	X	
	<i>Gyraulus parvus</i>	ash gyro	X	X	X	
	<i>Physa</i> sp.	physa		X	X	
	<i>Planorbella tenuis</i>	Mexican rams-horn snail		X	X	
	<i>Pristiloma gabrielinum</i>	waxy tightcoil snail		X		X

<sup>a</sup>Natural History Museum of Los Angeles County Invertebrate Paleontology Section.  
<sup>b</sup>FW: fresh water;  
T: terrestrial.  
<sup>c</sup>sp.: species.

The following discussion regarding the mollusk specimens from the younger alluvium is after Groves (1998; see Table 11, Appendix I). With the exception of the shells of the waxy tightcoil snail *Pristiloma gabrielinum*, all of the shells recovered at the station site represent fresh-water snails and clams whose modern representatives inhabit clear, quiet, permanent to subpermanent, flowing streams and/or lakes with muddy to sandy bottoms that contain abundant rooted vegetation. Of the species recovered at the Universal City station site, *Pisidium compressum*, *Gyraulus parvus*, and *Planorbella tenuis* also have been recovered in Pit 91 at the La Brea tar pits (Lamb, 1989), and *Amnicola longinqua* and *Physa* have been recovered from the late Pleistocene marine Palos Verdes Sand in the Palos Verdes Hills (Woodring and others, 1946). Modern representatives of the terrestrial waxy tightcoil snail occur in areas characterized by a Mediterranean climate with mild wet winters and hot dry summers, and commonly are found in leaf litter occurring under logs lying near bodies of water.

The molluscan assemblage from the younger alluvium at the Universal City station site is scientifically highly important because it probably represents the first reported fossil occurrence of an early Holocene nonmarine molluscan assemblage from the Los Angeles basin and vicinity (including San Fernando Valley), and includes the first reported fossil occurrence of *Pristiloma gabrielinum* (Groves, 1998). Moreover, the mollusk remains have been critical in paleoenvironmental reconstruction of the station site and paleoclimatic reconstruction of the San Fernando Valley and vicinity during the early Holocene Epoch.

**6.11.2.D Continental Vertebrates.**—Nearly fifty identifiable fossilized bones and teeth representing fifteen small continental vertebrate species, as well as hundreds of fossilized bones and bone fragments representing otherwise unidentifiable small continental vertebrate species, were recovered at three newly recorded LACMVP fossil sites (LACMVP 6306, 6385, 6386), all having been

**Table 12.**—Taxonomic list, vertebrates, younger alluvium, Los Angeles Metro Red Line Segment 3 construction zone, Universal City station site, Los Angeles, California. After Whistler (1998). See Table 3, Figures 1, 7, 9, Appendices M, O, AA.

Class	Genus, Species	Common Name	LACMVP <sup>a</sup> Fossil Site Number		
			6306	6385	6386
Osteichthyes	Gasterosteidae, gen. and sp. undet. <sup>b</sup>	stickleback	X	X	
Amphibia	Hylidae, gen. and sp. undet.	tree frog	X	X	
	<i>Rana</i> sp.	pond frog			
Reptilia	<i>Gerrhonotus</i> sp.	alligator lizard	X		
	<i>Uta</i> sp.	side-blotched lizard	X		
	<i>Thamnophis</i> sp.	garter snake	X		
	<i>Tantilla</i> sp.	black-headed snake	X		
Aves	Aves, gen. and sp. undet.	bird	X		
Mammalia	<i>Sorex</i> sp.	shrew	X		
	<i>Sylvilagus</i> sp.	cottontail	X		
	<i>Thomomys bottae</i>	Botta's pocket gopher	X		X
	<i>Perognathus</i> sp.	pocket gopher	X		
	<i>Dipodomys</i> sp.	kangaroo rat	X		
	<i>Microtus</i> sp.	vole	X		
	<i>Peromyscus</i> sp.	deer mouse	X		

<sup>a</sup>Natural History Museum of Los Angeles County Vertebrate Paleontology Section.  
<sup>b</sup>gen.: genus;  
sp.: species;  
undet.: undetermined.

recovered as a result of processing fossiliferous rock samples (see Whistler, 1998; Tables 3, 4, 12, Figures 7, 9, Appendices M, O, AA). All of the species are represented at LACMVP fossil site 6306, which yielded virtually all of the fossil specimens. However, fossil remains representing the large extinct late Pleistocene land mammal species typical of the Rancholabrean NALMA and the late Pleistocene Epoch in the Los Angeles basin were not recovered from the younger alluvium at the Universal City station site.

The following discussion regarding the fossil

vertebrate specimens and the continental vertebrate assemblage from the younger alluvium is after Whistler (1998; see Table 12, Appendix AA). The identifiable specimens represent fresh-water fishes, frogs, lizards, snakes, birds, insectivores, lagomorphs, and rodents. The assemblage is dominated by species whose modern descendants inhabit moister terrestrial environments. The assemblage is similar to modern assemblages inhabiting the margins of permanent fresh-water streams and ponds in southern California, and the fishes are similar to those now inhabiting these streams and ponds. Moreover, the fossil-bearing sediments, fine grained and organic rich, appear to

represent stream and pond deposits. The station site, only 0.25 mile south of the modern Los Angeles River channel, might have been in and/or immediately adjacent to the river channel during the early Holocene Epoch.

Fishes are represented in the Universal City station fossil vertebrate assemblage by a small, otherwise unidentified species of stickleback (Family Gasterosteidae), a species that today inhabits brackish-water and fresh-water streams in southern California. Two species of frogs, including a small species of tree frog (Family Hylidae) and the larger pond frog *Rana* sp., also are documented as occurring in the assemblage, as are two species of snakes, including the comparatively common, semi-aquatic garter snake *Thamnophis* sp. and the comparatively rare black-headed snake *Tantilla* sp., which also inhabits relatively moist environments. Two lizard species, the alligator lizard *Gerrhonotus* sp., which inhabits comparatively moist environments, and the side-blotched lizard *Uta* sp., which inhabits more arid environments, occur in the assemblage. A small sparrow-sized species of bird also occurs in the assemblage, as do the shrew *Sorex* sp., cottontail *Sylvilagus* sp., and five rodent species, including Botta's pocket gopher *Thomomys bottae*, the pocket mouse *Perognathus* sp., the kangaroo rat *Dipodomys* sp., the vole *Microtus* sp., and the deer mouse *Peromyscus* sp. Although gophers, voles, and pocket mice today inhabit comparatively moist environments and grassy habitats, pocket mice also occupy more arid environments, while kangaroo rats and deer mice occur in a diversity of habitats. Environmental preferences of the modern representatives of the species comprising the Universal City station fossil vertebrate assemblage, lithology of the fossil-bearing sediments, and the proximity of the station site to the modern Los Angeles River channel suggest the fossil sites were in and/or along the Los Angeles River channel during the early Holocene Epoch. All of the species represented in the Universal City station assemblage also occur in the late Pleistocene assemblage from the older alluvium at the La Brea tar pits (see Jefferson, 1991a, -b).

The vertebrate assemblage from the younger alluvium at the Universal City station site is scientifically highly important because it is comparatively diverse taxonomically and probably represents the first reported fossil occurrence of an early Holocene continental vertebrate assemblage from the Los Angeles basin and vicinity (including San Fernando Valley) (Whistler, 1998). Moreover, the vertebrate remains have been critical in paleoenvironmental

reconstruction of the station site during the early Holocene Epoch.

**6.11.2.E Land Plants.**—Numerous specimens of fossilized wood of trees were recovered from the younger alluvium at one newly recorded UCMP plant fossil site (UCMP PB-98002), as were the fossilized spores and pollen of other land plants (see Tables 3, 4, Figures 7, 9, Appendices N, U). The wood specimens represent *Populus* (probably cottonwood) (Fisk, 1998; see Table 10, Appendix U). Some of the wood specimens occurred as logs up to 11 feet in length in a silt immediately above the basal gravel. The logs were oriented in a southwesterly direction, presumably as a result of a major flood along the ancestral Los Angeles River, and their ends subsequently were truncated by a later flood that partially scoured through and deposited coarse-grained sand over and around the fossil-bearing layer. Some of the wood specimens received extensive media coverage in 1996 and 1997.

The following discussion regarding the *Populus* specimens from the younger alluvium is after Fisk (1998; see Table 10, Appendix U). The identifications primarily are based on the presence of diffuse vessels with simple perforation plates and uniseriate homocellular rays. The presence of *Populus* in the younger alluvium does not provide detailed information regarding the early Holocene climate of the San Fernando Valley because modern species in this genus occur over a wide range of temperatures and elevations. In southern California today, cottonwood occurs at elevations ranging from near sea level to approximately 8,000 feet, and most commonly is found either in the riparian zone or along the borders of rivers, lakes, and wet meadows, appearing to require permanently moist soil. Cottonwood is part of the riparian woodland plant community. The fossil site is only 0.25 mile south of the modern Los Angeles River channel and might have been immediately adjacent to the river during the early Holocene Epoch. The presence of cottonwood in the San Fernando Valley approximately 7,850 to 10,500 years ago is not inconsistent with associated palynological data (occurrence of *Ephedra nevadensis?* pollen; see Haga, H., in Micropaleo Consultants, Inc., 1996a; Tables 3, 4, 10, Figures 7, 9, Appendix Q) from the Universal City station site that suggest the early Holocene climate of the region was considerably dryer and more extreme, with hotter summers and colder winters, than today and especially during the late Pleistocene Epoch at least 10,750 years ago. Today, *Ephedra nevadensis* (Mormon tea) occurs in

the Mojave Desert and the adjacent lower slopes of the northern San Gabriel and San Bernardino Mountains. However, spores of *Selaginella* (clubmoss), *Sphagnum* (peat moss), and the Polypodiaceae (ferns) suggest cooler and wetter environments, including those found in restricted habitats, such as bogs.

The floral assemblage from the younger alluvium at the Universal City station site and in the San Fernando Valley tunnel segment is scientifically highly important because it probably represents the first reported fossil occurrence of an early Holocene floral assemblage from the Los Angeles basin and vicinity (including San Fernando Valley) (Fisk, 1998). Moreover, the plant remains have been critical in paleoenvironmental reconstruction of the station site and paleoclimatic reconstruction of the San Fernando Valley and vicinity during the early Holocene Epoch, and, based on carbon-14 dating analysis, in documenting the early Holocene age of the younger alluvium.

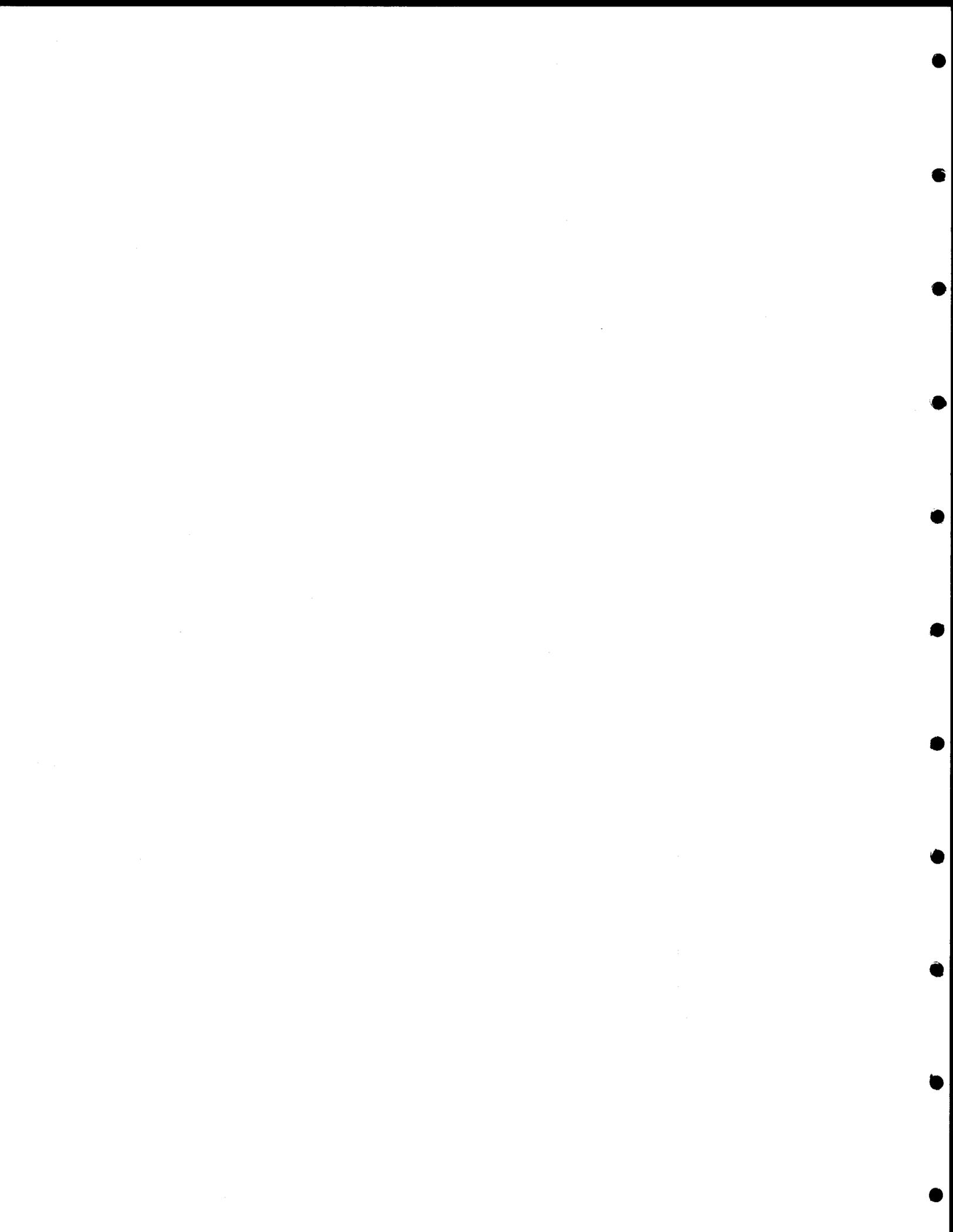
**6.11.2.F Summary.**—Environmental preferences of the modern descendants of the species represented by the land plant remains from the older alluvium in the San Fernando Valley tunnel segment and at the North Hollywood station site suggest the early Holocene climate that characterized the Los Angeles basin approximately 7,850 to 10,500 years ago was considerably dryer and more extreme, with hotter summers and colder winters, than the Mediterranean climate that characterizes the region today and especially the maritime climate that characterized the region during the late Pleistocene Epoch, and might have been similar to the modern climate of the Mojave Desert and the adjacent lower slopes of the northern San Gabriel and San Bernardino Mountains to the north.

The oldest carbon-14 age determination (10,500 years) for the fossilized wood specimens from the younger alluvium at the Universal City station site and the youngest, presumably reliable age determinations (11,130, 10,940 years from Pits 81, 61/67, respectively; Marcus and Berger, 1984) for Rancho Labrean land mammal remains from the older alluvium at the La Brea tar pits suggest the Pleistocene-Holocene Epoch boundary is approximately 10,750 years in age (Lander, 1999; see above). Moreover, the middle to late Pleistocene Segment 3 fossil assemblage from the older alluvium is at least 35,840 years older than the assemblage from the younger alluvium.

The Segment 3 fossil specimens from the younger alluvium are scientifically highly important because they represent a taxonomically moderately large and diverse assemblage of associated land plant, nonmarine invertebrate, and continental vertebrate species, and have been critical in documenting and refining estimates of the age of the rock unit and in reconstructing the depositional paleoenvironments and paleoclimates represented by its sediments (see Beta Analytic Inc., 1995, 1997; Fisk, 1998; Groves, 1998; Micropaleo Consultants, Inc., 1996a; Whistler, 1998). Moreover, such an association is comparatively rare in the fossil record.

## **6.12 ARTIFICIAL FILL**

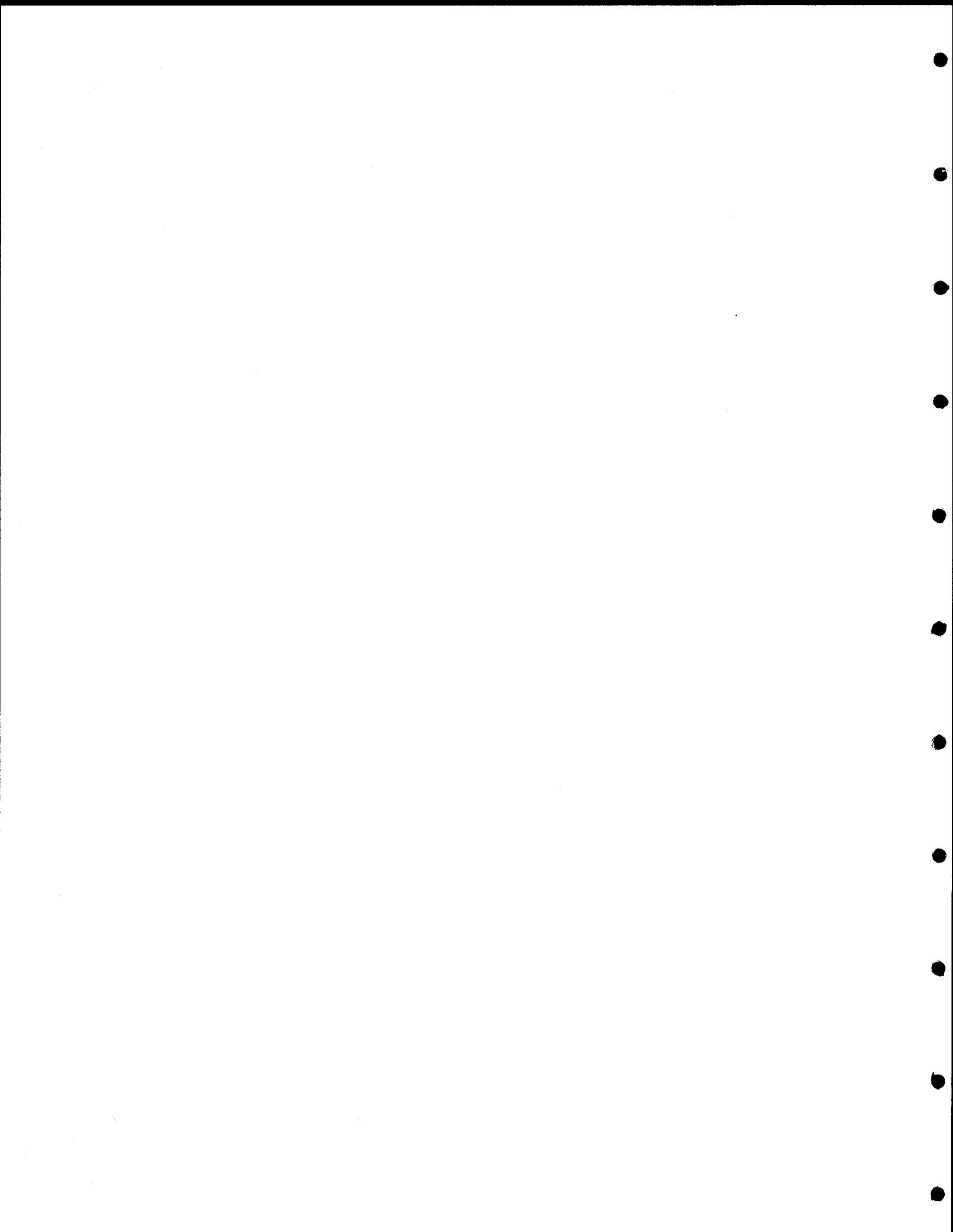
No fossil remains were recovered from the artificial fill as a result of the Segment 3 mitigation program because the rock unit probably is unfossiliferous. Moreover, any fossil remains in this rock unit would have lacked any original geologic or geographic context. Therefore, excavation of the rock unit was not monitored by a PEAI paleontologic construction monitor as part of the mitigation program.



SECTION 7

ACRONYMS AND ABBREVIATIONS

CEQA	California Environmental Quality Act
CWDD	Converse Ward Davis Dixon
DPW	David P. Whistler, PEAI
F&F	F & F GeoResource Associates, Inc.
G&A	Greenwood and Associates
GTT	Gary T. Takeuchi, PEAI
LACM	Natural History Museum of Los Angeles County, Los Angeles
LACMIP	LACM Invertebrate Paleontology Section
LACMVP	LACM Vertebrate Paleontology Section
LACTC	Los Angeles County Transportation Commission
MM	Michael W. Morris, PEAI
MTA	Los Angeles County Metropolitan Transportation Authority
NALMA	North American land mammal age
NEPA	National Environmental Policy Act
PA	project archaeologist
PD	Parsons-Dillingham
PEAI	Paleo Environmental Associates, Inc.
PES	Parsons Engineering Science, Inc.
RCC	LACTC Rail Construction Corporation
RDT	Robin D. Turner, PEAI
SCRTD	Southern California Rapid Transit District
SM-H-RHFZ	Santa Monica-Hollywood-Raymond Hill Fault Zone
SVP	Society of Vertebrate Paleontology
TLS	Trudy L. Stubbs, PEAI
UCLA	University of California, Los Angeles, Department of Geology
UCMP	University of California Museum of Paleontology Paleobotany Section, Berkeley
UMTA	U.S. Department of Transportation Urban Mass Transportation Administration



SECTION 8

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**LOS ANGELES METRO RED LINE PROJECT  
SEGMENTS 2 AND 3  
PALEONTOLOGIC RESOURCE  
IMPACT MITIGATION PROGRAM  
FINAL TECHNICAL REPORT OF FINDINGS—  
PART 4: APPENDICES**

PALEO ENVIRONMENTAL ASSOCIATES

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APPENDIX A

METRO RAIL PROJECT  
SPECIFICATIONS SECTION 01170,  
ARCHAEOLOGICAL AND PALEONTOLOGICAL COORDINATION

Southern California Rapid Transit District,

Los Angeles County Transportation Commission,

and

Los Angeles County Metropolitan Transportation Authority

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**PART 1 - GENERAL**

**1.1 DESCRIPTION** - The Work specified in this Section consists of coordinating excavation operations with the Project Archaeologist (PA), temporary suspension of excavation operations at specific isolated locations for archaeological and paleontological excavations, and relocating excavation operations temporarily to bypass archaeological discovery sites.

**1.2 JOB CONDITIONS**

A. An Archaeological Technical Report, a Paleontological Technical Report, an Identification Study and a Treatment Plan have been prepared for the Metro Rail Project Stations by WESTEC Services, Inc. These reports indicate that the site of the Work could contain one or more deposits of archaeological or paleontological resources.

B. Pre-excavation Meeting - Before commencement of excavation at the construction site, hold a pre-excavation meeting to discuss the excavation methods to be used in the field, and establish lines of communication between the Contractor, District or its designee and the PA regarding archaeological or paleontological discoveries and their removal. The meeting shall familiarize the Contractor with the specific types of archaeological or paleontological materials that may be encountered, the extent of cooperation with the PA, and the methods of dealing with the discovery of resources. The Contractor shall familiarize the PA with his excavation procedures.

C. The District or its designee will remain the single authority on the job site. Coordination between the PA and the Contractor will flow through the District or its designee.

**1.3 MEASUREMENT**

A. The Work of this Section will be measured per hour that excavation work is suspended during normal working hours for each archaeological or paleontological discovery, starting from the time the PA identifies an archaeological or paleontological discovery until excavation is resumed.

B. The Work required for archaeological or paleontological discovery excavation, removal, and relocation will not be measured for payment.

**1.4 PAYMENT** will be made under:

Item No. 01170.01 - Archaeological or paleontological recovery - per hour.

**PART 2 - PRODUCTS**

Products are not required for this Section.

**PART 3 - EXECUTION**

**3.1 COORDINATION** - The Contractor shall coordinate excavation operations with the PA. The PA will be responsible for monitoring the removal of earth from station sites and other cut-and-cover locations for archaeological or paleontological resources. If such resources are encountered, the PA will determine their significance and, if required, will recover the

resources and the associated data.

**3.2 MONITORING**

- A. The PA will provide full-time monitoring of the excavation to ensure that discrete deposits or individual archaeological or paleontological resources are not inadvertently lost.
- B. The PA will assign a trained monitor to observe earth moving activities. It may be necessary to temporarily suspend earth-moving activities if archaeological or paleontological resources are found. The PA will determine the type, period and significance of the resource and the appropriate excavation and removal procedures to be followed.
- C. Monitoring activities will continue until the excavation has passed the zone where archaeological or paleontological finds are considered likely.

**3.2 TREATMENT OF DISCOVERY** - If an archaeological or paleontological deposit is encountered during excavation, it will be necessary to temporarily halt work in the immediate area so that the PA can conduct an evaluation to determine whether the discovery is significant. Work stoppage for evaluation and data recovery, if necessary, will be held to a minimum.

**3.4 RECOVERY**

- A. When the PA determines an archaeological or paleontological discovery is significant, the Contractor shall provide the labor, materials and equipment to excavate, load, transport and unload the discovery within the project limits as requested by the PA and approved the District or its designee.
- B. Archaeological or paleontological discovery excavation, removal, and relocation will be paid for under Article 41, Force Account, of the General Conditions.

APPENDIX B

SOCIETY OF VERTEBRATE PALEONTOLOGY—  
ASSESSMENT AND MITIGATION OF ADVERSE IMPACTS TO  
NONRENEWABLE PALEONTOLOGIC RESOURCES: STANDARD GUIDELINES

Robert E. Reynolds, Chairman  
Society of Vertebrate Paleontology  
Conformable Impact Mitigation Guidelines Committee

Society of Vertebrate Paleontology News Bulletin Number 163

January 1995

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INTRODUCTION

Vertebrate fossils are significant nonrenewable paleontologic resources that are afforded protection by federal, state, and local environmental laws and guidelines. The potential for destruction or degradation by construction impacts to paleontologic resources on public lands (federal, state, county, or municipal) and land selected for development under the jurisdiction of various governmental planning agencies is recognized. Protection of paleontologic resources includes: (a) assessment of the potential for property to contain significant nonrenewable paleontologic resources which might be directly or indirectly impacted, damaged, or destroyed by development, and (b) formulation and implementation of measures to mitigate adverse impacts, including permanent preservation of the site and/or permanent preservation of salvaged materials in established institutions. Decisions regarding the intensity of the Paleontological Resource Impact Mitigation Program (PRIMP) will be made by the Project Paleontologist on the basis of the paleontologic resources, not on the ability of an applicant to fund the project.

ASSESSMENT OF THE PALEONTOLOGICAL POTENTIAL OF ROCK UNITS

Sedimentary rock units may be described as having (a) high (or known) potential for containing significant nonrenewable paleontologic resources, (b) low potential for containing nonrenewable paleontologic resources, or (c) undetermined potential.

It is extremely important to distinguish between archaeological and paleontological (= fossil) resource sites when defining the sensitivity of rock units. The boundaries of archaeological sites define the areal extent of the resource. Paleontologic sites, however,

indicate that the containing sedimentary rock unit or formation is fossiliferous. The limits of the entire rock formation, both areal and stratigraphic, therefore define the scope of the paleontologic potential in each case. Paleontologists can thus develop maps which suggest sensitive areas and units that are likely to contain paleontological resources. These maps form the bases for preliminary planning decisions. Lead agency evaluation of a project relative to paleontologic sensitivity maps should trigger a "request for opinion" from a state paleontologic clearing house or an accredited institution with an established paleontological repository.

The determination of a site's (or rock unit's) degree of paleontological potential is first founded on a review of pertinent geological and paleontological literature and on locality records of specimens deposited in institutions. This preliminary review may suggest particular areas of known high potential. If an area of high potential cannot be delimited from the literature search and specimen records, a surface survey will determine the fossiliferous potential and extent of the sedimentary units within a specific project. The field survey may extend outside the defined project to areas where rock units are better exposed. If an area is determined to have a high potential for containing paleontologic resources, a program to mitigate impacts is developed. In areas of high sensitivity, a pre-excavation survey prior to excavation is recommended to locate surface concentrations of fossils which might need special salvage methods.

The sensitivity of rock units in which fossils occur may be divided into three operational categories.

A. HIGH POTENTIAL

Rock units from which vertebrate or significant invertebrate fossils or significant suites of plant

distribution of taxa, or evolutionary, ecological, or depositional deductions.

#### **I. STORAGE**

Adequate storage in a recognized repository institution for the recovered specimens is an essential goal of the program. Specimens will be cataloged and a complete list will be prepared of specimens introduced into the collections of a repository by the curator of the museum or university. Adequate storage includes curation of individual specimens into the collections of a recognized, nonprofit paleontologic specimen repository with a permanent curator, such as a museum or a university. A complete set of field notes, geologic maps, and stratigraphic sections accompany the fossil collections. Specimens are stored in a fashion that allows retrieval of specific, individual specimens by researchers in the future.

#### **J. SITE PROTECTION**

In exceptional instances the process of construction may reveal a fossil occurrence of such importance that salvage or removal is unacceptable to all concerned parties. In such cases, the design concept may be modified to protect and exhibit the occurrence with the project's design, e.g., as an exhibit in a basement mall. Under such circumstances, the site may be declared and dedicated as a protected resource of public value. Associated fragments recovered from such a site will be placed in an approved institutional repository.

#### **K. FINAL REPORT**

A report is prepared by the project paleontologist including a summary of the field and laboratory methods, site geology and stratigraphy, faunal list, and a brief statement of the significance and relationship of the site to similar fossil localities. A complete set of field notes, geological maps, stratigraphic sections, and a list of identified specimens accompany the report. The report is finalized only after all aspects of the program are completed. The Final Report together with its accompanying documents constitute the goals of a mitigation project. Full copies of the Final Report are deposited with the Lead Agency and the repository institution.

#### **L. COMPLIANCE**

The Lead Agency assures compliance with measures

to protect fossil resources from the beginning of the project by:

1. requesting an assessment and program for impact mitigation which includes salvage and protection during the initial planning phases;
2. by arranging for recovered specimens to be housed in an institutional paleontologic repository; and
3. by requiring the Final Report.

The supervising paleontologist is responsible for:

1. assessment and development of the program for impact mitigation during initial planning phases;
2. the repository agreement;
3. the adequacy and execution of the mitigation measures; and
4. the Final Report.

Acceptance of the Final Report for the project by the Lead Agency signifies completion of the program of mitigation for the project. Review of the Final Report by a vertebrate paleontologist designated by the Lead Agency will establish the effectiveness of the program and adequacy of the report. Inadequate performances in either field comprise noncompliance, and may result in the Lead Agency removing the paleontologist from its list of qualified consultants.

#### **DEFINITIONS**

**A QUALIFIED VERTEBRATE PALEONTOLOGIST** is a practicing scientist who is recognized in the paleontologic community and is proficient in vertebrate paleontology, as demonstrated by:

1. institutional affiliations or appropriate credentials;
2. ability to recognize and recover vertebrate fossils in the field;
3. local geological and biostratigraphic expertise;
4. proficiency in identifying vertebrate fossils; and
5. publications in scientific journals.

**A PALEONTOLOGICAL REPOSITORY** is a publicly supported, not-for-profit museum or university employing a permanent curator responsible

for paleontological records and materials. Such an institution assigns accession and catalog numbers to individual specimens which are stored and conserved to ensure their preservation under adequate security and climate control. The repository will also retain site lists of recovered specimens, and any associated field notes, maps, diagrams, or associated data. It makes its collections of cataloged specimens available to researchers.

**SIGNIFICANT NONRENEWABLE PALEONTOLOGIC RESOURCES** are fossils and fossiliferous deposits here restricted to vertebrate fossils and their taphonomic and associated environmental indicators. This definition excludes invertebrate or botanical fossils except when present within a given vertebrate assemblage. Certain plant and invertebrate fossils or assemblages may be defined as significant by a project paleontologist, local paleontologist, specialists, or special interest groups, or by Lead Agencies or local governments.

**A SIGNIFICANT FOSSILIFEROUS DEPOSIT** is a rock unit or formation which contains significant nonrenewable paleontologic resources, here defined as comprising one or more identifiable vertebrate fossils, large or small, and any associated invertebrate and plant fossils, traces and other data that provide

taphonomic, taxonomic, phylogenetic, ecologic, and stratigraphic information (ichnites and trace fossils generated by vertebrate animals, e.g., trackways, or nests and middens which provide datable material and climatic information). Paleontologic resources are considered to be older than recorded history and/or older than 5,000 years BP.

**A LEAD AGENCY** is the agency responsible for addressing impacts to nonrenewable resources that a specific project might generate.

**PALEONTOLOGIC POTENTIAL** is the potential for the presence of significant nonrenewable paleontological resources. All sedimentary rocks, some volcanic rocks, and some metamorphic rocks have potential for the presence of significant nonrenewable paleontologic resources. Review of available literature may further refine the potential of each rock unit, formation, or facies.

**PALEONTOLOGIC SENSITIVITY** is determined only after a field survey of the rock unit in conjunction with a review of available literature and paleontologic locality records. In cases where no subsurface data are available, sensitivity may be determined by subsurface excavation.



APPENDIX C

SOCIETY OF VERTEBRATE PALEONTOLOGY—  
CONDITIONS OF RECEIVERSHIP FOR PALEONTOLOGIC SALVAGE COLLECTIONS  
[final draft]

Robert E. Reynolds, Chairman  
Conformable Impact Mitigation Guidelines Committee

Society of Vertebrate Paleontology  
News Bulletin  
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February 1996

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1. The repository museum and its curator maintain the right to accept or refuse the materials.
  2. The materials received must fit with the repository museum's mission and policy requirements.
  3. All repository arrangements must be made with the curator in advance of receipt. All arrangements for inventory numbers and locality numbers must be made in advance. "Museums are not a dumping ground."
  4. The museum will act as the trustee for the specimens. A deed of gift from the land owner or agent must be provided. A loan form or M.O.U. must be prepared for specimens from governmental lands.
  5. Specimens must receive discrete locality numbers. Locality data must be to the maximum specificity available and plotted on 7.5 minute topographic maps, and as specific as allowed by stratigraphic collecting and field mapping. The repository may require the repositor to bear the cost of entering locality data into computerized data files.
  6. All reports prepared to meet mitigation requirements, field notes, and photographs must be provided at the time of transfer to the repository museum.
  7. Specimens must be delivered to the repository fully prepared and stabilized. Standards of stabilization and modern conservation techniques must be established prior to preparation and must be acceptable to the repository institution. Details of stabilizing materials and chemicals must be provided by the repositor. For microvertebrates, this means sorting and mounting. For large specimens, including whales, this means removal of all unnecessary materials and full stabilization. Fossiliferous matrix must be washed and processed. Earth-quake-proofing includes inventory numbers on corks and in vials. In storage, specimens must be insulated or cushioned to protect each from contact or abrasion. Oversized specimens must be stored on shelves or on racks developed to fit existing constraints of the repository museum. The repositor must provide for all nonstandard materials for storage.
  8. Specimens must be individually inventoried in accordance with the established system at the repository museum. The specimen inventory must be acceptable to and meet the requirements of the lead agency. Specimens must be identified to element and to maximum reasonable taxonomic specificity. Batch or bulk cataloging must be avoided.
  9. Specimens must be cataloged in accord with the repository system so that specimens are retrievable to curators and to researchers. The repository museum may require that the repositor bear the cost of having repository staff catalog specimens into computerized data bases.
  10. The repository may require the repositor to bear the cost for completing preparation and stabilization, completing inventory, and completing cataloging.
  11. There will be a one-time fee charged by the repository for permanent storage of specimens. This fee will be used to compensate the

repository for storage space, cabinets or shelves, access or aisle space, a retrievable catalog system, additional preparation, specimen filing, and labor involved in the above. The repository

reserves the right to charge the repositior for unpacking and placement of specimens in approved storage cabinets.

APPENDIX D

DISCOVERY CLAUSE/TREATMENT PLAN,  
PALEONTOLOGIC MONITORING PROGRAM,  
LOS ANGELES METRO RED LINE  
MINIMUM OPERABLE SEGMENT 2  
WILSHIRE/VERMONT STATION (B-211)

E. Bruce Lander,  
Principal Investigator

Paleo Environmental Associates, Inc.

1991

DISCOVERY CLAUSE

1. In the event an unusually large and/or complete vertebrate fossil specimen or the unusual concentration of megainvertebrate or vertebrate fossil specimens is uncovered by excavation associated with construction of Minimum Operable Segment (MOS-) 2, the paleontologic monitor will have construction temporarily avoid the fossil site by diverting excavation around the occurrence. Any delay of construction will be kept to a minimum.

If not on site when the fossil occurrence is uncovered by excavation, construction personnel will ensure excavation avoids the fossil site, and the monitor will be called to the site immediately. If the monitor cannot be reached, the program manager or field supervisor will be called to the fossil site. Any delay of construction will be kept to a minimum.

If archaeological resources are uncovered by construction, excavation will be diverted around the archaeological site until Greenwood and Associates (G&A) personnel have been called to the site, examined the resources, assessed their importance, and determined the measures, if any, required for treating the resources. No further action will be taken by PEAI personnel. The Treatment Plan presented below does not pertain to archaeological resources.

2. The paleontologist (manager, supervisor, or monitor) will examine the fossil occurrence and determine if the occurrence is important enough to warrant removal, and if the occurrence can be removed by the paleontologist without significantly delaying construction, diverting

manpower away from monitoring, or allocating additional personnel to assist in the removal of the remains.

3. **Option A.**—If the fossil occurrence is determined not to be important, the paleontologist will allow excavation to proceed through the fossil site and no additional measure will be required to protect the site.

**Option B.**—If determined to be important but easily removed by the paleontologist without assistance, significantly delaying construction, or diverting manpower away from monitoring, the fossil occurrence will be removed as quickly as possible and construction allowed to proceed through the fossil site by the paleontologist. When such a determination is made, the Treatment Plan will be implemented to allow for the additional treatment of the occurrence. If the paleontologist determines additional treatment (flotation, picking, preparation, sorting, mounting, identification, cataloging, curation, storage) of the fossil occurrence is required, the monitor, if appropriate, will call the program manager or field supervisor, who, in turn, will call G&A. G&A will inform LACTC of the need for additional funding to allow for the completion of these tasks. If warranted, the paleontologist will have the construction contractor assist in removing the fossil remains to reduce any construction delay.

**Option C.**—If the paleontologist determines a significant delay in construction will be required to remove the fossil occurrence, the monitor, if appropriate, will call the program manager or field supervisor, who, in turn, will call G&A. G&A will inform the LACTC, who, in turn, will

inform the construction contractor of the need to divert excavation around the fossil site until the fossil occurrence has been removed and construction has been allowed to proceed through the site by the paleontologist. When such a determination is made, the Treatment Plan will be implemented to expedite the recovery and additional treatment of the occurrence without diverting manpower away from monitoring. The plan will allow for the allocation of additional manpower to assist in the removal of the remains to reduce any possible construction delay. If the paleontologist determines additional treatment (heavy-liquid flotation, picking, preparation, sorting, mounting, identification, cataloging, curation, storage) of the fossil occurrence is required, the monitor, if appropriate, will call the program manager or field supervisor, who, in turn, will call G&A. G&A will inform LACTC of the need for additional funding to allow for the completion of these tasks. If warranted, the paleontologist will have the construction contractor assist in removing the fossil remains to reduce any construction delay.

4. If warranted by the high potential for the disturbance of additional fossil occurrences during construction, the program manager will request monitoring be increased from the current schedule of 6 hours/week.

The following personnel represent the lines of communication to be used if an important fossil occurrence is uncovered by construction.

PEAI personnel and their phone numbers are:

Program Manager:

E. Bruce Lander (818/797-9895)

Field Supervisor:

Mark A. Roeder (714/241-8880)

Paleontologic Monitors:

Trudy L. Stubbs (818/760-2663)

Gary Takeuchi (213/264-0613)

Robin Turner (310/202-7818)

G&A personnel and their phone numbers are:

Principal Investigator:

Roberta S. Greenwood (310/454-3091)

Archaeological Monitor:

Neal Kaptain (213/271-1913)

LACTC Environmental Compliance personnel and their phone numbers are:

Manager: James L. Sowell (213/233-6730)

Construction contractor Resident Engineers and their phone numbers are:

B-211: Dane Hudson (213/380-8465)

### TREATMENT PLAN

With the approval of the LACTC, this Treatment Plan will be implemented immediately following the discovery of a fossil occurrence determined by the paleontologist to be highly important. The plan will allow for the rapid and proper excavation and removal of a fossil occurrence and its transport to an offsite location for additional treatment. The program manager will allocate additional hours to the paleontologic monitor or assign additional personnel to remove the remains. If necessary, the manager will ask for the assistance of Natural History Museum of Los Angeles County (LACM) personnel and for an estimate of the costs for all required museum field and laboratory personnel, services, and supplies. PEA I and LACM rates are presented below.

The Treatment Plan will ensure the monitor is not diverted from the basic monitoring schedule of 6 hours/week, and that any potential delay of construction at the fossil site is kept to a minimum. The plan will also ensure the fossil occurrence and associated geologic and geographic data are salvaged and preserved in a museum for later study by qualified investigators. The preservation of scientifically highly important fossil remains and associated data will result in a substantial reduction in the adverse environmental impacts (loss of fossil remains to excavation and unauthorized fossil collecting by construction personnel) resulting from construction of MOS-2.

If an unusually large or complete vertebrate fossil specimen or the unusual concentration of megainvertebrate or vertebrate fossil specimens is encountered by construction, the remains and/or a sample of the fossiliferous rock will be excavated by PEA I personnel (field supervisor, paleontologic monitor, and/or field technician) with the assistance of LACM personnel, if required, and transported to the LACM for final treatment (preparation [may be performed by PEA I personnel at another location], identification, cataloguing, curation, storage) of larger fossil remains. If warranted, the paleontologist will

have the construction contractor assist in removing the fossil remains or the rock sample to reduce any construction delay. The remainder of the rock sample will undergo initial (on-site) processing (wet screening) for smaller fossil remains by a PEAI paleontologist(s). The concentrate generated by initial processing will be transported to the LACM for final processing (heavy-liquid flotation, picking, preparation, sorting, mounting, identification, cataloging, curation, storage) by LACM personnel. The results of any work conducted under the Treatment Plan will be included in the monthly progress reports and in the monitoring program final report for MOS-2. If necessary, the program manager

will request additional budget for completing an expanded final report to include the results of work conducted under the Treatment Plan.

An agreement has been reached with the LACM regarding their providing personnel and services, if required, to assist PEAI in conducting the monitoring program under the Treatment Plan, as well as their acceptance of any fossil remains collected during the monitoring program.

LACM personnel and their phone numbers are:

Curator: Dr. David P. Whistler (213/744-3310)



APPENDIX E

ACCEPTANCE OF METRO RED LINE INVERTEBRATE FOSSIL COLLECTION BY  
THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY,  
INVERTEBRATE PALEONTOLOGY SECTION

[storage agreement]

Lindsey T. Groves  
Collections Manager

Natural History Museum of Los Angeles County Malacology/Invertebrate Paleontology Section

March 24, 1995

900 Exposition Boulevard  
Los Angeles, California 90007  
(213) 744-3376/3485  
fax (213) 746-2999

24 MARCH 1995

Dr. E. Bruce Lander, President  
Paleo Environmental Associates  
2248 Winrock Avenue  
Altadena, CA 91001

Subject: Acceptance of Metro Red Line invertebrate fossil collection by the Natural History Museum of Los Angeles County, Invertebrate Paleontology Section.

Dear Dr. Lander:

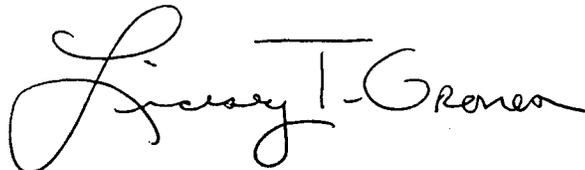
This letter will confirm my statement of 20 March 1995 to you regarding acceptance of the Metro Red Line Segment 2 invertebrate fossil collection by the Invertebrate Paleontology Section of the Natural History Museum of Los Angeles County (LACMIP). The section is willing to accept the collection if the following conditions are met:

All specimens will be prepared and identified to the lowest taxonomic level possible.

All specimens will be accompanied by geologic and geographic site data.

Please contact me at (213) 744-3376 or 3485 if you have any questions regarding these requirements.

Sincerely,



Lindsey T. Groves  
Collections Manager Malacology/Invertebrate Paleontology



APPENDIX F

ACCEPTANCE OF METRO RED LINE VERTEBRATE FOSSIL COLLECTION BY  
NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY  
VERTEBRATE PALEONTOLOGY SECTION  
[storage agreement]

Dr. Samuel A. McLeod  
Collections Manager

Natural History Museum of Los Angeles County Vertebrate Paleontology Section

December 1, 1994

of Los Angeles County  
Vertebrate Paleontology Section  
Telephone: (213) 744-3325  
FAX: (213) 746-7431  
e-mail: smcleod @ vm.usc.edu

900 Exposition Boulevard  
Los Angeles, California 90007  
1 December 1994

Dr. E. Bruce Lander  
Paleo Environmental Associates, Inc.  
2248 Winrock Avenue  
Altadena, CA 91001

Subject: acceptance of Metro Red Line vertebrate fossil collection by Natural History Museum of Los Angeles County Vertebrate Paleontology Section

Dear Dr. Lander:

This letter will confirm my statement of 1 November 1994 to you regarding acceptance of the Metro Red Line Segment 2 vertebrate fossil collection by the Vertebrate Paleontology Section of the Natural History Museum of Los Angeles County [LACM-VP]. The section is willing to accept the collection if all the following conditions are met:

All specimens will be prepared, identified to the lowest taxonomic level possible, and assigned LACM-VP specimen and site numbers

All specimens will be accompanied by geologic and geographic site data

All specimen data will be entered into the section specimen catalogue and computerized database

The collection will be accompanied by specimen cabinets, drawers, and trays similar to those used by the section

A storage and maintenance fee prorated at \$13.50 per cubic foot will be assessed upon receipt of the collection to cover permanent storage and maintenance of the collection by the section

Please contact me at (213) 744-3325 if you have any questions regarding these requirements.

Sincerely,



Samuel A. McLeod  
Vertebrate Paleontology



George C. Page Museum, Hancock Park, 5801 Wilshire Boulevard, Los Angeles, California 90036, (213) 857-6311  
William S. Hart Museum, Hart Park, 24151 San Fernando Road, Newhall, California 91321, (805) 254-4584

APPENDIX G

ACCEPTANCE OF METRO RED LINE PLANT FOSSIL COLLECTION BY  
UNIVERSITY OF CALIFORNIA MUSEUM OF PALEONTOLOGY,  
BERKELEY, CALIFORNIA  
[storage agreement]

Howard E. Schorn  
Museum Scientist (active emeritus)

University of California Museum of Paleontology

August 14, 1995

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO



SANTA BARBARA • SANTA CRUZ

MUSEUM OF PALEONTOLOGY

BERKELEY, CALIFORNIA 94720

Telephone: 510-643-5205; Fax: 510-642-1822; E-mail: [howards@ucmp1.berkeley.edu](mailto:howards@ucmp1.berkeley.edu)

23 May 1995

Dr. E. Bruce Lander, President  
Paleoenvironmental Associates  
2248 Winrock Avenue  
Altadena, CA 91001

Subject: acceptance of Metro Red Line fossil plant collection by the University of California Museum of Paleontology, Berkeley, California.

Dear Dr. Lander:

This letter will confirm my statement of 23 May 1995 to you regarding acceptance of the Metro Red Line Segment 2 fossil plant collection by the University of California Museum of Paleontology. The Museum is willing to accept the collection if all the following conditions are met:

All specimens will be prepared (i.e., excess rock is trimmed away from the actual fossil)

All specimens will be accompanied by geologic and geographic site data

An accessioning fee of \$50.00 will be assessed upon receipt of the collection to cover permanent storage and maintenance of the collection by the Paleobotany Section. Please make check payable to The Regents of the University of California and send to the attention of Dr. David Lindberg, Assistant Director.

Please contact me at 510-643-5205 if you have any questions regarding these requirements.

Sincerely,

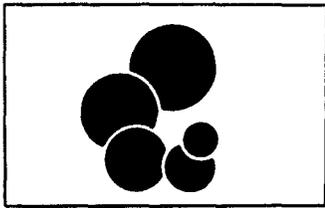
Howard E. Schorn

**APPENDIX H**

**[letter report on results of analysis of microfossil sample from Wilshire/Vermont station site]**

**Micropaleo Consultants, Inc.**

**January 11, 1993**



**MICROPALEO**  
CONSULTANTS, INC.

January 11, 1993

Mr. Bruce Lander  
797 New York Drive  
Altadena, California 91001

Dear Mr. Lander:

Enclosed is our report on the microfossil examination of the Vermont Station Metrorail sample.

As per Mark Roeder's instructions, we looked at the Foraminifera, calcareous nannoplankton, and the diatoms/silicoflagellates. The sample contains upper Mohnian Foraminifera. The calcareous nannoplankton suggest zone CN9A, which is upper Mohnian to possible upper Mohnian/"Delmontian" transition. The siliceous microfossils indicate an age of no older than the *Denticulopsis hustedtii* zone, which is also an upper Mohnian equivalent.

We should point out that calcareous nannoplankton zone CN9A and the siliceous *Denticulopsis hustedtii* zone do not overlap, i.e., the latter is slightly older than the former. The siliceous occurrences, while very diverse, only provide a base for the age; it may well be that the slightly younger age suggested by the calcareous nannoplankton is more reliable.

If you have any questions about this report, give me a call. We previously invoiced for this sample and have received the payment.

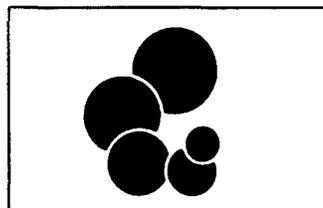
Sincerely,

*Richard S. Boettcher*

Richard S. Boettcher  
MICROPALEO CONSULTANTS, INC.

RSB:be

Enclosure



**MICROPALEO**  
CONSULTANTS, INC.

## FORAMINIFERA

The sample was crushed, boiled in Quaternary-O, and then washed over 20 and 200 mesh screens. The coarser fraction is used for a lithology description, while the material caught on the 200 mesh screen is used for the fossil examination.

We present the foraminiferal information in terms of the provincial California Stage terminology of Kleinpell (1938, 1980). In addition, the works of Finger (1990, 1992) provide useful data.

Paleoenvironmental assignments generally follow the models of Ingle (1980), plus modifications noted by Ingle in Finger (1990).

The frequency symbols used in this study and their numerical equivalents are: V = very rare (1); R = rare (2-10); F = frequent (11-32); C = common (33-100); and A = abundant (100+).

AGE: Late Miocene, Upper Mohnian Stage

ENVIRONMENT: Upper Middle Bathyal

FOSSILS: *Baggina* sp. (R), *Bolivina bramlettei?* (R), *B. granti* (R), *B. hughesi?* (V), *B. pseudospissa* (F), *B. tongi* (R), *B. vaughani* (R), *B. woodringi* (F), *Bulimina inflata* (R), *Buliminella subfusiformis* (R), *Cassidulina* aff. *crassa* (R), *C. delicata* (R), *Epistominella subperuviana* (C), *Eponides multicameratus* (R), *E. cf. rosaformis* (R), *Gyroidina* cf. *rotundimargo* (C), *Nonion goudkoffi* (F), *Valvulineria araucana araucana* (R), *Globigerina bulloides* (F), *G. pachyderma dex?* (R), *G. quadrilatera* (F), *Turborotalia scitula* (R), diatoms (A), fish remains (C), Radiolaria (A)

REMARKS: Lithology is a light to medium brown sublaminated mudstone. The species noted are typical of upper Mohnian Puente deposits.

Interpreted by:

*Richard S. Boettcher*

Richard S. Boettcher  
MICROPALEO CONSULTANTS, INC.

## CALCAREOUS NANNOPLANKTON

The sample was disaggregated in water and the resulting slurry allowed to settle for a few seconds while coarse particles settled out. Portions of the fine suspension were then transferred to cover glasses and dried. The cover glasses were permanently mounted on glass slides for examination in transmitted light.

For age determinations, the zonation of Bukry (Okada and Bukry, 1980) was used, with ages reported in terms of the standard international or European time scale to which microfossil zonations are usually referred. Additional information on the ranges of some species was obtained from Perch-Nielsen (1985).

Species abundances are reported in categories with the following abbreviations and numerical estimates: abundant (A, 1000+), common (C, 101-1000), few (F, 11-100), rare (R, 2-10) and very rare (V, 1 specimen).

AGE: Late Miocene

ZONE: Probable CN 9A

SPECIES: *Braarudosphaera bigelowi* (R), *Coccolithus pelagicus* (C), *Calcidiscus macintyreii* (F), *Discoaster brouweri* (R), *D. intercalaris* (R), *D. loeblichii* (R), *D. surculus* (F), *Dictyococcites antarcticus* (C), *D. minutus* (A), *Reticulofenestra pseudoumbilica* (F), *Sphenolithus moriformis* (R).

REMARKS: Identification of the discoasters is hindered by poor preservation of the tips of rays. *D. surculus*, which has not been reported from zones below CN 9A, is identified with reasonable confidence. A form with asymmetrically branched tips is probably *D. loeblichii*, which is normally restricted to Zone CN 8B but has occasionally been reported from CN 9A.

Interpreted by:



Stanley A. Kling  
MICROPALÉO CONSULTANTS, INC.

## SILICEOUS MICROFOSSILS

Samples were disaggregated in water with hydrogen peroxide and acidized with hydrochloric acid to eliminate calcium carbonate. The rinsed material was then sieved on a screen with 30-micrometer openings. Fractions greater than and less than 30 micrometers were mounted on glass slides for examination in transmitted light.

Ages are reported in terms of the standard international or European time scale to which microfossil zonations are usually referred. The diatom zonation presented in Barron (1981) and modified by Barron (1986) is used for general age interpretations in this report.

Species abundances are reported in categories with the following abbreviations and numerical estimates: abundant (A, 1000+), common (C, 101-1000), few (F, 11-100), rare (R, 2-10) and very rare (V, 1 specimen).

AGE: Late Miocene

ZONE: Probable *Denticulopsis hustedtii*.

KEY SPECIES: *Actinocyclus ingens* (R), *Denticulopsis hustedtii* (R), *D. hyalina* (V), *Nitzschia fossilis* (R), *Stephanopyxis appendiculata* (R).

*Dictyocha aspera* (C), *D. subclinata* (C).

ADDITIONAL SPECIES:

*Actinocyclus ehrenbergii* (R), *A. ingens* (R), *Actinoptychus splendens* (R), *A. senarius* (R), *Campyloneis grevillei* (R), *Coscinodiscus asteromphalus* (R), *C. marginatus* (R), *C. nodulifera* (R), *Delphineis sachalinensis* (R), *D. surella* (R), *Denticulopsis hustedtii* (R), *D. hyalina?* (V), *Diploneis* sp. (R), *D. smithii* (R), *Endictya oceanica* (R), *Grammatophora* sp. (R), *Hemidiscus cuneiformis* (R), *Melosira sulcata* (C), *Navicula praetexta* (R), *N. lyra* (R), *N. pennata* (R), *Nitzschia fossilis* (R), *Opephora schwartzii* (R), *Rhizosolenia hebetata* (C), *Stephanopyxis appendiculata* (R), *S. turris* (R), *Stictodiscus californicus* (R), *Thalassionema nitzschioides* (C), *Thalassiosira lineata* (F), *T. sp.* (F), *Thalassiothrix longissima* (C).

*Ammodochium rectangulare* (R), *Dictyocha aspera* (C), *D. fibula* (R), *D. subclinata* (C), *Distephanus speculum* (R).

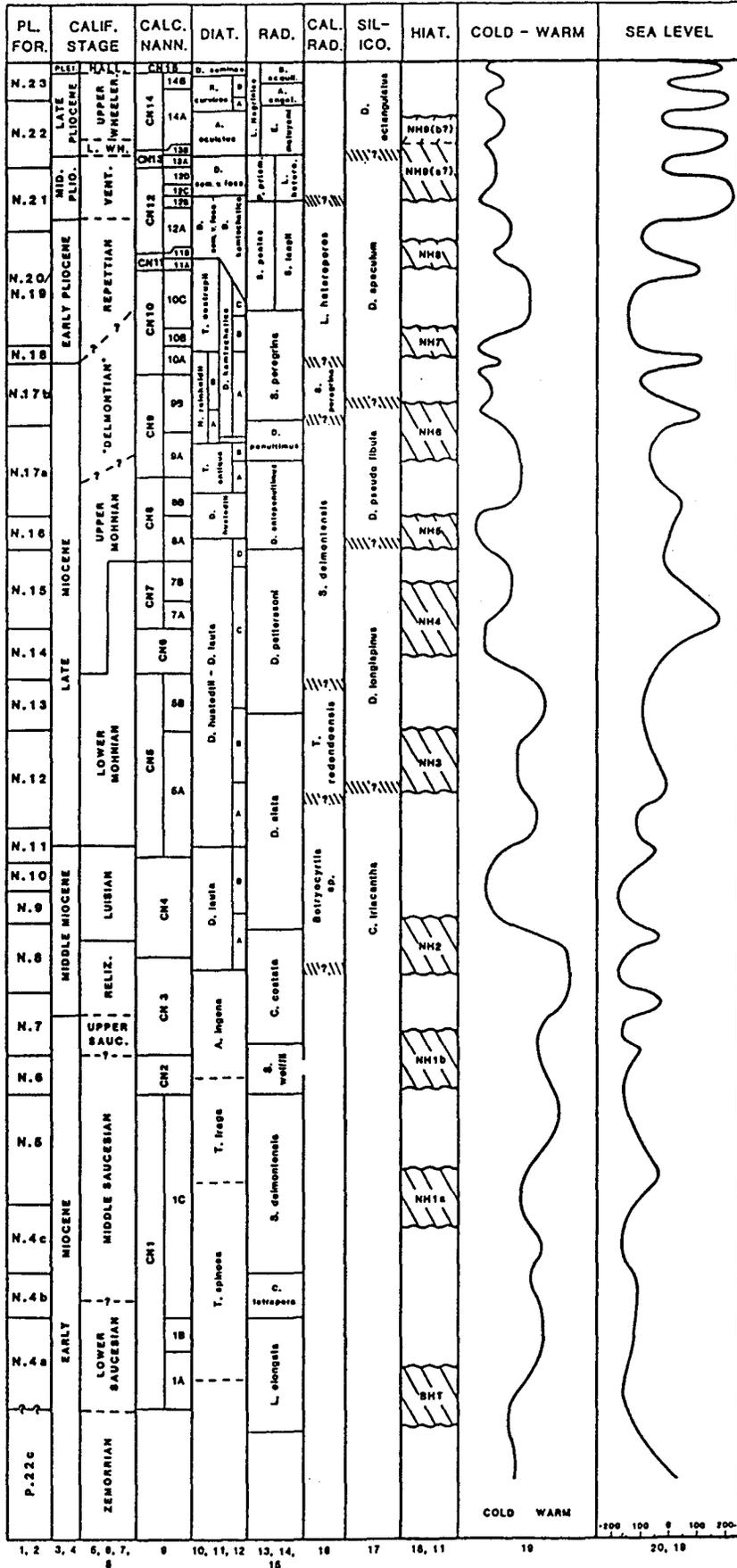
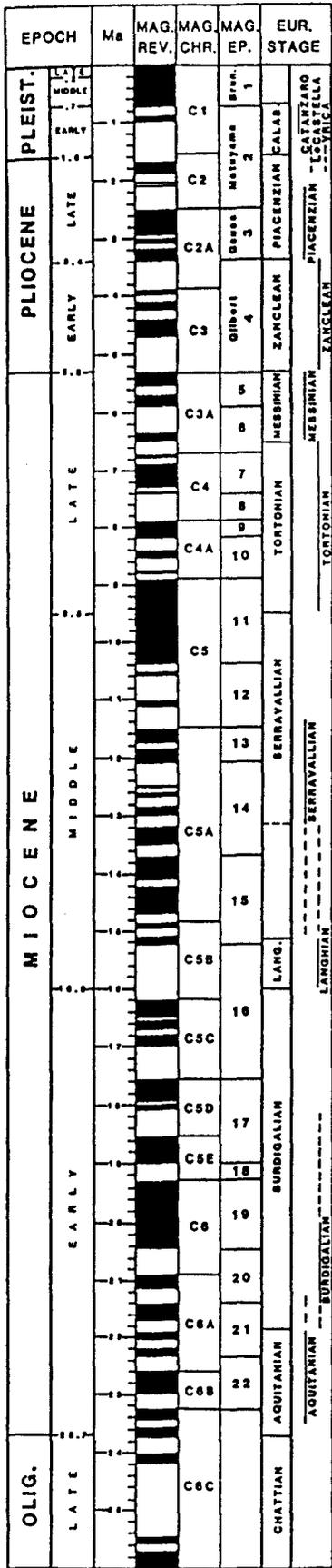
REMARKS:

Although all siliceous microfossil groups are abundant in this sample, many key zone diagnostic species are lacking. Barron (1986) reports the lowest occurrence of *N. fossilis* near the top of the *D. hustedtii* Zone. Forms indicating younger zones are absent, as are other forms that would normally be expected in this zone.

Interpreted by:

*Stanley A. King*

Stanley A. King  
MICROPALEO CONSULTANTS, INC.



**REFERENCES**

- Barron, J. A., 1981. Late Cenozoic diatom biostratigraphy and paleoceanography of the middle-latitude eastern North Pacific, Deep Sea Drilling Project Leg 63. *In*: Yates, R. S., Haq, B. U., et al., Init. Repts. DSDP, 63: Washington (U.S. Govt. Printing Office), 507-538.
- \_\_\_\_\_, 1986. Updated diatom biostratigraphy for the Monterey Formation of California. *In*: Casey, R. E. and Barron, J. A., Eds., Siliceous microfossil and microplankton studies of the Monterey Formation and modern analogs. Pacific Section, Soc. Econ. Paleontologists and Mineralogists, Special Publications, Book 45, 105-119.
- Finger, K.L., 1990. Atlas of California Neogene Foraminifera: Cushman Found., Foraminiferal Research, Spec. Publ. No. 28, 271 pp.
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- Ingle, J.C., Jr., 1980. Cenozoic paleobathymetry and depositional history of selected sequences with the southern California continental borderlands: Cushman Found. Foraminiferal Research, Spec. Publ. No. 19, p. 163-195.
- Kleinpell, Robert M., 1938. Miocene stratigraphy of California: Tulsa, Okla., AAPG Publ., p. 1-450.
- \_\_\_\_\_, and Others, 1980. The Miocene stratigraphy of California revisited: Am. Assoc. Petrol. Geol., Studies in Geology No. 11, 182 pp.
- Okada, H. and Bukry, D., 1980. Supplementary modification and introduction of code numbers to the lower latitude coccolith biostratigraphic zonation (Bukry, 1973; 1975). *Marine Micropaleontology*, 5(3), 321-325.
- Perch-Nielsen, K., 1985. Cenozoic calcareous nannofossils. *In*: Bolli, H. M., et al., eds.: *Plankton Stratigraphy*; 427-554. Cambridge University Press, Cambridge.

APPENDIX I

INVERTEBRATE FOSSIL REMAINS FROM  
UNNAMED LATE MIOCENE MARINE SHALE,  
METRO RED LINE SEGMENT 2 CONSTRUCTION ZONE,  
LOS ANGELES, CALIFORNIA

Lindsey T. Groves  
Senior Invertebrate Paleontologist

Paleo Environmental Associates, Inc.

August 1997

SUMMARY

Numerous marine invertebrate fossil remains were recovered from the unnamed late Miocene marine shale (= upper part of Puente Formation of earlier workers) as a result of the paleontologic resource impact mitigation program for Los Angeles Metro Red Line Segment 2 (Lander, in preparation). Modern species of the marine invertebrate genera represented by the remains from the Segment 2 construction zone (Table 1) exist today off the coast of southern and central California. Modern examples of *Mitrella permodesta*, *Acesta*, *Delectopecten*, and *Lepas* in the Natural History Museum of Los Angeles County (LACM) Malacology Section collection are documented as living in mud underlying the sea floor and at ocean depths greater than about 500 meters (1,650 feet) below sea level. However, examples of *Corbula* and *Periploma* are never or only rarely recorded at depths greater than 100 and 400 meters (330 and 1,300 feet), respectively. Sea star species of the Zoroasteridae? are common at depths greater than 100 meters and the type species of *Paleopneustes* (*P. cristatus*) has been reported as occurring at ocean depths of "100 fathoms [600 feet, 185 meters] off Barbados" (Grant and Hertlein, 1938).

Hickman (1984) described six types of Cenozoic deep-water marine mollusk communities that are based on paleobathymetric (depth) ranges and paleoecological criteria. Two of these community types, the *Acesta* and Mud Pecten Communities, occur in the Segment 2 construction zone, and are represented by *Acesta* and *Delectopecten*, respectively. Based on depth preferences of the modern species of these genera, the communities ranged from 589 to 704 meters (1,935 to 2,310 feet) (*Acesta* Communities) and from 20 to 700 meters (65 to 2,300 feet) (Mud Pecten Communities) below sea level, although *Delectopecten* now occurs at depths

down to 2,010 meters (6,600 feet) (Hickman, 1984). Both communities were dominated by epifaunal suspension feeders and are preserved in laminated and/or massive siltstone strata (Hickman, 1984). The fossil communities are very similar taxonomically to modern mollusk communities living off the southern and central California coast.

The depth preferences of some of the genera comprising the mollusk/echinoderm fauna from the unnamed marine shale indicate a comparatively deep-water marine habitat at ocean depths probably between 589 and 704 meters (1,935 and 2,310 feet) below sea level. Presumably, remains of shallower-water marine species might have been transported into deeper water by turbidity currents.

Grant and Hertlein (1938) and Woodring (1938) reported *Acesta hamlini*, *Corbula binominata*, *Delectopecten pedroanus* (= *Delectopecten peckhami*), *Periploma cryphia*, and *Paleopneustes holmani* as occurring in the early Pliocene "Repetto" Formation (= Repetto [lower] Member, Fernando Formation) of the Los Angeles basin (identification of Segment 2 specimen of *Paleopneustes holmani* by Mrs. Yvonne Albi, LACM Malacology/Invertebrate Paleontology Section). *Mitrella permodesta* presumably also is from the "Repetto" Formation in the Los Angeles basin, and *Delectopecten vancouverensis fernandoensis?* is from the "Repetto" Formation (= Towsley Formation) in northern Los Angeles County (Eldridge and Arnold, 1907; Moore, 1984). With the exception of *Delectopecten peckhami*, their occurrences in the unnamed late Miocene marine shale are the oldest records of these species, which have been reported previously as occurring in the Miocene fossil record only in the Sycamore Canyon Formation of the Puente Hills (Groves, 1997; Lander, 1997, in preparation). *Delectopecten peckhami* is known from Eocene

through early Pliocene rock units of central and southern California (Moore, 1984), and has been reported as occurring in "beds of supposed Miocene age in the Puente Hills" by Eldridge and Arnold (1907). The invertebrate fauna from the unnamed late Miocene marine shale is very similar to the mollusk/echinoderm fauna described by Woodring (1938) from the "Repetto" Formation in the Los Angeles basin.

**LITERATURE CITED**

Eldridge, G.H., and Arnold, R. 1907. Santa Clara Valley, Puente Hills, and Los Angeles oil districts, southern California. U.S. Geological Survey Bulletin 309:1-266.

Grant, U.S., IV, and Hertlein, L.G. 1938. The west American Cenozoic Echinoidea. Publications of the University of California at Los Angeles in Mathematical and Physical Sciences 2:1-225.

Groves, L.T. 1997. Invertebrate fossil remains from Puente Hills Landfill expansion area, northwestern Puente Hills, Los Angeles County, California. In Lander, E.B. Paleontologic resource impact mitigation program final report, Puente Hills Landfill expansion, Los Angeles County, California. Paleo

Environmental Associates, Inc., project 94-17. Prepared for County Sanitation Districts of Los Angeles County Solid Waste Management Department.

Lander, E.B. 1997. Paleontologic resource impact mitigation program final report, Puente Hills Landfill expansion, Los Angeles County, California. Paleo Environmental Associates, Inc., project 94-17. Prepared for County Sanitation Districts of Los Angeles County Solid Waste Management Department.

Lander, E.B. In preparation. Los Angeles Metro Red Line Project paleontologic resource impact mitigation program final technical report of findings. Paleo Environmental Associates, Inc., project 94-6A/B. Prepared for Los Angeles County Metropolitan Transportation Authority.

Moore, E.J. 1984. Tertiary marine pelecypods of California and Baja California: Propeamussiidae and Pectinidae. U.S. Geological Survey Professional Paper 1228B:B1-B112.

Woodring, W.P. 1938. Lower Pliocene mollusks and echinoderms from the Los Angeles basin, California. U.S. Geological Survey Professional Paper 190:1-67.

**Table 1.**—Taxonomic list, marine invertebrates, unnamed late Miocene marine shale, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California.

<b>PHYLUM</b>		
<b>Class</b>		
<b>Genus, Species</b>	<b>Common Name</b>	<b>LACMIP<sup>a</sup> Fossil Site Number</b>
<b>MOLLUSCA</b>		
<b>Bivalvia</b>		
<sup>b</sup> <i>Acesta hamlini</i> (Dall?, 1900)	Hamlin's fileclam	16840, 16844, 16845, 16847
<sup>b</sup> <i>Corbula binominata</i> Hanna?, 1924	Corbula clam	16843, 16845
<sup>b</sup> <i>Delectopecten vancouverensis fernandoensis</i> (Hertlein?, 1923)	mudpecten	16843
<sup>b</sup> <i>Delectopecten peckhami</i> (Gabb, 1869) of Arnold, 1906	mudpecten	16840, 16841, 16842, 16843, 16844, 16845, 16846, 16847
<sup>b</sup> <i>Delectopecten</i> sp. indet. <sup>c</sup>	mudpecten	17137, 17138
<sup>b</sup> <i>Periploma cryphia</i> Woodring?, 1938	spoonclam	16843
Bivalvia, gen. & sp. indet.	clams	16841, 16843, 16844, 16845, 16847, 17138
<b>Gastropoda</b>		
<i>Mitrella permodesta</i> (Dall, 1890)	dove-snail	16843
Gastropoda, gen. & sp. indet.	snails	16843, 16844

**ARTHROPODA**

**Crustacea**

*Lepas?* sp. indet. barnacle 16842, 16843, 16845, 16847, 17138

**ECHINODERMATA**

**Asteroidea**

Zoroasteridae?, gen. & sp. indet. sea star 16843, 16847

**Echinoidea**

<sup>b</sup>*Paleopneustes holmani* Grant & Hertlein, 1938 sea urchin 16842

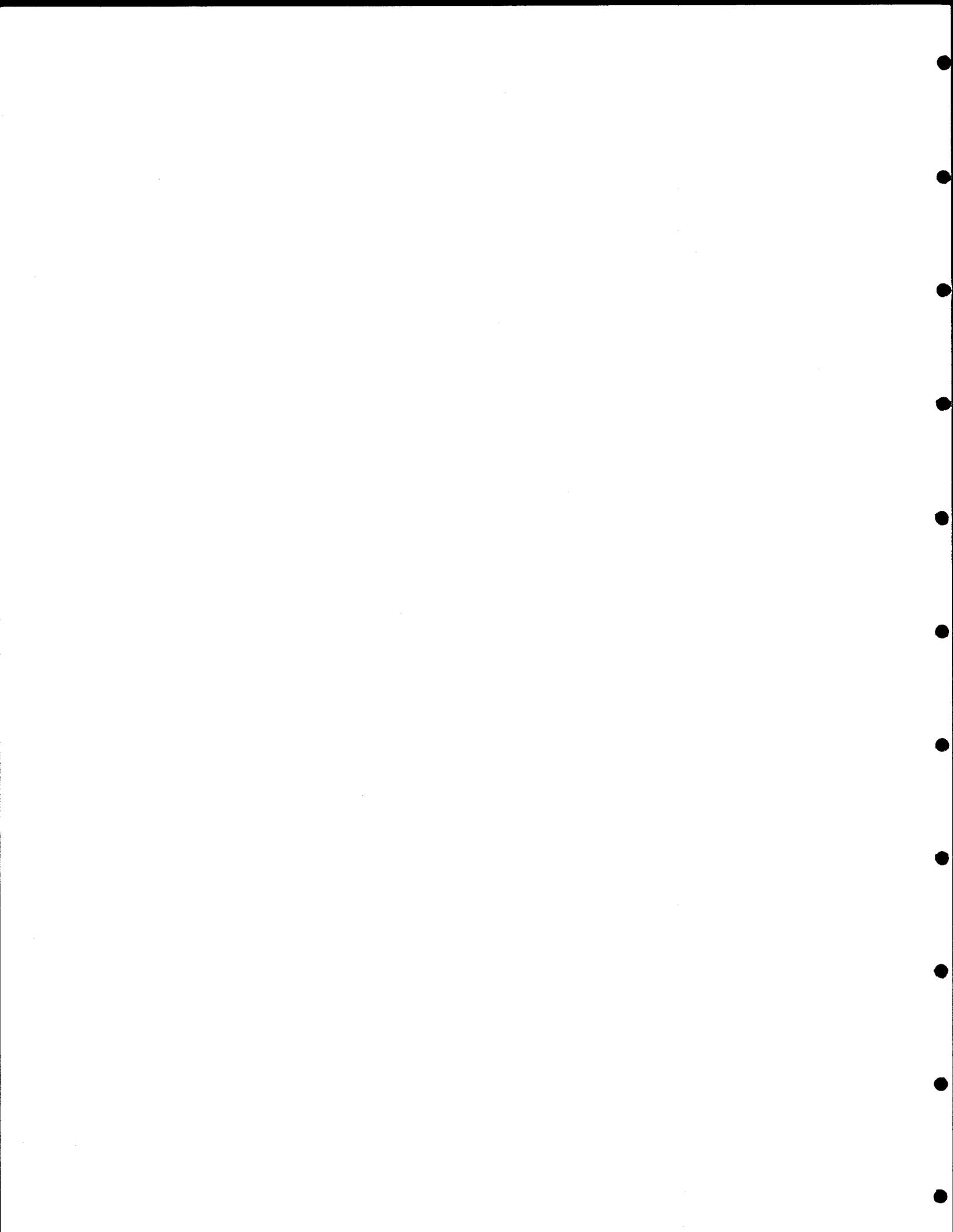
<sup>a</sup>Natural History Museum of Los Angeles County Invertebrate Paleontology Section.

<sup>b</sup>Extinct species.

<sup>c</sup>gen.: genus;

indet.: indeterminate;

sp.: species.



APPENDIX J

FOSSIL FISH REMAINS FROM  
UNNAMED LATE MIOCENE MARINE SHALE,  
METRO RED LINE SEGMENT 2 CONSTRUCTION ZONE,  
LOS ANGELES, CALIFORNIA

Richard W. Huddleston  
Senior Vertebrate Paleontologist

Paleo Environmental Associates, Inc.

August 1997

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INTRODUCTION

Over 5,000 fossil marine fish specimens were recovered from the unnamed late Miocene marine shale (= Puente Formation of earlier workers) as a result of the paleontologic resource impact mitigation program for Los Angeles Metro Red Line Segment 2 (Lander, in preparation). Each specimen was evaluated and over 3,000 specimens were discarded because they were determined too incomplete or poorly preserved to be identifiable, even if subjected to additional study. The remaining approximately 2,090 specimens, which consist of complete and partial skeletons, scales, and otoliths (ear ossicles), were identified. Approximately 235 otherwise unidentified fish specimens were assigned to the Teleostei (advanced bony fish) because they were determined potentially identifiable to a lower taxonomic level only with additional study. The approximately 1,825 specimens remaining were identified to the lowest possible taxonomic level before the retained specimens were submitted for preparation, curation, cataloguing, and transfer to the Natural History Museum of Los Angeles County Vertebrate Paleontology Section (LACMVP) for permanent storage and maintenance.

OTOLITHS

Otoliths aid a living fish in hearing and in maintaining balance. These elements are the most diagnostic part of most fish skeletons, and it is possible to identify the fish species represented based only on an otolith. At least 41 Segment 2 fish species are represented, at least in part, by otoliths and comprise taxonomically the largest and most diverse late Miocene fossil otolith assemblage ever reported from the California fossil record. Seventeen of these species are represented only by otoliths. Unfortunately, otoliths rarely are preserved with the rest of the skeleton

because of a preservational bias. Otoliths are associated with identifiable skeletal remains only at one other late Miocene fossil site (Chalk Hill) in southern California. The Chalk Hill fossil site, which occurs in the Yorba Member of the marine Monterey Formation in the Puente Hills of the northeastern Los Angeles basin, has yielded five or six marine fish species that are represented by associated otoliths and skeletal remains. However, at least 25 Segment 2 fish species identified from the unnamed marine shale are represented by associated otoliths and skeletal remains. This very rare association of otoliths and identifiable skeletal remains in the unnamed marine shale is scientifically highly important because it is possible to document, in some cases for the first time, that particular fish species based on otoliths are synonymous with particular species based on skeletal remains. Moreover, the taxonomic diversity of these otoliths and associated skeletal remains provides an opportunity to compare the Segment 2 fish fauna with other late Miocene marine fish faunas and with middle Miocene and Pliocene marine fish assemblages in the southern California fossil record, making it possible to identify the fish species comprising these other faunas and to resolve many of the taxonomic problems that resulted from the last major study of the faunas by David (1943).

FAUNA

The Segment 2 fish fauna from the unnamed late Miocene marine shale is scientifically highly important because it is the taxonomically largest and most diverse fossil marine fish assemblage reported from the late Miocene fossil record of southern California. The fauna is represented by 36 families, of which 1 family is extinct, 57 genera, and 66 (1 extant, 64 extinct) species, of which 39 of the extinct species are new, not having been reported previously in the scientific literature. Many of these new species are

deep-water or very-deep-water marine forms. A taxonomic list of the Segment 2 fish fauna is presented in Table 1.

Some of the Segment 2 fossil fish specimens are scientifically highly important in part because they represent very rare fossil occurrences for their respective genera and families, and include the

first reported fossil occurrences of the Anoplogasteridae (fangtooths), Coryphaenidae (dolphinfishes), Neoscopelidae (blackchins), Oneirodidae (dreamers), Opisthoproctidae (barreleyes, spookfishes), and Platyroctidae (tubeshoulders), and of *Centrobranchus?* and *Taaningichthys* (Myctophidae; lanternfishes);

second reported fossil occurrences of the Linophrynidae (netdevils) and of *Bolinichthys?* and *Diogenichthys?* (Myctophidae; lanternfishes) (see Pietsch and Lavenberg, 1980);

third reported fossil occurrence of *Leuroglossus* (Bathylagidae; smoothtongue) (see Lander, 1991);

oldest reported fossil occurrences of *Genyonemus* (Sciaenidae; white croaker), *Leuroglossus* (Bathylagidae; smoothtongue), *Ceratoscopelus*, *Stenobranchius*, *Tarletonbeania*, *Triphoturus* (Myctophidae; lanternfishes), *Paralabrax* (Serranidae; sand bass), and *Scopelogadus* (Melamphaeidae; bigscale; additional late Miocene fossil occurrence reported from marine Capistrano Formation, Orange County, California; see Ebeling, 1962; see Lander, in preparation, regarding fossil occurrence incorrectly reported as being from late Miocene Yorba Member, Monterey Formation, Orange County) (see Lander, 1991);

oldest reported North American fossil occurrences of *Argentina* (Argentinidae; argentines), *Benthoosema?* (Myctophidae; lanternfish), and *Physiculus* (Moridae; codling/mora; see Lander, in preparation, regarding fossil occurrence incorrectly reported as being from late Miocene Yorba Member, Monterey Formation, Orange County);

oldest reported American fossil occurrence of *Symbolophorus* (Myctophidae; lanternfish);

first reported North American fossil occurrences of the Alepocephalidae (slickheads),

Photichthyidae (lightfishes), and Trichiuridae (cutlassfishes, scabbardfishes), and of *Bolinichthys?* and *Diogenichthys?* (Myctophidae; lanternfishes; previous identification by Fitch, 1969, of *Diogenichthys?* from unspecified Miocene marine rock unit, Veracruz, Mexico, incorrect), *Stomias* and genus A (Stomiidae; scaly dragonfishes), one member (genus A) of the Melamphaeidae (big scales), and possibly of *Nemichthys* (Nemichthyidae; snipe eel) (see Fitch and Lavenberg, 1968);

first reported fossil occurrences of otoliths of the Alepocephalidae (slickheads), Gempylidae? (snake mackerels, escolars, oilfishes), and possibly Nemichthyidae (snipe eels) (see Fitch and Lavenberg, 1968);

first reported fossil occurrences of otoliths preserved with skeletal remains of the Alepocephalidae (slickheads), Anoplogasteridae (fangtooths), Bathylagidae (deepsea smelts), Coryphaenidae (dolphinfishes), Gempylidae? (snake mackerels, escolars, oilfishes), Neoscopelidae (blackchins), Oneirodidae (dreamers), Paralichthyidae (sanddabs), and Serranidae (sea basses, groupers), and for *Genyonemus* (Sciaenidae; white croaker), *Physiculus* (Moridae; codling/mora), *Pleuronichthys* (Pleuronectidae; turbot), and *Scopelogadus* (Melamphaeidae; bigscale) (see Ebeling, 1962; Fitch and Barker, 1972);

second reported fossil occurrence of otoliths preserved with skeletal remains of the Moridae (deepsea cods, moras) (see Fitch and Barker, 1972);

and the first reported North American fossil occurrences of otoliths preserved with skeletal remains of the Cynoglossidae? (tonguefishes) and Platyroctidae (tubeshoulders).

Without an examination of the type specimens of the various species of *Bathylagus* (Bathylagidae; deepsea smelts) reported from the late Miocene fossil record of southern California, it is not possible to determine if one or more of these species should be reassigned to *Leuroglossus* (Bathylagidae; smoothtongue), and if the Segment 2 specimens of *Leuroglossus* are referable to one of these species or to a new species.

Other reported fossil occurrences of *Leuroglossus*, *Stenobranchius*, and *Triphoturus* are from the early (but not earliest) Pliocene to middle Pleistocene

Repetto Member of the marine Fernando Formation, which overlies the unnamed marine shale. These fossil records were recovered as a result of the paleontologic resource impact mitigation program conducted during excavation for the Metro Red Line Segment 1 Pershing Square (Fifth/Hill) station (Lander, 1991).

Remains of the Myctophidae (lanternfishes) were determined to be a very common element in the Segment 2 fossil collection. Most articulated and semiarticulated skeletons retain the otoliths, and numerous isolated myctophid otoliths also are present. Although associated myctophid skeletal remains and otoliths have been reported previously from the fossil record (Fitch 1969; Fitch and Lavenberg 1968), they have never been recorded in such abundance as in the unnamed marine shale. In addition, a cetacean (whale/porpoise) coprolite (fossilized feces) was found to be composed primarily of lanternfish otoliths, and is the only fossil record of such an otolith occurrence. The Segment 2 lanternfish assemblage, which contains fifteen genera and sixteen species of lanternfishes, is taxonomically the largest and most diverse lanternfish assemblage reported from the fossil record. However, twenty-two species of lanternfishes now exist off the coast of southern California.

The stomach contents of the specimen representing the Anoplogasteridae (fangtooths) contains the skeletal remains and associated otoliths of an individual of the Bathylagidae (deepsea smelts), and is the only fossil record of such an otolith occurrence for the Bathylagidae.

Four other fish families, including the Merlucciidae (hakes), Sciaenidae (croakers/drums), Scorpaenidae (rockfishes/rockcods), and Sternoptycidae (marine hatchetfishes), are represented either by isolated otoliths or by otoliths and associated skeletal elements.

The Metro Red Line Segment 1 fish fauna from the unnamed marine shale at the Tom Bradley/Civic Center station (LACMVP fossil site 5961) has yielded fish families and genera also found in the Segment 2 fish fauna, including the Clupeidae (herring ?*Xyne grex*), Gonostomatidae (bristlemouth *Cyclothone*), Bathylagidae (deepsea smelts), and Myctophidae (lanternfishes; two genera) (Lander, 1990, in preparation; Stewart, 1990). Reexamination of the Segment 1 specimens has resulted in the questionable recognition of the Argentinidae (herring smelts) (Lander, in preparation).

## PALEOENVIRONMENT

The Segment 2 fossil marine fish specimens also are scientifically highly important because the specimens, along with the species they represent, allow paleoenvironmental reconstruction of the downtown Los Angeles/Hollywood area during the late Miocene Epoch. Unlike other marine fish faunas of similar age from southern California, the Segment 2 fish fauna is the first reported as containing the very-deep-water marine (middle bathypelagic) fish genera *Anoplogaster* (Anoplogasteridae; fangtooth) and *Oneirodes* (Oneirodidae; dreamers), in addition to the deep-water (upper bathypelagic) and moderately deep-water marine (mesopelagic) fish species comprising the other faunas (including Chalk Hill fish fauna), which do not contain these middle bathypelagic fish genera. Moreover, the middle bathypelagic Linophrynidae (netdevils), which are represented by only one individual in the Chalk Hill fish fauna (Pietsch and Lavenberg, 1980), are represented by several individuals in the Segment 2 fish fauna and, in combination with the other bathypelagic fish species, also suggest the Segment 2 fauna represents a greater depth below sea level than the Chalk Hill fauna.

The Segment 2 fish fauna also contains pelagic (open-ocean marine) species of the Clupeidae (herrings, sardines), Scombridae (mackerels), and Belonidae (needlefishes). These surface and near-surface/shallow-water marine (upper epipelagic) species usually are represented by comparatively poorly preserved, incomplete, and disarticulated specimens, individual fishes, following their deaths, decaying and slowing sinking from shallower ocean depths, passing through the greater depths inhabited by the deeper-water marine (mesopelagic and bathypelagic) fish species, and, along with individuals of the deeper-water marine species, eventually settling on the sea floor before being covered by sediment being deposited on the sea floor. The shallow-water benthic marine fish species of the Paralichthyidae (sanddabs) and Pleuronectidae (righteye flounders), remains of which, like the remains of the epipelagic fish species, are poorly preserved, presumably were transported offshore, downward, and into the Segment 2 construction zone from a near-shore marine environment. The remaining species in the Segment 2 fish fauna are pelagic forms that were living in the water column above the sea floor. Therefore, the depositional environment of the sediments comprising the unnamed marine shale occurred at depths below sea level even greater than the depths inhabited by the

pelagic fish species.

The presence of middle bathypelagic species in the Segment 2 fish fauna and the comparatively well-preserved, complete, and articulated nature of the delicate bathypelagic and mesopelagic fish specimens suggest the sea floor was in or below an anoxic or oxygen-minimum zone, which was between approximately 1,500 and 3,000 meters (5,000 and 10,000 feet; 1 and 2 miles) below sea level during the late Miocene Epoch and would have prevented decay or disruption of the fish skeletons by bottom-dwelling organisms. This conclusion is corroborated by the apparent absence of any evidence indicating bioturbation of the fossil-bearing strata. Presumably the sea floor in the Segment 2 construction zone was deeper than at any other known southern California marine fossil site during the late Miocene Epoch.

With the exception of the epipelagic Clupeidae, the Segment 1 specimens from the unnamed marine shale represent mesopelagic fish species. However, the apparent absence of bathypelagic fish species might reflect the small number of fish specimens recovered rather than the actual absence of these species from the Segment 1 construction zone during the late Miocene Epoch.

Documenting the taxonomic differences between the marine fish faunas of southern California and establishing their respective environmental (depth) preferences will make it possible to relate these differences to the major tectonically induced sea-level changes and accompanying coastline transgressions that occurred in coastal southern California, particularly the Los Angeles basin, during the Miocene and Pliocene Epochs.

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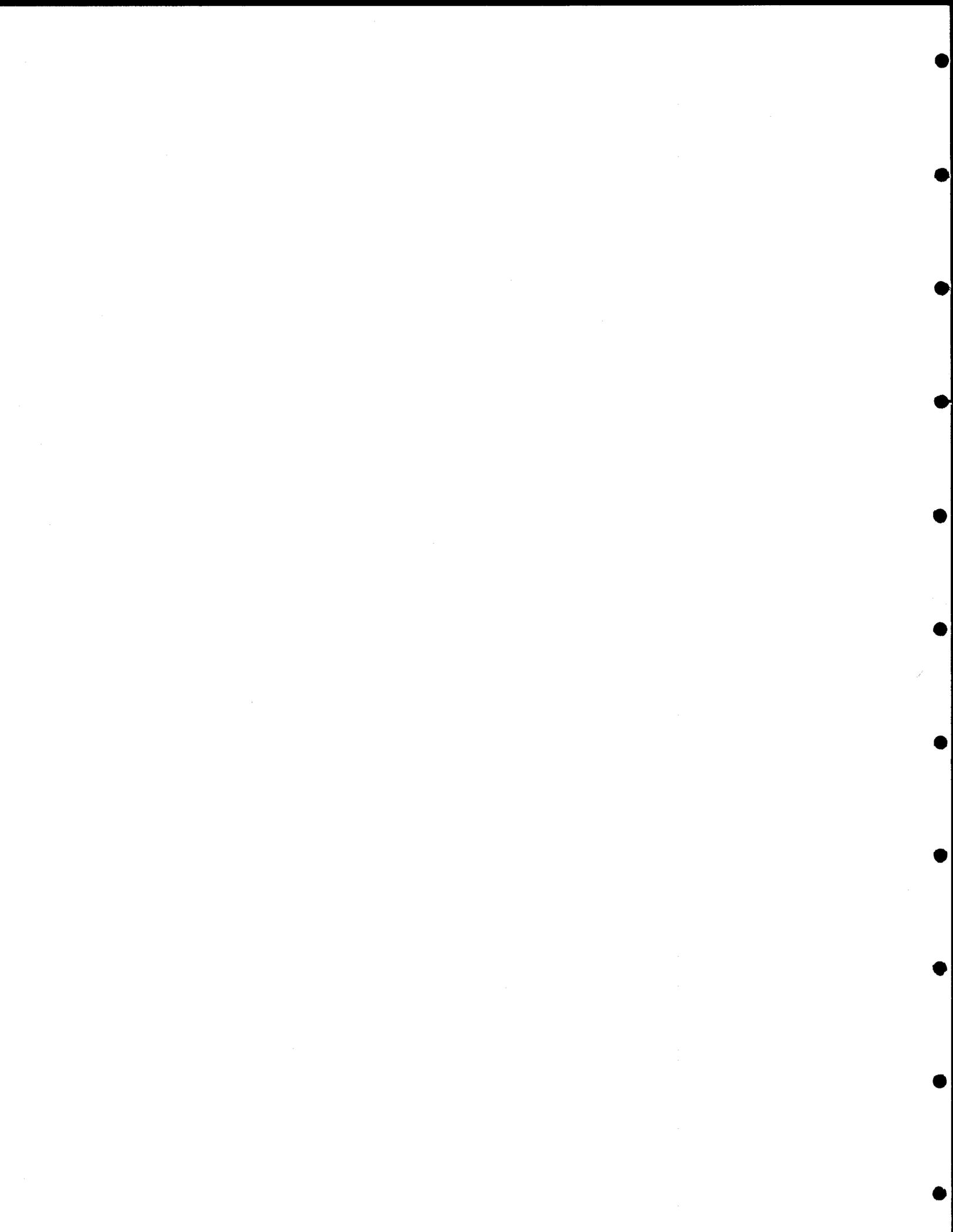
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**Table 1.**—Taxonomic list, teleost fishes (Class Actinopterygii, Subclass Neopterygii, Division Teleostei), unnamed late Miocene marine shale, Los Angeles Metro Red Line Segment 2 construction zone, Los Angeles, California. Classification and common names after California Academy of Sciences (undated), Carroll (1988), Nelson (1994), Paxton and Eschmeyer (1995), and Robins and others (1980).

Subdivision	Superorder	Order	Suborder	Superfamily	Family	Subfamily	Genus, Species	Common Name
Elopomorpha		Anguilliformes	Congroidei		Nemichthyidae undetermined		<i>Nemichthys?</i> , n. sp. <sup>a</sup> gen. undet., n. sp.	snipe eel eel
Clupeomorpha		Clupeiformes	Clupeoidei		Clupeidae		<i>Ganolytes cameo</i> <i>Xyne grex</i>	cameo sardine herring
Euteleostei	Protacanthopterygii	Salmoniformes	Argentinoidei	Argentinoidea	Argentinidae?		<i>Argentina</i> sp. gen. undet., n. sp.	argentine argentine?
					Bathylagidae		<i>Bathylagus</i> sp. <i>Leuroglossus</i> sp.	deepsea smelt smoothtongue
				Alepocephaloidea	Opisthoproctidae Alepocephalidae	Alepocephalinae	gen. undet., n. sp. gen. undet. A, n. sp. gen. undet. B, n. sp.	barreleye/spookfish slicthead slicthead
					Platyroctidae (= Searsiidae) Gonostomatidae Sternoptychidae		gen. undet., n. sp.	tubeshoulder
	Stenopterygii	Stomiiformes	Gonostomatoidei			Sternoptychinae	<i>Cyclothone</i> sp. <i>Argyropelecus</i> sp. A <i>Argyropelecus</i> sp. B <i>Argyropelecus</i> sp. <i>Danaphos</i> , n. sp.	bristlemouth silver hatchetfish silver hatchetfish silver hatchetfish bottlelight
			Photichthyoidei		Photichthyidae Stomiidae	Stomiinae	<i>Vinciguerria?</i> , n. sp. <i>Stomias</i> sp. gen. undet., n. sp.?	lightfish scaly dragonfish scaly dragonfish
	Scopelomorpha	Myctophiformes			Chauliodontidae Neoscopelidae Myctophidae	Myctophinae	<i>Chauliodus eximius</i> <i>Scopelengys?</i> , n. sp. <i>Bentho sema?</i> , n. sp. <i>Centrobranchus?</i> , n. sp. <i>Diogenichthys?</i> , n. sp. <i>Hygophum</i> , n. sp. A <i>Hygophum</i> , n. sp. B <i>Myctophum</i> sp. <i>Symbolophorus</i> , n. sp. <i>Tarletonbeania</i> , n. sp.	viperfish blackchin lanternfish lanternfish Diogenes lanternfish lanternfish lanternfish lanternfish lanternfish lanternfish
						Lampanyctinae	<i>Bolinichthys?</i> , n. sp. <i>Ceratoscopelus</i> , n. sp. <i>Diaphus</i> sp. <i>Lampanyctus</i> sp. <i>Notoscopelus?</i> sp. <i>Stenobranchius</i> , n. sp. <i>Taaningichthys</i> , n. sp. <i>Triphoturus</i> sp.	lanternfish dogtooth lampfish headlightfish broadfin lampfish lampfish northern lampfish lampfish Mexican lampfish

Paracanthopterygii	Gadiformes	Macrouroidei Gadoidei		Macrouridae Moridae  Merlucciidae	Macrourinae	gen. undet., n. sp. <i>Physiculus</i> , n. sp. gen. undet., n. sp. <i>Merluccius</i> , n. sp.	grenadier codling/mora deepsea cod/mora hake
Acanthopterygii	Lophiiformes	Ceratioidei	Ceratioidea	Oneirodidae Linophrynidae		<i>Oneirodes</i> , n. sp. gen. undet., n. sp. <i>Strongylura</i> sp.	dreamer netdevil needlefish
	Exocoetoidei Beryciformes	Belonoidei Berycoidei Stephanoberycoidei	Scomberesocoeida Anoplogasteroidea Stephanoberycoidea	Belonidae Anoplogasteridae Melamphaeidae		<i>Anoplogaster</i> , n. sp. <i>Scopelogadus</i> sp. gen. A., n. sp. <i>Sebastes</i> , n. sp. A <i>Sebastes</i> , n. sp. B <i>Paralabrax</i> , n. sp.? gen. undet., n. sp. <i>Pseudoseriola</i> ? sp. <i>Coryphaena</i> ?, n. sp. <i>Decapterus</i> sp. gen. & sp. undet.	fangtooth bigscale bigscale rockfish rockfish sand bass sea bass/grouper bluefish dolphinfish Mexican scad pompano/jack/ amberjack
	Scorpaeniformes	Scorpaenoidei		Scorpaenidae	Sebastinae		
	Perciformes	Percoidei	Percoidea	Serranidae  Pomatomidae Coryphaenidae Carangidae			
			Scombroidei		Sparidae Sciaenidae  Gempylidae?  Zaphlegidae <sup>b</sup> (= Gempylidae) Trichiuridae	Trichiurinae	<i>Plectrutes classeni</i> ? <i>Cynoscion</i> ? sp. <i>Lompoquia</i> sp. gen. undet., n. sp.  <i>Thyrsoles</i> sp.  gen. undet., n. sp.
	Pleuronectiformes	Pleuronectoidei		Scombridae Paralichthyidae (= Bothidae) Pleuronectidae  Cynoglossidae	Scombrinae	<i>Sarda</i> sp. <i>Scomber</i> ? sp. <i>Citharichthys</i> ?, n. sp.  <i>Hippoglossus</i> sp. <i>Pleuronichthys</i> sp. gen. undet., n. sp.	bonito mackerel sanddab  halibut turbot tongue sole/ tonguefish

<sup>a</sup>gen.: genus;  
n.: new;  
sp.: species;  
undet.: undetermined.

<sup>b</sup>Extinct family.

APPENDIX K

IDENTIFICATION OF PLANT FOSSILS FROM THE  
UNNAMED LATE MIOCENE MARINE SHALE,  
METRO RED LINE SEGMENT 2 CONSTRUCTION ZONE,  
LOS ANGELES, CALIFORNIA

Howard E. Schorn  
Museum Scientist Emeritus

University of California Museum of Paleontology

August 14, 1995

UNIVERSITY OF CALIFORNIA, BERKELEY

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SANTA BARBARA • SANTA CRUZ

MUSEUM OF PALEONTOLOGY

BERKELEY, CALIFORNIA 94720

Telephone: 510-643-5205; Fax: 510-642-1822; E-mail: [howards@ucmp1.berkeley.edu](mailto:howards@ucmp1.berkeley.edu)

14 August 1995

Dr. E. Bruce Lander, President  
Paleoenvironmental Associates  
2248 Winrock Avenue  
Altadena, CA 91001

Subject: Identification of plant fossils from the Unnamed Late Miocene Shale, Metro Red Line Segment 2 Construction Zone, Los Angeles, California.

Dear Dr. Lander:

Approximately 150 fossil plant specimens from five (5) sites were received from your company. The preservation ranges from poor to moderate. Some of the specimens were indetermined fragments of wood and poorly preserved fragmentary alga remains. Twenty specimens from two (2) sites, Metro Rail Site 1 and Metro Rail Site 2, were retained and are now housed in the University of California Museum of Paleontology. These specimens were accessioned under UCMP Lot or Accession Number 4548, and the material from Metro Rail Site 1 was assigned UCMP Locality Number PA722, and that from Metro Rail Site 2 was assigned UCMP Locality Number PA723 (please see enclosed UCMP Locality files).

The brief list of taxa from these two sites follows on the next page.

**FLORAL LIST**

**METRO RAIL SITE 1 (UCMP LOCALITY NUMBER PA722)**

All the material from this site appears to belong to a single species of non-calcareous marine alga

*Paleohalidrys liguliformis* Parker et Dawson

**METRO RAIL SITE 2 (UCMP LOCALITY NUMBER PA723)**

The material from this site appears to belongs to a single species of non-calcareous marine alga

*Paleohalidrys liguliformis* Parker et Dawson

and, a single incomplete specimen of a dicotyledonous leaf resembling an oak (Genus *Quercus*) or member of the laurel family (Family Lauraceae)

**REFERENCE:**

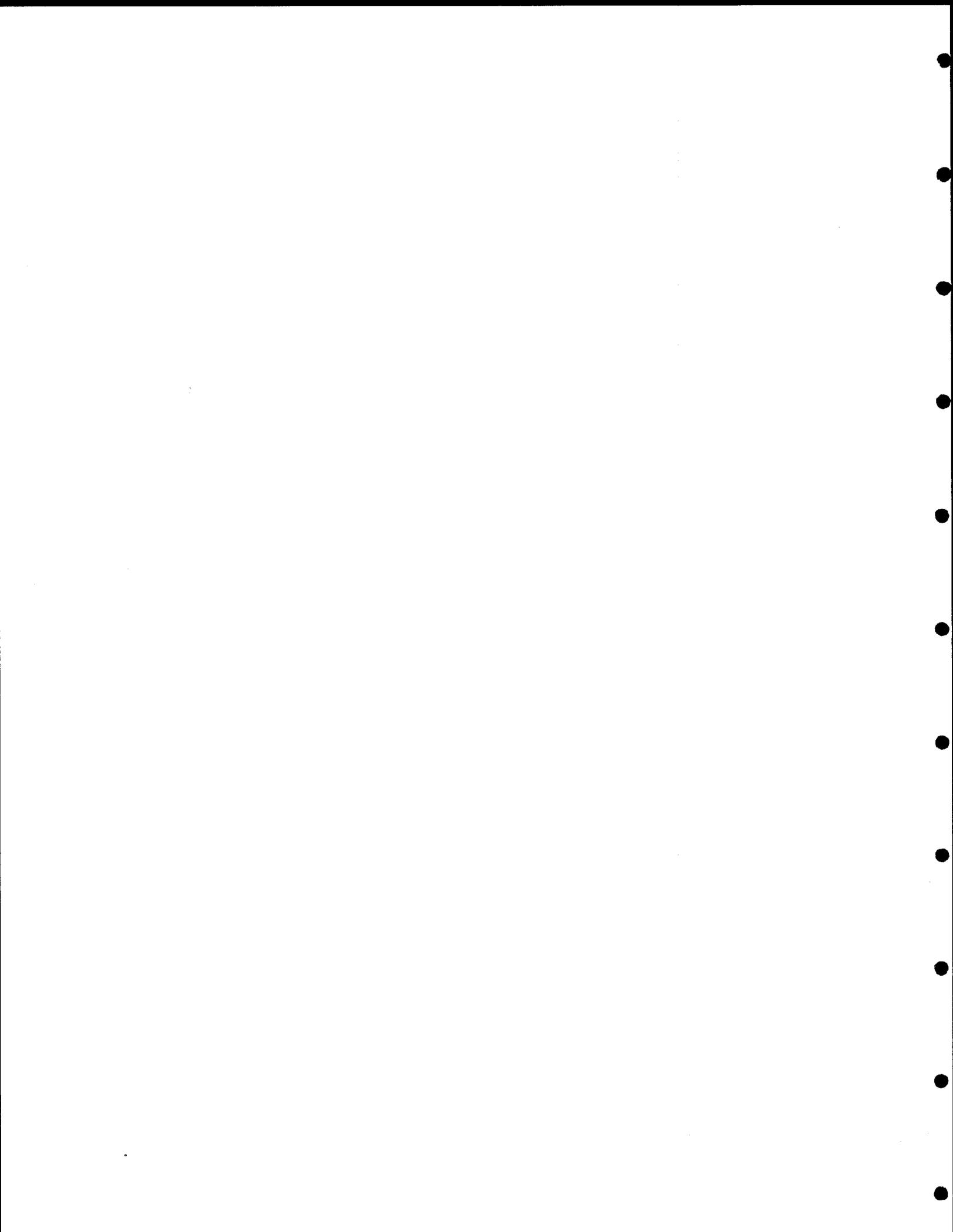
Parker, B.C. and Dawson, E.Y. 1965. Non calcareous marine algae from California Miocene deposits. *Nova Hedwigia*, vol. 10, nos. 1 and 2, pp. 273-295.

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I hope this is of help to you. Please contact me at 510-643-5205 if you have any questions regarding this report.

Sincerely,

Howard E. Schorn



APPENDIX L

NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY  
INVERTEBRATE PALEONTOLOGY SECTION  
FOSSIL SITE CATALOG—  
METRO RED LINE CONSTRUCTION ZONE,  
LOS ANGELES, CALIFORNIA

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 16840

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles County, CA  
COUNTY STATE

Hollywood, CA USGS 7.5'  
MAP

1981 1:24000  
EDITION & SCALE

34 03'34" N, 118 16'43" W  
SURVEY COORDINATES OR GRID

Puente Formation  
FORMATION

Robin D. Turner  
COLL. BY

RDT 73192-B/MC 30 JULY 1992  
FIELD NO. & DATE

LOC. DESCR.: Metro Rail Red Line, Wilshire Blvd. subway tunnel. Fossils found during excavation 400' W of MacArthur Park pocket track and 60' beneath Wilshire Blvd. Elevation 210 ft. Alternating olive-gray to dark-gray (moist) siltstone and brown to light-brown (moist) laminated siltstone. Fresh medium soft to medium hard. Material includes Delectopectens. Deep-sea teleost fish also found. Site is no longer accessible (= LACMI' 6198).  
(see map on back of card)

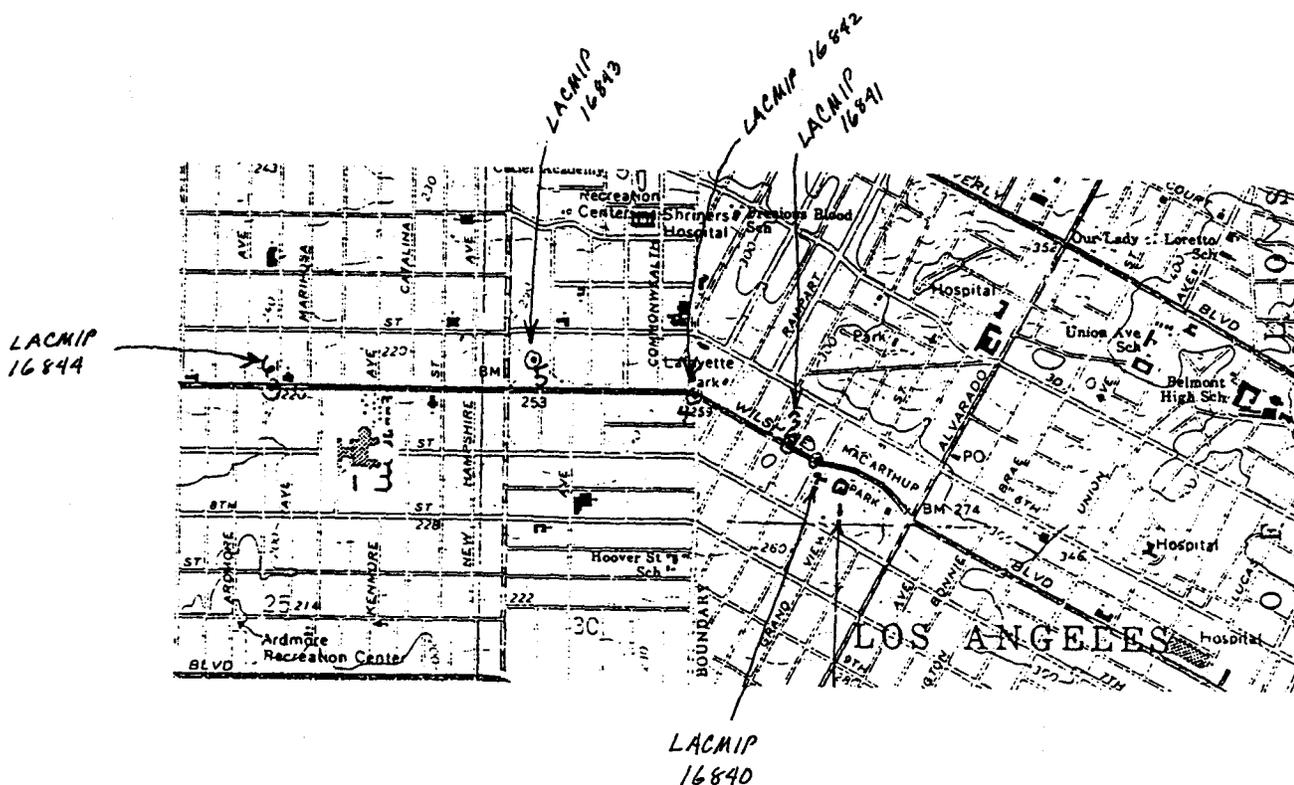
L.T. Groves

4 APRIL 1995

761357

ENTERED BY

DATE



LACMIP  
16840

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY  
Miocene  
AGE \_\_\_\_\_

LOC. NO. 16841  
ACC. NO. \_\_\_\_\_

Los Angeles County, CA Hollywood, CA USGS 7.5' 1981 1:24000  
COUNTY STATE MAP EDITION & SCALE

34 03'37"N, 118 16'47"W Puente Formation  
SURVEY COORDINATES OR GRID FORMATION

Robin D. Turner RDT 81192C/MC 6 AUG 1992  
COLL. BY FIELD NO. & DATE

LOC. DESCR.: Metro Rail Red Line, Wilshire Blvd. subway tunnell. Fossils found during excavation 650' west of MacArthur Park pocket track and 60' beneath Wilshire Blvd. Elevation 210' Alternating olive-gray to dark-gray (moist) siltstone and brown to light brown (moist) laminated siltstone. Fresh material medium soft to medium hard. Fossils include mollusks and deep-sea teleost fish. Site is no longer accessible.

(see map on back of 16840) (= LACMVP 6200)

761357 L.T. Groves 11 APRIL 1995  
ENTERED BY DATE

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY  
Miocene  
AGE \_\_\_\_\_

LOC. NO. 16842  
ACC. NO. \_\_\_\_\_

Los Angeles County, CA Hollywood, CA USGS 7.5' 1981 1:24000  
COUNTY STATE MAP EDITION & SCALE

34°03'37"N, 118°16'59" Puente Formation  
SURVEY COORDINATES OR GRID FORMATION

COLL. BY \_\_\_\_\_ FIELD NO. & DATE \_\_\_\_\_

LOC. DESCR.: Metro Rail Red Line Wilshire Blvd. subway tunnell. Fossils found during excavation between MacArthur Park pocket track and Wilshire Blvd./ Vermont Ave. station (STA AR274+00 to STA AR309+54-3554'). 215-237' elevation West bulkhead center is 852' W and 308' N from NW corner of Wilshire Blvd. and Alvarado St. E bulkhead center is 252' W and 62' N from NW corner Westmoreland Ave. and Wilshire Blvd. Alternating beds of Olive-gray to dark-gray (moist) silstone and brown to light-brown (moist) laminated siltstone. Fresh material soft to medium hard. Fossil material includes mollusks and deep-sea teleost fish.

(see map on back of 16840) (= LACMVP 6201)

761357 \_\_\_\_\_ ENTERED BY \_\_\_\_\_ DATE \_\_\_\_\_

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 16843

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles County, CA Hollywood, CA USGS 7.5' 1981 1:24000  
COUNTY STATE MAP EDITION & SCALE

34°03'47"N, 118°17'23" W Puente Formation  
SURVEY COORDINATES OR GRID FORMATION

April 1992-October 1993  
FIELD NO. & DATE

COLL. BY

LOC. DESCR.:

Metro Rail Red Line Wilshire Blvd./Vermont Ave. subway station 844' long excavation runs N56°W. 58' width between E bulkhead and soldier pile 105, 30' width at soldier pile 106 widening to 64' at W bulkhead. W bulkhead center is 64'S and 36' W from SE corner of 6th St. and Vermont Ave. E bulkhead center is 252' W and 62' N from NW corner of Westmorland Ave. and Wilshire Blvd. Fossils were collected at 155-210' elevation that runs to 260' Alternating olive-gray to dark-gray (moist) siltstone and brown to light-brown (moist) laminated siltstone. Fresh material is medium soft to medium hard; parallel bedding; laterally continuous, olive-gray to dark-gray siltstone is interbedded w/laminae of fine-grained soft sandstone. Thin ash beds are intercalated. Approximate strike = N76°W, dip = 20-30°SW. W bulkhead is at 34°03'49"N, 118°17'27"W. E bulkhead is at 34°03'43"N, 118°17'18". Fossils include mollusks and deep-sea teleost fish. Site no longer accessible.

(see map on back of 16840) (= LACMVP 6202)

L.T. Groves

11 April 1995

761357

ENTERED BY

DATE

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 16844

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles County, CA Hollywood, CA USGS 7.5' 1981 1:24000  
COUNTY STATE MAP EDITION & SCALE

34°03'43"N, 118°17'59"W Puente Formation  
SURVEY COORDINATES OR GRID FORMATION

Robin D. Turner

COLL. BY

FIELD NO. & DATE

LOC. DESCR.:

Metro Rail Red Line Wilshire Blvd/Normandie Ave. subway station. Fossils found at E side of excavation. 112'W and 40'N from SW corner of Wilshire Blvd. and Normandie Ave. (soldier pile 6 to soldier pile 8). 60' below ground. Elevation 162'. Alternating olive-gray (moist) siltstone and brown (moist) laminated siltstone. Fresh material medium hard to hard. Fossils include mollusks. Site is no longer accessible.

(see map on back of 16840)

L.T. Groves

11 APRIL 1995

761357

ENTERED BY

DATE

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 16845

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles County, CA  
COUNTY STATE

Hollywood, CA USGS 7.5'  
MAP

1981 1:24,000  
EDITION & SCALE

34°06'05"N, 118°17'32"W  
SURVEY COORDINATES OR GRID

Puente Formation  
FORMATION

31 March-23 June, 1993  
FIELD NO. & DATE

COLL. BY \_\_\_\_\_

LOC. DESCR.:

Metro Rail Red Line Vermont Ave. subway tunnel. Fossils found during excavation of twin tunnels 22' diameter and 18' apart. 317-334' elevation. Only first 176' of AR tunnel (north) and first 72' of AL tunnel (south) collected. Tunnel entrance at Barnsdall Park access shaft E wall 271' E and 142' S from NE corner of N. Berendo St. and Hollywood Blvd. and 91' below grade elevation of 416'. Alternating dark olive-gray to olive-gray siltstone and dark-brown to brown laminated siltstone. Fresh material medium hard to hard, sheared. Fossils include mollusks and teleost fish. Site is no longer accessible

(see map on back of card)

(= LACMP 6205)

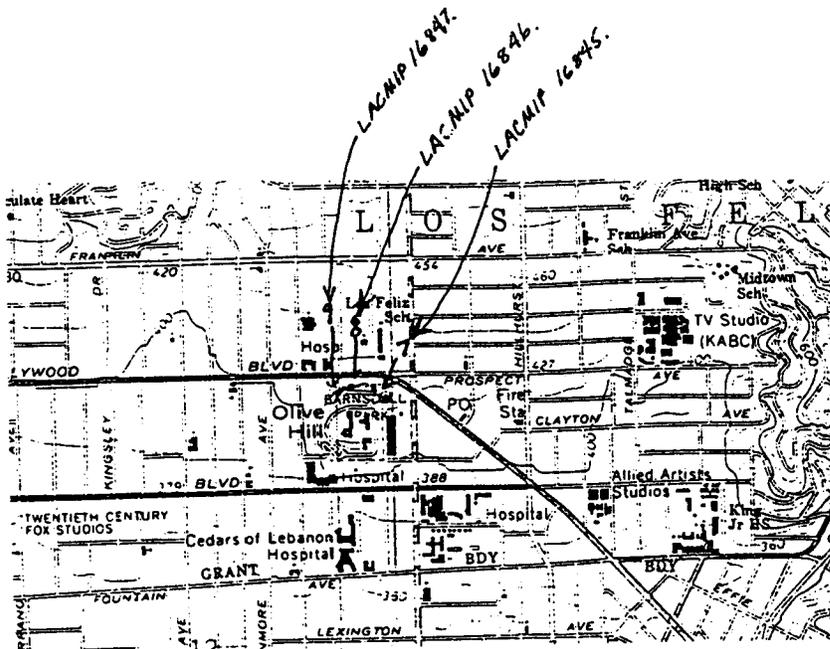
L.T. Groves

11 APRIL 1995

761357

ENTERED BY \_\_\_\_\_

DATE \_\_\_\_\_



LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 16846

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles County, CA

Hollywood, CA USGS 7.5'

1981 1:24000

COUNTY STATE  
34°06'06"N, 118°17'38"W

MAP FORMATION  
Puente Formation

EDITION & SCALE

SURVEY COORDINATES OR GRID

FORMATION

28 December-28 January 1993

COLL. BY

FIELD NO. & DATE

LOC. DESCR.:

Metro Rail Red Line Barnsdall Park subway tunnel. Fossils found during excavation of muck conveyor shaft 415' long and 10'x10'. Trends N76°E and inclined 16°. Shaft top at 412.5' grade elevation and bottom at 296'W. Top 225'S and 171'W from NE corner of N. Berendo St. and Hollywood Blvd. Base of oxidized beds is 171' S and 14' W from NE corner of N. Berendo St. and Hollywood Blvd. Fossils from upper 213' of shaft from 412.5-350' elevation in oxidized thin-bedded clayey siltstone that is yellowish-brown, Fresh material soft to medium soft. Fossil material includes mollusks and deep-sea teleost fish. Site is no longer accessible.

(see map on back of 16845) (= LACMVP 6206)

761357

L.T. Groves

11 APRIL 1995

ENTERED BY

DATE

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 16847

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles County, CA

Hollywood, CA USGS 7.5'

1981 1:24000

COUNTY STATE  
34°06'05"N, 118°17'37" W

MAP FORMATION  
Puente Formation

EDITION & SCALE

SURVEY COORDINATES OR GRID

FORMATION

28 January-4 March 1993

COLL. BY

FIELD NO. & DATE

LOC. DESCR.:

Metro Rail Red Line Barnsdall Park subway tunnel. Fossils found during excavation of muck conveyor shaft 415' long and 10'x10'. Trends N76E and inclined 16°. Base of shaft is 128'S and 185'W from NE corner of Berendo St. and Hollywood Blvd. Top of fresh Puente Formation is 171'S and 14'W from NE corner of Berendo St. and Hollywood Blvd. Fossils from fresh Puente Formation in lower 202' between 350-296' elevation. Thin bedded dark olive-gray to olive-gray siltstone. Fresh material hard to very hard, heavily sheared. West end of shaft is at 34°06'04"N, 118°17'34"W. Material includes mollusks and teleost fish. Site is no longer accessible.

(see map on back of 16845) (= LACMVP 6207)

L.T. Groves

11 APRIL 1995

ENTERED BY

DATE

761357

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 16966

AGE Holocene

ACC. NO. \_\_\_\_\_

Los Angeles Co., CA Burbank 7.5' topo quad. 1966 (PR 1972)  
COUNTY STATE MAP EDITION & SCALE

\_\_\_\_\_  
SURVEY COORDINATES OR GRID "Younger alluvium" 1:24000  
FORMATION

Mike Morris \_\_\_\_\_  
COLL. BY FIELD NO. & DATE

LOC. DESCR.:

Metro Rail Red Line segment 3 construction zone, Universal City cross over. Construction zone is bounded by Universal Pl., Willowcrest Ave., Bluffside Dr., Lankershim Blvd., and the onramp to the Hollywood Fwy (US 101). Locality is no longer accessible.

(see map on back of card)

761357

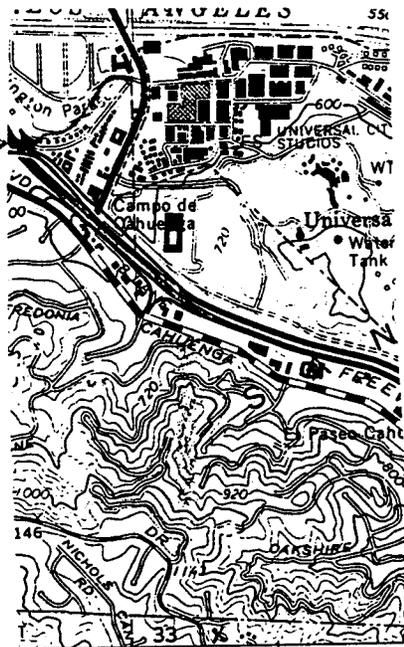
L.T. Groves

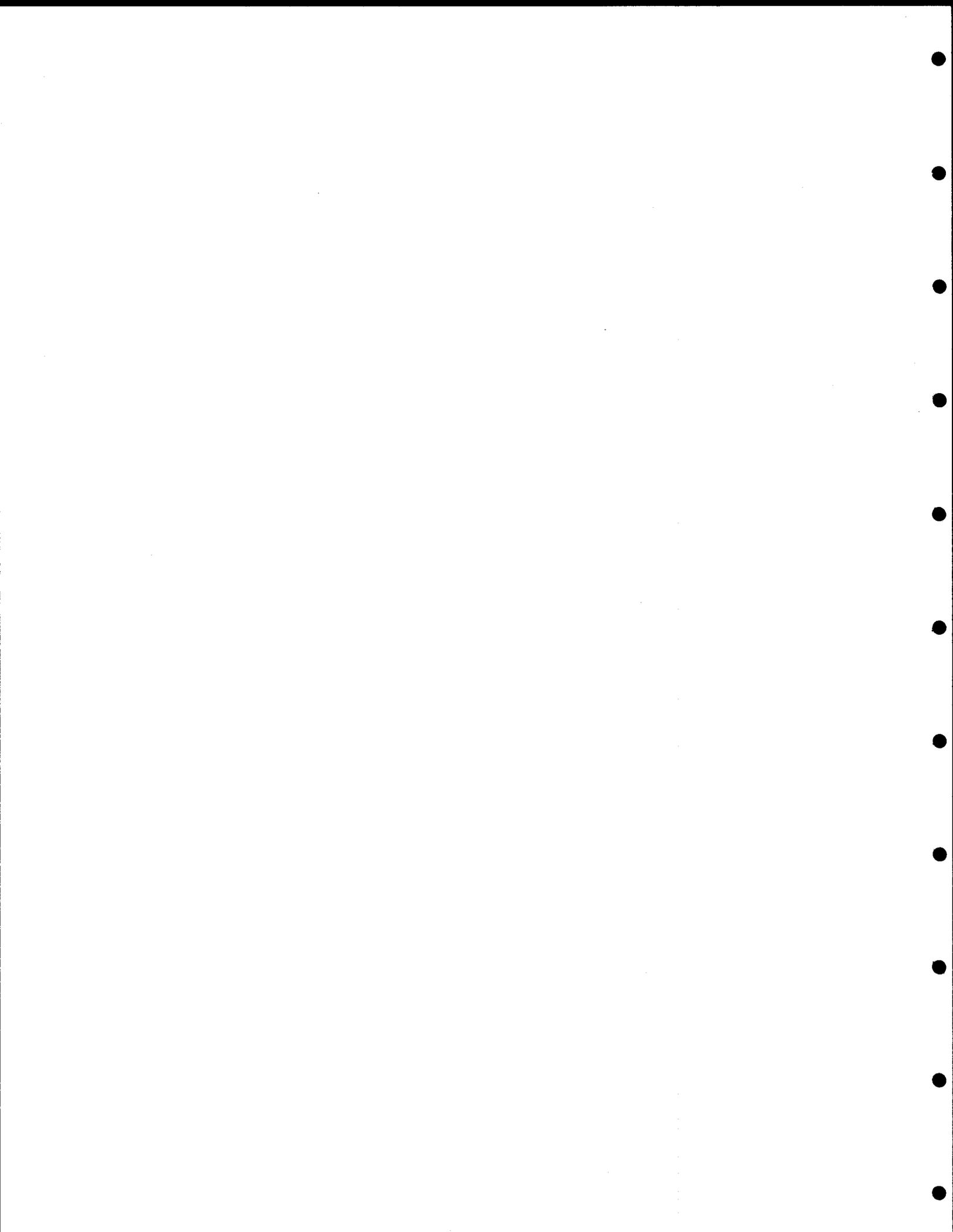
10 MAR 1998

ENTERED BY

DATE

LACMIP  
16966 ±  
16967  
Within  
Construction  
Zone





LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 16967

AGE Holocene

ACC. NO. \_\_\_\_\_

Los Angeles Co., CA  
COUNTY STATE

Burbank 7.5' topo quad.  
MAP

1966 (Pr 1972)  
EDITION & SCALE

\_\_\_\_\_  
SURVEY COORDINATES OR GRID

"Younger alluvium"  
FORMATION

1:24000

Mike Morris & Robin Turner  
COLL. BY

MM 961220 & MM 961024-1  
FIELD NO. & DATE

(= RDT 961015 &  
RDT 970212)

LOC. DESCR.:  
.

Metro Rail Red Line segment 3 construction zone, Universal City station. Fossils collected from between soldier piles ES-22 & ES-23 and W11 & W14 at between 40 to 55 ft. depth. Construction zone is bounded by Universal Pl., Willowcrest Ave., Bluffside Dr., Lankershim Blvd., and the onramp to the Hollywood Fwy (US 101). Locality is no longer accessible.

(see map on back of LACMIP loc. 16966)

761357

L.T. Groves

10 MAR 1998

ENTERED BY

DATE

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 17099

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles Co., CA

Burbank 7.5' topo quad.

1966 (PR 1972)

COUNTY Los Angeles Co., CA  
STATE CA

MAP Burbank 7.5' topo quad.

EDITION & SCALE 1966 (PR 1972)  
1:24000

SURVEY COORDINATES OR GRID

FORMATION Topanga Canyon Fm.

unknown  
COLL. BY \_\_\_\_\_

unknown  
FIELD NO. & DATE \_\_\_\_\_

LOC. DESCR.:

Metro Rail Red Line tunnel station. Bivalve fragments collected from between soldier piles 1171 & 1173 on west side of tunnel at 700 +/- 20 ft. depth. Locality plots on map at 4700 ft. SE of north access tunnel located near intersection of Ventura Blvd. & Lankershim Blvd., Universal City. Matrix is dark gray siltstone. Locality is no longer accessible.

(see map on back of card)

761357

L.T. Groves

17 March 1998

ENTERED BY

DATE



LACMIP 17099

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
 INVERTEBRATE PALEONTOLOGY

LOC. NO. 17137

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles Co., CA

Hollywood topo quad

1981 1:24000

COUNTY

STATE

MAP

EDITION & SCALE

S-SE sect. 13, T1S, R14W

Puente Formation

SURVEY COORDINATES OR GRID

FORMATION

Mike Morris

MM 970520-2

May 1997

COLL. BY

FIELD NO. & DATE

LOC. DESCR.:

Metrorail Red Line Vermont Ave./Beverly Blvd. subway station entrance. Specimens collected during cut and cover excavation of 40 ft. X 30 ft.; 60 ft. deep; elevation 300 ft. to 240 ft. Station entrance located at NW corner of Vermont Ave. & Beverly Blvd. intersection. Weathered yellowish brown thin bedded siltstone and shale. Underlying and overlying beds not exposed at site. Locality no longer accessible. (= LACMIP loc. 6946)

(see map on back of this card)

761357

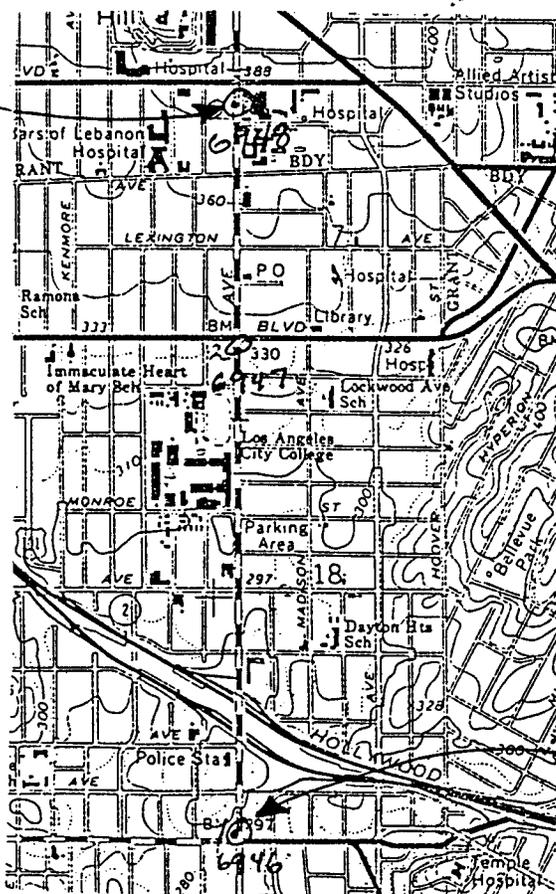
L.T. Groves

23 FEB 1999

ENTERED BY

DATE

LACMIP loc.  
17138



LACMIP loc.  
17137

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY  
INVERTEBRATE PALEONTOLOGY

LOC. NO. 17138

AGE Miocene

ACC. NO. \_\_\_\_\_

Los Angeles Co, CA Hollywood topo quad. 1981 1:24000  
COUNTY STATE MAP EDITION & SCALE

N-NE sect. 12, T1S, R14W Puente Formation  
SURVEY COORDINATES OR GRID FORMATION

Mike Morris MM 970424, MM 970515, MM 970522  
COLL. BY FIELD NO. & DATE

LOC. DESCR. :

Metrorail Red Line Vermont Ave./Sunset Blvd. subway station. Station located directly beneath Vermont Ave. between Delongpre Ave. and Sunset Blvd. Specimens collected during cut and cover excavation of station box (732 ft. x 64 ft; 80 ft. below grade). Fossils collected between elevations 360 ft. to 310 ft. Yellowish brown to gray bedded siltstone and shale. Locality is no longer accessible. (=LACMVP loc. 6948)

(see map on back of LACMIP loc. 17137)

L.T. Groves

23 FEB 1999

761357

ENTERED BY

DATE

APPENDIX M

NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY  
VERTEBRATE PALEONTOLOGY SECTION  
FOSSIL SITE CATALOG—  
METRO RED LINE CONSTRUCTION ZONE,  
LOS ANGELES, CALIFORNIA

## LACM 6198

Name: Metro Rail Wilshire Tunnel Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: N-NE Sect. 30, T 1 S, R 13 W Air Photo: \_\_\_\_\_  
 Lat: 34° 03' 34" N Long: 118° 16' 43" W Elev. 210 FT  
 Describer: Takeuchi: Gary T. Field No.: RDT 73192-B3/Mc Date: 30 Jul 1992  
 Field Notes: y Access. Data: n Photo No.: \_\_\_\_\_  
 Description:

Metro Rail Red Line Wilshire Blvd. subway tunnel. Fossils found during excavation 400' W of McArthur Park pocket track & 60' beneath Wilshire Blvd. 22' tunnel diameter. Alternating olive gray to dark gray [moist] siltstone & brown to light brown [moist] laminated siltstone. Fresh medium soft to medium hard. Fossil fish found in brown to light brown laminated siltstone. Upper Mohnian Stage.

Material: Osteichthyes  
 Entered By: Samuel A. McLeod Date: 3 Jun 1994

## LACM 6199

Name: Metro Rail Wilshire Tunnel Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: N-NE Sect. 30, T 1 S, R 13 W Air Photo: \_\_\_\_\_  
 Lat: 34° 03' 36" N Long: 118° 16' 45" W Elev. 210 FT  
 Describer: Takeuchi: Gary T. Field No.: RDT 81892-A/Mc Date: 4 Aug 1992  
 Field Notes: y Access. Data: n Photo No.: \_\_\_\_\_  
 Description:

Metro Rail Red Line Wilshire Blvd. subway tunnel. Fossils found during excavation 577' W of McArthur Park pocket track & 60' beneath Wilshire Blvd. 22' tunnel diameter. Alternating olive gray to dark gray [moist] siltstone & brown to light brown [moist] laminated siltstone. Fresh medium soft to medium hard. Fossil fish found in brown to light brown laminated siltstone. Upper Mohnian Stage.

Material: Osteichthyes  
 Entered By: Samuel A. McLeod Date: 3 Jun 1994

## LACM 6200

Name: Metro Rail Wilshire Tunnel Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: N-NE Sect. 30, T 1 S, R 13 W Air Photo: \_\_\_\_\_  
 Lat: 34° 03' 37" N Long: 118° 16' 47" W Elev. 210 FT  
 Describer: Takeuchi, Gary T. Field No.: RDT 81192-C2/Mc Date: 6 Aug 1992  
 Field Notes: y Access. Data: n Photo No.: \_\_\_\_\_  
 Description:

Metro Rail Red Line Wilshire Blvd. subway tunnel. Fossils found during excavation 650' W of McArthur Park pocket track & 60' beneath Wilshire Blvd. 22' tunnel diameter. Alternating olive gray to dark gray [moist] siltstone & brown to light brown [moist] laminated siltstone. Fresh medium soft to medium hard. Fossil fish found in brown to light brown laminated siltstone. Upper Mohnian Stage.

Material: Osteichthyes  
 Entered By: Samuel A. McLeod Date: 3 Jun 1994

## LACM 6201

Name: Metro Rail Wilshire Tunnel Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: N-NE Sect. 30, T 1 S, R 13 W Air Photo: \_\_\_\_\_  
 Lat: 34° 03' 37" N Long: 118° 16' 59" W Elev. 226 FT  
 Describer: Takeuchi, Gary T. Field No.: \_\_\_\_\_ Date: 1992  
 Field Notes: y Access. Data: n Photo No.: \_\_\_\_\_  
 Description:

Metro Rail Red Line Wilshire Blvd. subway tunnel. Fossils found during excavation between McArthur Park pocket track & Wilshire Blvd. / Vermont Ave. Station [STA AR 274+00 to STA AR 309+54 - 3554']. 22' tunnel diameter. 215-237' elevation. McArthur Park pocket track W bulkhead center is 852' W & 308' N from NW corner Wilshire Blvd. & Alvarado St. Wilshire / Vermont station E bulkhead center is 252' W & 62' N from NW corner of Westmoreland Ave. & Wilshire Blvd. Alternating beds of olive gray to dark gray [moist] siltstone. Fresh medium soft to medium hard. Fossil fish found in brown to light brown laminated siltstone. W bulkhead is at 34° 03' 32" N 118° 16' 40" W. E bulkhead is at 34° 03' 43" N 118° 17' 18" W. Upper Mohnian Stage.

Material: Osteichthyes  
 Entered By: Samuel A. McLeod Date: 3 Jun 1994

## LACM 6202

Name: Metro Rail Wilshire Vermont Station Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: S-SW Sect. 19, T 1 S, R 13 W Air Photo: \_\_\_\_\_  
 Lat: 34° 03' 47" N Long: 118° 16' 23" W Elev. 182 FT  
 Describer: Takeuchi, Gary T. Field No.: \_\_\_\_\_ Date: Oct 1993  
 Field Notes: y Access. Data: n Photo No.: \_\_\_\_\_

## Description:

Metro Rail Red Line Wilshire Blvd. / Vermont Ave. subway station. 844' long excavation runs N 56° W. 58' width between E bulkhead & soldier pile 105; 30' width between E bulkhead & soldier pile 106; widening to 64' at W bulkhead. W bulkhead center is 64' S & 36' W from SE corner of 6th St. & Vermont Ave. E bulkhead center is 252' W & 62' N from NW corner of Westmoreland Ave. & Wilshire Blvd. Fossils between 155-210' elevation that runs to 260'. Alternating olive gray to dark gray [moist] siltstone & brown to light brown [moist] laminated siltstone. Fresh medium soft to medium hard; parallel-bedded; laterally continuous. Olive gray to dark gray siltstone is interbedded w laminae of fine grained soft sandstone. Thin ash beds are intercalated. Approximate strike is N 76° W w dip of 20-30° SW. W bulkhead is at 34° 03' 49" N 118° 17' 27" W. E bulkhead is at 34° 03' 43" N 118° 17' 18" W.

Material: Osteichthyes  
 Entered By: Samuel A. McLeod Date: 3 Jun 1994

## LACM 6203

Name: Metro Rail Wilshire Tunnel Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: SE-SE Sect. 24, T 1 S, R 14 W Air Photo: \_\_\_\_\_  
 Lat: 34° 03' 48" N Long: 118° 17' 32" W Elev. 170 FT  
 Describer: Takeuchi, Gary T. Field No.: TLS 4892/V Date: \_\_\_\_\_  
 Field Notes: y Access. Data: n Photo No.: \_\_\_\_\_

## Description:

Metro Rail Red Line Wilshire Blvd. subway tunnel. Fossils found during excavation 502' W of Wilshire Blvd. / Vermont Ave. station W bulkhead & 80' beneath surface. 22' tunnel diameter. Alternating olive gray to dark gray [moist] siltstone & brown to light brown [moist] laminated siltstone. Medium soft to medium hard fresh; parallel-bedded & laterally continuous. Fish found in brown to light brown laminated siltstone. Upper Mohnian Stage.

Material: Osteichthyes  
 Entered By: Samuel A. McLeod Date: 3 Jun 1994

## LACM 6204

Name: Metro Rail Wilshire Western Station Age: Rancholabrean  
 Geography: USA, California, Los Angeles Co.  
 Formation: \_\_\_\_\_  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: N-NW Sect. 25, T 1 S, R 14 W Air Photo: \_\_\_\_\_  
 Lat: 34° 03' 43" N Long: 118° 17' 21" W Elev. 140 FT  
 Descriptor: Takeuchi; Gary T. Field No.: RDT 72191-A-1+72191-A-2 Date: 22 Jul 1992  
 Field Notes: y Access. Data: n Photo No.: \_\_\_\_\_

## Description:

Metro Rail Red Line Wilshire Blvd. / Western Ave. subway station. Specimen found at E side of excavation. 132' W & 32' N from SE corner of Serrano Ave. & Wilshire Blvd. [soldier pile S 21 between struts D6 & D7] 65' below grade. Old alluvium: pebble-gravel; sand; silt & clay of detritus derived from Santa Monica Mountains. Unconsolidated to weakly consolidated.

## Material: \_\_\_\_\_

Entered By: Samuel A. McLeod Date: 3 Jun 1994

## LACM 6205

Name: Metro Rail Vermont Tunnel Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: SE-NE Sect. 12, T 1 S, R 14 W Air Photo: \_\_\_\_\_  
 Lat: 34° 06' 05" N Long: 118° 17' 32" W Elev. 328 FT  
 Descriptor: Takeuchi; Gary T. Field No.: \_\_\_\_\_ Date: 23 Jun 1993  
 Field Notes: y Access. Data: n Photo No.: \_\_\_\_\_

## Description:

Metro Rail Red Line Vermont Ave. subway tunnel. Fossils found during excavation of twin tunnels 22' diameter & 18' apart. 317-339' elevation. Only collected during 1st 176' of AR tunnel [north] & 1st 72' of AL tunnel [south]. Tunnel entrance at Barnsdall Park Access shaft E wall 271' E & 142' S from NE corner of N. Berendo St. & Hollywood Blvd. & 91' below grade elevation of 416'. Alternating dark olive gray to olive gray siltstone & dark brown to brown laminated siltstone. Fresh medium hard to hard; sheared. Fossil fish found in dark brown to brown laminated siltstone. Collected from 31 March to 23 June 1993. Upper Mohnian Stage.

Material: Osteichthyes

Entered By: Samuel A. McLeod Date: 3 Jun 1994

# LACM 6206

Name: Metro Rail Barnsdall Park Shaft Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: SE-NE Sect. 12 T 1 S, R 14 Air Photo:  
 Lat: 34° 06' 06" N Long: 118° 17' 38" W Elev. 381 FT  
 Describer: Takeuchi, Gary T. Field No.: Date: 28 Jan 1993  
 Field Notes: y Access. Data: n Photo No.:

Description:

Metro Rail Red Line Barnsdall Park subway tunnel. Fossils found during excavation of muck conveyor shaft 415' long & 10x10'. Trends N 76° E & inclined 16°. Shaft top at 412.5' grade elevation & bottom at 296' w top 225' S & 193' W from NE corner of N. Berendo St. & Hollywood Blvd. Base of oxidized beds is 171' S & 14' W from NE corner of N. Berendo St. & Hollywood Blvd. Fossils from upper 213' of shaft in oxidized thin bedded clayey siltstone yellowish brown; soft to medium soft. Collected from 28 Dec 1992 - 28 Jan 1993. Upper Mohnian Stage.

Material: Osteichthyes  
 Entered By: Samuel A. McLeod Date: 3 Jun 1994

# LACM 6207

Name: Metro Rail Barnsdall Park Shaft Age: Clarendonian  
 Geography: USA, California, Los Angeles Co.  
 Formation: Puente Fm  
 Map: Hollywood, 1/24000, USGS, 1981 Plotted: y  
 Township: SE-NE Sect. 12, T 1 S, R 14 W Air Photo:  
 Lat: 34° 06' 05" N Long: 118° 17' 37" W Elev. 323 FT  
 Describer: Takeuchi, Gary T. Field No.: Date: 4 Mar 1993  
 Field Notes: y Access. Data: n Photo No.:

Description:

Metro Rail Red Line Barnsdall Park subway tunnel. Fossils found during excavation of muck conveyor shaft 415' long & 10x10'. Trends N 76° E & inclined 16°. Base of shaft is 128' S & 185' W from NE corner of Berendo St. & Hollywood Blvd. Top of fresh Puente Fm is 171' S & 14' W from NE corner of Berendo St. & Hollywood Blvd. Fossils from fresh Puente Fm. in lower 202' between 350-296' elevation. Thin bedded dark olive gray to olive gray siltstone. Fresh hard to very hard; heavily sheared. W end of shaft is at 34° 06' 04" N 118° 17' 34" W. Collected from 28 Jan - 4 Mar 1993. Mohnian Stage.

Material: Osteichthyes  
 Entered By: Samuel A. McLeod Date: 3 Jun 1994



# LACM 6298

Name Metro Rail Hollywood Tunnel Age Rancholabrean [ ]  
 Geography USA California Los Angeles Co.  
 Formation \_\_\_\_\_  
 Map Hollywood, 1:24000, USGS, 1981 Plotted y  
 Township N-NE Sect. 11, T 1 S, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 6' 6" N Longitude 118° 18' 38" W Elevation 328 Ft  
 Describer Takeuchi: Gary T. Field No. MAR 4594-1 Date 31 Mar 1994  
 Field Notes y Accessory Data \_\_\_\_\_ Photo No. \_\_\_\_\_

**Description**

Metro Rail Red Line Hollywood Blvd. subway tunnel. Fossil found during excavation 725' W of Hollywood / Western subway station (station 514+35) and 60' beneath Hollywood Blvd. 22' tunnel diameter. Old alluvium: pebble-gravel; sand; sand & clay of detritus derived from Santa Monica Mountains. Unconsolidated to weakly consolidated.

Material Mammut americanum - LACM 140856  
 Entered by: Samuel A. McLeod Date 11/18/1996

# LACM 6299

Name Metro Rail Hollywood Tunnel Age Rancholabrean [ ]  
 Geography USA California Los Angeles Co.  
 Formation \_\_\_\_\_  
 Map Hollywood, 1:24000, USGS, 1981 Plotted y  
 Township N-NE Sect. 11, T 1 S, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 6' 7" N Longitude 118° 18' 41" W Elevation 330 Ft  
 Describer Takeuchi: Gary T. Field No. MAR 4594-2 Date 2 Apr 1994  
 Field Notes y Accessory Data \_\_\_\_\_ Photo No. \_\_\_\_\_

**Description**

Metro Rail Red Line Hollywood Blvd. subway tunnel. Fossil found during excavation 975' W of Hollywood / Western subway station (station 516+89.4) and 60' beneath Hollywood Blvd. 22' tunnel diameter. Old alluvium: pebble-gravel; sand; sand & clay of detritus derived from Santa Monica Mountains. Unconsolidated to weakly consolidated.

Material Bison - LACM 140857  
 Entered by: Samuel A. McLeod Date 11/18/1996

## LACM 6300

Name Metro Rail Hollywood Tunnel Age Rancholabrean [ ]  
 Geography USA California Los Angeles Co.  
 Formation \_\_\_\_\_  
 Map Hollywood, 1:24000, USGS, 1981 Plotted y  
 Township N-NE Sect. 11, T 1 S, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 6' 2" N Longitude 118° 18' 48" W Elevation 316 Ft  
 Describer Takeuchi: Gary T. Field No. MAR 42894-1 Date 20 Apr 1994  
 Field Notes y Accessory Data \_\_\_\_\_ Photo No. \_\_\_\_\_

## Description

Metro Rail Red Line Hollywood Blvd. subway tunnel. Fossil found during excavation 2075' W of Hollywood / Western subway station (station 527+86) and 80' beneath Hollywood Blvd. 22' tunnel diameter. Old alluvium: pebble-gravel; sand; sand & clay of detritus derived from Santa Monica Mountains. Unconsolidated to weakly consolidated.

Material Camelops - LACM 140858-140859  
 Entered by: Samuel A. McLeod Date 11/18/1996

## LACM 6306

Name Metrorail Universal City Station Age Rancholabrean [ Holocene Early]  
 Geography USA California Los Angeles Co.  
 Formation \_\_\_\_\_  
 Map Burbank, 1:24000, USGS, 1953 Plotted y  
 Township Sect. , T 1 N, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 8' 20" N Longitude 118° 21' 44" W Elevation 580 Ft  
 Describer Whistler + Takeuchi Field No. GTT 951025 Date 25 Oct 1995  
 Field Notes y Accessory Data \_\_\_\_\_ Photo No. \_\_\_\_\_

## Description

Fossils from dark gray sandy mudstone approximately 60 feet below surface in excavation of the station box for the Metropolitan Transit Authority Universal City Station for the MTA Red Line subway. Fossils associated with fossil wood carbon-14 dated at 8880 +/- 60 ybp. Age is early Holocene; rock unit is unnamed younger alluvium.

Material OS; Anura; Lacertilia; Serpentes; Insectivora; Rodentia  
 Entered by: David P. Whistler Date 12/17/1996

**LACM 6385**

Name Metrorail Universal City Station Age Rancholabrean [ Holocene Early]  
 Geography USA California Los Angeles Co.  
 Formation \_\_\_\_\_  
 Map Burbank, 1:24000, USGS, 1953 Plotted y  
 Township Sect. , T 1 N, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 8' 20" N Longitude 118° 21' 44" W Elevation 590 Ft  
 Describer Whistler + Takeuchi Field No. MM 961220 + RDT 970212 Date 20 Dec 1996  
 Field Notes n Accessory Data \_\_\_\_\_ Photo No. \_\_\_\_\_

## Description

Fossils from dark gray sandy mudstone approximately 40-50 feet below surface in excavation of the station box for the Metropolitan Transit Authority Universal City Station for the MTA Red Line subway. Fossils associated with fossil wood carbon-14 dated at 8880 +/- 60 ybp. Age is early Holocene; rock unit is unnamed younger alluvium. Collected by Michael Morris & Robin D. Turner.

Material OS; Anura; Rodentia  
 Entered by: David P. Whistler Date 02/11/1998

**LACM 6386**

Name Metrorail Universal City Station Age Rancholabrean [ ]  
 Geography USA California Los Angeles Co.  
 Formation \_\_\_\_\_  
 Map Burbank, 1:24000, USGS, 1953 Plotted y  
 Township Sect. , T 1 N, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 8' 20" N Longitude 118° 21' 44" W Elevation 580 Ft  
 Describer Whistler: David P. Field No. TLS 71696a Date 16 Jul 1996  
 Field Notes n Accessory Data \_\_\_\_\_ Photo No. \_\_\_\_\_

## Description

Fossils from dark gray sandy mudstone approximately 60 feet below surface in excavation of the station box for the Metropolitan Transit Authority Universal City Station for the MTA Red Line subway. This is probably same level as LACM 6306 but recovered 100 feet NE of LACM 6306 at East end of station box. Fossils associated with fossil wood carbon-14 dated at 8880 +/- 60 ybp. Age is early Holocene; rock unit is unnamed younger alluvium. Collected by Trudy L. Stubbs.

Material Rodentia  
 Entered by: David P. Whistler Date 02/18/1998

## LACM 6946

Name Metrorail Vermont / Beverly Statio Age Clarendonian [      ]  
 Geography USA California Los Angeles Co.  
 Formation Puente Fm  
 Map Hollywood, 1:24000, USGS, 1981 Plotted y  
 Township S-SE Sect. 13, T 1 S, R 14 W Air Photo       
 Latitude 34° 4' 35" N Longitude 118° 17' 27" W Elevation 280 Ft  
 Describer Takeuchi: Gary T. Field No. GTT 96715-B Date 15 Jul 1996  
 Field Notes y Accessory Data n Photo No.     

## Description

Metrorail Red Line Vermont Ave. / Beverly Blvd. subway station entrance. Specimens collected during cut & cover excavation of 40 ft. x 30 ft.; 60 ft. deep; elevation 300 ft. to 240 ft. Station entrance located at NW corner of Vermont Ave. & Beverly Blvd. intersection. Weathered yellowish brown thin bedded siltstone shale. Underlying & overlying beds not exposed at site. Locality graded away.

Material Osteichthyes  
 Entered by: Gary T. Takeuchi Date 09/09/1998

## LACM 6947

Name Metrorail Vermont / Santa Monica Age Clarendonian [      ]  
 Geography USA California Los Angeles Co.  
 Formation Puente Fm  
 Map Hollywood, 1:24000, USGS, 1981 Plotted y  
 Township N-NE Sect. 13, T 1 S, R 14 W Air Photo       
 Latitude 34° 5' 26" N Longitude 118° 17' 27" W Elevation 250 Ft  
 Describer Takeuchi: Gary T. Field No. TLS 8395 + TLS 72695 Date 3 Aug 1995  
 Field Notes y Accessory Data n Photo No.     

## Description

Metrorail Red Line Vermont Ave. / Santa Monica Blvd. subway station. Station located directly beneath Vermont Ave. between Lockwood Ave. & Santa Monica Blvd. Specimens collected during cut & cover excavation of station box. Excavation 989 ft. x 64 ft.; 70 ft. deep; elevation 320 ft. to 250 ft. Specimens found at N end of excavation. 240 ft. S & 48 ft. E from SW corner of Vermont Ave. & Santa Monica Blvd. Weathered light gray thin bedded siltstone shale. Locality graded away. Field Numbers are for Trudy L. Stubbs.

Material Osteichthyes  
 Entered by: Gary T. Takeuchi Date 09/09/1998

**LACM 6948**

Name Metrorail Vermont / Sunset Station Age Clarendonian [      ]  
 Geography USA California Los Angeles Co.  
 Formation Puente Fm  
 Map Hollywood, 1:24000, USGS, 1981 Plotted y  
 Township N-NE Sect. 12, T 1 S, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 4' 50" N Longitude 118° 17' 28" W Elevation 310 Ft  
 Describer Takeuchi: Gary T. Field No. \_\_\_\_\_ Date \_\_\_\_\_  
 Field Notes y Accessory Data n Photo No. \_\_\_\_\_

## Description

Metrorail Red Line Vermont Ave. / Sunset Blvd. subway station. Station located directly beneath Vermont Ave. between Delongpre Ave. & Sunset Blvd. Specimens collected during cut & cover excavation of station box (732 ft. x 64 ft.; 80 ft. below grade). Fossils collected between elevations 360 ft. to 310 ft. Yellowish brown to gray bedded siltstone shale. Locality graded away & buried. Fossils collected between Sep 1995 to May 1997.

Material Osteichthyes  
 Entered by: Gary T. Takeuchi Date 09/09/1998

**LACM 6969**

Name Metrorail Universal City Station Age Barstovian [      ]  
 Geography USA California Los Angeles Co.  
 Formation Topanga Fm  
 Map Burbank, 1:24000, USGS, 1953 Plotted y  
 Township N-NW Sect. 28, T 1 N, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 8' 27" N Longitude 118° 21' 39" W Elevation 565 Ft  
 Describer Takeuchi: Gary T. Field No. \_\_\_\_\_ Date \_\_\_\_\_  
 Field Notes n Accessory Data n Photo No. \_\_\_\_\_

## Description

Metrorail Redline Universal City subway station. Station located at the intersection of Hollywood Freeway (Highway 101) & Lankershim Blvd. Fossils collected during cut & cover excavation of station box. Lithology: dark gray siltstone shale with sandstone lens. Overlying unit alluvium. Underlying unit not exposed. Locality graded away & buried. Fossils collected between January 1996 to May 1997. Elevation is 580' - 550'.

Material Osteichthyes  
 Entered by: Gary T. Takeuchi Date 02/23/1999

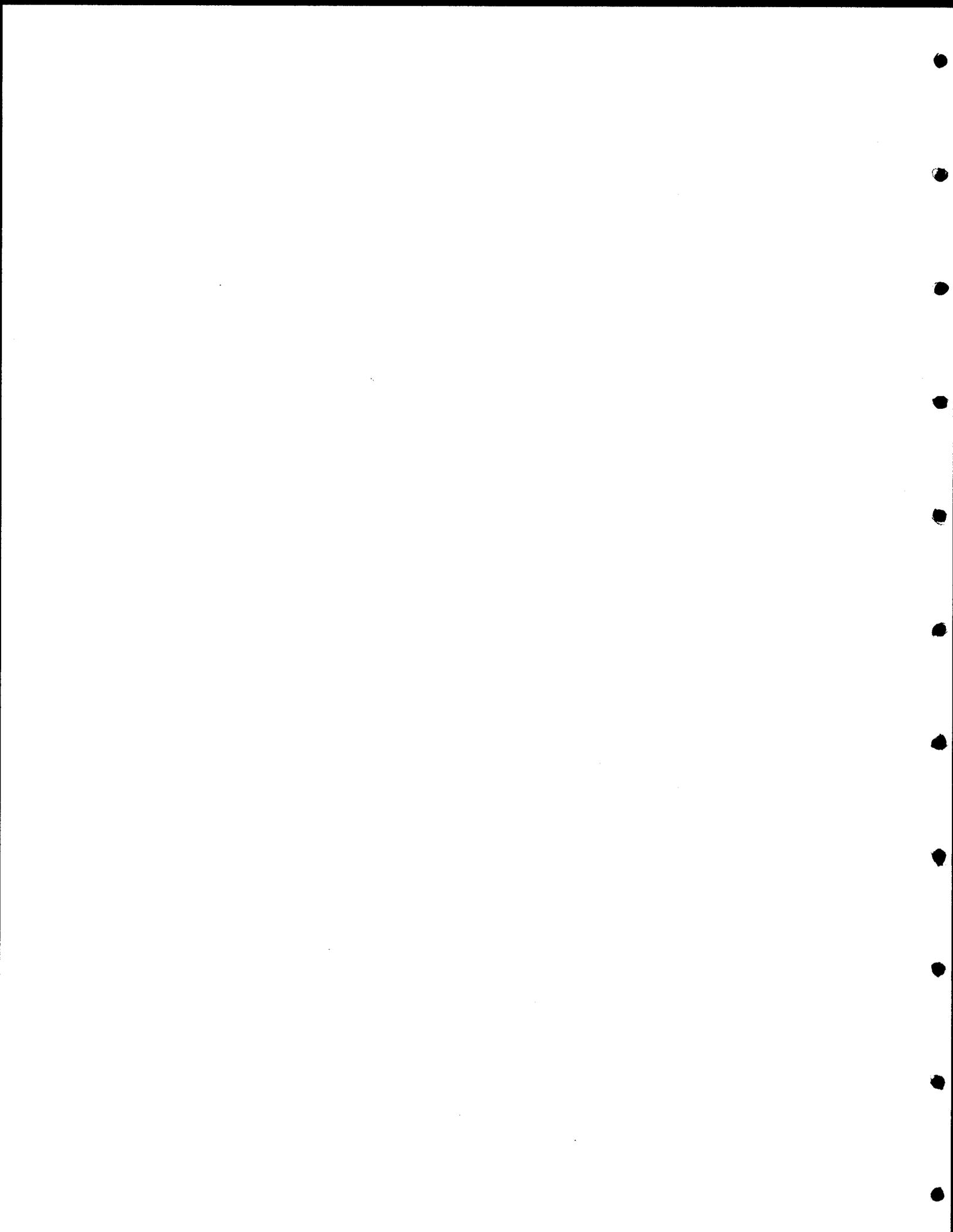
# LACM 6970

Name Metrorail U.C. Station - H. Tunnel Age Rancholabrean [ ]  
 Geography USA California Los Angeles Co.  
 Formation \_\_\_\_\_  
 Map Burbank, 1:24000, USGS, 1953 Plotted y  
 Township S-SW Sect. 28, T 1 N, R 14 W Air Photo \_\_\_\_\_  
 Latitude 34° 8' 57" N Longitude 118° 21' 52" W Elevation 497 Ft  
 Describer Takeuchi: Gary T. Field No. \_\_\_\_\_ Date Jun 1996  
 Field Notes n Accessory Data n Photo No. \_\_\_\_\_

Description

Metrorail Redline Universal City to North Hollywood Tunnel general locality. Located beneath Lankershim Blvd. Tunnel 22 feet in diameter. Tunnel between 60' to 82' below surface grade. Fossils collected during tunneling operations between Aqua Vista St. & Hortense St. (Sta 955+94 to Sta 991+90). Old alluvium; pebble - gravel; sand; silt & clay. Underlying unit not exposed. Locality graded away. Fossils collected between March to June 1996. Elevation is 508' - 486'.

Material Glossotherium; Camelops; Bison  
 Entered by: Gary T. Takeuchi Date 02/23/1999



APPENDIX N

UNIVERSITY OF CALIFORNIA MUSEUM OF PALEONTOLOGY  
PLANT FOSSIL SITE CATALOG—  
METRO RED LINE CONSTRUCTION ZONE,  
LOS ANGELES, CALIFORNIA

UNIVERSITY OF CALIFORNIA - MUSEUM OF PALEONTOLOGY - LOCALITY CATALOGUE

<u>PA722</u> Loc.No.	<u>LA Metro Rail - 1</u> Locality Name	<u>4548</u> Acc.No.	<u>PA722</u>
<u>NA</u> Continent/Ocean	<u>Hollywood</u> Map Name		
<u>USA</u> Country	<u>USGS</u> Map Source	<u>1981</u> Edition	
<u>California</u> State	<u>24000</u> Scale		
<u>Los Angeles.</u> County/Province	<u>34°03'37"N; 118°16'59"W ;</u> Lat. (N or S) Long. (E or W) Variance		
<u>Sec.</u> Section	<u>T1 S</u> Township	<u>R13 W</u> Range	<u></u> Subdivisions
<u>69 m 226 ft</u> Elevation			<u>Tertiary</u> System/Period
<u></u> Group			<u>Miocene</u> Age/Epoch
<u>Unnamed marine shale</u> Formation			<u>Upper Miocene</u> Stage/Age
<u></u> Member			<u>Late Miocene</u> Storage Age
<u>Supplied by E.B. Lander (see Memo)</u> Field notes			
<u>No</u> Photo coverage			<u>Suppl. File? N</u>
<u>See Parker and Dawson, 1965.</u> Publication			

Remarks1: RECORD #1860

Remarks2:

Detailed description:

Metro Rail Red Line Wilshire Blvd. subway tunnel. Fossils found during excavation between McArthur Park pocket track and Wilshier Blvd./Vermont Ave. station. Alternating beds of olive gray to dark gray fine-grained siltstone and brown to light brown laminated siltstone.

Site no longer accessible; buried under structures.

## UNIVERSITY OF CALIFORNIA - MUSEUM OF PALEONTOLOGY - LOCALITY CATALOGUE

<u>PA723</u>	<u>LA Metro Rail - 2</u>	<u>4548</u>	<u>PA723</u>
Loc. No.	Locality Name	Acc. No.	
<u>NA</u>	<u>Hollywood</u>		
Continent/Ocean	Map Name		
<u>USA</u>	<u>USGS</u>	<u>1981</u>	
Country	Map Source	Edition	
<u>California</u>	<u>24000</u>		
State	Scale		
<u>Los Angeles.</u>	<u>34°03'47"N; 118°16'23"W</u>		
County/Province	Lat. (N or S)	Long. (E or W)	Variance
<u>Sec. 19</u>	<u>T19 S</u>	<u>R13 W</u>	<u>S 1/2, SW 1/4</u>
Section	Township	Range	Subdivisions
<u>55</u>	<u>m</u>	<u>182</u>	<u>ft</u>
Elevation			
<u></u>			
Group			
<u>Unnamed marine shale</u>			
Formation			
<u></u>			
Member			
<u>Supplied by E.B. Lander (see Memo)</u>			
Field notes			
<u>No</u>			<u>Suppl. File? N</u>
Photo coverage			
<u>See Parker and Dawson, 1965.</u>			
Publication			

Remarks1: RECORD #1861

Remarks2:

## Detailed description:

Metro Rail Red Line Wilshire Blvd./Vermont Ave. subway station. Alternating olive gray to dark gray fine-grained siltstone and brown to light brown laminated fine-grained siltstone. Fresh, medium soft to medium hard parallel bedded; laterally continuous olive gray to dark gray siltstone is interbedded with laminae of fine-grained soft sandstone. Thin ash beds are intercalated. Approximate strike is N76 degrees W, dip 20-30 degrees SW.

Excavation is 105 feet deep. Fossils come from between elevation of 210 to 155 feet above SL.

Site no longer accessible; buried under structures.

UNIVERSITY OF CALIFORNIA - MUSEUM OF PALEONTOLOGY - LOCALITY CATALOGUE

<u>PB98002</u>	<u>Metrorail Universal City Station</u>	<u>4597</u>	<u>PB98002</u>
<small>Loc. No.</small>	<small>Locality Name</small>	<small>Acc. No.</small>	
<u>North America</u>	<u>Burbank</u>		
<small>Continent/Ocean</small>	<small>Map Name</small>		
<u>United States</u>	<u>USGS</u>	<u>1953</u>	
<small>Country</small>	<small>Map Source</small>	<small>Edition</small>	
<u>California</u>	<u>24000</u>		
<small>State</small>	<small>Scale</small>		
<u>Los Angeles.</u>	<u>34°08'20"N; 118°21'44"W</u>		
<small>County/Province</small>	<small>Lat. (N or S)</small>	<small>Long. (E or W)</small>	<small>Variance</small>
<u>Sec. 00</u>	<u>T01 N</u>	<u>R14 W</u>	
<small>Section</small>	<small>Township</small>	<small>Range</small>	<small>Subdivisions</small>
<u>180 m 590 ft</u>			
<small>Elevation</small>			
<u>Quaternary</u>			
<small>System/Period</small>			
<u>Early Holocene</u>			
<small>Age/Epoch</small>			
<u>Holocene</u>			
<small>Stage/Age</small>			
<u>Holocene</u>			
<small>Storage Age</small>			
<u>Whistler, D.P., DPW2505, DPW2508, DPW2509; Turner, R.D., RDT961015, RDT968</u>			
<small>Field notes</small>			

Suppl. File?     

Photo coverage

Paleontology mitigation report to follow.

Publication

Remarks1: Equivalent to LACM Vert Paleo 6306, 6385, 6386; LACM IT16967.

Remarks2: gray clay to sand

Detailed description:

Fossils from coarse-grained sand with dark gray clay rip-up clasts approximately 45-61 feet below surface in excavation of the station box for the LA County Metropolitan Transportation Authority (MTA) Universal City Station for the MTA Redline subway. Fossil woods carbon-14 dated at 7860+/-80 ybp (RDT961015, sample Beta-102794, from 45 ft. down); 8880+/-60 ybp (DPW2505, sample Beta-86689); and 10500 +/- 70 ybp (RDT96822, sample Beta-102795). Age is early Holocene, rock unit is unnamed younger alluvium. Underlying unit is the Upper Topanga Formation, contact unconformable. Locality is no longer accessible.

Entered by: Erwin, D.M., 11 March 1998.

Updated: DME, 20 March 1998.

UNIVERSITY OF CALIFORNIA - MUSEUM OF PALEONTOLOGY - LOCALITY CATALOGUE

PB98003 Metrorail North Hollywood Station 4597 PB98003  
 Loc.No. Locality Name Acc.No.

North America Van Nuys  
 Continent/Ocean Map Name  
United States USGS 1966  
 Country Map Source Edition  
California 24000  
 State Scale  
Los Angeles. 34°10'04"N; 118°22'32"W  
 County/Province Lat. (N or S) Long. (E or W) Variance

Sec.00 T01 N R14 W  
 Section Township Range Subdivisions

164 m 537 ft Quaternary  
 Elevation System/Period  
Group Late Pleistocene  
 Age/Epoch  
Formation Rancholabrean  
 Stage/Age  
Member Pleistocene  
 Storage Age

Whistler, D.P., DPW2516  
 Field notes

Photo coverage Suppl. File? \_\_\_

Paleontology mitigation report to follow.  
 Publication

Remarks1:

Remarks2: tan clayey silt

Detailed description:

Fossil wood from tan clayey silt approximately 80 feet below surface in excavation of station box for Metropolitan Transportation Authority (MTA) North Hollywood Station for the MTA Redline Subway. Fossil wood (sample Beta-90086) carbon-14 dated at >46,340ybp. Age is late Pleistocene, rock unit is unnamed older alluvium. Locality is no longer accessible.

Entered by: Erwin, D.M., 11 March 1998.  
 Updated: DME, 20 March 1998.

## UNIVERSITY OF CALIFORNIA - MUSEUM OF PALEONTOLOGY - LOCALITY CATALOGUE

<u>PB98004</u>	<u>Metrorail North Hollywood Tunnel</u>	<u>4597</u>	<u>PB98004</u>
Loc.No.	Locality Name	Acc.No.	
<u>North America</u>	<u>Van Nuys</u>		
Continent/Ocean	Map Name		
<u>United States</u>	<u>USGS</u>	<u>1966</u>	
Country	Map Source	Edition	
<u>California</u>	<u>24000</u>		
State	Scale		
<u>Los Angeles.</u>	<u>34°13'31"N; 118°23'13"W</u>		
County/Province	Lat. (N or S)	Long. (E or W)	Variance
<u>Sec.00</u>	<u>T02 N</u>	<u>R14 W</u>	
Section	Township	Range	Subdivisions
<u>158 m 518 ft</u>			
Elevation			
<u>Group</u>			<u>Quaternary</u>
			System/Period
<u>Formation</u>			<u>Late Pleistocene</u>
			Age/Epoch
<u>Member</u>			<u>Rancholabrean</u>
			Stage/Age
<u>Whistler, D.P., DPW2565, DPW2566</u>			<u>Pleistocene</u>
Field notes			Storage Age
			<u>Suppl. File?</u>
<u>Photo coverage</u>			
<u>Paleontology mitigation report to follow.</u>			
Publication			

Remarks1:

Remarks2: clay

## Detailed description:

Fossils from gray clay 67 feet below surface in North Hollywood Tunnel for the Metropolitan Transportation Authority (MTA). Tunnel station 977 + 30, between Landale and Moorpark streets. Fossil wood carbon-14 dated at >48,620 ybp (DPW2565, sample Beta-099228). Rock unit is unnamed younger alluvium. Pollen analysis was done on matrix sample DPW2566. UCMP given one prepared pollen slide. Locality is no longer accessible.

Entered by: Erwin, D.M., 11 March 1998.

Updated: DME, 20 March 1998.

## UNIVERSITY OF CALIFORNIA - MUSEUM OF PALEONTOLOGY - LOCALITY CATALOGUE

PB99003	LA Metrorail:Vermont/Sunset Station			4618	PB99003
Loc.No.	Locality Name			Acc.No.	
North America	Hollywood				
Continent/Ocean	Map Name				
United States	USGS			1981	
Country	Map Source			Edition	
California	24000				
State	Scale				
Los Angeles.	34°04'50"N; 118°17'28"W				
County/Province	Lat. (N or S) Long. (E or W) Variance				
Sec.12	T1 S	R14 W	N-NE		
Section	Township	Range	Subdivisions		
94	m	310	ft		
Elevation					
Group				Tertiary	
				System/Period	
Puente				Miocene	
Formation				Age/Epoch	
				Clarendonian	
				Stage/Age	
Member				Miocene	
				Storage Age	
MM970422, MM970318-02, RDT970414(1-3), GTT951218s, GTT951013s					
Field notes					
				Suppl. File? Y	
Photo coverage					
Paleontology report to follow.					
Publication					

Remarks1: Equivalent to LACMVP6948, LACMIP17138

Remarks2: shale

## Detailed description:

Metrorail Red Line Vermont Ave./Sunset Blvd. subway station. Station located directly beneath Vermont Ave. between Delongpre Ave. and Sunset Blvd. Specimens collected during cut and cover excavation of station box (732 ft. x 64 ft.; 80 ft. below grade). Fossils collected from Sept. 1995-May 1997 between elevations 360 to 310 ft. Yellowish brown to gray bedded siltstone and shale. Locality no longer accessible.

Fossils repositied at UCMP include fossil alga and Populus leaf.

Entered by: Erwin, D.M., 12 March 1999.

UNIVERSITY OF CALIFORNIA - MUSEUM OF PALEONTOLOGY - LOCALITY CATALOGUE

<u>PB99030</u>	<u>LA Metrorail Red Line Aqua Vista/Chiquita</u>	<u>4626</u>	<u>PB99030</u>
<small>Loc. No.</small>	<small>Locality Name</small>	<small>Acc. No.</small>	
<u>North America</u>	<u>Burbank</u>		
<small>Continent/Ocean</small>	<small>Map Name</small>		
<u>United States</u>	<u>USGS</u>	<u>1953</u>	
<small>Country</small>	<small>Map Source</small>	<small>Edition</small>	
<u>California</u>	<u>24000</u>		
<small>State</small>	<small>Scale</small>		
<u>Los Angeles.</u>	<u>34°08'44"N; 118°21'18"W</u>		
<small>County/Province</small>	<small>Lat. (N or S) Long. (E or W) Variance</small>		
<u>Sec. T1 N R14 W</u>			
<small>Section Township Range Subdivisions</small>			
<u>174 m 571 ft</u>			
<small>Elevation</small>			
<u>Group</u>	<u>Tertiary</u>		
	<small>System/Period</small>		
<u>Topanga</u>	<u>Middle Miocene</u>		
<small>Formation</small>	<small>Age/Epoch</small>		
<u>Member</u>	<u>Miocene</u>		
	<small>Storage Age</small>		
<u>Field notes</u>			
<u>Photo coverage</u>	<u>Suppl. File? ___</u>		
<u>Paleontology mitigation report to follow.</u>			
<small>Publication</small>			

Remarks1:

Remarks2: wood

Detailed description:

Site is part of Los Angeles Metrorail Red Line subway project. One specimen of fossil wood collected from the southbound (left) tunnel at sta.953 + 89, 60 to 80 feet below grade under Lankershim Blvd, between Aqua Vista and Chiquita Streets, Los Angeles.

Entered by: Erwin, D.M., 14Dec1999.

## APPENDIX O

**NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY**  
**VERTEBRATE PALEONTOLOGY SECTION**  
**FOSSIL SPECIMEN CATALOG—**  
**METRO RED LINE CONSTRUCTION ZONE,**  
**LOS ANGELES, CALIFORNIA**

LACMVP <sup>a</sup> Specimen Number	Taxon	Element <sup>b</sup>	LACMVP Fossil Site Number
136278	Scombridae	Hypural Fan + Fin Rays	6198
136279	Scombridae	Vertebrae post	6198
136280	Teleostei	Skull + Skeleton ant	6199
136281	<i>Bathylagus</i>	Skeleton w Otolith	6200
136282	Moridae	Skull w Otolith + Skeleton ant	6200
136283	Moridae	Skull w Otolith + Vertebrae ant	6201
136284	Moridae	Skull + Skeleton ant	6201
136285	<i>Cyclothone</i>	Skeleton	6201
136286	Moridae	Neurocranium w Otolith	6201
136287	Belonidae	Skull	6201
136288	Myctophidae	Skull Otolith	6201
136289	Myctophidae	Skull Otolith	6201
136290	Myctophidae	Skull Otolith	6201
136291	Myctophidae	Skull Otolith	6201
136292	Myctophidae	L Skull Otolith	6201
136293	Myctophidae	R Skull Otolith	6201
136294	Myctophidae	Skull Otolith	6201
136295	Myctophidae	R Skull Otolith	6201
136296	Teleostei	Skeleton post incompl	6201
136297	Alepocephalidae	Skeleton	6201
136298	Vertebrata	Coprolite w Teleostei bone frags	6201
136299	Vertebrata	Coprolite w Teleostei bone frags	6201
136300	Teleostei	Vertebra	6201
136301	Teleostei	Skull + Skeleton ant	6201
136302	Teleostei	Skull w Otolith	6201
136303	Cetacea	Rib prox ?	6254
136304	Pleuronectoidei	Skull + Skeleton ant	6202
136305	Pleuronectoidei	Skull + Skeleton ant	6202
136306	Pleuronectoidei	Skull + Skeleton ant	6202
136307	Pleuronectoidei	Skull w Otolith + Skeleton ant	6202
136308	<i>Pleuronichthys</i>	Skeleton w L+R Otolith	6202
136309	Pleuronectoidei	Skeleton w L+R Otolith	6202
136310	Pleuronectoidei	Skeleton	6202
136311	Pleuronectoidei	Skull w Otolith	6202
136312	Pleuronectoidei	Skull	6202
136313	Pleuronectoidei	Skull	6202
136314	Pleuronectoidei	Skeleton mid	6202
136315	Pleuronectoidei	Skeleton mid	6202
136316	Pleuronectoidei	Skeleton post	6202
136317	Pleuronectoidei	Skeleton post	6202
136318	Pleuronectoidei	Fin Caudal	6202
136319	Pleuronectoidei	Skull disarticulated + Skeleton ant	6202

136320	<i>Argyropelecus</i>	Skull + Skeleton ant	6202
136321	<i>Argyropelecus</i>	Skeleton	6202
136322	<i>Argyropelecus</i>	Skeleton	6202
136323	<i>Argyropelecus</i>	Skeleton	6202
136324	<i>Sebastes</i>	Skull + Skeleton ant	6202
136325	<i>Sebastes</i>	Skeleton w L+R Otolith	6202
136326	<i>Sebastes</i>	R Skull Otolith	6202
136327	Belonidae	Skull ant	6202
136328	Belonidae	Skull	6202
136329	Belonidae	Skull	6202
136330	Belonidae	Skull	6202
136331	Belonidae	Skeleton mid	6202
136332	Belonidae	Skeleton mid	6202
136333	Belonidae	Skeleton mid	6202
136334	Belonidae	Skeleton mid	6202
136335	Belonidae	Skeleton mid	6202
136336	Belonidae	Skeleton mid	6202
136337	Belonidae	Skeleton mid	6202
136338	Belonidae	Skeleton mid	6202
136339	Belonidae	Skull + Skeleton ant	6202
136340	Belonidae	Skull + Skeleton ant	6202
136341	Belonidae	Skull + Skeleton ant	6202
136342	Belonidae	Skull + Skeleton ant	6202
136343	Belonidae	Skull + Skeleton ant	6202
136344	Belonidae	Skull + Skeleton ant	6202
136345	<i>Strongylura</i>	Skull + Skeleton ant	6202
136346	Belonidae	Skull + Skeleton ant	6202
136347	Belonidae	Skull + Skeleton ant	6202
136348	Belonidae	Scale patch	6202
136349	Stomiidae	Skeleton	6202
136350	<i>Stomias</i>	Skull + Skeleton ant	6202
136351	<i>Chauliodus eximius</i>	Skeleton	6202
136352	<i>Stomias</i>	Skeleton	6202
136353	<i>Chauliodus eximius</i>	Skull + Skeleton ant	6202
136354	<i>Chauliodus eximius</i>	Skull + Skeleton ant	6202
136355	<i>Chauliodus eximius</i>	Skull + Skeleton ant	6202
136356	<i>Chauliodus eximius</i>	Skull + Skeleton ant	6202
136357	<i>Chauliodus eximius</i>	Skull + Skeleton ant	6202
136358	<i>Chauliodus eximius</i>	Skull + Skeleton ant	6202
136359	<i>Chauliodus eximius</i>	Skull + Skeleton ant	6202
136360	<i>Chauliodus eximius</i>	Skull + Skeleton ant	6202
136361	<i>Chauliodus eximius</i>	Skull	6202
136362	<i>Chauliodus eximius</i>	Skull	6202
136363	<i>Chauliodus eximius</i>	Skull	6202
136364	<i>Chauliodus eximius</i>	Skull	6202
136365	<i>Chauliodus eximius</i>	Skull	6202
136366	<i>Chauliodus eximius</i>	Skull	6202
136367	<i>Chauliodus eximius</i>	Skull	6202
136368	<i>Chauliodus eximius</i>	Skull disarticulated	6202
136369	<i>Chauliodus eximius</i>	Skeleton mid	6202
136370	<i>Chauliodus eximius</i>	Skeleton mid	6202
136371	<i>Chauliodus eximius</i>	Skeleton mid	6202
136372	<i>Chauliodus eximius</i>	Dentary + Skull elements	6202
136373	<i>Chauliodus eximius</i>	R Dentary	6202
136374	<i>Chauliodus eximius</i>	Dentary + Premaxilla	6202

136375	<i>Chauliodus eximius</i>	L+R Dentaries	6202
136376	Scombridae	Vertebrae post + Fin Caudal	6202
136377	Scombridae	Skeleton post	6202
136378	Scombridae	Skeleton post	6202
136379	Scombridae	Skeleton post	6202
136380	Scombridae	Skeleton post	6202
136381	Scombridae	Skeleton mid	6202
136382	Scombridae	Skeleton mid	6202
136383	Scombridae	Skeleton mid	6202
136384	Scombridae	Skeleton mid	6202
136385	Scombridae	Skeleton mid	6202
136386	Scombridae	Skeleton mid	6202
136387	Scombridae	Skeleton mid	6202
136388	Scombridae	Skeleton mid	6202
136389	Scombridae	Skeleton mid	6202
136390	<i>Thyrsocles</i>	Skeleton mid	6202
136391	Scombridae	Skeleton mid	6202
136392	Scombridae	Skull + Skeleton ant	6202
136393	Scombridae	Skull + Skeleton ant	6202
136394	Scombridae	Skull incompl + Skeleton ant	6202
136395	Scombridae	Skeleton	6202
136396	Scombridae	Skeleton incompl	6202
136397	Scombridae	Skull	6202
136398	Scombridae	Skull	6202
136399	Scombridae	Skull	6202
136400	Scombridae	Skull	6202
136401	<i>Thyrsocles</i>	Skull	6202
136402	Scombridae	Skull	6202
136403	Scombridae	Skull ant	6202
136404	Scombridae	Skull elements	6202
136405	<i>Thyrsocles</i>	Skull incompl	6202
136406	Scombridae	Skull incompl	6202
136407	Scombridae	Neurocranium	6202
136408	Scombridae	Neurocranium	6202
136409	Scombridae	Skull Sclerotic	6202
136410	Scombridae	Skull Sclerotic	6202
136411	Scombridae	Skull Sclerotic	6202
136412	Scombridae	Skull Sclerotic	6202
136413	<i>Thyrsocles</i>	Dentary	6202
136414	<i>Thyrsocles</i>	Dentary incompl	6202
136415	<i>Thyrsocles</i>	L Dentary	6202
136416	<i>Thyrsocles</i>	Urohyal	6202
136417	Scombridae	Fin Caudal	6202
136418	Scombridae	Scale patch	6202
136419	Scombridae	Scale mass	6202
136420	<i>Scomber?</i>	Skeleton mid	6202
136421	<i>Scomber?</i>	Skeleton mid	6202
136422	<i>Scomber?</i>	Fin Caudal	6202
136423	<i>Lompoquia</i>	Skeleton mid	6202
136424	<i>Lompoquia</i>	Skeleton mid	6202
136425	<i>Lompoquia</i>	Skeleton mid	6202
136426	<i>Lompoquia</i>	Skull + Skeleton ant	6202
136427	<i>Lompoquia</i>	Skull + Skeleton ant	6202
136428	<i>Lompoquia</i>	Skull incompl w Scales	6202
136429	<i>Lompoquia</i>	Skull	6202

136430	<i>Lompoquia</i>	Scale patch	6202
136431	Carangidae	Skeleton mid	6202
136432	Serranidae	R Skull Otolith	6202
136433	<i>Ganolytes cameo</i>	Scale	6202
136434	<i>Ganolytes cameo</i>	Scale	6202
136435	<i>Ganolytes cameo</i>	Scale	6202
136436	<i>Ganolytes cameo</i>	Scale	6202
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136475	<i>Ganolytes cameo</i>	Scale	6202
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136502	<i>Ganolytes cameo</i>	Scale	6202
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136504	<i>Ganolytes cameo</i>	Scale	6202
136505	<i>Ganolytes cameo</i>	Scale	6202
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136509	<i>Ganolytes cameo</i>	Scale	6202
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136519	<i>Ganolytes cameo</i>	Scale	6202
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136539	<i>Ganolytes cameo</i>	Scale	6202
136540	<i>Ganolytes cameo</i>	Scale	6202
136541	<i>Ganolytes cameo</i>	Scale	6202
136542	<i>Ganolytes cameo</i>	Scale	6202
136543	<i>Ganolytes cameo</i>	Scale mass	6202
136544	<i>Ganolytes cameo</i>	Scale mass	6202
136545	<i>Ganolytes cameo</i>	Scale mass	6202
136546	<i>Ganolytes cameo</i>	Scale patch	6202
136547	<i>Ganolytes cameo</i>	Scale patch	6202
136548	<i>Ganolytes cameo</i>	Scutes + Scales ventral	6202
136549	<i>Ganolytes cameo</i>	Skull incompl + Skeleton ant	6202
136550	<i>Ganolytes cameo</i>	Skull disarticulated + Skeleton ant	6202
136551	<i>Ganolytes cameo</i>	Skull disarticulated	6202
136552	<i>Ganolytes cameo</i>	Skull disarticulated	6202
136553	<i>Ganolytes cameo</i>	Skull disarticulated	6202
136554	<i>Ganolytes cameo</i>	Skull	6202
136555	<i>Ganolytes cameo</i>	Skull	6202
136556	<i>Ganolytes cameo</i>	Skull	6202
136557	<i>Ganolytes cameo</i>	Skull	6202
136558	<i>Ganolytes cameo</i>	Neurocranium	6202
136559	<i>Ganolytes cameo</i>	Neurocranium w Skull elements	6202
136560	<i>Ganolytes cameo</i>	Skull Opercular incompl	6202
136561	<i>Ganolytes cameo</i>	Skull Opercular	6202
136562	<i>Ganolytes cameo</i>	Skull Opercular	6202
136563	<i>Ganolytes cameo</i>	Skull Opercular	6202
136564	<i>Ganolytes cameo</i>	Skull Opercular	6202
136565	<i>Ganolytes cameo</i>	Skull Opercular	6202
136566	<i>Ganolytes cameo</i>	Skull Opercular	6202
136567	<i>Ganolytes cameo</i>	Skull Opercular	6202
136568	<i>Ganolytes cameo</i>	L Skull Opercular	6202
136569	<i>Ganolytes cameo</i>	Skull Opercular series	6202
136570	<i>Ganolytes cameo</i>	Skull Preopercular	6202
136571	<i>Ganolytes cameo</i>	Vertebra column incompl	6202
136572	<i>Ganolytes cameo</i>	Vertebra column incompl	6202
136573	<i>Ganolytes cameo</i>	Skull + Skeleton ant	6202

136574	<i>Ganolytes cameo</i>	Skull + Skeleton ant	6202
136575	<i>Ganolytes cameo</i>	Skeleton mid	6202
136576	<i>Ganolytes cameo</i>	Skeleton mid	6202
136577	<i>Ganolytes cameo</i>	Skeleton mid	6202
136578	<i>Ganolytes cameo</i>	Skeleton mid	6202
136579	<i>Ganolytes cameo</i>	Fin Caudal	6202
136580	<i>Ganolytes cameo</i>	Fin Caudal	6202
136581	<i>Ganolytes cameo</i>	Skeleton post	6202
136582	<i>Ganolytes cameo</i>	Skeleton post	6202
136583	<i>Ganolytes cameo</i>	Skeleton	6202
136584	<i>Ganolytes cameo</i>	Skeleton incompl	6202
136585	<i>Xyne grex</i>	Skull + Skeleton ant	6202
136586	<i>Xyne grex</i>	Skull + Skeleton ant	6202
136587	<i>Xyne grex</i>	Skull + Skeleton ant	6202
136588	<i>Xyne grex</i>	Skull + Skeleton ant	6202
136589	<i>Xyne grex</i>	Skull + Skeleton ant	6202
136590	<i>Xyne grex</i>	Skull + Skeleton ant	6202
136591	<i>Xyne grex</i>	Skull + Skeleton ant	6202
136592	<i>Xyne grex</i>	Skeleton post	6202
136593	<i>Xyne grex</i>	Skeleton post	6202
136594	<i>Xyne grex</i>	Skeleton post	6202
136595	<i>Xyne grex</i>	Fin Caudal	6202
136596	<i>Xyne grex</i>	Fin Caudal	6202
136597	<i>Xyne grex</i>	Fin Caudal	6202
136598	<i>Xyne grex</i>	Fin Caudal	6202
136599	<i>Xyne grex</i>	Skeleton mid	6202
136600	<i>Xyne grex</i>	Skeleton mid	6202
136601	<i>Xyne grex</i>	Skull	6202
136602	<i>Xyne grex</i>	Skull	6202
136603	<i>Xyne grex</i>	Skull	6202
136604	<i>Xyne grex</i>	Skull	6202
136605	<i>Xyne grex</i>	Skull incompl	6202
136606	<i>Xyne grex</i>	Skull Opercular series	6202
136607	<i>Xyne grex</i>	Skull Opercular series	6202
136608	<i>Xyne grex</i>	Skull Opercular series	6202
136609	<i>Xyne grex</i>	Skull Opercular	6202
136610	<i>Xyne grex</i>	Skull Opercular	6202
136611	<i>Xyne grex</i>	Skull Opercular	6202
136612	<i>Xyne grex</i>	Skull Opercular	6202
136613	<i>Xyne grex</i>	Skull Opercular	6202
136614	<i>Xyne grex</i>	Skull Opercular	6202
136615	<i>Xyne grex</i>	R Skull Opercular	6202
136616	<i>Xyne grex</i>	R Skull Opercular	6202
136617	<i>Xyne grex</i>	L Skull Opercular	6202
136618	<i>Xyne grex</i>	Scale	6202
136619	<i>Xyne grex</i>	Skeleton incompl	6202
136620	<i>Xyne grex</i>	Skeleton incompl	6202
136621	<i>Xyne grex</i>	Skeleton incompl	6202
136622	<i>Xyne grex</i>	Skeleton incompl	6202
136623	<i>Xyne grex</i>	Skeleton incompl	6202
136624	<i>Xyne grex</i>	Skeleton	6202
136625	<i>Xyne grex</i>	Skeleton	6202
136626	<i>Xyne grex</i>	Skeleton	6202
136627	<i>Xyne grex</i>	Skeleton	6202
136628	<i>Xyne grex</i>	Skeleton	6202

136629	<i>Xyne grex</i>	Skeleton	6202
136630	<i>Xyne grex</i>	Skeleton	6202
136631	<i>Xyne grex</i>	Skeleton	6202
136632	<i>Xyne grex</i>	Skeleton	6202
136633	<i>Xyne grex</i>	Skeleton	6202
136634	<i>Xyne grex</i>	Skeleton	6202
136635	<i>Xyne grex</i>	Skeleton	6202
136636	<i>Xyne grex</i>	Skeleton	6202
136637	<i>Xyne grex</i>	Skeleton	6202
136638	<i>Xyne grex</i>	Skeleton disarticulated	6202
136639	Clupeidae	Skull Otolith	6202
136640	Gempylidae?	Skull Otolith in coprolite	6202
136641	Clupeidae	Skull Otolith	6202
136642	Clupeidae	Skull Subopercular	6202
136643	Clupeidae	Skeleton post	6202
136644	Moridae	Skeleton incompl	6202
136645	Moridae	Skull	6202
136646	Teleostei	Scale	6202
136647	<i>Physiculus</i>	Skull Otolith	6202
136648	Moridae	Skull Otolith	6202
136649	Moridae	Skull Otolith	6202
136650	Moridae	Skull Otolith	6202
136651	Moridae	Skull Otolith	6202
136652	Moridae	Skull Otolith	6202
136653	Moridae	Skull w Otoliths	6202
136654	Moridae	Skull w Otolith	6202
136655	Moridae	Skull w Otolith	6202
136656	Moridae	Skull w Otolith	6202
136657	Moridae	Skull w Otolith	6202
136658	Moridae	Skull incompl w Otolith	6202
136659	Moridae	Skull incompl w Otolith	6202
136660	Moridae	Skull incompl w Otolith	6202
136661	Moridae	Neurocranium w Otolith	6202
136662	Moridae	Neurocranium w Otolith	6202
136663	Moridae	Neurocranium w Otolith	6202
136664	<i>Merluccius</i>	Skull Otolith	6202
136665	Moridae	Skeleton post	6202
136666	Moridae	Skeleton post	6202
136667	Moridae	Skeleton post	6202
136668	Moridae	Skeleton post	6202
136669	Moridae	Skeleton post	6202
136670	Moridae	Skeleton mid	6202
136671	Moridae	Skeleton post	6202
136672	Moridae	Skeleton post	6202
136673	<i>Physiculus</i>	Skeleton post	6202
136674	Moridae	Skeleton post	6202
136675	Moridae	Skeleton post	6202
136676	Moridae	Skeleton post	6202
136677	Moridae	Skeleton mid	6202
136678	Moridae	Skeleton mid	6202
136679	Moridae	Skeleton mid	6202
136680	Moridae	Skeleton mid	6202
136681	Moridae	Skeleton mid	6202
136682	Moridae	Skeleton mid	6202
136683	Moridae	Skeleton mid	6202

136684	Moridae	Skeleton mid	6202
136685	Moridae	Skeleton mid	6202
136686	Moridae	Skeleton mid	6202
136687	Moridae	Skeleton mid	6202
136688	Moridae	Skeleton mid	6202
136689	Moridae	Skeleton mid	6202
136690	Moridae	Skeleton mid	6202
136691	Moridae	Skeleton mid	6202
136692	Moridae	Skeleton mid	6202
136693	Moridae	Skeleton mid	6202
136694	Moridae	Skeleton mid	6202
136695	Moridae	Skeleton mid	6202
136696	Moridae	Skeleton mid	6202
136697	Moridae	Skeleton mid	6202
136698	Moridae	Skeleton mid	6202
136699	Gadoidei	Skeleton ant	6202
136700	Gadoidei	Skeleton ant	6202
136701	Gadoidei	Skull + Skeleton ant	6202
136702	Moridae	Skull + Skeleton ant	6202
136703	Moridae	Skull + Skeleton ant	6202
136704	Gadoidei	Skull + Skeleton ant	6202
136705	Moridae	Skull + Skeleton ant	6202
136706	Moridae	Skull + Skeleton ant	6202
136707	<i>Physiculus</i>	Skull + Skeleton ant	6202
136708	Moridae	Skull + Skeleton ant	6202
136709	Moridae	Skull + Skeleton ant	6202
136710	Moridae	Skull + Skeleton ant	6202
136711	Moridae	Skull + Skeleton ant	6202
136712	Gadoidei	Skull + Skeleton ant	6202
136713	Moridae	Skull + Skeleton ant	6202
136714	Moridae	Skull + Skeleton ant	6202
136715	Moridae	Skull + Skeleton ant	6202
136716	Moridae	Skull + Skeleton ant	6202
136717	Moridae	Skull + Skeleton ant	6202
136718	Moridae	Skull + Skeleton ant	6202
136719	Moridae	Skull w Otolith + Skeleton ant	6202
136720	Moridae	Skull w Otolith + Skeleton ant	6202
136721	Moridae	Skull w Otolith + Skeleton ant	6202
136722	Moridae	Skull w Otolith + Skeleton ant	6202
136723	Moridae	Skull w Otolith + Skeleton ant	6202
136724	Moridae	Skull w Otolith + Skeleton ant	6202
136725	Moridae	Skull w Otolith + Skeleton ant	6202
136726	Moridae	Skull w Otolith + Skeleton ant	6202
136727	Moridae	Skull w Otolith + Skeleton ant	6202
136728	Moridae	Skull w L+R Otolith + Skeleton ant	6202
136729	Moridae	Skull w L+R Otolith + Skeleton ant	6202
136730	Moridae	Skull w L+R Otolith + Skeleton ant	6202
136731	Moridae	Skeleton post	6202
136732	Moridae	Skeleton post	6202
136733	Moridae	Skeleton post	6202
136734	Moridae	Skull incompl	6202
136735	Moridae	Skull incompl	6202
136736	Moridae	Skull incompl w Otolith	6202
136737	<i>Chauliodus eximius</i>	Skull post	6202
136738	Moridae	Neurocranium w L+R Otolith	6202

136739	Moridae	Skull	6202
136740	Gadoidei	Skull	6202
136741	Moridae	Skull	6202
136742	Moridae	Skull	6202
136743	Moridae	Skull disarticulated	6202
136744	Moridae	Skull w Otolith	6202
136745	Moridae	Skull w Otolith	6202
136746	Moridae	Skull w Otolith	6202
136747	Moridae	Skull w Otolith	6202
136748	Gadoidei	Skull w Otolith	6202
136749	Moridae	Skull w L+R Otolith	6202
136750	Moridae	Skull w L+R Otolith	6202
136751	Moridae	Skull w L+R Otolith	6202
136752	Moridae	Skull w L+R Otolith	6202
136753	Moridae	Skull w L+R Otolith	6202
136754	Moridae	Skull w L+R Otolith	6202
136755	Moridae	Skull w L+R Otolith	6202
136756	Moridae	Skull w L+R Otolith	6202
136757	Moridae	Skull w L+R Otolith	6202
136758	Moridae	Skeleton	6202
136759	Moridae	Skeleton	6202
136760	Moridae	Skeleton	6202
136761	Moridae	Skeleton	6202
136762	Moridae	Skeleton	6202
136763	Moridae	Skeleton	6202
136764	Moridae	Skeleton incompl	6202
136765	Moridae	Skeleton w Otolith	6202
136766	Moridae	Skeleton w 2 Otoliths	6202
136767	Moridae	Skeleton w 2 Otoliths	6202
136768	Perciformes	Skull incompl	6202
136769	Perciformes	Skull incompl	6202
136770	Perciformes	Vertebra incompl + Skull frags	6202
136771	Vertebrata	Coprolite w Teleostei bone frags	6202
136772	Vertebrata	Coprolite w Teleostei bone frags	6202
136773	Vertebrata	Coprolite w Teleostei bone frags	6202
136774	Vertebrata	Coprolite w Teleostei bone frags	6202
136775	Vertebrata	Coprolite w Teleostei bone frags	6202
136776	Vertebrata	Coprolite w Teleostei bone frags	6202
136777	Vertebrata	Coprolite w Teleostei bone frags	6202
136778	Vertebrata	Coprolite w Teleostei bone frags	6202
136779	Vertebrata	Coprolite w Teleostei bone frags	6202
136780	Vertebrata	Coprolite w Teleostei bone frags	6202
136781	Vertebrata	Coprolite w Teleostei bone frags	6202
136782	Vertebrata	Coprolite w Teleostei bone frags	6202
136783	Vertebrata	Coprolite w Teleostei bone frags	6202
136784	Vertebrata	Coprolite w Teleostei bone frags	6202
136785	Vertebrata	Coprolite w Teleostei bone frags	6202
136786	Vertebrata	Coprolite w Teleostei bone frags	6202
136787	Vertebrata	Coprolite w Teleostei bone frags	6202
136788	Vertebrata	Coprolite w Teleostei bone frags	6202
136789	Vertebrata	Coprolite w Teleostei bone frags	6202
136790	Vertebrata	Coprolite w Teleostei bone frags	6202
136791	Vertebrata	Coprolite w Teleostei bone frags	6202
136792	Vertebrata	Coprolite w Teleostei bone frags	6202
136793	Vertebrata	Coprolite w Teleostei bone frags	6202

136794	Vertebrata	Coprolite w Teleostei bone frags	6202
136795	Vertebrata	Coprolite w Teleostei bone frags	6202
136796	Vertebrata	Coprolite w Teleostei bone frags	6202
136797	Vertebrata	Coprolite w Teleostei bone frags	6202
136798	Vertebrata	Coprolite w Teleostei bone frags	6202
136799	Vertebrata	Coprolite w Teleostei bone frags	6202
136800	Vertebrata	Coprolite w Teleostei bone frags	6202
136801	Vertebrata	Coprolite w Teleostei bone frags	6202
136802	Vertebrata	Coprolite w Teleostei scales	6202
136803	Vertebrata	Coprolite w <i>Ganolytes cameo</i> scales	6202
136804	Vertebrata	Coprolite w Clupeidae scales	6202
136805	Vertebrata	Coprolite w Clupeidae scales	6202
136806	Vertebrata	Coprolite w <i>Xyne grex</i> scales	6202
136807	Vertebrata	Coprolite w rounded pebbles	6202
136808	Vertebrata	Coprolite w Myctophidae otoliths	6202
136809	Ceratioidei	Skull + Skeleton	6202
136810	Ceratioidei	Skeleton	6202
136811	<i>Cyclothone</i>	Skull	6202
136812	<i>Cyclothone</i>	Skull	6202
136813	<i>Cyclothone</i>	Skull	6202
136814	<i>Cyclothone</i>	Skull	6202
136815	<i>Cyclothone</i>	Skull	6202
136816	<i>Cyclothone</i>	Skull	6202
136817	<i>Cyclothone</i>	Skull	6202
136818	<i>Cyclothone</i>	Skull	6202
136819	<i>Cyclothone</i>	Skull	6202
136820	<i>Cyclothone</i>	Skull	6202
136821	<i>Cyclothone</i>	Skull	6202
136822	<i>Cyclothone</i>	Skull	6202
136823	<i>Cyclothone</i>	Skull	6202
136824	<i>Cyclothone</i>	Skull	6202
136825	<i>Cyclothone</i>	Skull	6202
136826	<i>Cyclothone</i>	Skull	6202
136827	<i>Cyclothone</i>	Skull	6202
136828	<i>Cyclothone</i>	Skull	6202
136829	<i>Cyclothone</i>	Skull	6202
136830	<i>Cyclothone</i>	Skull	6202
136831	<i>Cyclothone</i>	Skull	6202
136832	<i>Cyclothone</i>	Skull	6202
136833	<i>Cyclothone</i>	Skull	6202
136834	<i>Cyclothone</i>	Skull	6202
136835	<i>Cyclothone</i>	Skull	6202
136836	<i>Cyclothone</i>	Skull	6202
136837	<i>Cyclothone</i>	Skull	6202
136838	<i>Cyclothone</i>	Skull	6202
136839	<i>Cyclothone</i>	Skull	6202
136840	<i>Cyclothone</i>	Skull	6202
136841	<i>Cyclothone</i>	Skull	6202
136842	<i>Cyclothone</i>	Skull	6202
136843	<i>Cyclothone</i>	Skull	6202
136844	<i>Cyclothone</i>	Skull	6202
136845	<i>Cyclothone</i>	Skull	6202
136846	<i>Cyclothone</i>	Skull	6202
136847	<i>Cyclothone</i>	Skull	6202
136848	<i>Cyclothone</i>	Skull	6202

136849	<i>Cyclothone</i>	Skull	6202
136850	<i>Cyclothone</i>	Skull	6202
136851	<i>Cyclothone</i>	Skull	6202
136852	<i>Cyclothone</i>	Skull	6202
136853	<i>Cyclothone</i>	Skull	6202
136854	<i>Cyclothone</i>	Skull	6202
136855	<i>Cyclothone</i>	Skull	6202
136856	<i>Cyclothone</i>	Skull	6202
136857	<i>Cyclothone</i>	Skull	6202
136858	<i>Cyclothone</i>	Skull	6202
136859	<i>Cyclothone</i>	Skull	6202
136860	<i>Cyclothone</i>	Skull	6202
136861	<i>Cyclothone</i>	Skull	6202
136862	<i>Cyclothone</i>	Skull	6202
136863	<i>Cyclothone</i>	Skull	6202
136864	<i>Cyclothone</i>	Skull	6202
136865	<i>Cyclothone</i>	Skull	6202
136866	<i>Cyclothone</i>	Skull	6202
136867	<i>Cyclothone</i>	Skull	6202
136868	<i>Cyclothone</i>	Skull	6202
136869	<i>Cyclothone</i>	Skull	6202
136870	<i>Cyclothone</i>	Skull	6202
136871	<i>Cyclothone</i>	Skull	6202
136872	<i>Cyclothone</i>	Skull w Otolith	6202
136873	<i>Cyclothone</i>	Skull incompl	6202
136874	<i>Cyclothone</i>	Skull incompl	6202
136875	<i>Cyclothone</i>	Skull incompl	6202
136876	<i>Cyclothone</i>	Skull incompl	6202
136877	<i>Cyclothone</i>	Skull incompl	6202
136878	<i>Cyclothone</i>	Skull incompl	6202
136879	<i>Cyclothone</i>	Skull + Skeleton ant	6202
136880	<i>Cyclothone</i>	Skull + Skeleton ant	6202
136881	<i>Cyclothone</i>	Skull + Skeleton ant	6202
136882	<i>Cyclothone</i>	Skull + Skeleton ant	6202
136883	<i>Cyclothone</i>	Skull + Skeleton ant	6202
136884	<i>Cyclothone</i>	Skeleton w L+R Otolith	6202
136885	<i>Cyclothone</i>	Skeleton	6202
136886	<i>Cyclothone</i>	Skeleton	6202
136887	<i>Cyclothone</i>	Skeleton	6202
136888	<i>Cyclothone</i>	Skeleton	6202
136889	<i>Cyclothone</i>	Skeleton	6202
136890	<i>Cyclothone</i>	Skeleton	6202
136891	<i>Cyclothone</i>	Skeleton	6202
136892	<i>Cyclothone</i>	Skeleton	6202
136893	<i>Cyclothone</i>	Skeleton	6202
136894	<i>Cyclothone</i>	Skeleton	6202
136895	<i>Cyclothone</i>	Skeleton	6202
136896	<i>Cyclothone</i>	Skeleton	6202
136897	<i>Cyclothone</i>	Skeleton	6202
136898	<i>Cyclothone</i>	Skeleton	6202
136899	<i>Cyclothone</i>	Skeleton	6202
136900	<i>Cyclothone</i>	Skeleton	6202
136901	<i>Cyclothone</i>	Skeleton	6202
136902	<i>Cyclothone</i>	Skeleton	6202
136903	<i>Cyclothone</i>	Skeleton	6202

136904	<i>Cyclothone</i>	Skeleton	6202
136905	<i>Cyclothone</i>	Skeleton	6202
136906	<i>Cyclothone</i>	Skeleton	6202
136907	<i>Cyclothone</i>	Skeleton	6202
136908	<i>Cyclothone</i>	Skeleton	6202
136909	<i>Cyclothone</i>	Skeleton	6202
136910	<i>Cyclothone</i>	Skeleton	6202
136911	<i>Cyclothone</i>	Skeleton	6202
136912	<i>Cyclothone</i>	Skeleton	6202
136913	<i>Cyclothone</i>	Skeleton	6202
136914	<i>Cyclothone</i>	Skeleton	6202
136915	<i>Cyclothone</i>	Skeleton	6202
136916	<i>Cyclothone</i>	Skeleton	6202
136917	<i>Cyclothone</i>	Skeleton	6202
136918	<i>Cyclothone</i>	Skeleton	6202
136919	<i>Cyclothone</i>	Skeleton	6202
136920	<i>Cyclothone</i>	Skeleton	6202
136921	<i>Cyclothone</i>	Skeleton	6202
136922	<i>Cyclothone</i>	Skeleton	6202
136923	<i>Cyclothone</i>	Skeleton	6202
136924	<i>Cyclothone</i>	Skeleton	6202
136925	<i>Cyclothone</i>	Skeleton	6202
136926	<i>Cyclothone</i>	Skeleton	6202
136927	<i>Cyclothone</i>	Skeleton	6202
136928	<i>Cyclothone</i>	Skeleton	6202
136929	<i>Cyclothone</i>	Skeleton	6202
136930	<i>Cyclothone</i>	Skeleton	6202
136931	<i>Cyclothone</i>	Skeleton	6202
136932	<i>Cyclothone</i>	Skeleton	6202
136933	<i>Cyclothone</i>	Skeleton	6202
136934	<i>Cyclothone</i>	Skeleton	6202
136935	<i>Bathylagus</i>	Skull	6202
136936	<i>Leuroglossus</i>	Skull	6202
136937	<i>Bathylagus</i>	Skull	6202
136938	Bathylagidae	Skull	6202
136939	Bathylagidae	Skull + Skeleton	6202
136940	Bathylagidae	Skull	6202
136941	Bathylagidae	Skull	6202
136942	Bathylagidae	Skull	6202
136943	Bathylagidae	Skull	6202
136944	Bathylagidae	Skull	6202
136945	Bathylagidae	Skull	6202
136946	Bathylagidae	Skull	6202
136947	Gadoidei	Skull	6202
136948	Teleostei	Skull	6202
136949	Teleostei	Skull	6202
136950	Teleostei	Skull	6202
136951	Teleostei	Skull	6202
136952	Bathylagidae	Skull	6202
136953	Teleostei	Skull	6202
136954	Bathylagidae	Skull	6202
136955	Teleostei	Skull	6202
136956	Bathylagidae	Skull	6202
136957	Bathylagidae	Skull	6202
136958	Bathylagidae	Skull	6202

136959	Bathylagidae	Skull	6202
136960	Bathylagidae	Skull	6202
136961	Bathylagidae	Skull	6202
136962	Bathylagidae	Skull	6202
136963	<i>Leuroglossus</i>	Skull	6202
136964	Bathylagidae	Skull	6202
136965	Bathylagidae	Skull	6202
136966	Bathylagidae	Skull	6202
136967	Bathylagidae	Skull	6202
136968	Bathylagidae	Skull	6202
136969	Bathylagidae	Skull	6202
136970	Teleostei	Skull	6202
136971	Bathylagidae	Skull	6202
136972	Bathylagidae	Skull	6202
136973	<i>Bathylagus</i>	Skull	6202
136974	<i>Bathylagus</i>	Skull	6202
136975	Bathylagidae	Skull	6202
136976	Bathylagidae	Skull	6202
136977	Bathylagidae	Skull	6202
136978	<i>Leuroglossus</i>	Skull	6202
136979	Teleostei	Skull w Otolith	6202
136980	<i>Leuroglossus?</i>	Skull w Otolith	6202
136981	<i>Bathylagus</i>	Skull w Otolith	6202
136982	<i>Bathylagus</i>	Skull w Otolith	6202
136983	<i>Bathylagus</i>	Skull w R Otolith	6202
136984	Bathylagidae	Skull + Skeleton	6202
136985	Bathylagidae	Skull w L+R Otolith	6202
136986	Clupeidae	Skull w L+R Otolith	6202
136987	Bathylagidae	Skull w L+R Otolith	6202
136988	<i>Leuroglossus</i>	Skull w L+R Otolith	6202
136989	<i>Bathylagus</i>	Skull + Skeleton ant	6202
136990	Bathylagidae	Skull + Skeleton ant	6202
136991	Bathylagidae	Skull + Skeleton ant	6202
136992	<i>Bathylagus</i>	Skull + Skeleton ant	6202
136993	Bathylagidae	Skull + Skeleton ant	6202
136994	Bathylagidae	Skull + Skeleton ant	6202
136995	Bathylagidae	Skull + Skeleton ant	6202
136996	Teleostei	Skull + Skeleton ant	6202
136997	Myctophidae?	Skull + Skeleton ant	6202
136998	<i>Bathylagus</i>	Skull + Skeleton ant	6202
136999	Bathylagidae	Skull + Skeleton ant	6202
137000	Bathylagidae	Skull + Skeleton ant	6202
137001	Bathylagidae	Skull + Skeleton ant	6202
137002	Teleostei	Skull + Skeleton ant	6202
137003	<i>Leuroglossus?</i>	Skull + Skeleton ant	6202
137004	<i>Leuroglossus?</i>	Skull + Skeleton ant	6202
137005	<i>Leuroglossus</i>	Skull + Skeleton ant	6202
137006	<i>Leuroglossus?</i>	Skull + Skeleton ant	6202
137007	Bathylagidae	Skull + Skeleton ant	6202
137008	Teleostei	Skull + Skeleton ant	6202
137009	<i>Bathylagus</i>	Skull w Otolith + Skeleton ant	6202
137010	Bathylagidae	Skeleton	6202
137011	Bathylagidae	Skeleton	6202
137012	Bathylagidae	Skeleton	6202
137013	Alepocephalidae	Skeleton	6202

137014	<i>Leuroglossus?</i>	Skeleton	6202
137015	<i>Leuroglossus?</i>	Skeleton	6202
137016	<i>Leuroglossus?</i>	Skeleton	6202
137017	Teleostei	Skeleton incompl	6202
137018	Bathylagidae	Skull Otolith	6202
137019	Bathylagidae	Skull Otolith	6202
137020	Bathylagidae	Skull Otolith	6202
137021	Bathylagidae	Skull Otolith	6202
137022	Bathylagidae	Skull Otolith	6202
137023	Bathylagidae	Skull Otolith	6202
137024	Bathylagidae	L Skull Otolith	6202
137025	Bathylagidae	L Skull Otolith	6202
137026	Bathylagidae	L Skull Otolith	6202
137027	<i>Bathylagus</i>	Skull w R Otolith	6202
137028	<i>Bathylagus</i>	Skull w R Otolith	6202
137029	<i>Bathylagus</i>	Skull w Otolith	6202
137030	<i>Bathylagus</i>	Skull	6202
137031	<i>Bathylagus</i>	Skull w Otolith + Skeleton ant	6202
137032	<i>Bathylagus</i>	Skeleton	6202
137033	<i>Bathylagus</i>	Skeleton	6202
137034	<i>Bathylagus</i>	Skeleton	6202
137035	<i>Bathylagus</i>	Skeleton w L+R Otolith	6202
137036	<i>Bathylagus</i>	Skeleton w L+R Otolith	6202
137037	<i>Bathylagus</i>	Skull Otolith	6202
137038	<i>Bathylagus</i>	Skull Otolith	6202
137039	<i>Bathylagus</i>	Skull Otolith	6202
137040	<i>Diaphus</i>	Skeleton w L Otolith	6202
137041	<i>Diaphus</i>	R Skull Otolith	6202
137042	<i>Lampanyctus</i>	Skull Otolith	6202
137043	<i>Lampanyctus</i>	Skull Otolith	6202
137044	<i>Lampanyctus</i>	Skull Otolith	6202
137045	<i>Lampanyctus</i>	Skull Otolith	6202
137046	<i>Lampanyctus</i>	Skull Otolith	6202
137047	<i>Lampanyctus</i>	L Skull Otolith	6202
137048	<i>Lampanyctus</i>	Skull w L+R Otolith + Skeleton ant	6202
137049	<i>Lampanyctus</i>	Skeleton w L+R Otolith	6202
137050	<i>Lampanyctus</i>	Skeleton w L+R Otolith	6202
137051	Myctophidae	Skeleton	6202
137052	Myctophidae	Skeleton	6202
137053	Myctophidae	Skeleton	6202
137054	Myctophidae	Skeleton	6202
137055	Myctophidae	Skeleton	6202
137056	Myctophidae	Skeleton	6202
137057	Myctophidae	Skeleton	6202
137058	Myctophidae	Skeleton	6202
137059	Myctophidae	Skeleton	6202
137060	Myctophidae	Skeleton	6202
137061	Myctophidae	Skeleton	6202
137062	Myctophidae	Skeleton	6202
137063	Myctophidae	Skeleton	6202
137064	Myctophidae	Skeleton	6202
137065	Myctophidae	Skeleton	6202
137066	Myctophidae	Skeleton	6202
137067	Myctophidae	Skeleton	6202
137068	Bathylagidae	Skeleton	6202

137069	Myctophidae	Skeleton	6202
137070	Myctophidae	Skeleton	6202
137071	Myctophidae	Skeleton	6202
137072	Myctophidae	Skeleton	6202
137073	Myctophidae	Skeleton	6202
137074	Myctophidae	Skeleton	6202
137075	Myctophidae	Skeleton	6202
137076	Myctophidae	Skeleton	6202
137077	Myctophidae	Skeleton	6202
137078	Myctophidae	Skeleton	6202
137079	Myctophidae	Skeleton	6202
137080	Myctophidae	Skeleton	6202
137081	Myctophidae	Skeleton	6202
137082	Myctophidae	Skeleton w Otolith	6202
137083	Myctophidae	Skeleton w Otolith	6202
137084	Myctophidae	Skeleton w Otolith	6202
137085	Myctophidae	Skeleton w Otolith	6202
137086	Myctophidae	Skeleton w Otolith	6202
137087	Myctophidae	Skeleton w Otolith	6202
137088	Myctophidae	Skeleton w Otolith	6202
137089	Myctophidae	Skeleton w Otolith	6202
137090	Myctophidae	Skeleton w Otolith	6202
137091	Myctophidae	Skeleton w Otolith	6202
137092	Myctophidae	Skeleton w Otolith	6202
137093	Myctophidae	Skeleton w Otolith	6202
137094	Myctophidae	Skeleton w Otolith	6202
137095	Myctophidae	Skeleton w Otolith	6202
137096	Myctophidae	Skeleton w Otolith	6202
137097	Myctophidae	Skeleton w Otolith	6202
137098	Myctophidae	Skeleton w Otolith	6202
137099	Myctophidae	Skeleton w Otolith	6202
137100	Myctophidae	Skeleton w Otolith	6202
137101	Myctophidae	Skeleton w Otolith	6202
137102	Myctophidae	Skeleton w Otolith	6202
137103	Myctophidae	Skeleton w Otolith	6202
137104	Myctophidae	Skeleton w Otolith	6202
137105	Myctophidae	Skeleton w Otolith	6202
137106	Myctophidae	Skeleton w Otolith	6202
137107	Myctophidae	Skeleton w Otolith	6202
137108	Myctophidae	Skeleton w Otolith	6202
137109	Myctophidae	Skeleton w Otolith	6202
137110	Myctophidae	Skeleton w Otolith	6202
137111	Myctophidae	Skeleton w Otolith	6202
137112	Myctophidae	Skeleton w Otolith	6202
137113	Myctophidae	Skeleton w Otolith	6202
137114	Myctophidae	Skeleton w Otolith	6202
137115	Myctophidae	Skeleton w Otolith	6202
137116	Myctophidae	Skeleton incompl	6202
137117	Myctophidae	Skeleton w L Otolith	6202
137118	Myctophidae	Skeleton w L Otolith	6202
137119	Myctophidae	Skeleton w L Otolith	6202
137120	Myctophidae	Skeleton w L Otolith	6202
137121	Myctophidae	Skeleton w R Otolith	6202
137122	Myctophidae	Skeleton w R Otolith	6202
137123	Myctophidae	Skeleton w R Otolith	6202

137124	Myctophidae	Skeleton w R Otolith	6202
137125	Myctophidae	Skeleton w L+R Otolith	6202
137126	Myctophidae	Skeleton w L+R Otolith	6202
137127	Myctophidae	Skeleton w L+R Otolith	6202
137128	Myctophidae	Skeleton w L+R Otolith	6202
137129	Myctophidae	Skeleton w L+R Otolith	6202
137130	Melamphaeidae	Skeleton w L+R Otolith	6202
137131	Myctophidae	Skeleton w L+R Otolith	6202
137132	Myctophidae	Skeleton w L+R Otolith	6202
137133	Myctophidae	Skeleton w L+R Otolith	6202
137134	Myctophidae	Skeleton w L+R Otolith	6202
137135	Myctophidae	Skeleton w L+R Otolith	6202
137136	Myctophidae	Skeleton w L+R Otolith	6202
137137	Myctophidae	Skeleton w L+R Otolith	6202
137138	Myctophidae	Skeleton w L+R Otolith	6202
137139	Myctophidae	Skeleton w L+R Otolith	6202
137140	Myctophidae	Skeleton w L+R Otolith	6202
137141	Myctophidae	Skeleton w L+R Otolith	6202
137142	Myctophidae	Skeleton w L+R Otolith	6202
137143	Myctophidae	Skeleton w L+R Otolith	6202
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137163	Myctophidae	Skeleton w L+R Otolith	6202
137164	Myctophidae	Skeleton incompl w L+R Otolith	6202
137165	Myctophidae	Skull + Skeleton ant	6202
137166	Myctophidae	Skull + Skeleton ant	6202
137167	Stomiidae	Skull + Skeleton ant	6202
137168	Myctophidae	Skull + Skeleton ant	6202
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137173	Myctophidae	Skull + Skeleton ant	6202
137174	Myctophidae	Skull + Skeleton ant	6202
137175	Myctophidae	Skull w L+R Otolith + Skeleton ant	6202
137176	Myctophidae	Skull w L+R Otolith + Skeleton ant	6202
137177	Myctophidae	Skull w L+R Otolith + Skeleton ant	6202
137178	Myctophidae	Skull w L+R Otolith + Skeleton ant	6202

137179	Myctophidae	Skull w L+R Otolith + Skeleton ant	6202
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137581	Myctophidae	R Skull Otolith	6202
137582	Myctophidae	L Skull Otolith	6202
137583	Myctophidae	R Skull Otolith	6202
137584	Myctophidae	L Skull Otolith	6202
137585	Myctophidae	R Skull Otolith	6202
137586	Myctophidae	L Skull Otolith	6202
137587	Myctophidae	R Skull Otolith	6202
137588	Myctophidae	L Skull Otolith	6202
137589	Myctophidae	R Skull Otolith	6202
137590	Myctophidae	L Skull Otolith	6202
137591	Myctophidae	R Skull Otolith	6202
137592	Myctophidae	R Skull Otolith	6202
137593	Myctophidae	L Skull Otolith	6202
137594	Myctophidae	Skull Otolith mass	6202
137595	Myctophidae	Skull Otolith mass	6202
137596	Myctophidae	Skull Otolith mass	6202
137597	Myctophidae	Skull Otolith mass	6202
137598	Myctophidae	Skull Otolith mass	6202
137599	Myctophidae	Skull Otolith mass	6202
137600	Myctophidae	Skull Otolith mass	6202
137601	Myctophidae	Skull Otolith mass	6202
137602	<i>Stenobranchius,</i> <i>Symbolophorus,</i> <i>Tarletonbeania</i>	Skull Otolith mass	6202
137603	Myctophidae	Skull Otolith mass	6202
137604	Myctophidae	Skull Otolith mass	6202
137605	Myctophidae	Skull Otolith mass	6202
137606	Myctophidae	Skull Otolith mass	6202
137607	Myctophidae	Skull Otolith mass	6202
137608	Myctophidae	Skull Otolith mass	6202
137609	<i>Lampanyctus</i>	Skull Otolith mass	6202
137610	Myctophidae	Skull Otolith mass	6202
137611	Melamphaeidae	Skeleton	6202
137612	Melamphaeidae	Skeleton	6202
137613	Teleostei	Skeleton	6202
137614	<i>Stomias</i>	Skeleton	6202
137615	Alepocephalidae	Skeleton	6202
137616	Teleostei	Skeleton	6202

137617	Teleostei	Skeleton	6202
137618	Bathylagidae	Skeleton	6202
137619	Bathylagidae	Skeleton	6202
137620	Bathylagidae	Skeleton	6202
137621	Alepocephalidae	Skeleton	6202
137622	Teleostei	Skeleton	6202
137623	Alepocephalidae	Skeleton	6202
137624	<i>Argyropelecus</i>	Skeleton	6202
137625	<i>Anoplogaster</i>	Skeleton	6202
137626	Teleostei	Skeleton	6202
137627	<i>Scopelogadus</i>	Skeleton	6202
137628	Alepocephalidae	Skeleton	6202
137629	Teleostei	Skeleton	6202
137630	Teleostei	Skeleton	6202
137631	Teleostei	Skeleton	6202
137632	<i>Bathylagus</i>	Skeleton	6202
137633	<i>Argyropelecus</i>	Skeleton	6202
137634	Stomiidae	Skeleton	6202
137635	Teleostei	Skeleton	6202
137636	Teleostei	Skeleton	6202
137637	Teleostei	Skeleton w Otolith	6202
137638	Alepocephalidae	Skeleton w Otolith	6202
137639	Teleostei	Skeleton w Otolith	6202
137640	Bathylagidae	Skeleton w L+R Otolith	6202
137641	Teleostei	Skeleton w L+R Otolith	6202
137642	<i>Scopelogadus</i>	Skeleton w L+R Otolith	6202
137643	<i>Scopelogadus</i>	Skeleton w L+R Otolith	6202
137644	Melamphaeidae	Skeleton w L+R Otolith	6202
137645	Melamphaeidae	Skeleton w L+R Otolith	6202
137646	Teleostei	Skeleton w L+R Otolith	6202
137647	Teleostei	Skeleton w L+R Otolith	6202
137648	Teleostei	Skeleton w L+R Otoliths	6202
137649	Teleostei	Skeleton incompl	6202
137650	Teleostei	Skeleton incompl	6202
137652	Perciformes	Skull + Skeleton ant	6202
137653	Ceratioidei	Skull + Skeleton	6202
137654	Teleostei	Skull + Skeleton ant	6202
137655	Perciformes	Skull + Skeleton ant	6202
137656	Alepocephalidae	Skull + Skeleton ant	6202
137657	Teleostei	Skull + Skeleton ant	6202
137658	Bathylagidae	Skull + Skeleton ant	6202
137659	Teleostei	Skull + Skeleton ant	6202
137660	Teleostei	Skull + Skeleton ant	6202
137661	Teleostei	Skull + Skeleton ant	6202
137662	Teleostei	Skull + Skeleton ant	6202
137663	<i>Chauliodus eximius</i>	Skull + Skeleton mid	6202
137664	<i>Stomias</i>	Skull + Skeleton ant	6202
137665	Trichiuridae	Skull + Skeleton ant	6202
137666	Serranidae	Skull + Skeleton ant	6202
137667	Scombridae	Skull + Skeleton ant	6202
137668	Teleostei	Skull + Skeleton ant	6202
137669	Bathylagidae	Skull + Skeleton ant	6202
137670	Teleostei	Skull + Skeleton ant	6202
137671	Teleostei	Skull + Skeleton ant	6202
137672	Teleostei	Skull + Skeleton ant	6202

137673	Teleostei	Skull frags + Skeleton incompl	6202
137674	Ceratioidei	Skull + Skeleton ant	6202
137675	Melamphaeidae	Skull w Otolith + Skeleton ant	6202
137676	Platyroctidae	Skull w L+R Otolith + Skeleton ant	6202
137677	Teleostei	Skull w L+R Otolith + Skeleton ant	6202
137678	Alepocephalidae	Skull w L+R Otolith + Skeleton ant	6202
137679	Teleostei	Skull	6202
137680	Stomiidae	Skull	6202
137681	Trichiuridae	Skull	6202
137682	Bathylagidae	Skull	6202
137683	Teleostei	Skull	6202
137684	Teleostei	Skull	6202
137685	<i>Stomias</i>	Skull	6202
137686	Argentinoidei	Skull	6202
137687	Bathylagidae	Skull	6202
137688	Teleostei	Skull	6202
137689	Argentinidae	Skull	6202
137690	Moridae	Skull	6202
137691	Teleostei	Skull	6202
137692	Gadoidei	Skull + Skeleton ant	6202
137693	Moridae	Skull	6202
137694	Gadoidei	Skull	6202
137695	Teleostei	Skull	6202
137696	Ceratioidei	Skull w Otolith	6202
137697	Teleostei	Skull	6202
137698	Scombridae	Skull	6202
137699	Myctophidae	L Otolith	6202
137700	<i>Chauliodus eximius</i>	Skull	6202
137701	Teleostei	Skull	6202
137702	Teleostei	Skull	6202
137703	Ceratioidei	Skull	6202
137704	Teleostei	Skull	6202
137705	Teleostei	Skull	6202
137706	Teleostei	Skull	6202
137707	Teleostei	Skull	6202
137708	Scombridae	Skull	6202
137709	Teleostei	Skull	6202
137710	Teleostei	Skull	6202
137711	Trichiuridae	Skull	6202
137712	Teleostei	Skull	6202
137713	<i>Xyne grex</i>	Skull	6202
137714	Teleostei	Skull	6202
137715	Teleostei	Skull	6202
137716	Teleostei	Skull	6202
137717	Teleostei	Skull	6202
137718	Bathylagidae	Skull	6202
137719	Teleostei	Skull	6202
137720	Bathylagidae	Skull	6202
137721	Teleostei	Skull	6202
137722	Teleostei	Skull ant	6202
137723	Teleostei	Skull ant	6202
137724	Teleostei	Skull w Otolith	6202
137725	Teleostei	Skull w Otolith	6202
137726	Melamphaeidae	Skull w Otolith	6202
137727	Myctophidae	Skull w Otolith	6202

137728	<i>Physiculus</i>	Skull w Otolith	6202
137729	Alepocephalidae	Skull w Otolith	6202
137730	Teleostei	Skull w Otolith	6202
137731	Teleostei	Skull w Otolith	6202
137732	Teleostei	Skull w Otolith	6202
137733	Teleostei	Skull w Otolith	6202
137734	Melamphaeidae	Skull w Otolith	6202
137735	Moridae	Skull w Otolith	6202
137736	Teleostei	Skull w Otolith	6202
137737	Trichiuridae	Skull w Otolith	6202
137738	Gadoidei	Skull w Otolith	6202
137739	Gadoidei	Skull w Otolith	6202
137740	Teleostei	Skull w Otolith	6202
137741	<i>Scopelogadus</i>	Skull w Otolith	6202
137742	Cynoglossidae	Skull w Otolith	6202
137743	Teleostei	Skull w Otolith	6202
137744	Bathylagidae	Skull w Otolith	6202
137745	Bathylagidae	Skull w Otolith	6202
137746	<i>Vinciguerria?</i>	Skull w Otolith	6202
137747	Teleostei	Skull w Otolith	6202
137748	<i>Cynoscion?</i>	Skull w L+R Otolith	6202
137749	Moridae	Skull w L+R Otolith	6202
137750	Moridae	Skull w L+R Otolith	6202
137751	Moridae	Skull w L+R Otolith	6202
137752	Teleostei	Skull w L+R Otolith	6202
137753	Teleostei	Skull w L+R Otolith	6202
137754	Teleostei	Skull w L+R Otolith	6202
137755	Moridae	Skull w L+R Otolith	6202
137756	Moridae	Skull w L+R Otolith	6202
137757	Moridae	Skull w L+R Otolith	6202
137758	Gadoidei	Skull w L+R Otolith	6202
137759	Moridae	Skull w L+R Otolith	6202
137760	Moridae	Skull w L+R Otolith	6202
137761	Teleostei	Skull incompl	6202
137762	Teleostei	Skull incompl	6202
137763	Moridae	Skull incompl w Otolith	6202
137764	Teleostei	Skull incompl w Otolith	6202
137765	<i>Citharichthys?</i>	Skull incompl w L+R Otolith	6202
137766	Teleostei	Skull incompl w L+R Otolith	6202
137767	<i>Chauliodus eximius</i>	Skull disarticulated	6202
137768	Teleostei	Skull disarticulated	6202
137769	Carangidae	Skull disarticulated	6202
137770	<i>Chauliodus eximius</i>	Skull disarticulated	6202
137771	Teleostei	Skull disarticulated	6202
137772	Teleostei	Skull disarticulated w Otolith	6202
137773	Macrouridae	Skull disarticulated w Otolith	6202
137774	Moridae	Neurocranium	6202
137775	Teleostei	Neurocranium	6202
137776	Teleostei	Neurocranium	6202
137777	Teleostei	Neurocranium	6202
137778	Teleostei	Neurocranium	6202
137779	Teleostei	Neurocranium	6202
137780	Moridae	Neurocranium	6202
137781	Teleostei	Neurocranium	6202
137782	Teleostei	Neurocranium	6202

137783	Scombridae	Neurocranium	6202
137784	<i>Xyne grex</i>	Neurocranium	6202
137785	Teleostei	Neurocranium	6202
137786	Teleostei	Neurocranium	6202
137787	Moridae	Neurocranium	6202
137788	Moridae	Neurocranium	6202
137789	Moridae	Neurocranium w Otolith	6202
137790	Teleostei	Neurocranium w Otolith	6202
137791	Moridae	Neurocranium	6202
137792	Moridae	Neurocranium w Otolith	6202
137793	Moridae	Neurocranium w Otolith	6202
137794	Moridae	Neurocranium w L+R Otolith	6202
137795	Teleostei	Neurocranium w L+R Otolith	6202
137796	Teleostei	Neurocranium w L+R Otolith	6202
137797	Teleostei	Skull post w Otolith	6202
137798	Scombridae	Skull incompl	6202
137799	Teleostei	Skull incompl w Otolith	6202
137800	Teleostei	Skull elements + Otolith	6202
137801	Moridae	Skull disarticulated w Otoliths	6202
137802	Teleostei	Bone frags	6202
137803	Teleostei	Bone frags	6202
137804	Teleostei	Bone frags	6202
137805	Myctophidae	Skull Opercular	6202
137806	Teleostei	Skull Opercular	6202
137807	Teleostei	Skull Opercular	6202
137808	Teleostei	Skull Opercular	6202
137809	Teleostei	Skull Opercular	6202
137810	Teleostei	Skull Subopercular	6202
137811	Teleostei	Dentaries	6202
137812	Teleostei	Dentary	6202
137813	Teleostei	Dentary	6202
137814	Teleostei	Dentary	6202
137815	Teleostei	Dentary	6202
137816	<i>Chauliodus eximius</i>	L Dentary	6202
137817	<i>Hippoglossus</i>	Dentary ant	6202
137818	Teleostei	Dentary incompl	6202
137819	Teleostei	Dentary incompl	6202
137820	Teleostei	Tooth	6202
137821	<i>Scopelogadus</i>	Skull Otolith	6202
137822	Teleostei	Skull Otolith	6202
137823	Teleostei	Skull Otolith	6202
137824	Myctophidae	Skull Otolith	6202
137825	Teleostei	Skull Otolith	6202
137826	Melamphaeidae	Skull Otolith	6202
137827	Teleostei	Skull Otolith	6202
137828	Moridae	Skull Otolith	6202
137829	Teleostei	Skull Otolith	6202
137830	<i>Sebastes</i>	R Skull Otolith	6202
137831	Myctophidae	Skull Otolith	6202
137832	<i>Scopelogadus</i>	Skull Otolith	6202
137833	Myctophidae	L Skull Otolith	6202
137834	Teleostei	Skull Otolith	6202
137835	Serranidae	R Skull Otolith	6202
137836	Teleostei	Skull Otolith	6202
137837	Opisthoproctidae	L Skull Otolith	6202

137838	Teleostei	Skull Otolith	6202
137839	<i>Sebastes</i>	Skull Otolith	6202
137840	<i>Coryphaena?</i>	Skull Otolith	6202
137841	Teleostei	Skull Otolith	6202
137842	Teleostei	Skull Otolith	6202
137843	Teleostei	Vertebra column	6202
137844	Teleostei	Scale patch	6202
137845	Teleostei	Scale patch	6202
137846	Teleostei	Scale patch	6202
137847	Teleostei	Scale patch	6202
137848	Teleostei	Scale patch	6202
137849	Teleostei	Scale patch	6202
137850	Teleostei	Scale patch	6202
137851	Teleostei	Scale	6202
137852	Teleostei	Scale	6202
137853	Teleostei	Scale	6202
137854	Teleostei	Scale	6202
137855	Teleostei	Scale	6202
137856	Teleostei	Scale	6202
137857	Teleostei	Scale	6202
137858	Teleostei	Scale	6202
137859	Teleostei	Scale	6202
137860	Alepocephalidae	Skeleton post	6202
137861	Carangidae	Skeleton post	6202
137862	Teleostei	Skeleton mid	6202
137863	Teleostei	Skeleton mid	6202
137864	Alepocephalidae	Skeleton mid	6202
137865	Teleostei	Skeleton mid	6202
137866	Congroidei	Skeleton mid	6202
137867	Teleostei	Skeleton mid	6202
137868	Teleostei	Skeleton mid	6202
137869	Teleostei	Skeleton mid	6202
137870	<i>Pseudoseriola?</i>	Skeleton mid	6202
137871	Scombridae	Skeleton mid	6202
137872	<i>Sarda</i>	Skeleton mid	6202
137873	Macrouridae	Skeleton post	6202
137874	Teleostei	Skeleton post	6202
137875	Teleostei	Skeleton post	6202
137876	Teleostei	Skeleton post	6202
137877	Teleostei	Skeleton post	6202
137878	Teleostei	Skeleton post	6202
137879	Teleostei	Skeleton post	6202
137880	Stomiidae	Skeleton post	6202
137881	Teleostei	Skeleton post	6202
137882	Teleostei	Skeleton post	6202
137883	Teleostei	Skeleton post	6202
137884	Teleostei	Skeleton post	6202
137885	Teleostei	Skeleton Caudal	6202
137886	Teleostei	Skeleton Caudal	6202
137887	Teleostei	Skeleton Caudal	6202
137888	Teleostei	Skeleton Caudal	6202
137889	Teleostei	Skeleton Caudal	6202
137890	Teleostei	Skeleton Caudal	6202
137891	Teleostei	Skeleton Caudal	6202
137892	Teleostei	Fin Caudal frag	6202

137893	Teleostei	Fin Caudal rays	6202
137894	Teleostei	Rib	6202
137895	Teleostei	Skeleton elements	6202
137896	Teleostei	Skeleton post incompl	6202
137897	Teleostei	Skeleton mid	6202
137898	Teleostei	Skeleton post	6202
137899	Ceratioidei	Skull + Skeleton w Otoliths	6202
137900	Congroidei	Skeleton	6203
137901	Belonidae	Skeleton disarticulated	6203
137902	<i>Mammuthus</i>	Tooth: tusk frags	6204
137903	Bathylagidae	Skeleton	6205
137904	Bathylagidae	Skeleton	6205
137905	Bathylagidae	Skeleton	6205
137906	Bathylagidae	Skull	6205
137907	Bathylagidae	Skull	6205
137908	Bathylagidae	Skull	6205
137909	Bathylagidae	Skull	6205
137910	Bathylagidae	Skull	6205
137911	Bathylagidae	Skull w R Otolith	6205
137912	Bathylagidae	Skull w Otoliths	6205
137913	Bathylagidae	Skeleton post	6205
137914	<i>Ganolytes cameo</i>	Scale	6205
137915	<i>Ganolytes cameo</i>	Scale	6205
137916	<i>Ganolytes cameo</i>	Scale	6205
137917	<i>Ganolytes cameo</i>	Scale	6205
137918	<i>Ganolytes cameo</i>	Scale	6205
137919	<i>Ganolytes cameo</i>	Scale	6205
137920	<i>Ganolytes cameo</i>	Scale	6205
137921	<i>Ganolytes cameo</i>	Scale	6205
137922	<i>Ganolytes cameo</i>	Scale	6205
137923	<i>Ganolytes cameo</i>	Scale	6205
137924	<i>Ganolytes cameo</i>	Scale	6205
137925	<i>Ganolytes cameo</i>	Skull Opercular	6205
137926	<i>Ganolytes cameo</i>	Skull Opercular	6205
137927	<i>Xyne grex</i>	Skeleton Caudal	6205
137928	Moridae	Skull + Skeleton ant	6205
137929	Gadoidei	Skeleton post	6205
137930	<i>Cyclothone</i>	Skull	6205
137931	<i>Cyclothone</i>	Skull	6205
137932	<i>Cyclothone</i>	Skull	6205
137933	<i>Cyclothone</i>	Skeleton	6205
137934	<i>Cyclothone</i>	Skeleton	6205
137935	Myctophidae	Skeleton	6205
137936	Myctophidae	Skeleton	6205
137937	Myctophidae	Skeleton	6205
137938	Myctophidae	Skeleton	6205
137939	Myctophidae	Skeleton w Otolith	6205
137940	Myctophidae	Skeleton w Otolith	6205
137941	Myctophidae	Skeleton w L+R Otolith	6205
137942	Myctophidae	Skeleton w L+R Otolith	6205
137943	Myctophidae	Skeleton w L+R Otolith	6205
137944	Myctophidae	Skeleton w L+R Otolith	6205
137945	Myctophidae	Skeleton post	6205
137946	Myctophidae	Skull w L+R Otolith	6205
137947	Myctophidae	Skull w L+R Otolith	6205

137948	Myctophidae	Skull w L+R Otolith	6205
137949	Myctophidae	Skull + Skeleton ant	6205
137950	Myctophidae	Skull w L+R Otolith + Skeleton ant	6205
137951	Myctophidae	R Skull Otolith	6205
137952	Myctophidae	L Skull Otolith	6205
137953	Myctophidae	Skull Otolith	6205
137954	Myctophidae	Skull Otolith	6205
137955	Myctophidae	Skull Otolith	6205
137956	Myctophidae	Skull Otolith	6205
137957	Myctophidae	Skull Otolith	6205
137958	Myctophidae	R Skull Otolith	6205
137959	Myctophidae	R Skull Otolith	6205
137960	Myctophidae	L Skull Otolith	6205
137961	Myctophidae	Skull Otolith	6205
137962	Myctophidae	Skull Otolith	6205
137963	Myctophidae	Skull Otolith	6205
137964	Myctophidae	Skull Otolith	6205
137965	Myctophidae	Skull Otolith	6205
137966	Myctophidae	Skull Otolith	6205
137967	Myctophidae	Skull Otolith	6205
137968	Myctophidae	Skull Otolith	6205
137969	Scombridae	Skull	6205
137970	Alepocephalidae	Skeleton	6205
137971	Melamphaeidae	Skeleton w Otolith	6205
137972	<i>Danaphos</i>	Skeleton w L+R Otolith	6205
137973	Teleostei	Skull	6205
137974	Teleostei	Skull	6205
137975	Argentinidae	Skull	6205
137976	Teleostei	Skull w Otolith	6205
137977	Teleostei	Skull w Otolith	6205
137978	Teleostei	Skull w Otolith	6205
137979	Teleostei	Skull w L+R Otolith	6205
137980	Teleostei	Skull Otolith	6205
137981	Teleostei	Skull Otolith	6205
137982	Teleostei	Skull Otolith	6205
137983	Argentinidae	Skull + Skeleton ant	6205
137984	Teleostei	Skull + Skeleton ant	6205
137985	Teleostei	Skull w Otolith + Skeleton ant	6205
137986	Belonidae	Skeleton mid	6205
137987	Teleostei	Skeleton mid	6205
137988	Teleostei	Skeleton post	6205
137989	Teleostei	Scale	6205
137990	<i>Ganolytes cameo</i>	Scale	6206
137991	<i>Ganolytes cameo</i>	Skull disarticulated + Scales	6206
137992	<i>Cyclothone</i>	Skull	6206
137993	Myctophidae	Skeleton w L+R Otolith	6206
137994	Teleostei	Skull	6206
137995	Vertebrata	Coprolite w Teleostei bones	6206
137996	<i>Ganolytes cameo</i>	Scale	6207
137997	<i>Ganolytes cameo</i>	Scale	6207
137998	<i>Ganolytes cameo</i>	Scale	6207
137999	<i>Ganolytes cameo</i>	Scale	6207
138000	<i>Ganolytes cameo</i>	Scale	6207
138001	<i>Ganolytes cameo</i>	Scale	6207
138002	<i>Cyclothone</i>	Skull	6207

138003	<i>Cyclothone</i>	Skull	6207
138004	<i>Cyclothone</i>	Skull	6207
138005	<i>Diaphus</i>	Skull Otolith	6207
138006	Myctophidae	Skeleton	6207
138007	Myctophidae	Skeleton	6207
138008	Myctophidae	Skull Otolith	6207
138009	Myctophidae	Skull w Otolith + Skeleton ant	6207
138010	<i>Lompoquia</i>	Scale	6207
138011	Teleostei	Skull	6207
138012	Teleostei	Neurocranium w Otolith	6207
138013	Teleostei	Neurocranium w L+R Otolith	6207
138014	Teleostei	Skull w Otolith + Skeleton ant	6207
138189	<i>Ganolytes cameo</i>	Scale	6202
138190	<i>Ganolytes cameo</i>	Skeleton	6202
138191	<i>Ganolytes cameo</i>	Skeleton post	6202
138192	<i>Xyne grex</i>	Skeleton	6202
138193	<i>Xyne grex</i>	Skeleton	6202
138194	<i>Xyne grex</i>	Skeleton	6202
138195	Perciformes	Skull: Otolith	6202
138196	<i>Sebastes</i>	R Skull: Otolith	6202
138197	Pleuronectoidei	Skeleton mid	6202
138198	<i>Argyropelecus</i>	Skull	6202
138199	<i>Argyropelecus</i>	Skeleton ant	6202
138200	Alepocephalidae	Skeleton	6202
138201	Alepocephalidae	Skeleton	6202
138202	Alepocephalidae	Skeleton	6202
138203	Alepocephalidae	Skeleton	6202
138204	Gadoidei	Skeleton ant	6202
138205	Moridae	Skeleton ant w Otolith	6202
138206	Linophrynidae	Skeleton	6202
138207	<i>Oneirodes</i>	Skeleton w Otoliths	6202
138208	Bathylagidae	Skeleton	6202
138209	Bathylagidae	Skeleton	6202
138210	Bathylagidae	Skeleton	6202
138211	Bathylagidae	Skeleton ant	6202
138212	Bathylagidae	Skull w Otolith	6202
138213	Gonostomidae	Skeleton	6202
138214	<i>Cyclothone</i>	Skeleton	6202
138215	<i>Cyclothone</i>	Skeleton	6202
138216	<i>Cyclothone</i>	Skeleton	6202
138217	<i>Cyclothone</i>	Skeleton	6202
138218	<i>Cyclothone</i>	Skeleton	6202
138219	<i>Cyclothone</i>	Skeleton	6202
138220	<i>Cyclothone</i>	Skeleton	6202
138221	<i>Cyclothone</i>	Skeleton	6202
138222	<i>Cyclothone</i>	Skeleton	6202
138223	<i>Cyclothone</i>	Skeleton	6202
138224	Myctophidae	Skull: Otolith	6202
138225	Myctophidae	L Skull: Otolith	6202
138226	Myctophidae	R Skull: Otolith	6202
138227	Myctophidae	L Skull: Otolith	6202
138228	Myctophidae	L Skull: Otolith	6202
138229	Myctophidae	L Skull: Otolith	6202
138230	Myctophidae	R Skull: Otolith	6202
138231	Myctophidae	L Skull: Otolith	6202

138232	Myctophidae	L Skull: Otolith	6202
138233	Myctophidae	Skeleton ant	6202
138234	Myctophidae	Skull + Skeleton w Otolith	6202
138235	Myctophidae	Skull + Skeleton w Otolith	6202
138236	Myctophidae	Skeleton	6202
138237	Myctophidae	Skull w Otoliths	6202
138238	Teleostei	Bones in coprolite	6202
138239	Teleostei	Skeleton	6202
138240	Teleostei	Skeleton	6202
138241	Teleostei	Skeleton post	6202
138242	Teleostei	Skeleton ant	6202
138243	Teleostei	Skull	6202
138244	Teleostei	Skull	6202
138245	Teleostei	Skull w Otolith	6202
138246	Teleostei	Skull post	6202
138247	Teleostei	Skull post w Otolith	6202
138248	Teleostei	Skull post w Otolith	6202
138249	Teleostei	Scale	6202
138250	Teleostei	Dentary	6202
138251	<i>Chauliodus eximius</i>	Skeleton ant	6202
138252	<i>Vinciguerria?</i>	Skull: Otolith	6202
140855	<i>Equus "occidentalis"</i>	R 1 <sup>st</sup> phalanx III	6297
140856	<i>Mammut americanum</i>	L m2	6298
140857	<i>Bison antiquus</i>	L metacarpal	6299
140858 <sup>c</sup>	<i>Camelops hesternus</i>	L M1	6300
140859 <sup>c</sup>	<i>Camelops hesternus</i>	R M1	6300
141007	Gasterosteidae	Vertebra	6306
141008	Gasterosteidae	Fin Rays Dorsal	6306
141009	Gasterosteidae	Fin Rays Dorsal	6306
141010	Gasterosteidae	Fin Rays Dorsal	6306
141011	<i>Gerrhonotus</i>	R Skull Pterygoid	6306
141012	<i>Gerrhonotus</i>	L Skull Frontal	6306
141013	<i>Gerrhonotus</i>	R Skull Articular	6306
141014	<i>Gerrhonotus</i>	Osteoscute	6306
141015	<i>Uta</i>	Dentary incompl	6306
141016	<i>Uta</i>	Dentary incompl	6306
141017	<i>Thamnophis</i>	Vertebra Dorsal Mid	6306
141018	<i>Thamnophis</i>	Vertebra	6306
141019	<i>Thamnophis</i>	Vertebra frag	6306
141020	Colubridae	Vertebra	6306
141021	<i>Tantilla</i>	Vertebra	6306
141022	Hylidae	Illium	6306
141023	Hylidae	Scapula	6306
141024	<i>Rana</i>	Scapula	6306
141025	<i>Sorex</i>	L Dentary w m2	6306
141026	<i>Sorex</i>	Tooth: i3	6306
141027	<i>Perognathus</i>	R Maxilla w m3	6306
141028	<i>Perognathus</i>	Tooth: M1 frag	6306
141029	<i>Perognathus</i>	Tooth: I1	6306
141030	<i>Perognathus</i>	Tooth: I1	6306
141031	<i>Thomomys bottae</i>	R Tooth: p4	6306
141032	<i>Thomomys bottae</i>	R Tooth: m3	6306
141033	<i>Thomomys bottae</i>	Tooth: M3	6306
141034	<i>Thomomys bottae</i>	Tooth: m	6306
141035	<i>Thomomys bottae</i>	R Tooth: dp4	6306

141036	<i>Thomomys bottae</i>	Tooth: dP4	6306
141037	<i>Thomomys bottae</i>	Tooth: dP4	6306
141038	<i>Thomomys bottae</i>	Tooth: dP4	6306
141039	<i>Thomomys bottae</i>	Tooth: M3	6306
141040	<i>Dipodomys</i>	R Tooth: I	6306
141041	<i>Microtus</i>	R Tooth: M2	6306
141042	<i>Microtus</i>	Tooth: M2	6306
141043	<i>Microtus</i>	L Tooth: m1	6306
141044	<i>Microtus</i>	R Tooth: m2	6306
141045	<i>Microtus</i>	Tooth: m2	6306
141046	<i>Peromyscus</i>	R Tooth: M2	6306
141047	<i>Sylvilagus</i>	Tooth: m frag	6306
141048	<i>Thomomys bottae</i>	Tooth: i	6306
141049	Aves	Humerus dist	6306
143228	Gasterosteidae	Vertebra	6385
143229	Gasterosteidae	Skull element	6385
143230	Gasterosteidae	Skull element	6385
143231	Gasterosteidae	Vertebra dorsal spine	6385
143232	Hylidae	Tibiofibula	6385
143233	<i>Thomomys bottae</i>	Tooth: M	6386
144144	<i>Chauliodus eximius</i>	Skeleton ant	6948
144145	<i>Decapterus</i>	Skeleton post	6948
144146	Alepocephalidae	Skeleton	6948
144147	Alepocephalidae	Skeleton	6948
144148	Alepocephalidae	Skeleton	6948
144149	Alepocephalidae	Skeleton	6948
144150	Alepocephalidae	Skull	6948
144151	<i>Argentina</i>	Skeleton ant	6948
144152	<i>Genyonemus</i>	Skeleton	6948
144153	Myctophidae	Skeleton	6948
144154	Myctophidae	Skeleton	6948
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	<i>Nemichthyes</i>	Skull Otolith	6948
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144287	Bathylagidae	Skeleton ant	6948

144288	Bathylagidae	Skeleton ant	6948
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144316	Bathylagidae	Skeleton ant	6948
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144318	Bathylagidae	Skull	6948
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144325	Bathylagidae	Skeleton ant	6948
144326	Bathylagidae	Skeleton ant	6948
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144328	Gadoidei	Skeleton	6948
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144330	Gadoidei	Skeleton ant	6948
144331	Gadoidei	Skull	6948
144332	Gadoidei	Skull	6948
144333	Moridae	Skeleton	6948
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144349	Moridae	Skull Neurocranium	6948
144350	Perciformes	Skeleton mid	6948
144351	Perciformes	Skull	6948
144352	Sciaenidae	Skeleton ant	6948
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144365	Sciaenidae	Scale	6948
144366	<i>Lompoquia</i>	Skeleton ant	6948

144367	Serranidae	Skeleton	6948
144368	<i>Paralabrax</i>	Skeleton ant	6948
144369	Scombridae	Skeleton mid	6948
144370	Scombridae	Skeleton mid	6948
144371	Scombridae	Skeleton mid	6948
144372	Scombridae	Skeleton mid	6948
144373	Scombridae	Scale	6948
144374	Scombridae	Scale	6948
144375	<i>Sarda</i>	Scale patch	6948
144376	<i>Scomber</i>	Skeleton mid	6948
144377	<i>Thyrsocles</i>	Skeleton mid	6948
144378	<i>Thyrsocles</i>	Skeleton ant	6948
144379	Clupeidae	Scale	6948
144380	Clupeidae	Scale	6948
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144384	Clupeidae	Scale patch	6948
144385	<i>Xyne grex</i>	Scale	6948
144386	<i>Xyne grex</i>	Scale	6948
144387	<i>Xyne grex</i>	Scale	6948
144388	<i>Xyne grex</i>	Scale	6948
144389	<i>Xyne grex</i>	Skeleton	6948
144390	<i>Xyne grex</i>	Skeleton post	6948
144391	<i>Xyne grex</i>	Skeleton post	6948
144392	<i>Xyne grex</i>	Skeleton ant	6948
144393	<i>Xyne grex</i>	Skull	6948
144394	<i>Xyne grex</i>	Skull Opercular	6948
144395	<i>Ganolytes cameo</i>	Scale	6948
144396	<i>Ganolytes cameo</i>	Scale	6948
144397	<i>Ganolytes cameo</i>	Scale	6948
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144401	<i>Ganolytes cameo</i>	Skeleton ant	6948
144402	<i>Scopelengys</i>	Skeleton ant	6948
144403	<i>Cyclothone</i>	Skeleton	6948
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144419	<i>Cyclothone</i>	Skeleton	6948
144420	<i>Cyclothone</i>	Skeleton	6948
144421	<i>Argyropelecus</i>	Skeleton	6948

144422	Teleostei	Skeleton	6948
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144436	Teleostei	Skull Preopercular	6948
144437	Teleostei	Skull Preopercular	6948
144438	Teleostei	Scale	6948
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144448	Teleostei	Scale	6948
144449	Teleostei	Scale	6948
144907	<i>Bathylagus</i>	Skeleton	6946
144908	Bathylagidae	Skeleton	6946
144909	Myctophidae	Skeleton ant	6946
144910	Myctophidae	Skeleton	6946
144911	<i>Cyclothone</i>	Skeleton	6946
144912	Scombridae	Skeleton post	6946
144913	Teleostei	Scale	6946
144914	Teleostei	Scale	6946
144915	<i>Xyne grex</i>	Scale	6946
144916	<i>Ganolytes cameo</i>	Scale	6947
144917	<i>Cyclothone</i>	Skeleton ant	6947
144918	Sciaenidae	Scale	6947
144971	Clupeidae	Scale	6206
144972	Clupeidae	Scale	6206
144973	Clupeidae	Scale	6206
144974	Clupeidae	Scale	6206
144975	Clupeidae	Scale	6206
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144978	Clupeidae	Scale	6206
144979	<i>Ganolytes</i>	Scale	6206
144980	<i>Ganolytes</i>	Scale	6206
144981	<i>Ganolytes</i>	Scale	6206
144982	<i>Ganolytes</i>	Scale	6206
144983	<i>Ganolytes cameo</i>	Scale	6206
144984	<i>Ganolytes cameo</i>	Scale	6206
144985	<i>Cyclothone</i>	Skull	6206

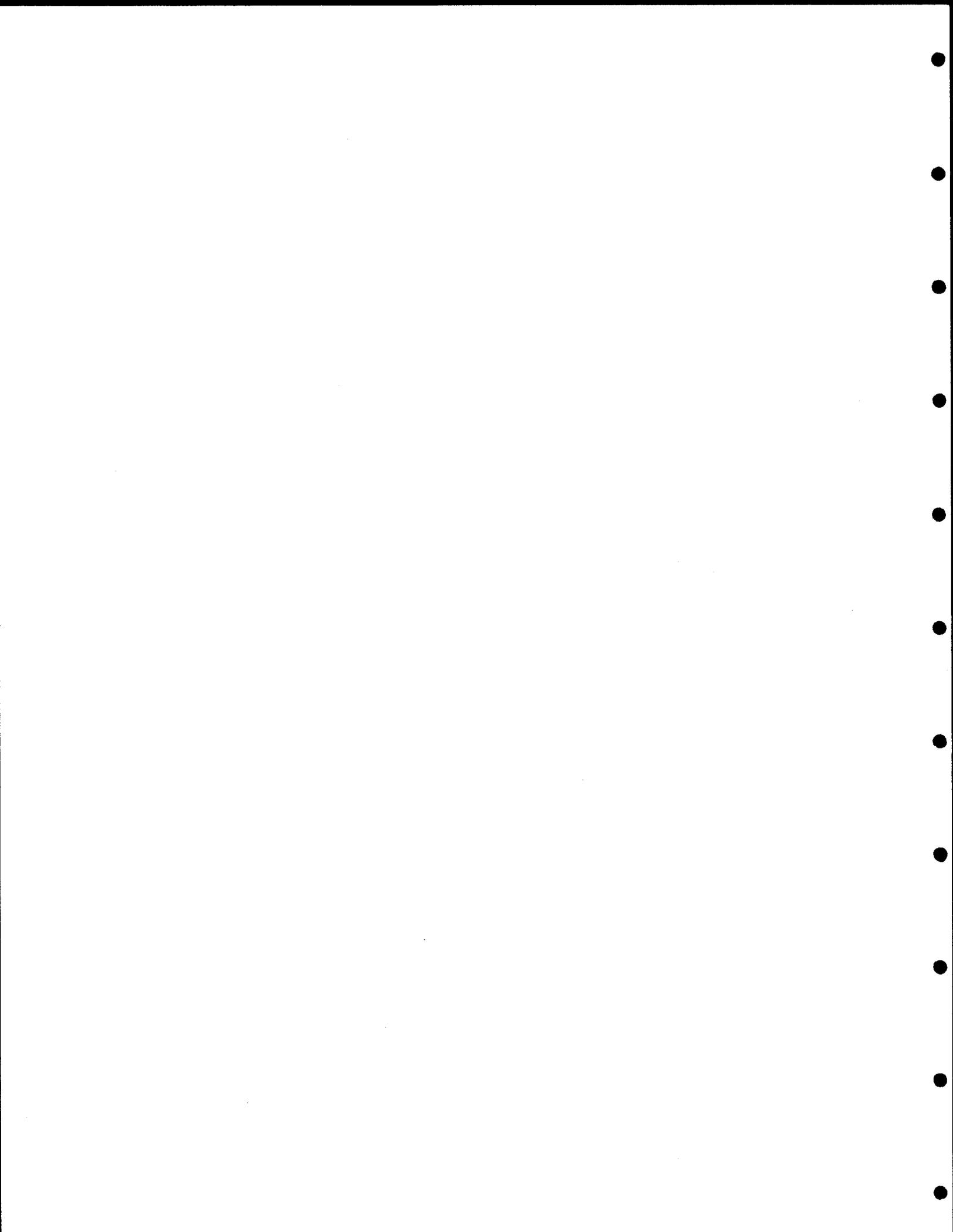
144986	<i>Cyclothone</i>	Skull	6206
144987	Myctophidae	L Skull Otolith	6206
144988	Myctophidae	R Skull Otolith	6206
144989	Sciaenidae	Scale	6206
144990	Teleostei	Scale	6206
144991	Teleostei	Scale	6206
144992	<i>Cyclothone</i>	Skeleton	6946
144993	Myctophidae	Skeleton ant	6946
144994	Myctophidae	Skeleton ant	6946
144995	Myctophidae	Skeleton ant	6946
144996	<i>Ganolytes</i>	Scale	6948
144997	Bathylagidae	Skeleton	6948
144998	<i>Cyclothone</i>	Skeleton	6948
144999	Myctophidae	Skeleton ant	6948
145000	<i>Plectrutes classeni</i>	Skeleton ant	6948
145001	Clupeidae	Scale	6969
145002	Clupeidae	Scale	6969
145003	Clupeidae	Scale	6969
145004	Clupeidae	Scale	6969
145005	Clupeidae	Scale	6969
145006	Clupeidae	Skeleton	6969
145007	Clupeidae	Skeleton	6969
145008	<i>Ganolytes</i>	Scale	6969
145009	<i>Etringus</i>	Scale	6969
145010	<i>Sardinella</i>	Scale	6969
145011	<i>Sardinella</i>	Scale	6969
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145016	<i>Sardinella</i>	Scale	6969
145017	<i>Sardinella</i>	Skeleton	6969
145018	Gadoidei	Skeleton	6969
145019	Gadoidei	Skull	6969
145020	Gadoidei	Skeleton mid	6969
145021	Gadoidei	Skeleton ant	6969
145022	Gadoidei	Skeleton ant	6969
145023	Bregmacerotidae	Skeleton	6969
145024	Atherinidae	Skeleton	6969
145025	Atherinidae	Skeleton	6969
145026	Caproidae	Skeleton	6969
145027	Caproidae	Skeleton	6969
145028	Caproidae	Skeleton	6969
145029	Priacanthidae	Skeleton	6969
145030	Sciaenidae	Scale	6969
145031a	Scombridae	Skeleton post	6969
145031b	<i>Decapterus</i>	Scale	
145032	Teleostei	Skull	6969
145033	Teleostei	Skeleton mid	6969
145034	<i>Glossotherium harlani</i>	Vertebra Caudal	6970
145035	<i>Bison antiquus</i>	L Metatarsal dist	6970
145036	<i>Bison antiquus</i>	R Tooth: p4 + m1? + m3	6970
145037	<i>Bison antiquus</i>	Sacrum frags	6970
145038	<i>Bison latifrons</i>	R Tibia dist	6970
145039	<i>Camelops hesternus</i>	L Radio-ulna prox	6970

145040	<i>Camelops hesternus</i>	R Pubis	6970
145041	<i>Camelops hesternus</i>	Vertebra frag	6970
145042	Proboscidea	R Rib prox	6970

<sup>a</sup>Natural History Museum of Los Angeles County Vertebrate Paleontology Section.

<sup>b</sup>ant: anterior;  
frags: fragments;  
incompl: incomplete;  
L: left;  
M: upper molar;  
m: lower molar;  
post: posterior;  
R: right;  
w: with.

<sup>c</sup>LACMVP fossil specimens 140858 and 140859 represent same individual.



APPENDIX P

AGREEMENT CONCERNING METRO RED LINE SEGMENT 2 FOSSILS  
[deed of gift]

Los Angeles County Metropolitan Transportation Authority

and

Natural History Museum of Los Angeles County

November 18, 1997



December 1, 1997

FILE NR: R81-EN025-PD443

Los Angeles County  
Metropolitan  
Transportation  
Authority

Dr. John Harris  
Chief Curator, Paleontology  
Los Angeles County Museum of Natural History  
900 Exposition Blvd.  
Los Angeles, CA 90007

One Gateway Plaza  
Los Angeles, CA  
90012

Dear Mr. Harris:

CURATION AGREEMENT FOR SEGMENT 2 FOSSILS

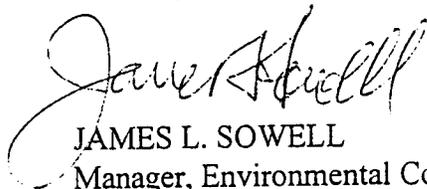
213.922.6000

Fossils and associated data discovered during construction of the Metro Red Line Segment 2 Project in Los Angeles, have been retrieved and cataloged, and we have made arrangements through Dr. Bruce Lander of Paleo Environmental Associates for their curation by the County Museum of Natural History.

Please, find enclosed a signed and executed copy of the Curation Agreement for the Metro Red Line Segment 2 fossils for your files, and the Fossil Specimen Catalog of the fossils found during the Metro Red Line Segment 2 construction.

If you have any questions regarding this matter, please contact me at (213) 922-7306.

Sincerely,

  
JAMES L. SOWELL  
Manager, Environmental Compliance

JLS/VL/me

Enclosures: Fossil Specimen Catalog

## AGREEMENT CONCERNING METRO RED LINE SEGMENT 2 FOSSILS

This Agreement concerning Metro Red Line Segment 2 Fossils ("Agreement") is dated as of March 21, 1997 by and between the Los Angeles County Metropolitan Transportation Authority ("Authority") and the Natural History Museum of Los Angeles County ("the Museum"). The Authority and the Museum are collectively referred to as the parties.

### RECITALS

- A. While constructing the Metro Red Line Segment 2 Project in Los Angeles from Wilshire/Vermont to Wilshire/Western and from Wilshire/Vermont to Hollywood/Vine, the Authority has discovered fossils and associated data that have been retrieved and catalogued.
- B. The parties desire to transfer certain fossils and associated data discovered at these sites to the Museum for the purpose of curating such materials.

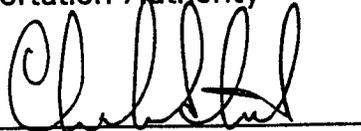
NOW THEREFORE, the parties hereby agree to the following terms and conditions:

- 1. The Museum shall receive the fossils and associated data listed in Attachment 1 (collectively, the "paleontologic materials") from the Authority for curation purposes. Authority hereby grants ownership of the paleontologic materials to the Museum which, as a public trust institution, shall serve as permanent repository for the paleontologic materials. The parties may agree to amend Attachment 1 from time to time to add or delete paleontologic materials. Such amendment shall be effective upon both parties' signature on the revised Attachment 1.
- 2. The Museum shall provide space and facilities to maintain and protect the paleontologic materials.

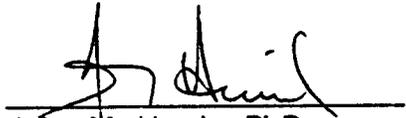
3. In consideration, the Museum shall make paleontologic materials available to qualified researchers within a reasonable time of being requested.
4. The Museum shall make the paleontologic materials available to MTA and to third parties, in accordance with museum collection and loan policies (attached) subject to reasonable security precautions and agreement.
5. This agreement may be terminated by the Museum upon 30 days written notice if the Museum can no longer adequately maintain and protect the paleontologic materials. Upon termination of this agreement, the Museum shall transfer all the paleontologic materials being curated to such tax exempt scientific or educational organization, institution, or foundation whose objectives and purpose relate to the study of paleontology, and which are qualified for approved exempt status under the Interior Revenue Code and whose curation standards meet the Society of Vertebrate Paleontology guidelines. The guidelines provide that satisfactory curation occurs when the depository has adequate space and facilities; specimens and records are maintained and protected; collections are accessible to qualified researchers within a reasonable time of being requested; and collections are available for interpretive purposes, subject to reasonable security precautions and agreements.
6. The Museum will acknowledge the Authority in the curation of the paleontologic materials.
7. The Museum hereby represents and warrants to the Authority that it has independently and personally inspected the paleontologic materials. The Museum hereby accepts the paleontologic materials in an as-is condition. The Museum acknowledges that no person at the Authority has made any representation, agreement, statement, warranty, guarantee, or promises regarding the paleontologic materials.
8. The covenants and agreements of this agreement shall inure to the benefit of, and shall be binding upon each of the parties and their respective successors and assigns.

NOW THEREFORE, the parties hereby execute this Agreement as of the dates below.

Los Angeles County Metropolitan  
Transportation Authority

By:   
Charles W. Stark  
Executive Officer, Construction

Los Angeles County Museum of  
Natural History

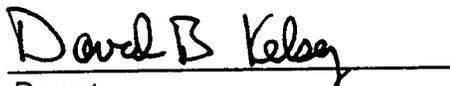
By:   
John M. Harris, PhD  
Chief Curator, Paleontology

Date: 11/24/97

Date: 11/19/97

APPROVED AS TO FORM:

Dewitt W. Clinton  
County Counsel

By:   
Deputy

[TRANSFER] A:\LACMNH.DOC

AGREEMENT CONCERNING METRO RED LINE SEGMENT 2 FOSSILS—  
ATTACHMENT

INATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY  
INVERTEBRATE AND VERTEBRATE PALEONTOLOGY SECTIONS  
FOSSIL SITE/SPECIMEN CATALOGS—  
METRO RED LINE CONSTRUCTION ZONE,  
LOS ANGELES, CALIFORNIA  
(see Appendices L, M, O)]

APPENDIX Q

MICROPALAEONTOLOGY REPORT, LOS ANGELES METRORAIL SAMPLES

Micropaleo Consultants, Inc.

March 6, 1996



March 6, 1996

Dr. Larry H. Fisk, Project Paleontologist  
Paleo Environmental Associates, Inc.  
1017 El Camino Lane  
Santa Ana, California 92705-2936

Dear Dr. Fisk:

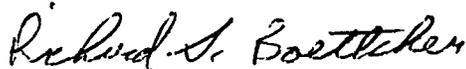
Enclosed is our report on the two Metrorail samples you sent us. Sample DPW-2502 was examined for palynology, ostracods, and siliceous microfossils, while DPW-2516 was examined for palynology only.

Sample DPW-2502 contains a fairly diverse and abundant spore-pollen assemblage of Pleistocene to Recent age. No fossils of cottonwood or willow are present. This sample also contains a sparse ostracod lake (pond?) fauna of the same age as the palynomorphs. No siliceous microfossils are present.

Sample DPW-2516 contains an extremely rare probable Pleistocene to Recent spore-pollen flora. Again, no cottonwood or willow forms are present. For both of these samples we refer you to the more detailed individual reports.

A copy of our bill is also enclosed, plus the palynomorph slides. Please note that the slide from sample DPW-2516 is cracked. We received it this way from the company that processed the slide. If you have any questions or would like us to try to get a replacement for the cracked slide, give me a call.

Sincerely,

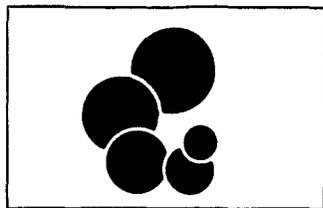


Richard S. Boettcher  
MICROPALEO CONSULTANTS, INC.

RSB:be

Enclosures

cc: Dr. Bruce Lander



**MICROPALEO**  
CONSULTANTS, INC.

**PALEO ENVIRONMENTAL ASSOCIATES  
1017 EL CAMINO LANE  
SANTA ANA, CALIFORNIA**

**MICROPALEONTOLOGY REPORT  
LOS ANGELES METRORAIL SAMPLES  
MARCH 6, 1996**

**PALYNOLOGY REPORT**

The palynology preparations were made using standard techniques. This procedure included hydrochloric, hydrofluoric and nitric acid treatments. The resultant organic residues were further concentrated by a heavy liquid separation, sonification and a sieving/panning technique. Permanent slide mounts were made for each sample.

The reported palynomorph abundances represent the following quantities: V = very rare (single specimen), R = rare (2 - 5 specimens), F = frequent (6 - 15 specimens), C = common (16 - 30 specimens) and A = abundant (greater than 30 specimens).

**SAMPLE DPW-2502**

Age: Quaternary  
Pleistocene - Recent

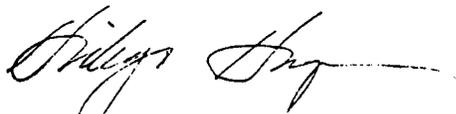
Environment: Nonmarine

Palynomorphs: Caryophyllaceae (F)  
Chenopodiaceae (V)  
Compositae:  
    *Artemisia* (C)  
    Helianthus-type (C)  
    Taraxacum-type (F)  
*Ephedra* cf. *E. nevadensis* (R)  
*Eriogonum* (F)  
?Liquidambar (R)  
*Pinus* (V)  
Polypodiaceae (C)  
Selaginella (F)  
*Sphagnum* (F)  
Indeterminate rugulate spore (R)

Discussion: The spore-pollen assemblage reflects a relatively dry temperate climate. The assemblage is essentially barren of any higher elevation coniferous pollen. Also absent are the warmer temperate genera, such as *Carya* (Hickory) and *Ulmus* (Elm). These latter forms would be expected in Pliocene or older age strata.

No pollen attributable to Salicaceae (Willow family) were observed.

Interpreted by:



---

Hideyo Haga  
MICROPALEO CONSULTANTS, INC.

## **OSTRACOD REPORT**

### **MICROFAUNAL ANALYSIS**

**SAMPLE DPW-2502**

#### **Faunal Recovery**

Fifteen (15) disarticulated valves were recovered representing two ostracod species: *Limnocythere staplini* Gutentag and Benson accounts for 14 specimens, whereas *Limnocythere paraornata?* Delorme is represented by a single specimen. Only one specimen is in pristine condition, the others are weathered or broken. Size-sorting is not apparent. This sample did not yield any other microfauna or fragments of macrofauna.

### **INTERPRETATION**

**Biostratigraphy:** Pleistocene - Holocene

- Both *Limnocythere* species range Pleistocene - Holocene.

**Paleoenvironment:** Lake (pond?), possibly alkaline

- *Limnocythere* is a freshwater species known to occur in pluvial lakes at various stages of their existence.
- *Limnocythere staplini* is a nearctic lacustrine species tolerant of moderate to high salinities - its predominance here could be indicative of an interglacial warming stage as increased evaporation and decreased runoff resulted in increasing salinity.

- *Limnocythere paraornata* inhabits nearctic streams. The questionable specimen could have been transported into the standing body of water.
- Disarticulated valves and absence of complete carapaces indicate relatively slow rate of deposition.
- The lack of size sorting and presence of juveniles (instars) indicates quiet (low-energy) environment.

**Paleogeography:** Correlative with inland migratory routes of aquatic birds

- Lacustrine species are widely distributed by migratory aquatic birds such as pelicans (Sandberg, 1964, Sandberg and Plusquellec, 1974). Thus, inland lakes of similar chemistry tend to have correlative ostracod faunas.
- *Limnocythere staplini* and *L. paraornata* have been recorded from pluvial sediments of Lake Bonneville, Utah (Lister, 1975).

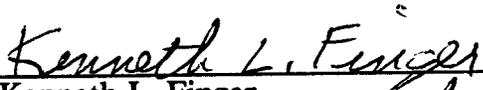
**Additional Comments**

During the late Cenozoic, freshwater ostracods such as *Limnocythere* were evolutionarily conservative. Most of the species known from North American lakes occur in both Pleistocene and Holocene faunas. Pleistocene climatic fluctuations apparently had little effect on the evolution of North American species of freshwater ostracods. This is because dispersal of ostracods by migratory birds ensured genetic homogenization within species over wide areas, thereby preventing evolution within genetically isolated populations. Stratigraphic studies of ostracods (as opposed to "spot" samples) are particularly useful in deciphering the chemical evolution of lakes because species are sensitive to changes in water chemistry.

**REFERENCES**

- Lister, K. H., 1975. Quaternary freshwater Ostracod from the Great Salt Lake Basin, Utah. University of Kansas, Paleontological Contributions, Paper 78, 34 pp.
- Sandberg, P. A., 1964. The ostracod genus *Cyprideis* in the Americans. Stockholm Contributions to Geology, v. 12, pp. 1-178.
- Sandberg, P. A. and Plusquellec, P. L., 1974. Notes on the anatomy and passive dispersal of *Cyprideis* (Cytheracea, Ostracod), Geoscience and Man, v. 6, pp. 1-26.
- Swain, F. M., 1977. Paleocological implications of Holocene and Late Pleistocene Ostracod, Lake Lahonton Basin, Nevada. In: Loffler, H. and Danielopol, D., eds., Aspects of Ecology and Zoogeography of Recent and Fossil Ostracod. Sixth International Ostracod Symposium, The Hague, Junk, pp. 309-320.

Interpreted by:

  
Kenneth L. Finger  
Consulting Paleontologist *by RSB*

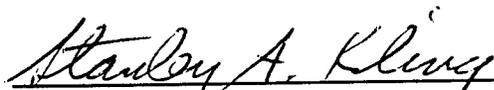
**SILICEOUS MICROFOSSIL REPORT**

**SAMPLE DPW-2502**

Age: Indeterminate

Remarks: Barren of siliceous microfossils.

Interpreted by:

  
Stanley A. Kling  
Consulting Paleontologist *by PCB*

**PALYNOLOGY REPORT**

**SAMPLE DPW-2516**

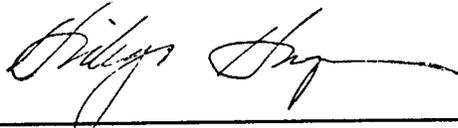
Age: Quaternary  
Pleistocene - Recent

Environment: Nonmarine

Palynomorphs: *Alnus* (R)  
*?Selaginella* (V)

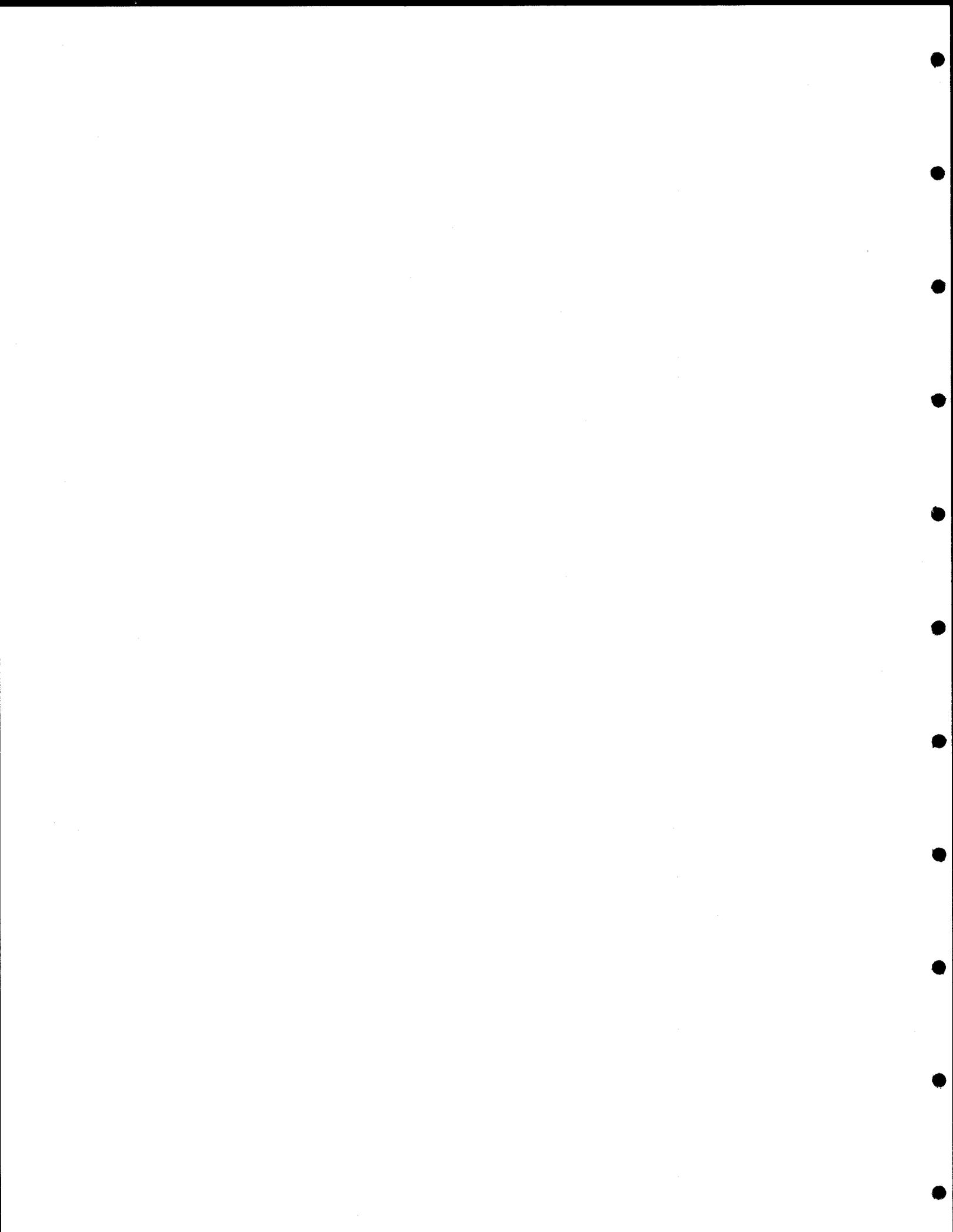
Discussion: This sample yielded very little organic material. Only three palynomorph specimens were recorded. A few other fragments of probable spore-pollen were observed, but no identifications could be made.

Interpreted by:



---

Hideyo Haga  
MICROPALEO CONSULTANTS, INC.



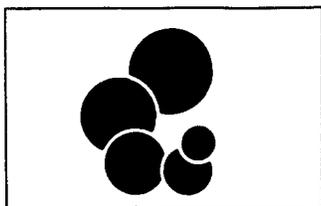
APPENDIX R

PALYNOLOGY REPORT - TWO MATRIX SAMPLES: DPW-2566 & GTT 96819

[note: sample GTT96819 does not apply to Metro Red Line or this report]

Micropaleo Consultants, Inc.

November 27, 1996



**MICROPALÉO**  
CONSULTANTS, INC.

November 27, 1996

TO: Dr. David P. Whistler  
Paleo Environmental Associates, Inc.  
7017 Whitaker Ave.  
Van Nuys CA 91406

SUBJECT: Palynology Report - Two matrix samples: DPW-2566 &  
GTT96819

Introductory Summary

The two matrix samples were processed for palynological analysis. The samples yielded numerous spore-pollen and a few fungal spores and hyphae. The recoveries were sufficient to provide an age interpretation of Pliocene to Pleistocene for both samples.

The palynology preparations were made using hydrochloric and hydrofluoric acid treatments. The resultant organic residue was further concentrated by a heavy liquid separation, sonification and a sieving/panning technique. Permanent slide mounts were made for each sample.

Results

DPW-2566

Age. Pliocene - Pleistocene

Environment. Nonmarine

Palynomorphs. Caryophyllaceae (R)  
Chenopodiaceae (V)  
Compositae (*Ambrosia*-type) (C)  
Compositae (*Helianthus*-type) (C)  
*Eriogonum* sp. (V)  
*Pinus* sp. (A)  
*Selaginella sinuites* (R)  
Taxodiaceae (R)  
*Diporites* sp. (R) fungal spore  
Fungal sporangia (R)

Remarks. The presence of Caryophyllaceae and *Eriogonum* suggest an age of Pliocene or younger.

GTT96819

Age. Pliocene - Pleistocene

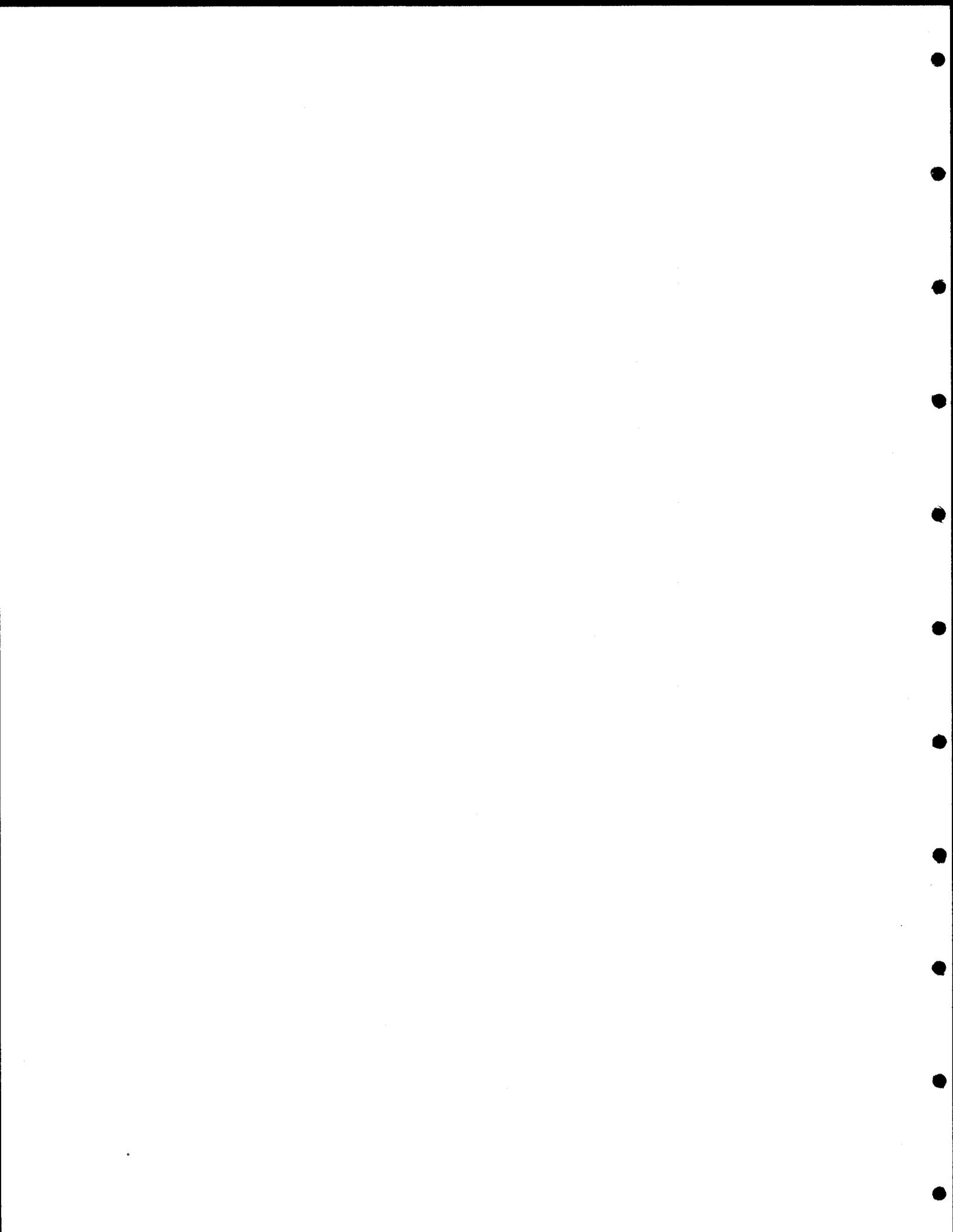
Environment. Nonmarine

Palynomorphs. Chenopodiaceae (R)  
Compositae (*Ambrosia*-type) (F)  
Compositae (*Helianthus*-type) (A)  
Compositae (*Taraxacum*-type) (R)  
*Eriogonum* sp. (R)  
*Juglanspollenites* sp. (V)  
Onagraceae (V)  
*Pinus* sp. (F)  
?Polemoniaceae (R)  
*Selaginella sinuites* (C)  
*Diporites* sp. (R) fungal spore  
Fungal sporangia (R)

Remarks. The presence of the *Eriogonum* suggests an age of Pliocene or younger.



Hideyo Haga  
MICROPALEO CONSULTANTS, INC.

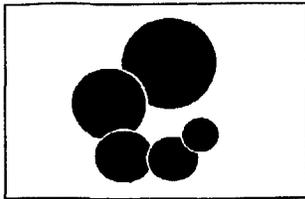


APPENDIX S

MICROPALAEONTOLOGY REPORT, PALEOENVIRONMENTAL [sic.] ASSOCIATES  
METRORAIL [sic.] SAMPLES, LOS ANGELES BASIN

Micropaleo Consultants, Inc.

October 16, 1998



October 16, 1998

**MICROPALEO**  
CONSULTANTS, INC.

Dr. Bruce Lander  
Paleoenvironmental Associates, Inc.  
2248 Winrock Avenue  
Altadena, California 91001

RE: Metrorail Samples  
M.C.I. Job No. 98-101(M)

Dear Bruce:

Enclosed is our report on the Metrorail samples you sent us several weeks ago.

The first sample (MM 970225) was worked for Foraminifera and calcareous nannoplankton. The forams are not very definitive but probably reflect Luisian deposition. This sample is age indeterminate on the basis of calcareous nannofossils.

Sample GTT 9510135 was done for Foraminifera, calcareous nannoplankton, and siliceous microfossils. The rather poor foram recoveries indicate a Luisian to Mohnian age, possibly Luisian (middle Miocene). The calcareous nannofossils say possible late Miocene, but neither discipline is very definitive. No siliceous microfossils are present.

The final sample (MAR 435) was also done for all three disciplines. No Foraminifera or calcareous nannoplankton are present. Good siliceous recoveries indicate an early Pliocene age.

Also enclosed is our invoice for these three samples. If you have any questions about either the bill or the report, give me a call.

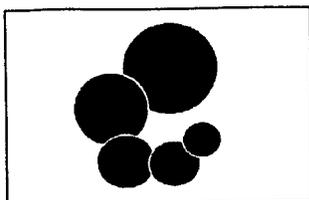
Sincerely,

*Richard S. Boettcher*

Richard S. Boettcher  
MICROPALEO CONSULTANTS, INC.

RSB:be

Enclosures



**MICROPALEO**  
CONSULTANTS, INC.

**MICROPALEONTOLOGY REPORT**  
**PALEOENVIRONMENTAL ASSOCIATES**  
**METRORAIL SAMPLES**  
**LOS ANGELES BASIN**

MM 970225

**FORAMINIFERA**

Age: Probable Luisian

Environment: Lower Middle Bathyal (4700 to 6250 feet), possibly near the upper part of this range.

Fossils: *Bolivina imbricata?* (FW), *B. spp.* (FW), *Buccella spp.* (FW), *Buliminella curta* (FW), *B. subfusiformis* (FW), *Elphidium crispum* (FW), *Epistominella subperuviana* (V), *Planulina sp.* (R), *Pullenia miocenica* (FW), *Uvigerinella spp.?* (FW), *Valvulineria californica obesa?* (V), *V. miocenica?* (FT), Fish remains (FT)

Washed Lithology: Sand, carbonaceous material, mica

**CALCAREOUS NANNOPLANKTON**

Age: Indeterminate

Species: *Coccolithus pelagicus* (A), *Dictyococcites antarcticus* (V)

Remarks: This essentially monospecific assemblage is not age diagnostic. *Coccolithus pelagicus* ranges through the entire Cenozoic. The single specimen of *Dictyococcites antarcticus*, although it ranges from Eocene to Miocene, is not considered significant in such low abundance.

**GTT 9510135**

**FORAMINIFERA**

Age: Luisian to Mohnian

Environment: Upper Middle Bathyal (1560 to 4700 feet)

Fossils: *Bolivina* sp. (V), *Epistominella subperuviana* (R), *Nonion* sp. (R), *Uvigerina hootsi* (R), *Uvigerinella* sp.? (R), arenaceous spp. (FW), *Globigerina* spp. (FT), Fish remains (A), Radiolaria (C), Tasmanites (A)

Washed Lithology: Medium brown mudstone

**CALCAREOUS NANNOPLANKTON**

Age: Possible Late Miocene

Zone: Indeterminate

Species: *Braarudosphaera bigelowi* (V), *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* (R), *D. minutus* (R), *Reticulofenestra pseudoumbilica* (R)

Remarks: The species identified are not precisely age-diagnostic, but the assemblage is commonly encountered in late Miocene samples.

**SILICEOUS MICROFOSSILS**

Age: Indeterminate

REMARKS: Barren of diatoms and other smaller siliceous microfossils.

**MAR 435**

**FORAMINIFERA**

Age: Indeterminate

Environment: Marine

Fossils: Barren of Foraminifera. Diatoms (FW), Fish remains (R), Radiolaria (Flood), Spicules (C)

Washed Lithology: White tuff

**CALCAREOUS NANNOPLANKTON**

Age: Indeterminate  
Remarks: Barren of calcareous nannoplankton.

**SILICEOUS MICROFOSSILS**

Age: Early Pliocene  
Zone: *Thalassiosira oestrupii*

Species: Diatoms  
*Actinocyclus curvatus* (R), *A. oculatus?* (V),  
*Actinoptychus senarius* (R), *Coscinodiscus*  
*marginatus* (R), *C. vetustissimus* (R), *Nitzschia*  
*reinholdii* (F), *N. rolandii* (R), *Rhizosolenia*  
*barboi* (R), *R. styliiformis* (R), *Thalassionema*  
*nitzschioides* (F), *Thalassiosira antiqua* (F), *T.*  
*oestrupii* (R), *T. praeoestrupii* (R), *T. spp.* (F)

Silicoflagellates

*Distephanus boliviensis* (F), *D. jimligii* (R)

Remarks: The age of this sample is interpreted as early Pliocene based on the appearance of *Thalassiosira oestrupii*, whose earliest occurrence defines the base of the zone named for that species and is considered to represent the Miocene - Pliocene boundary. *Thalassiosira praeoestrupii* has a very short range in the latest Miocene to Earliest Pliocene, suggesting that this sample represents the lower part of the zone, near the Miocene Pliocene boundary.

Interpreted by:

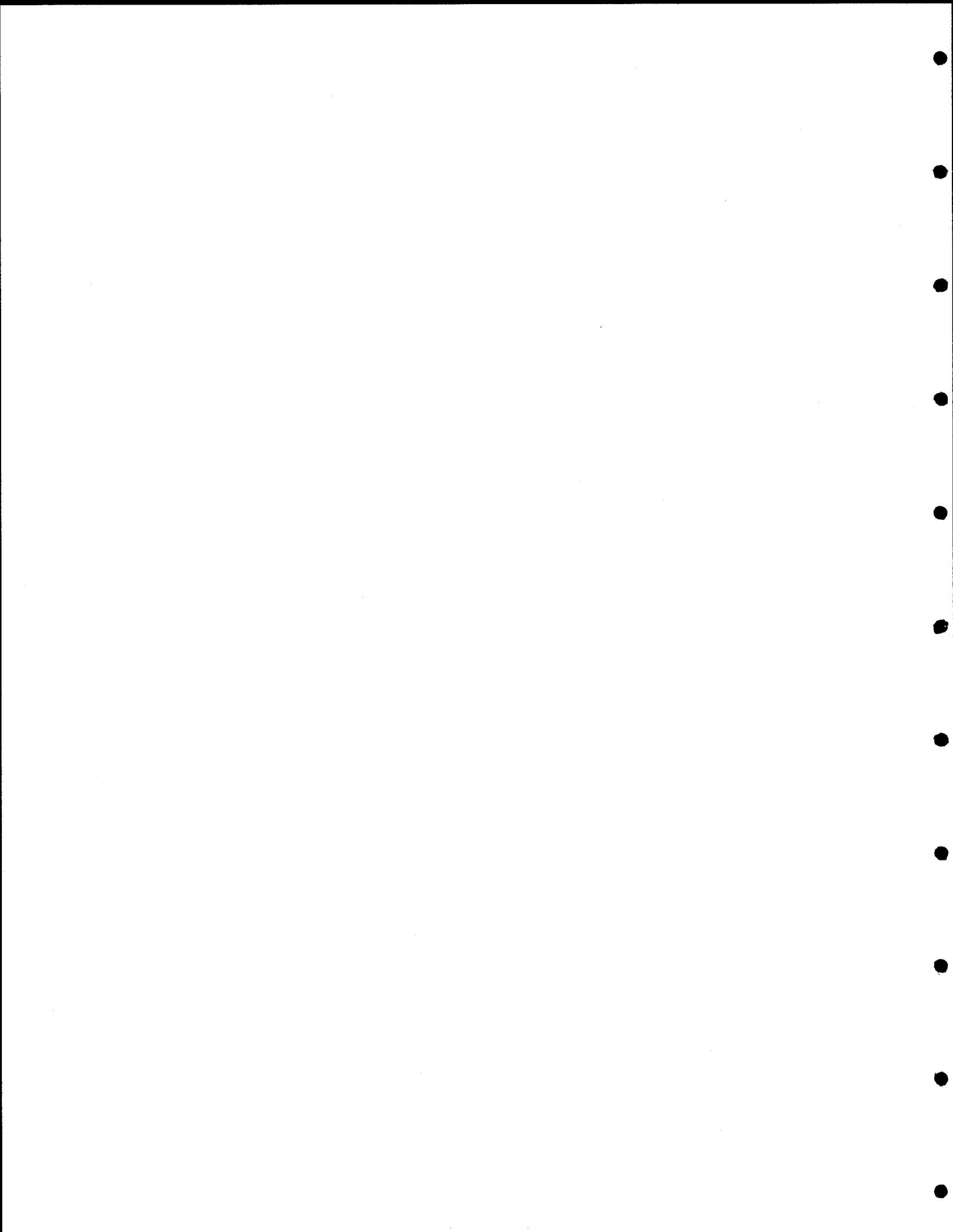
*Richard S. Boettcher*  
Richard S. Boettcher  
Foraminifera  
MICROPALEO CONSULTANTS, INC.

*Stanley A. Kling*  
Stanley A. Kling  
Calcareous Nannoplankton  
Siliceous Microfossils

RSB:SAK:be

October 16, 1998

M.C.I. Job No. 98-101(M)



APPENDIX T

MIDDLE MIOCENE FOSSIL FISH REMAINS FROM UPPER TOPANGA FORMATION,  
METRO RED LINE SEGMENT 3 CONSTRUCTION ZONE,  
UNIVERSAL CITY STATION SITE, LOS ANGELES, CALIFORNIA

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INTRODUCTION

The remains of thirty-three fossil marine fish specimens were recovered from the middle Miocene marine Upper Topanga Formation at the Universal City station site as a result of the paleontologic resource impact mitigation program conducted during construction of Los Angeles Metro Red Line Segment 3 (Lander, in preparation). The specimens, which consist of scales and partial and complete skeletons, were identified to the lowest taxonomic level possible before being submitted for preparation, curation, cataloguing, and eventual transfer to the Natural History Museum of Los Angeles County Vertebrate Paleontology Section for permanent storage and maintenance.

FAUNA

The Segment 3 fish fauna from the Upper Topanga Formation is scientifically highly important because taxonomically it is unlike any fish assemblage previously reported from the Miocene fossil record of southern California. The fauna is represented by 8 families, at least 12 and possibly as many as 14 genera, and 14 extinct species of marine fishes, most of the species being new, not having been reported previously in the scientific literature. A taxonomic list of the Segment 3 fish assemblage is presented in Table 1.

Some of the Segment 3 fossil fish specimens are scientifically highly important in part because they represent new species and very rare fossil occurrences for their respective genera and families, and include the

first possible reported fossil occurrences of at least one and as many as three as-yet unidentified genera of the Clupeidae (herrings);

first reported North American fossil occurrences of the Caproidae (boarfishes) and possibly the Priacanthidae (bigeyes) and *Sardinella* (Clupeidae; sardinella);

first possible reported North American Pacific Coast fossil occurrence of the Bregmacerotidae (codlets);

and the oldest reported North American fossil occurrence of the Atherinidae (silversides).

The Segment 3 fish fauna is highly unusual because of the diversity of clupeids (six species and at least four and possibly as many as six genera) represented in a taxonomically limited assemblage.

The fossil specimen assigned to the Atherinidae is unusual because it has fewer vertebrae in previously recognized genera of the family and probably represents a new species and possibly a new genus.

A digestive mass from an otherwise unidentified species of fish contained a scale possibly assignable to *Decapterus* (Carangidae; Mexican scad).

PALEOENVIRONMENT

The Segment 3 fossil marine fish specimens also are scientifically highly important because the specimens, along with the families, genera, and species they represent, allow paleoenvironmental reconstruction of the Santa Monica Mountains/San Fernando Valley area during the middle Miocene Epoch.

Unlike other fossil marine fish faunas from the Miocene fossil record of southern California, the Segment 3 fish fauna is the first reported to contain a diversity of tropical fish taxa, including two genera of the Caproidae (boarfishes), three species and at least one and possibly as many as three as-yet unidentified

genera of the Clupeidae (herrings), and possibly the Bregmacerotidae (codlets) and Priacanthidae (bigeyes) and *Sardinella* (Clupeidae; sardinella). Modern representatives of nearly all of these taxa do not occur off the southern California coast today, but rather occur far to the south in warmer tropical and subtropical marine waters.

The Segment 3 fish fauna is dominated by neritic (near-shore) epipelagic (shallow-water) forms whose modern representatives inhabit ocean depths less than 250 meters below sea level (Angel, 1997), deeper-water (mesopelagic, bathypelagic) marine species not being represented.

Documenting the taxonomic differences between the marine fish faunas of southern California and establishing their respective environmental (temperature) preferences will make it possible to relate these differences to the major climatic changes that occurred during the Miocene Epoch.

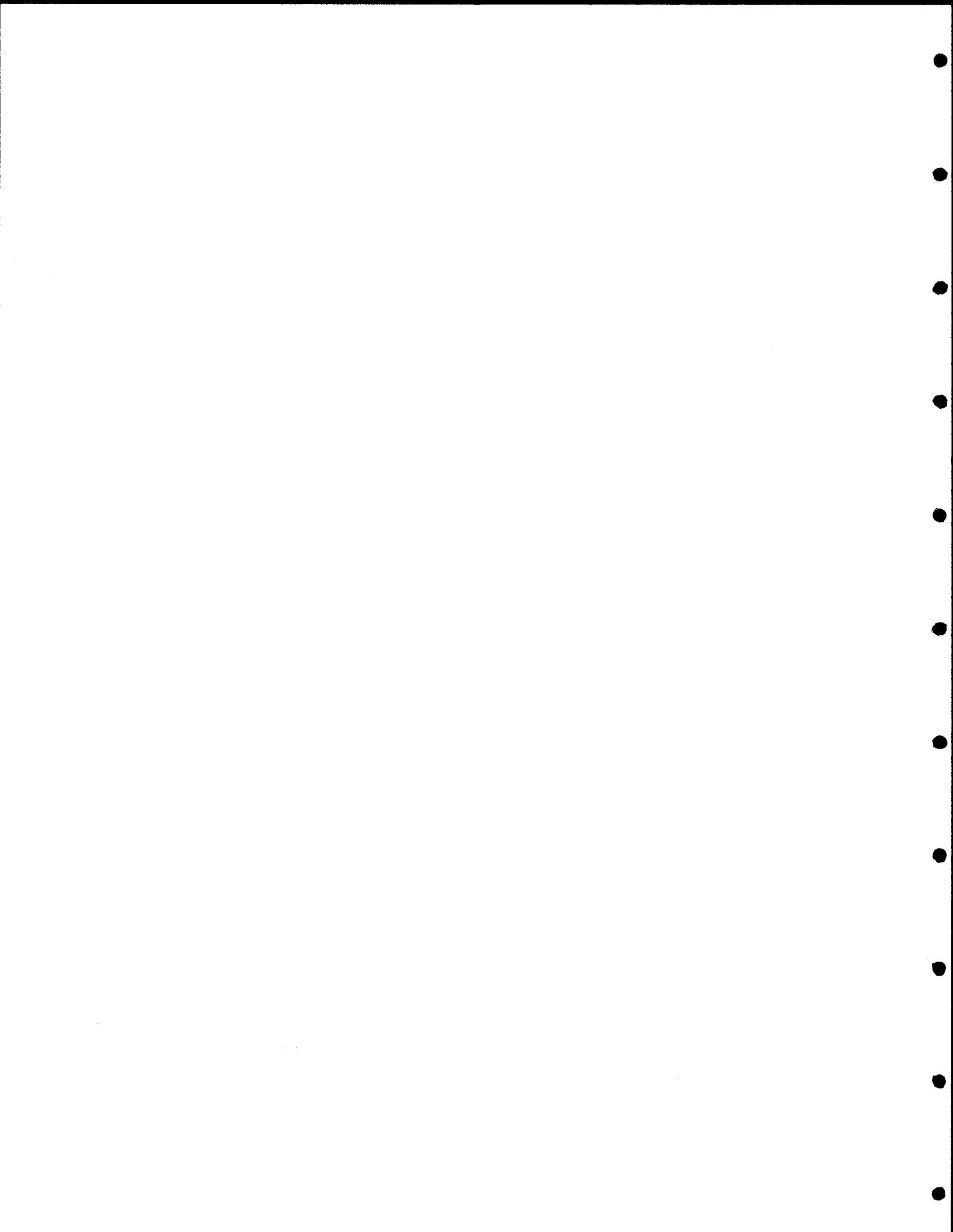
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**Table 1.**—Taxonomic list, teleost fishes (Class Actinopterygii, Subclass Neopterygii, Division Teleostei), Upper Topanga Formation, Los Angeles Metro Red Line Segment 3 construction zone, Universal City station site, Los Angeles, California. Classification and common names after California Academy of Sciences (undated), Carroll (1988), Eschmeyer and others (1983), Nelson (1994), Paxton and Eschmeyer (1995), and Robins and others (1980).

Subdivision	Superorder	Order	Suborder	Superfamily	Family	Subfamily	Genus, Species	Common Name	
Clupeomorpha		Clupeiformes	Clupeoidei		Clupeidae	Clupeinae	<i>Ganolytes?</i> , sp. undet. <sup>a</sup>	sardine	
							<i>Sardinella?</i> , n. sp.	sardinella?	
Euteleostei	Paracanthopterygii	Gadiformes	Gadoidei		Bregmacerotidae?	Dussumieriinae	gen. undet., n. sp.? A	herring	
							gen. undet., n. sp.? B	herring	
	Acanthopterygii	Atheriniformes			Atherinidae		gen. undet., n. sp.? C	herring	
							<i>Etringus</i> , sp. undet.	round herring	
	Zeiformes				Caproidae		gen. undet., n. sp.?	codlet?	
							n. gen.? & sp.	silversides	
	Perciformes		Perciformes	Percoidei	Percoidea	Priacanthidae?		gen. undet. A, n. sp.?	boarfish
								gen. undet. B, n. sp.?	boarfish
	Scombroidei					Carangidae		gen. undet., n. sp.?	bigeye
								gen. & sp. undet.	Mexican scad?
					Sciaenidae?		gen. & sp. undet.	croaker?	
							gen. & sp. undet.	mackerel	

<sup>a</sup>gen.: genus;  
n.: new;  
sp.: species;  
undet.: undetermined.



APPENDIX U

ANALYSIS OF FOSSIL WOOD SPECIMENS FROM  
METRO RED LINE SEGMENT 3 CONSTRUCTION ZONE,  
SAN FERNANDO VALLEY, LOS ANGELES, CALIFORNIA

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SUMMARY

Numerous specimens of fossilized wood representing conifers (cone-bearing trees) and angiosperms (broadleaf flowering trees) were recovered from the middle Miocene marine Upper Topanga Formation and the unconformably overlying undifferentiated Quaternary older and younger alluvium in the San Fernando Valley segment of the Los Angeles Metro Red Line Segment 3 construction zone, Los Angeles, California. The specimen from the Upper Topanga Formation; two specimens from the older alluvium, one previously determined to be greater than 46,340 years, and the other, greater than 48,620 years (late Pleistocene) in age; and two specimens from the overlying younger alluvium, one previously determined to be 8,880 years (early Holocene) in age, subsequently were submitted to F & F GeoResource Associates, Inc. (F&F), for identification and paleoenvironmental analysis. Two other specimens from approximately the same stratigraphic level in the younger alluvium at the Universal City station site have been determined to be 7,860 and 10,500 years (early Holocene) in age.

The specimen from the Upper Topanga Formation represents either a conifer or an angiosperm, but is poorly preserved and, therefore, otherwise taxonomically indeterminate. Nevertheless, this specimen still is scientifically highly important because the wood of land plants is very rare in the marine fossil record and has not been reported previously from the Upper Topanga Formation in the Santa Monica Mountains.

The specimens from the older alluvium at the North Hollywood station site and in the San Fernando Valley tunnel segment represent neither an angiosperm nor a member of the family Pinaceae (pines), but instead represent a conifer other than pine. As in members of the family Cupressaceae

(cedars) and unlike members of the families Taxodiaceae (redwoods) and Taxaceae (yews), the specimens are characterized by the presence of ray parenchyma with nodular end walls and the absence of spiral thickenings in the tracheid walls. The specimens are assignable to *Calocedrus* (= *Libocedrus*) and indistinguishable from the modern species *Calocedrus decurrens* (incense cedar).

Today, *Calocedrus* occurs in the mountains of southern California at elevations greater than 2,500 to 3,000 feet above sea level. The presence of *Calocedrus* in the older alluvium suggests that the late Pleistocene climate of the San Fernando Valley at least 46,000 years ago was considerably wetter and probably cooler than now and comparable to climates found at higher elevations in southern California today. Moreover, uniform tracheid size throughout each growth ring and growth rings delineated by only a few smaller cells suggest an equable cool-wet climate with a relatively long uniform growing season and only a short period unfavorable for growth. However, narrow growth rings only 1.0 to 1.5 mm wide suggest that, although the climate was equable, it was not ideal for growth. A uniformly cool climate with a short cold winter and a relatively uniform seasonal distribution of rainfall is more likely. The climate that probably characterized the San Fernando Valley at least 46,000 years ago is in marked contrast to the strong seasonality characteristic of the Mediterranean climate, with its hot dry summers and warm wet winters, that exists in the region today, and presumably was similar to climates found at higher elevations and/or higher latitudes in California today. This conclusion is consistent with palynological (pollen) evidence demonstrating the association of redwood/sequoia with *Calocedrus* in the San Fernando Valley tunnel segment. Modern redwood and sequoia are restricted to areas of northern and central California characterized by a much cooler and wetter climate than that found in the San Fernando

Valley today.

The floral assemblage from the older alluvium at the North Hollywood station site and in the San Fernando Valley tunnel segment is scientifically highly important because it probably represents the first reported fossil occurrence of a late Pleistocene floral assemblage from the San Fernando Valley and includes the first reported fossil occurrence of *Calocedrus*. Moreover, the plant remains have been critical in paleoenvironmental reconstruction of the San Fernando Valley tunnel segment and North Hollywood station site and paleoclimatic reconstruction of the San Fernando Valley and vicinity during the late Pleistocene Epoch.

The fossil specimens from the younger alluvium at the Universal City station site represent *Populus* (probably cottonwood). The identifications primarily are based on the presence of diffuse vessels with simple perforation plates and uniseriate homocellular rays. The presence of cottonwood in the San Fernando Valley approximately 9,000 years ago is not inconsistent with associated palynological data (occurrence of *Ephedra*, cf. *E. nevadensis* pollen) from the Universal City station site that suggest the early Holocene climate of the region was considerably dryer and more extreme, with hotter summers and colder winters, than today and especially during the late Pleistocene Epoch at least 46,000 years ago. Today, *Ephedra nevadensis* (Mormon tea) occurs in the Mojave Desert and the adjacent lower slopes of the northern San Gabriel and San Bernardino Mountains. However, spores of *Selaginella* (clubmoss), *Sphagnum* (peat moss), and the Polypodiaceae (ferns) suggest cooler and wetter environments, including those found in restricted habitats, such as bogs.

The floral assemblage from the younger alluvium at the Universal City station site is scientifically highly important because it probably represents the first reported fossil occurrence of an early Holocene floral assemblage from the Los Angeles basin and vicinity (including San Fernando Valley). Moreover, the plant remains have been critical in paleoenvironmental reconstruction of the station site and paleoclimatic reconstruction of the San Fernando Valley and vicinity during the early Holocene Epoch.

### INTRODUCTION

Numerous specimens of fossilized wood representing conifers (cone-bearing trees) and angiosperms (broadleaf flowering trees) were recovered from the

middle Miocene marine Upper Topanga Formation and the unconformably overlying undifferentiated Quaternary older and younger alluvium as a result of the paleontologic resource impact mitigation program conducted by Paleo Environmental Associates, Inc. (PEAI), during excavation in the Los Angeles Metro Red Line Segment 3 construction zone, Los Angeles, California. One specimen from a depth of 68 to 80 feet below current grade in the Upper Topanga Formation was recovered in the San Fernando Valley tunnel segment. Two specimens (PEAI fossil specimens DPW [David P. Whistler] 2516, 2565) from depths 67 and 80 feet below current grade in the older alluvium and previously determined to be greater than 46,340 and 48,620 years (late Pleistocene) in age (Beta Analytic Inc., 1996a, -b, sample numbers Beta-90086, -99228) on the basis of carbon-14 dating analyses, were recovered at the North Hollywood station site and in the San Fernando Valley tunnel segment (Lander, in preparation). Two specimens (DPW 2505, 2509) from a depth 58 feet below previous grade in the younger alluvium, one previously determined to be 8,880 years (early Holocene) in age (Beta Analytic Inc., 1995, sample number Beta-86689), were recovered at the Universal City station site (Lander, in preparation). These specimens subsequently were submitted to F&F for identification and paleoenvironmental analysis. This technical report of findings presents the results of the latter tasks. Two other specimens recovered at approximately the same stratigraphic level in the younger alluvium at the Universal City station site have been determined to be 7,860 and 10,500 years (early Holocene) in age (Beta Analytic Inc., 1997, sample numbers Beta-102794, 102795; Lander, in preparation). The three age determinations for the specimens from the younger alluvium have an average age of 9,080 years (Lander, in preparation).

### METHODS

#### Upper Topanga Formation

Because the fossil wood specimen from the Upper Topanga Formation is permineralized and partially replaced, the specimen was prepared for analysis using a cellulose acetate peel technique modified from that described by Andrews (1947). The specimen first was cut on a rock saw to obtain three oriented surfaces (transverse, longitudinal radial, longitudinal tangential), and each surface then was polished using progressively finer abrasives. After polishing, one surface was etched by immersing in 52% hydrochloric acid for 30 to 60 seconds. The surface then was gently rinsed in tap water and

allowed to dry. The specimen then was placed in sand so that the surface was oriented horizontally. The surface subsequently was flooded with acetone and immediately covered with a thin sheet of acetate previously cut to cover the surface with a slight overlap. After drying, the acetate sheet was peeled off the surface, a thin layer of wood tissue adhering to the sheet. An acetate peel section was prepared in this way for each of the three polished surfaces. The detailed cellular anatomy of each peel section then was examined and photographed using Polaroid black and white film in a Polaroid camera mounted on a Zeiss photomicroscope.

#### Undifferentiated Older and Younger Alluvium

Because the wood specimens from the undifferentiated older and younger alluvium are not petrified, a different technique was used to prepare the wood samples for analysis. Oriented 5-mm cubic blocks of wood were cut from each fossil specimen from the older and younger alluvium. The blocks first were softened by gently boiling in a 50:50 mixture of water and 5% acetic acid until they became waterlogged and sank (approximately 1 hour) and then by boiling in 50% glycerol for approximately 1 additional hour. Some of the specimens then were immersed in a 50:50 mixture of commercial hydrogen peroxide and glacial acetic acid for up to 1 hour to further softening, bleach darkened wood, and to remove lignin and tannin from heartwood. Further chemical treatment, embedding, and staining were not required. After softening, the transverse, radial, and tangential surfaces of each block were cut using a razor blade. Transverse (cross), longitudinal tangential, and longitudinal radial thin sections approximately 50 to 100 microns thick then were cut from these surfaces using a razor blade. The thin sections were permanently mounted on standard microscope slides using Harleco Synthetic Resin as the mounting medium and covered with a cover slip. Slides then were labeled with the specimen number, family, genus, and fossil site data. The detailed cellular anatomy of each thin section was examined and photographed using Polaroid black and white film in a Polaroid camera mounted on a Zeiss photomicroscope. The specimens were identified by comparing their anatomical details with those in thin sections of previously identified modern wood specimens and with those of wood specimens illustrated and described by Barefoot and Hankins (1982), Greguss (1955), Hoadley (1990), Kribs (1968), Metcalfe and Chalk (1950), Panshin and de Zeeuw (1970), Phillips (1941, 1948), Record (1919), and Wheeler and others (1986). The remaining

softened wood blocks were stored in a weak solution of glycerol and acetic acid in sealed and labeled glass vials to prevent decay.

### RESULTS

#### Upper Topanga Formation

Prior to preparation, the specimen from the Upper Topanga Formation was a 7.5 x 12.5 x 25.5-cm fragment of deformed, poorly preserved, permineralized, partially replaced, medium-brown wood with small veins of pyrite. Cellular detail was not visible under hand-lens (10X) magnification. Under microscopic examination, the specimen was observed to contain faint growth rings, but no cellular detail was visible. The specimen represents either a conifer or an angiosperm, but, because of poor preservation, is otherwise taxonomically indeterminate. Nevertheless, this specimen is scientifically highly important because the wood of land plants is very rare in the marine fossil record and has not been reported previously from the Upper Topanga Formation in the Santa Monica Mountains.

#### Older Alluvium

Prior to preparation, specimen DPW 2516 consisted of several pieces of wood, the largest being 6.0 x 10.0 x 10.5 cm, cut from a larger piece of very well preserved, medium-brown wood probably broken from the outer portion of a trunk greater than 30.0 cm in diameter. Specimen DPW 2565 was a 2.5 x 3.5 x 15.5-cm piece of well preserved, desiccated, 'stringy', dark-brown wood probably from the outer section of a root greater than 7.0 cm in diameter. The periderm (bark) was present. The rings were distinct and approximately 1.5 mm wide in DPW 2516 and less than 1.0 mm wide in DPW 2565, and small thin rays were visible on the radial surfaces of DPW 2516. No vessels or resin ducts were observed in either specimen, but cellular detail was visible under hand-lens (10X) magnification.

Under microscopic examination, both specimens were observed to contain distinct growth rings with an abundance of parenchyma in each ring, ray cells with cupressoid cross-field pitting, tracheid walls without spiral thickenings, some uniseriate xylary rays exceeding 20 cells in height, ray parenchyma with nodular end walls, and otherwise unidentified dark contents (possibly oils/resins) (see Figures 1, 2). No vessels or resin ducts were observed.

The absence of vessels and resin ducts indicates that

the specimens represent neither an angiosperm nor a member of the family Pinaceae (pines), but instead represent a conifer other than pine. As in members of the family Cupressaceae (cedars) and unlike members of the families Taxodiaceae (redwoods) and Taxaceae (yews), the specimens are characterized by the presence of ray parenchyma with nodular end walls and the absence of spiral thickenings in the tracheid walls. Both specimens are assignable to *Calocedrus* (= *Libocedrus*) and indistinguishable from the modern species *Calocedrus decurrens* (incense cedar).

Today, *Calocedrus* occurs in the mountains of southern California at elevations greater than 2,500 to 3,000 feet above sea level (McMinn and Maino, 1963; Peattie, 1991; Storer and Usinger, 1963). *Calocedrus*, along with *Pinus ponderosa* (ponderosa pine), *Abies concolor* (white fir), *Pseudotsuga menziesii* (Douglas fir), *Pinus lambertiana* (sugar pine), and in some areas *Pinus coulteri* (Coulter pine), is part of the montane coniferous forest plant community (Ornduff, 1974).

The presence of *Calocedrus* in the older alluvium suggests that the late Pleistocene climate of the San Fernando Valley at least 46,000 years ago was considerably wetter and probably cooler than now and comparable to climates found at higher elevations in southern California today. Moreover, uniform tracheid size throughout each growth ring and growth rings delineated by only a few smaller tracheids in both specimens of fossilized wood submitted for analysis (see Figures 1, 2) suggest an equable cool-wet climate with a relatively long uniform growing season and only a short period unfavorable for growth. However, comparatively narrow growth rings only 1.0 to 1.5 mm wide suggest that, although the climate was equable, it was not ideal for growth. A uniformly cool climate with a short cold winter and a relatively uniform seasonal distribution of rainfall is more likely. The climate that probably characterized the San Fernando Valley at least 46,000 years ago is in marked contrast to the strong seasonality characteristic of the Mediterranean climate, with its hot dry summers and warm wet winters, that exists in the region today, and presumably was similar to climates found at higher elevations and/or higher latitudes in California today. This conclusion is consistent with palynological (pollen) evidence (Haga, H., in Micropaleo Consultants Inc., 1996b) demonstrating the association of redwood/sequoia with *Calocedrus* in the San Fernando Valley tunnel segment. Modern redwood and sequoia are restricted to areas of northern and central California

characterized by a much cooler and wetter climate than found in the San Fernando Valley today (McMinn and Maino, 1963; Peattie, 1991; Storer and Usinger, 1963).

The floral assemblage from the older alluvium at the North Hollywood station site and in the San Fernando Valley tunnel segment is scientifically highly important because it probably represents the first reported fossil occurrence of a late Pleistocene floral assemblage from the San Fernando Valley and includes the first reported fossil occurrence of *Calocedrus*. Moreover, the plant remains have been critical in paleoenvironmental reconstruction of the San Fernando Valley tunnel segment and North Hollywood station site and paleoclimatic reconstruction of the San Fernando Valley and vicinity during the late Pleistocene Epoch at least 46,000 years ago.

#### Younger Alluvium

Prior to preparation, specimen DPW 2505 was a 5.0 x 11.0 x 16.0-cm fragment of deformed, poorly preserved, dense, medium-brown wood probably broken from the inner portion of a trunk greater than 25.0 cm in diameter. Specimen DPW 2509 was a 3.0 x 9.5 x 10.5-cm piece cut from a larger piece of desiccated, partially charcoaled, soft, very-dark-brown to black wood from the outer section of a trunk or limb probably greater than 30.0 cm in diameter. Growth rings, vessels, and resin ducts were not visible in either specimen during initial visual examination, although fine rays were visible on the radial face of DPW 2509, and cellular detail was not visible under hand-lens (10X) magnification.

Under microscopic examination, both specimens were observed to consist of semi-diffuse porous hardwood with early-wood vessels somewhat larger than those in late wood; indistinct growth rings; vessels arranged in radial multiples of 1 to 3 (DPW 2509) or 4 (DPW 2505) (1 most common); simple perforation plates on vessel end walls; intervascular pits that are bordered, alternate, simple, and oval to angular in shape; abundant non-sclerotic tyloses; and rays that are uniseriate (rarely biseriate), homocellular, 5 to 9 (DPW 2505) or 7 to 12 (DPW 2509) cells high, and, in DPW 2505, with central cells that are larger and round in shape (see Figures 3, 4).

The presence of vessels indicates both specimens represent angiosperms. A combination of characters, including diffuse vessels, indistinct growth rings, simple perforation plates, and uniseriate rays,

indicates both specimens are assignable to the family Salicaceae (willows). However, neither specimen is assignable to *Platanus* (sycamore), which lacks uniseriate rays. Although *Populus* (cottonwood, aspen) and *Salix* (willow) are very similar to one another, the rays in *Salix* always are heterocellular, but essentially are homocellular in *Populus* (Panshin and de Zeeuw, 1970). Ray cells in specimen DPW 2509 nearly always appear to be homocellular. Therefore, the specimens are assignable to *Populus*. Moreover, the specimens came from relatively long straight logs typical of *Populus*, while *Salix* most often is a low bush and usually does not grow as a tree with a single straight trunk.

A palynological (pollen) sample (DPW 2502) recovered from fine-grained sediments associated with specimen DPW 2505 and subsequently submitted for microfossil analysis did not contain pollen of *Populus* or *Salix* (Haga, H., in Micropaleo Consultants, Inc., 1996a). However, the pollen cell wall of *Populus* is one of the thinnest of all tree pollen and easily destroyed (Faegri and Iversen, 1975). The absence of *Populus* pollen is not inconsistent with the presence of its wood. On the other hand, pollen of *Salix* is much more resilient, is produced in large quantities, and is easily recognizable. Therefore, the absence of *Salix* pollen corroborates identification of the fossilized wood specimens as *Populus*.

According to Panshin and de Zeeuw (1970), cottonwoods can be distinguished from aspens based on the diameter of vessels measured in tangential sections. Cottonwoods have vessel diameters ranging from 75 to 150 microns, while aspen vessel diameters range from 50 to 100 microns. In specimens DPW 2505 and 2509, vessel diameters range from 58 to 106 and from 61 to 115 microns with mean tangential diameters of 83 and 79 microns, respectively. Although not confined to the observed range of either species, these figures probably are low as a result of degradation and of compression of the wood during compaction of the surrounding sediments, suggesting that both specimens of fossilized wood submitted for analysis represent cottonwood rather than aspen. This conclusion is consistent with the current fossil site elevation (approximately 515 feet above sea level), which is within the range of cottonwood, but far below that of aspen, which does not occur at elevations less than 5,000 feet above sea level (McMinn and Maino, 1963).

The presence of *Populus* in the younger alluvium does not provide detailed information regarding the

early Holocene climate of the San Fernando Valley because modern species in this genus occur over a wide range of temperatures and elevations. In southern California today, cottonwood occurs at elevations ranging from near sea level to approximately 8,000 feet, and most commonly is found either in the riparian zone or along the borders of rivers, lakes, and wet meadows, appearing to require permanently moist soils (McMinn and Maino, 1963). Cottonwood is part of the riparian woodland plant community (Ornduff, 1974). The fossil site is only 0.25 mile south of the modern Los Angeles River channel and might have been immediately adjacent to the river during the early Holocene Epoch. The presence of cottonwood in the San Fernando Valley approximately 9,000 years ago is not inconsistent with associated palynological data (occurrence of *Ephedra*, cf. *E. nevadensis* pollen; Haga, H., in Micropaleo Consultants, Inc., 1996a) from the Universal City station site that suggest the early Holocene climate of the region was considerably dryer and more extreme, with hotter summers and colder winters, than today and especially during the late Pleistocene Epoch at least 46,000 years ago. Today, *Ephedra nevadensis* (Mormon tea) occurs in the Mojave Desert and the adjacent lower slopes of the northern San Gabriel and San Bernardino Mountains. However, spores of *Selaginella* (clubmoss), *Sphagnum* (peat moss), and the Polypodiaceae (ferns) suggest cooler and wetter environments, including those found in restricted habitats, such as bogs.

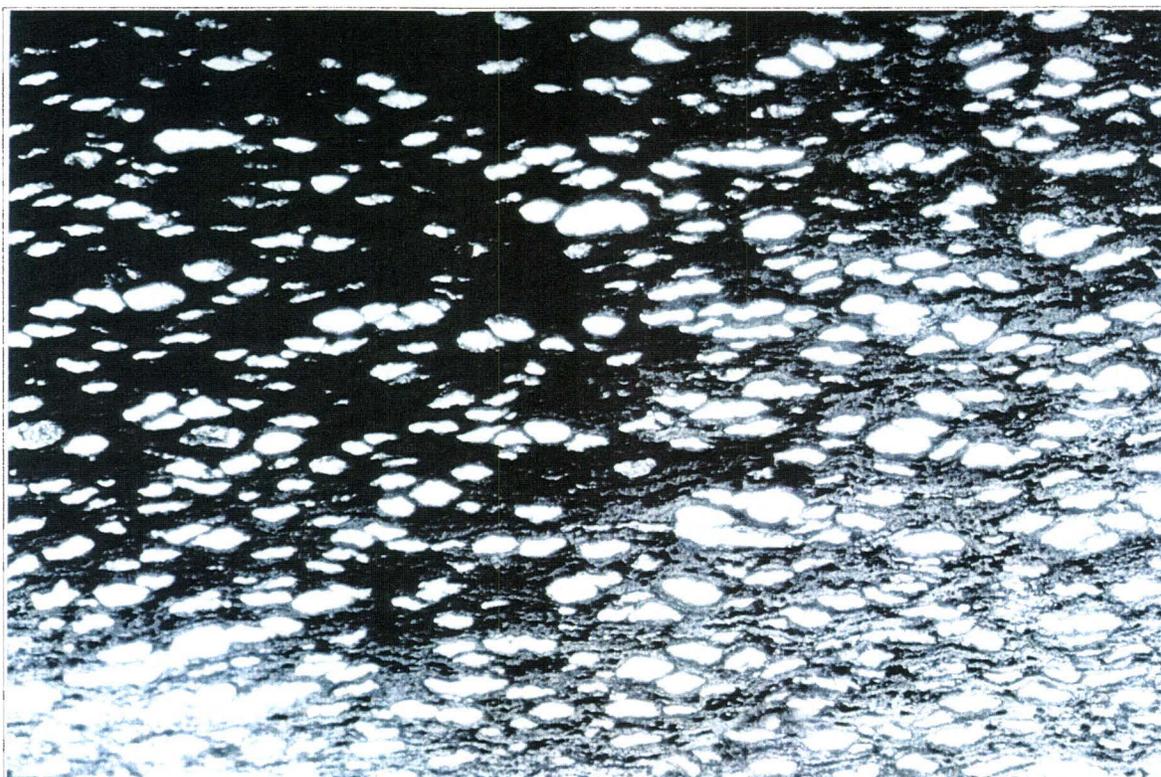
The floral assemblage from the younger alluvium at the Universal City station site is scientifically highly important because it probably represents the first reported fossil occurrence of an early Holocene floral assemblage from the Los Angeles basin and vicinity (including San Fernando Valley). Moreover, the plant remains have been critical in paleoenvironmental reconstruction of the station site and paleoclimatic reconstruction of the San Fernando Valley and vicinity during the early Holocene Epoch approximately 9,080 years ago.

#### ACRONYMS AND ABBREVIATIONS

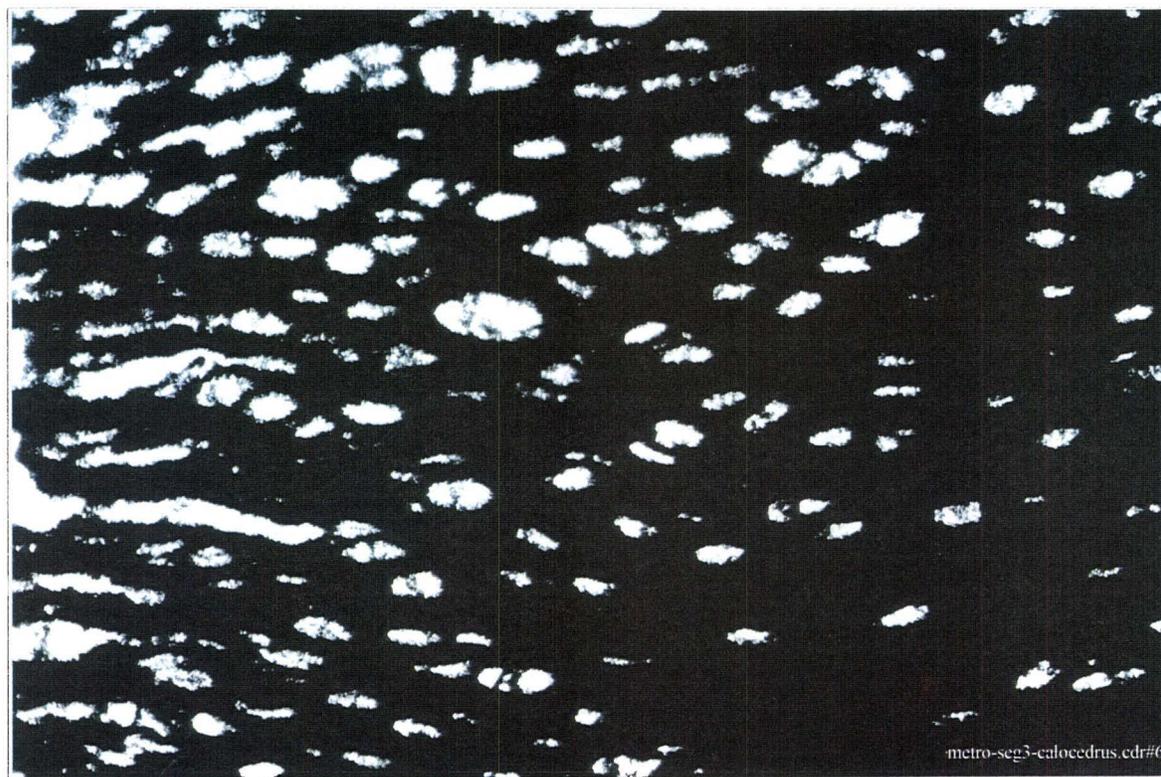
cm	centimeter
DPW	David P. Whistler, PEAI
F&F	F & F GeoResource Associates, Inc.
mm	millimeter
PEAI	Paleo Environmental Associates, Inc.
RDT	Robin D. Turner, PEAI
X	times

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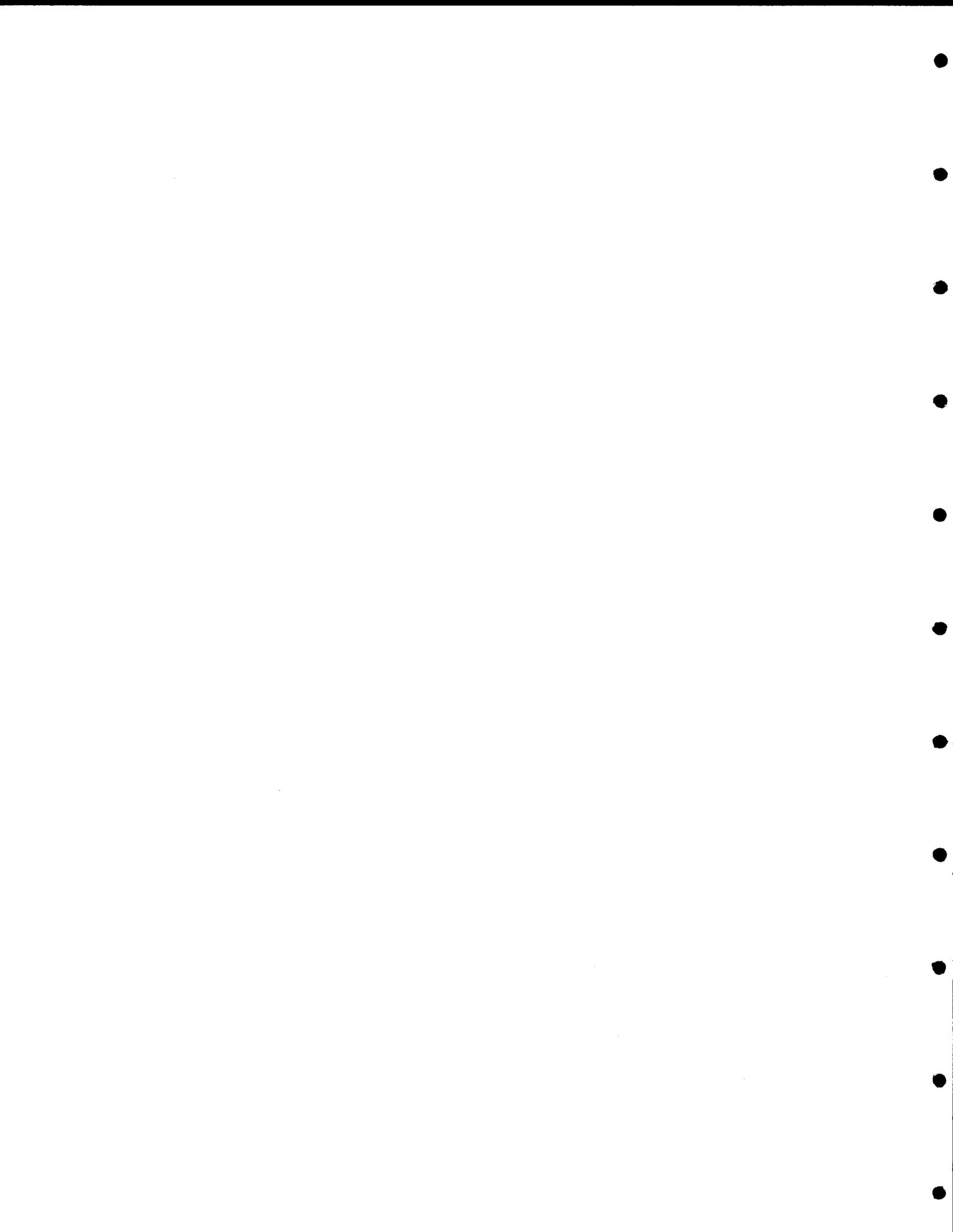
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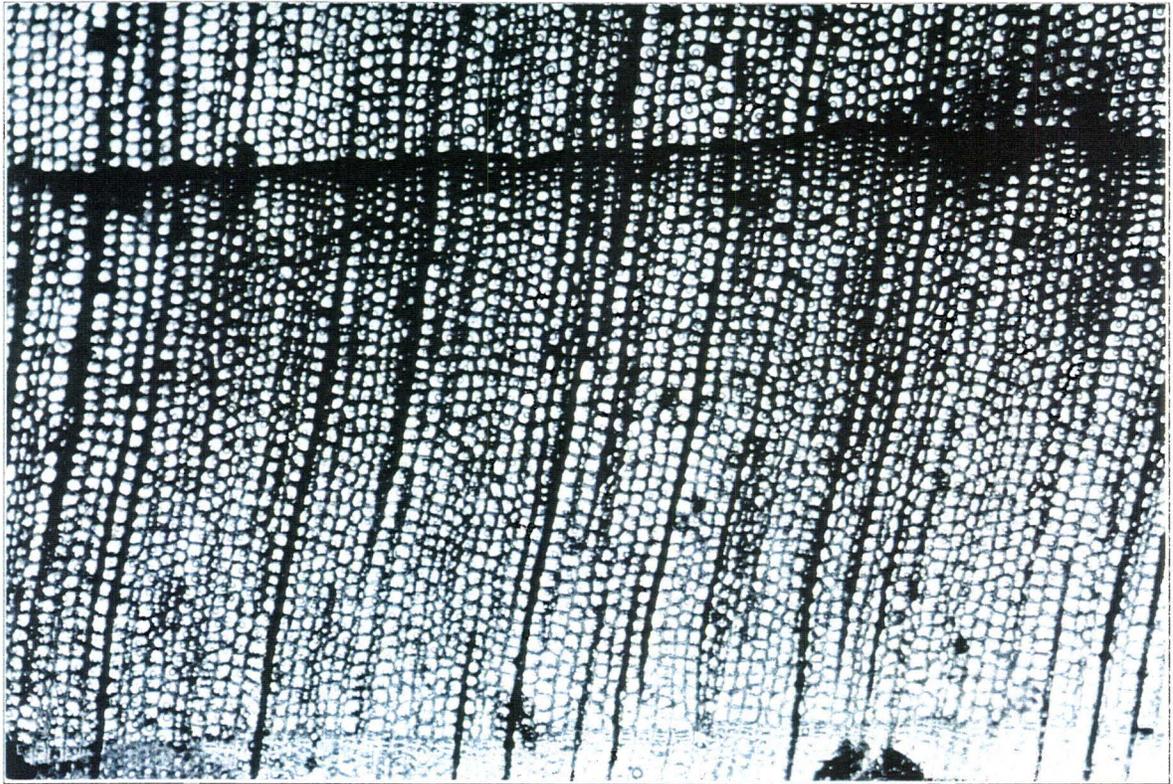


**Figure 1.**—Photomicrograph of *Calocedrus* (PEAI fossil specimen DPW 2516), older alluvium, North Hollywood station site. Transverse section. 400 times natural size.

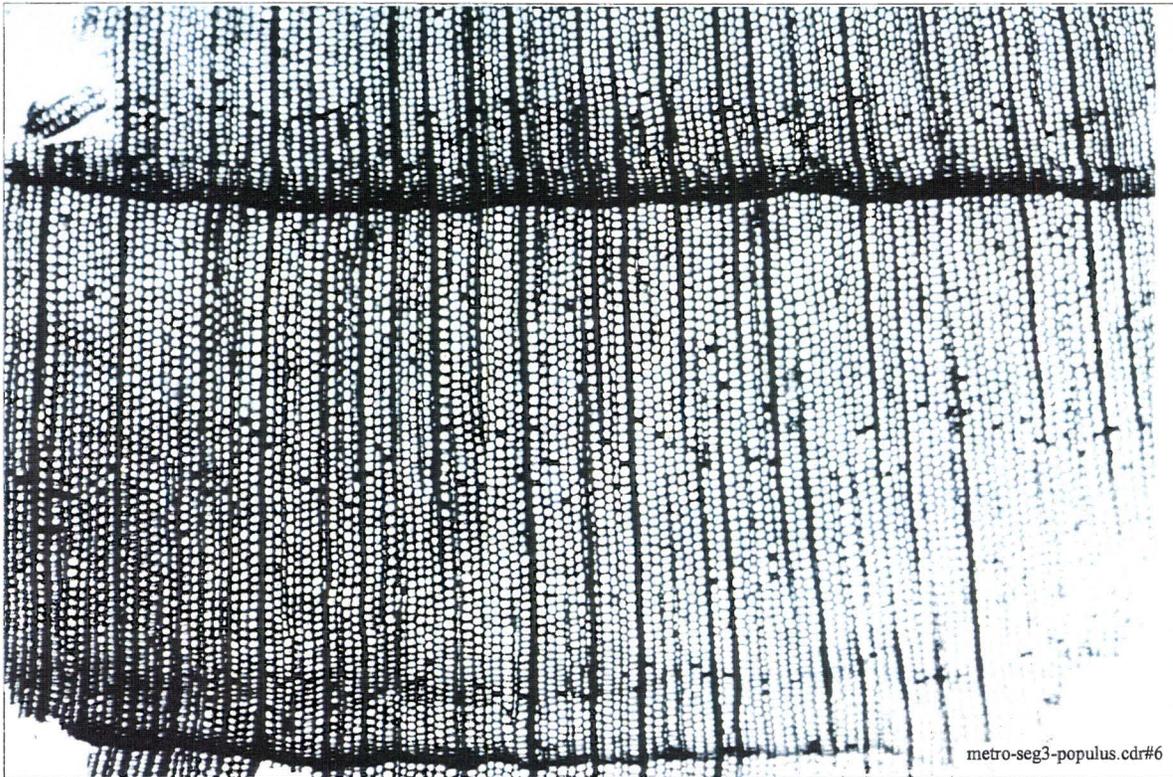


**Figure 2.**—Photomicrograph of *Calocedrus* (PEAI fossil specimen DPW 2565), older alluvium, San Fernando Valley tunnel segment. Transverse section. 400 times natural size.





**Figure 3.**—Photomicrograph of *Populus* (PEAI fossil specimen DPW 2502), younger alluvium, Universal City station site. Transverse section. 400 times natural size.



**Figure 4.**—Photomicrograph of *Populus* (PEAI fossil specimen DPW 2509), younger alluvium, Universal City station site. Transverse section. 400 times natural size.



**APPENDIX V**

**[letter report regarding results of analysis of fossil wood sample number Beta-86689 (PEAI DPW 2505)]**

**Beta Analytic Inc.**

**November 28, 1995**



**BETA ANALYTIC INC.**

DR. J.J. STIPP and DR. M.A. TAMERS

UNIVERSITY BRANCH  
 4985 S.W. 74 COURT  
 MIAMI, FLORIDA, USA 33155  
 PH: 305/667-5167 FAX: 305/663-0964  
 E-mail: beta@analytic.win.net

**REPORT OF RADIOCARBON DATING ANALYSES**

FOR: Dr. David P. Whistler  
 Paleo Environmental Associates

DATE RECEIVED: October 16, 1995  
 DATE REPORTED: November 28, 1995

Sample Data	Measured C14 Age	C13/C12 Ratio	Conventional C14 Age (*)
Beta-86689	8880 +/- 60 BP	-25.0* o/oo	8880 +/- 60* BP

SAMPLE #: DPW 2505  
 ANALYSIS: radiometric-standard  
 MATERIAL/PRETREATMENT:(wood): acid/alkali/acid

NOTE: It is important to read the calendar calibration information and to use the calendar calibrated results (reported separately) when interpreting these results in AD/BC terms.

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (\*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: estimated C13/C12=-25; lab mult.=1)

Laboratory Number: Beta-86689

Conventional radiocarbon age\*: 8880 +/- 60 BP

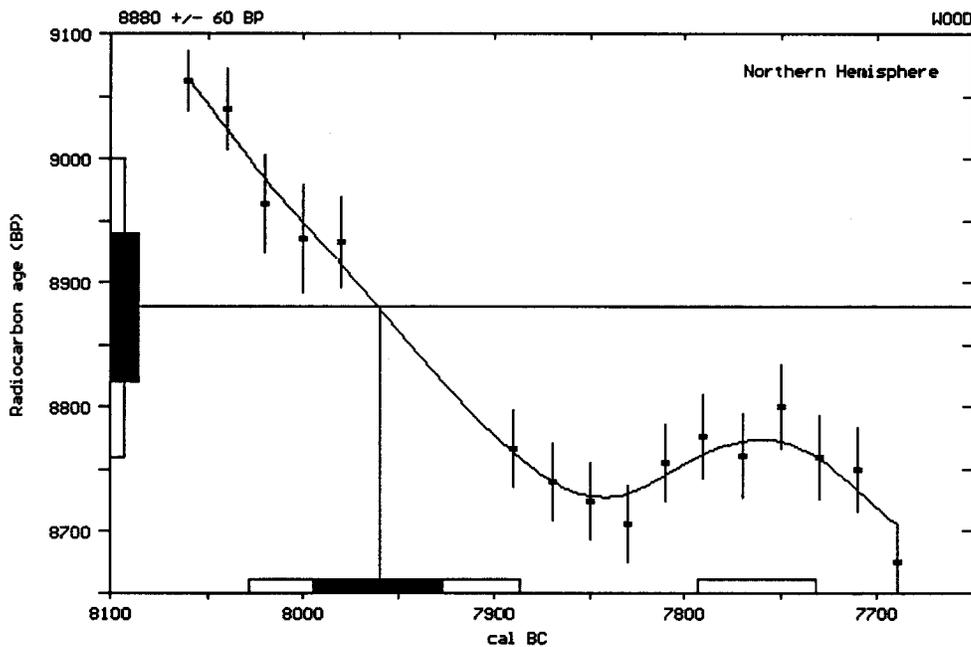
Calibrated results: cal BC 8030 to 7885 and  
(2 sigma, 95% probability) cal BC 7795 to 7730

\* C13/C12 ratio estimated

Intercept data:

Intercept of radiocarbon age  
with calibration curve: cal BC 7960

1 sigma calibrated results: cal BC 7995 to 7925  
(68% probability)

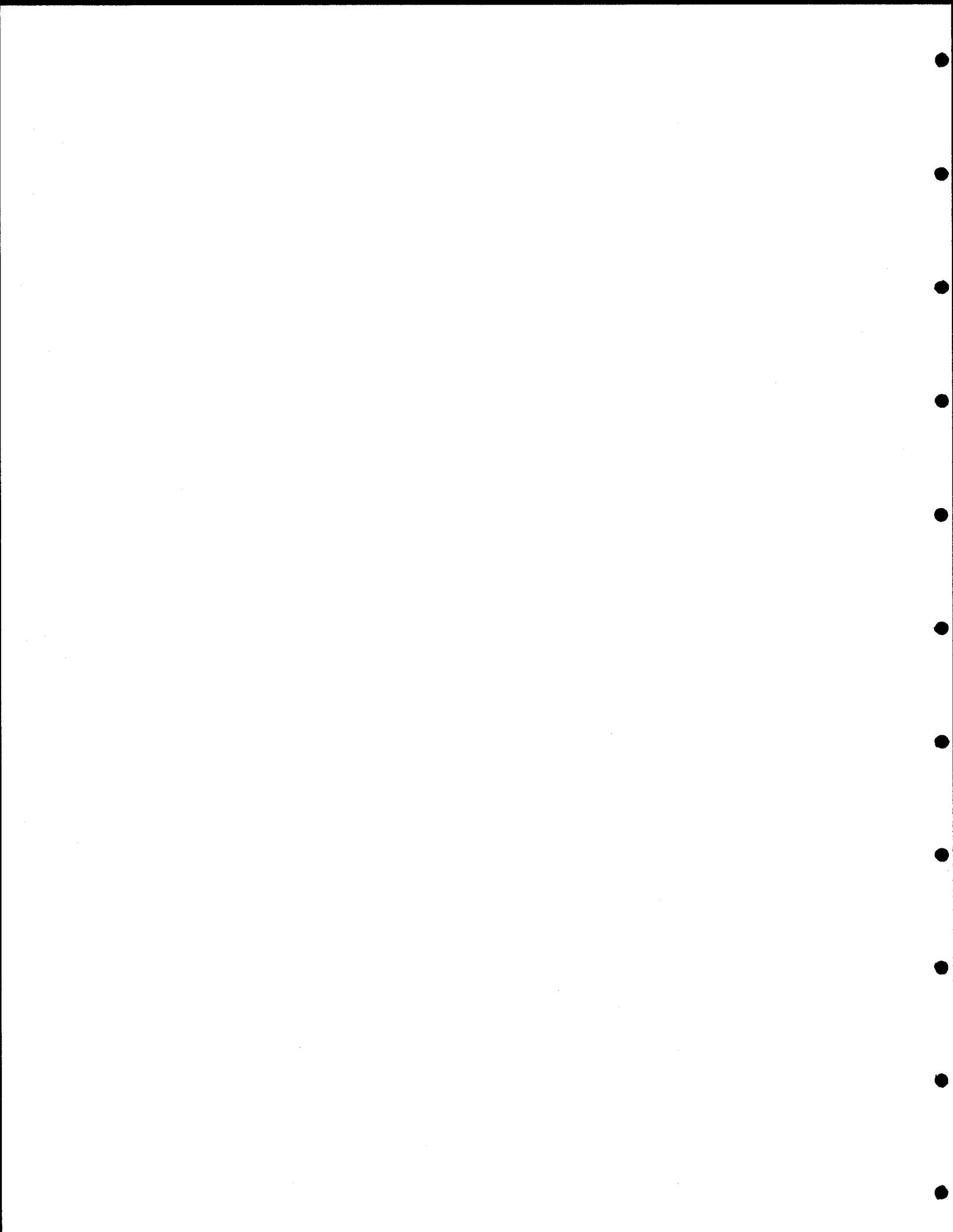


References:

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- A Simplified Approach to Calibrating C14 Dates*  
Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
- Calibration - 1993*  
Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

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**APPENDIX W**

**[letter report regarding results of analysis of fossil wood sample number Beta-90086 (PEAI DPW 2516)]**

**Beta Analytic Inc.**

**February 27, 1996**



**BETA ANALYTIC INC.**

DR. J.J. STIPP and DR. M.A. TAMERS

UNIVERSITY BRANCH  
 4985 S.W. 74 COURT  
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 E-mail: beta@analytic.win.net

**REPORT OF RADIOCARBON DATING ANALYSES**

FOR: Dr. David P. Whistler  
 Paleo Environmental Associates

DATE RECEIVED: January 29, 1996  
 DATE REPORTED: February 27, 1996

Sample Data	Measured C14 Age	C13/C12 Ratio	Conventional C14 Age (*)
Beta-90086	> 46340 years BP	-25.0* o/oo	> 46340 years BP*
SAMPLE #: DPW2516 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(wood): acid/alkali/acid			

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (\*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

**APPENDIX X**

**[letter report regarding results of analysis of fossil wood sample number Beta-99228 (PEAI DPW 2565)]**

**Beta Analytic Inc.**

**December 31, 1996**



**BETA ANALYTIC INC.**

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH  
 4985 S.W. 74 COURT  
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 E-MAIL: beta@radiocarbon.com

**REPORT OF RADIOCARBON DATING ANALYSES**

FOR: Dr. David P. Whistler  
 Paleo Environmental Associates

DATE RECEIVED: November 15, 1996  
 DATE REPORTED: December 31, 1996

Sample Data	Measured C14 Age	C13/C12 Ratio	Conventional C14 Age (*)
Beta-099228	> 48620 years BP	-25.0* o/oo	> 48620 years BP

SAMPLE #: DPW 2565  
 ANALYSIS: radiometric-standard  
 MATERIAL/PRETREATMENT:(wood): acid/alkali/acid

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (\*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

APPENDIX Y

[letter report regarding results of analyses of fossil wood sample  
numbers Beta-102794, -102795 (PEAI RDT 96822, 961015)]

Beta Analytic Inc.

March 26, 1997



**BETA ANALYTIC INC.**

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH  
 4985 S.W. 74 COURT  
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**REPORT OF RADIOCARBON DATING ANALYSES**

FOR: Dr. David P. Whistler  
 Paleo Environmental Associates

DATE RECEIVED: February 14, 1997  
 DATE REPORTED: March 26, 1997

Sample Data	Measured C14 Age	C13/C12 Ratio	Conventional C14 Age (*)
Beta-102794	7860 +/- 80 BP	-25.0* o/oo	7860 +/- 80* BP

SAMPLE #: RDT 961015  
 ANALYSIS: radiometric-standard  
 MATERIAL/PRETREATMENT:(wood): acid/alkali/acid

Beta-102795	10500 +/- 70 BP	-25.0* o/oo	10500 +/- 70* BP
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SAMPLE #: RDT 96822  
 ANALYSIS: radiometric-standard  
 MATERIAL/PRETREATMENT:(wood): acid/alkali/acid

NOTE: It is important to read the calendar calibration information and to use the calendar calibrated results (reported separately) when interpreting these results in AD/BC terms.

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (\*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

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(Variables: estimated C13/C12=-25; lab mult.=1)

Laboratory Number:      Beta-102794

**Conventional radiocarbon age\*:**      **7860 ± 80 BP**

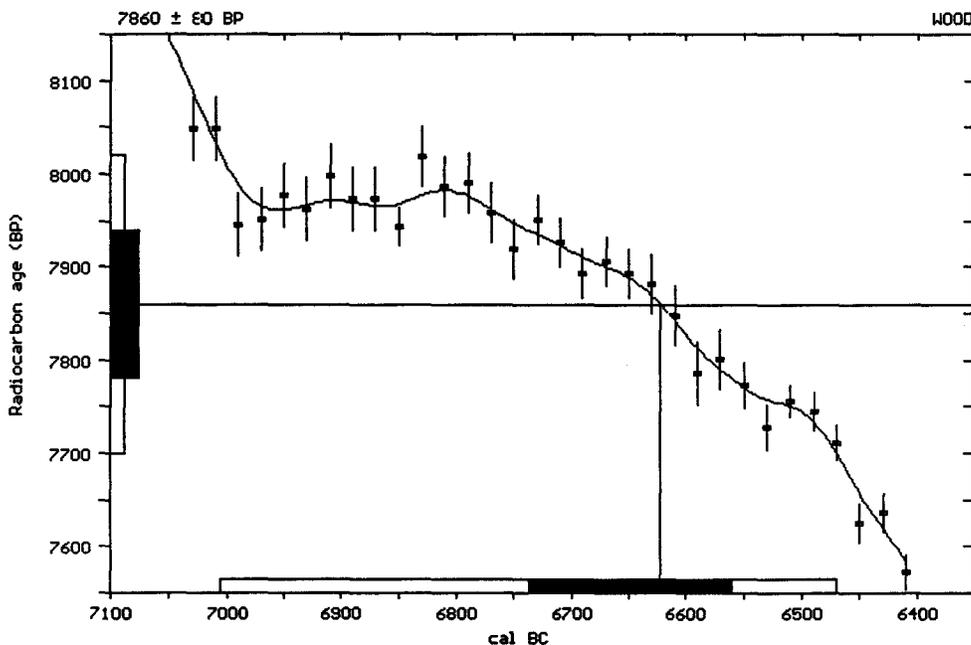
**Calibrated results:**      **cal BC 7005 to 6470**  
 (2 sigma, 95% probability)

\* C13/C12 ratio estimated

Intercept data:

Intercept of radiocarbon age  
with calibration curve:      cal BC 6625

1 sigma calibrated results:      cal BC 6735 to 6560  
 (68% probability)



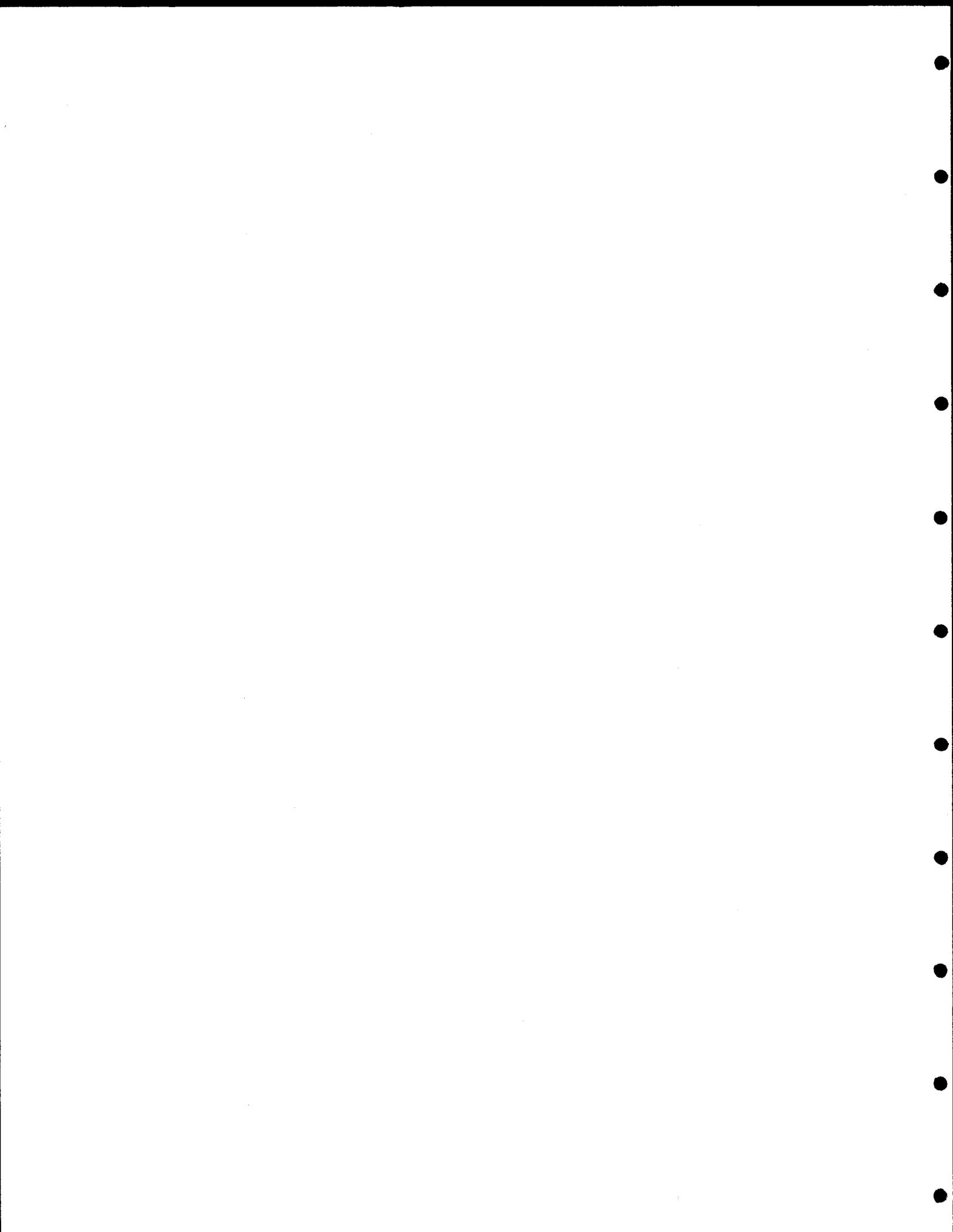
References:

- Pretoria Calibration Curve for Short Lived Samples*  
 Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
- A Simplified Approach to Calibrating C14 Dates*  
 Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
- Calibration - 1993*  
 Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

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APPENDIX Z

EARLY HOLOCENE FOSSIL MOLLUSK REMAINS FROM YOUNGER ALLUVIUM,  
METRO RED LINE SEGMENT 3 CONSTRUCTION ZONE,  
UNIVERSAL CITY STATION SITE, LOS ANGELES, CALIFORNIA

Lindsey T. Groves  
Senior Invertebrate Paleontologist

Paleo Environmental Associates, Inc.

March 1998

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SUMMARY

The shells of nonmarine mollusks were recovered from early Holocene strata in the younger alluvium at two newly recorded Natural History Museum of Los Angeles County Invertebrate Paleontology Section (LACMIP) fossil sites at the Los Angeles Metro Red Line Universal City station site (Lander, in preparation). The shells were identified using standard taxonomic references (Henderson, 1935; Taylor, 1966; Woodring and others, 1940) and the environmental preferences of their respective genera determined.

With the exception of the shells of the waxy tightcoil snail *Pristiloma gabrielinum*, all of the shells recovered at the station site represent fresh-water snails and clams whose modern representatives inhabit clear, quiet, permanent to subpermanent, flowing streams and/or lakes with muddy to sandy bottoms that contain abundant rooted vegetation. Of the species recovered at the station site, *Pisidium compressum*, *Gyraulus parvus*, and *Planorbella tenuis* also have been recovered in Pit 91 at the La Brea tar pits (Lamb, 1989), and *Amnicola longinqua* and *Physa* have been recovered from the late Pleistocene marine Palos Verdes Sand in the Palos Verdes Hills (Woodring and others, 1946). Modern representatives of the terrestrial waxy tightcoil snail occur in areas characterized by a Mediterranean climate with mild wet winters and hot dry summers, and commonly are found in leaf litter occurring under logs lying near bodies of water.

The fossil molluscan assemblage from the younger alluvium at the Universal City station site is scientifically highly important because it probably represents the first reported fossil occurrence of an early Holocene nonmarine molluscan assemblage from the Los Angeles basin and vicinity (including

San Fernando Valley), and includes the first reported fossil occurrence of *Pristiloma gabrielinum*. Moreover, the mollusk remains have been critical in paleoenvironmental reconstruction of the station site and paleoclimatic reconstruction of the San Fernando Valley during the early Holocene Epoch.

LITERATURE CITED

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Lander, E.B. In preparation. Los Angeles Metro Red Line Project paleontologic resource impact mitigation program final technical report of findings. Paleo Environmental Associates, Inc., project 94-6A/B. Prepared for Los Angeles County Metropolitan Transportation Authority.

Henderson, J. 1935. Fossil non-marine Mollusca of North America. Geological Society of America Special Paper 3:1-313.

Taylor, D.W. 1966. Summary of North American Blancan nonmarine mollusks. *Malacologia* 4(1):1-172.

Woodring, W.P., Bramlette, M.N., and Kew, W.S.W. 1946. Geology and paleontology of the Palos Verdes Hills, California. U.S. Geological Survey Professional Paper 207:1-145.

Woodring, W.P., Stewart, R., and Richards, R.W. 1940. Geology of the Kettleman Hills oil field, California. U.S. Geological Survey Professional Paper 195:1-170.

**Table 1.**—Taxonomic list, mollusks, younger alluvium, Los Angeles Metro Red Line Segment 3 construction zone, Universal City station site, Los Angeles, California.

Class	Genus, Species	Common Name	LACMIP <sup>a</sup> Fossil Site Number		Environment	
			16966	16967	FW <sup>b</sup>	T <sup>b</sup>
Bivalvia	<i>Anodonta</i> sp. <sup>c</sup>	floaters clam		X		X
	<i>Pisidium compressum</i> Prime?, 1851	ridged-beak peaclam		X		X
Gastropoda	<i>Amnicola longinqua</i> Gould?, 1855	dusky snail		X		X
	<i>Gyraulus parvus</i> (Say?, 1817)	ash gyro	X	X		X
	<i>Physa</i> sp.	physa		X		X
	<i>Planorbella tenuis</i> (Dunker?, 1850)	Mexican rams-horn snail		X		X
	<i>Pristiloma gabrielinum</i> (Berry?, 1924)	waxy tightcoil snail		X		X
<sup>a</sup> Natural History Museum of Los Angeles County Invertebrate Paleontology Section.						
<sup>b</sup> FW: fresh water;						
T: terrestrial.						
<sup>c</sup> sp.: species.						

APPENDIX AA

EARLY HOLOCENE CONTINENTAL VERTEBRATE  
FOSSIL REMAINS FROM YOUNGER ALLUVIUM,  
METRO RED LINE SEGMENT 3 CONSTRUCTION ZONE,  
UNIVERSAL CITY STATION SITE, LOS ANGELES, CALIFORNIA

David P. Whistler, Ph.D.  
Senior Vertebrate Paleontologist

Paleo Environmental Associates, Inc.

March 1998

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SUMMARY

Forty-nine identifiable fossil bones and teeth representing fifteen small continental vertebrate species, as well as hundreds of fossil bones and bone fragments representing otherwise unidentifiable small continental vertebrate species, were recovered at three newly recorded Natural History Museum of Los Angeles County Vertebrate Paleontology Section (LACMVP) fossil sites (LACMVP fossil sites 6306, 6385, 6386) in the lower 10 feet of the Holocene younger alluvium at the Metro Red Line Segment 3 Universal City station site. The specimens were recovered as a result of the paleontologic resource impact mitigation program conducted by Paleo Environmental Associates, Inc., most of the specimens having been recovered at LACMVP fossil site 6306. The identifiable specimens, which represent fresh-water fishes, frogs, lizards, snakes, birds, insectivores, lagomorphs, and rodents, subsequently were assigned LACMVP fossil specimen numbers.

The continental fossil vertebrate assemblage from the younger alluvium at the Universal City station site, early Holocene and, based on an average of three carbon-14 radiometric age determinations, approximately 9,080 years in age (Beta Analytic Inc., 1995, 1997; Lander, in preparation), is dominated by species whose modern descendants inhabit moister terrestrial environments. The assemblage is similar to modern assemblages inhabiting the margins of permanent fresh-water streams and ponds in southern California, and the fishes are similar to those now inhabiting these streams and ponds. Moreover, the fossil-bearing sediments, fine grained and organic rich, appear to represent stream and pond deposits. The station site, only 0.25 mile south of the modern Los Angeles River channel, might have been in and/or immediately adjacent to the river channel

during the early Holocene Epoch.

Fishes are represented in the Universal City station fossil vertebrate assemblage by a small, otherwise unidentified species of stickleback (Family Gasterosteidae), a species that today inhabits brackish-water and fresh-water streams in southern California. Two species of frogs, including a small species of tree frog (Family Hylidae) and the larger pond frog *Rana* sp., also are documented as occurring in the assemblage, as are two species of snakes, including the comparatively common, semi-aquatic garter snake *Thamnophis* sp. and the comparatively rare black-headed snake *Tantilla* sp., which also inhabits relatively moist environments. Two lizard species, the alligator lizard *Gerrhonotus* sp., which inhabits comparatively moist environments, and the side-blotched lizard *Uta* sp., which inhabits more arid environments, occur in the assemblage. A small sparrow-sized species of bird also occurs in the assemblage, as do the shrew *Sorex* sp., cottontail *Sylvilagus* sp., and five rodent species, including Botta's pocket gopher *Thomomys bottae*, the pocket mouse *Perognathus* sp., the kangaroo rat *Dipodomys* sp., the vole *Microtus* sp., and the deer mouse *Peromyscus* sp. Although gophers, voles, and pocket mice today inhabit comparatively moist environments and grassy habitats, pocket mice also occupy more arid environments, while kangaroo rats and deer mice occur in a diversity of habitats. Environmental preferences of the modern representatives of the species comprising the Universal City station fossil vertebrate assemblage, lithology of the fossil-bearing sediments, and the proximity of the station site to the modern Los Angeles River channel suggest the fossil sites were in and/or along the Los Angeles River channel during the early Holocene Epoch, approximately 9,080 years ago. All of the species represented in the Universal City station assemblage also occur in the late Pleistocene continental

vertebrate assemblage from the older alluvium at the La Brea tar pits in the Hancock Park area of Los Angeles (see Jefferson, 1991a, -b).

The vertebrate assemblage from the younger alluvium at the Universal City station site is scientifically highly important because it is comparatively diverse taxonomically and probably represents the first reported fossil occurrence of an early Holocene continental vertebrate assemblage from the Los Angeles basin and vicinity (including San Fernando Valley). Moreover, the vertebrate remains have been critical in paleoenvironmental reconstruction of the station site during the early Holocene Epoch, approximately 9,080 years ago.

#### LITERATURE CITED

Beta Analytic Inc. 1995. [Letter report dated 11/28/95 to D.P. Whistler, Paleo Environmental Associates, Inc., regarding results of analysis of fossil wood sample number Beta-86689 (PEAI DPW 2505)]. Prepared for Paleo Environmental Associates, Inc.

Beta Analytic Inc. 1997. [Letter report dated 2/14/96 to D.P. Whistler, Paleo Environmental Associates, Inc., regarding results of analyses of fossil wood sample numbers Beta-102794, 102795 (PEAI RDT 96822, 961015)]. Prepared for Paleo Environmental Associates, Inc.

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Jefferson, G.T. 1991b. A catalogue of late Quaternary vertebrates from California: Part Two, Mammals. Natural History Museum of Los Angeles County Technical Reports Number 7:1-129.

Lander, E.B. In preparation. Los Angeles Metro Red Line Project paleontologic resource impact mitigation program final technical report of findings. Paleo Environmental Associates, Inc., project 94-6A/B. Prepared for Los Angeles County Metropolitan Transportation Authority.

APPENDIX BB

ANALYSIS OF FOSSIL PLANT SPECIMENS FROM  
UNNAMED LATE MIOCENE MARINE SHALE,  
METRO RED LINE SEGMENT 2 CONSTRUCTION ZONE,  
LOS ANGELES, CALIFORNIA

Lanny H. Fisk, Ph.D.

F & F GeoResource Associates, Inc.

January 1999

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SUMMARY

Six fossil noncalcareous intertidal benthic marine algal (seaweed) specimens representing the red algal species *Chondrides flexilis* and the fleshy brown algal species *Paleocystophora plumosa* and *Paleohalidrys californica*, a new species of *Paleohalidrys*, and a new genus and species of brown alga, as well as two fossil leaf specimens representing the land plant species *Populus pliotremuloides* (aspen) and *Rhamnus precalifornica* (buckthorn), were recovered from an unnamed late Miocene shale at the Metro Red Line Segment 2 Vermont/Sunset station site, Los Angeles, California.

The association of land plant and intertidal marine algal remains and their comparatively well-preserved nature indicate that the sediments comprising the marine shale were deposited in a near-shore deep-water marine environment.

The fossil plant remains recovered from the marine shale are scientifically highly important because they have been critical in reconstructing the depositional paleoenvironments represented by the sediments comprising the marine shale. Moreover, the occurrence of plant remains, particularly the association of marine and land plant remains, is comparatively rare in the fossil record. Finally, some of the marine algal remains represent new taxa and the land plant remains represent the first reported fossil occurrences of their respective taxa from the marine shale.

INTRODUCTION

Although plant remains have been reported previously as occurring at numerous fossil sites in middle or late Miocene to early Pliocene marine strata of the Los Angeles basin, some of the fossil

plant remains reported previously as occurring at fossil sites in the Monterey and Puente Formations (as recognized by earlier workers) in the Los Angeles basin actually are from an unnamed late Miocene marine shale as now recognized by Dibblee (1989). The land plant leaf specimen reported by Soper and Grant (1941) as occurring in the Puente Formation at a fossil site in the downtown Los Angeles area is from either the marine shale or the underlying Monterey Formation, and at least some of the noncalcareous benthic marine algal remains reported by Parker and Dawson (1965) as occurring in the Monterey Formation at fossil sites in the northern Santa Monica Mountains also are from the marine shale (Lander, in preparation). The remainder of the specimens presumably are from the Monterey Formation as recognized by Dibblee (1989).

Several specimens of the brown algal species *Paleohalidrys liguliformis* and a fossil leaf specimen resembling the oak *Quercus* (beech family) and members of the laurel family were recovered from the marine shale as a result of the paleontologic resource impact mitigation program conducted by Paleo Environmental Associates, Inc. (PEAI), personnel during excavation at the Los Angeles Metro Red Line Segment 2 Wilshire/Vermont station site and tunneling for the eastern Wilshire Boulevard tunnel segment (Lander, in preparation; Schorn, 1995).

Six fossil marine algal specimens and two fossil angiosperm (land plant) leaf specimens subsequently were recovered from the marine shale as a result of the mitigation program conducted by PEA I personnel during excavation at the Segment 2 Vermont/Sunset station site (Lander, in preparation). These specimens subsequently were submitted to F & F GeoResource Associates, Inc., for identification and paleoenvironmental analysis. This technical report of findings presents the results of the latter tasks. The

plant remains from the Vermont/Sunset station site are from a level stratigraphically lower in the marine shale and, therefore, are older than those from the Wilshire/Vermont station site (Lander, in preparation).

All fossil specimens were prepared and the more complete specimens were identified to the lowest taxonomic level possible by comparing them with fossil plant specimens previously described and illustrated by Axelrod (1936, 1939, 1940, 1944, 1979, 1995), Berry (1916), Dorf (1930), MacGinitie (1962), and Parker and Dawson (1965). The fossil leaf specimens are preserved as impressions with none of the original carbonaceous material remaining, although some morphological details are high-lighted by limonite staining. Primary and secondary venation is visible, but tertiary and quaternary venation is not. The fossil algal specimens are preserved as compressions with some of the original carbonaceous material remaining, although fine morphological details are not well preserved because of the lack of vascularization and the absence of the cuticle. All specimens are incomplete.

## RESULTS

### MARINE ALGAE

Four of the fossil marine algal specimens recovered from unnamed late Miocene marine shale at the Los Angeles Metro Red Line Segment 2 Wilshire/Vermont station site represent noncalcareous intertidal benthic marine algae assignable to the form taxa *Chondrides flexilis*, *Paleocystophora plumosa*, and *Paleohalidrys californica* (Table 1). These taxa and *Paleohalidrys liguliformis* were named, described, and illustrated by Parker and Dawson (1965), and, with the possible exception of *Chondrides flexilis*, occur in the upper marine shale at previously recorded fossil sites in the Santa Monica Mountains (Parker and Dawson, 1965). One of the two remaining specimens probably represents a new species of *Paleocystophora* and the last specimen probably represents a new genus and species of brown alga.

The specimen of *Chondrides flexilis* consists of a fleshy foliose thallus with an apparently flexible, cylindrical primary axis. This specimen appears to be a terminal vegetative branchlet consisting of a dense fascicle of supple, radially branching filaments up to 10 cm in length and gradually tapering to an acute point at the apex. In terms of size and morphology, the specimen resembles the extant algal genus

*Neogardhiella* (previously *Agardhiella*), a common and morphologically extremely variable, intertidal to subtidal red algal species (Division Rhodophyta) found along the Pacific Coast from British Columbia to Baja California (Abbott and Hollenberg, 1976; Smith, 1969).

Each of the two specimens of *Paleocystophora plumosa*, a fleshy brown algal species (Division Phaeophyta), has a foliose thallus with branchlets that are widely spaced and arranged nearly opposite one another, and that occasionally bear irregularly spaced teeth or small projections. Parker and Dawson (1965) noted the morphological similarity of the extinct genus *Paleocystophora* and the modern genus *Cystophora*.

The specimen of *Paleohalidrys californica*, a fossil fleshy brown algal species originally described and named by Gardner (1923) and subsequently illustrated and redescribed by Parker and Dawson (1965), consists of the apex or a lateral branch terminus of an apparently fleshy, symmetrically bipinnately branching, vegetative thallus. Pinnules are short, but irregular in length; lanceolate in shape, but blunt tipped; and congested. Extant, morphologically similar species are referred to the modern genera *Halidrys* and *Cystoseira*. In *Cystoseira*, the apices are deciduous and the basal portion of the thallus is perennial, while, in *Halidrys*, the entire thallus is perennial. In both genera, the apical and basal portions of the thallus have different morphologies and both portions exhibit considerable morphological variability in certain environments. *Halidrys* and *Cystoseira* inhabit lower intertidal to subtidal rocky shorelines along the Pacific Coast from northern Oregon to Baja California (Abbott and Hollenberg, 1976; Smith, 1969).

Two fossil algal specimens from the marine shale at the Wilshire/Vermont station site do not appear to be referable to any previously described algal species and probably represent new species (Table 1). One specimen tentatively is assigned to the form genus *Paleocystophora*. This latter specimen differs from those of *Paleocystophora plumosa* in having more closely spaced pinnules that are distinctly alternate in arrangement and branch from the main axis at a more acute angle. As in *Paleocystophora plumosa*, the specimen has occasional, irregularly spaced teeth or small projections.

The second fossil algal specimen from the Wilshire/Vermont station site has dichotomously branching, antler-like axes, but the two branches of

**Table 1.**—Floral list, late Miocene unnamed marine shale, Los Angeles Metro Red Line Segment 2 Vermont/Sunset station construction zone, Los Angeles, California.

PEAI <sup>a</sup> Fossil Specimen Number	Taxon	Common Name
<b><u>Land-Plants</u></b>		
GTT-951013S-2 <sup>b</sup>	<i>Rhamnus precalifornica</i>	buckthorn
GTT-951218S	<i>Populus pliotremuloides</i>	aspen
<b><u>Marine Algae</u></b>		
GTT-951013S-1	new genus and species	fleshy benthic brown alga
MM-970318-2	<i>Paleocystophora plumosa</i>	fleshy benthic brown alga
MM-970422	<i>Paleocystophora</i> , new species	fleshy benthic brown alga
RDT-970414-1	<i>Chondrides flexilis</i>	noncalcareous benthic red alga
RDT-970414-2	<i>Paleohalidrys californica</i>	fleshy benthic brown alga
RDT-970414-3	<i>Paleocystophora plumosa</i>	fleshy benthic brown alga
<sup>a</sup> PEAI:	Paleo Environmental Associates, Inc.	
<sup>b</sup> GTT:	Gary T. Takeuchi, PEAI;	
MM:	Michael W. Morris, PEAI;	
RDT:	Robin D. Turner, PEAI.	

the dichotomy generally are unequal in length and width. All axes appear to have been nearly cylindrical or compressed. The entire thallus appears to have been barren of any foliose component. The morphology of this specimen suggests it is assignable to the Order Fucales of the Division Phaeophyta. The gross morphological features of the specimen closely resemble the vegetative branches of some species of the modern fucoid brown algal genera *Pelvetia* and *Pelvetiopsis*. It is likely that this latter specimen represents a new genus and species of fleshy brown alga.

**LAND PLANTS**

The fossil plant remains recovered from the unnamed late Miocene marine shale at the Wilshire/Vermont station site include the leaves of the land plant species *Populus pliotremuloides*, which is indistinguishable from the modern aspen *Populus tremuloides*, and *Rhamnus precalifornica*, which is the presumed ancestor of the modern buckthorn *Rhamnus californica* (Table 1).

The fossil leaf specimen assigned to *Populus pliotremuloides* is distinguishable from the leaves of other Tertiary species of *Populus* by its smaller size and thicker texture. Fossil leaves similar to *Populus pliotremuloides* have been reported previously as occurring in the Puente Formation at a fossil site near Alhambra by Chaney (1921), who assigned the latter specimens to *Populus crassa*. The latter fossil site is in the Monterey Formation (stratigraphically underlies marine shale) if it is the same site as the one mentioned by David (1941) (see Dibblee, 1989). *Populus pliotremuloides*, which occurs in the Pliocene Mount Eden Flora of southern California and was named for fossil leaves described and illustrated by Axelrod (1936), also has been reported from the middle Miocene Tehachapi Flora of southern California (Axelrod, 1939), the middle Miocene Purple Mountain Flora of Nevada (Axelrod, 1995), the Pliocene Alvord Creek Flora of Oregon (Axelrod, 1944), and the early Pliocene Repetto (lower) Member of the Fernando Formation in the Puente Hills of the northeastern Los Angeles basin (Fisk, 1997; Lander, 1997).

The fossil leaf specimen assigned to *Rhamnus precalifornica* is simple and symmetrical with pinnate venation that is predominantly alternate in arrangement, and has an entire (smooth) margin. This specimen appears to have had a firm, thick, or coriaceous texture, as in leaves of the modern buckthorn. Land plant species represented by fossil leaves of similar shape and structure also occur in the middle Miocene Tehachapi and Purple Mountain Floras and were illustrated by Axelrod (1939, 1995). Fossil leaf specimens recovered near Alhambra, presumably from the Monterey Formation (see above), and subsequently referred to *Sapindus* by Chaney (1921) also might be assignable *Rhamnus precalifornica*.

### PALEOENVIRONMENTAL ANALYSIS

The comparatively well-preserved nature of the delicate fossil plant specimens from the marine shale at the Wilshire/Vermont station site suggests that, during the late Miocene Epoch, the sea floor was in or below an anoxic or oxygen-minimum zone, which would have prevented decay or disruption of the plant remains by bottom-dwelling organisms (see Parker and Dawson, 1965). Moreover, the association of intertidal marine algal and land plant remains suggest the remains were deposited in a near-shore marine environment. Chaney (1921) reported that *Sapindus* (= *Rhamnus*) lived along the shoreline and in coastal swamps.

### SCIENTIFIC IMPORTANCE

The fossil plant remains recovered from the unnamed late Miocene marine shale at the Metro Red Line Segment 2 Vermont/Sunset station site are scientifically highly important because they have been critical in reconstructing the depositional paleoenvironments represented by the sediments comprising the marine shale. Moreover, the occurrence of plant remains, particularly the association of marine and land plant remains, is comparatively rare in the fossil record. Finally, some of the marine algal remains represent new taxa and the land plant remains represent the first reported fossil occurrences of their respective taxa from the marine shale.

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