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## DISCUSSION

This map is one of three in the U.S. Geological Survey open-files that emphasize the nature and distribution of upper Quaternary deposits in the Antelope Valley and the adjacent canyons of the Transverse Ranges and Tehachapi Mountains in south-central California (see index map). The area covered by the set of three maps encompasses about 4200 square kilometers of northern Los Angeles County and parts of San Bernardino and Kern Counties, excluding Angeles National Forest and parts of Edwards Air Force Base. Topography in the area ranges from rugged semiarid mountains and steep canyons to broad valleys and arid desert flatlands; elevations range from about 300 meters in valley lowlands to more than 1,800 meters on mountain peaks. About 150,000 people live in the area, with most of the population in the cities and towns of Lancaster, Palmdale, Rosamond, Quartz Hill, Littlerock, Saugus, and Newhall.

The map serves two purposes. Valley and canyon deposits of Quaternary age are those that most affect and are most affected by land-use decisions, and so this map should be useful to planners and engineers as an aid in assessing areas subject to flash floods, foundation and drainage problems, severe ground motion during earthquakes, and other geologic hazards. The distribution, age, and pattern of faulting and folding of the deposits of this map also provide earth scientists with an overview of the nature of sediment deposition and deformation in one of the most tectonically active regions of the world.

This map is designed as a regional appraisal of the distribution and properties of late Quaternary materials. It is accurate for its scale and purpose as an aid to earthquake hazard zonation, land-use planning, and regional tectonic analysis. However, it should be considered only as background information and not as a substitute for large-scale, site-specific studies where land-use and engineering decisions require more detailed geotechnical information.

Upper Quaternary alluvial, colluvial, lacustrine, and eolian deposits are differentiated on the map. These materials have accumulated in the valleys and canyons of the area in response to uplift and erosion of the Transverse Ranges and Tehachapi Mountains and to subsidence of the Antelope Valley Basin during the last half-million years or so. All the upper Quaternary map units are unconsolidated, they have similar, primarily granitic, clast lithologies, and they retain some or all of their original depositional surfaces. These characteristics distinguish the deposits from older Quaternary and pre-Quaternary formations of diverse lithology which are weakly to firmly consolidated and deformed and which preserve none of their original depositional surfaces.

Alluvial deposits of seven major episodes of deposition are the most widely exposed upper Quaternary materials in the area. Correlative colluvium with generally similar textural characteristics and alluvium whose texture has been modified by the addition of windblown sand are shown on the map with distinguishing patterns. Materials deposited during the high stands of shallow lakes, alluvium that has been modified by the addition of large amounts of calcium carbonate around the lake shorelines, and dunes of uniform sand that migrate during dry lake periods occupy the valley lowlands.

We determined the relative ages of the upper Quaternary deposits and the distribution of textural facies in deposits by compilation of U.S. Soil Conservation Service soils maps, by interpretation of aerial photographs, and by study in the field. Preliminary maps were first produced by compiling soils maps of Woodruff and others (1970). Using their descriptions of the major soil series in the region, we were able to identify various ages of the deposits and to obtain approximate grain size distributions in soil parent materials. We could do this because for deposits that still retain some of their original surfaces, the degrees of profile development and textures of the soils directly reflect the relative ages and textures of the deposits upon which the soils formed. The compilation of soils mapping then served as a guide to field inspection of soil samples from channel edge exposures, road cuts, and thousands of shallow auger holes throughout the study area. From this information we determined a sequence of soils and deposits of seven distinct ages. Other criteria such as superposition of deposits, topographic position, and degree of fan surface dissection were also useful for relative dating of deposits, particularly in areas of high relief, structural complexity, and windblown sand veneers.

The grain size distributions within the geologic units differ significantly in some localities from the grain size interpreted from soils descriptions, and we therefore relied on field reconnaissance and the examination of several hundred collected and sieved samples to establish the locations of the facies. Wide variations in grain size over small distances in some of the materials make accurate delineation of facies impossible at map scale, and contacts between facies within units should be considered as only approximately located.

Radiometric ages of the upper Quaternary units are unknown because datable material is very rare in deposits of the area, but we can estimate their ages from stratigraphic position and comparision with dated deposits elsewhere. The Pleistocene Harold Formation, containing land mammal fossils of Rancholabrean age, directly underlies the oldest Q1 deposits in the southeastern part of the area (Noble, 1953; A. G. Barrows, oral communication, 1979). Estimated age of the oldest Rancholabrean fossils is 450,000 years (Repenning, 1980), and the late Quaternary sequence of deposits on this map is thus probably no older than about 400,000 years. The ages of upper Quaternary units within the alluvial sequence are estimated on the assumption that the deposits result from climatically controlled episodes of alluviation that are essentially synchronous over broad regions (Ponti, 1980; Ponti and others, 1980). The units are quite extensive and can be recognized along both the Transverse Ranges and Tehachapi mountain fronts in diverse tectonic settings and across the various microclimates of the Antelope Valley and adjacent highlands. They appear to have their origins as pulses of sediment produced during fluctuations of climate from glacial to interglacial times and can be tentatively correlated with climatically controlled deposits in other regions. Good correspondence occurs between the Antelope Valley units and the Riverbank and Modesto formations in the San Joaquin Valley. Q1, Q2, and Q3 deposits appear equivalent to the upper, middle and lower members of the Riverbank Formation, which have estimated ages from 450,000 to 130,000 years (Marchand and Allwardt, 1980). Units Q4, Q5, and Q6 appear equivalent to the Modesto Formation, which has an age estimated to span the period from 90,000 to 9,000 years ago (Marchand and Allwardt, 1980). Lacustrine deposits (Qpl) and calcium carbonate affected alluvium (Quca) result from deposition in and groundwater influences of pluvial lakes which filled the Antelope Valley basin during the most recent (post-Q3) glacial periods. Units Q7, present stream beds (Qs), and sand dunes (Qds) are in part historic and change each season with winter rainfall, summer flash floods, and springtime winds.

Contacts between units beneath upper Quaternary materials are compiled and simplified from large- and intermediate-scale mapping by the U.S. Soil Conservation Service (Woodruff and others, 1970), and from Barrows (1977 and 1980), Barrows and others (1976), Beeby (1977), Dibblee (1960, 1961, 1963, 1967), Jahns and Muehlberger (1954), Kahle (1977), and Kahle and others (1975).

Geologic structures in the Antelope Valley are from unpublished mapping by D. B. Burke and C.W. Hedel, those in the rift zone of the San Andreas fault are from recent studies by the California Division of Mines and Geology (Barrows, 1977 and 1980; Barrows and others, 1976; Beeby (1977); Kahle, 1977; Kahle and others, 1975), those in the Garlock fault zone are from Clark (1973), and those in the San Gabriel Mountains are from Jahns and Muehlberger (1954).

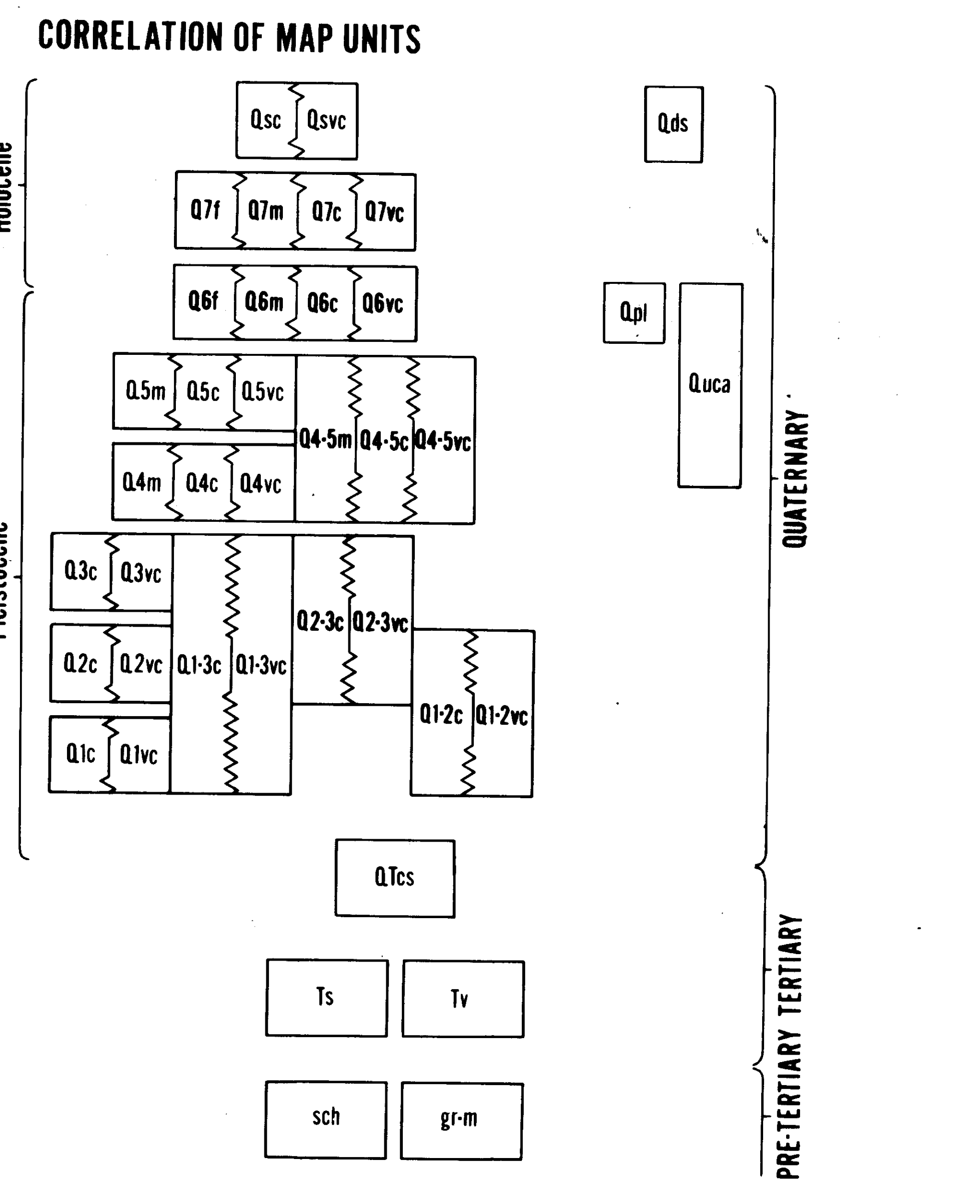
## EXPLANATION

Note: Symbols for stratigraphic units on this map are not in accord with U.S.G.S. standards and will be modified on a later published version.

Some textural facies of upper Quaternary deposits that are shown in the correlation diagram and some bedrock units that are named in the descriptions that follow are not exposed within this map area, because the following explanation applies to this and two other maps that together cover the entire Antelope Valley and its surroundings.

Upper Quaternary alluvial and colluvial units, which are symbolized by the initial letter Q followed by either the numbers 1 through 7 or the letter s, are subdivided into very coarse-, coarse-, medium-, and fine-grained textural facies, with the particle size ranges and names as defined by Wentworth (1922).
These facies are indicated by the final letters vc, c, m, and f in the geologic symbols: Very coarse-grained materials are boulder gravel with some clasts as large as 1 meter in diameter in a matrix of cobble and pebble gravel, sand, and silt. Coarse-grained materials lack a bouldery component and comprise either pebble gravel with a sand and silt matrix or coarse to very coarse sand with a prominent gravel fraction. Medium-grained materials consist primarily of fine to medium sand with lesser amounts of silt and clay as matrix or as thin interbeds (where present, a small fraction of coarse sand and fine gravel in these materials forms a conspicuous thin surface lag). Fine-grained materials are largely silt and clay with lesser very fine and fine sand within the matrix or as thin interbeds. Material compaction, rounding and sorting of clasts, and evident stratification all increase through the transition from the very coarse- to the fine-grained facies of units, while bedding thicknesses generally decrease.

### CORRELATION OF MAP UNITS




### DESCRIPTION OF MAP UNITS

**Qsc Qsvc** — Unconsolidated, poorly stratified, and poorly-sorted flash-flood deposits of modern stream channels. The very coarse-grained facies occurs in upper reaches of large washes in fans and in the channels of steep canyons; the coarse-grained facies occurs further downstream in large washes and channels, and in smaller washes and channels with lower gradients or with eroded materials that are not very coarse. Many narrow channels that are filled with these deposits are included with older units where map scale prevents their delineation. Soil weathering has not yet begun on these materials, which are intermittently reworked during seasons of high rainfall and runoff. The U.S. Soil Conservation Service land type mapped on these materials by Woodruff and others (1970) is RIVERWASH.

**Q7f Q7m Q7c Q7vc** — Unconsolidated, poorly- to moderately-stratified, and poorly- to well-sorted materials on floodplains adjacent to modern washes and channels and moderately- to well-stratified and sorted materials in ponded washes and closed depressions. Very coarse-, coarse-, and medium-grained deposits grade downstream from mountainous areas to piedmonts; medium- to fine-grained deposits occur at the distal ends of washes, in playas, and in recently faulted and folded areas. Soils on these materials are very weakly developed, with virtually unformed horizons, unweathered clasts, and grey to light-brown colors. Common soil series mapped thereon are ARIZO and SOBOBA. The age of these deposits ranges from probably not more than 4,000 years to historically recent.

**Q6f Q6m Q6c Q6vc** — Unconsolidated, moderately- to well-stratified, and moderately- to well-sorted materials in low terraces along channels in mountain and foothill valleys, in the youngest generation of coalesced alluvial fans of the piedmonts and Antelope Valley bajada, and in colluvial aprons around bedrock hills. Very coarse- and coarse-grained deposits that are close to bedrock sources of the mountains, foothills, and isolated buttes grade down to medium-grained deposits on the bajada and are commonly incised a meter or more in their upper parts; fine-grained deposits occur distant from bedrock sources on the Antelope Valley plain and in ponded areas along zones of faulting. Soils on these materials are weakly developed, have incipient horizon formation but no textural B profiles, contain sound but somewhat oxidized clasts, and are pale- to medium-brown in color. The soil series commonly mapped thereon are CAJON, HESPERIA, ROSAMOND, and some HANFORD. These deposits are latest Pleistocene and Holocene in age; similarity of soil development indicates general correspondence with the upper (youngest) member of the Modesto Formation and post-Modesto I deposits of the San Joaquin Valley, which have $C^{14}$ ages between 14,000 and 4,000 years (Marchand and Allwardt, 1980).

**Q5m Q5c Q5vc / Q4-5m Q4-5c Q4-5vc / Q4m Q4c Q4vc** — Unconsolidated, moderately- to well-stratified, and moderately- to well-sorted materials in intermediate terrace deposits of mountain and foothill valleys, in uplifted and slightly dissected alluvial fans of the piedmonts that are locally entrenched as much as 10 meters, and in dissected colluvial aprons around bedrock hills. Very coarse- and coarse-grained facies that are close to bedrock sources predominate in exposures because finer-grained distal materials are buried by younger deposits. These two units are grouped together because of their similarities of geomorphic expression and soil development. Isolated terraces and fan materials are commonly shown as undifferentiated deposits (Q4-5), but most of these are probably the older and much more widespread of the two (Q4). Soils on these materials are moderately developed, have distinct horizons and clay accumulation in textural B profiles less than 50 cm thick, contain generally sound but oxidized granitic clasts and friable shistose clasts, and are medium- to dark-brown in color, with occasional reddish-brown mottling in the older unit (Q4). The soil series commonly mapped on the younger unit (Q5) are GREENFIELD, VERNALIS, and some HANFORD; those on the older unit (Q4) are GREENFIELD and some ADELANTO. These deposits are late Pleistocene in age; similarities of soil development indicate general correspondence with the lower member and a lower portion of the upper member of the Modesto Formation in the San Joaquin Valley which yield uranium-trend and $C^{14}$ dates that suggest a range in age between about 90,000 and 17,000 years (Marchand and Allwardt, 1980).

**Q3c Q3vc / Q2-3c Q2-3vc / Q2c Q2vc / Q1-3c Q1-3vc / Q1-2c Q1-2vc / Q1c Q1vc** — Unconsolidated to weakly consolidated, moderately-stratified, and poorly- to moderately-sorted materials in high terrace deposits of mountain and foothill valleys and in uplifted and moderately to severely dissected alluvial fans along mountain fronts. The very coarse- and coarse-grained facies are the only ones exposed, because finer-grained materials of the lowlands are buried by younger deposits. These three units are grouped together because of their similarities of geomorphic expression and soil development. The distribution of the oldest unit (Q1) has no relationship to present mountain canyons or drainage patterns and it locally contains a variety of clasts that is quite unlike that in nearby modern channels. The younger two units (Q2 and Q3) have progressively closer relationships to present topography and clast sources. As much as 90% of the original surfaces of the oldest unit (Q1), about 50% of the middle unit (Q2), and 10% to 30% of the youngest unit (Q3) have been eroded. Isolated terrace and fan materials are shown in some areas as completely undifferentiated (Q1-3) or as differentiated only as one of the younger two (Q2-3) or one of the older two (Q1-2) of the three units. Soils on these materials are moderately- to well-developed, have distinct well-formed horizons and clay accumulations in blocky textural B profiles, contain oxidized and generally friable clasts of all compositions, and are distinctly reddish-brown in color. B profile development ranges from about 50 cm in the youngest of the three units (Q3) to about 2 m in the oldest (Q1). The soil series commonly mapped on the youngest unit (Q3) are RAMONA and some ADELANTO, those on the middle unit (Q2) are RAMONA and MOJAVE, and that on the oldest unit (Q1) is RAMONA, together with the land type TERRACE ESCARPMENT. These deposits are late Pleistocene in age; similarities of soil development indicate close correspondence of the three units (Q1, Q2, and Q3) with the lower, middle, and upper members of the Riverbank Formation of the San Joaquin Valley, which have an estimated age of between 450,000 and 330,000 years for the lower member and uranium-trend dates of 260,000 ± 40,000 years and 140,000 ± 40,000 years for the middle and upper members (Marchand and Allwardt, 1980).

**Qds** — Unconsolidated, well-sorted fine to medium sand in dune hills and ridges up to several meters high. Included are dunes that are presently shifting and others that are stabilized by vegetation. Most dune accumulation and migration has occurred since drying of pluvial lakes in valley lowlands. No soil has developed on these materials. The land type mapped thereon is DUNE LAND.

**Qpl** — Compact, medium- to well-sorted, and medium- to well-stratified light-colored lacustrine silt and clay with minor loose well-sorted sand and fine gravel in valley lowlands surrounding dry lake playas. Medium- and coarse-grained beach and alluvial materials are included in areas too small to be mapped. Soil development is limited and characterized by large quantities of salts within the profile. The soil series mapped thereon are POND, POND-OBAN COMPLEX, and TRAY. These sediments were deposited in the shallow-water margins of the last pluvial lake that filled valley lowlands until about 12,000 years ago.

**Quca** — Compact to firmly lithified undifferentiated alluvial materials around pluvial lake shorelines containing abundant disseminated and massive stratiform white to light grey caliche in at least the upper several meters. The parent materials were initially generally medium-grained, moderately- to well-sorted, and moderately- to well-stratified, but the textural character and soil color and development has been completely dominated by the addition of calcium carbonate, apparently during groundwater fluctuations at the times of high pluvial lake stands. The soil series mapped thereon is SUNRISE. Most parent materials are probably late Pleistocene in age and were equivalent to Q4, Q5, and Q6 sediments.

**QTcs** — Moderately- to well-consolidated continental sediments of diverse lithology in mountain foothills, along the San Andreas fault zone, and in larger mountain valleys. Includes the Anaverde, Crowder, Harold, Hungry Valley, Meeke Mine, Peace Valley, and Saugus Formations. These sedimentary units are deformed and faulted, and their original depositional surfaces have been obliterated by weathering and erosion during deformation. Plant and land mammal fossils in the units indicate that they range in age from Pliocene to late Pleistocene (5 m.y. maximum to about .5 m.y.).

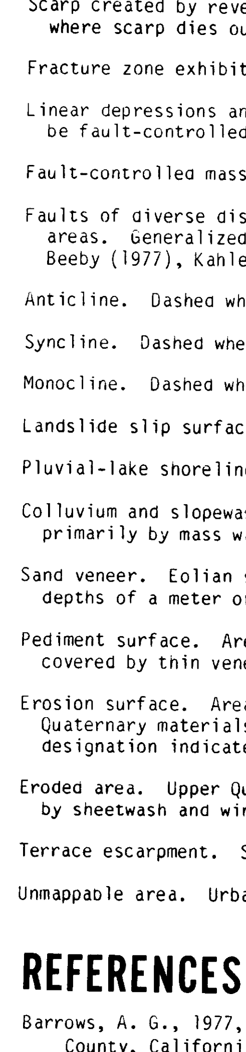
**Ts** — Consolidated continental and marine sedimentary rocks in mountainous areas. Continental units include the Fiss, Mint Canyon, Oso Canyon, Punchbowl, and Tick Canyon Formations, as well as parts of the Gem Hilland Vasquez Formations; marine units include the Castaic, Quail Lake, San Francisquito, and Towsley Formations. These units range in age from Paleocene to early Pliocene (65 to 1.8 m.y.).

**Tv** — Volcanic rocks consisting of flows, flow breccia, tuff, and related shallow intrusive bodies in mountain areas. Includes the Neenach Volcanics and parts of the Gem Hill and Vasquez Formations. These units are Oligocene(?), Miocene(?), and Miocene in age (perhaps 40 m.y. to 5 m.y.).

**sch** — Schistose rocks in large bodies scattered throughout mountain areas. Includes the Pelona and Portal Schists. May be as old as Precambrian or as young as Cretaceous (older than 63 m.y.).

**gr-m** — Granitic and metamorphic rocks (exclusive of large schist bodies) in mountainous areas and low-lying desert pediments. Plutonic igneous rocks range from diorite to granite in composition and are gneissose in part; metamorphic rocks in pendants within plutons include marble, quartzite, phyllite, other metasedimentary rocks, and minor metavolcanic rocks. The rocks range in age from precambrian(?) to Cretaceous (older than 63 m.y.).

### MAP SYMBOLS




Contact. Sharp between late Quaternary units where channels have cut and filled with one unit against another; approximately located where a younger unit thins to an edge on older units; gradational between textural facies within units. Generalized between bedrock units.

Sharp scarps created by steep normal or reverse faulting. Hachures on downthrown sides; dashed where scarp dies out. Dotted where most recently faulted deposits are buried. Where known, lateral displacements are indicated by arrows.

Subdued or eroded scarps created by steep normal or reverse faulting. Balls on downthrown sides; dashed where scarp dies out. Dotted where most recently faulted deposits are buried. Where known, lateral displacements are indicated by arrows.

Scarp created by reverse faulting with little lateral displacement. Barbs on upthrown side; dashed where scarp dies out. Dotted where most recently faulted deposits are buried.

Fracture zone exhibiting no evident topographic expression of faulting. Displacement unknown.

Linear depressions and stream channels, vegetation alinements, and other topographic elements that may be fault-controlled.

Fault-controlled masses of caliche in bedrock regolith.

Faults of diverse displacement within the San Andreas and Garlock fault zones and in mountainous areas. Generalized from large-scale maps by Barrows (1977 and 1980), Barrows and others (1976), Clark (1973), Beeby (1977), Kahle (1977), Kahle and others (1975), and Jahns and Muehlberger (1954).

Anticline. Dashed where fold dies out.

Syncline. Dashed where fold dies out.

Monocline. Dashed where fold dies out.

Landslide slip surface. Arrow shows direction of slide movement.

Pluvial-lake shoreline feature, elevation in meters.

Colluvium and slopewash. Similar in general character to correlative alluvial materials but transported primarily by mass wasting and sheetwash from local bedrock sources.

Sand veneer. Eolian sand on depositional surfaces and incorporated with alluvial materials to depths of a meter or more. Sand collects around vegetation, causing hummocky microrelief.

Pediment surface. Areas of deeply and uniformly eroded granitic and metamorphic bedrock that are covered by thin veneers of sheetwash materials and that contain stratiform caliche in bedrock regolith.

Erosion surface. Areas of low relief on bedrock that grade into the surfaces beneath late Quaternary materials and that may have once been covered by upper Quaternary deposits. The letter and number designation indicates the unit with which the surface is probably associated.

Eroded area. Upper Quaternary materials with depositional surfaces stripped to shallow depths by sheetwash and wind deflation.

Terrace escarpment. Steep channel edges in late Quaternary materials.

Unmappable area. Urbanized areas, artificial fills, mine tailings, gravel quarries, etc.

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