QUATERNARY GEOLOGY OF NORTHERN SACRAMENTO COUNTY, CALIFORNIA

Annual Field Trip Guidebook of the Geological Society of Sacramento
May 1967

By
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GEOLOGICAL SOCIETY OF SACRAMENTO
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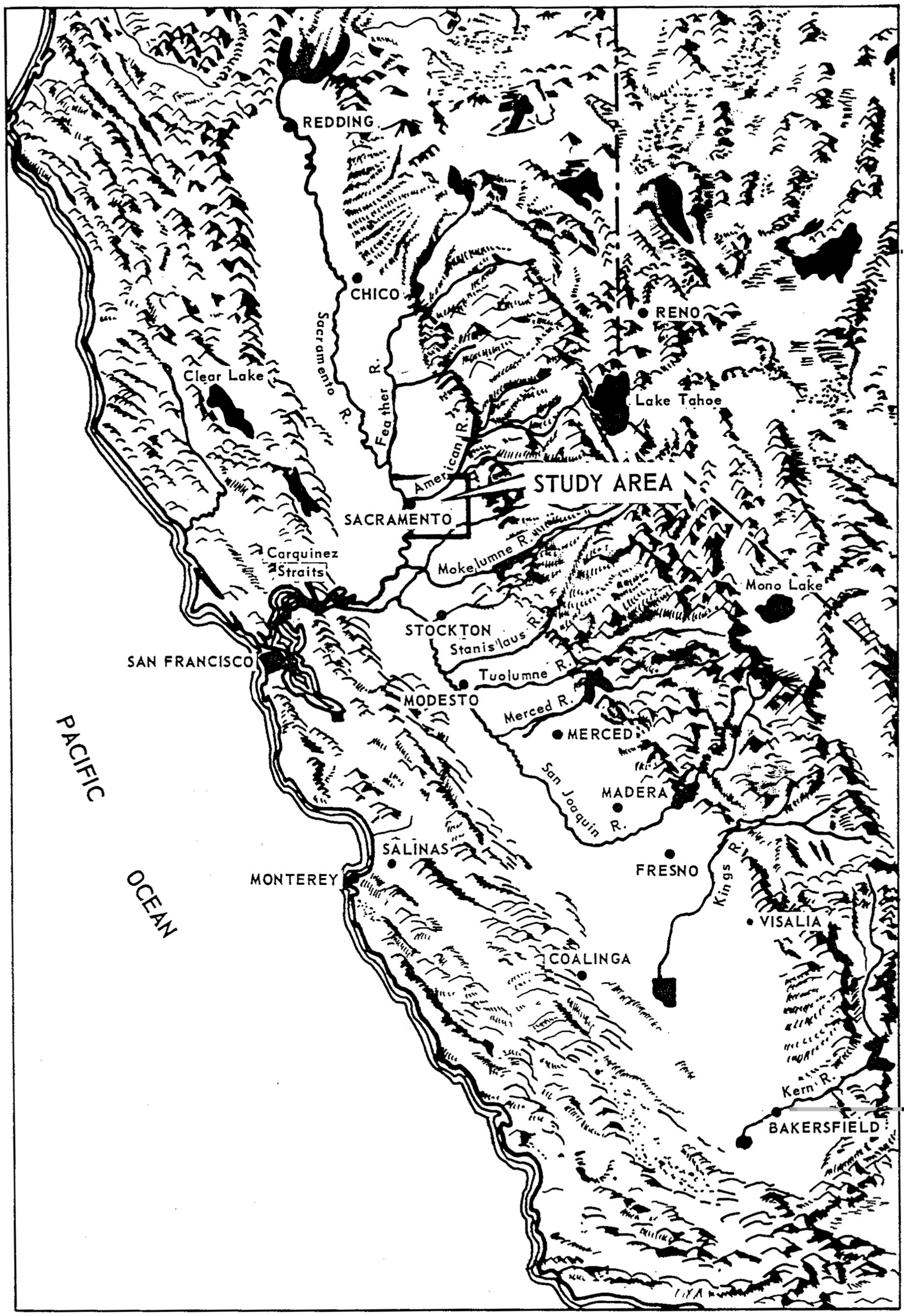


Figure 1 – Physiographic diagram of a portion of Northern California showing the study area in northern Sacramento County in relation to the Sierra Nevada, Coast Ranges, Great Valley and associated major drainage systems.

Introduction

The Sacramento area is a highly urbanized region located in the southeastern part of the Sacramento Valley (Figure 1). Elevations range from approximately 20 feet above sea level near the confluence of the American and Sacramento Rivers to about 500 feet near the Placer County line; relief is generally low reaching a maximum near the town of Fair Oaks where the American River has migrated northward forming the "Fair Oaks bluffs".

Northern Sacramento County is composed primarily of constructional landforms, namely, alluvial fans, river terraces, and natural levees and basins. Heretofore the region was not subject to detailed mapping and stratigraphic analysis apparently due to the inherent low relief and the sparsity of natural exposures. However, the effect of urbanization has been to provide numerous man-made exposures in the form of foundation and road cuts. In addition, as indicated in the road logs, a reconstruction of the local geomorphic history is facilitated by the availability of data from numerous water well logs and bridge test borings.

Soils have also been very useful for analyzing the Quaternary history of the region, especially for separating Pleistocene and Recent sediments and for local correlation. The soil series referred to in this Guidebook are those defined and mapped in a 1941 survey (Weir, 1950; Cole et al, 1954). The relationship of these soils to specific landforms and geologic formations in northern Sacramento County is summarized in Table 1.

A geologic map of northern Sacramento County (in pocket) was originally prepared in conjunction with a geomorphic study of the region (Shlemon, 1967) but has been reproduced for this Guidebook. The location of water wells and bridge borings, description of soils and measured sections, and a stratigraphic analysis of the area -- referred to in the road logs-- were detailed in the earlier study. A block diagram showing the general association of major landforms and soils along the lower American River is presented in Figure 2.

General Stratigraphy

The geologic formations recognized in Sacramento County are shown in Table 2. The youngest Pleistocene units, the Modesto and Riverbank Formations, were defined by Davis and Hall (1959) in Stanislaus County but are extended into this area primarily on the basis of stratigraphic position in the alluvial sequence, lithology, and association of "key" soils. The Arroyo Seco, Laguna, and Mehrten Formations, described by Piper et al (1939) in the Mokelumne area are also recognized in the Sacramento area, especially south of the American River (geologic map in pocket). In addition to the above units, a "Laguna-Mehrten transitional zone" is informally established for a sequence of sediments exposed along the Cosumnes River and the name "Fair Oaks Formation" is

TABLE

Relationship of Landforms, Soils, and Geology in Northern Sacramento County, California

SOILS		GEOLOGY	
Mapped Soil Series	Relative Profile Development	Physiographic Division	Geologic Formation and Associated Soils
Honcut loam (over San Joaquin hardpan substratum)	Undeveloped	Low river terrace	Modesto (predominantly granitic alluvium) Late Pleistocene American River sediments over Middle Pleistocene alluvial fan deposits.
Honcut very fine sandy loam (over Bear Creek gravelly loam)	Undeveloped	Low river terrace	Modesto (predominantly granitic alluvium) Late Pleistocene Cosumnes River sediments over early Late Pleistocene mixed granitic-andesitic channel deposits.
Pentz loam; sandy loam	Undeveloped (lithosol)	Upland	Mehrten: Mehrten-Laguna transition (predominantly fluviatile andesitic tuff, interbedded fine- to medium-grained granitic sediments) Develops on steep slopes of Mehrten formation.
Pentz-Redding gravelly loam	Undeveloped (lithosol)	Upland	Mehrten; Arroyo Seco (fluviatile andesitic tuff;metamorphic gravels) Arroyo Seco sand and gravel deposited as colluvium on eroded slopes of underlying Mehrten formation.
Perkins gravelly loam	Moderate	High river terrace	Riverbank (predominantly metamorphic pebbles and cobbles, granitic sand matrix) American River terrace III

TABLE 1 (CONT.)

SOILS		GEOLOGY	
Mapped Soil Series	Relative Profile Development	Physiographic Division	Geologic Formation
Peters clay	Undeveloped (grumosol)	Upland	Mehrten (andesitic tuff; locally interbedded fluviatile andesitic tuff and granitic sediments) Develops on very fine-grained tuff; gentle or concave slopes.
Redding cobbly loam; gravelly loam	Very strong (hardpan)	Dissected pediment and high river terrace	Arroyo Seco (metamorphic pebbles and cobbles, granitic sand matrix)
Sacramento silty clay loam	Slight	Floodplain-Alluvial basin	Modesto and recent (mixed granitic-sedimentary rock alluvium) Develops on Late Pleistocene-Recent Sacramento River deposits; transitional zone between natural levees and flood basins.
San Joaquin loam; sandy loam	Very strong (hardpan)	Moderately dissected alluvial plain	Riverbank (granitic fluviatile alluvium)
San Joaquin loam; sandy loam (deep phase)	Very strong (hardpan)	Low river terrace	Riverbank (medium-grained fluviatile alluvium) Late Middle Pleistocene - Early Late Pleistocene overbank deposits along lower Cosumnes River.
"Scabland"	Undeveloped (lithosol)	Upland	Mehrten (andesitic channel gravels)
"Terrace breaks", Redding-Corning soil material	Undeveloped (lithosol)	Dissected pediment	Arroyo Seco (predominantly metamorphic pebbles and cobbles, granitic sand matrix) Locally derived Arroyo Seco colluvial deposits on strongly dissected slopes of underlying formations.

TABLE 1 (CONT.)

SOILS		GEOLOGY	
Mapped Soil Series	Relative Profile Development	Physiographic Division	Geologic Formation
Whiterock stony loam	Undeveloped (lithosol)	Upland	Mariposa (meta-sedimentary and slate)
Whitney fine sandy loam; gravelly sandy loam	Undeveloped (lithosol) to Moderate	Strongly dissected alluvial plain	Fair Oaks and Laguna (interbedded fluviatile granitic silt and sand; local metamorphic gravels)

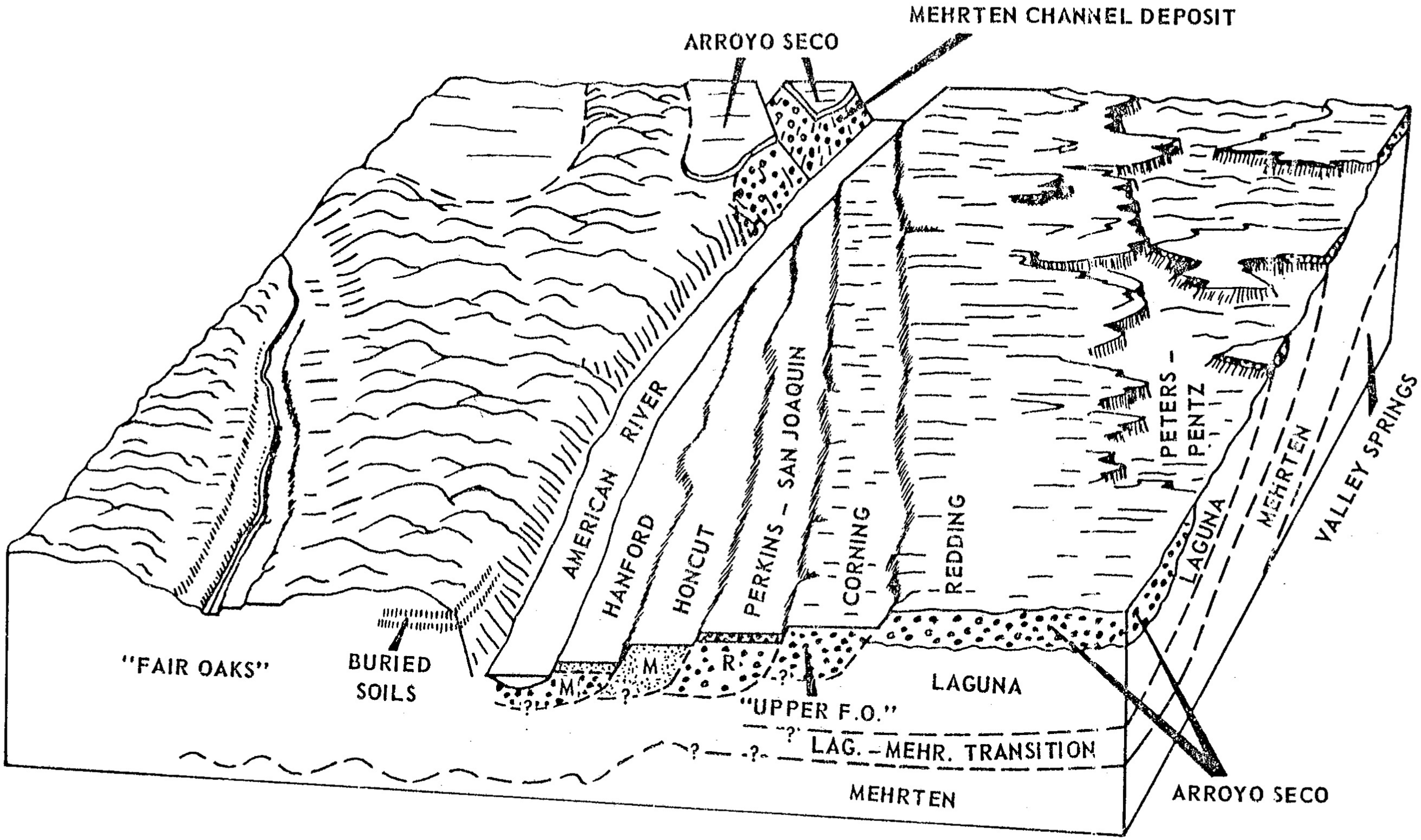


Figure 2 –Block diagram showing the general association of major landforms and soils along the lower American River. Characteristic soil series indicated on landform surface; geologic unit identified below surface: M = Modesto Formation, R = Riverbank Formation, F.O. = Fair Oaks Formation, A. S. = Arroyo Seco Gravel, Lag. = Laguna Formation, Mehr. = Mehrten Formation.

suggested for an assemblage of sediments north of the American River which cannot be directly associated with previously described geologic formations in the Great Valley. The lithology and attitude of these formations is discussed in the road log section of this Guidebook; the relationship of soils and geologic units, and the tentative correlations indicated in Table 2 were detailed in an earlier study of the area (Shlemon, 1967).

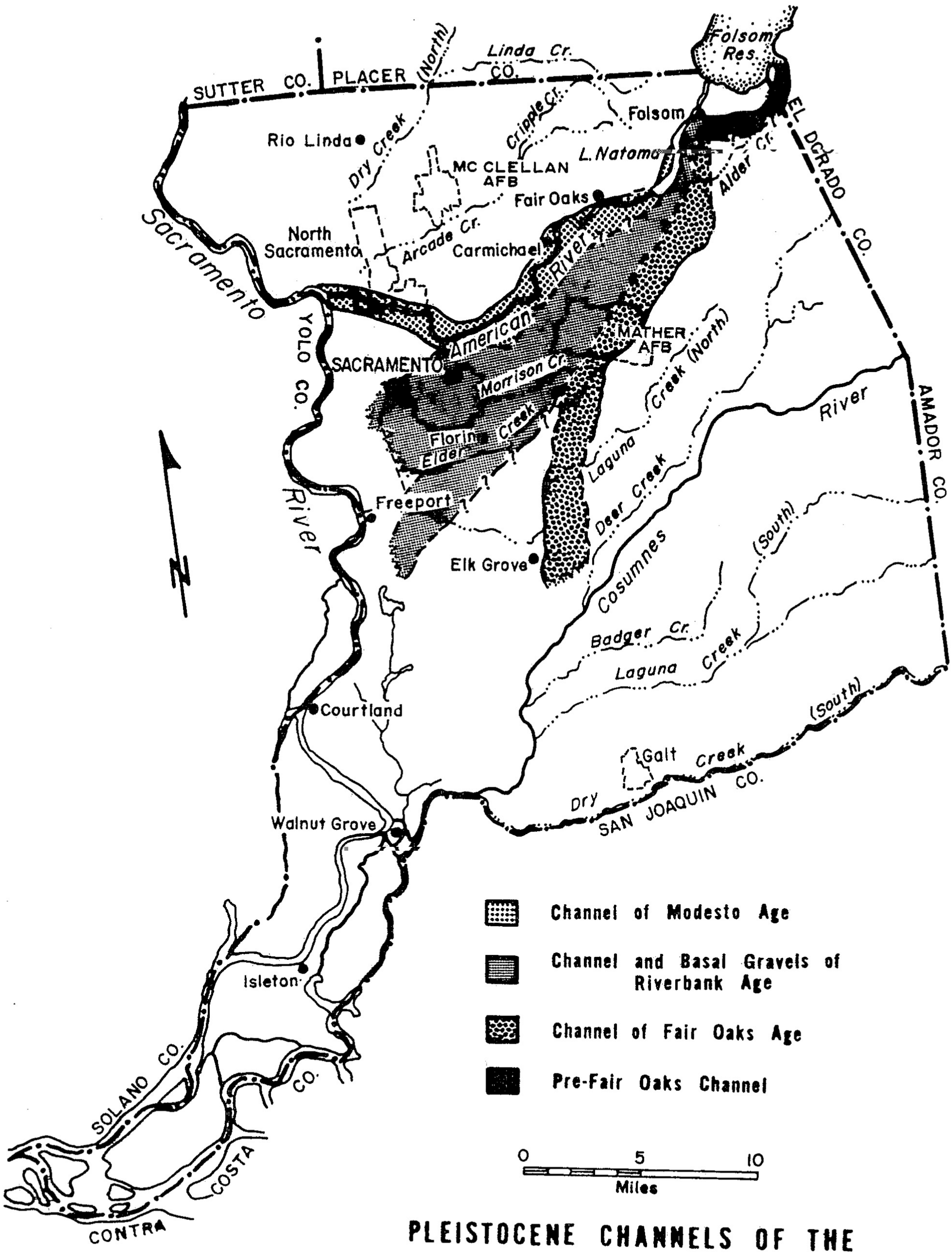
An inferred correlation of the alluvial sediments in northern Sacramento County and the glacial deposits in the Sierra Nevada is presented in Table 3. It is recognized, however, that no direct connection between Sierran glaciation and Valley deposition as yet has been made (Arkley, 1962; Janda, 1965; Wahrhaftig, 1965). The glacial chronology so noted is taken from three recent studies in various sections of the Sierra Nevada. The correlation of Sierran glacial events with the standard mid-Continental sequence (Table 3) represents the thinking of Birman (1964) and should not be construed as being completely acceptable to all students of Pleistocene chronology in California.

American River Terraces and Ancestral Channels

Four distinct terraces of the American River are recognized in Sacramento County. For convenience they are identified in topographic sequence by Roman numeral and so indicated in the discussion sections of the road logs. Three of these terraces are composed of gravels which extend into the subsurface where they can be traced as ancestral channels of the American River. As shown on Figure 3, the oldest, clearly defined channel trended southwest from Folsom in Fair Oaks time (terrace IV). It is buried by younger sediments south of Mather Air Force Base but can be identified in well logs east of Elk Grove 60 feet below the surface. The next oldest channel (Riverbank age) also emerged from the foothills near Folsom where it is expressed as terrace III. It likewise can be traced in the subsurface; in this case to a point near Franklin approximately 40 feet below present sea level (Figure 3). The youngest channel (Modesto age) underlies the present course of the American River to the confluence of the Sacramento River where the gravels are identified in bridge borings 35 feet below sea level. A block diagram illustrating the association of these terraces and the three major subsurface channels is presented as Figure 4. These relationships are also shown in two generalized structure sections drawn across the American River at Fair Oaks (A-A') and Rancho Cordova (B-B; Figures 5 and 6).

At least three distinct episodes of Pleistocene fluvial deposition are recognized in northern Sacramento County. Most, if not all, of the deposits possibly are a consequence of climatic change; a change manifest in the adjacent Sierra Nevada by glacial-interglacial alternations and in the Valley Trough possibly by eustatic fluctuations of sea level. However, several landforms and geologic units may owe their particular characteristics to regional tectonic uplift in the Sierra Nevada and Coast Ranges or subsidence of the Valley Trough.

Each of the major alluvial sequences in northern Sacramento County represents a period of aggradation preceded and followed by erosion.



PLEISTOCENE CHANNELS OF THE LOWER AMERICAN RIVER

SACRAMENTO COUNTY, CALIFORNIA

Figure 3

The stratigraphic relationship of buried stream channels and alluvium, as well as other geomorphic evidence, suggests that most of the sediments probably were deposited during glacial epochs. However, there is some evidence to suggest that locally deposition was taking place during inter glacial time.

TABLE 3

CHRONOLOGY AND INFERRED CORRELATION OF ALLUVIAL DEPOSITS IN NORTHERN SACRAMENTO COUNTY AND GLACIAL EVENTS IN THE SIERRA NEVADA. CORRELATION WITH MID-CONTINENTAL GLACIATIONS AFTER BIRMAN (1964, p. 71-74) AND MORRISON (1965, p. 268).

MID-CONTINENTAL GLACIATIONS	GLACIAL CHRONOLOGY IN THE SIERRA NEVADA: 1	GLACIAL CHRONOLOGY IN THE SIERRA NEVADA: 2	ALLUVIAL CHRONOLOGY IN NORTHERN SACRAMENTO COUNTY: North of the American River			ALLUVIAL CHRONOLOGY IN NORTHERN SACRAMENTO COUNTY: South of the American River	
		Matthes Recess Peak Hilgard	Alluvium and Basin Deposits			Alluvium and Basin Deposits	
WISCONSIN	Frog Lake Tioga	Tioga Tenaya	Modesto Formation		Upper Member	Modesto Formation	Upper Member
	Tahoe	Tahoe			Lower Member		Lower Member
ILLINOIAN	Donner Lake	Mono Basin	Riverbank Formation			Riverbank Formation	
KANSAN	Hobart	Sherwin	Fair Oaks Formation	Upper Member	Deposits Overlying Upper Buried Soil -?-?-?-?- Deposits Between Lower and Upper Buried Soils		3 Upper Member Of The Fair Oaks Formation
NEBRASKAN		McGee		Lower Member	Gravels Underlying The Lower Arroyo Seco Surface		Gravels Underlying The Lower Arroyo Seco Surface

(1) Birkeland (1964) North Of Lake Tahoe

(2) Sharp + Birman (1963) in Mono Lake Region; and Birman (1964) Along Upper San Joaquin River

(3) Identified only as terrace gravel south of the American River

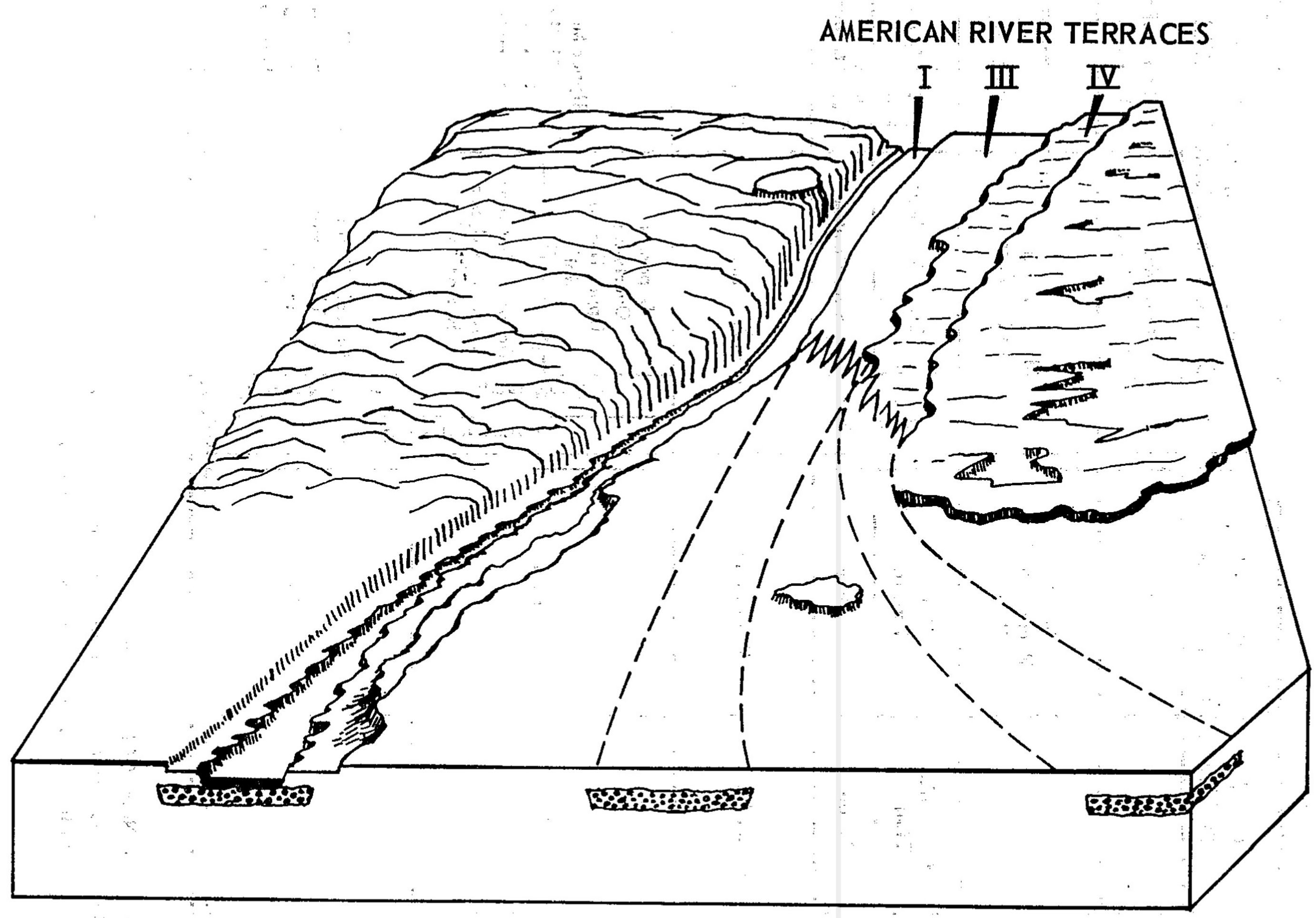
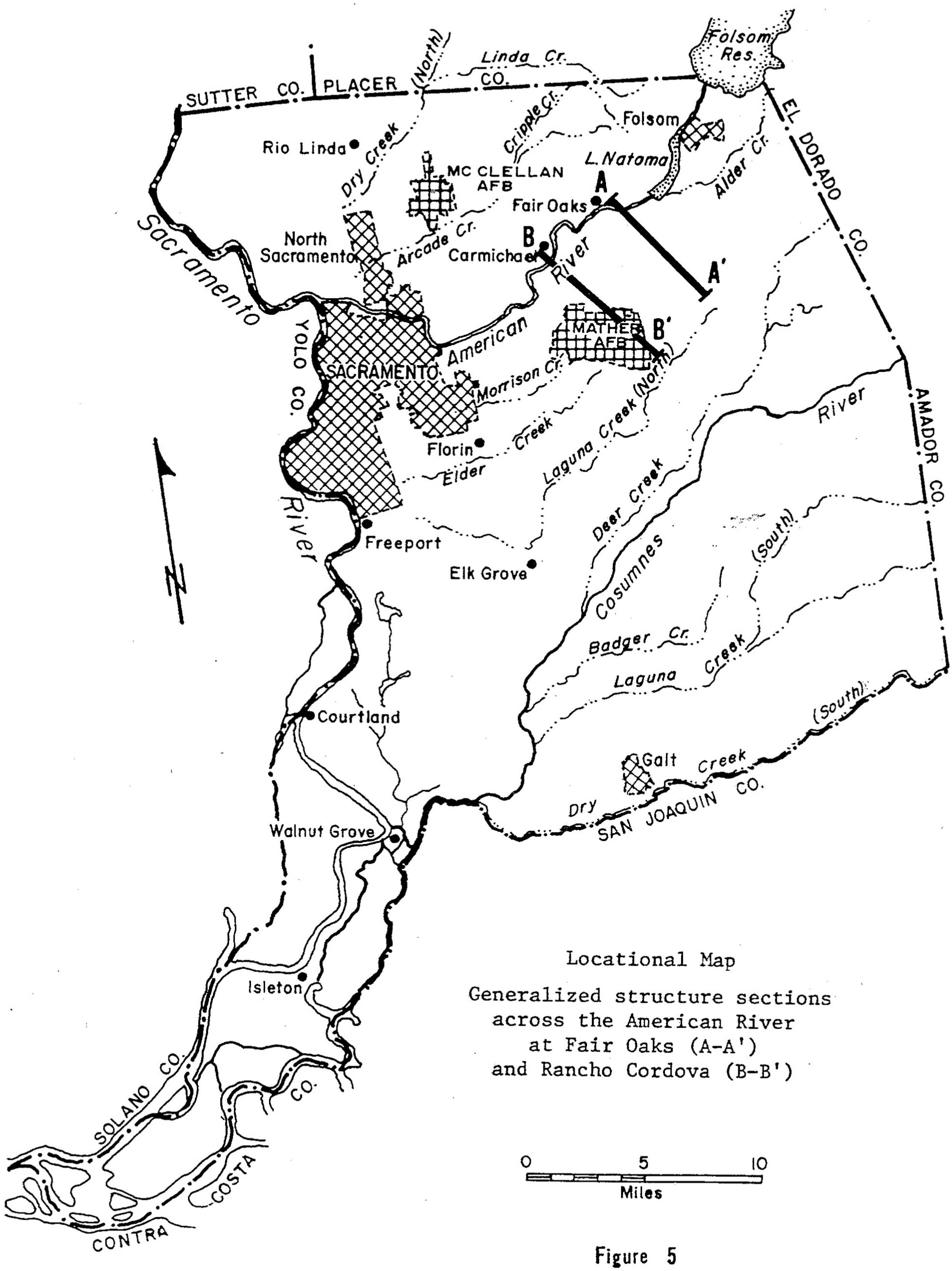


Figure 4 – Block diagram illustrating the association of terraces and the three major subsurface channels of the lower American River. The river has moved progressively northward since early Pleistocene (?) time and presently occupies a position first established in Tahoe (?) time.



Locational Map

Generalized structure sections across the American River at Fair Oaks (A-A') and Rancho Cordova (B-B')

Figure 5

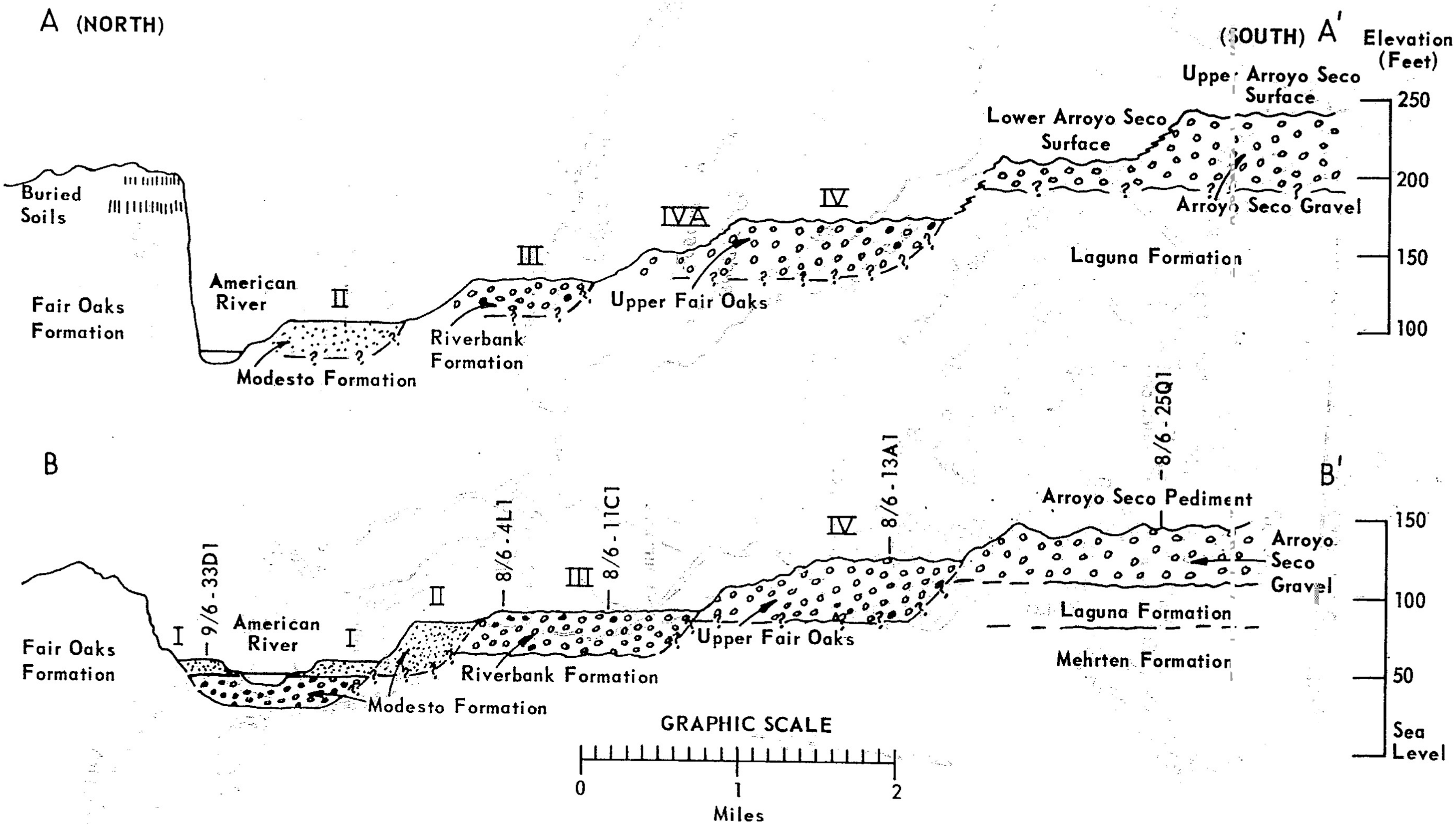


Figure 6 – Generalized structure sections across the American River at Fair Oaks (A-A') and downstream near the Rancho Cordova District (B-B'). American River terraces designated by Roman numerals; subsurface contacts along section B-B' based on well log control as indicated e.g., 9/6 - 33D1, 8/6 - 4L1 etc.

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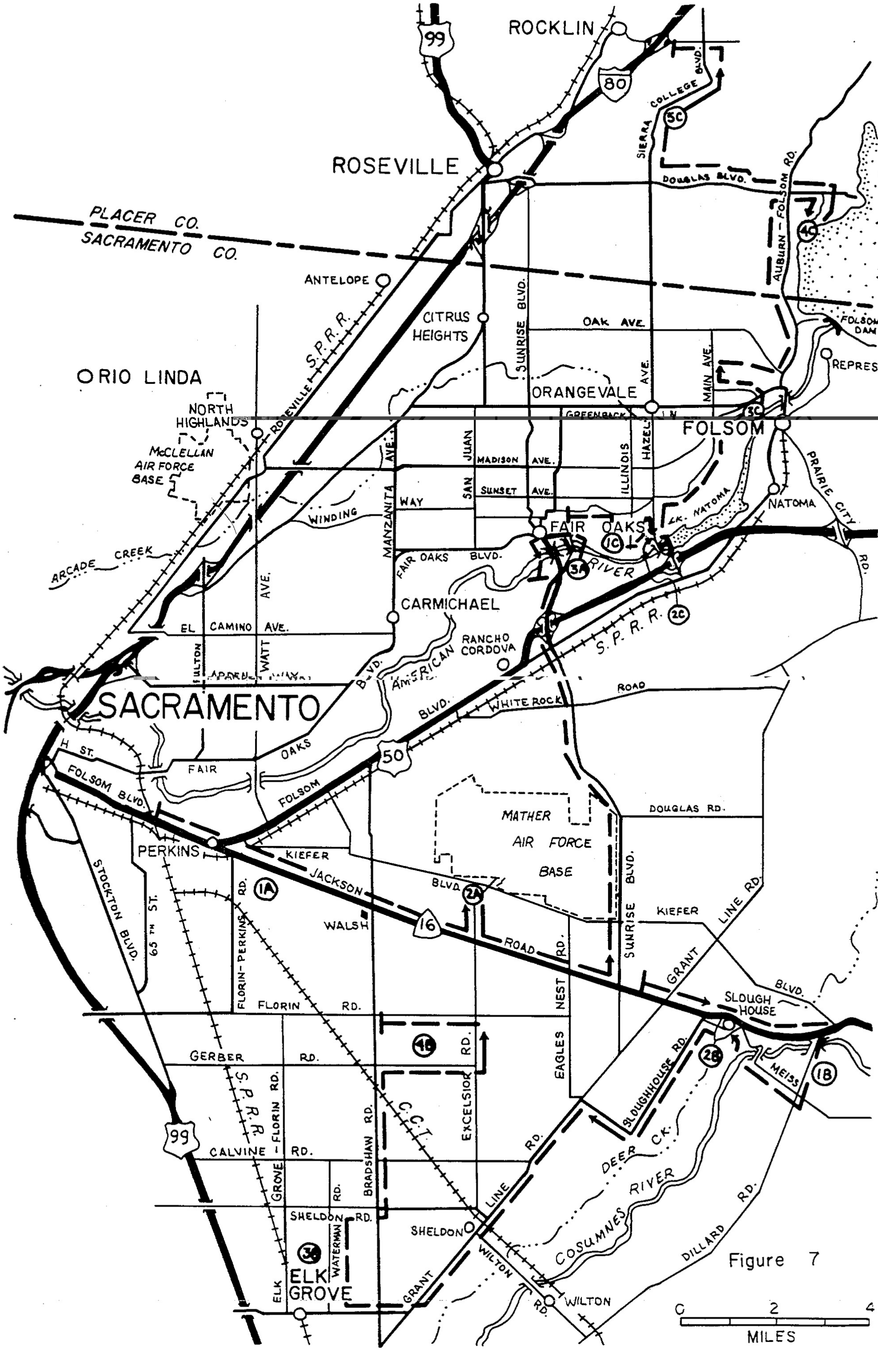
FIELD TRIP ROAD LOGS

As shown on the route guide (Figure 7), the 1967 field excursion is divided into three separate trips. Field trip "A" starts at the eastern limits of the City of Sacramento, crosses three terraces of the American River near Mather Air Force Base, and ends at the bluffs of the American River at Fair Oaks. Trip "B" begins near Sloughhouse, trends southwestward along the Cosumnes River, and ends north of Elk Grove. Trip "C" originates at Fair Oaks, traverses terrain north of the American River, and extends into southern Placer County ending at the town of Rocklin. Allowing time for examination of road and river cuts, as noted in the road logs, it is anticipated that two of the three trips can be completed in one day. Identification of a number of the landforms described in the road logs will be greatly facilitated if the participant has the following U.S.G.S. 7 1/2' topographic map quadrangles in his possession:

Sacramento East	Rocklin
Florin	Folsom
Citrus Heights	Buffalo Creek
Carmichael	Sloughhouse
Elk Grove	


ROCKLIN
ROSEVILLE
PLACER CO.
SACRAMENTO CO.
ANTELOPE
CITRUS HEIGHTS
ORIO LINDA
NORTH HIGHLANDS
McCLELLAN AIR FORCE BASE
ARCADE CREEK
S.P.R.R.
ORANGEVALE
FOLSOM
NATOMA
REPRESSA
FOLSOM DAM
PRAIRIE CITY RD.
FAIR OAKS
CARMICHAEL
RANCHO CORDOVA
AMERICAN RIVER
SACRAMENTO
H ST.
FOLSOM BLVD.
PERKINS
STOCKTON BLVD.
65TH ST.
JACKSON ROAD
KIEFER BLVD.
WALSH
MATHER AIR FORCE BASE
SUNRISE BLVD.
DOUGLAS RD.
KIEFER
GRANT LINE RD.
SLOUGH HOUSE
SLOUGHHOUSE RD.
MEISS
FLORIN RD.
GERBER RD.
CALVINE RD.
SHELDON RD.
SHELDON
ELK GROVE
WILTON
WILTON RD.
COSUMNES RIVER
DEER CK.
DILLARD RD.
C.C.T.
EXCELSIOR RD.
BRADSHAW RD.
EAGLES NEST RD.
WATERMAN RD.
GROVE - FLORIN RD.
ELK GROVE
FLORIN - PERKINS RD.
DOUGLAS BLVD.
SIERRA COLLEGE BLVD.
AUBURN - FOLSOM RD.
OAK AVE.
MAIN AVE.
HAZEL AVE.
ILLINOIS
GREENBACK LN.
MADISON AVE.
SUNSET AVE.
SAN JUAN
MANZANITA AVE.
WINDING WAY
FAIR OAKS BLVD.
EL CAMINO AVE.
WATT AVE.
FULTON
WHITE ROCK ROAD
LK. NATOMA
99
80
50
16
1A 1B 1C 2A 2B 2C 3A 3B 3C 4B 4C 5C
0 2 4
MILES
Figure 7

ROAD LOG FOR GEOLOGIC FIELD TRIP A - NORTHERN SACRAMENTO COUNTY, CALIFORNIA

Mileage is given in the left-hand margin; first figure is cumulative mileage for the trip and second figure is mileage since last reference.

MILLEAGE	
0.0/0.0	START FIELD TRIP A: Proceed east on Folsom Blvd., cross under Southern Pacific R.R. tracks (3 lane road).
0.8/0.8	Cross Power Inn Road (traffic lights); continue east on Folsom Blvd. (U.S. 50). The highway is now on an alluvial plain underlain by the Riverbank Formation. Approximately 300 yards to the left (north) is a terrace of the American River about five feet lower in elevation than the Riverbank surface. This terrace, of Modesto age, appears to converge with the Riverbank surface near this point; eastward, in the Rancho Cordova district, the difference in elevation between the two surfaces increases to approximately 20 feet (see Carmichael 7 1/2' Quadrangle).
1.3/0.5	Turn right on Jackson Road (Highway 16).
1.9/0.6	Florin-Perkins Road intersection (traffic signals); proceed east on Jackson Road.
2.0/0.1	Old quarry to the left (north) is about 45 feet deep and is excavated to approximately five feet above sea level. About 15 feet of granitic silt and fine-grained sand overlie 20 feet of metamorphic gravels. These gravels are basal channel deposits of the Riverbank age American River. In the wall at the north end of the quarry, under the high voltage lines, a number of teeth of *Equus* and a partial femur of a probable *Camelops* were recently located by the writer and fellow

workers in the silt above the gravels. These fossils were identified by D.E. Savage who reported that as yet these faunal remains could not be assigned to species but, in terms of the known fossil record, indicate a probable middle or late Pleistocene age for the Riverbank Formation; a general date previously established on the basis of position in the local stratigraphic sequence. (1) As far as is known, no diagnostic fossils have been recovered from the Riverbank or other Quaternary units in Sacramento County.

2.3/0.3 Teichert Aggregate Quarry operation; processing gravel from the channel of the Riverbank age American River.

2.6/0.3 Turn right on dirt road leading into Teichert Aggregate Quarry; pink house on right. Continue approximately 100 yards and turn right to main pit. Caution: Heavy truck traffic in this area. Park along side of road at top of pit.

STOP 1A: Observation and discussion of (1) representative landuse associated with the surface of the Riverbank Formation (San Joaquin soil), (2) basal channel gravels of the Riverbank age American River, and (3) possible origin of "tongues" in the San Joaquin soil.

The general terrain and landuse, observable from this point, is typical of the surface of the Riverbank Formation along the east side of the Central Valley. The surface is slightly dissected and is often characterized by an undulating microrelief, locally called "hogwallows". An "open landscape" is dominant, influenced to a large degree by the presence of the San Joaquin soil - a strongly developed

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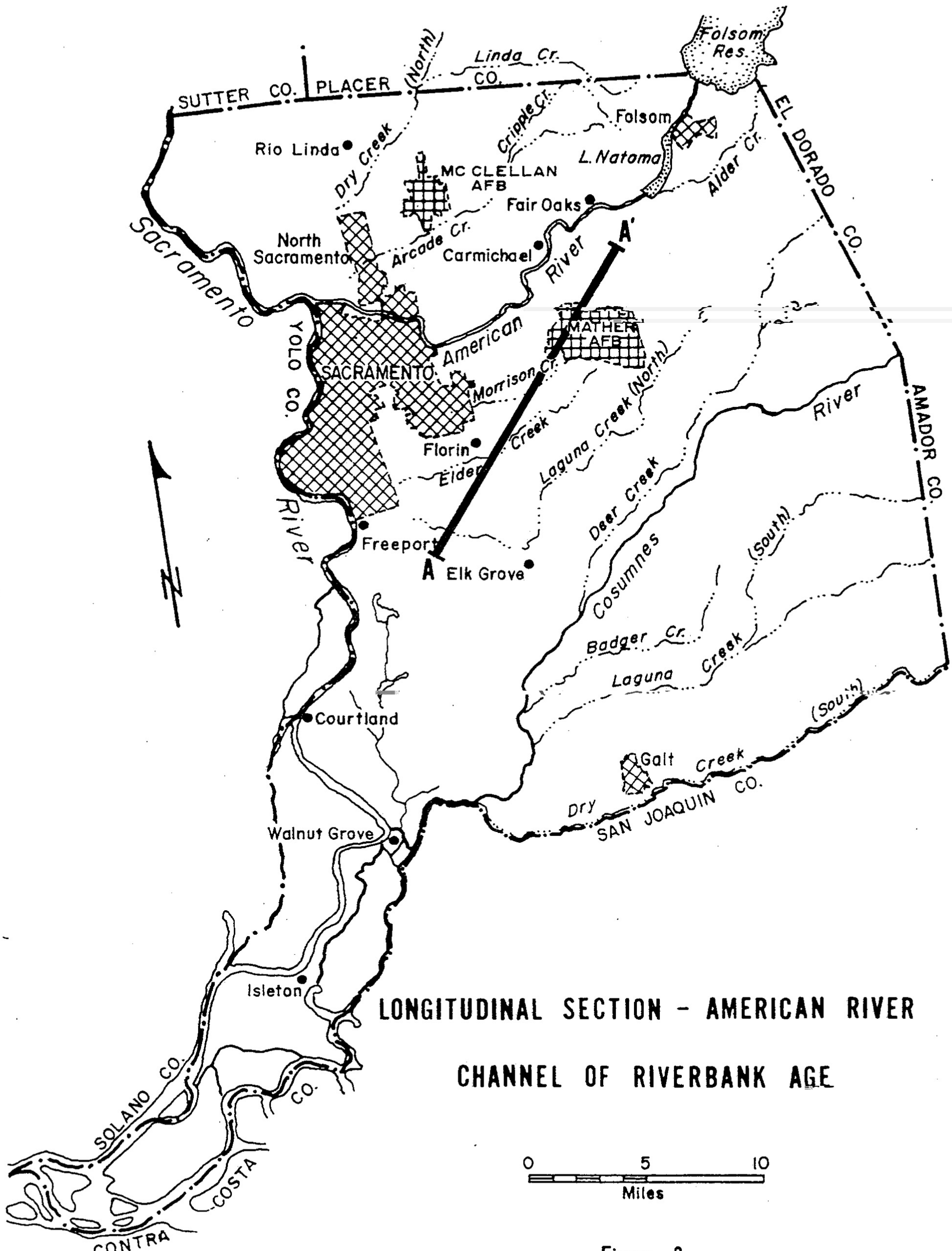
(1) The fossils were located in November 1966 by the writer, E. G. Begg, and G. L. Huntington (University of California, Davis). They are presently in the collection of the U.C. Museum of Paleontology, Berkeley (UCMP loc. V-6747; D. E. Savage, personnal communication, April 3, 1967).

profile (maximally developed Noncalcic Brown) formed on granitic sand and silt of the Riverbank Formation. A distinctive feature of the San Joaquin soil is an iron-silica cemented hardpan (Cm horizon) which generally is impermeable to gravitational water and almost impenetrable by roots of most cultivated plants. Thus few orchards are present on the surface of the Riverbank Formation; a striking contrast to the numerous orchards and hop fields characteristic of the younger, less well developed soils of the adjacent Modesto Formation.

Approximately 25 feet of channel gravels are presently exposed in this pit. Composed predominantly of metamorphic pebbles and cobbles with a granitic sand matrix, these gravels can be traced westward to the vicinity of Franklin as a distinct subsurface channel (Figure 3). Based primarily on stratigraphic position, intraformational lithologic sequence, and correlation with terraces along the south side of the American River, it is thought that these gravels represent deposits laid down by the American River during the initial phases of a glaciation in the Sierra Nevada. At present no obvious physical connection is known to exist between the alluvial sequence in the Sacramento area and glacial deposits in the Sierra. However, it is inferred that the basal Riverbank channel gravels are possibly correlative with Sierran glacial deposits of Donner Lake (?) age (Birkeland, 1964; Table 3).

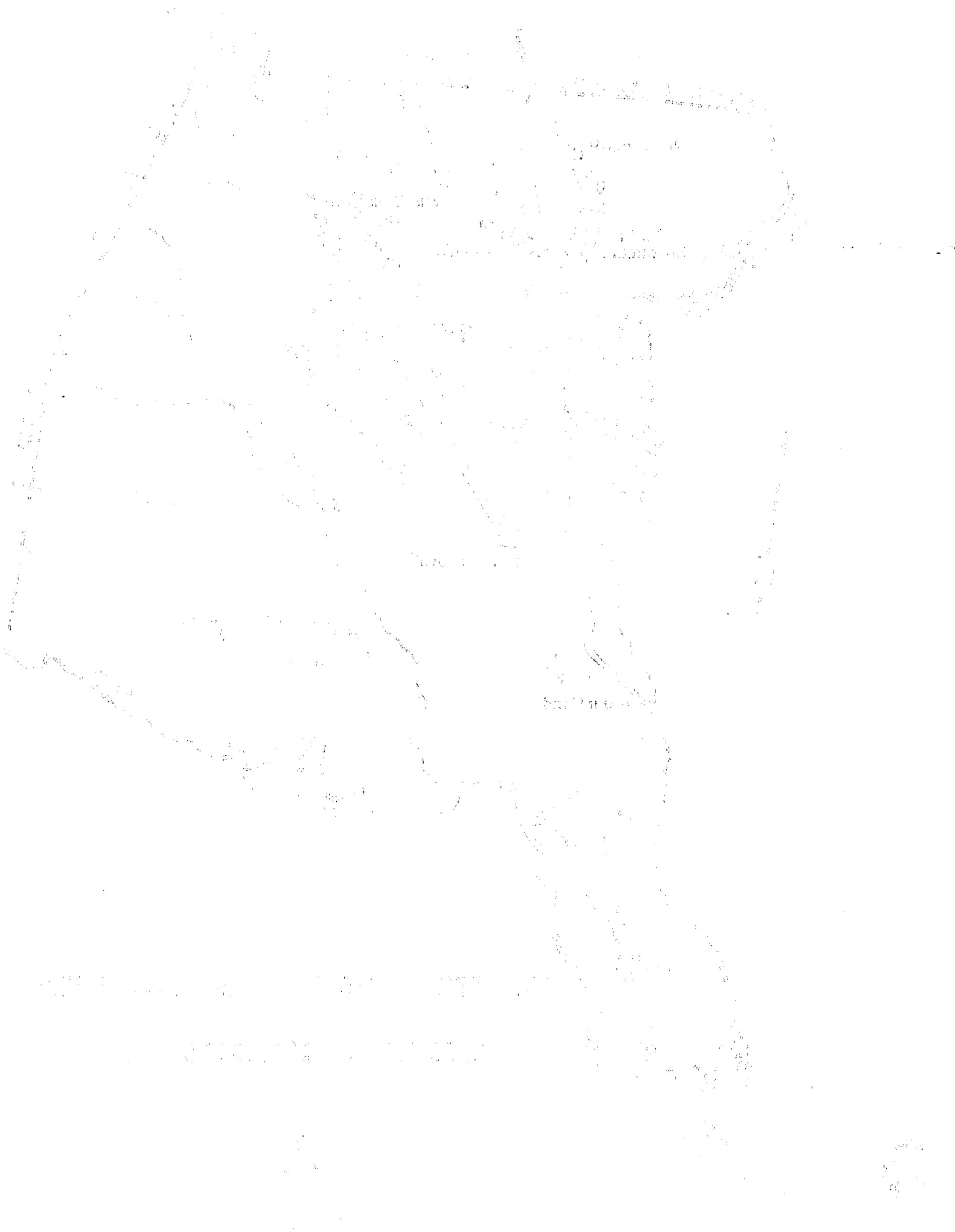
Interpretation of well log data indicates that the Riverbank age American River deposited gravels to a depth approximately 30 feet below present sea level near the town of Franklin (Figure 9). In conjunction with similar depths attained by young and older channels of the American River, it is inferred that this depth may represent local base level



LONGITUDINAL SECTION - AMERICAN RIVER

CHANNEL OF RIVERBANK AGE

Figure 8



in Sacramento County during early Riverbank time; a level possibly controlled by eustatic fluctuations of sea level. It is recognized, however, that, in part, the depth of the channel may be a consequence of post-Riverbank tectonic activity i.e., subsidence in the Valley Trough or uplift in the adjacent Sierra Nevada (Christensen, 1965; 1966). Inferentially, the sand and silt overlying the gravel channel were deposited during the latter phases of a Sierran glaciation (Donner Lake ?) in response to a change in the hydraulic regimen of the American River, possibly influenced by a rising base level.

The San Joaquin soil, as exposed at this site, is atypical in that numerous soil tongues are present. These tongues are areas ranging in width from several inches to 20 feet in which the B2 horizon extends through the hardpan (Cm horizon) approximately seven feet into unweathered parent material. The origin of the tongues is unknown. Cursory examination shows no obvious association of tongues with contemporary drainage, vegetation or micro-relief. Superficially the tongues resemble frost wedges or peri-glacial phenomena described in the Midwest and elsewhere (Horberg, 1949; Smith, 1949; Wolfe, 1953; Yehle, 1954); however, the former presence of peri-glacial climate in the Sacramento area is, at best, conjectural.

Return to Jackson Road (Highway 16); turn right (east).

5.4/2.8 Cross Bradshaw Road (traffic signals). Lithologic data from water well logs indicate that the Riverbank Formation is 40 feet thick in this area; the lower 30 feet are composed of the channel gravels observed at Stop 1A.

6.6/1.2 Jackson Road now ascends a dominant rise (for this area) of ten feet onto an American River terrace of Fair Oaks age.

Note the gravels and striking red color of the soil (Corning gravelly loam) exposed in roadcuts. The surface of this terrace is slightly more dissected than the Riverbank surface.

7.5/0.9 Turn left (north) on Excelsior Road (to Mather Air Force Base). The road now crosses the slightly dissected American River terrace of Fair Oaks age (terrace IV).

8.4/0.9 Roadcut exposures of the Corning soil; Excelsior Road curves to the northeast and descends 15 feet to the surface of the Riverbank Formation.

9.3/0.4 STOP 2A: Kiefer Boulevard (Middle Jackson Road) intersection. Observation of the Corning soil and discussion of the nature and the age of pre-Riverbank terraces of the American River.

The Corning soil (Cole *et al*, 1954), as exposed in the roadcuts at this stop, is strongly developed having a dense claypan. However, unlike the Redding soil, which characterizes adjacent older, higher surfaces, or the San Joaquin soil, formed on the younger, lower Riverbank Formation, the Corning does not have a distinctive hardpan. Nevertheless it is a very useful geomorphic and stratigraphic marker for it not only defines the surface of American River terrace IV but also identifies the top of the Fair Oaks Formation in the subsurface.

As shown in Figure 3 , the gravels of this terrace (IV) define a pre-Riverbank age American River channel which flowed from the Folsom area southwest to a point east of the town of Elk Grove or approximately 12 miles southeast of the present Sacramento-American River confluence. Based primarily on terrace elevation, relative soil profile development, and stratigraphic position, these gravels are correlated with a sequence of granitic sands and silts north of the American

River (Fair Oaks Formation) and are thought to have been deposited in response to a major glaciation in the Sierra Nevada. As yet, these sediments cannot be directly correlated with the glacial sequence in the Sierra Nevada. However, based on soil development and lateral correlation with sediments occupying a similar stratigraphic position in the San Joaquin Valley (Janda, 1965), it is inferred that these Fair Oaks age gravels possibly represent outwash associated with the Hobart (?) glaciation of Birkeland (1965).

Underlying Mather Air Force Base, to the north, are the Riverbank age channel gravels (terrace III) surficially represented here by the moderately developed Perkins soil (Perkins gravelly loam; Cole et al, 1954). The Perkins is generally restricted to this immediate area for upstream, near Nimbus and Folsom, this soil and the gravelly parent material underlying the terrace III surface have been substantially altered by gold dredging activities in the late 19th and early 20th Centuries.

Make a "U-turn" at this stop and return to the Excelsior-Jackson Road intersection.

10.6/1.3 Turn left (east) on Jackson Road.

10.7/0.1 Ascending a 15 foot escarpment onto the Arroyo Seco Pediment (?) of Piper et al (1939). This surface (Redding soil), underlain by weathered metamorphic gravels with a granitic sand matrix (Arroyo Seco Gravel ?), may possibly represent an American River fill channel of pre-Fair Oaks age. However, it may well be a surface cut into the Arroyo Seco Pediment. Unfortunately well log data for this area is too inconclusive to resolve the problem. For convenience, therefore, it is informally referred to as the "lower Arroyo Seco surface".

11.1/0.4 Cross under high voltage lines; traverse the lower Arroyo Seco surface. Although not easily observable in this region, the Arroyo Seco surfaces (Redding soil) are often characterized by an undulating microrelief ("hogwallows") which, according to Arkley (1954), represents the activity of pocket gophers. The swales or the inter-mound areas are poorly drained and typically swampy during the rainy (winter) season.

11.6/0.5 Ascend a 10 foot escarpment. This "break in slope" is not continuous and probably represents a minor erosional feature cut by a tributary of Elder Creek (Carmichael 7 1/2' Quad.).

12.3/0.7 Eagles Nest Inn (S. side of road); now descending into Laguna Creek drainage. A well in this area (8/6E - 25Q1) penetrates 40 feet of gravel (Arroyo Seco Gravel ?), 26 feet of granitic sand (Laguna Formation), and bottoms in andesitic sand (Mehrten Formation).

12.7/0.4 Cross Eagles Nest Road. Although not readily evident, the roadcuts at this intersection and the next one-half mile along Jackson Road expose approximately three feet of the Laguna Formation; a granitic sand and silt unit unconformably overlain by the Arroyo Seco Gravel (Piper *et al*, 1939). This is one of the few exposures of the Laguna Formation north of the Cosumnes River (geologic map in pocket).

13.7/1.0 Sunrise Boulevard intersection. FIELD TRIP A TURN LEFT AND CONTINUE NORTHWARD ALONG SUNRISE BOULEVARD. THIS POINT IS ALSO THE START OF FIELD TRIP B WHICH PROGRESSES EASTWARD ALONG JACKSON ROAD (Figure 7).

This portion of Sunrise Boulevard from Jackson Road approximately five miles north to Natomas Road was completed in 1966. Therefore, a number of new roadcuts are now available on which to interpret better the geomorphic and stratigraphic history of the area. As a consequence, the formational contacts for this area, noted on the geologic map (in pocket), could be slightly altered. In addition, two distinct river channels of Fair Oaks age, inferred in Shlemon (1967), can now be identified.

14.2/0.5 Road cut exposures of the Laguna (?) or Riverbank (?) Formation. The claypan visible in these cuts is discontinuous laterally and may represent stratification within the parent material rather than pedogenic clay.

14.8/0.6 Ascend the lower Arroyo Seco surface.

15.0/0.2 Kiefer Road (Middle Jackson Road) intersection; continue north along Sunrise Boulevard.

16.1/1.1 Stream cut (Morrison Creek) to the left (west) exposed approximately 10 feet of the Redding soil and the Arroyo Seco Gravel. This is one of the better natural exposures in the area.

16.7/0.6 New roadcuts exposing the upper portion of the Arroyo Seco Gravel and the Redding soil. Several "Mima mounds" have been dissected by the roadway, but, as seen by the burrowed holes and recently moved soil, are still occupied by squirrels. In this area the Redding soil, as delimited by Cole <u>et al</u> (1954), is polygenetic. A claypan (B horizon), evidently unrelated to the lower portion of the soil, occurs approximately 10 inches below the surface. This horizon is parallel to the contemporary surface and apparently has formed or is forming under the influence of the present climate. About four feet below the surface, however, is a distinct, red B2 horizon, now degraded. Relief along the "older" B1 (?)-B2 horizon boundary varies from 6 to 10 inches. Krotovinas within and below the B2 horizon are common. The iron-silica cemented hardpan, diagnostic of the Redding soil, in this area is discontinuous and is apparently associated with the older or lower B2 horizon. This degraded portion of the profile is preserved only at the highest elevation and is truncated by the younger soil along the contemporary drainage ways; evidently it formed on a landsurface of lesser relief than the present. Comparative relief and superposition of the two soils (not differentiated in the Sacramento County Survey; Cole et al, 1954) suggests that the geomorphic surface (lower Arroyo Seco), here traversed by Sunrise Boulevard, has been subject to at least two distinct weathering epochs; each perhaps more "intense" than the present or operative over a long period of time.

17.3/0.6 Sunrise Boulevard now descends 20 feet to the surface of American River terrace IV (Fair Oaks age). This new cut also exposes the Redding soil and the Arroyo Seco Gravel. A few strongly weathered granitic cobbles are present in this section; a contrast to the typically metamorphic gravels and granitic sand matrix of the Arroyo Seco Gravel.

17.4/0.1 Douglas Road intersection; continue north along Sunrise Boulevard.

18.3/0.9 Descend to a lower terrace. The surface now traversed is not well defined. Eastward, it has been substantially altered by dredging activity; westward, it appears to merge into the terrace of Fair Oaks age. Based primarily on its elevation, and topographic position with respect to adjacent channel deposits and to buried soils within the Fair Oaks Formation, it is thought this surface is also of Fair Oaks age. It is not known whether the terrace is strath or fill in origin. It is, however, also characterized by the Corning soil and, as shown in Figure 6 , is formally designated as terrace IVA.

18.8/0.5 Descend escarpment onto channel gravels of the Riverbank Formation (terrace III). The road cuts in this area expose gravels of Fair Oaks age and the Corning soil.

19.8/1.0 Whiterock road intersection; continue north on Sunrise Boulevard.

21.0/1.2 Folsom Boulevard intersection (traffic lights); continue north on Sunrise Boulevard toward Fair Oaks. Less than five feet of elevation separate Riverbank age deposits (underlying terrace III) from younger Modesto age sediments (terrace II; geologic map in pocket). At the Freeway overcrossing, approximately 10 feet of mixed granitic and andesitic sediments of the lower member of the Modesto Formation (Qml; geologic map in pocket) overlie the Riverbank age gravels of terrace III.

21.9/0.9 Coloma Road intersection; continue north on Sunrise Boulevard.

22.4/0.5 Descending a 15 foot escarpment onto the surface of terrace I. This terrace is underlain primarily by sediments of late Modesto age although younger sediments are undoubtedly present owing to historic changes in the hydraulic regimen of the American River. As indicated in Table 2 , sediments of early and late Modesto age along the American River are generally defined by the occurrence of Honcut and Hanford soils, respectively (Cole <u>et al</u>, 1954).

Keep in right hand lane; be prepared to turn right <u>before bridge</u>.

22.7/0.3 Turn right on Citrus Blvd. (not well marked) on the south side of the American River. Bluffs on north side of the American River (Fair Oaks Formation) visible through trees. Continue east (upstream).

23.7/0.4 Old Fair Oaks Bridge Road; cross intersection and continue east toward Pacific Cement and Aggregates plant. Stop at end of road; park cars and walk approximately 100 yards to the south bank of the American River.

STOP 3A: Observation of the "type locality" and buried soils within the Fair Oaks Formation. Discussion of age and correlation with terraces of the American River.

Seen in the bluffs on the north side of the American River, are approximately 145 feet of silt and fine-grained granitic sand. At present, using topographic expression, lateral continuity, or soil development, this sequence cannot be directly correlated to previously described alluvial sediments in the Sacramento-San Joaquin Valley. Hence the term "Fair Oaks Formation", after the nearby town of that name, is informally applied to these sediments (Shlemon, 1967).

Near the top of the Fair Oaks Formation and, as observed from this stop, are two strongly developed buried soils. The upper soil is slightly less obvious than the lower soil and evidently formed on a surface with local relief of approximately 10 to 15 feet. The lower buried soil is distinctly red in color and formed on a very gently undulating surface. Roadcut exposures and interpretation of well log data suggest that both paleo-surfaces sloped to the west with an apparent gradient of 10 feet/mile; a value not significantly different than those for younger surfaces in the Sacramento area.

Although still the subject of some debate, it is inferred that both soils formed during an interglacial interval; the underlying and overlying fine-grained fluvial deposits probably represent glacial outwash laid down as overbank and distributary deposits. It is possible that the buried soils observed here formed in a relatively short period of time, assuming interglacial climatic conditions were more conducive to profile development than they are today. However, as previously noted, as yet there is no evidence, botannical or geomorphological, to suggest that the Pleistocene climate in

Sacramento County was greatly different than the present. Presumably, therefore, the Fair Oaks buried soils represent profile development influenced primarily by time rather than climate. Thus these soils evidently formed on a relatively stable landscape over a long period of time, possibly in the order of thousands of years.

The buried soils seen here appear to be at elevations similar to the surface of terraces IV and IVA (?) south of the American River. Based on the similarity of elevation and relative position in the stratigraphic sequence, it is suggested that the buried soils represent interglacial weathering intervals following, inferentially, two Sierran glacial epochs which resulted in formation of the American River terraces of Fair Oaks age (IV and IVA). Because the Valley alluvial sequence as yet cannot be directly tied to Sierran deposits, a positive correlation cannot be made. However, as shown in Table 3 , it is inferred that one or possibly both Fair Oaks age terraces (and buried soils) may be associated with Hobart (?) deposits recognized by Birkeland (1964) in the Sierra Nevada.

Data from numerous well logs north of the American River indicate that the Fair Oaks Formation overlies fluvial andesitic sand of the Mehrten Formation. This stratigraphic superposition is similar to a sequence in the Mokelumne area and in southern Sacramento County where Piper et al (1939) recognized granitic sand and silt of the Laguna Formation overlying Mehrten sediments. Based on lithologic similarity and stratigraphic position, it is tentatively suggested that the section of Fair Oaks Formation above the Mehrten Formation but below the lower buried soil, in whole or part, is correlative to the Laguna Formation (Table 2). Inferentially, the Arroyo Seco Gravel should occur within

within this sequence. However, the Arroyo Seco Gravel is found north of the American River only as a thin veneer covering a narrow, sinuous andesitic channel of Mehrten age near Nimbus Dam (geologic map in pocket; see Field Trip C). Thus, in this area, the Arroyo Seco Gravel may have been removed by pre-Fair Oaks erosion or possibly never have been deposited. Wells north of the American River penetrate numerous gravel lenses but most of these are too discontinuous to be identified as the Arroyo Seco Gravel or gravels of equivalent age.

In summation, the post-Mehrten -- pre-Riverbank stratigraphy north of the American River is extremely complex and the geomorphic history and suggested correlations noted in Shlemon (1967) and in this Guidebook are at best tentative and for the present must be considered as working hypotheses.

Return to cars, make U-turn, and continue into Fair Oaks via old Fair Oaks Bridge (Bridge Street).

23.2/0.1 Cross old Fair Oaks Bridge. Note the "paleo-relief" indicated by the buried soils. East of the bridge (upstream) the buried soils locally merge indicating that portions of the lower soil were subject to two distinct periods of pedogenesis.

23.9/0.7 Fair Oaks Boulevard (stop sign). NOTE: This is the starting point for Field Trip C into northeastern Sacramento and southwestern Placer Counties. Field trip A continues for 0.4 miles through the town of Fair Oaks.

24.0/0.1 Sunrise Boulevard (traffic signals); turn left toward American River. The lower Fair Oaks buried soil is well exposed in roadcuts approaching the bridge.

24.3/0.3 Sunrise Boulevard Bridge across the American River. Just before the bridge, on the northeast corner, is the informal "type locality" of the Fair Oaks Formation defined and measured by Shlemon (1967). Ascent up this cut face is facilitated by the presence of a fence and the numerous "steps" now present on the slope. The upper buried soil, which crops out at the top of this cut, is polygenetic in that the upper horizons are now subject to contemporary weathering processes. Except for the surface of the upper soil, all other horizons in this and the lower buried soil have a field measured pH of 8.0; an abnormally high value presumably due to post-pedogenetic influence of gravitational water.

Continue across bridge (south).

25.5/1.2 Coloma Boulevard intersection (traffic signals). END OF FIELD TRIP A. Continue along Sunrise Boulevard to Freeway, then west into Sacramento <u>or</u> return to Fair Oaks for Field Trip C.

ROAD LOG FOR GEOLOGIC FIELD TRIP B - NORTHERN SACRAMENTO COUNTY, CALIFORNIA

Mileage is given in the left-hand margin; first figure is cumulative mileage for the trip and second figure is mileage since last reference.

MILEAGE

0.0/0.0 START FIELD TRIP B: Junction of Highway 16 (Jackson Road) and Sunrise Boulevard (see Figure 7). Proceed east on Jackson Road.

0.1/0.1 Cross Laguna Creek. There are two Laguna Creeks in Sacramento County. This one, which flows to the southwest, crosses the Elk Grove Outlier and debouches into a poorly drained area near Freeport (Beach Lake), is herein identified as Laguna Creek north. The other Laguna Creek, which is the first major drainage south of the Cosumnes River and enters that stream at a point approximately eight miles north of Galt, is informally called Laguna Creek south. It is this southern Laguna Creek for which granitic sand and silt sediments of the Laguna Formation were named by Piper et al (1939).

0.2/0.1 Ascend a rise of approximately 10 feet onto the lower Arroyo Seco surface. As indicated in Field Trip A, this gravelly surface may be an American River Channel of pre-Fair Oaks age.

1.0/0.8 Cross Grant Line Road.

1.3/0.3 Jackson Road now begins to ascend the upper Arroyo Seco surface. This surface, also characterized by Redding soils (Cole et al, 1954), in this area is approximately 50 feet higher than the lower Arroyo Seco surface and is limited to the drainage divide between the Cosumnes and American River drainage (locally Laguna Creek north drainage). It slopes to the southwest trending parallel to younger channel fill surfaces of the American River. Its topographic relationship to the surrounding terrain may be best observed on the Buffalo Creek 7 1/2' Quadrangle (10 foot contour interval) along a profile connecting Coyote (SW 1/4, sec. 30, T. 9 N., R. 8 E.) and Wagon bench-marks (NE 1/4, sec. 23, T. 8 N., R. 7 E.). This upper Arroyo Seco surface may be equivalent to the Arroyo Seco Pediment described by Piper et al (1939) in the Mokelumne area. As shown on the geologic map (Pocket), however, its underlying gravels are not distinguished from those of the lower surface and both are thus identified as the Arroyo Seco Gravel (Qas).

The roadcuts along both sides of Jackson Road reveal the general lithologic composition of the Arroyo Seco Gravel (predominately metamorphic gravels and granitic sand matrix) overlying granitic sand of the Laguna Formation.

1.9/0.6 Sloughhouse Road intersection; continue east on Jackson Road, The Cosumnes River floodplain is straight ahead. The road descends from the upper Arroyo Seco surface onto a gravelly terrace approximately 60 feet above the Cosumnes River floodplain. This terrace is not easily observable from Jackson Road but is readily apparent from Sloughhouse Road at a point approximately one mile south of these cuts.

2.4/0.5 Meiss Road intersection and turnoff into Sloughhouse; continue east on Jackson Road.

2.6/0.2 Cross bridge. The white building and the cemetary on hill at right (south) are situated on a thin veneer of gravel (Arroyo Seco ?). The orchard on the left (north) is planted on the Hanford soil; an undeveloped profile (A-C profile), forming on fine- to medium-grained granitic sand.

2.8/0.2 Cross Deer Creek overflow bridge.

4.1/1.3 Ascend levee forming north bank of the Cosumnes River.

4.4/0.3 Dillard Road intersection; turn right. The rounded "haystack hills" in the foreground are underlain primarily by andesitic sand and silt of the Mehrten Formation. Typically, more resistant silt lenses crop out as ledges along the hill sides. The relatively flat-topped hills in this region, especially to the east, consist of fluviatile andesitic sands (Mehrten Formation) or granitic sands (Laguna Formation) capped by a resistant veneer of Arroyo Seco Gravel.

4.5/0.1 Cross the Dillard Road bridge (Cosumnes River). Five bridge test bores, drilled to a depth approximately 40 feet below the river bed (elevation 90 feet), do not penetrate any distinct gravel beds - in contrast to the several well defined gravel units (early glacial deposits ?) along the American River. However, the driving rate of all bores, measured in blows per foot, decreases very rapidly approximately 35 feet below the river bed. By analogy with more complete bridge boring data available from the American River, it is suggested that this sudden increase in sediment compaction may represent the subsurface contact between the Riverbank (?) and the Modesto (?) formations.

Several miles downstream, bores for the Wilton-Sheldon bridge do encounter thick (30 feet) continuous gravel units below the Cosumnes River bed. As yet, however, the bridge data is too inconclusive to determine if these gravels are of Riverbank or of Modesto age.

4.8/0.3 STOP 1B: Observation of the "Laguna-Mehrten transitional zone".

Approximately 65 feet of interbedded andesitic and granitic sand and silt are exposed in these cuts along Dillard Road. The black, fluvial cross-bedded andesitic sands, predominant at the base of the cuts, are indicative of the Mehrten Formation; the light colored sand and silt near the top of the cuts are representative of the Laguna Formation. As seen here, the contact between these two formations is not sharp and this section, therefore, has been informally designated as the "Laguna-Mehrten transitional zone" (Shlemon, 1967; mapped Qlm, geologic map in pocket).

Near the top of this cut, above the bench on the east side of Dillard Road, are two buried soils. The lower soil is continuous across the cut and is the better developed of the two; a blocky structure, root casts, and distinct clay films are common in the preserved B horizons of both soils. The degree of profile development and stratigraphic position of these soils is similar to the buried soils exposed in bluffs of the American River near Fair Oaks (Field Trip A, Stop 3A). At present, however, it is not known whether the respective "sets" of soils were formed during the same intervals. Mineralogical studies and more detailed stratigraphic analysis of the intervening area might demonstrate that the soils are of the same age. If so, these buried soils would be extremely useful stratigraphic markers and would help to correlate more accurately the pre-Riverbank age sequence between the Cosumnes and American Rivers.

In the subsurface, the andesitic sands of the Mehrten Formation are frequently identified as "black lava sand" by well drillers. It is thus relatively easy to recognize the first appearance of the Mehrten in well logs. Westward, toward the Valley Trough, granitic sediments predominate and are designated as the Laguna Formation; eastward, toward the Sierra foothills, andesitic sediments are dominant and are identified as the Mehrten Formation. Both formations are unconformably overlain by the Arroyo Seco Gravel.

As shown on the geologic map (in pocket), the Laguna-Mehrten transitional zone is recognized only south of the American River. North of the river, the Mehrten Formation is represented by andesitic channel gravels; Laguna sediments are thought to be correlative with granitic sand and silt underlying the lower buried soil within the Fair Oaks Formation (Table 2).

From the top of these Dillard Road cuts, looking toward the west, one can observe relatively flat-topped mesa-like hills which are the topographic representation of the Laguna Formation protected by a cap of Arroyo Seco Gravel. To the north and east, the topography is generally rounded; the Arroyo Seco Gravel has been removed and sediments of the Mehrten Formation or the Laguna-Mehrten transitional zone are presently exposed.

Return to cars; continue south on Dillard Road

5.3/0.5 Roadcut exposures of the Mehrten Formation (andesitic silt) to the right (west). Cole <u>et al</u> (1954) have mapped Peters soils on gently sloping terrain and Pentz soils on more dissected slopes (Table 1).

Approximately one mile east of this point, trending to the southwest and essentially parallel to Dillard Road, is an old channel of the Cosumnes River. This feature is topographically expressed on the Sloughhouse 7 1/2' Quadrangle as an area of low relief extending southwest from the Cosumnes River

School area (SW 1/4, sec. 6, T. 7 N., R. 8 E.) seven miles to a junction with the present day Cosumnes River about three miles northeast of Wilton (projected sec. 29, T. 7 N., R. 7 E). The stratigraphic relationships in this area suggest that the Cosumnes River occupied this channel in Riverbank time (?). If so, this may explain why no channel gravels are encountered in the subsurface below the Dillard Road bridge.

5.8/0.5 Meiss Road intersection; turn right. The local topography is characterized by gently undulating terrain underlain by the Mehrten Formation and the Laguna-Mehrten transitional zone. Remnants of the Arroyo Seco Gravel are exposed in cuts along this road and as lag gravel in the adjacent fields. The higher surface straight ahead (west) is the surficial expression of the Arroyo Seco Gravel capping the Laguna Formation.

6.0/0.2 Meiss Road now descends onto a small terrace remnant approximately 20 feet above the Cosumnes River floodplain. The sediments underlying this terrace are non-gravelly granitic sands and silts (Riverbank Formation ?).

6.9/0.9 Right turn in road to old bridge; cross bridge (CAUTION: cross slowly and one car at a time). Hop fields in this area planted on Hanford soil (granitic sand parent material). The Cosumnes River is presently confined to a narrow channel bordered by levees.

The width of the floodplain, its topographic relationship to older sediments, and data from well logs suggest that at least part of the sediments in the one mile wide floodplain (at this point) of the Cosumnes River were deposited during a glaciation in the Sierra Nevada (Tahoe ?; Tioga?). However, Recent sediments are undoubtedly present but as yet cannot be readily separated from Modesto age deposits in this area.

7.9/1.0 Cross Deer Creek bridge and proceed toward Sloughhouse. Deer Creek is presently entrenched approximately 10 feet in the Cosumnes River floodplain. As shown on the Sloughhouse 7 1/2' Quadrangle, Deer Creek flows approximately 14 miles to the southwest paralleling the Cosumnes River floodplain, Deer Creek meanders as an underfit stream across a sediment filled plain approximately one-half mile wide (e.g. secs. 19 and 30, T. 8 N., R. 8 E.). The sediments underlying this plain consist of mixed granitic and andesitic alluvium apparently derived from local outcrops of the Arroyo Seco Gravel and Mehrten Formation, respectively.

8.0/0.1 Continue through Sloughhouse and straight ahead on old highway (south of Jackson Road).

8.4/0.4 STOP 2B: Roadcuts through the Arroyo Seco Gravel (underlying high Arroyo Seco surface) and a "high" Cosumnes River terrace.

The river terrace, cut at this point by the old road, is best observed from a vantage point on Sloughhouse Road approximately one mile ahead of these exposures. This terrace occurs as a well defined level about 60 feet above the Cosumnes River floodplain. It may be cut within the Arroyo Seco Gravel or is possibly of fill origin. The exposures at this point, however, do not shed sufficient evidence to resolve the problem. However, as seen on the Sloughhouse 7 1/2' Quadrangle (e.g. projected sec. 4, T. 7 N., R. 7 E.), several small, flat basins are cut within the high Arroyo Seco surface but extend onto the surface of this terrace. These features, terrace continuity, and analogy to younger, better preserved terraces, suggest that the sediments underlying the surface observed at this stop were deposited as channel fill.

At present this surface cannot be directly correlated with terraces along the American River. However it is similar to the American River terrace of Fair Oaks age (IV) in terms of soil profile (Corning-like) and relative elevation above the present drainage.

Continue up old road to the junction of Sloughhouse Road. The cuts at the top of the road expose the Arroyo Seco Gravel.

8.7/0.3 Sloughhouse Road junction (stop sign); turn left on Sloughhouse Road (SW). The road now crosses the top of the upper Arroyo Seco surface (Arroyo Seco Pediment ?). The gravelly high terrace of the Cosumnes River, discussed at the last stop, may be seen to the left (east).

9.3/0.6 Sloughhouse Road now descends from the upper Arroyo Seco surface onto the "high" Cosumnes River terrace. Road cuts at this point expose a well-developed red, gravelly soil without a hardpan, similar in appearance to the Corning soil developing on the American River terrace of Fair Oaks age (terrace IV).

11.6/2.3 Sharp right turn; continue on Sloughhouse Road (to the NW). At this turn, to the south, is a relatively undissected terrace approximately 25 feet lower in elevation than the gravelly surface just traversed. This lower surface is 20 feet above the present Cosumnes River floodplain and is characterized by the well-developed San Joaquin soil. On the basis of elevation, lithology, and relative profile development, it is suggested that this surface is of Riverbank age (geologic map in pocket).

Sloughhouse road now ascends a saddle almost to the crest of the upper Arroyo Seco surface.

12.2/0.6 Crest of hill; roadcut exposures of the Arroyo Seco Gravel.

12.6/0.4 Sloughhouse Road now crosses a gently undulating surface underlain by the Laguna (?) Formation or backfill (?) deposits of the Riverbank Formation. Very few natural or man-made exposures are present in this area.

12.9/0.3 Grant Line Road intersection (stop sign); turn left; proceed to the SW along Grant Line Road.

14.5/1.7 Calvine Road intersection; continue SW along Grant Line Road. In this area the slightly dissected surface to the SW (left) is underlain by granitic sand and silt of the Riverbank Formation; to the north (right) a series of low hills, approximately 5 to 10 feet higher than the surrounding terrain are underlain by small metamorphic gravels (Arroyo Seco Gravel ?).

16.4/1.8 Cross tracks of the Central California Traction Company and continue SW on Grant Line Road through the town of Sheldon; still crossing terrain underlain by the Riverbank Formation.

17.2/0.8 Cross Bond Road intersection. To the SW (left), the surface of the Riverbank and Modesto Formation begin to merge. The mouths of gullies cut within the Riverbank surface are dammed by probable Modesto age sediments to form closed depressions at least 25 feet deep indicating that the Modesto Formation was deposited as a distinct alluvial fill (projected secs. 18 and 19, T. 7 N., R. 7 E.; projected secs. 26, and 34, T. 7 N., R. 6 E.; projected sec. 11, T. 6 N., R. 6 E.).

17.4/0.2 Cross under high voltage lines. Note the undissected local terrain (surface of the Riverbank Formation).

18.5/1.1 Elk Grove Boulevard; turn right (west).

19.0/0.5 Bradshaw Road (stop sign); continue west on Elk Grove Boulevard.

19.0/0.9 High voltage line.

20.0/0.1 Waterman Road intersection; turn right (north).

20.4/0.4 STOP 3B: Park on shoulder of road; walk to old cemetary borrow pit on west side of Waterman Road. Observation of the Arroyo Seco Gravel and discussion of the origin of the Elk Grove Outlier.

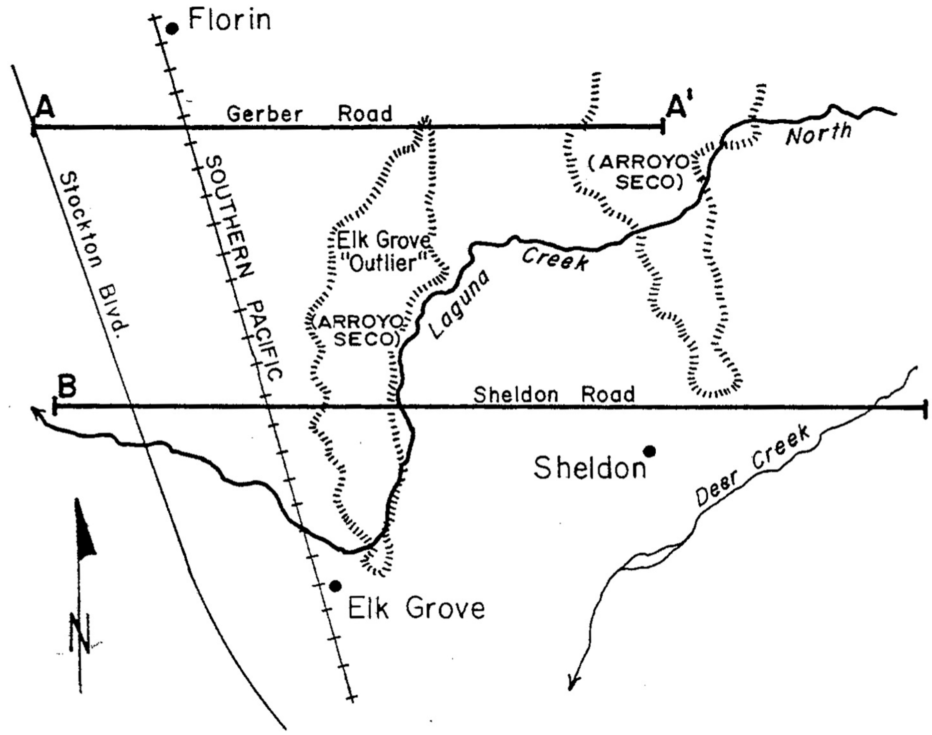
Exposed in this old cemetary quarry are approximately 15 feet of metamorphic gravels and granitic sands. This area, apparently, is the westernmost limit of the Arroyo Seco Gravel and Arroyo Seco Pediment of Piper *et al* (1939).

From this point and extending five miles to the north is a distinct ridge, capped by gravel and rising 35 feet above the adjacent terrain (see Elk Grove 7 1/2' Quadrangle, secs. 8, 17, 18, 19, 20, 29, 30, 31, and 32, T. 7 N., R. 6 E.). This ridge is informally called the "Elk Grove Outlier". The southern end and lowest elevation of the Outlier (65 feet) may be an erosional remnant of a pre-Fair Oaks age channel of the American River. It appears to lie on a plane projected westward from the top of the lower Arroyo Seco surface. In addition, there is some evidence suggesting the southern end of the Elk Grove Outlier was covered at least once by younger sediments, possibly glacially derived (?) silt and sand. This evidence is in the form of the unique drainage pattern of Laguna Creek (north) which, as observed on the Elk Grove 7 1/2' Quadrangle, flows in an entrenched channel across the lower Arroyo Seco surface north of Sheldon (e.g. secs. 2, 10, and 11, T. 7 N., R. 6 E.); thence westward across a low plain (Riverbank Formation) until reaching the eastern boundary of the Elk Grove Outlier. Here it is apparently structurally controlled for it turns due south (sec. 17, T. N., R. 6 E.) and flows parallel to the Outlier. It then cuts directly across the crest of the Elk Grove Outlier (secs. 29 and 31, T. 7 N., R. 6 E.) where it now flows in an entrenched channel approximately 25 feet below the surface of the Outlier. At this point it is two miles from the Cosumnes River but does not flow into that stream. Rather, it continues westward some nine miles debouching into a basin adjacent to the Sacramento River near Freeport. In conjunction with other geomorphic evidence, it appears that those sections of Laguna Creek entrenched into the lower Arroyo Seco surface and the Elk Grove Outlier are superimposed and possibly developed on a former surface that just topped the southern end of the Outlier.

To the west of this stop, exposures in several quarries (secs. 30 and 31, T. 7 N., R. 6 E) reveal that the gravel derived therefrom is weathered and lithologically very similar to the gravel capping the Elk Grove Outlier. The sand fraction, however, is essentially unweathered and is probably younger in age. The lithology and some imbricate structure in the gravels suggest that most of the gravels were locally derived from the Elk Grove Outlier; probably in Riverbank time when the Outlier existed as a ridge approximately 70 feet above the glacial (?) channel of the American River. This relationship is illustrated in two east-west structure sections drawn across the Elk Grove Outlier at Sheldon Road and Gerber Road (Figures 10, 11, and 12). In addition, as shown on the structure sections, basal channel gravels of the Fair Oaks age American River can be identified in the subsurface between the Elk Grove Outlier and the Arroyo Seco "highlands" to the east (Figure 3). The gravels of this channel rise to the surface approximately five miles northeast of Elk Grove (secs. 4 and 9, T. 7 N., R. 6 E.) where they are topographically evident as American River terrace IV (Fair Oaks age). In

Figure 10

LOCATION MAP FOR FIGURES 11 AND 12



the subsurface they are traced to a point immediately east of this stop at an elevation close to present sea level or approximately 60 feet below the surface (Figure 3).

Return to cars; proceed north on Waterman Road.

20.7/0.3 Disposal site at left; unfortunately the exposures here are ephemeral. Continue north on Waterman Road.

30.1/0.4 Bridge across Laguna Creek (north). The stream here is entrenched approximately 25 feet into the Elk Grove Outlier. Make jog across bridge and continue north on Waterman Road traversing the crest of the Elk Grove Outlier.

31.0/1.0 Sheldon Road intersection; turn right.

31.3/0.2 Descend the Elk Grove Outlier and cross Laguna Creek (north) bridge. At this point Laguna Creek is flowing due south along the eastern edge of the Outlier. The terrain ahead (along Sheldon Road) is relatively undissected. The surface soil is the San Joaquin(surface of the Riverbank Formation ?), however, the sediments between the soil and the underlying channel gravels may in part be of Fair Oaks age (Figure 11).

32.0/0.8 Bradshaw Road intersection; turn left (north). The road here crosses a plain underlain by sediments of the Riverbank Formation. In this area the channel of Fair Oaks age is approximately 30 feet thick and is encountered by wells 20 feet below the surface (e.g. wells 7/6E - 20J1; 7/6E - 16J1; 16P1). The Elk Grove Outlier is on the skyline to the left (west).

33.1/1.0 Calvine Road intersection; continue north on Bradshaw Road.

33.5/0.4 Cross Laguna Creek (north).

34.3/0.8 Cross tracks of the Central California Traction Company. The base of the microwave tower on the Elk Grove Outlier to the left (west) is at elevation 96 feet, the highest point of the Outlier and approximately 40 feet above the terrain now being traversed. A well at this point on the Outlier (7/6E - 8P1) penetrates 33 feet of gravels before bottoming in granitic sand and silt of the Laguna Formation (Figure 11).

35.1/0.8 Gerber Road intersection; turn right (east).

35.2/0.1 Road cuts exposing gravels underlying American River terrace of Fair Oaks age (IV) and the Corning soil.

36.2/1.0 Vineyard Road junction; continue east on Gerber Road which now ascends a 20 foot escarpment onto the lower Arroyo Seco surface.

36.9/0.7 STOP 4B (OPTIONAL): Entrance to the Gerber Road County Disposal Site.

It is often difficult to secure permission to enter the disposal site and to examine the exposures. Also the cuts are quite ephemeral, usually being filled with refuse in about two months. Normally, however, at least one 40 foot cut is present which exposes the entire sequence of Arroyo Seco Gravel and the top 15 or 20 feet of the underlying Laguna Formation. At present, this is the only site known in Sacramento County at which to observe the Arroyo Seco - Laguna contact.

Return to cars; continue east on Gerber Road.

37.2/0.3 Excelsior Road intersection; turn left (north). The road now traverses the lower Arroyo Seco surface; numerous road-cuts expose the Redding soil developed on this plain.

38.2/1.0 Florin Road intersection; turn left (west).

38.7/0.5 The cuts at this locality expose the Redding soil and the top of the lower Arroyo Seco surface as the road descends onto the surface of American River terrace IV (Fair Oaks age).

39.3/0.6 Approximately two feet of granitic sand (Riverbank Formation) overlie channel gravels of Fair Oaks age (terrace IV) in this area. The Corning soil, marking the top of the gravels, is easily reached by auger at this point. This soil appears to be as well developed in the subsurface as it does on the surface suggesting that it reached its present state of development before burial in Riverbank time.

40.2/0.9 Bradshaw Road intersection. To the west and north, Elder Creek and its tributaries are entrenched less than five feet into the surface of the Riverbank Formation; to the south, low gravel capped hills mark the northern end of the Elk Grove Outlier.

END OF FIELD TRIP B: Return to Sacramento via Bradshaw Road or proceed to Fair Oaks for Field Trip C (Figure 7).

ROAD LOG FOR GEOLOGIC FIELD TRIP C - NORTHERN SACRAMENTO COUNTY, CALIFORNIA

Mileage is given in the left hand margin; first figure is cumulative mileage for the trip and second figure is mileage since the last reference.

MILEAGE

0.0/0.0 START FIELD TRIP C: Intersection of Fair Oaks and Sunrise Boulevard, town of Fair Oaks (Figure 7). Proceed east on Fair Oaks Boulevard.

0.7/0.7 Fair Oaks Boulevard-Winding Way junction (stop sign); proceed straight ahead (east) on Winding Way. The dissected surface of the Fair Oaks Formation is very evident in this area. This dissection plus urbanization makes it difficult to identify remnants of a soil which presumably developed on the original aggradational surface of the Fair Oaks Formation. (Contrast the "degree of dissection" north and south of the American River; Citrus Heights and Carmichael 7 1/2' Quadrangles, respectively).

1.1/0.4 Cross bridge. The numerous metamorphic gravel channels, as seen here, are characteristic of the Fair Oaks Formation. Some of the larger ones continue for at least two miles (identified in adjacent roadcuts) and all appear to be trending south toward the American River. In this area, however, the present drainage divide between the American River and smaller streams to the north (e.g. Arcade, Cripple, and Linda Creeks) is less than a mile from the American River; the smaller drainages trend to the NW for three or four miles before turning SW to flow down the regional slope (see Citrus Heights and Folsom 7 1/2' Quadrangles).

2.5/1.4 Illinois Avenue intersection (stop sign); turn right (south) onto Illinois Avenue.

2.7/0.2 Fair Oaks Gravel Company gate. If gate is closed, secure entrance permission from watchman (house at right), park cars and walk down roadway (0.2 mile) to roadcut exposures of American River terrace gravels.

2.9/0.2 STOP 1C: Roadcut exposures of terrace gravels.

These gravels are lithologically similar to those underlying the American River terrace of Fair Oaks age (IV; Figure 6). As yet, however, it is not known whether the gravels observed here are coeval with channel deposits south of the present stream. Also, a Fair Oaks intraformational channel, identified in roadcuts on Greenback Lane and Madison Avenue, appears to head south toward this point. The gravels exposed here may be a continuation of that channel.

3.1/0.2 Enter the Fair Oaks Gravel Company yard. The prominant hill to the east is underlain by andesitic cobbles and boulders of the Mehrten Formation which, in turn, are overlain by a veneer of metamorphic gravels (Arroyo Seco Gravel). The hill is the southern-most topographic expression of a Mehrten age channel which, although discontinuous, can be traced at least 10 miles to the northeast (Mooney Ridge, Placer County; sec. 12, T. 10 N., R. 7 E.; see discussion, Stop 4C).

Return to cars; proceed north on Illinois Avenue to Winding Way.

3.6/0.5 Illinois Avenue-Winding Way intersection; turn right (east) onto Winding Way.

3.9/0.3 Curve in road; bear straight ahead on Baliff Way.

4.2/0.3 Hazel Avenue junction (stop sign); turn right (south) onto Hazel Avenue.

4.6/0.4 STOP 2C: Approach to the Hazel Avenue Bridge and entrance to Folsom Lake State Recreational Area. Park cars on shoulder; walk toward bridge. Examination of new roadcuts exposing channel gravels of Mehrten age.

At time of preparation of this road log (March 1967), the Hazel Avenue Bridge was not completed and the new approach cuts were not landscaped. In the near future, however, it will undoubtedly be more difficult to examine the exposures in this area. These cuts were not present when the geologic map of Northern Sacramento County (pocket) was completed. However, the Mehrten channel deposits now seen here were mapped on the basis of upstream exposure and topographic expression.

Most of the sediments are andesitic; very coarse-grained fluvial sand is well exposed near the base of these cuts. Granitic sand is not uncommon although granitic cobbles and boulders are. Some of the boulders are at least 6 inches in diameter. In general, the size of the gravels tends to increase eastward (seen later in this trip). Channel relief in this area varies from 5 to 15 feet. To the south, across the American River, are the numerous tailing piles which were formed when terraces I and II (Modesto age) were destroyed by dredging operations.

Return to cars and turn east onto road leading into State Park.

4.8/0.2 Nimbus Dam overview; general observation stop.

The surfaces of American River terraces II and III (Modesto and Riverbank age, respectively) may be seen in the foreground immediately beyond the Nimbus Fish Hatchery. In the distance (to the south) are the rocket test stands of the Aerojet and Douglas Companies, built on American River terraces of Riverbank and Fair Oaks age. The immensity of the American River terraces and the difficulty of correlating them with sediments north of the stream perhaps can be appreciated from this vantage point.

The city of Folsom may be seen across the River, northeast of this point. Folsom is built on at least three terraces of the American River. In addition, the southern edge of the town appears to be underlain by a pre-Arroyo Seco (?) gravel channel which trended southwestward from a point now within Folsom Reservoir to the City of Folsom (Figure 3). This old channel, first recognized by Kiersch and Treasher (1955) is informally called "ancestral South Fork American River" (mapped Qasx; geologic map in pocket). It apparently pre-dates all Pleistocene channels south of the American River.

Return to cars; proceed north on Hazel Avenue. Along this road and adjacent streets (e.g. La Serena Drive, Kruitof Way etc.), cuts expose two to five feet of Arroyo Seco Gravel overlying the Mehrten channel deposits.

6.0/1.2 Sunset Avenue intersection (stop sign); turn right (east) onto Sunset Avenue.

6.2/0.2 Entrance to Phoenix Field (Fair Oaks Airport). Open field on the right (south) is capped by the Arroyo Seco Gravel (Redding soil). This field also has a fairly well developed microrelief ("hogwallows"). These hogwallows, however, are smaller than those typically found on surfaces underlain by the Arroyo Seco Gravel.

6.7/0.5 Sunset Avenue now descends 120 feet to a level slightly above Lake Natoma on the American River. Roadcuts on the left expose Arroyo Seco Gravel overlying Mehrten channel gravels.

6.9/0.2 Main Avenue, Orangevale (stop sign); turn left (north). To the left are Mehrten channel gravels forming the bluffs of the American River; to the right are dredge tailing derived from river terraces of Modesto (?) or Riverbank (?) age.

8.4/1.5 Madison Avenue intersection (stop sign); turn right (east) onto Madison Avenue.

8.9/0.5 Greenback Lane intersection (stop sign); continue straight ahead. Roadcuts in this area expose dark colored andesitic sand of the Mehrten Formation overlain by a veneer of Arroyo Seco Gravel.

9.0/0.1 STOP 3C: Orangevale Avenue intersection; pull off road in "parking area" just before intersection. Inspection of bluffs and general discussion of geomorphic history of the region.

The bluffs at this locality are a continuation of the Mehrten channel observed at Stop 2C. Eastward from this point, toward Folsom, the Mehrten channel overlies progressively older fluvial granitic and andesitic sand, marine sandstone ("Chico Formation"), and granitic bedrock. As seen in the "canyon" roadcut along Orangevale Avenue, the boulders within the Mehrten channel are well-rounded, almost exclusively andesitic, and larger than those observed "downstream" at Stop 2C. Locally, as in this area, the Mehrten channel is capped by the Arroyo Seco Gravel. The sinuous nature and extent of the Mehrten channel, its topographic form, and its contact relief with underlying rocks, suggest that an inversion of topography has taken place since deposition of channel gravels. Apparently the surrounding topography, especially the granitic terrain, has been lowered by post-Mehrten erosion but deposits of the original channel were preserved and now exist as a discontinuous ridge.

Turn sharp left at Orangevale Avenue and proceed through the "canyon" cut in the Mehrten channel.

9.6/0.6 Main Avenue intersection (stop sign); turn right on Main Avenue.

9.8/0.2 Cross Central Avenue; continue north on Main Avenue.

10.3/0.5 Elm Avenue; continue north on Main Avenue. The streams in this area head within one mile of the American River yet drain to the NW, away from the major drainage. The granitic sand in the upper section of the Fair Oaks Formation, as exposed in this locality, is relatively unweathered and apparently is locally derived from granitic rocks which crop out on the adjacent Roseville Surface. Although discontinuous, a gravelly well-developed buried soil occurs approximately 10 to 20 feet below the surface in this region. Superficially it is similar to the Corning soil which occurs on the terrace of Fair Oaks age (1V) south of the American River. As yet, however, the stratigraphic relationship of this buried soil and those near Fair Oaks and south of the American River is unknown.

10.8/0.5 Oak Avenue (stop sign); turn right (east) onto Oak Avenue.

11.8/1.0 Curve in road; bear to right; continue on Oak Avenue. Granitic rocks are exposed in cuts to the left (east); gravels of the Mehrten channel overlie granitic rocks to the right. Large granitic tors seen along the roadside are common in this area.

12.5/0.7 Folsom-Auburn Road junction (stop sign); turn left (north) onto Folsom-Auburn Road. Granitic rocks exposed in roadcuts.

13.1/0.6 Metamorphic rocks exposed in massive cut to the left (west).

13.9/0.8 Curve in road; entrance to Folsom Dam on right. Kiersch and Treasher (1955, p. 284), in geologic investigations at the Folsom Damsite, report that large outcrops of quartz diorite (seen as tors in this area), apparently representative of bedrock, were underlain by "thoroughly decomposed material to a considerable depth". Topographic evidence of granitic weathering may be seen in the Mooney Ridge area, south of Folsom Lake (see Stop 4C; sec. 12, T. 10 N., R. 7 E.).

14.5/0.6 Placer Couny line. Granitic rocks are exposed in cuts; the road now ascends and crosses granitic rock and the Mehrten channel which form the natural western boundary of Folsom Lake.

16.7/212 Douglas Boulevard; turn right (east).

17.1/0.4 Road narrows to two lanes; continue straight ahead.

17.3/0.2 Mooney Drive intersection (Lakeridge subdivision); turn right; cross granitic terrain and ascend Mooney Ridge. Note granitic rocks exposed in cuts at the base of the ridge; andesitic gravels cap the ridge.

17.7/0.4 STOP 4C: Cross Sierra Drive and park along the shoulder of Lakeshore Drive (very narrow; the lake is more than 150 feet below!). Observation of the Mehrten channel-granitic rock contact and discussion of a possible regional inversion of topography (?).

The roadcuts along Lakeshore Drive show that the Mehrten channel was flowing on granitic bedrock at this point. Local contact relief is 5 to 10 feet. In several places along the ridge, large boulders (2 feet in diameter) are found within the andesitic gravels. The size of these rocks attests to the competence of the stream that carried them in Mehrten time.

Although not measured, the Mehrten gravels are about 40 feet thick at this locality. As seen to the southeast (overlooking Folsom Reservoir) or to the northwest, these channel gravels appear to form a protective cap on the granitic rocks underlying the main body of Mooney Ridge; the top of which is now 200 to 250 feet higher than the surrounding granitic terrain. Inferentially, an inversion of topography has occurred and Mooney Ridge is now the topographic expression of a Mehrten age stream which flowed southwest to the area near the present Nimbus Dam (Stop 3C). Alternatively, the irregular topography of the granitic terrain underlying the andesitic cobbles and boulders may possibly have weathered along irregular joints, washed clear of grüss, and subsequently filled by pediment gravel.

The undulating granitic terrain below Mooney Ridge, crossed by Douglas Boulevard, is informally called the "Roseville Surface." This surface appears to merge almost imperceptibly into dissected terrain underlain by fluvial granitic sediments of the Fair Oaks Formation near the Sacramento-Placer County line (Figure 13).

Return to Mooney Drive-Douglas Boulevard intersection.

18.5/0.8 Douglas Boulevard intersection; turn left (west) on Douglas Boulevard.

19.1/0.6 Folsom-Auburn Road intersection (stop sign); continue straight ahead on Douglas Boulevard. The road crosses undulating terrain

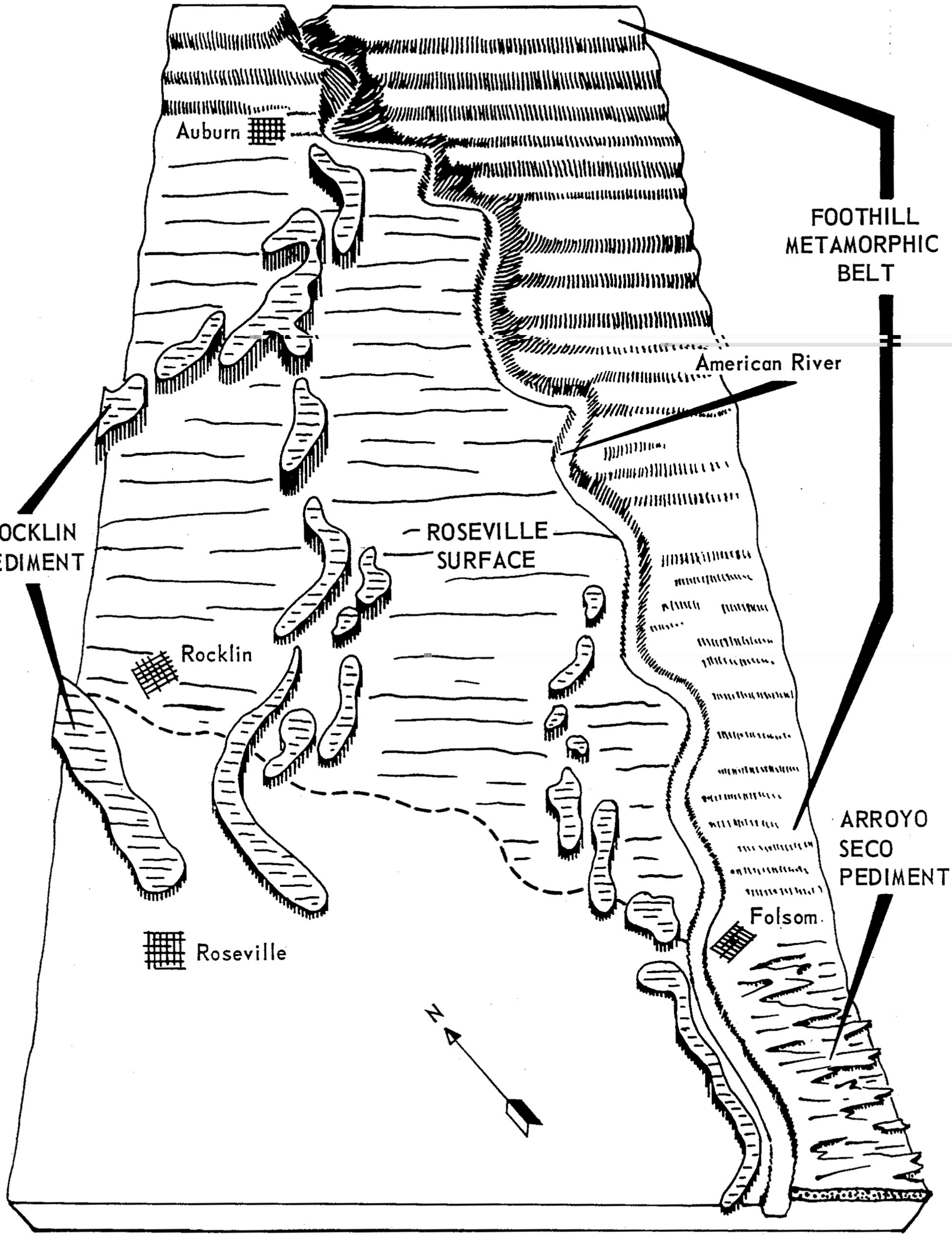


Figure 13 – Generalized diagram illustrating the topographic relationship of the Arroyo Seco Pediment, Rocklin Pediment, and Roseville Surface in northeastern Sacramento and southwestern Placer counties. The American River forms the northern boundary of northwestward trending ridges of the foothill metamorphic belt. Granitic rocks of the Roseville Surface merge imperceptibly into the dissected alluvial plains (Fair Oaks Formation) near Roseville.

of the Roseville Surface for the next several miles.

22.1/3.0 Sierra College Boulevard (stop sign); turn right.

22.5/0.4 Fluvial andesitic sands and gravels (Mehrten Formation) are exposed in roadcuts along Sierra College Boulevard. The road now ascends an unnamed ridge underlain by andesitic channel gravels and breccia. These rocks, representing two distinct phases of Mehrten deposition, are well exposed in these fresh cuts.

23.1/0.6 Continuous roadcuts exposing gravel and breccia deposits.

24.4/1.3 Top of ridge; elevation 519 feet (sec. 29, T. 11 N., R 7 E.); road curves to the right.

24.6/0.2 INFORMAL STOP 5C: This region is outside the mapped area and the exposures here have not been examined in detail. However, these rocks may be similar to the Mehrten deposits underlying the Fair Oaks Formation in Sacramento County and penetrated by numerous water wells. Also, these cuts are still fresh and do expose the entire section of the Mehrten Formation; a fortuitous occurrence.

25.2/0.6 Descend the ridge to granitic terrain of the Roseville Surface. Roadcuts in this area reveal the presence of several large granitic boulders within the lower section of andesitic gravel.

25.8/0.6 Rocklin Road intersection (stop sign); turn left on Rocklin Road. Continue past Sierra College and into the town of Rocklin.

26.7/0.9 Free onramp; END OF FIELD TRIP C; return to Sacramento via Freeway (Interstate 80).