Petrology of Sediments Underlying Areas of Land Subsidence in Central California

GEOLOGICAL SURVEY PROFESSIONAL PAPER 497-C

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By ROBERT H. MEADE

MECHANICS OF AQUIFER SYSTEMS

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With emphasis on the petrologic characteristics that influence the compaction behavior of the sediments: particle size, clay minerals, and associated ions

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By Robert H. Meade

ABSTRACT

A diversity of particle sizes and a uniformity of clay-mineral assemblages has been shown by a study of the petrologic characteristics that influence compaction—particle sizes, clay minerals, and associated ions—in fresh-water-bearing sediments underlying areas of land subsidence related to ground-water withdrawal in central California.

The sediments underlying the Los Banos-Kettleman City area of the western San Joaquin Valley are alluvial-fan, flood-plain, lacustrine, and deltaic deposits; the sources of the sediments were the Sierra Nevada and Diablo Range. They are diverse and heterogeneous in texture, often poorly sorted, and their geometric-mean particle size is probably between 30μ and 60μ. Montmorillonite is the principal clay mineral, accounting for 70 percent of the clay-mineral assemblage and 10 percent of the sediments as a whole. Calcium is the predominant exchangeable cation.

The sediments underlying the Tulare-Wasco area of the southeastern San Joaquin Valley are mainly alluvial-fan and shallow-marine deposits, plus subsidiary flood-plain and lacustrine deposits; all are derived from the Sierra Nevada. The nonmarine sediments are mostly poorly sorted and heterogeneous, having a mean particle size of 40μ–80μ. The shallow-marine sediments are more uniform, consisting of siltstone (mean particle size 5μ–10μ) and fairly well sorted sands (mean particle size 250μ–500μ). Montmorillonite (plus some vermiculite) is the principal clay mineral, comprising about 10 percent of the nonmarine sediments and 20 percent of the marine siltstones. Calcium is the dominant exchangeable cation in the nonmarine sediments. The exchangeable-cation assemblage in the marine siltstones is more diverse, consisting of variable proportions of calcium, sodium, magnesium, and hydrogen.

The uppermost 1,000 feet of sediments underlying the Santa Clara Valley is alluvial, with perhaps a few minor interbedded lacustrine deposits; the sources of the sediments were the adjoining Santa Cruz and Diablo Ranges. Coarser sands and gravels (mean size on the order of 500μ–1,000μ) are found below the courses of the main streams of the valley. Finer silts and clays (mean size on the order of 5μ–10μ) underlie the parts of the valley away from the main streams. Montmorillonite is again the dominant clay mineral, comprising between 5 and 25 percent of the sediments, depending on the general fineness of their particle size. Calcium is the dominant exchangeable cation.

In the sediments underlying the Arvin-Maricopa area at the southern end of the San Joaquin Valley, the clay-mineral assemblage is also dominated by montmorillonite.

INTRODUCTION

The petrologic characteristics of sediments determine their responses to changes in overburden load. Detailed knowledge of these characteristics—especially particle size, clay-mineral and exchangeable-cation composition, and the constituents dissolved in interstitial waters—and how they vary in any group of sediments is therefore necessary for a fuller understanding of the compaction of the sediments.

The sediments whose compaction accounts for the subsidence of the land surface in four areas of the San Joaquin and Santa Clara Valleys of California (fig. 1) are the subject of this report. The compaction and

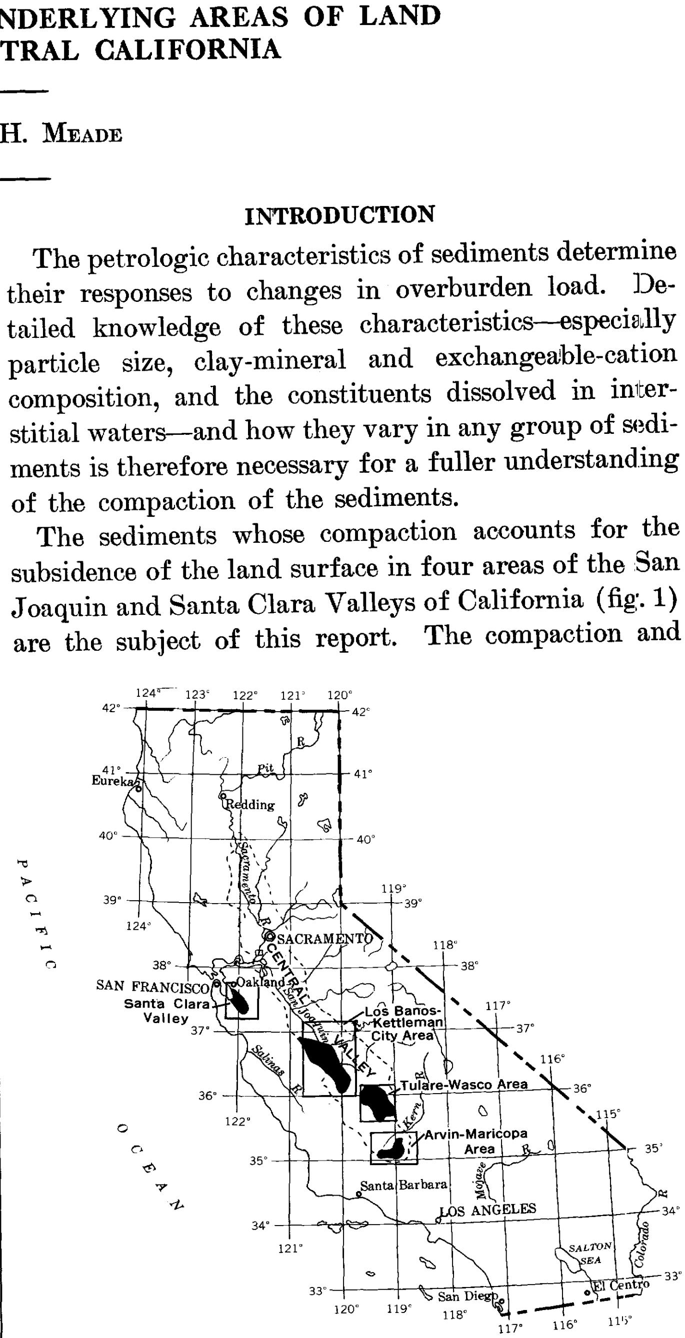

FIGURE 1.—Principal areas of land subsidence in central California. Heavy lines enclose areas of larger scale maps in figures 2, 16, 28, and 36.

land subsidence in these areas are clearly related to the depletion of artesian pressure (increase of grain-to-grain load) in the sediments, which is a result of confined ground water being pumped from the sediments faster than it is being replenished. Because the rates of compaction and subsidence are rapid and can be measured, these areas were selected as field laboratories for a program of study of the mechanics of aquifer systems. Because the compaction represents an acceleration of the natural processes that would have taken place with the further accumulation of overlying sediments, these are also opportune areas for general studies of the compaction of sediments. A fuller discussion of the problems of land subsidence and aquifer compaction and the ways in which the problems have been approached in this program are given by J. F. Poland in his foreword to the first chapter of this series (Johnson and others, 1967).

PURPOSES OF REPORT

This report is one of a series, all chapters of Professional Paper 497, on the mechanics of aquifer systems in California and elsewhere. It is also the second of three chapters by the same author that treat the petrologic aspects of compaction. The first of these three chapters, B (Meade, 1964), is a comprehensive review of previous work on the factors that influence pore volume and fabric of clayey sediments under increasing overburden loads. The second of the chapters—this report—is mainly descriptive and is intended to serve a dual purpose. Its first concern is the variation and distribution of some of the petrologic factors that the review of previous work shows to be significant influences on compaction. It is also meant to be a contribution to the general petrology of the post-Miocene fresh-water-bearing sediments of the San Joaquin and Santa Clara Valleys of California. The results are presented in a form that can be compared readily with the results of similar analyses of sediments in other areas—whether the comparison be for petrologic or engineering purposes. The third chapter (R. H. Meade, Compaction of sediments underlying areas of land subsidence in central California, in preparation as Prof. Paper 497-D) relates, by statistical analysis, the variations in overburden load and petrologic factors to variations in the pore volume and fabric of the sediments. Although it may inconvenience the reader, the division of the petrologic study into three chapters limits the bulk and, hopefully, enhances the readability of the separate reports.

Descriptions of the sources and inferred modes of deposition begin the discussions in this report of the sediments of each of the areas. These descriptions are mainly meant to provide a general background and a spatial framework for the discussions of specific petrologic characteristics that follow them.

The sections of this report that deal with particle size are an extension of the presentation and discussion of particle-size data given by Johnson, Moston, and Morris 1967). Although the two discussions are based on the same sets of size analyses, they overlap only slightly. Whereas Johnson and his associates presented the results of the analyses with no interpretation, the discussions in my report are aimed toward (1) describing the variations in particle size and arriving at meaningful estimates of average size, (2) describing the spatial variations in particle size, (3) describing the relations of particle size to source areas and types of deposits, and (4) finding consistent relations between the particle-size measures themselves. These efforts involve a moderate use of statistical techniques.

The sections of the report that concern the clay minerals and associated ions are aimed toward (1) estimating the total amount of clay-mineral material as well as the relative amounts of the different clay-mineral species in the sediments, (2) describing the exchangeable cations and soluble salts associated with the clay minerals, and (3) making some tentative judgments of the origins of the different clay minerals.

COLLECTION OF SAMPLES

The samples on which this study is based came mostly from eight core holes, four in the Los Banos-Kettleman City area and two each in the Tulare-Wasco area and Santa Clara Valley, and from one test hole in the Arvin-Maricopa area. All the coring was done by drilling crews of the U.S. Bureau of Reclamation. Details of the coring are given in table 1. Locations of the holes are shown in figures 2, 16, 28, and 36. The sediments were sampled with a rotary-driven core barrel 3 inches in diameter. Cores were logged by visual examination at the drilling sites, and selected samples were sealed in wax for later study. Samples from seven of the holes—all but the Oro Loma core in the Los Banos-Kettleman City area and the few sediments that were cored in the Lakeview test hole in the Arvin-Maricopa area—were analyzed for physical and hydrologic properties by the Hydrologic Laboratory of the U.S. Geological Survey in Denver. Samples from all the holes were studied petrographically.

In addition to the core-hole samples, surficial samples from the Los Banos-Kettleman City area and the Santa Clara Valley were included in the study of clay minerals. These samples were collected by W. B. Bull, T. J. Conomos, and me.

TABLE 1.—*Core holes and details of coring*

Nearest town	Location of core hole (township/range-section: Mount Diablo base line and meridian)	Depth of core hole (feet below land surface)	Cored intervals (feet below land surface)	Core recovery (percent total cored intervals)
Los Banos-Kettleman City area				
Oro Loma	12S/12E -16	1,005	30-40, 70-85, 110-120, 150-160, 180-190, 230-240, 270-281, 320-329, 360-1,005.	73
Mendota	14S/13E -11	1,500	30-40, 70-80, 110-120, 150-160, 190-200, 230-240, 270-280, 310-320, 350-360, 390-400, 430-440, 470-480, 510-520, 550-560, 590-600, 630-1,497.	70
Cantua Creek	16S/15E -34	2,000 [1] (2,007)	250-260, 290-300, 330-340, 370-380, 410-420, 450-460, 490-1,050, 1,150-1,600, 1,630-1,640, 1,670-1,680, 1,710-1,720, 1,750-1,760, 1,790-1,800, 1,830-1,840, 1,870-1,880, 1,910-1,920, 1,950-1,960, 1,990-2,000.	57
Huron	19S/17E -22	2,203	30-40, 80-90, 120-130, 160-170, 210-220, 230-240, 270-280, 310-320, 350-360, 390-400, 430-440, 470-480, 510-520, 550-560, 590-600, 630-640, 670-680, 710-2,110.	58
Tulare-Wasco area				
Pixley	23S/25E -16	760	30-40, 70-80, 110-120, 150-160, 190-200, 230-240, 260-752	73
Richgrove	24S/26E -36	2,200	50-1,900, 1,908-1,965, 2,000-2,012, 2,040-2,061, 2,090-2,110, 2,140-2,180.	81
Santa Clara Valley				
Sunnyvale	6S/ 2W-24	1,001	30-265, 300-365, 400-467, 512-581, 600-675, 710-995.	69
San Jose	7S/ 1E -16	1,002	30-40, 70-80, 107-140, 150-165, 185-290, 300-356, 401-455, 500-618, 694-850, 900-956.	30
Arvin-Maricopa area				
Lakeview	11N/21W-3 [2]	1,500	335-339, 392-404, 530-543, 660-666, 685-696, 830-836, 1,146-1,155, 1,455-1,460.	57

[1] Depth from electric log. After electric log was run, the drill pipe (newly acquired) was measured and found to be 0.35 ft longer per 100 ft than figured during coring.
[2] San Bernardino base line and meridian.

ACKNOWLEDGMENTS

This report describes the results of a large number of laboratory analyses and programs, many of which were carried out by members of the U.S. Geological Survey other than me. The Hydrologic Laboratory of the Survey in Denver made the particle-size analyses. David Handwerker wrote a machine program to compute statistics from the particle-size analyses. J. C. Hathaway, H. C. Starkey, and G. W. Chloe determined the clay minerals in a group of 25 samples from the Los Banos-Kettleman City area. T. J. Conomos determined the clay minerals in sediments from San Francisco Bay. Claude Huffman, A. J. Bartel, H. H. Lipp, and I. C. Frost determined the soluble anions associated with the clays. H. C. Starkey and T. Manzanares determined the exchangeable cations. K. E. Lohman, Ellen J. Moore, Patsy B. Smith, and D. W. Taylor identified some of the fossil remains. Meyer Rubin provided a radiocarbon date.

I. E. Klein, of the U.S. Bureau of Reclamation, lent me a large collection of core-hole samples that were taken for his use, and he determined the source areas of the sediments in the Oro Loma core. The San Jose Water Works and the California Department of Water Resources provided chemical analyses of ground water in the Santa Clara Valley.

In the determination of clay minerals, I was assisted in the laboratory by J. O. Berkland, W. R. Cotton, F. P. Naugler, and, most extensively and ably, by J. B. Corliss. L. K. Lustig reviewed sections of the manuscript. The counsel and guidance of J. F. Poland and Julius Schlocker, as well as the observations, findings, discussions, and criticisms of my colleagues on the project—W. B. Bull, J. H. Green, A. I. Johnson, B. E. Lofgren, R. E. Miller, and R. P. Moston—contributed heavily to the substance and form of the report.

SEDIMENTS IN THE LOS BANOS-KETTLEMAN CITY AREA

In the Los Banos-Kettleman City area, the sediments whose compaction accounts for the observed land subsidence are almost entirely nonmarine—mostly alluvial. They came from the Diablo Range that forms the southwestern border of the area and from the Sierra Nevada that lies across the San Joaquin Valley to the northeast. The sediments occur chiefly within the Tulare Formation or the alluvium that lies above the Tulare. Locally, however, in the southern part of the area, deep water wells tap sediments within the Etchegoin and San Joaquin Formations. The age of these sediments is not closely defined; but the lowermost are no older than middle Pliocene, and the uppermost were deposited in modern times.

This study is based on samples taken from four core holes that were drilled into these sediments, about to the base of the Tulare Formation. Locations of the core holes, all of which are in western Fresno County, are shown in figure 2.

The geology of the sediments that are undergoing artificially induced compaction is described in detail by Miller, Green, and Davis, in preparation as Professional Paper 437-E. Other reports by Bull (1964a, b),

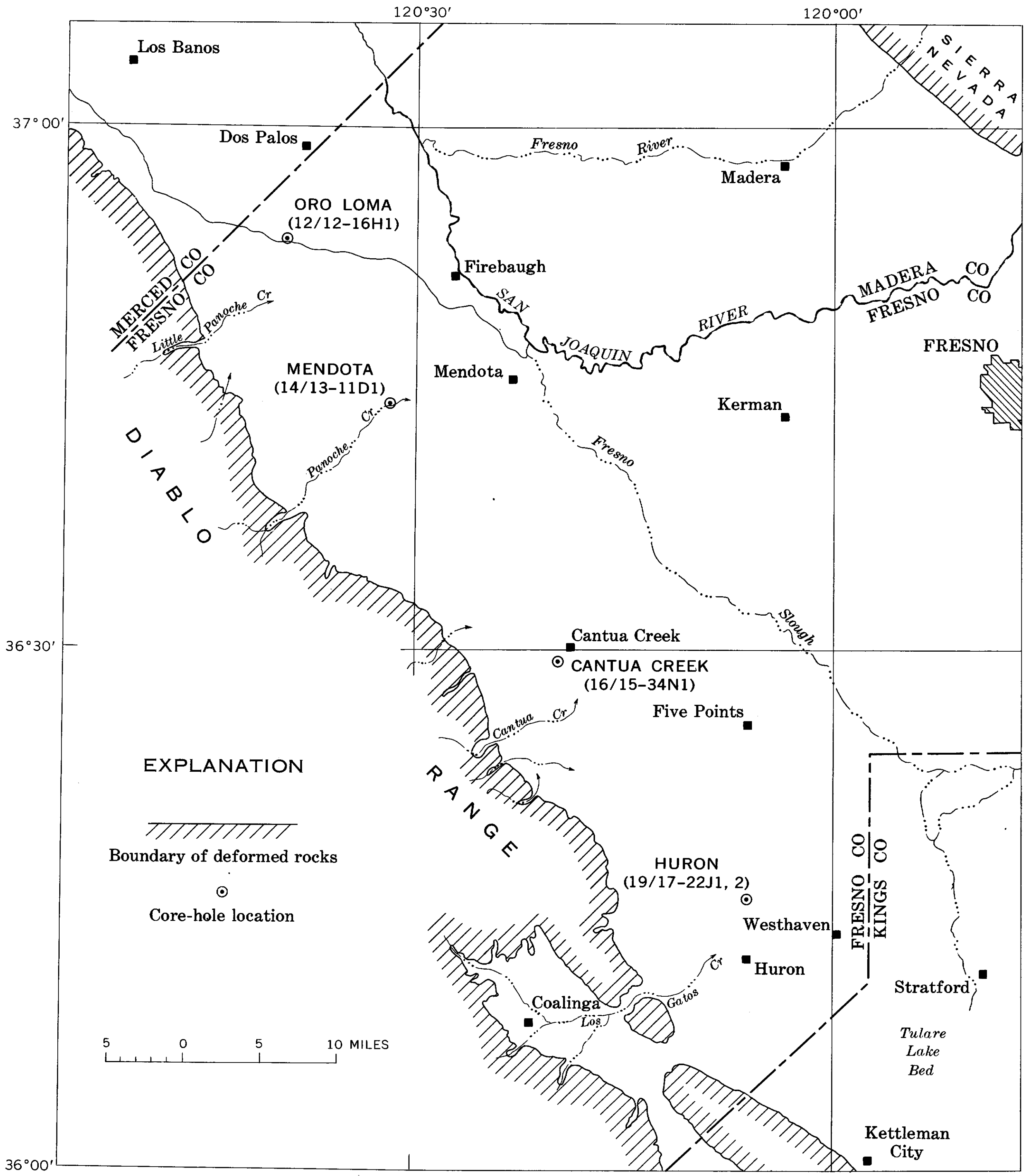

Figure 2.—Los Banos-Kettleman City area showing location of core holes.

describe the lithology and depositional history of the alluvial deposits of Quaternary age in the Los Banos-Kettleman City area.

SOURCES OF SEDIMENTS

The Tulare Formation and younger alluvium represented by the cores in the Los Banos-Kettleman City area were derived from two mountainous terranes: the Diablo Range on the west side of the San Joaquin Valley and the Sierra Nevada on the east side (fig. 2). The streams that flow from the Diablo Range into this part of the valley drain mostly areas of folded, but otherwise unmetamorphosed, Cretaceous and Cenozoic sedimentary rocks; some streams also drain areas underlain by the partly metamorphosed sediments and ultramafic rocks of the middle-to-late Mesozoic Franciscan Formation. In the central Sierra Nevada, the rocks underlying the principal drainage basins are markedly different from the rocks in the Diablo Range. Sierra Nevada rocks are mainly granitic but include lesser amounts of metamorphic rocks and Cenozoic sediments. Deposits derived from the two sides of the valley, therefore, are easily distinguished from each other on the basis of their minerals and lithic fragments.

SOURCE CRITERIA

The sources of the Tulare Formation and younger sediments in the four cores were determined by examining silts, sands, and what gravels were available under the binocular microscope. This examination was supplemented by petrographic-microscope examination of a few thin sections of well-sorted sands. The clays were assumed to have come from the same sources as intercalated silts, sands, and gravels.

The typical sands from the Sierra Nevada are light-colored and micaceous and contain more than 25 percent feldspar—enough for them to be called "arkosic" by Gilbert's definition (Williams and others, 1955, p. 292–295). The amount of mica ranges from 2 to 5 percent and is nearly all biotite in fresh-looking flakes or books. The biotite grains are usually the same size as the principal nonmica grains or larger. The sands also contain 1–2 percent of green hornblende in prismatic grains.

Sands from the Diablo Range are darker—some consisting of more than 30 percent dark grains—and generally contain more lithic fragments. The characteristic dark constituents are subrounded rock fragments: partly altered andesite, greenish serpentinite in rounded and often oblate grains, and brick-red chert in subangular to subrounded grains. Mica is present in amounts of 2 percent or less, usually in weathered-looking flakes that are the same size as the principal nonmica grains or smaller.

The principal sources of the core-hole sediments, as determined by the above criteria, are shown in figure 3. Small admixtures—for example, a few grains of chert and serpentine mixed with sediments mainly from the Sierra Nevada—are not shown. Such mixtures are typical of flood-plain and lacustrine deposits. The sources of the sediments below 1,600 feet in the Cantua Creek core could not be determined with certainty because only 25 percent of this interval of sediment was cored and only 15 percent of the interval was recovered.

ANDESITIC SANDS

Andesitic detritus is a common constituent of the sands from the Diablo Range. It is especially abundant in the sands that lie between 1,500 and 1,000 feet below the surface in the Mendota core and between 1,000 and 500 feet in the Oro Loma core. It is probably derived from older Pliocene andesitic sandstones of the Etchegoin and San Joaquin Formations that crop out on the east flank of the Range.

These Pliocene sandstones have been described by Lerbekmo (1957, 1961). They consist largely—in some places almost entirely—of fresh andesitic debris: intermediate plagioclase, 40–70 percent andesitic rock fragments, and 10–30 percent ferromagnesian minerals. A characteristic feature is their striking blue color, which is caused by grain coatings of authigenic montmorillonite derived from the solution of volcanic detritus within the sandstones.

The andesitic sands in the Tulare Formation and younger sediments as examined in the cores differ significantly from the Pliocene sandstones, and the differences indicate that the sands probably came in part from older rocks. Andesitic detritus in the younger sands is always mixed with other Diablo Range material—most conspicuously chert and serpentine—and andesite rock fragments generally comprise less than 25 percent. These andesite fragments are generally somewhat altered. Within the Mendota core, the alteration seems to increase with a decrease in the age of the sediments, suggesting that perhaps the andesitic material was reworked more than once. The grain coatings are only sporadically developed and are not so intensely blue as those in the sandstones of the Pliocene Etchegoin and San Joaquin Formations exposed on Anticline Ridge.

TYPES OF DEPOSITS

Three main types of deposits, all waterlaid, have been recognized in the Tulare Formation and younger sediments of the area: these are alluvial-fan, flood-plain, and lacustrine deposits. As figure 3 suggests, the two

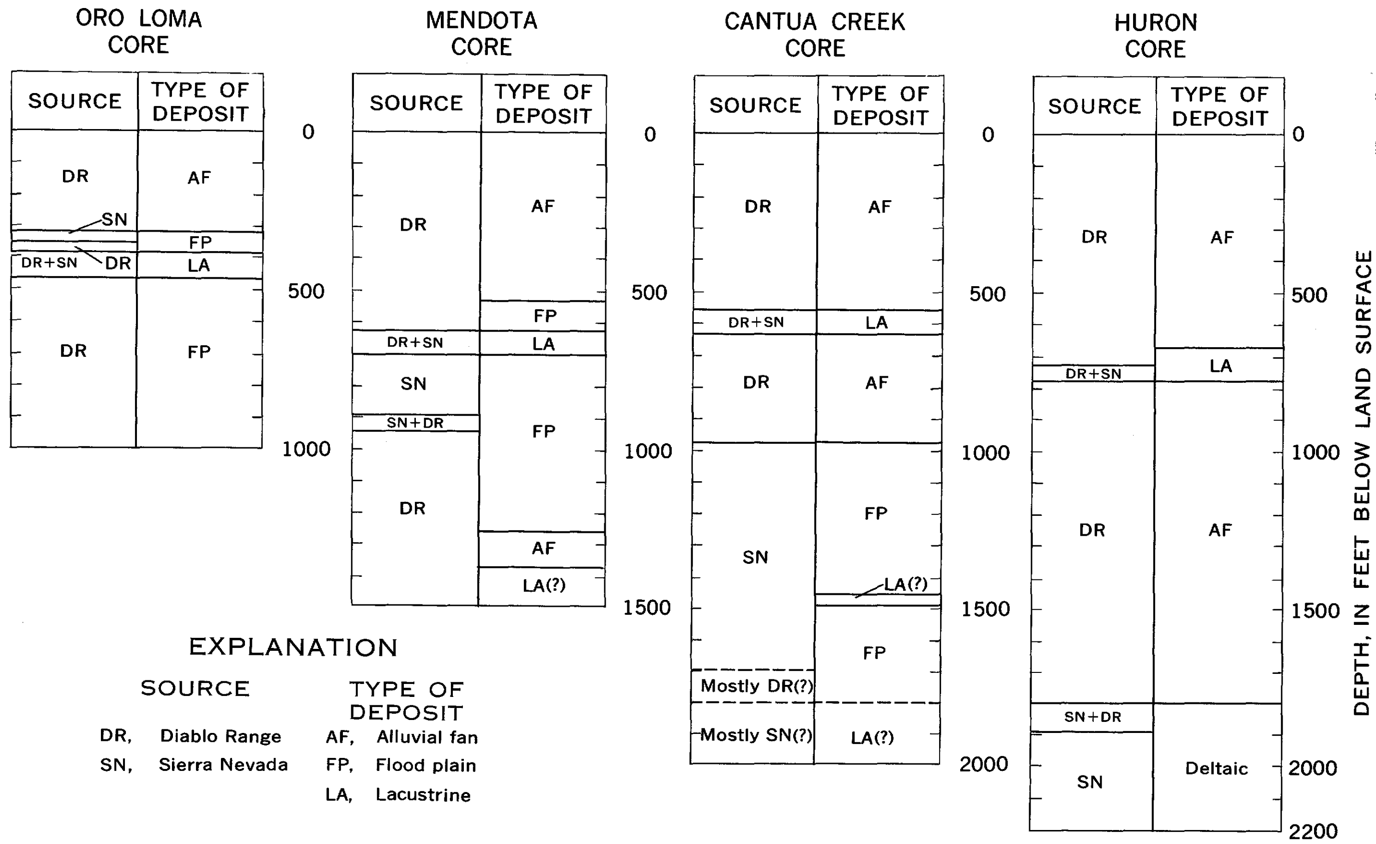

FIGURE 3.—Principal sources and types of deposits represented by sediments cored in the Los Banos-Kettleman City area. Sources of Oro Loma core identified by I. E. Klein. Types of deposits identified mainly by R. E. Miller.

alluvial types are far more abundant than lacustrine deposits. A subsidiary type, the deltaic deposits, was identified near the bottom of the Huron core.

These deposits were recognized and delineated mainly by R. E. Miller, from whom much of this section of the report has been taken. Only selective descriptions of the deposits and their modes of deposition are given here; they are intended to emphasize the conditions that influenced the response of the sediments to compaction. Fuller description of the deposits and their spatial distributions are given in the report by Miller, Green, and Davis, in preparation as Professional Paper 437–E.

CRITERIA FOR DISTINGUISHING PRINCIPAL TYPES OF DEPOSITS

LARGE-SCALE CRITERIA

Table 2 gives the large-scale criteria, developed mainly by R. E. Miller, that were used to distinguish the types of deposits. These criteria reflect the different sets of conditions—mainly hydraulic and chemical—that constitute the different depositional "environments." They are listed in decreasing order of the use that was made of them in separating the different depositional types. See the geologic cross sections and isopach maps of Miller, in preparation as Professional Paper 437E, for evidence on the distribution and shape of the several types of deposits.

Alluvial-fan deposits were the easiest to distinguish from the other types, primarily on the basis of the color of the sediments, substantiated by their wedge shape in three dimensions. The characteristic yellow brown is a result of the long period of oxidation between deposition and burial below the water table. The "oxidized" color is retained even after burial to 1,500 feet or more below the water table.

The distinction between flood-plain and lacustrine deposits is less certain, for it has to be made on the basis of organic remains and the nature and distribution of the sediments within the deposit. The distinction between the two types becomes tenuous in the case of nonfossiliferous and generally fine-grained sediments that were deposited in large depressions or abandoned channels on a flood plain. Such sediments were called flood-plain deposits unless correlation of electric logs showed them to be extensive, continuous, and consistently fine grained.

TEXTURAL EVIDENCE OF PROCESSES OF DEPOSITION IN FINE-GRAINED SEDIMENTS

Further evidence of the depositional history of the fine-grained sediments—clays and clayey silts—came

TABLE 2.—*Criteria for distinguishing alluvial-fan, flood-plain, lacustrine, and deltaic deposits, Los Banos-Kettleman City area*

[Color code from Rock-Color Chart (Goddard and others, 1948)]

Criterion	Alluvial-fan deposits	Flood-plain deposits	Lacustrine deposits	Deltaic deposits
Color of sediment	Yellowish brown (10*YR*); lesser amounts of grayish brown (5*YR*) and olive brown (5*Y*). Color due to staining of grains by iron oxide.	Greenish grays and grayish greens (5*G*, 5*GY*, 10*G*), dark gray (*N*), bluish gray (5*B*), blue green (5*BG*). Authigenic iron sulfides often present.	Same as flood-plain deposits.	Same as flood-plain deposits.
Nature and distribution of sediment within the large-scale deposit.	Heterogeneous and variable; lenses, tongues, and beds of clay, silt, sand, and gravel grade into one another or change abruptly both vertically and laterally. Sands may be crossbedded.	Same as alluvial-fan deposits.	Uniform; may be homogeneous for thicknesses of tens of feet. Generally fine grained.	Heterogeneous but generally coarse grained. Sands commonly crossbedded.
Source of constitutent grains	From one side of the San Joaquin Valley only.	From both sides of the San Joaquin Valley.	From both sides of the San Joaquin Valley.	From both sides of the San Joaquin Valley but chiefly from Sierra Nevada.
Three-dimensional shape of deposit in large scale (horizontal dimensions in miles or tens of miles).	Wedge shaped, with thickest part toward mountains from which materials came.	Lenticular.	Layered or lenticular, but widespread and fairly uniform in thickness.	Lenticular.
Organic material	Plant material in small fragments disseminated through sediment; in trace amounts or a few percent at most.	Plant material in fragments both large and small; larger pieces often intact enough for structures to be discerned.	Plant material in fragments, often large and structurally intact. Also fresh-water organisms such as diatoms and mollusks.	Plant material in fragments, often large and structurally intact, in peatlike accumulations. High proportion of finely disseminated organic material in some clays. Fragments of fresh- and brackish-water mollusks; fish remains.

from observations or measurements made on short core samples, 2–5 cm thick. Diagnostic textural features are listed in table 3 in decreasing order of their usefulness. In small samples one cannot make the three-way distinction illustrated in table 2, but must confine oneself to two categories: sediments deposited by moving streams and those deposited in standing water. Because of the lack of definitive criteria in small samples, neither distinction could be made in hand specimens of coarser grained sediments.

The most distinctive textural feature of the fine-grained sediments deposited by moving streams in the Los Banos-Kettleman City area is a chaotic fabric. In some hand specimens the clay-size particles seem to be concentrated in sand-sized aggregates which are usually rounded to subrounded and are platy, oblate, or spherical in shape. The aggregates, when present, are in a matrix of sand-silt-clay, in concentrations ranging from a few percent to nearly half the sediment. In thin sections the aggregates appear to consist mainly of well oriented clay-mineral particles. The orientation of the aggregates with regard to each other, however, is generally random.

TABLE 3.—*Criteria for distinguishing conditions under which fine-grained sediments were deposited, Los Banos-Kettleman City area*

Criterion	Deposited by moving water	Deposited in standing water
Fabric:		
Discernible in hand specimen	Often chaotic: Clays in chunks or rounded sand-sized aggregates in matrix of poorly sorted sand-silt-clay. May be bedded: Marked differences in particle size between adjoining laminae. Clay laminae may have graded contact with underlying laminae and abrupt contact with overlying laminae.	Uniform or distinctly and finely laminated; only small differences in particle size between adjoining laminae.
Discernible in thin section	Chaotic: Small aggregates of well-oriented clay in random orientation with regard to other aggregates. A little mass extinction in matrix.	Regular preferred orientation of platy particles parallel to bedding. Mass extinction well developed over large areas.
Clay-particle orientation ratios measured by X-ray method. [1]	1.5 or less	1. 5 or more.
Porosity	Relatively less [2]	Relatively greater. [2]
Organic material	Plant material in traces, or a few percent at most, disseminated in small fragments.	As much as 10 percent. Original vegetal structures may be intact. Often associated with authigenic sulfide minerals.
Coarsest particle in sediment as measured by C, the 1st percentile of the size distribution.	Generally larger than 100μ	Generally smaller than 250μ.

[1] Method explained in earlier paper (Meade, 1961). Orientation ratios near 1.0 denote random orientation; ratios larger than 1.0 signify preferred orientation of clay particles parallel to bedding.

[2] No numbers assigned: porosity variable with depth and particle size.

The aggregates probably originated in two ways: as fragments of shale that were carried out of the mountains and rounded en route and from disruption of previously deposited thin layers of clay. Evidence of the latter process is found preserved in all degrees of disruption, from the undisturbed clay layers to the chaotic array of clay aggregates (fig. 4). Apparently, after a clay layer has dried to the point where it cracks into pieces, the pieces may be picked up and incorporated into the sediment load of subsequent water flows. The pieces are then broken, rounded, and deposited in a random array together with the other constituents of the sediment load.

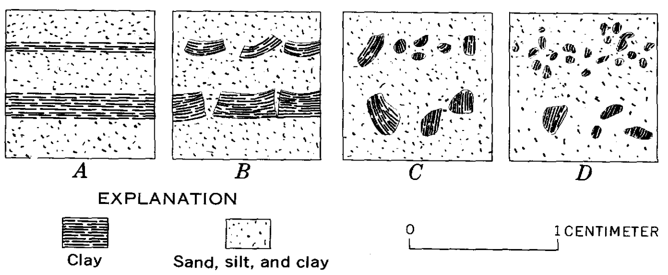

FIGURE 4.—Cross sections of clay aggregates showing progressive stages of development from undisturbed clay layers.

In contrast, the fabric of clays and silts that seem to have been deposited in standing water is often uniform. Clay particles are oriented parallel to the bedding or nearly so. Standing-water deposits are often finely bedded, are more consistently fine grained, and are often better sorted.

The porosity of standing-water sediments seems to be greater than that of moving-stream sediments of the same particle size. This impression is supported by the observations summarized by Gaither (1953, p. 184), to the effect that sands deposited in standing water generally have greater porosities than those deposited subaerially. Perhaps this difference also exists in silts and clays. Other factors, however, may be at least partly responsible for the greater porosities of the standing-water sediments. The lacustrine Corcoran Clay Member of the Tulare Formation contains diatom skeletons whose openwork structure seems to contribute to the porosity of the enclosing sediments. Another coincidental factor is the greater proportion of sodium adsorbed by the clays in the lower parts of the cored intervals (fig. 15), included in which are most of the standing-water sediments other than the Corcoran Clay Member. A greater proportion of adsorbed sodium, relative to other cations, may contribute to the greater porosity of these clays (Meade, 1964, fig. 11). Higher porosity, therefore, is not a definitive criterion in these cores for distinguishing the two types of deposits.

No single criterion given in table 3 is enough to identify the conditions of deposition: the proper combination of fabric and porosity is fairly convincing, but three criteria are generally necessary for unequivocal identification. Most of the fine-grained alluvial-fan deposits in the Los Banos-Kettleman City area fall unequivocally into the moving-stream category, although a few oxidized sediments within large wedges of alluvial-fan deposits fell into the standing-water category. Lacustrine deposits should fall certainly into the standing-water category. Silts and clays deposited on flood plains can fall into either category. In small segments of cores, one cannot tell whether a nonfossiliferous highly porous greenish- to bluish-gray uniformly and finely bedded clay is a lacustrine or flood-plain sediment—this must be determined on the basis of the large-scale geometry of the deposit.

ALLUVIAL-FAN DEPOSITS

The alluvial fans that occupied this part of the San Joaquin Valley in the past are thought of as similar to the fans that line the west side of the valley today (described in detail by Bull, 1964a, b). The alluvial-fan deposits found in the core holes have been derived, as are the modern fan deposits in the area, entirely from the Diablo Range. They were deposited by water-flows—streams and sheet flows; very few, if any, mud-flows seem to have moved as far out into the valley as the locations of the core holes.

The sediments are unsaturated for substantial depths below the surfaces of the modern fans. Throughout most of the area, the water table lies more than a hundred feet below the land surface and as much as several hundred feet below the surface along the mountain front. The principal streams flow only during the rainy winter months and are usually dry for more than half the year. After leaving the mountain front and flowing into the main San Joaquin Valley, they are never in complete hydraulic continuity with the water table (Rantz and Richardson, 1961; Richardson and Rantz, 1961, p. 19, 24, 26, 29). Water from the principal streams percolates into the underlying sediments and moves to the water table mainly by unsaturated flow. The smaller streams are ephemeral; that is, they flow only for short periods after rainstorms and are never in hydraulic continuity with the water table. They supply very little influent seepage to the ground-water body. Most of the sediments, consequently, remain unsaturated and subject to oxidation between the time they are deposited and the time they are buried below the water table.

FLOOD-PLAIN DEPOSITS

The flood plains that occupied this part of the San Joaquin Valley in the past are thought of as those of perennial streams. Sands and gravels were deposited in or near the principal stream channels; silts and clays were deposited on the adjoining plains when the streams overflowed their banks. The water table beneath the flood plains was probably close to the land surface: the state of preservation of some of the plant remains and the presence of authigenic sulfides suggest that the flood-plain sediments were not subjected to continued aeration and oxidation.

At different times each side of the valley was the principal contributor of the flood-plain sediments found in the core holes.

LACUSTRINE DEPOSITS

Lakes occasionally covered large portions of this part of the valley in late Pliocene and Pleistocene time. Sediment was carried into the lakes by streams coming from both the Diablo Range and the Sierra Nevada, was moved about by currents within the lakes, and was deposited by slow settling in relatively still water.

The most conspicuous of the lacustrine deposits is the Corcoran Clay Member of the Tulare Formation which lies at depths ranging from 200 to 900 feet below the present land surface in nearly half the San Joaquin Valley. It has been described and discussed by Frink and Kues (1954), and Davis and others (1959, p. 76–81). Potassium-argon dating has shown that volcanic ash immediately overlying the Corcoran is about middle Pleistocene in age (Janda, R. J., in Bull, 1964b, p. A5). It is fine grained and ranges in thickness from 0 to 120 feet. Diatom remains are abundant—as much as 75 percent of some sediments—in its middle and lower parts. Substantial thicknesses of the Corcoran Clay Member, 85 and 75 feet, respectively, were cored in the Oro Loma and Mendota holes.

Other sediments designated lacustrine, in the lower parts of the Mendota and Cantua Creek cores, are indicated in figure 3 as of questionable lacustrine origin. R. E. Miller identified these deposits as lacustrine (?) on the basis of their color, fine-grained texture, large-scale extent, and dimensions. However, the petrographic characteristics of the cored samples of these deposits—especially the degree of regularity of their fabric—do not show clear evidence of their having been formed in lakes.

DELTAIC DEPOSITS

The lowermost 400 feet of sediment penetrated by the Huron core hole is interpreted by R. E. Miller as a deltaic deposit, on the basis of correlation with typical delta deposits to the east. These sediments are similar to the flood-plain deposits, except that they contain generally more organic remains. Reed, grass, and wood remains constitute 15–20 percent of some of the fine-grained sediments. Other sediments, in which plant remains are not so apparent are colored dark gray (*N*2–*N*3, Goddard and others, 1948) by finely divided organic material. Also found in these deposits (at 2,054 ft) were fragments of the brackish-water gastropod assemblage: *Littorina*, *Amnicola*, and *Fluminicola*.

PARTICLE SIZES

The study of particle size in the Los Banos-Kettleman City area is based on 305 samples from 3 core holes: Mendota, Cantua Creek, and Huron (locations shown in fig. 2). No particle-size analyses were available for samples from the Oro Loma core. The mean grain size in the 305 samples probably lies in the range of fine to medium silt, or between 10μ and 20μ (microns). Allowing for the fact that the coarsest sediments were not sampled adequately (see the discussion of "Sampling and particle-size analysis" p. C48), I estimate that the mean particle size of the sediments in the cored interval is in the coarse-silt range, or between 30μ and 60μ. This estimate is based on a comparison of the electrical-resistivity logs of the core holes and the particle-size data on the recovered material.

Details of the 305 size analyses are given in table 5. Percentiles were read from cumulative curves provided by the Hydrologic Laboratory. Measures of sorting and skewness, computed from the percentiles, are defined on pages C49–C50.

PARTICLE-SIZE DISTRIBUTIONS OF RECOVERED SEDIMENTS

The particle-size distributions of the cored sediments will be illustrated in two main ways: on triangular plots of the proportions of sand, silt, and clay; and as grouped information about the average sizes, sorting, and skewness of the samples.

The triangular diagram is one of many ways in which size data may be summarized, and it is well suited to give an overall impression of the range and distribution of particle sizes. The reference diagram in figure 5*A* shows the nomenclatural system of Shepard (1954). The samples are segregated by depositional type in figures 5*B*–5*E*; source areas are indicated by open circles (Sierra Nevada), dark circles (Diablo Range), and crosses (mixed Sierra and Diablo Range). Triangular diagrams of the sediments grouped by core holes are given by Johnson, Moston, and Morris (1967).

Looking at figures 5*B*–5*E* as a whole, one can see the variety and heterogeneity of the particle sizes. There is little or no concentration of samples in any category.

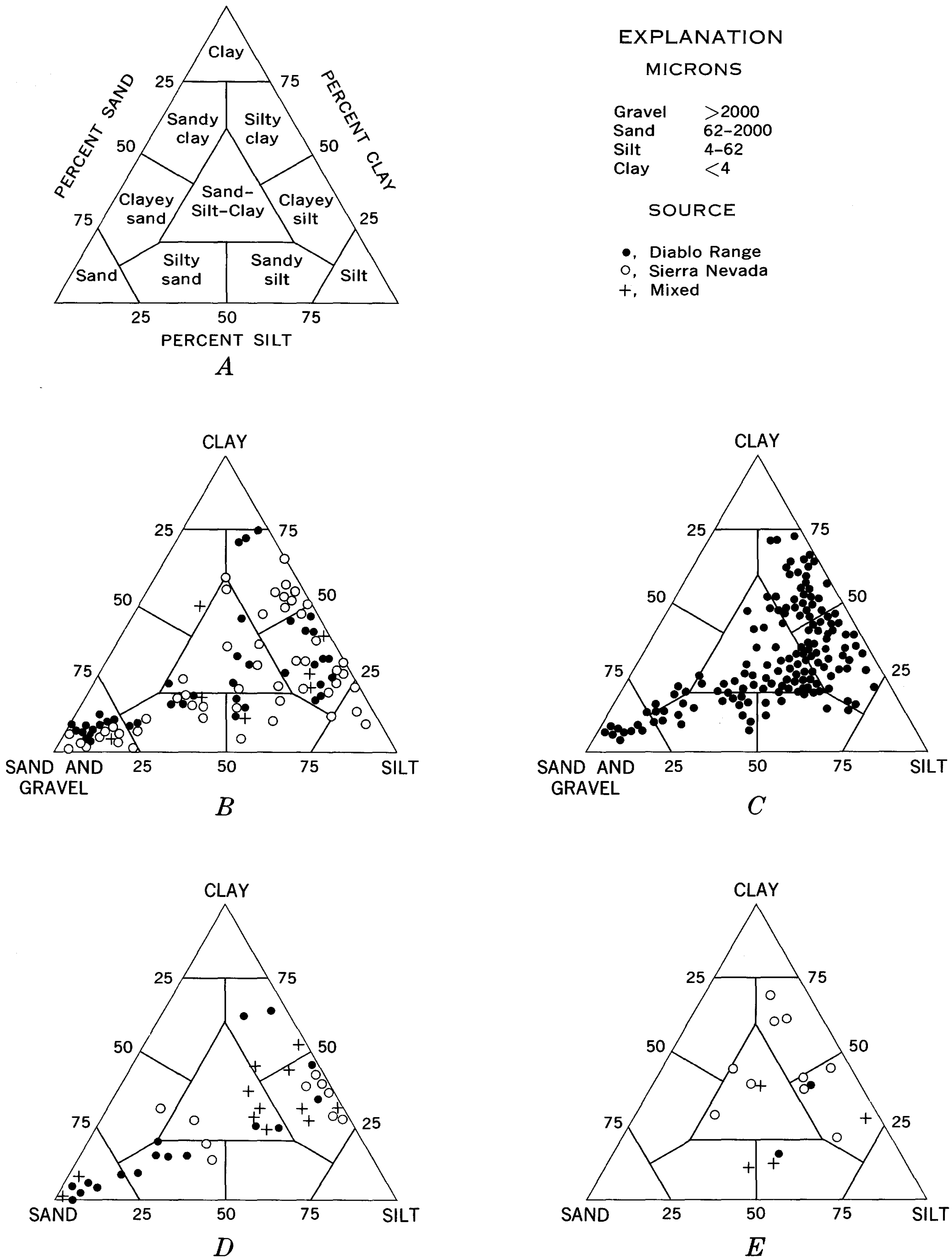

FIGURE 5.—Sand-silt-clay percentages of sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area. Based on data from the Hydrologic Laboratory of the Geological Survey. *A*, Nomenclature after Shepard (1954). *B*, Flood-plain sediments. *C*, Alluvial-fan sediments. *D*, Lacustrine—including lacustrine(?)—sediments. *E*, Deltaic sediments (from Huron core only).

Even though nearly two-thirds of the samples fall into the silty clay, clayey silt, and sand-silt-clay fields, and more samples fall into the clayey-silt field than into any other, the coarser sediment categories in the diagram are also well represented. All but 11 of the samples contain 5 percent or more clay. The amount of gravel included in "sand and gravel" in figure 5 (*B* and *C*) is not large. Only 24 samples contained gravel (particles larger than 2,000μ in diameter), and of these, only 12 contained 1 percent or more. Only four, all flood-plain sediments from the Mendota core, had as much as 5 percent gravel.

The particle-size characteristics of the several types of deposits or of the sediments from the two source areas, as shown in the triangular diagrams, are rather similar. Heterogeneity is characteristic of all. Perhaps the only readily visible difference is between the two sources of flood-plain sediments, as shown in figure 5*B*: sediments from the Sierra Nevada seem to be better sorted (points closer to the sand-silt and silt-clay joins) than those from the Diablo Range. The relations of sizes and sorting to sources and depositional types is treated further in the section "Relations between particle-size measures and their bearing on the depositional history of sediments"; see especially figure 12.

Another way of generalizing particle-size data is by summarizing the measures of central tendency—the mean, median, and mode—of the particle-size distributions. Only the median and modal diameters, which are more easily determined than mean diameters, are given here.

The distribution of the median diameters (*Md*) of the 305 samples is shown graphically in the top row of figure 6. The median "is that diameter which is larger than 50 percent [by weight] of the diameters in the distribution, and smaller than the other 50 percent" (Krumbein and Pettijohn, 1938, p. 229). Most of the median diameters fall in the range from 2μ to 250μ. More medians fall into the 8μ–16μ intervals, the fine silt category, than into any other interval. This does not necessarily mean that 8μ–16μ is the most abundant median-particle range in the sediments of the area. It may reflect selective sampling: that is, perhaps more of the visually estimated "average" samples (p. C48) had median diameters in this size interval than in any other. A secondary maximum in the 125μ–250μ interval suggests that, had the gravels and coarse sands in the section been recovered more completely, the distribution of *Md* values might have had two principal maxima, one in the fine-silt interval and the other in the sand-sized range.

Where the distribution of median diameters gives a better impression of the "average" particle size, the distribution of modal diameters tells more about the

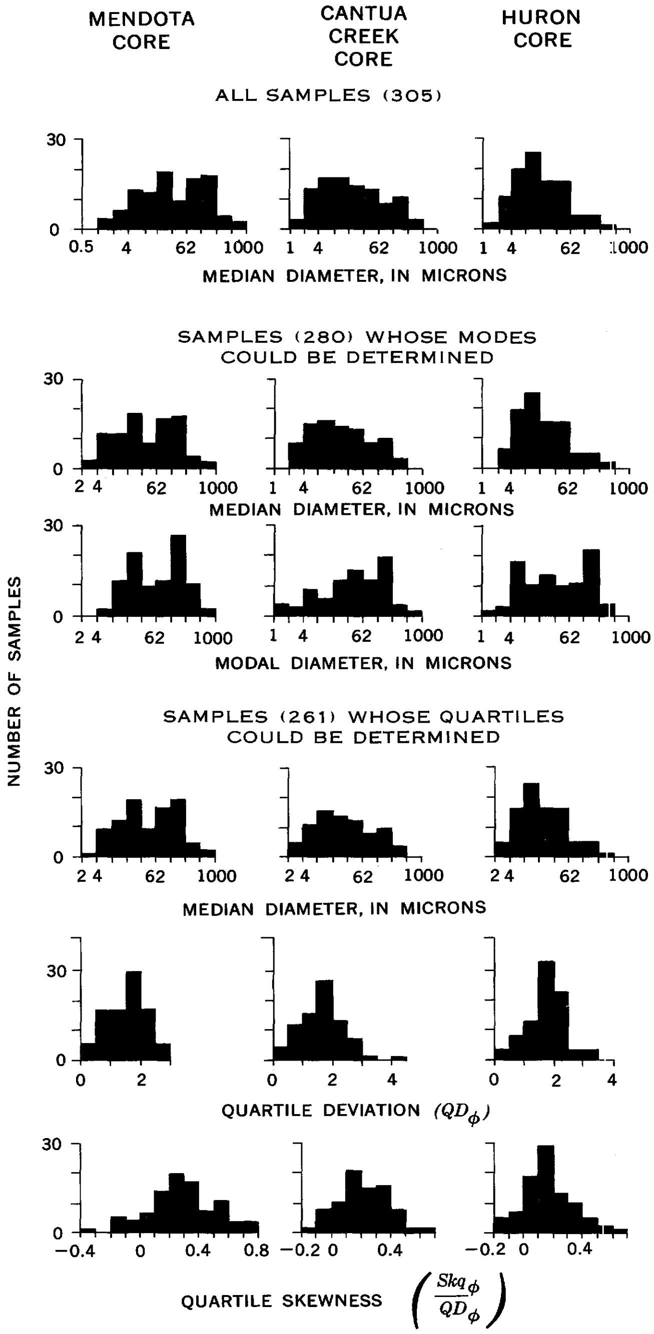

FIGURE 6.—Measures of average size, sorting, and skewness in sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area. Measures of sorting (QD_ϕ) and skewness (Skq_ϕ/QD_ϕ) defined on page C49.

relative abundance of grain sizes. The modal size interval of a sediment (National Research Council's size intervals in this study, see table, p. C49) is the one that contains more material by weight than any other. The distribution of 280 modal sizes is shown in the third row of figure 5. The modal sizes of the other 25 samples could not be determined because too much of each sample was finer than 1.0μ, and the distributions of sizes smaller than 1.0μ were not determined. Fine sand (125μ–250μ) is the most abundant material in 70 samples, in spite of the fact that sediments whose median diameters fell into this category were poorly recovered. The abundance of fine sand is probably related to the relative ease with which this material, compared to particles of other sizes, is picked up and transported by running water (see fig. 8 and the accompanying discussion).

Neither of these two measures of central tendency provides a perfect means of summarizing data on complex particle-size distribution. Ideally, in a normal frequency distribution, the median and mode coincide, but very few of the sediments considered in this report consist of particles whose sizes are distributed normally. The second row of figure 6 consists of histograms of the median diameters of the same 280 samples whose modal sizes are illustrated in the third row. One can readily see from these histograms that conclusions drawn about sediments from a single one of these measures are likely to be incomplete.

SPATIAL DISTRIBUTION OF PARTICLE SIZES

The differences between the parameters of particle-size distribution in the three cores are shown in the bottom three rows of figure 6. The sediments from the Huron core are generally finer grained, less well sorted, and less skewed than the sediments from the Mendota core. Furthermore, the parameters of particle-size distribution seem to be more uniform (less dispersion, as shown by the histograms) in the Huron core. The particle-size properties of sediments from the Cantua Creek core are intermediate between those of sediments from the other two cores. Although this suggests a progressive change in a southeasterly direction toward finer grained, more poorly sorted, less skewed, and more uniform sediments, more comprehensive regional analysis of the sediments of the area, using electric logs and data from other core holes (Miller and others, in preparation as Prof. Paper 437–E), does not show such a progressive trend. The differences between the cored sediments are local rather than regional features.

Figure 7 shows the patterns of change in particle size with depth in the three cores. The resistivities of the sediments (from electric logs), as well as their median diameters, indicate particle size. The higher resistivities in these sediments are associated with the coarser sizes. Using the same symbols as in figure 5, sources are indicated by open circles (Sierra Nevada), dark circles (Diablo Range), and crosses (mixed). Types of deposits are indicated in the right column of each composite log. For composite logs that contain other information, namely the spontaneous potentials and generalized lithologies of the sediments, see the report by Johnson, Moston, and Morris (1967).

The Mendota core shows the most regular changes in particle size with depth. Consider the sediments from the bottom of the core to the top—the order in which they were deposited. Progressively coarser sediment (1,500–1,200 ft) was deposited as the environment changed from a lake(?) to an alluvial fan and then to a flood plain. The flood-plain deposits became progressively finer (1,200–1,000 ft), and then coarser again as the source shifted from the Diablo Range to the Sierra (1,000 to about 750 ft). Above them was deposited the uniformly fine grained and lacustrine Corcoran Clay Member of the Tulare Formation (700–625 ft). Although too few median diameters were measured in sediments above the Corcoran in the Mendota core, the resistivities suggest that the sediments coarsen progressively between the top of the Corcoran and the present land surface.

In the Cantua Creek core the variations in particle size are not so regular. Although the resistivity log suggests that the lacustrine(?) and flood-plain deposits penetrated in the lowest 300 feet of the hole are uniformly fine grained, the few median diameters measured in this part of the core do not suggest uniformity. Even more scattered is the distribution of the median diameters of the flood-plain deposits from the Sierra (1,700–980 ft) and of the alluvial-fan sediments from the Diablo Range (980 ft to the surface). The resistivity log suggests a coarsening of the flood-plain deposits (1,100–1,000 ft) just before the change to alluvial-fan deposition. Too few median-diameter measurements are available to support this observation, however; the interval between 1,150 and 1,050 was not sampled because of an interruption in the coring schedule to correct an excessive drift of the hole away from the vertical. Within the alluvial-fan deposits, at about 600 feet below the surface, lies 60 feet of well-sorted sand that was deposited here (perhaps as a beach) while the Corcoran Clay Member was being deposited elsewhere in the valley. Although the Cantua Creek core contains some short segments within which the particle size is fairly uniform, the general characteristic of the particle sizes in this core is diversity. Changes are not progressive but are mainly abrupt and local.

The changes in the particle sizes of sediments in the Huron core are also mainly abrupt and local. As indicated in the histograms in figure 6, however, the median sizes in the Huron core are not scattered so widely as those in the other two cores. The pattern of median-diameter distribution in the deltaic sediment at the bottom of the core suggests a gradual coarsening as the source changed from the Sierra to the Diablo Range

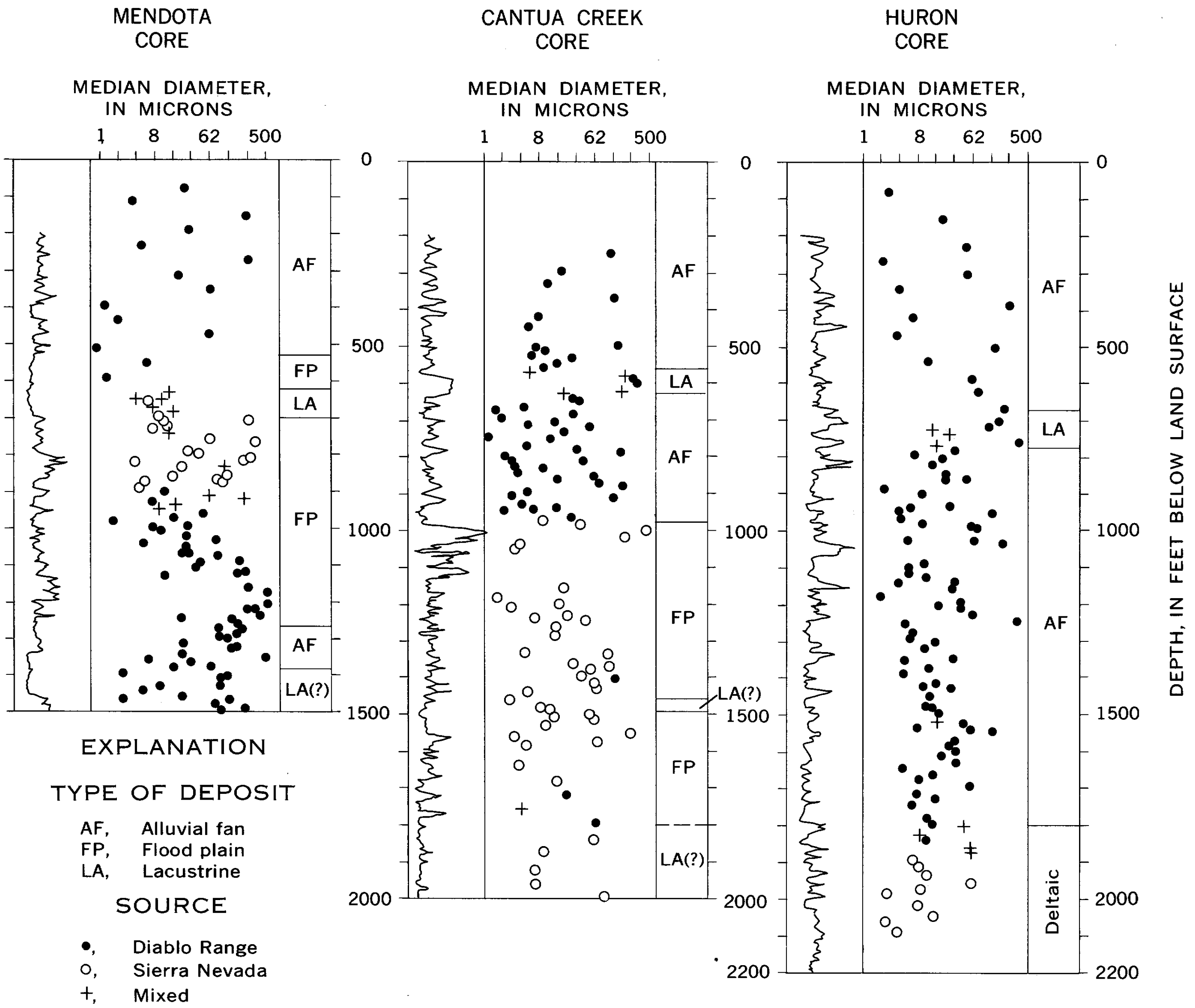

FIGURE 7.—Variations in particle size with depth, Los Banos-Kettleman City area. Resistivity log is left column of each composite; range, from left to right, is 0–30 ohms m²/m.

(2,100–1,800 ft), but no such increase in grain size is indicated by the resistivity log of the same sediments. And although the resistivity log suggests a gradual coarsening of the alluvial-fan sediments between 1,800 and 800 feet, the distribution of median diameters shows no such change. Both the resistivities and the median diameters suggest a progressive decrease in grain size from the lacustrine sands near 700 feet through the alluvial-fan sediments to the present land surface.

In summarizing the particle sizes of the sediments of the Los Banos-Kettleman City area, one may say that their outstanding feature is diversity. This is an important factor in the compaction of the sediments. Had the sediments been consistently coarse grained, their response to increasing effective overburden loads would have been less than has occurred—coarse-grained sediments are compacted less per unit load increment than fine-grained sediments. Had they been consistently fine grained, their low permeabilities would have slowed the compaction to rates much less than those observed. The heterogeneous interlayering of compressible fine-grained sediments and permeable coarse-grained sediments constitutes an aquifer system that responds efficiently to changes in overburden load by compacting rapidly and substantially.

RELATIONS BETWEEN PARTICLE-SIZE MEASURES AND THEIR BEARING ON THE DEPOSITIONAL HISTORY OF SEDIMENTS

Some sedimentologists have found that graphing particle-size measures against each other—especially average size against other measures—has helped them in understanding the hydraulic processes involved in the transport and deposition of clastic sediments. The work of some of these sedimentologists is reviewed in this section of the report. Then follow graphs of median diameter against measures of sorting, skewness, and the coarsest percentile for the sediments of the Los Banos-Kettleman City area. For those interested only in the direct description of the particle-size characteristics of the sediments, this section of the report is largely a digression that can be passed over quickly.

REVIEW OF PREVIOUS WORK

RELATIONS OF AVERAGE PARTICLE SIZE TO SORTING AND SKEWNESS

In many waterlaid sediments, the deviation (sorting) and skewness of particle-size distributions seem to vary in systematic and consistent ways with the average diameter. Inman (1949) pointed out these variations in a summary of studies of shallow-water marine sands and silts (fig. 8) and presented convincing evidence and arguments that they reflected the hydrodynamic relations that exist between running water and sediment particles.

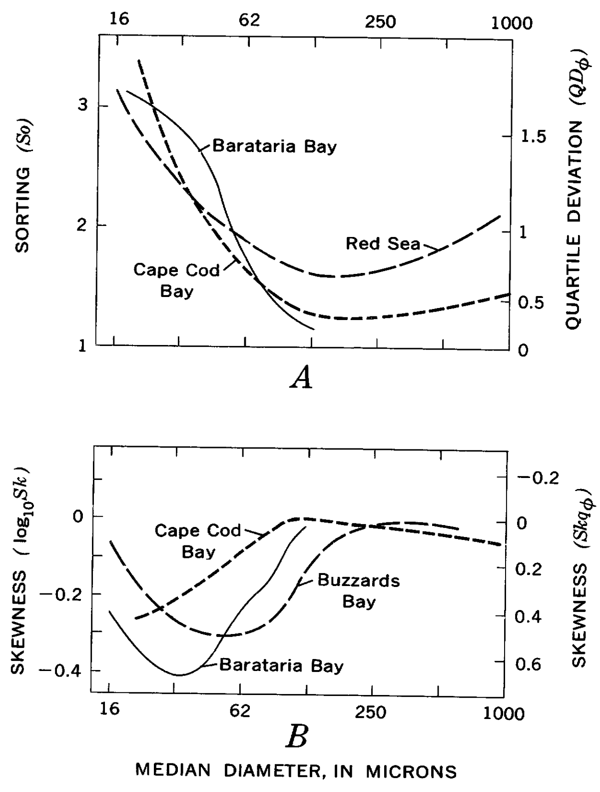

FIGURE 8.—Relation of median diameter to (*A*) sorting and (*B*) skewness in shallow marine sediments. Modified after Inman (1949, p. 52); chief modification is addition of skewness data from Buzzards Bay (Hough, 1940, p. 23–26). Other data sources: Cape Cod Bay (Hough, 1942, p. 21), Barataria Bay (Krumbein and Aberdeen, 1937, p. 8–9), Red Sea (Shukri and Higazy, 1944, p. 62–63). *So* and *Sk* are sorting and skewness coefficients of Trask (1930, p. 594), based on quartiles.

Sorting reflects the relative ease with which particles of different sizes are picked up and transported by water. The best sorted sediments are those whose median diameters fall into the category of fine sand (125μ–250μ). Inman states (1949, p. 61) that fine sands

> are hydrodynamically unique from all other sizes in that: (1) they are moved by weaker currents than grains smaller or larger than themselves; (2) once moved they do not have as great a tendency to go into suspension as do smaller grains; and (3) they are more readily carried into suspension than larger material.

Because materials both coarser and finer than fine sand

> are more difficult to move and since very fine material is readily carried into suspension, bottom sediment in the process of transportation tends to become progressively better sorted as its median diameter nears 0.18 mm [180μ]. Sediments with median diameters either larger or smaller than 0.18 mm tend to be more poorly sorted; the tendency toward poor sorting being more pronounced for fine sediments. This may be accounted for by the fact that the fluid does not as readily differentiate between the smaller diameters.

Skewness seems to reflect the different means by which water transports particles of different sizes. In sands and finer materials, as suggested by figure 8*B*, the sediments with the least skewed particle-size distributions ($\log_{10}Sk \sim 0$) seem to be the sands and fine silts (*Md* 125μ–1000μ or finer than 16μ). The most skewed distributions are found in intermediate mixtures of sand and finer materials (*Md* 30μ–60μ). Such relations between particle size and skewness might be due to the fact that sand in most streams of moderate size (and presumably in currents in shallow seas) is transported as bed load—rolled and bounced along the bottom—and that materials finer than sand are usually carried in suspension. The less skewed sediments may have been transported by one means only, either as bed load or in suspension. The more skewed intermediate sediments may represent mixtures of material transported by both means and, for some reason, deposited together.

Since Inman published these curves and his interpretations of them, many more studies of the size distributions of sediments have confirmed the existence of the relations of average diameter to sorting and skewness. For example, see the papers by Folk and Ward (1957), Füchtbauer and Reineck (1963, p. 298), Griffiths (1951), Inman and Chamberlain (1955), Shumway (1960, p. 665), and Walger (1961).

CM DIAGRAMS

Another graphical method of portraying the particle-size distributions of sediments has been proposed by Passega (1957, 1960, 1964). He focuses attention on the coarser half of a sediment by graphing the median diameter against the first (coarsest) percentile, which he calls "C." The first percentile is used as a measure of the competence of the depositing medium, and the median diameter represents the average grain size of the material deposited. By using parameters based only on the coarser half of a sediment, one considers the part of the sediment that reflects most sensitively the carrying and sorting capacities of the transporting and depositing media.

An example of Passega's graph, which he calls a "CM diagram" is shown in figure 9. He has suggested that aqueous sediments might fall into characteristic patterns according to the way in which they were transported or deposited. The solid-line sinuous pattern labeled *NOPQRS* is characteristic of sediments carried by rivers and other tractive currents. The pattern enclosed by the dashed line seems to be characteristic of the deposits of turbidity currents; sediments deposited slowly in still water fall in or near the circular pattern.

The pattern *NOPQRS*, derived empirically from modern riverbed sediments in the United States and from Tertiary sediments in the United States and Italy, implies that sediments associated with tractive currents fall into a family of curves (fig. 10*A*) that shows the effect of hydrodynamic sorting. In fine-grained tractive sediments (*RS* segment of the pattern), some fine sand will always be present (if available to the stream) regardless of how fine the rest of the sediment might be. Sediments that fall into the *QR* segment (*Md* in the range 100μ to 200μ) are the best sorted; they fall closest to the C=*Md* line in figure 9, and their curves in figure 10*A* have the steepest slope. As the stream increases in competence it is able to transport coarser particles (*PQ* segment); but the bulk of the sediment tends to consist of particles of the optimum hydrodynamic size—125μ–500μ. Provided that the appropriate particle sizes are available, these three segments—*RS*, *QR*, and *PQ*,

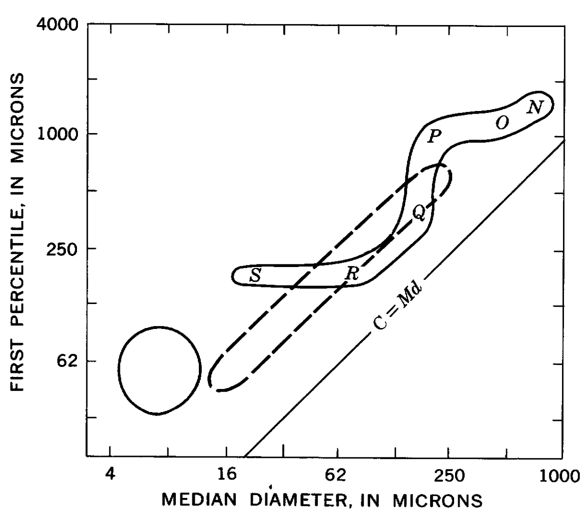

FIGURE 9.—CM patterns. After Passega (1960, p. 1734).

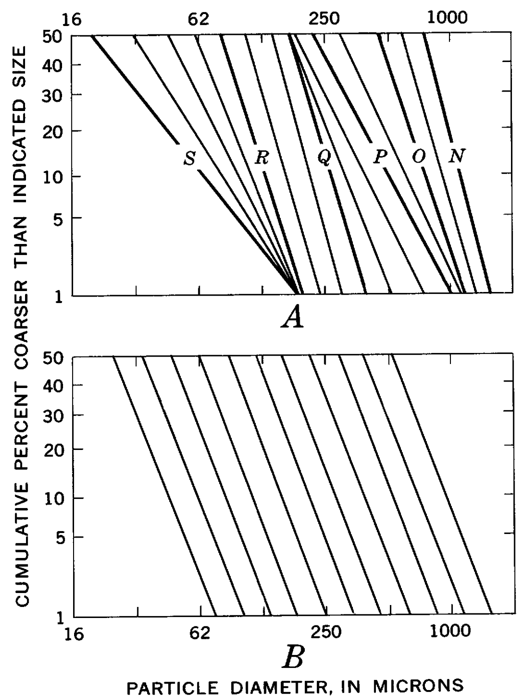

FIGURE 10.—Particle-size-distribution curves (probability scale) of sediments deposited by (*A*) tractive currents and (*B*) turbidity currents, implied by Passega's CM patterns.

should be characteristic of all tractive sediments. They reflect the same hydrodynamic circumstances as those Inman used to explain the relations between median size and sorting (fig. 8*A*).

The *OP* and *NO* segments are not characteristic of all tractive sediments but are said by Passega to represent special conditions. "In the *OP* part, the proportion of rolled grains increases, and the *ON* segment corresponds almost uniquely to a deposit of rolled grains" (Passega, 1960, p. 1735). These two segments did not appear in the sediments transported by the Mississippi, Enoree, and Niobrara Rivers or in the other tractive sediments described by Passega in 1957 (p. 1954, 1961–1963). Apparently, these segments of the pattern represent winnowed or reworked sands and gravels or sediments with restricted sources.

Passega also suggested that points representing the deposits of turbidity currents might fall into a characteristic pattern parallel to the C=*Md* line (enclosed by dashed lines in fig. 9). The distance of the pattern from the C=*Md* line is said to be a direct function of the density of the current. This implies that the cumulative curves representing the coarser halves of samples of sediments deposited by turbidity currents of similar density are parallel to one another (fig. 10*B*)—that is, as long as the current density remains constant, the sorting of the coarser half remains constant regardless of the size of C or *Md*. As represented in a CM dia-

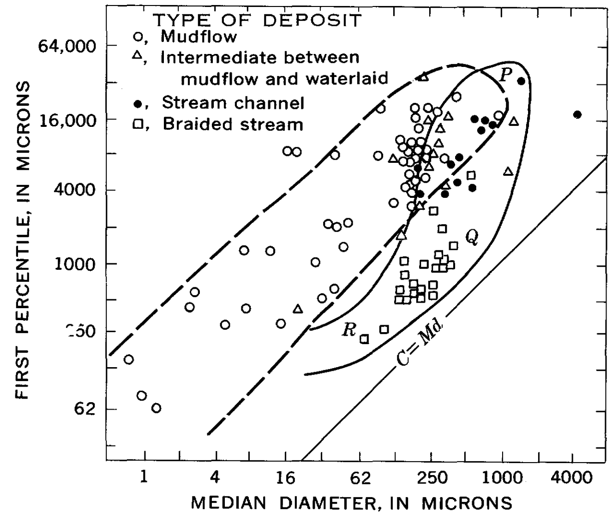

FIGURE 11.—CM patterns of modern surficial alluvial-fan deposits, Los Banos-Kettleman City area. After Bull (1962, p. 214). Tractive pattern enclosed by solid line; mudflow deposits inside dashed line.

gram, sediments with poorer sorting are associated with currents of greater density (Passega, 1957, p. 1967).

CM patterns prepared by Bull (1962) from analyses of sediments deposited in 1957–58 on alluvial fans in the Los Banos-Kettleman City area add support to Passega's ideas. Bull found (fig. 11) that samples of stream-channel and braided-stream deposits fell into the PQR segment of a tractive pattern. Mudflow deposits fell into a pattern nearly parallel to the $C=Md$ line—as one might have predicted from Passega's observations on what he supposed were turbidity-current deposits. The distance of the mudflow pattern from the $C=Md$ line supports Passega's proposed relation between current density and sediment sorting.

INTERRELATIONS OF PARTICLE-SIZE MEASURES IN CORED SEDIMENTS

Figure 12 shows graphs of median diameter against the coarsest percentile (C), sorting, and skewness for the flood-plain and alluvial-fan deposits of the Los Banos-Kettleman City area. Not included in the graphs are samples of sediments that are cemented or that contain interlaminations or other inhomogeneous mixtures of different-sized particles. Lacustrine sediments are not included because the identification of some of the deposits as lacustrine is questionable. Deltaic sediments are not included because too few samples of homogeneous material are available to show significant variations in the particle-size measures.

Quartile deviation (QD_ϕ) is used to represent sorting. Two measures of skewness are used—Bowley's measure (Skq_ϕ/QD_ϕ, used so far in this report) and a measure of absolute skewness, Skq_ϕ. The relation of Skq_ϕ to the $\log_{10} Sk$ measure is shown in the two calibrated

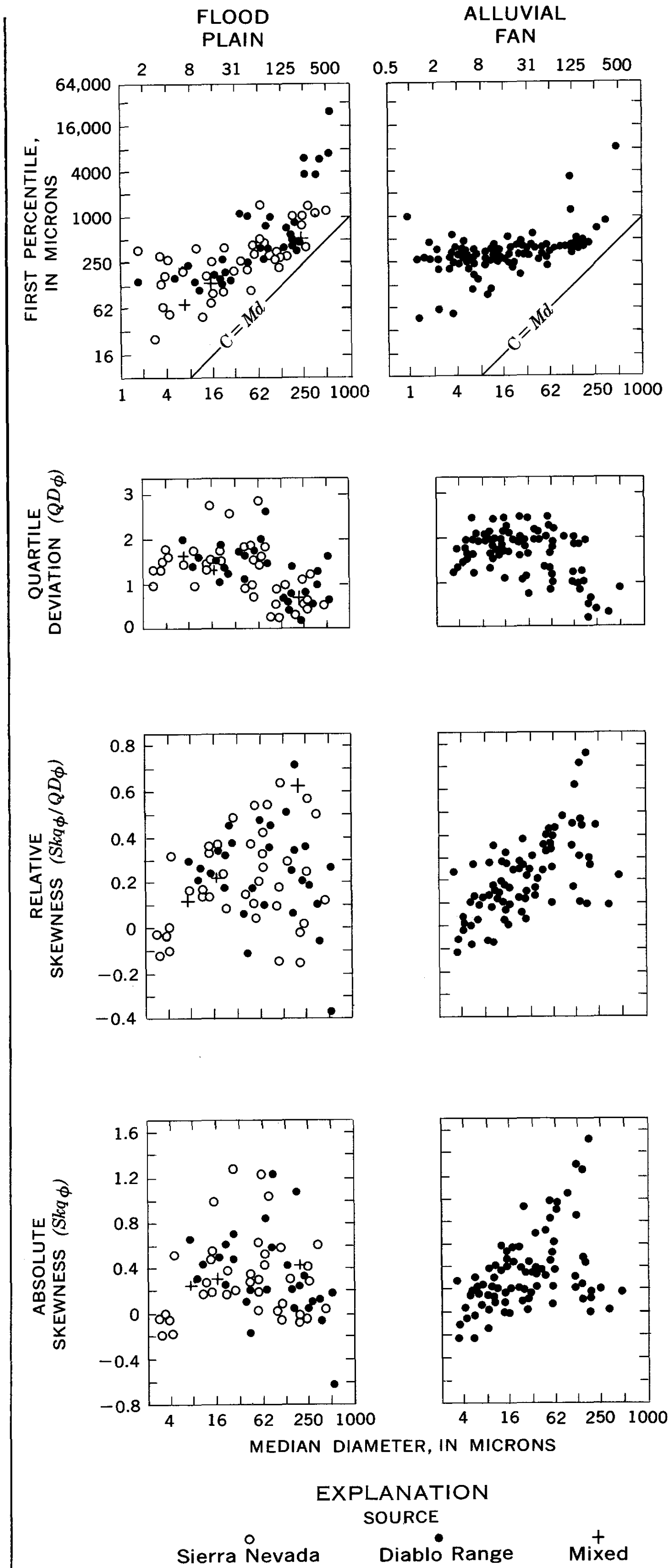

FIGURE 12.—Median diameter against coarsest percentile, sorting, and skewness in flood-plain and alluvial-fan sediments, Los Banos-Kettleman City area.

ordinates of figure 8*B;* note that positive values of Skq_ϕ correspond to negative values of $\log_{10} Sk$. These measures are defined in more detail on pages C49–C50.

FLOOD-PLAIN SEDIMENTS

The CM pattern for the flood-plain sediments of the Los Banos-Kettleman City area (upper row, left col., fig. 12) at first glance seems to be a scatter of points roughly parallel to the C=*Md* line. Judging from the CM pattern, the sorting is slightly poorer in the finer sediments (points generally farther from the C=*Md* line), but the degree and variability of the sorting of the coarser halves of the sediment do not change markedly with median diameter. A closer look at the pattern shows most of the scatter to be related to the samples of sediments from the Sierra Nevada (open circles). The distribution points representing flood-plain sediments from the Diablo Range (dark circles)—except for the two samples having C values slightly greater than 1,000μ and *Md* values slightly less than 62μ—could be interpreted as the *PQRS* segments of a tractive pattern. These observations suggest some kind of source-related control on the regularity of the relations between median diameter and sorting: perhaps a more uniform mode of transportation from the west side of the valley, or some differences in the disintegration and weathering of the different rock types represented on the two sides of the valley.

The relation of median diameter to quartile deviation in the flood-plain sediments is shown in the second row, left column, figure 12. Here also, the sediments derived from the Sierra Nevada show the greater scatter, but not as much so as in the CM pattern. The sediments fall generally into two groups, one of fairly well sorted sands and another of less well sorted finer sediments. No consistent variations with size or source area can be seen in the graphs of median diameter against skewness (third and fourth rows, left col., fig. 12).

The lack of clear relations between the particle-size measures probably reflects the diversity of the sediments that have been included in the category of flood-plain deposits. The category is a broad one, including sediments laid down in the channels of perennial streams as well as on the overflow lands associated with the valley drainage system under more humid conditions than exist today. This means that pond and small-lake deposits have been lumped with the deposits of more active fluvial systems.

ALLUVIAL-FAN SEDIMENTS

The alluvial-fan deposits, which came from a single source area and were deposited under a more uniform set of conditions than the flood-plain sediments, show more consistent relations between the particle-size measures.

The CM pattern of the alluvial-fan sediments (upper row, right col., fig. 12) seems to correspond to the *RS* segment of a tractive pattern. The sorting of the coarser half of the sediments varies directly with the median diameter; or, expressing the relation another way, regardless of the average particle size (in the *Md* range from 1μ to 250μ), some fine to medium sand is always present.

A *PQ* segment is probably part of the complete CM pattern of the alluvial-fan deposits, but no particle-size analyses of the appropriate sediments were made. The coarsest sediments were not available for analysis (p. C48). From visual inspection of the coarse alluvial-fan sediments that were recovered but not analyzed, I have the impression that their C values can be as coarse as 16,000μ, whereas their median diameters lie fairly consistently in the fine- to medium-sand range, 125μ to 500μ. Had the coarser samples been analyzed, a *PQ* segment probably would have appeared in the pattern. This supposition is reinforced by Bull's CM patterns of coarser grained alluvial-fan sediments (fig. 11).

The relation between median diameter and quartile deviation in the alluvial-fan sediments (second row, right col., fig. 12) is similar to that in the flood-plain sediments, except that the sorting of the finer grained alluvial-fan sediments seems to be poorer. The mean quartile deviation of sediments with medians finer than 62μ is about 2.0 in the alluvial-fan deposits, compared with 1.5–1.7 in the flood-plain deposits. Whereas the sorting of the coarser half of the sediments seems to change progressively with *Md*, the quartile deviation shows no consistent variation in the *Md* range from 4μ to 62μ.

The CM pattern and graph of *Md* versus QD_ϕ for the alluvial-fan sediments may be partly misleading. Many (but certainly not all) of the fine-grained alluvial-fan sediments contain clay and silt that were apparently transported and deposited in sand-sized aggregates (fig. 4). Many of these aggregates must have been broken up during size analysis and were recorded as smaller particles than they were when deposited (Bull, 1964c). This would affect the measurement of *Md* and QD_ϕ but not the measurement of C. That is, some of the sediments probably were better sorted and had coarser medians when deposited than is indicated in the graphs, but they still should fall into the *RS* segment of a CM pattern.

Skewness seems to vary fairly consistently with *Md* in the alluvial-fan sediments of the Los Banos-Kettleman City area. The patterns of both relative and absolute skewness (bottom two rows, right col., fig. 12) show a progressive increase in skewness between *Md* values of 4μ and 62μ. Combining the impressions from both measures of skewness, the alluvial-fan sediments are least skewed when their median diameters fall into the coarse-clay to fine-silt or fine- to medium-sand categories (2μ–8μ or 125μ–500μ). Mixtures of sand and finer materials (medians near 62μ) have the most skewed distributions. This is similar in general to the relations between median size and skewness summarized in figure 8*B*.

CLAY MINERALS AND ASSOCIATED IONS

CLAY MINERALS AND THEIR ASSEMBLAGES

The principal clay mineral in the Los Banos-Kettleman City area is montmorillonite. Subsidiary clay minerals present are illite and chlorite, and lesser amounts of a kaolinite-type mineral, mixed layer montmorillonite-illite, and a low-grade illite-montmorillonite mixture. The distribution of clay minerals in the four principal cores is shown in figure 13. The clay minerals in Recent sediments carried or deposited by the streams that flow into the area from the Diablo Range are shown in figure 14.

The detailed results of the clay-mineral analyses of 101 samples—85 from the deep core holes and 16 from streams and alluvial-fan deposits to a depth of 70 feet—are given in tables 11 and 12. Assuming that the 85 samples are representative, the average clay-mineral composition of the sediments of Pliocene to Recent age, of the Los Banos-Kettleman City area is approximately—

Clay minerals	*Percent*
Montmorillonite	70
Chlorite	10
Illite	10
Kaolinite-type mineral	5
Mixed-layer montmorillonite-illite and low-grade illite-montmorillonite	5

The identification criteria for these clay minerals and the means of estimating their relative proportions are given on pages C67–C71.

Two principal assemblages of clay minerals are found in the sediments of the area. Most of the stream and subsurface sediments contain an assemblage consisting, in decreasing order of abundance, of montmorillonite, type-B chlorite, illite, kaolinite-type mineral, and low-grade illite-montmorillonite (figs. 13, 14). This assemblage seems to be derived mainly from the sedimentary and volcanic rocks (Cretaceous through Pliocene in age) that crop out along both sides of the San Joaquin Valley and from the weathered granitic and metamorphic rocks that crop out in the Sierra Nevada and its foothills.

The second assemblage—illite, mixed-layer montmorillonite-illite, type-A chlorite, and subsidiary montmorillonite—is found only in Little Panoche Creek and its alluvial fan. I suspect that this assemblage is derived mainly from the slightly metamorphosed and locally sheared graywackes and shales of the late Mesozoic Franciscan Formation. It resembles closely the assemblage of clay minerals found in weathered rocks of the Franciscan Formation in the San Francisco area (Schlocker, Julius, oral commun., 1962). The proportion of the Little Panoche drainage basin underlain by the Franciscan Formation—41 percent—is more than twice the proportion underlying the drainage basins of the other principal streams in western Fresno County (Davis, 1961, p. B–7). Another 34 percent of the Little Panoche drainage basin is underlain by continental deposits derived mainly from the Franciscan Formation (W. B. Bull, written commun., 1964). The change in clay-mineral assemblages at some depth between 230 and 375 feet in the Oro Loma core (fig. 13) marks the extension of the Little Panoche Creek fan to this point in the valley.

The predominance of montmorillonite in the first assemblage, and in the assemblages in the sediments that lie beneath the other areas of land subsidence in central California, is an important factor in the compaction behavior of the sediments. Experimental studies, summarized in the earlier paper in this series (Meade, 1964, fig. 4), have shown that montmorillonitic clays are more compressible than illitic or kaolinitic clays. The presence of montmorillonites in these sediments probably contributes to the intensity of their response to changes in effective overburden load.

SOURCES OF CLAY MINERALS

SOURCES OF MONTMORILLONITE

Comparison of figures 3 and 13 shows that the clay-mineral assemblages derived from both sides of the valley are virtually identical. Montmorillonite predominates in both.

The soils and sedimentary rocks of the Diablo Range source area must contain a large proportion of montmorillonite, judging from the clay-mineral assemblages being carried by most of the streams entering the Los Banos-Kettleman City area from the southwest (fig. 14). Some of this montmorillonite may be forming in the soils, and some of it may represent the alteration of volcanic material within the sedimentary rocks. Vulcanism was widespread and frequent in central California during Mesozoic and Tertiary times (Jenkins, 1948; Lerbekmo, 1961; Taliaferro, 1943, p. 150); vol-

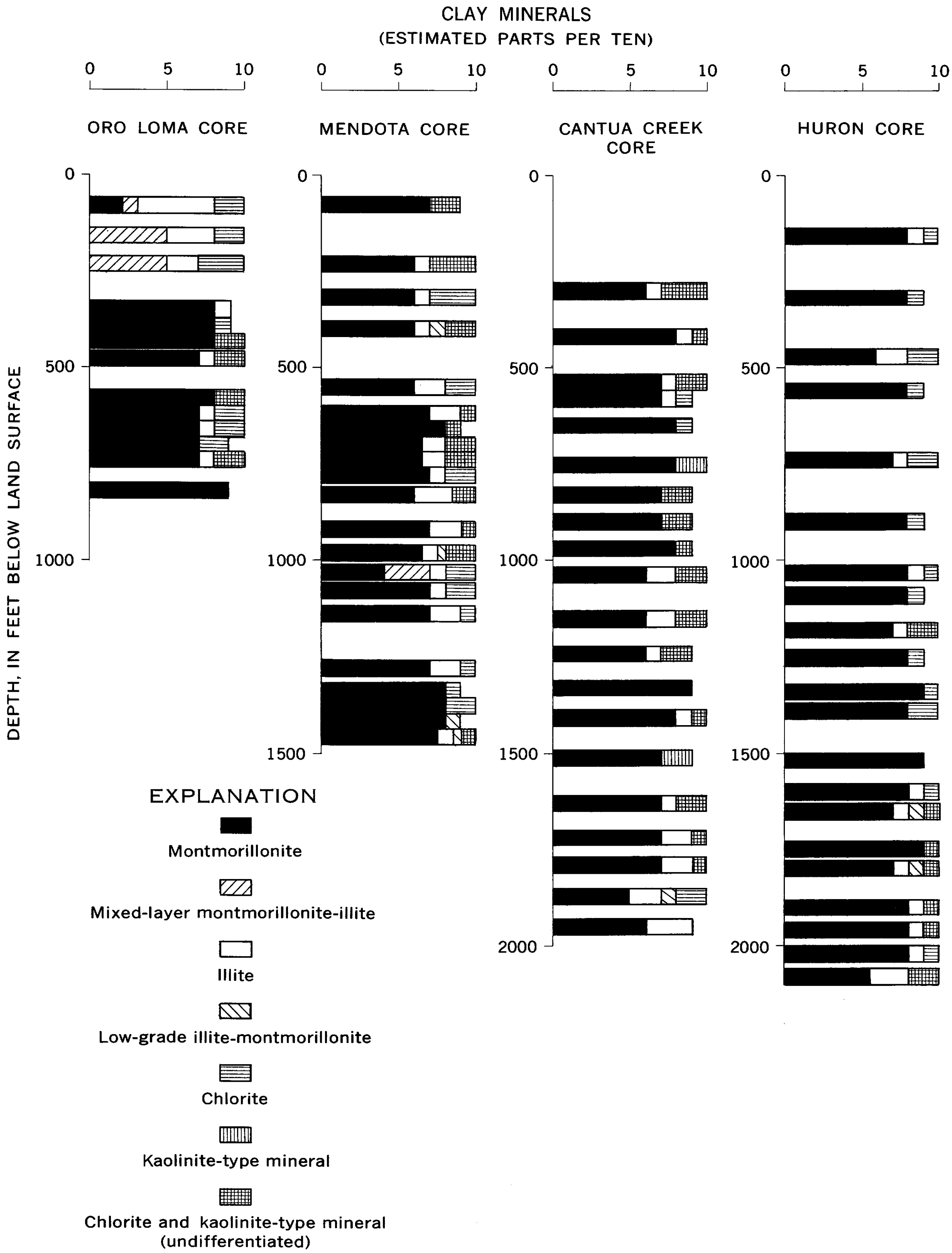

FIGURE 13.—Clay minerals in cored sediments, Los Banos-Kettleman City area. Trace amounts, given in table 11, not illustrated. Where two analyses were made less than 10 feet apart in cores, they were combined and illustrated as a single analysis. Twenty-five of illustrated analyses for Mendota and Huron cores were made by J. C. Hathaway, H. C. Starkey, and G. W. Chloe.

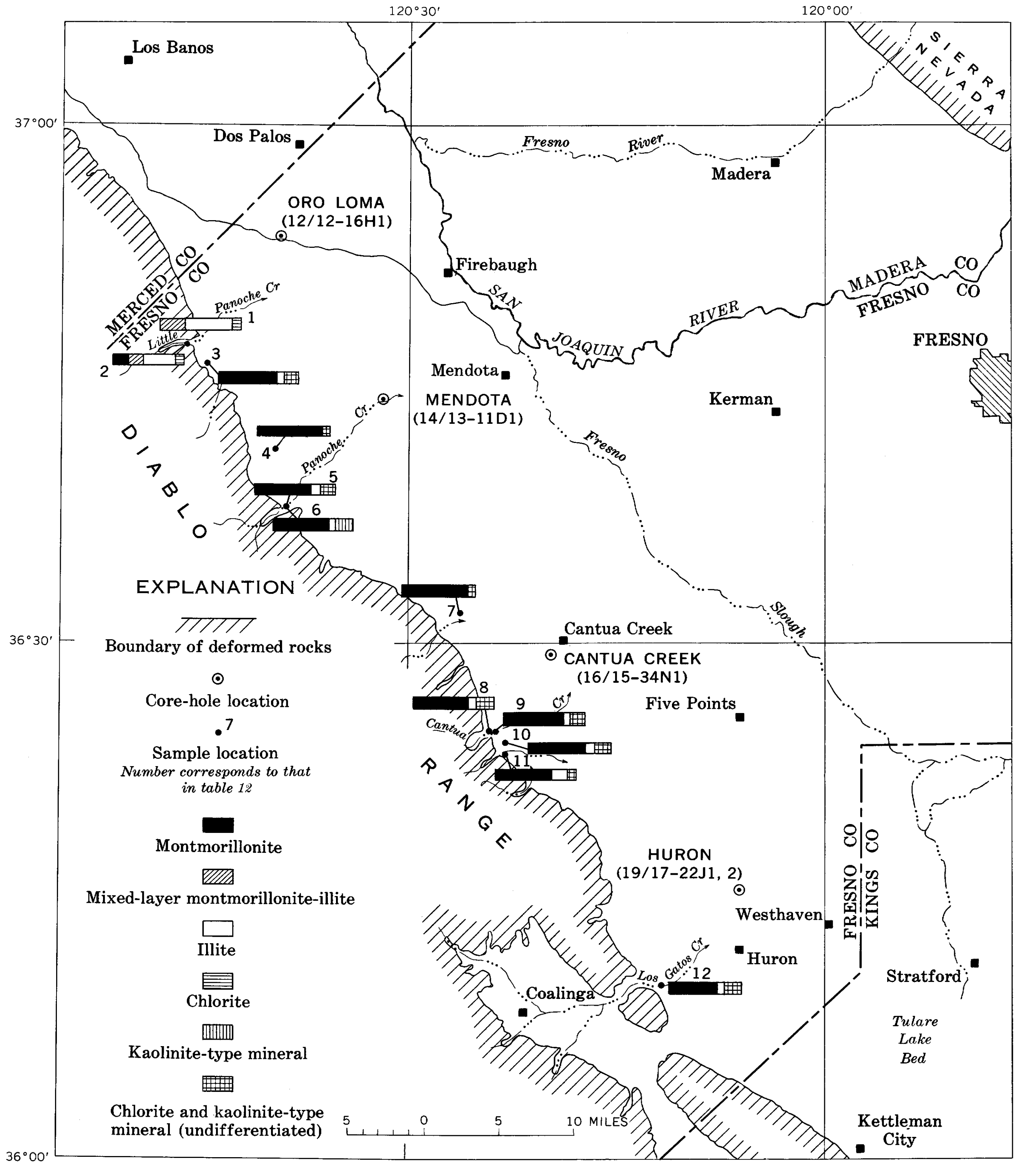

FIGURE 14.—Sampling sites for clay minerals in Recent surface alluvial sediments, Los Banos-Kettleman City area. Samples 3, 4, 7, and 11 collected by W. B. Bull.

canic minerals and rock fragments are significant constituents of many of the sediments deposited then. Much of the montmorillonite in the valley sediments from the Diablo Range may well have been derived from material that was deposited in and with older sediments as volcanic debris, altered to montmorillonite, and then eroded and redeposited as montmorillonite in the valley. However, no clay-mineral analyses of soils and rocks of the Diablo Range source area are available to substantiate this supposition.

A little montmorillonite has formed in the sediments from the Diablo Range since they were deposited. Some of the sand grains, especially those in the lowest 500 feet of the Mendota core, are coated with a material that colors them pale blue. Similar material has been identified in Pliocene sandstones from central California as montmorillonite that is derived from alteration of the volcanic detritus of andesitic composition that comprises large proportions—in some places nearly all—of these sandstones (Lerbekmo, 1957, 1961). In the sediments of the Tulare Formation and younger alluvium from the Diablo Range, however, the volcanic detritus is always mixed with such nonvolcanic constituents as serpentine and reddish chert, suggesting that these sediments are mixtures of reworked older volcanic sands and other materials. Because the coatings cover nonvolcanic as well as andesitic grains in the cored sediments, the coatings must have formed since the sediments were deposited.

Although montmorillonite has been formed within the sediments, no progressive increase in montmorillonite (relative to the other clay minerals) with depth of burial is evident (fig. 13). Perhaps the transformation of volcanic material to montmorillonite is not restricted to the sediments buried in the valley but is going on in the sediments and soils of the Diablo Range source areas at a similar or even greater rate.

The source of the montmorillonite in the sediments from the Sierra Nevada is uncertain. According to R. J. Janda (written commun., 1964, 1965), the principal clay mineral in the soils and alluvium of the upper San Joaquin River basin is kaolinite; subsidiary minerals are halloysite, vermiculite, montmorillonite, and illite. In many of these soils and sediments, montmorillonite is totally absent. Assuming that this represents the assemblage of clay minerals that the weathering of the granitic rocks in the Sierra Nevada has produced since Pliocene time, why do the Sierra-derived sediments of the valley contain an assemblage of clay minerals that is dominated by montmorillonite?

One possible source of the montmorillonite is the belt of metamorphic rocks in the western foothills of the Sierra Nevada. Perhaps montmorillonite has formed in the soils developed on these rocks and has been contributed to the streams that drain the Sierra in amounts sufficient to dilute the kaolinite-dominated assemblage contributed by the granitic terrane of the Sierra proper.

Another possible source of the montmorillonite is the Coast Ranges. The Sierra-derived sediments were designated as such on the basis of the assemblages of sand- and pebble-sized constituents. I assumed that the clay constituents of the same sediments also came from the Sierra. This may not necessarily be so. In the Los Banos-Kettleman City area, the cored sediments whose source is designated as Sierran were deposited on flood plains, in lakes, or in deltas. It is entirely possible that any, or all, of these deposits contain clay from the Diablo Range, even though none or very few of the sand and gravel constituents of these sediments came from the west. In the Tulare-Wasco area the fact that the shallow-marine sediments contain proportionately more montmorillonite than the alluvial-fan sediments (figs. 17, 24) may be indicative. That is, the marine deposits may have received clay that originated in the Coast Ranges and was moved in suspension to the east side of the shallow sea that occupied the southern part of the San Joaquin Valley at the time. The predominant clay mineral in the alluvial-fan deposits of the Tulare-Wasco area, however, is also montmorillonite. And, because these alluvial-fan sediments must have been derived exclusively from the Sierra, all the montmorillonite cannot have come from the Coast Ranges.

One must consider also that the montmorillonite in the Sierra-derived deposits may have formed by the alteration or transformation of other minerals soon after they were deposited in the valley. At least two possible sources, kaolinite and biotite, are worth considering.

Montmorillonite may have been formed from the kaolinite, either in soils that developed on the alluvial fans or as a diagenetic transformation in the high-pH environment of the valley sediments (see the pH measurements listed on p. C72 and in tables 11–13). The cored sediments, however, contain no evidence of such changes in the form of increasing proportions of montmorillonite and decreasing kaolinite with increasing depth of burial. The mechanism of such a transformation, involving a change from a two-layer structure to a three-layer structure, would seem to require energies that are not generally available in soils or in sediments buried under a few tens of feet of overburden. The degree of crystallinity of the kaolinite, on the other hand, is poor, and perhaps the transformation to montmorillonite could take place at low energy levels.

The montmorillonite may have been formed from biotite in the sequence: biotite→vermiculite→montmorillonite. Vermiculite is a common product of the weathering of biotite in California soils (Barshad, 1948). And montmorillonite could easily be formed from vermiculite with little change in the structure of the basic mineral lattice—the two minerals are so similar that distinction between them is often difficult. Biotite, in sand-sized flakes and books is a common constituent (2–5 percent) of the Sierra-derived sediments—probably more biotite than kaolinite, in terms of total sediment, is contributed by the Sierra to the valley. Alteration of some of the biotite (especially in the alluvial-fan sediments of the Tulare-Wasco area) from greenish black to golden yellow indicates that it has lost some of its identity as biotite. Vermiculite has been identified in the clay-mineral fractions of some of the sediments of the Pixley core from the Tulare-Wasco area, and it may be present in sediments in some of the other cores as well (but impossible to distinguish in the presence of the much greater proportions of montmorillonite). But no progressive alteration of biotite or change from vermiculite to montmorillonite has been observed with increasing depth of burial.

The question of the origin of the large proportions of montmorillonite in the valley sediments from the Sierra Nevada—in both the Los Banos-Kettleman City and the Tulare-Wasco areas—remains unanswered. One cannot choose the best hypothesis or combination of hypotheses on the basis of the evidence that is now available.

SOURCES OF OTHER CLAY MINERALS

Mixed-layer montmorillonite-illite seems to be derived entirely from the Diablo Range, probably from rocks of the late Mesozoic Franciscan Formation. It is a significant constituent of sediments in modern Little Panoche Creek, in the upper third of the Oro Loma core, and in the coarse lens of sediment at depths between 1,000 and 1,200 feet in the Mendota core.

Illite and chlorite are ubiquitous, but variations in their crystallinity are helpful in delineating their sources. Well-crystallized illite and type-A chlorite occur in conjunction with mixed-layer montmorillonite-illite, and seem to be derived from the Franciscan Formation. Type-B chlorite and less well crystallized illite seem to be derived mainly from Cretaceous and Tertiary sediments of the Diablo Range and Sierra Nevada foothills.

The kaolinite-type mineral or minerals could have come from many sources. Three possible sources of aluminum-rich kaolinite are weathered silicic intrusive rocks of the Sierra Nevada, hydrothermal alteration zones associated with quicksilver deposits in the Diablo Range (Eckel and Myers, 1946; Yates and Hilpert, 1945), and "anauxitic" Eocene sediments along the west side of the northern San Joaquin Valley (Allen, 1941; Briggs, 1953, p. 39–41). Serpentine minerals have kaolinite-type structures, and they may be present in the samples; serpentine bodies crop out in the drainage basins of all the major creeks that flow from the Diablo Range into the Los Banos-Kettleman City area.

An intriguing possibility is that some of the kaolinite-type material is derived from the weathering of chlorites. Nelson and Roy (1954, 1958) have shown that the polymorph of chlorite stable at low temperatures might have a kaolinite structure, and a mineral with a chloritic composition and kaolinite structure has been found in a low-temperature environment by Sigvaldason and White (1961, p. D–117, D–119). Considering that much of the chloritic material in the Tulare Formation and younger sediments of the valley represents chlorite from older sediments that has been through two or more periods of degradational weathering, the sequence of minerals represented as *A*, *B*, and *C* in figure 40 may represent a gradation from well crystallized 14–A chlorite to poorly crystallized 7–A chlorite.

TOTAL CLAY-MINERAL CONTENT OF SEDIMENTS

The total amount of clay-mineral material in the cored sediments of the Los Banos-Kettleman City area is about 15 percent, and the total amount of montmorillonite is about 10 percent.

This estimate was derived by a combination of visual examination and particle-size analysis. The visual examination was made with a petrographic microscope and an oil-immersion lens and consisted of point counts (100 points each) of specimens of 20 fine-grained sediments that had been stained with a mixture of malachite green and nitrobenzene. Malachite green stains clay minerals selectively without staining nonclay minerals (Mielenz and King, 1951, p. 1217). The point counts yielded a rough estimate of the proportion of clay-mineral material in each of the 20 sediments.

Particle-size analyses were also made for these 20 sediments—the core-hole sediments in table 6. The particle-size analyses were compared with the point counts to determine the percentile (particle diameter) that corresponded to the proportion of clay minerals estimated visually: say, for example, the visually estimated proportion of clay minerals was 40 percent, then the particle diameter that was coarser than 40 percent of the sediment was taken from the size-distribution curve. For the 20 sediments, the geometric mean of these particle diameters was 3.0μ (8.4ϕ) and their standard deviation was about 1.5μ (0.7ϕ). The weight percent finer than 3.0μ, therefore, was taken as the proportion of clay-mineral material in a sediment.

The next step consisted of determining the percents finer than 3.0μ in the 305 sediments whose particle sizes were discussed in the previous section (listed in table 5). The mean of these was 20 percent. This estimate was adjusted to 15 percent to allow for the coarser sediments that were not recovered during the coring operations.

IONS ASSOCIATED WITH CLAY MINERALS

The principal ions adsorbed by the clays and in waters associated with the clays are calcium, magnesium, sodium, bicarbonate, sulfate and chloride. These are listed in tables 11 and 12; the procedures used in their determination are described on pages C71–C72.

Figure 15 represents the cations adsorbed by the clays in sediments from the four principal streams and the four core holes. The percentages illustrated were adjusted by subtracting the equivalent of the total anions from the total calcium ions; this involves the assumptions (not necessarily true) that all the soluble salts in these sediments are calcium salts and that none of the anions are adsorbed by the clays. The accuracy of figure 15 is subject to the doubts and limitations discussed below, but the general picture is valid.

The adjusted sums of exchangeable cations in these samples, with one exception, are greater than the determined cation-exchange capacities. Several hypotheses to explain this disparity are listed below, but one cannot choose between them on the strength of the available evidence.

1. The adjustment is only a partial correction because the solubility of the principal salts in these sediments, calcite and gypsum, is greater in NH_4Cl solution (in which the adsorbed cations were determined) than in hot water (in which the soluble anions were determined).
2. The cation-exchange capacities, as determined, may be lower than the actual capacities because some of the ammonium ion that was added to displace the naturally held exchange cations may have been fixed so strongly on the clays that it was not removed by the alcohol-distillation procedure used in the analysis (Richards, 1954, p. 20).
3. The disparity may be related to differences in pH between the natural environment and the laboratory. The natural clays exist in an alkaline environment (pH>7), but their exchange capacities were determined at neutrality (pH=7). Kelley (1957, p. 473) says that cations are adsorbed from chemically alkaline solutions in greater quantities than from neutral solutions; and, as the pH of a clay-water suspension is lowered in the laboratory, the excess cations adsorbed at higher pH tend to hydrolize off the clays. Supporting evidence for this hypothesis is given by Pratt (1961) and in the titration curves summarized by Grim (1953, p. 130).

The single exception to the apparent excess of exchangeable cations over exchange capacity is the sediment from 1,801 feet in the Huron core. The sample contained pyrite (about 1 percent) and bituminous-appearing organic material (several percent). The pH of the hot-water leachate was 6.7, and the only anion determined in significant quantity was sulfate. Some of the exchange positions may have been occupied by hydrogen, which was not determined.

EXCHANGEABLE CATIONS IN MODERN STREAM SEDIMENTS

Calcium is by far the most abundant of the cations adsorbed by clays in the streams, although it is not the most abundant cation in solution in the stream waters. The cation composition of water samples from Little Panoche and Panoche Creeks and of sediments that were in approximate contact with these waters at the time they were sampled are given below. The cations conform to the generally recognized sequence of preferential adsorption at low electrolyte concentrations, Ca>Mg>Na (Carroll, 1959, p. 749).

	Ca	Mg	Na	K	Total dissolved solids (ppm)	Cation exchange capacity of clay-mineral assemblage (meq/100 g sample finer than 3μ)
	(percent of total cation equivalents)					
Little Panoche Creek						
In solution	35	24	39	2	432	----------
Adsorbed by clays in creek bed	71	29	0	0	--------	68
Panoche Creek						
In solution [1]	32	29	38	1	1, 310	----------
Adsorbed by clays in creek bank	84	16	0	0	--------	116

[1] More details of this analysis given by Davis (1961, p. 27, sample collected Mar. 17, 1958).

EXCHANGEABLE CATIONS IN SUBSURFACE SEDIMENTS

Several features of the distribution of cations in subsurface sediments are apparent in figure 15: a preponderance of calcium, a downward increase in adsorbed sodium, and, in all but the Oro Loma core, a downward decrease in adsorbed magnesium. The increase in adsorbed sodium is probably related to the downward increase in the sodium content of the ground water in the sediments, as is shown by the following data summarized from Davis and Poland (1957, p. 450–462).

Depth interval	Total dissolved solids (ppm)	Sodium (percent of total cation equivalents)
Surface to about 250 ft	3, 000	35
250 ft to top of Corcoran Clay Member	1, 500	55
Bottom of Corcoran Clay Member to base of fresh water	800	75
NaCl-water zone (below bottoms of core holes)	14, 000?	Very high

Although the percent sodium in the deeper fresh water averages about 75, the percent of adsorbed sodium never seems to exceed 35. The downward decrease in adsorbed magnesium is also related to a change in the cation composition of the ground water. Analyses given by Davis and Poland (1957, p. 454–455) show an average percent magnesium of 23 in the water above the Corcoran Clay Member and 6 in the water below the Corcoran.

SEDIMENTS IN THE TULARE-WASCO AREA

The sediments whose compaction accounts for the land subsidence observed in the Tulare-Wasco area include both marine and nonmarine deposits. They were derived from the Sierra Nevada, which borders the area on the east. The oldest of these sediments are probably upper Miocene; the youngest are Recent. The marine sediments have been assigned to the Santa Margarita Formation as used by Diepenbrock (1933) and an overlying upper Pliocene marine unit. Most of the land subsidence observed to date has been due to compaction of the nonmarine sediments (B. E. Lofgren, oral commun., 1962).

These sediments were studied in two cores. Locations of the core holes, both in southwestern Tulare County, are shown in figure 16. Other details of the coring are given in table 1. Note that the average core recovery was better in these sediments than it was in the sediments of the Los Banos-Kettleman City area or the Santa Clara Valley.

Two other reports bear on the depositional history of the sediments of the Tulare-Wasco area. Klausing and Lohman (1964) describe the upper Pliocene marine unit, as cored in the Richgrove hole. B. E. Lofgren and R. L. Klausing, in a report on land subsidence in the Tulare-Wasco area, Calif. (in preparation as Prof. Paper 437–B), describe briefly the geologic units and structure.

SOURCE OF SEDIMENTS

The sediments represented by the Pixley and Richgrove cores have come chiefly, if not entirely, from the Sierra Nevada and its foothills. Lacustrine sediments in the Pixley core and marine sediments in the Richgrove core may have received contributions from the non-Sierran drainage basins, but their sand and pebble constituents show little or no evidence of it. The silts, sands, and gravels are all arkosic, consisting mainly of quartz, feldspar, and fragments of granitic rock. The principal accessory constituents, which usually amount to 5–15 percent of the sediments, are biotite and green hornblende. These minerals reflect the assemblage of minerals in the granitic rocks of the Sierra Nevada. Minor constituents of the sediments are dark fragments of metamorphic rocks, mainly quartzite and slate plus a little serpentine, which probably were derived from the metamorphic terrane in the foothills of the Sierra.

A little volcanic detritus was also deposited with the sediments. Glassy basalt, in pebbles and granules, was found in some of the coarser sands at depths between 1,840 and 1,750 feet in the Richgrove area. Rhyolitic glass (index of refraction between 1.50 and 1.51), in silt-sized particles, was found at a depth of 1,058 feet—partly mixed with other detritus and partly concentrated (more than 90 percent glass) in a bedded deposit. I. E. Klein reported finding a thin layer of pumice at a depth of 540 feet in the Pixley core (B. E. Lofgren, written commun., 1964). Except for these minor occurrences, no other direct evidence of volcanic activity was found in the sediments.

TYPES OF DEPOSITS

The main distinction to be made in the sediments cored in the Tulare-Wasco area is between marine and nonmarine deposits. The evidence for the existence of both types of deposit is quite clear. The exact point of the transition from marine to nonmarine conditions is somewhat less so. The most detailed petrologic study was done on the Richgrove core because it contained both types of deposits. The Pixley core contains only nonmarine sediments. The distribution of deposits in the cores is shown in figure 17. The pertinent evidence gleaned from the Richgrove core and the conclusions reached from it are given in table 4. Inferences about the origins of the nonmarine deposits are based on the criteria used in the Los Banos-Kettleman City area.

MARINE DEPOSITS

The marine deposits in the Richgrove core can be divided conveniently into two units—a well-sorted sand (below 1,900 ft) and a fine-grained siltstone (1,700 to about 760 ft)—with 200 feet of transitional sediment between them. The well-sorted sand has been correlated by subsurface mapping with the Santa Margarita Formation as used by Diepenbrock (1933) of Miocene age (Klausing and Lohman, 1964, p. D–14). On the basis of a study of diatom assemblages by Lohman, the siltstone unit has been assigned to the upper Pliocene and may be the equivalent of part of the San Joaquin Formation exposed on the west side of the San Joaquin Valley, and the siltstone-sand transitional sediments have been assigned tentatively to the Pliocene(?).

The marine sediments probably were deposited in shallow water under mildly reducing conditions. The depth of water is suggested by the remains of shallow-water mollusks and Foraminifera that were found in the siltstone-sand transitional sediments. It is also suggested by some of the textural characteristics of the

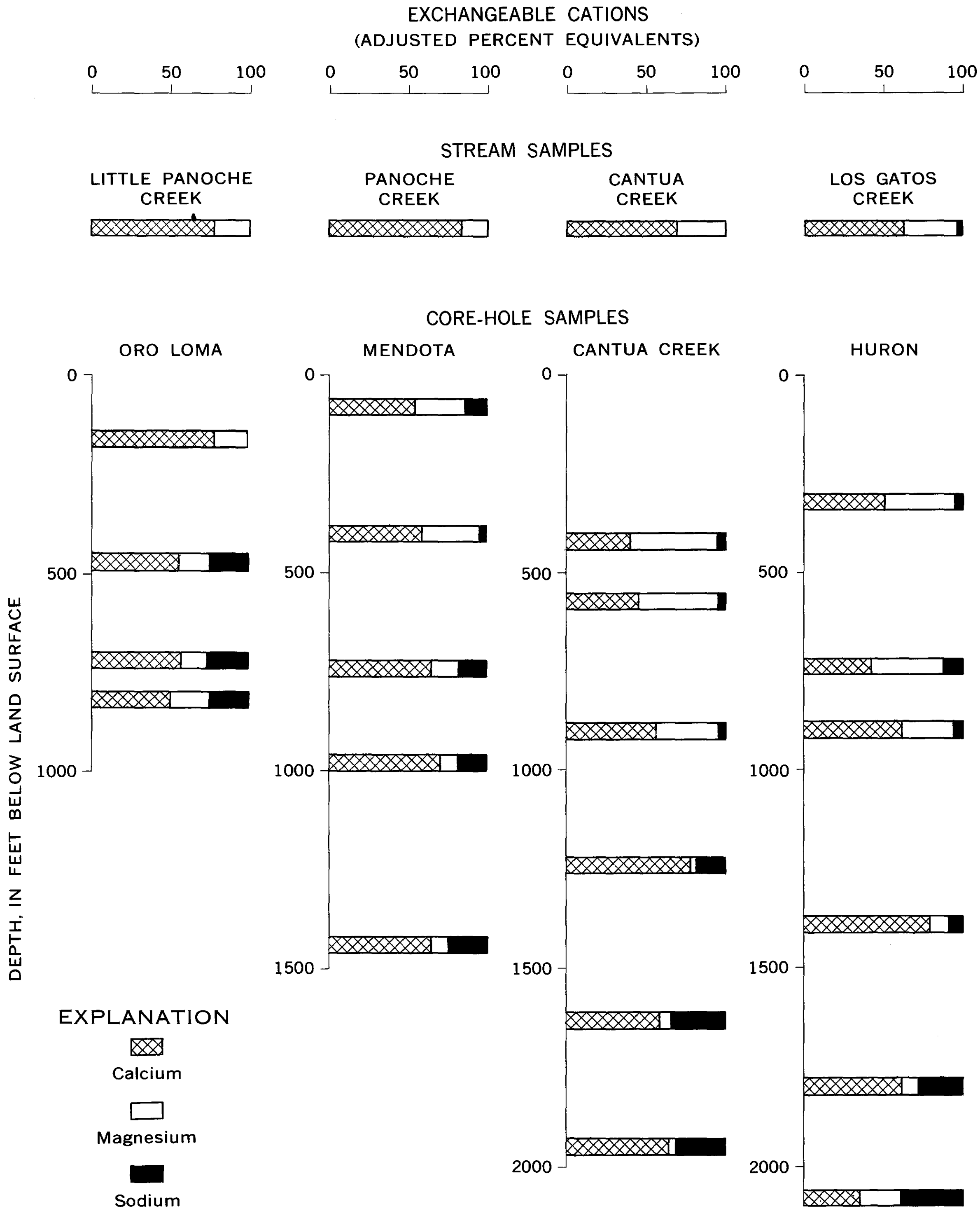

FIGURE 15.—Cations adsorbed by clay minerals in principal streams and cores, Los Banos-Kettleman City area. Determined by H. C. Starkey.

sediments. The good sorting of most of the sands in the 2,200- to 1,700-foot and 1,050- to 760-foot intervals, and the small-scale separation of sand and finer material in the siltstones in the 1,570- to 1,050-foot interval (described under "Other features" in table 4) suggest that a gentle winnowing process operated periodically during the deposition of these sediments. Reducing conditions are suggested by the good preservation of plant remains and by the ubiquitous presence of iron sulfides.

The upper boundary of the marine siltstone unit is not so abrupt as indicated in table 4 or in figure 124.2

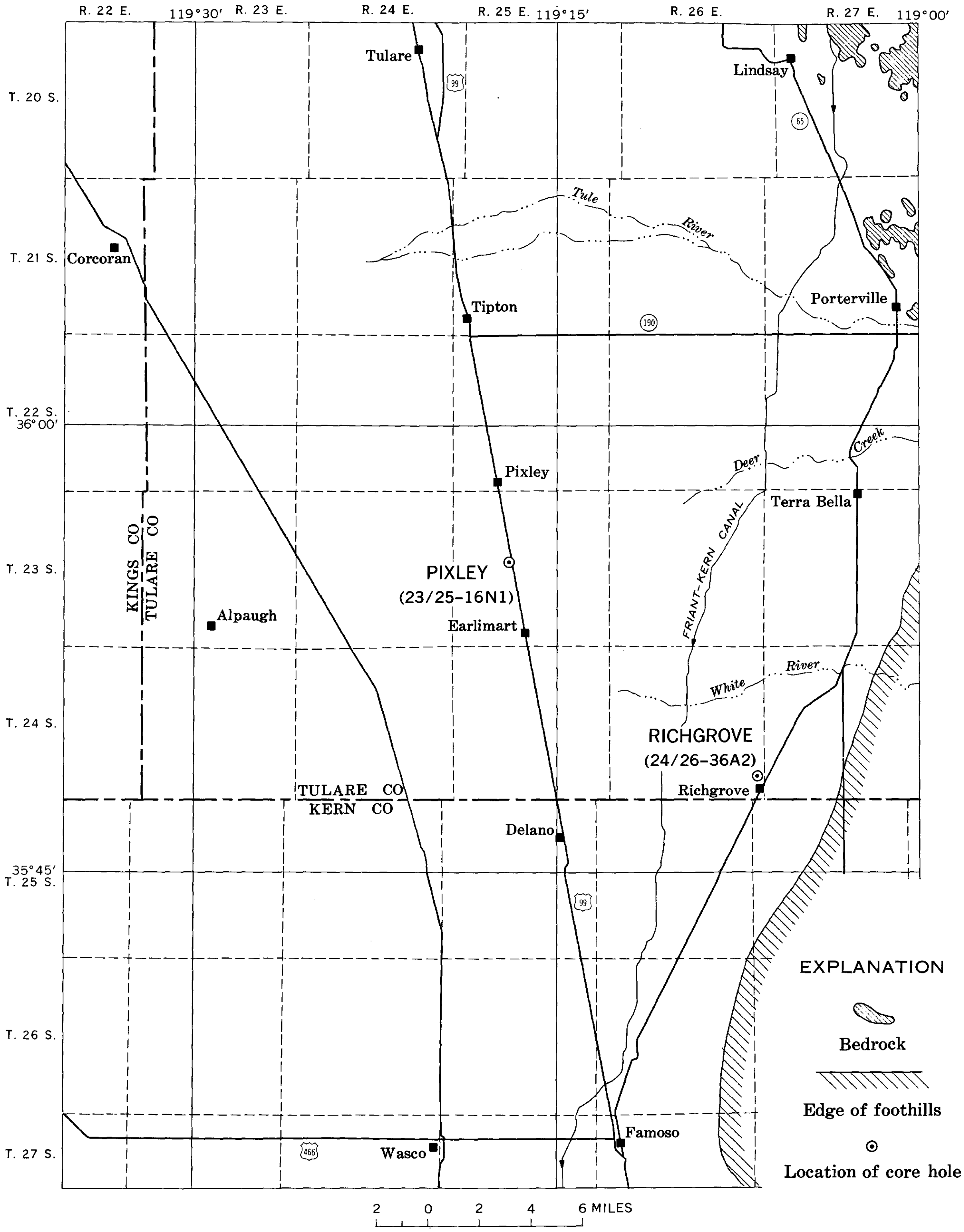

FIGURE 16.—Tulare-Wasco area showing locations of core holes.

of the paper by Klausing and Lohman (1964). Although the resistivity log (shown in fig. 22) shows an abrupt transition at a depth of 744 feet, visual examination of the sediments suggests a more gradual transition. In the 785- to 744-foot interval, interbedding of poorly sorted clayey silt with the massive siltstones suggests a gradual and fluctuating departure of the sea rather than a sudden and abrupt withdrawal.

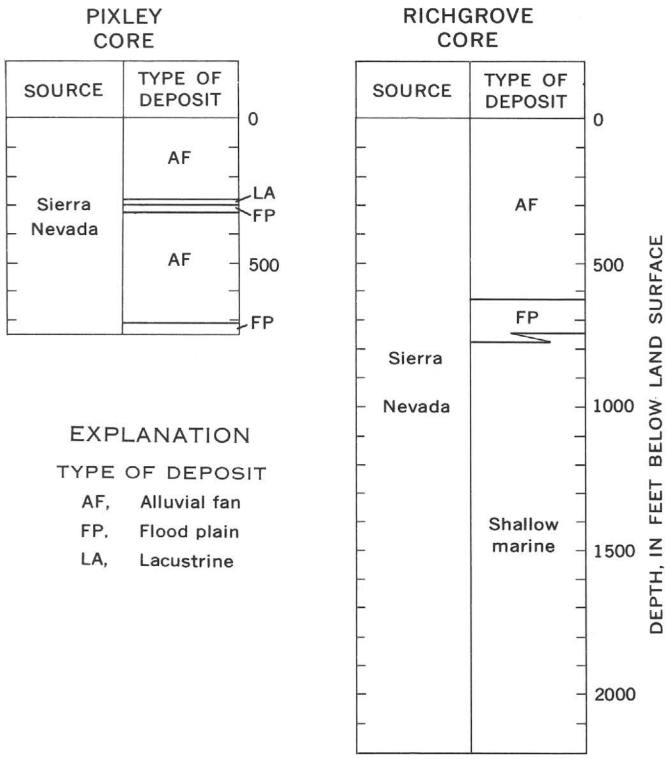

FIGURE 17.—Source and principal types of deposits represented by sediments cored in the Tulare-Wasco area.

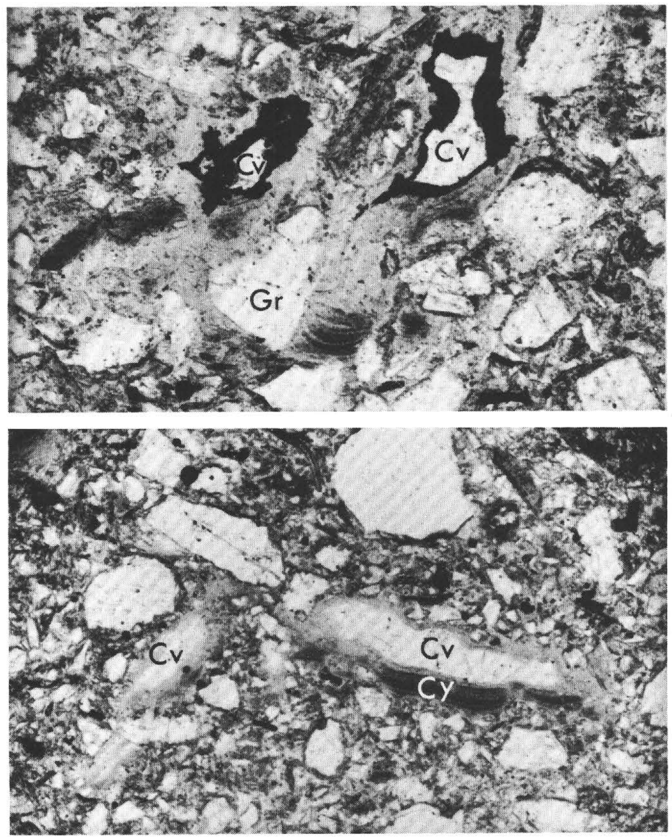

FIGURE 18.—Photomicrographs of soil textures in alluvial sediment from depth of 232 feet in Richgrove core, Tulare-Wasco area. Long dimension of each photograph is about 1,000μ. *Upper,* Cavities (Cv) lined with clay. Layered clay (Cy) shows preferred orientation, presumably resulting from successive depositions on walls of cavity. *Lower,* Cavities (Cv) lined with clay and carbonaceous matter (black). Grain (Gr) also surrounded by clay.

ALLUVIAL-FAN DEPOSITS

Most of the nonmarine sediments in the two cores were deposited on alluvial fans. The uppermost 620 feet of the Richgrove core and most of the Pixley core consist of alluvial-fan deposits, whose characteristics are given in table 2. The modern Tulare-Wasco area, like the Los Banos-Kettleman City area, is an area of alluvial-fan deposition.

The alluvial-fan deposits in the Tulare-Wasco area differ from those in the Los Banos-Kettleman City area in two ways. First, they are coarser grained, reflecting the generally larger size of material supplied by the Sierra Nevada source area. They contain few fine clays such as are common in the alluvial-fan sediments in the Los Banos-Kettleman City area. And they do not contain clay aggregates of the type illustrated in figure 4.

The second main difference is the evidence of more extensive soil-forming processes in the Tulare-Wasco area. Biotite has been intensely weathered: originally black flakes and books have gone partly or completely to fragile golden-yellow flakes. Soil textures (fig. 18)—mainly cavities lined with carbonaceous material, opaline material, or clay in oriented films (like those described and named "cutans" by Brewer, 1964, p. 205–233)—suggest that organic and mineral material had been moved about within the sediments since they were deposited. The development of these features suggests that the alluvial-fan sediments in the Tulare-Wasco area have accumulated more slowly than those across the San Joaquin Valley in the Los Banos-Kettleman City area.

LACUSTRINE AND FLOOD-PLAIN DEPOSITS

The lacustrine layer indicated in the Pixley core in figure 17 is the Corcoran Clay Member of the Tulare Formation, identified on the basis of its fine grain size and bluish-gray color and by subsurface correlation across the valley. The flood-plain deposits that lie below the alluvial-fan sediments in both cores were identified on the basis of criteria in table 4 and by their similarity to flood-plain deposits in the Los Banos-Kettleman City area. They may include some minor lacustrine deposits.

PARTICLE SIZES

The study of particle sizes in the Tulare-Wasco area is based largely on 157 samples from the two core holes.

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TABLE 4.—*Evidence for conditions of deposition represented by sediments in Richgrove core, Tulare-Wasco area*

Depth below land surface (feet)	Lithologic unit	Particle-size characteristics	Other features	Organic remains	Chemical indicators	Inferred type of deposit	Depth below land surface (feet)
0 500	Sand, silt, and clay in beds 1-10 ft thick.	Sand, silt, and clay mixed in varying proportions; poorly sorted.	Some of silts and clays contain cavities, tubular or irregularly oblate, which are lined with carbonaceous material, opaline material, or clay. Sediments loose to friable. Minerals, especially biotite, weathered. No preferred orientation of clay-mineral particles (mean orientation ratio 1.1).	Carbonaceous material in cavity linings or amorphous accumulations.	Iron oxides, disseminated. Calcite in hard nodules or soft irregular accumulations; rarely cementing layers a few centimeters thick. Yellow brown.	Alluvial fan (on basis of oxidized color, poor sorting of particle sizes, and cavities)	0 500
			Preferred orientation of clay-mineral particles (one sample with orientation ratio of 1.5).	Woody material, in isolated well-preserved fragments as much as a few centimeters long, or disseminated in small flecks.	Iron sulfides associated with woody material. Calcite as above. Greenish to bluish gray.	Flood plain	
1000	Siltstone[1] in beds 20-100 ft thick, intercalated with sand 2-15 ft thick.	Siltstone, fine to clayey, with a few sand grains; well sorted. Sand, medium to fine, well-sorted.	Siltstone, massive (virtually no visible bedding on small scale), hard (breaks with conchoidal or blocky fracture). Sand, loose. Preferred orientation of clay-mineral particles (mean orientation ratio 1.6).		Iron sulfides associated with woody material. Greenish to bluish gray.	Transitional Presumably shallow marine (on basis of lithologic similarity to underlying sediments)	1000
1500		Siltstone, fine to clayey, with a few sand grains; well sorted. Sand, coarse to clayey, poorly sorted.	Most of siltstone finely laminated: siltstone layers a few centimeters thick alternate with layers or discontinuous lenses, a few millimeters thick, of fine sand. Many sands contain oblate and rounded clasts of claystone as much as 2 centimeters across. Siltstone, hard; and loose sand. Preferred orientation of clay-mineral particles (mean orientation ratio 1.5).	Marine diatoms. Woody material as above.	Iron sulfides disseminated in small grains or concentrated near organic material; occasionally replace diatoms; partly or completely oxidized to gypsum and iron oxide. Gypsum in especially high concentrations in some siltstones below 1200 ft. Greenish to bluish gray.	Shallow marine (mainly on basis of fossils)	1500
			Siltstone, massive, hard. Sand, loose. Preferred orientation of clay-mineral particles (mean orientation ratio 1.7).	Woody material as above.			
	Siltstone[1] and sand in beds 2-20 ft thick.	Siltstone, fine to clayey, with a few sand grains; well-sorted. Sand, coarse to medium, well-sorted.		Shallow-marine mollusks, *Foraminifera*, fish scales, crab(?) remains. Woody material as above.			
2000	Sand, massive.	Sand, coarse to medium, well-sorted.	Sand, loose.	Woody material in isolated fragments as much as a few centimeters long. Shell fragments.	Iron sulfides associated with woody material, partly oxidized to gypsum and iron oxide.		2000

[1]Claystone as logged from core inspection at drilling site and as listed by Klausing and Lohman (1964, fig. 124.2); particle-size analyses indicate siltstone.

The number of samples analyzed from and the estimated mean particle size of the three principal lithologic units are summarized in the following table. The mean sizes of the sediments as a whole were estimated by comparing the mean sizes of the recovered sediments with the electrical-resistivity logs of the core holes. The difference between the mean size of the nonmarine sediments that were recovered and the size of the sediment particles in the nonmarine section as a whole is due to selective recovery, especially in the Pixley core. The difference in the marine siltstones and interbedded sands is due to selective sampling of the recovered core. Because the material was so uniform, the marine deposits were not sampled at close intervals. (See fig. 22 and table 8.)

Lithologic unit	Depth interval sampled (feet)	Number of samples	Estimated mean particle size (microns)	
			Recovered sediments	Section as a whole
Nonmarine and transitional	30– 785	121	20– 40	40– 80
Marine siltstone and interbedded sands	785–1, 900	28	16– 30	8– 16
Santa Margarita Formation as used by Diepenbrock (1933)	1, 900–2, 200	8	250–500	250–500

Selected percentiles, averages, and measures of sorting and skewness for each sample are given in table 8. The percentiles were interpolated by a digital computer from particle-size data provided by the Hydrologic Laboratory. The digital computer also determined the modal particle size and calculated the measures of sorting and skewness, which are defined on pages C49 and C50. Particle-size-distribution curves for some individual samples are presented by Johnson, Moston, and Morris (1967).

In order that the size characteristics of the nonmarine and marine deposits might be considered clearly and separately, the particle-size analyses of the transitional sediments (depths between 785 and 744 ft in the Richgrove core) have been left out of the discussions that concern figures 19–21, and 23. The transitional sediments are included, however, in fig. 22.

PARTICLE SIZES OF NONMARINE SEDIMENTS

Except for two samples from the lacustrine Corcoran Clay Member in the Pixley core, all the samples of nonmarine sediments represent alluvial deposits.

The triangular plots of the proportions of sand, silt, and clay (fig. 19*B*, *C*) show that the nonmarine sediments are not so diverse in particle size as those cored in the Los Banos-Kettleman City area (compare with fig. 5). The bulk of the points in figure 19*B* and *C* fall into the silty-sand and sand-silt-clay categories. The clay content ranges between 10 and 35 percent in most samples. Sixty-eight of the samples of nonmarine sediments (all from the Richgrove core) contain some gravel, but only 14 of these contain 5 percent or more of material coarser than 2,000μ. In general, then, the nonmarine sediments of the Tulare-Wasco area seem to be heterogeneous mixtures of sand, silt, and, to a lesser extent, clay.

This impression is supported by the measures of average size, sorting, and skewness (fig. 20). Most of the median and modal diameters fall into a fairly narrow range of sizes, as compared to the wider general range in the Los Banos-Kettleman City area (fig. 6). The most abundant size range, judging from the concentration of modal diameters, is 31μ to 62μ. As in the Los Banos-Kettleman City area, the degree of sorting ranges mostly from fair to poor, and the skewness of the particle-size distributions reflects a disproportionately large amount of fine-grained material.

The sediments in the Pixley area probably are not so fine grained on the whole as one might infer from the distribution of median diameters in the recovered sediments. Although the core recovery at Pixley was good (table 1), part of the section—200 of the uppermost 260 feet—was not cored. According to the electric logs of the core hole (fig. 22), many of the coarsest sediments in the section are in the uppermost 260 feet. Most of these, therefore, were not sampled.

The nonmarine sediments in the Richgrove core, on the other hand, were cored and sampled on a fairly representative basis. Although they do seem to be slightly coarser on the whole than sediments in the Pixley area, they are perhaps more representative than the sediments recovered at Pixley.

PARTICLE SIZES OF MARINE SEDIMENTS

In the unit of interbedded marine siltstone and sand that lies between depths of 785 and 1,900 feet in the Richgrove hole, the siltstones are in beds 20–100 feet thick, and the sands are mostly in layers 2–15 feet thick. The segregation into two types of sediments is not so well shown in figure 19*D* as it is in figure 21. The average diameters (median and mode) in this depth interval fall into two groups, one representing the siltstones and the other representing the sands. Because of selective sampling of the recovered core, however, the sands are overrepresented with regard to the siltstones. The highly skewed sediments—those with Skq_ϕ/QD_ϕ values larger than 0.4—represent bulk analyses of siltstones that contain thin laminae (a few millimeters thick) of fine sand.

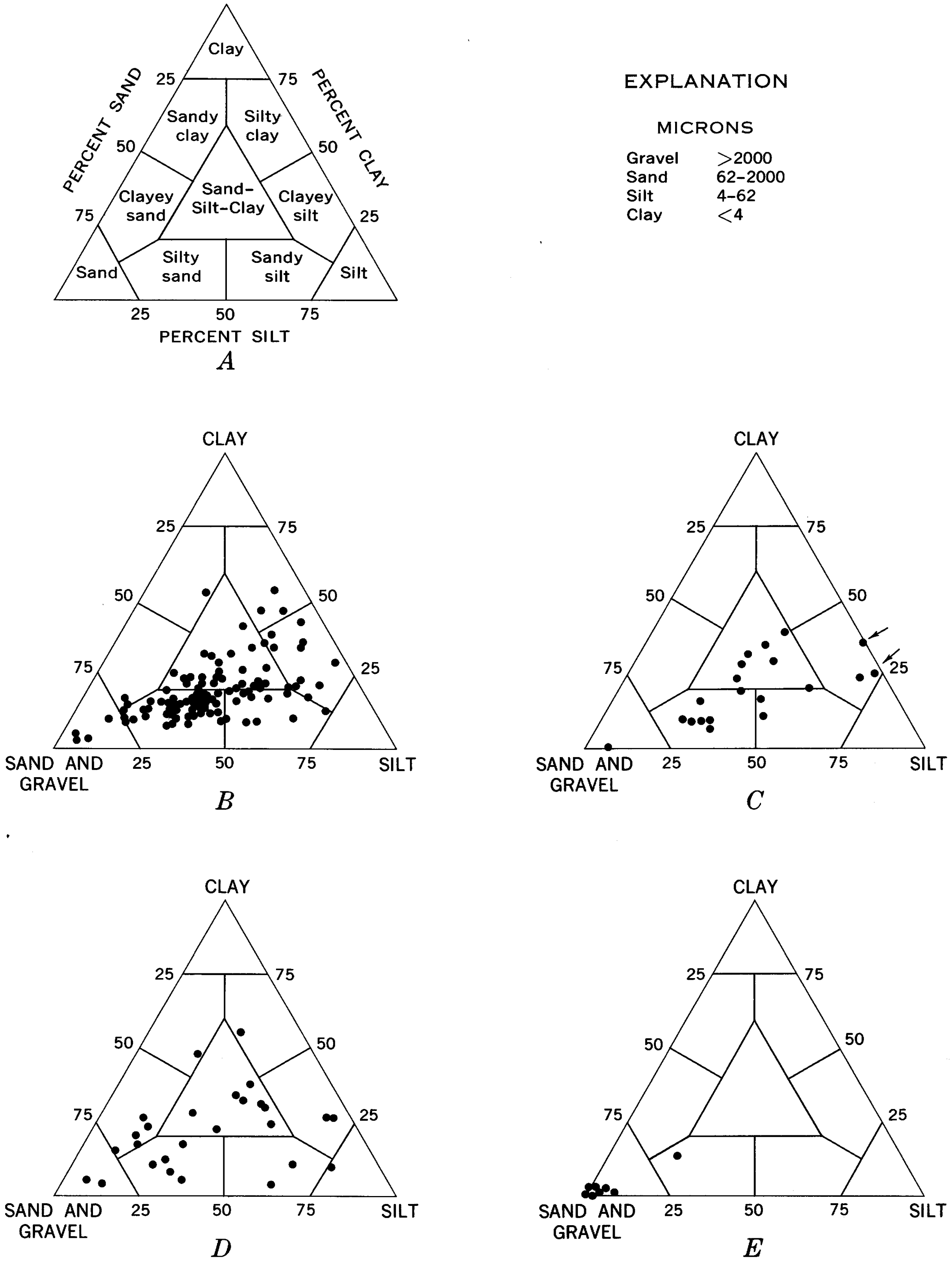

FIGURE 19.—Sand-silt-clay percentages of sediments cored in the Tulare-Wasco area. Based on data from the Hydrologic Laboratory of the U.S. Geological Survey, Denver, Colo. *A*, Nomenclature after Shepard (1954). *B*, Alluvial-fan sediments. *C*, Flood-plain sediments, plus two lacustrine sediments (indicated by arrows). *D*, Marine siltstones and interbedded sands. *E*, Santa Margarita Formation as used by Diepenbrock (1933).

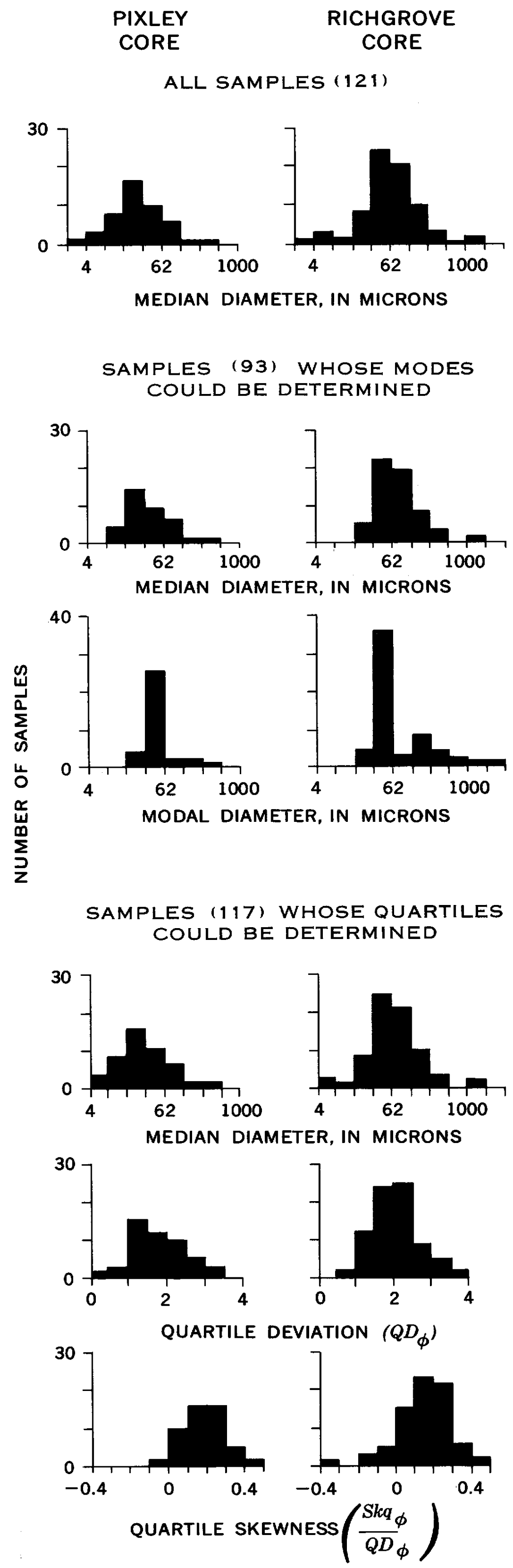

FIGURE 20.—Measures of average size, sorting, and skewness in nonmarine sediments cored in the Tulare-Wasco area.

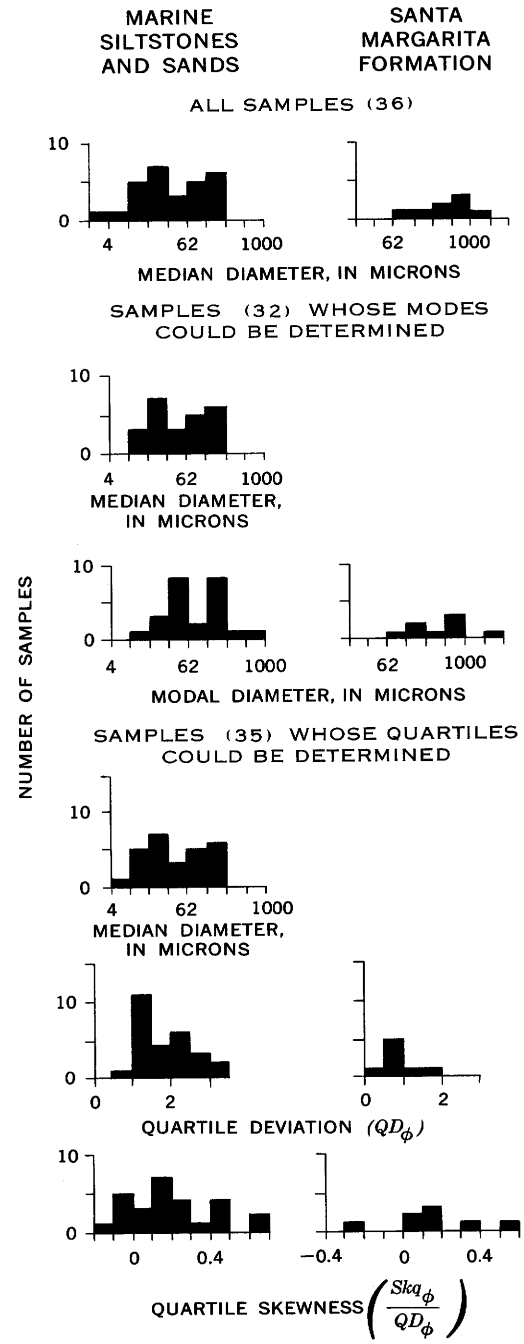

FIGURE 21.—Measures of average size, sorting, and skewness in marine sediments from the Richgrove core, Tulare-Wasco area.

The Santa Margarita Formation as used by Diepenbrock (1933), sampled at depths between 1,900 and 2,200 feet, is mainly a well-sorted sand. The eight samples whose characteristics are plotted in figures 19*E* and 21 seem to be representative of the cored intervals.

SPATIAL DISTRIBUTION OF PARTICLE SIZES

Figure 22 shows the variation in particle size with depth in the two cores and serves as a spatial summary

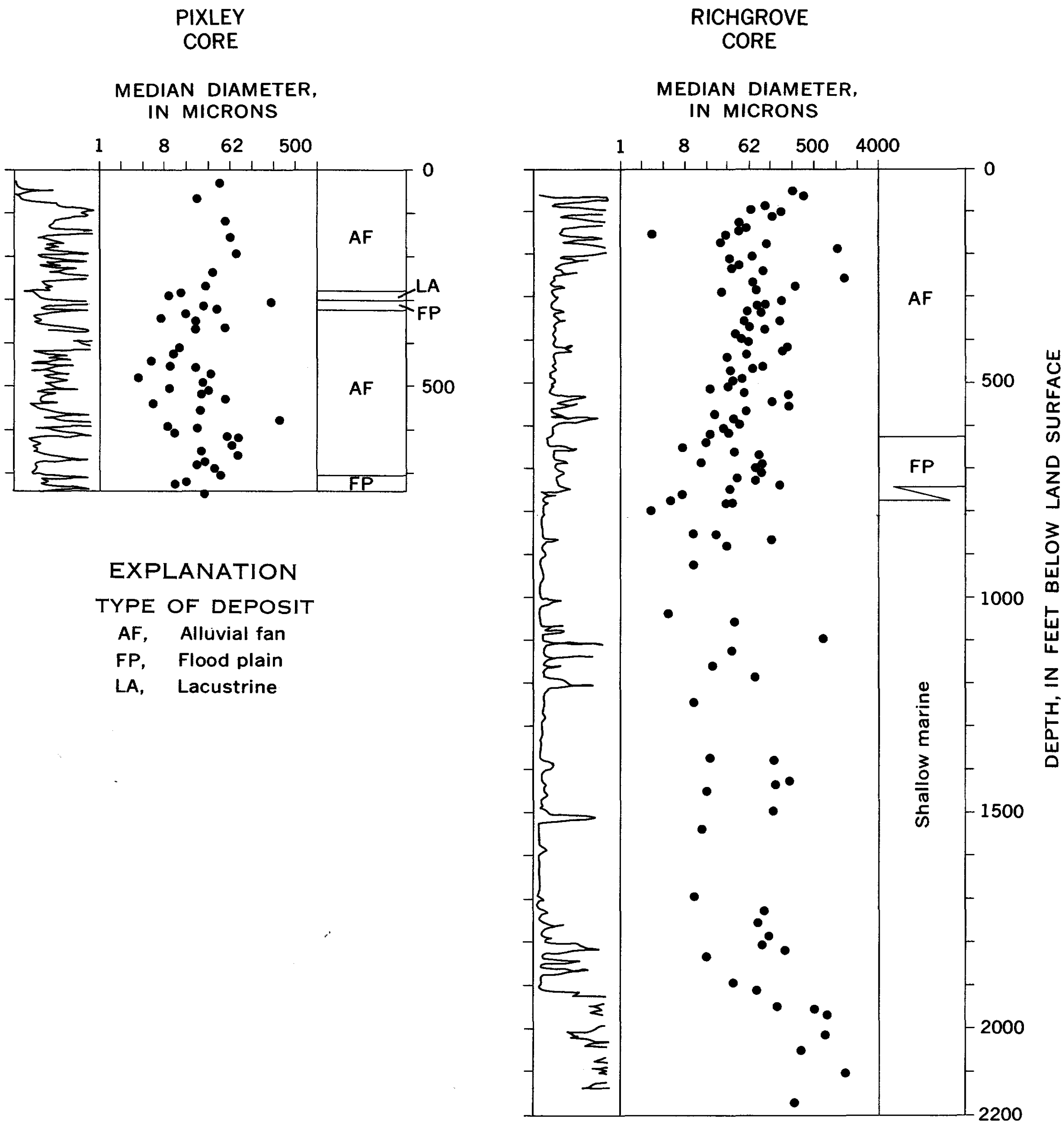

FIGURE 22.—Variations in particle size with depth, Tulare-Wasco area. Resistivity log is left column of each composite; range, from left to right, is 0–40 ohms m²/m.

of some of the foregoing descriptions of size. As in figure 7, median diameter and resistivity indicate particle size. The types of deposits are also included. The preponderance of silt in the section between 1,900 and 744 feet in the Richgrove core is better shown in the resistivity log than in the distribution of median diameters; selective sampling for size analysis of this section gave excessive emphasis to the interlayered sands. Based on the trend of median diameters, the nonmarine sediments of the Richgrove core seem to coarsen progressively between about 750 feet and the land surface, but no clear systematic variation appears in the Pixley core.

INTERRELATIONS OF PARTICLE-SIZE MEASURES

Figure 23 shows graphs of median diameter against the coarsest percentile (C), sorting, and skewness for the alluvial-fan and shallow-marine deposits of the Tulare-Wasco area. Not included in the graphs are samples that are cemented or that contain interlaminations, or whose conspicuous soil textures indicate that material has been moved around since the sediment was

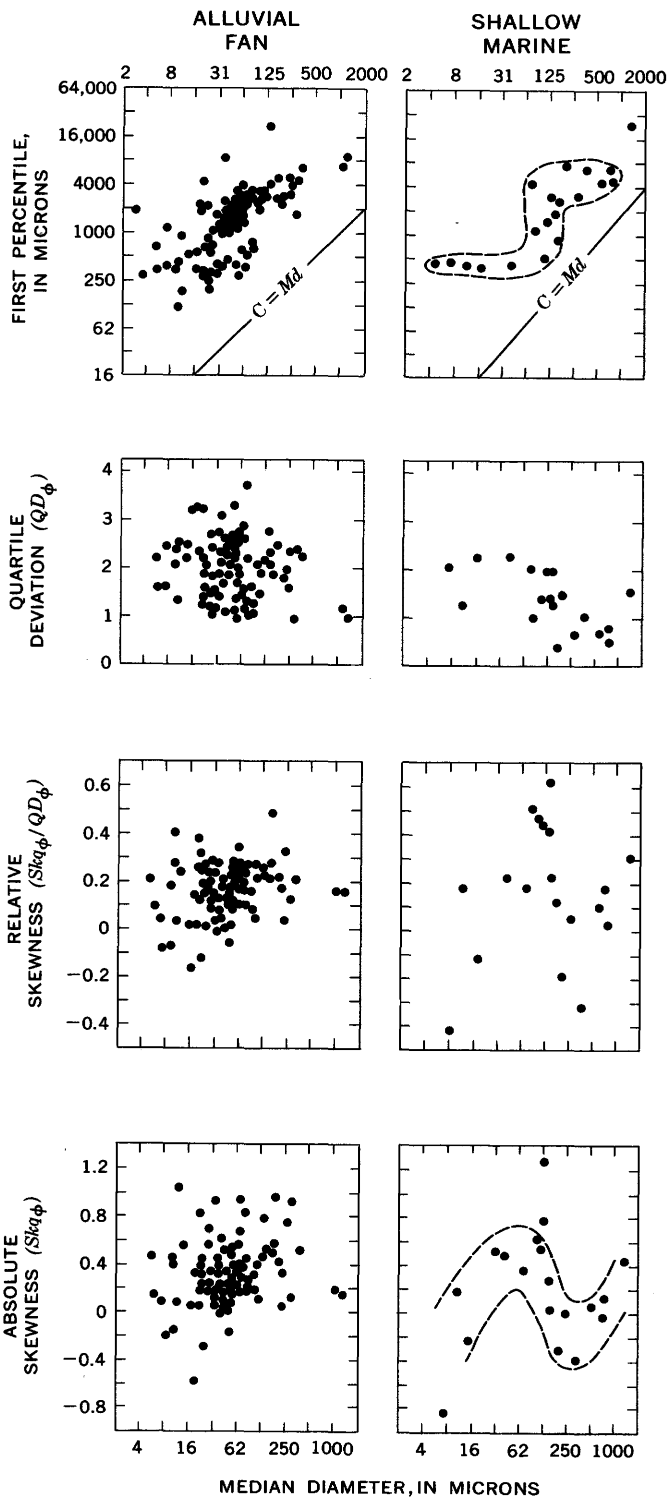

FIGURE 23.—Median diameter against coarsest percentile, sorting, and skewness in alluvial-fan and shallow-marine sediments, Tulare-Wasco area.

deposited. Flood-plain and lacustrine deposits are not included because too few samples of homogeneous material are available. The measures of sorting (QD_ϕ) and skewness (Skq_ϕ/QD_ϕ and Skq_ϕ) are defined on page C49. The reasons for attempting to graph these measures against median diameter were reviewed on page C13–C16.

ALLUVIAL-FAN SEDIMENTS

The relations between the particle-size measures in the alluvial-fan sediments of the Tulare-Wasco area (left col., fig. 23) seem to be fairly random. They are of little use in deciphering the depositional history of the sediments, unless one accepts the assumption that a lack of clearly visible relations signifies a lack of discrimination between particle sizes on the part of the transporting and depositing medium.

The only suggestion of discrimination is in the CM pattern (upper row, left col., fig. 23), a wide band of points roughly parallel to the C=*Md* line. This pattern is similar to the pattern for recent mudflow deposits given by Bull (fig. 11). The CM pattern in the upper left corner of figure 23, however, actually consists of two patterns, one from each core of alluvial-fan sediments taken in the Tulare-Wasco area. All the samples from the Pixley core have C values less than 2,000μ; all but two samples of alluvial-fan sediments from the Richgrove core have C values greater than 1,000μ. As the principal linear trends of points in the two constituent CM patterns lie at angles of 20°–30° to the overall trend suggested in figure 23, the overall pattern is probably not significant.

SHALLOW-MARINE SEDIMENTS

Particle-size measures for 20 shallow-marine sediments from the Richgrove core are graphed in the right column of figure 23. All the marine sediments that have median diameters of 250μ or more are from the well-sorted sand unit (Santa Margarita Formation as used by Diepenbrock, 1933); most of the finer marine sediments are from the units of interbedded siltstone and sand.

Although the samples are from two different stratigraphic units and are too few to define the relations with much certainty, there seem to be several regular relations between the particle-size measures. If the CM pattern actually is as enclosed by the dashed line (upper right cor., fig. 23), it is, of all the sediments treated in this report, the closest replica of Passega's ideal tractive pattern (compare with fig. 9). It implies a high degree of discrimination, on the part of the transporting and depositing medium, between particles of different sizes. The distinction between well-sorted sands and less well sorted finer sediments (second row, right col., fig. 23) is approximately the same as in the alluvial sediments of the Los Banos-Kettleman City area and the Santa Clara Valley. The relation between median diameter and skewness—especially the absolute skewness (lower right cor., fig. 23)—may be sinusoidal, as suggested by the dashed lines in the figure. This suggestion is supported by the pattern of decreasing skewness with decreasing size in the fine-grained alluvial-fan sediments of the Los Banos-Kettleman City area (fig. 12) and by a similar sinusoidal pattern observed in river sediments by Folk and Ward (1957, p. 19).

CLAY MINERALS AND ASSOCIATED IONS

CLAY MINERALS AND THEIR ASSEMBLAGES

As in the Los Banos-Kettleman City area, the principal clay mineral in the upper Cenozoic sediments of the Tulare-Wasco area is montmorillonite. Subsidiary clay minerals are illite, a kaolinite-type mineral, and vermiculite. Also present in minor amounts are chlorite and a low-grade illite-montmorillonite mixture. The distribution of clay minerals in the two cores from this area is shown in figure 24. The criteria for the identification of the clay minerals and the method of estimating their relative proportions are given on pages C67–C71. Detailed results of the clay-mineral analyses of 26 samples are given in table 13. Assuming that these samples are representative, the average clay-mineral composition of the upper Cenozoic sediments of the area is approximately as follows:

Clay minerals	In nonmarine sediments [1]	In marine siltstones
	Nearest 5 percent	
Montmorillonite	60	80
Illite	20	5
Kaolinite-type mineral	10	5
Vermiculite	10	0
Chlorite	0	5
Mixed-layer illite-montmorillonite	Trace	Trace

[1] Includes all sediments at depths of less than 760 ft, figure 22. The boundary between marine and nonmarine sediments in the Richgrove core is actually transitional between 785 and 744 ft.

Two, and perhaps three, clay-mineral assemblages are present in the upper Cenozoic sediments of the area. The differences between the assemblages are not so much in the minerals themselves as in the relative proportions of the same group of clay minerals. The assemblage in the fine-grained siltstone layers of the marine deposits, as given above, consists of a large proportion of montmorillonite and minor amounts of illite, a kaolinite-type mineral, and chlorite. In the nonmarine sediments a slightly different assemblage was found in each of the two cores. Montmorillonite is the principal mineral in both assemblages, amounting to 50–70 percent. In the Pixley core the subsidiary minerals are, in decreasing order of abundance: a kaolinite-type mineral, vermiculite, and illite. The subsidiary minerals in the upper

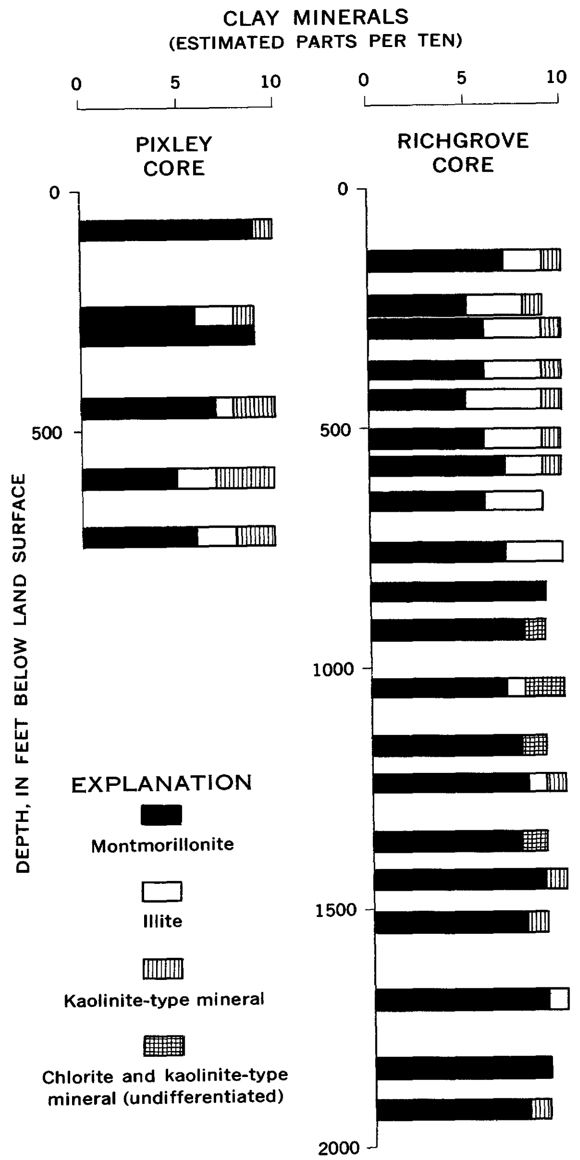

FIGURE 24.—Clay minerals in cored sediments, Tulare-Wasco area. Trace amounts not illustrated. Vermiculite in Pixley core included with montmorillonite.

760 feet of the Richgrove core, listed in the same order, are illite and a kaolinite-type mineral; vermiculite was not detected.

SOURCES OF CLAY MINERALS

The problem of the origin of montmorillonite in sediments from the Sierra Nevada was treated in the section, "Sources of montmorillonite" (p. C21–C22) and needs no further discussion here.

The kaolinite-type mineral in the sediments of the Tulare-Wasco area may well be true kaolinite or a member of the kaolinite group, derived from the weathering of granitic rocks in the Sierra Nevada. R. J. Janda (written commun., 1964, 1965) reports that kaolinite and halloysite are predominant clay-mineral constituents of the soils and alluvium in the upper San Joaquin basin in the Sierra.

Illite and vermiculite are probably derived from biotite, which is a conspicuous constituent (averaging about 5 percent) of the coarser sediments. The illite probably represents finely divided biotite. The vermiculite probably represents biotite that has been altered chemically during weathering. (See Barshad, 1948.)

TOTAL CLAY-MINERAL CONTENT OF SEDIMENTS

The total clay-mineral content of the sediments underlying the Tulare-Wasco area is estimated to be as follows:

Lithologic unit	Percent—	
	Clay minerals	Montmorillonite and vermiculite
Nonmarine sediments	15	10
Marine siltstones and sands	25	20
Santa Margarita Formation as used by Diepenbrock (1933)	<2	<2

These estimates were made on the same basis as the estimate of the clay-mineral and montmorillonite content of the sediments of the Los Banos-Kettleman City area: by averaging the percents finer than 3μ determined in the cored sediments (taken from the cumulative curves drawn in the Hydrologic Laboratory) and adjusting the average to allow for the effects of selective core recovery.

IONS ASSOCIATED WITH CLAY MINERALS

The principal ions adsorbed by the clays of the Tulare-Wasco area are calcium, magnesium, sodium, and hydrogen. The principal anions associated with the fine-grained sediments are sulfate and bicarbonate plus a little chloride. Results of the analyses for these ions are given in table 13.

DISTRIBUTION OF EXCHANGEABLE CATIONS

The exchangeable cations adsorbed by the clay minerals in the Pixley and Richgrove cores are represented in figure 25. As before, the illustrated percentages were adjusted by subtracting the equivalent of total anions from the total calcium ions—or, where insufficient calcium was available, from the total calcium and magnesium ions. As in the clays of the Los Banos-Kettleman City area, the adjusted sum of the exchangeable cations in most of the sediments exceeds the determined cation-exchange capacity.

In seven of the samples from the Richgrove core, however, including four of those that are shown to contain exchangeable hydrogen, the adjusted sum of the

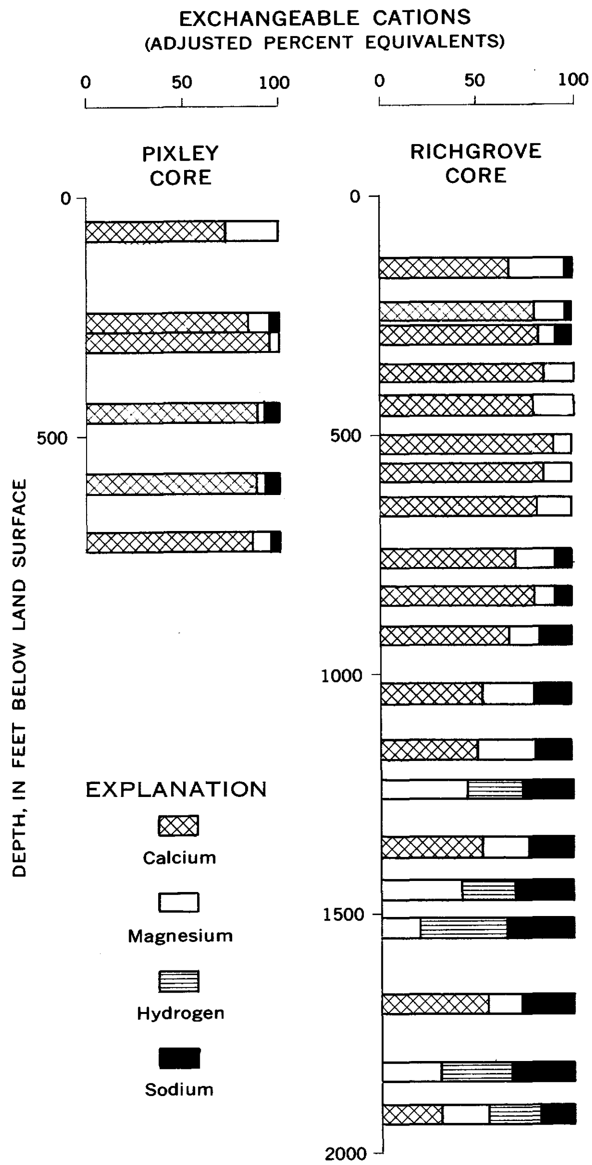

FIGURE 25.—Cations adsorbed by clay minerals in cored sediments, Tulare-Wasco area. Determined by H. C. Starkey.

cations is less than the determined exchange capacity (table 13). This difference may be due to one or more of the following causes.

1. The sum of the cations may have been overadjusted for the soluble anions; that is, some of the soluble anions (mainly sulfate) may not have been combined with calcium, but may have been in solution or adsorbed by the clay minerals. The work of Chao and others (1962) suggests that the sulfate adsorbed by clays is easily removed by leaching with water.
2. Some of the exchange sites may have been occupied by aluminum, which was not determined in the analyses. Aluminum may constitute a consider-

able part of the exchangeable cations in acid sediments (Wiklander, 1955, p. 110).

3. The disparity may be related to differences in pH between the natural environment and the laboratory. The cation-exchange capacities were determined at neutrality, whereas four of these sediments registered significantly acid pH values (fig. 27). Evidence collected by Pratt (1961) suggests that the cation-exchange capacity at low pH may be less than the exchange capacity of the same material at neutral pH.

The exchangeable-cation assemblage in the alluvial sediments at depths of less than 760 feet is dominated by calcium. Magnesium is subsidiary; exchangeable sodium is present in about half the samples. The clays in this depth interval are probably in near equilibrium with waters being pumped from the coarser grained sediments in the same interval—waters in the 120- to 770-foot interval in the Pixley area and in the 180- to 680-foot interval in the Richgrove area, as tabulated below.

Area	Depth interval (feet)	Total dissolved solids (ppm)	Sodium (percent of total cation equivalents)
Pixley	120– 770	200	70
Richgrove	180– 680	300	50
	500–1, 600	300	85
	1, 400–2, 200	400	90

These data were summarized from analyses (Hilton and others, 1960, p. 465, 475–479, 491) of water from wells whose perforated depths were known: 5 wells in the same township as the Pixley core hole and 16 wells within 5 miles of the Richgrove core hole.

The assemblage of exchangeable cations in the marine siltstones, as sampled at depths between 760 and 1,900 feet in the Richgrove core, is marked by a downward increase in sodium and a corresponding decrease in calcium. This may be related to any or all of the following factors.

1. The proportion of sodium relative to the other cations, in the water being pumped from these sediments, increases downward—see the table in the previous paragraph. The water, however, is being produced mainly from the sands, whereas the exchangeable cations were measured in the clayey siltstones, and the two types of sediments may not be in chemical equilibrium. Lack of equilibrium is suggested by the large concentrations of salts in the clays as compared to low concentrations of solids in the water being pumped from the sands and by the preponderance of sulfate over bicarbonate in the clays as compared to the reverse relation in the waters in the sands (discussed in more detail under "Sulfate in the marine siltstones").
2. The concentration of salts in the clays increases downward (fig. 27). The ratio of monovalent to divalent cations adsorbed by clay minerals is a direct function of the concentration of ions in the sediment-water mixture (Wiklander, 1955, p. 128). The data plotted in figure 26*A* suggest a definite relation between salt concentration and the proportion of adsorbed sodium.
3. The pH also is lower at lower depths (fig. 27). Work by Pratt and others (1962) shows that the ratio of adsorbed sodium to adsorbed calcium may vary directly with acidity—that is, inversely with pH. The data plotted in figure 26B suggest a defi-

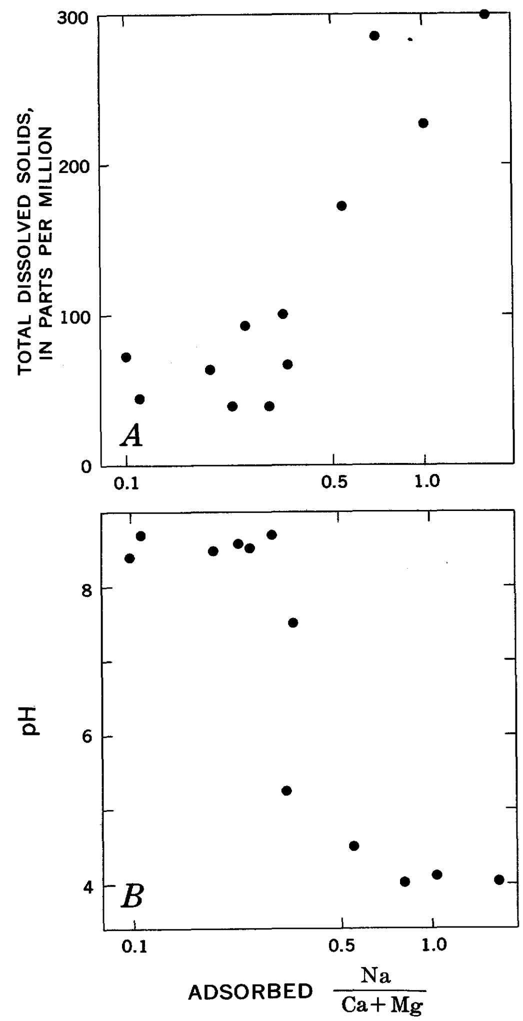

FIGURE 26.—Relation of the proportion of adsorbed sodium to salt concentration (*A*) and pH (*B*) in sediments below 760 feet in the Richgrove core, Tulare-Wasco area. Adsorbed cations determined by H. C. Starkey, who also determined the pH in 10 : 1 water-sediment mixtures. Total dissolved solids (dissolved from 10 g sediment in 500 ml hot water) measured by Claude Huffman and A. J. Bartel.

nite relation between pH and the proportion of adsorbed sodium.

On the basis of the evidence presented, I suspect that the variations in the proportions of adsorbed sodium are related in a complex way to both the acidity and the concentration of soluble salts.

SULFATE IN THE MARINE SILTSTONES

The soluble-anion analyses (table 13) show substantial amounts of sulfate in the marine siltstones. Visual examination of these sediments shows that they contain gypsum in irregular accumulations, often associated with organic material or partly oxidized iron sulfides.

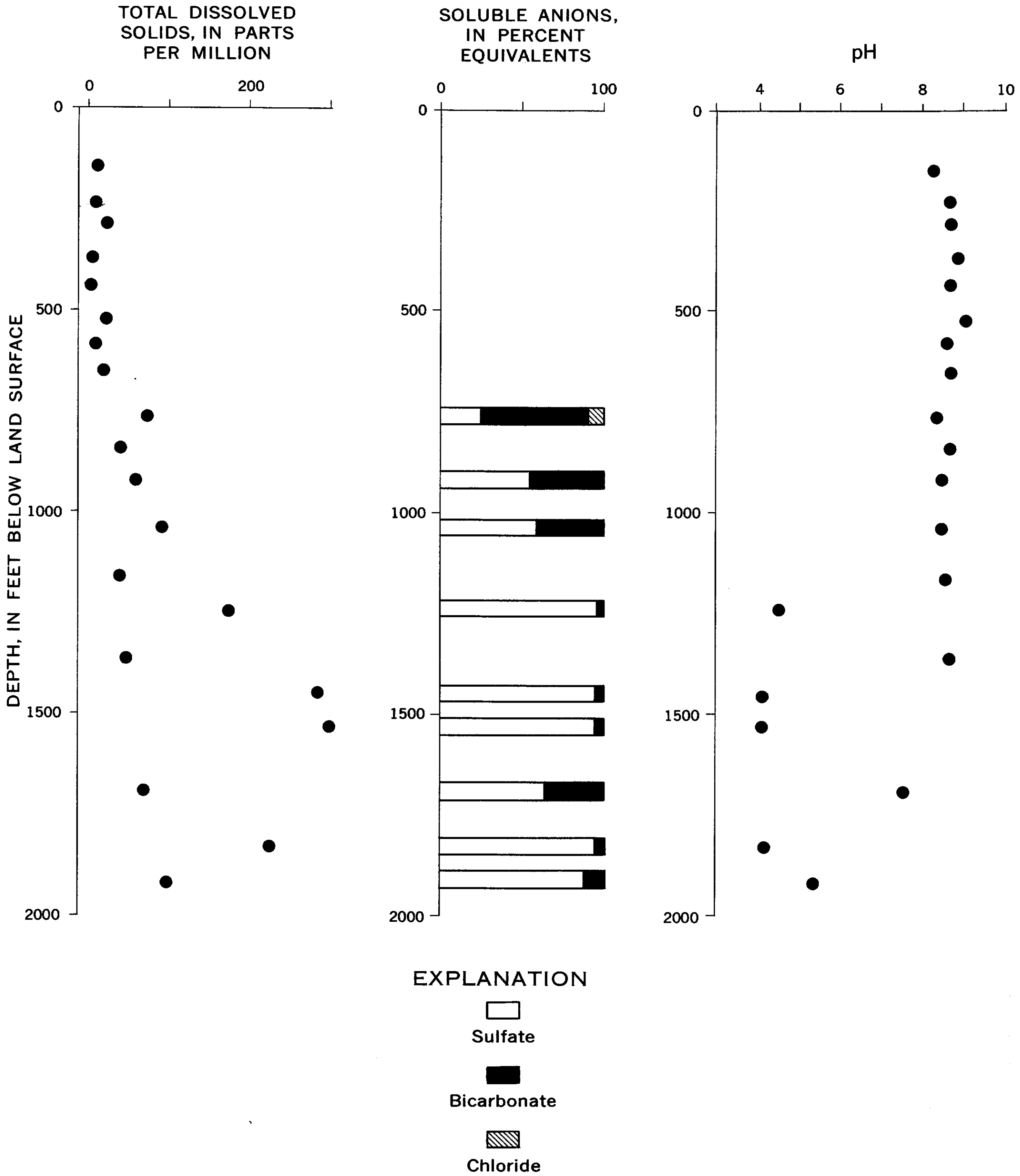

FIGURE 27.—Soluble salts, soluble anions, and pH of fine-grained sediments from the Richgrove core, Tulare-Wasco area. Total dissolved solids and soluble anions measured (by Claude Huffman and A. J. Bartel) in hot-water leach: 500 ml hot water to 10 g sediment. pH measured by H. C. Starkey in 10 : 1 water-sediment mixture.

When samples of the sediments were allowed to dry, clean surfaces became crusted with gypsum (selenite) crystals, indicating that the interstitial water of the sediments contained sulfate in significant amounts. The distribution of sulfate with regard to the other anions, salt concentration, and pH, is shown in figure 27. The data plotted in the figure suggest that the large concentrations of soluble salts are mainly sulfates, and that the low pH values recorded in the sediments are related to high concentrations of sulfate.

The origin of the sulfate is not clear from a study of the chemical data. The equivalent ratio of sulfate to bicarbonate, as large as 30 in some of the fine-grained sediments, is much greater than that in the water being pumped from the interbedded sands (0.5 or less, according to analyses reported by Hilton and others, 1960, p. 475–479, 491). The total solids leached from the clayey sediments suggest that the concentration of electrolyte in their interstitial waters may have been as great as 20,000 or even 30,000 ppm (parts per million); in contrast, only 300–400 ppm are dissolved in the pore water of the sands. The interstitial water of the clayey sediments cannot represent trapped sea water, as the soluble anions include virtually no chloride.

On the basis of petrographic evidence, however, one can suggest (and I thank D. E. White, of the Geological Survey, for this suggestion) that the sulfate has been formed by the oxidation of iron sulfides within the sediments since they were buried. Iron sulfides are present in nearly all the fine-grained sediments at depths below 620 feet in the Richgrove core: in some places, intimately associated with carbonaceous organic material or replacing diatom skeletons, and in other places, disseminated through the sediment with no apparent local relation to organic material. Much of the iron sulfide is partly oxidized, as shown by an iridescent tarnish on the grain surfaces and by reddish-brown staining of the adjoining sediment. Gypsum is also associated with the partly oxidized sulfide. In some sediments, one can see fragments of carbonaceous material that are surrounded by partly oxidized iron sulfide which, in turn, is surrounded by a band of gypsum-rich sediment. Apparently, the sulfides were formed in the presence of organic material shortly after the sediments were deposited. Subsequently, they were oxidized, forming sulfate ions in the pore solutions that reacted with calcium to form gypsum. The absence of chloride in the sediments implies that the original interstitial water (buried sea water) was removed from the sediment after the formation of the sulfides and before their subsequent oxidation.

SEDIMENTS IN THE SANTA CLARA VALLEY

Most of the sediments whose compaction causes the land subsidence in the Santa Clara Valley—that is, sediments to a depth of about 1,000 feet—were deposited by alluvial processes. They were eroded from the Santa Cruz and Diablo Ranges that border the valley to the southeast and northwest. The oldest deposits probably are late Pliocene; the youngest, Recent.

Most of this study is based on sediments from the two core holes whose locations are shown in figure 28. Both of these holes are in Santa Clara County. The San Jose core hole is on the bank of Coyote Creek, in the 12th Street Yard of the San Jose Water Co. The Sunnyvale core hole is in a highway interchange near the southeast corner of Moffett Field Naval Air Station. Details of the core recovery are given in table 1. Note the small amount of sediment recovered in the San Jose core, a reflection of the large amount of gravel (which could not be recovered by the rotary coring apparatus that was used) in the sediments that lie beneath the coring site.

Poland and Green (1962) have described some of the results of land-subsidence studies in the Santa Clara Valley. A more extensive report on the aquifer system and its compaction in the Santa Clara Valley is being prepared by J. H. Green as Professional Paper 437–F.

SOURCE OF SEDIMENTS

The Franciscan and Knoxville Formation of middle to late Mesozoic age constitute the principal source terrane of the sediments in the cores. These formations consist of sandstones (mostly graywackes), shales, cherts, and mafic and ultramafic rocks (mostly serpentine). They crop out in most of the areas of the Diablo and Santa Cruz Ranges that are drained by the two principal streams in the Santa Clara Valley, Coyote Creek, and Guadalupe River.

Sands in the Sunnyvale and San Jose cores are characteristically lithic, medium dark (30–60 percent dark grains), and nonmicaceous. Most of the sand- and gravel-sized rock fragments are serpentine (which amounts to 10 percent of some sediments, dark-red chert, porphyritic mafic rock (basalt and diabase?) with oxidized iron-stained groundmass, lithic sandstone, and shale. Among the easily recognizable accessory minerals are glaucophane and oxyhornblende. Micaceous minerals, usually biotite that appears to be altered, are rare and never amount to more than 1 percent of a sediment.

TYPES OF DEPOSITS

The deposits represented by the cored sediments are nonmarine, mostly alluvial, with possibly a few lacustrine deposits at depths below 700 feet.

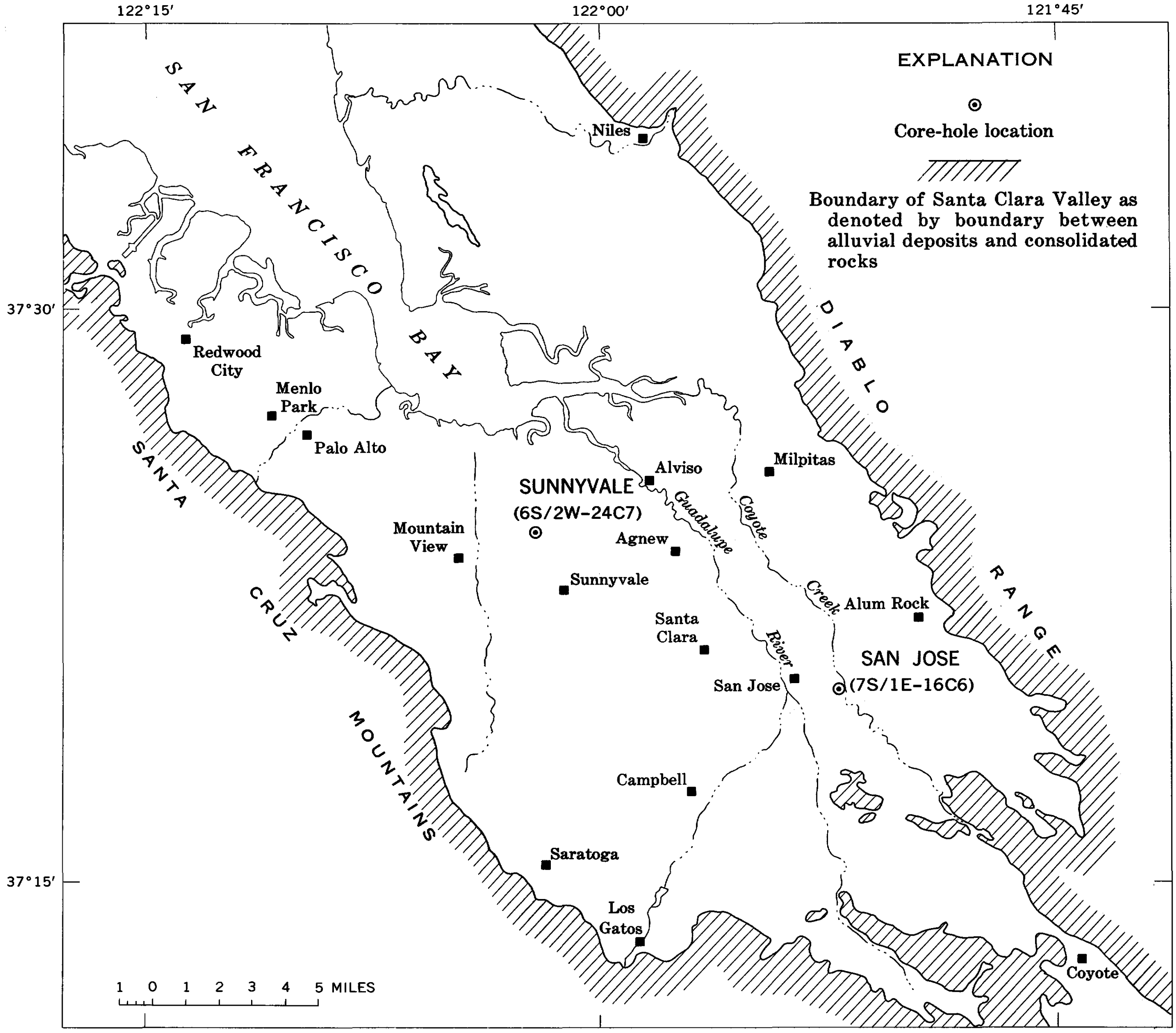

FIGURE 28.—Santa Clara Valley showing location of core holes.

MODERN ALLUVIAL SEDIMENTS AND SOILS

The alluvial sediments in the cores are perhaps best understood when they are compared with the sediments and soils exposed at the present-day land surface in the Santa Clara Valley. To illustrate the range of the conditions and materials that are present, two extreme types will be discussed.

Exposed near the major streams (Coyote Creek at the San Jose coring site, for example) are channel or overbank deposits. These are sandy, sometimes gravelly, sediments. Their yellow-brown color reflects the free iron oxide that coats or stains their constituent particles. Little soil has developed on the alluvial deposits found at low terrace and flood-plain levels along the streams (the Mocho soil series of Gardner and others, 1958, p. 95). On higher terrace levels above the streams, however, some soil has developed as shown by the segregation of calcium carbonate into layers or into accumulations along tubular openings, such as root holes, in the soil (the Sorrento soil series of Gardner and others, 1958, p. 119–120).

In the low-lying areas away from the major streams (as in the vicinity of the Sunnyvale core hole) quite another type of material is prevalent. This is a clay-rich black to dark gray highly calcareous soil (the Castro and Sunnyvale soil series of Gardner and others, 1958, p. 69–70, 123) formed on fine-grained alluvial sediments that were deposited at the edges of alluvial fans or flood plains. The deposition of this sediment must have been mainly subaerial. The modern soils on this type of sediment are poorly drained because they are on nearly level ground, they have very low permeabilities, and the water table is close to the surface (less than 20 ft at the Sunnyvale coring site in 1960). They are full of organic material and calcite—the calcite in nodules or large irregular blotches. When dry, the soils break into blocks along suborthogonal fractures. Before they were cultivated by man, these soils supported only grasses.

OLDER ALLUVIAL SEDIMENTS AND SOILS

Many of the older deposits in the cores are similar to the modern types found near the coring sites—the channel and overbank deposits being common in the San Jose core and the dark calcareous soils predominating in the Sunnyvale core. In the upper 500 feet of the cores, these two types, plus an intermediate-type material, are present almost to the exclusion of all other types. The intermediate-type material—a poorly sorted sand-silt-clay mixture, characteristically olive brown or blotchy (yellow-brown blotches in a dark-gray mass or vice versa)—is found in both cores.

Another type of fine-grained deposit was noted in sporadic occurrences in the upper part of the San Jose core. It is dark gray and has some of the characteristics given in table 3 for fine materials deposited in standing water—fine laminae and well-developed preferred orientation of clay-mineral particles. Ponds or depressions apparently existed on the flood plain or fan near Coyote Creek, and fine-grained material was deposited slowly in them.

Two other distinct types of sediments were found at depths below 500 feet in both cores: fossiliferous silts and rhythmically interlaminated silt and clay. Fossiliferous silts were found at depths near 760, 870, 900, 920, and 940 feet in the Sunnyvale core, and 830 feet in the San Jose core, in beds that ranged in thickness from 3 to 9 feet. The silts from the Sunnyvale core contain an assemblage of fresh-water mollusks identified by D. W. Taylor (report on referred fossils, 1962) as belonging to the genera *Pisidium*, *Fluminicola*, *Lymnaea*, *Gyraulus*, *Menetus*, and *Helisoma*. The silt from the San Jose core contains only fresh-water snails belonging to the genera *Lymnaea* and *Gyraulus* (Taylor, report on referred fossils, 1963). All but one of these forms (*Fluminicola yatesiana* Cooper) is still living. They inhabit lakes or perennial streams.

The interlaminated silt and clay—clayey silt in layers a few centimeters thick and silty clay in layers a few millimeters thick—is characteristically dark yellow brown or olive brown. The layers usually make up beds a few feet thick, interbedded with fossiliferous silts, coarser sands or gravels (in the San Jose core), or with dark-gray calcareous clayey silts (in the Sunnyvale core). The layers occasionally contain some calcite, but are often noncalcareous; they contain no cracks or other soillike structures. The clay particles have some preferred orientation parallel to the bedding—slight in the silt layers and better developed in the clay layers—the degree of orientation being less than that in the lacustrine Corcoran Clay Member in the Los Banos-Kettleman City area. Except for their color, these sediments have characteristics similar to those of the flood-plain deposits described from the Los Banos-Kettleman City area. The presence of these sediments, along with the fossiliferous silts, suggest that conditions were generally wetter when they were being deposited than conditions in the Santa Clara Valley today.

The spatial distribution of these types is not well enough known to be conveniently summarized in some such form as figures 3 and 17 or table 4. The different types are closely interbedded and are not uniform for large thicknesses. They are not continuous enough to be traced laterally by drillers' logs or by the few available electric logs. The recovery of the San Jose core was too poor (173 ft of the total 1,000-ft interval) for an accurate description of the sediments that it represents. One feature, however, is obvious: the main sense of the spatial variation is in the horizontal direction—from one part of the valley to another—in contrast to the mainly vertical sense of the variation in the Tulare-Wasco area.

ABSENCE OF ESTUARINE DEPOSITS

Although both core sites were near San Francisco Bay (the Sunnyvale site is only 3 miles from the bay and was 35 ft above mean sea level in 1961), neither core contains sediments that could be recognized as estuarine. In addition to the strong resemblance between the cored sediments and the modern alluvial deposits exposed at the land surface, the absence of estuarine sediments in the cores is suggested by the following lines of evidence.

1. No marine or estuarine fossils were found in the sediments. The only fossils recognized were plant debris and the fresh-water snails and clams listed above.
2. The salts in the core-hole sediments are not what one would expect to find in marine sediments. The predominant salt is calcium carbonate. No sulfate was noted, either visually or by chemical tests (Johnson and others, 1967, table 7). Sulfides are present, but they are much less common than in the marine sediments in the Richgrove core

or in the nonmarine sediments associated with sulfate-rich water in the Los Banos-Kettleman City area. The scarcity of chloride salts is suggested by the absence of detectable chloride in four clayey sediments from the cores (table 14).

3. Comparison of the clay-mineral assemblages in the core holes (fig. 33) with those in San Francisco Bay (samples 9–19, fig. 34) and in the drainage system of Coyote Creek and Guadalupe River (samples 5–7, fig. 34) suggests that the cored sediments are related more closely to the stream sediments than to the bay sediments. The ratio of illite to montmorillonite, especially, is larger in the bay sediments than it is in the cored sediments or the modern alluvial sediments.

RATES OF DEPOSITION

Two types of information, the determination of fresh-water fossils and a radiocarbon date, provide impressions of the rates of deposition in the Santa Clara Valley.

Fluminicola yatesiana, which is not believed to be younger than late Pliocene, was found at a minimum depth of 760 feet in the Sunnyvale core. Assuming 2 million years as the age of the fossils, the maximum average rate of deposition of the upper 760 feet of the Sunnyvale core, taken as a whole, must be less than 1 foot in 2,500 years. Considering that the upper 760 feet of the core contains deposits of several types, however, this rate should not be applied indiscriminately to the whole sequence.

The carbon-14 content was measured in a piece of redwood recovered from a depth of 73 feet in the San Jose core. According to Meyer Rubin,[1] who made the carbon-14 analysis, the age of the wood is 14,350 ± 400 years before the present. The upper 73 feet of sediment at the San Jose coring site, therefore, was deposited at an average rate of 1 foot in 200 years. This rapid rate is not necessarily incompatible with the slower inferred rate of deposition of the Sunnyvale core. It could well represent the post-Wisconsin backfilling of a trenched valley of Coyote Creek that was graded to a sea-level stand 250–300 feet below present sea level in Wisconsin time. This trenching and backfilling is characteristic of coastal streams in California (Poland, Piper, and others, 1956, p. 28–32, 44–48; Upson, 1949). The backfilling ancestral Coyote Creek was graded to a rapidly rising sea level which stood, according to Curray's (1960, p. 253–257) data from the gulf coast, 200–250 feet below its present level 14,000 years ago. The site of the Sunnyvale core, being away from the courses of the major valley streams, would not have experienced the postulated trenching and backfilling and thus should not be expected to reflect strongly the late Pleistocene fluctuations of sea level in its depositional history. At the Sunnyvale site, deposition very likely has been relatively continuous from late Pliocene time to the present, at the slower average rate.

[1] Geological Survey Isotope Geology Laboratory sample W–1145, July 1962.

PARTICLE SIZES

The study of the particle sizes in the Santa Clara Valley is based mainly on 87 samples from the two core holes whose locations are shown in figure 28. The two cored sections represent two types—perhaps the two extreme types—of particle-size assemblages in the Santa Clara Valley. The San Jose core hole, drilled next to the present channel of the largest stream in the valley, penetrates many coarse-grained alluvial deposits. The Sunnyvale core represents the fine-grained deposits that were deposited at some distance from the principal streams. The estimated mean particle size of the sediments is as follows:

Core hole	Number of samples	Estimated mean particle size (microns)	
		Recovered sediments	Section as a whole
Sunnyvale	60	4–8	5–10
San Jose	27	10–20	500–1,000

Recovery of core from the San Jose hole was very poor—30 percent of the cored interval and 17 percent of the section as a whole (table 1)—mainly because of the inability of the coring apparatus to recover the gravels that make up much of the section. Recovery from the Sunnyvale core hole was good and seems to be nearly representative of the interval as a whole in the Sunnyvale area. Details of the size analyses are tabulated in table 9; as in the Tulare-Wasco samples, the percentiles and other measures were determined by the digital computer from particle-size data provided by the Hydrologic Laboratory of the Geological Survey. Cumulative curves of some of the samples are given in the report by Johnson, Moston, and Morris (1967).

The fine-grained sediments of the Santa Clara Valley—those deposits that lie some distance from the main streams—are represented fairly adequately by the sediments recovered from both the core holes. The measures that describe these sediments are shown in figures 29 and 30. The samples fall mainly into three of the Shepard size categories—silty clay, clayey silt, and the most silty part of the sand-silt-clay category. Thirty of the samples (half of them from the San Jose core) contained gravel in amounts of 0.1–3.0 percent; only

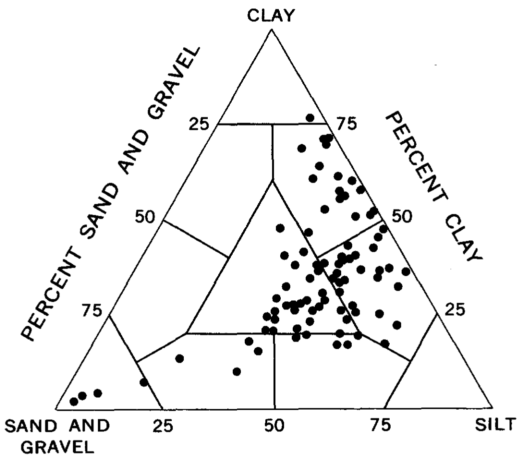

FIGURE 29.—Sand-silt-clay percentages of sediments cored in the Santa Clara Valley. Based on data from the Hydrologic Laboratory of the U.S. Geological Survey. Triangle subdivisions are those of the Shepard nomenclatural systems shown in figures 5*A* and 19*A*.

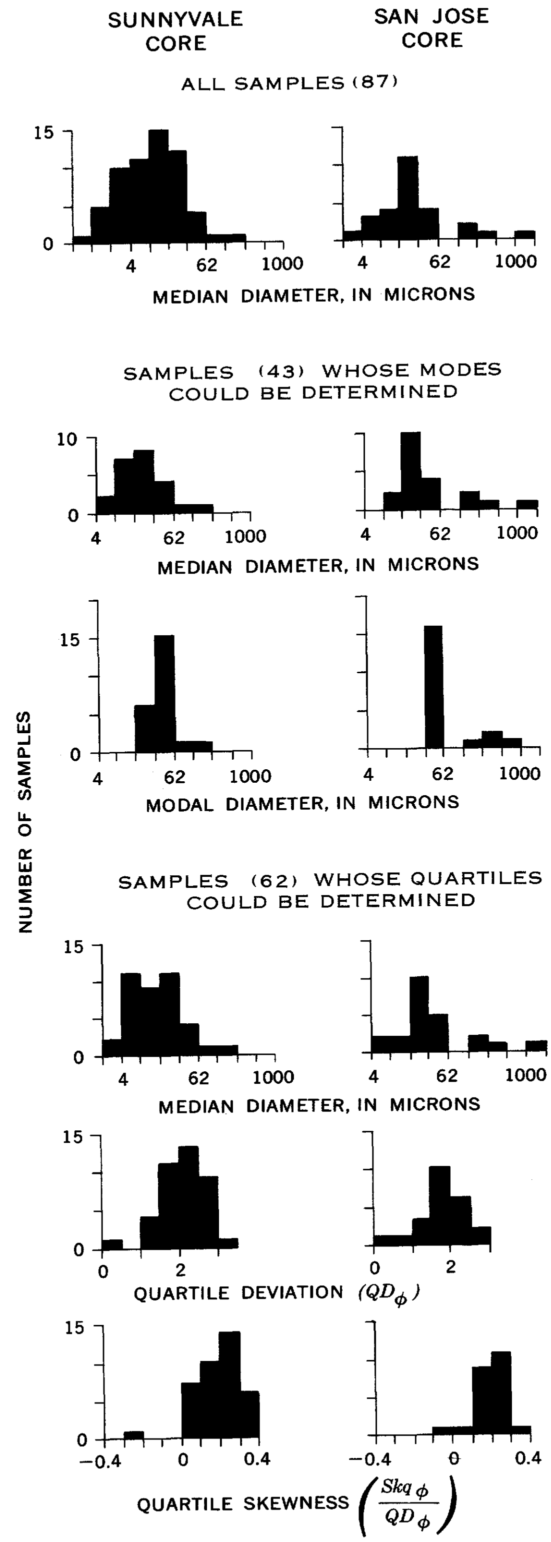

FIGURE 30.—Measures of average size, sorting, and skewness in sediments cored in the Santa Clara Valley.

five samples (all from the San Jose core) contained more than 3 percent gravel. Most of the median diameters fall in the fairly narrow range between 2μ and 31μ. Most of the modal diameters that could be determined fall, as in the nonmarine sediments of the Tulare-Wasco area, between 31μ and 62μ. The modes of most of the 44 samples that were not determined presumably should be finer than 31μ. In general, the fine-grained sediments are poorly sorted, and their distributions are skewed toward the finer sizes.

SPATIAL DISTRIBUTION OF PARTICLE SIZES

The distribution of sediments with regard to depth in the uppermost 1,000 feet in the Sunnyvale area (fig. 31) is fairly uniform: a series of fine sediments interrupted only sporadically by thin beds (10 ft thick at most) of sand or gravel. The exceptions to this uniformity are that more sand and gravel beds are found in the upper half of the cored interval than in the lower half, and that the silts and clays are generally finer grained in the lower half. The particle sizes seem to coarsen progressively between 1,000 and 500 feet, then becomes progressively finer again between 500 feet and the land surface.

In the sediments in the uppermost 1,000 feet at the San Jose coring site, fine sediments, such as those described above, are interbedded with coarser sediments. About a third of the interval here is gravel. The fine and coarse sediments are approximately equally distributed with regard to depth. The general range in bed thickness for both the fine and coarse sediments is 5–50 feet. The contrasts between the coarser gravels and the finer silts and clay, judging from the resistivity log in figure 31, are abrupt. There seems to be little material of "average" size that grades between the fine and coarse materials.

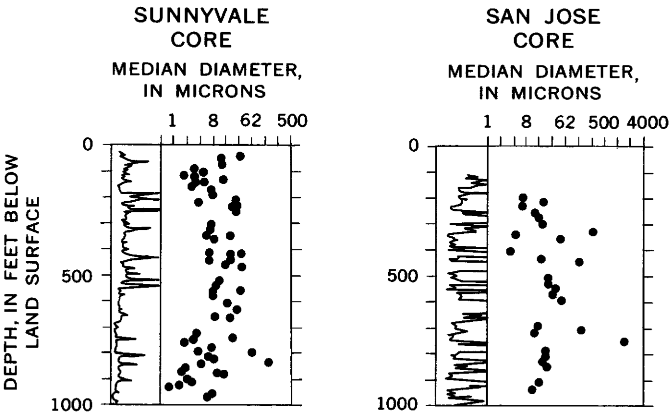

FIGURE 31.—Variations in particle size with depth, Santa Clara Valley. Resistivity log is left column of each composite; range, from left to right, is 0–50 ohms m²/m.

Because of the differences in grain size, the sediments in the two cores should be expected to respond differently to compacting pressures. The Sunnyvale sediments, being mostly silt and clay, should be compacted more per unit load, but their rate of compaction might be retarded by their uniformly low permeability. The San Jose sediments, because they contain more gravel layers, should be compacted less under the same unit load, but their rate of compaction should be greater because the gravel layers provide permeable routes for the escape of water.

INTERRELATIONS OF PARTICLE-SIZE MEASURES

Figure 32 shows the graphs of median diameter against the coarsest percentile (C), sorting, and skewness for the alluvial deposits of the Santa Clara Valley. Not included in the graphs are samples that contain cement, fossil mollusks, or interlaminations of sediment of different sizes. The measures of sorting (QD_ϕ) and skewness (Skq_ϕ/QD_ϕ and Skq_ϕ) are defined on page C49. The reasons for graphing these measures against median diameter are reviewed on pages C13–C16.

The graphs of median diameter against sorting and skewness for the alluvial sediments of the Santa Clara Valley (fig. 32) show about the same relations as the corresponding graphs for the alluvial-fan sediments of the Los Banos-Kettleman City area (fig. 12): the best sorting in sediments having median diameters between 125μ and 500μ, poorer sorting in the finer sediments; the greatest skewness in sediments having median diameters between 16μ and 62μ, and progressively less skewness in finer and coarser sediments.

The CM pattern (top graph, fig. 32), however, does not give much insight into the processes of deposition. Many of the sediments contain isolated granules or pebbles, seemingly distributed at random, whose presence produces a wide scattering of C values. How these pebbles and granules came to be deposited with otherwise fine sediments is not clear.

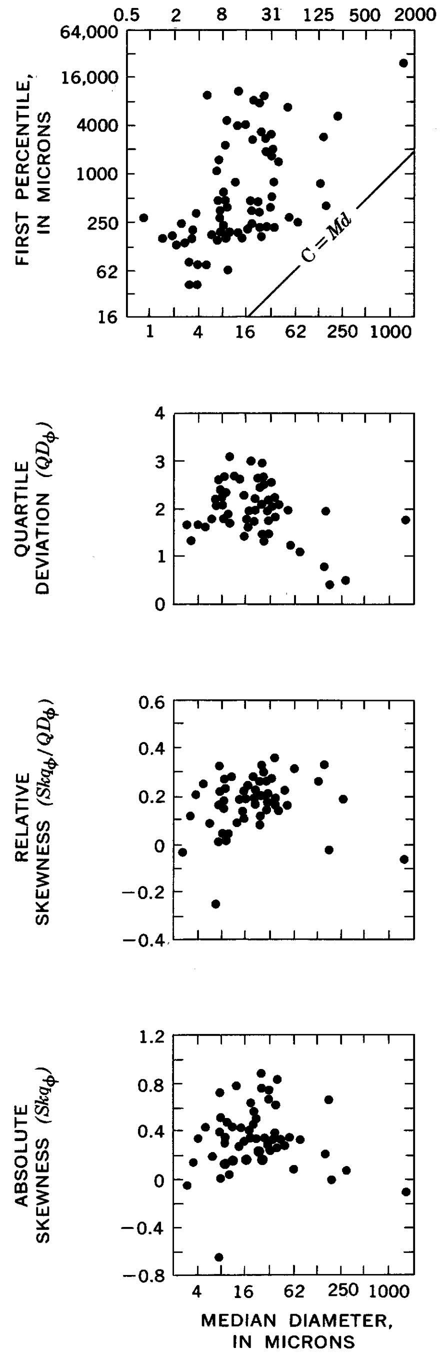

FIGURE 32.—Median diameter against coarsest percentile, sorting, and skewness in alluvial sediments, Santa Clara Valley.

CLAY MINERALS AND ASSOCIATED IONS

CLAY-MINERAL ASSEMBLAGE

The principal clay mineral in the upper 1,000 feet of sediments of the Santa Clara Valley, as in the areas of land subsidence in the San Joaquin Valley, is montmorillonite. Other constituents of the clay-mineral assemblage are chlorite (type B) and illite, plus trace amounts of low-grade illite-montmorillonite. The distribution of the clay minerals in the fine-grained sediments in the Sunnyvale and San Jose cores is represented in figure 33. Clay minerals in the near-surface sediments are shown in figure 34. Details are given in tables 14 and 15. Identification criteria and the method of estimating relative proportions of clay minerals are also given on pages C67–C71. Assuming that the 20 core-hole samples are representative, the average clay-mineral composition of these sediments is—

Clay minerals	*Percent*
Montmorillonite	70
Chlorite	20
Illite	5–10
Low-grade illite-montmorillonite	Trace

The 12–A chloritic mineral, although present in the surface sediments, was not detected in the core-hole sediments.

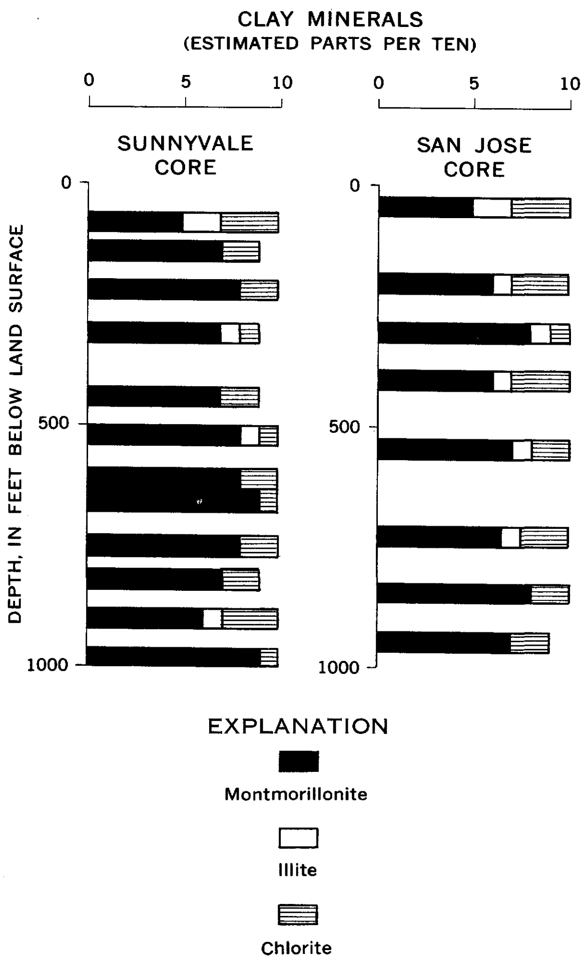

FIGURE 33.—Clay minerals in cored sediments, Santa Clara Valley. Trace amounts not illustrated. Determined with the assistance of J. B. Corliss.

The abundant montmorillonite must be derived largely from the weathering of the rocks of the Franciscan and Knoxville Formations, especially the shales, graywackes, and greenstones that are abundant in this rock assemblage. The chlorite and illite, likewise, are probably derived from fine-grained constituents of these sediments. The difference between this assemblage and the better crystallized assemblage of clay minerals, also from the Franciscan Formation, in Little Panoche Creek and the upper part of the Oro Loma core in the Los Banos-Kettleman City area (figs. 13, 14) may be related to different degrees of metamorphism in the source terranes.

TOTAL CLAY-MINERAL CONTENT OF SEDIMENTS

The estimates of the total clay-mineral content were made on the same basis as for the sediments of the Los Banos-Kettleman City and Tulare-Wasco areas.

Clay minerals probably make up 30–35 percent of the section of fine sediments penetrated by the Sunnyvale core hole. Montmorillonite, therefore, probably makes up 20–25 percent of the section. In the coarser sediments penetrated by the San Jose core hole, the amount of clay-mineral material is substantially less—on the order of 10 or 15 percent. In other parts of the Santa Clara Valley the amount of clay-mineral material in the alluvial sediments probably ranges between 10 and 35 percent.

EXCHANGEABLE CATIONS

The principal ions associated with the sediments in the Sunnyvale and San Jose cores are calcium, magnesium, bicarbonate, and a little sodium. Details are given in table 14.

The cations adsorbed by the clays in the cored sediments are represented in figure 35. The adjusted sum of the cations exceeds the cation-exchange capacity substantially (by a factor of 2 or more) in 7 of the 20 samples. Calcite was visible in these seven samples, and the difference between the adjusted sum and the determined capacity probably reflects the greater solubility of calcite in cold NH_4Cl solution (in which the cations were determined) than in hot water (in which the anions were determined). Calcium, nevertheless, is the principal exchangeable cation. In the sediments in which the adjusted sum of cations is close to the cation-exchange capacity, calcium accounts for two-thirds to three-quarters of the exchangeable-cation equivalents. Magnesium completes the exchangeable-cation assemblage in all but the four samples near the bottom of the Sunnyvale core that contain exchangeable sodium.

The water from neighboring wells that is being pumped from the coarse-grained sediments in the same

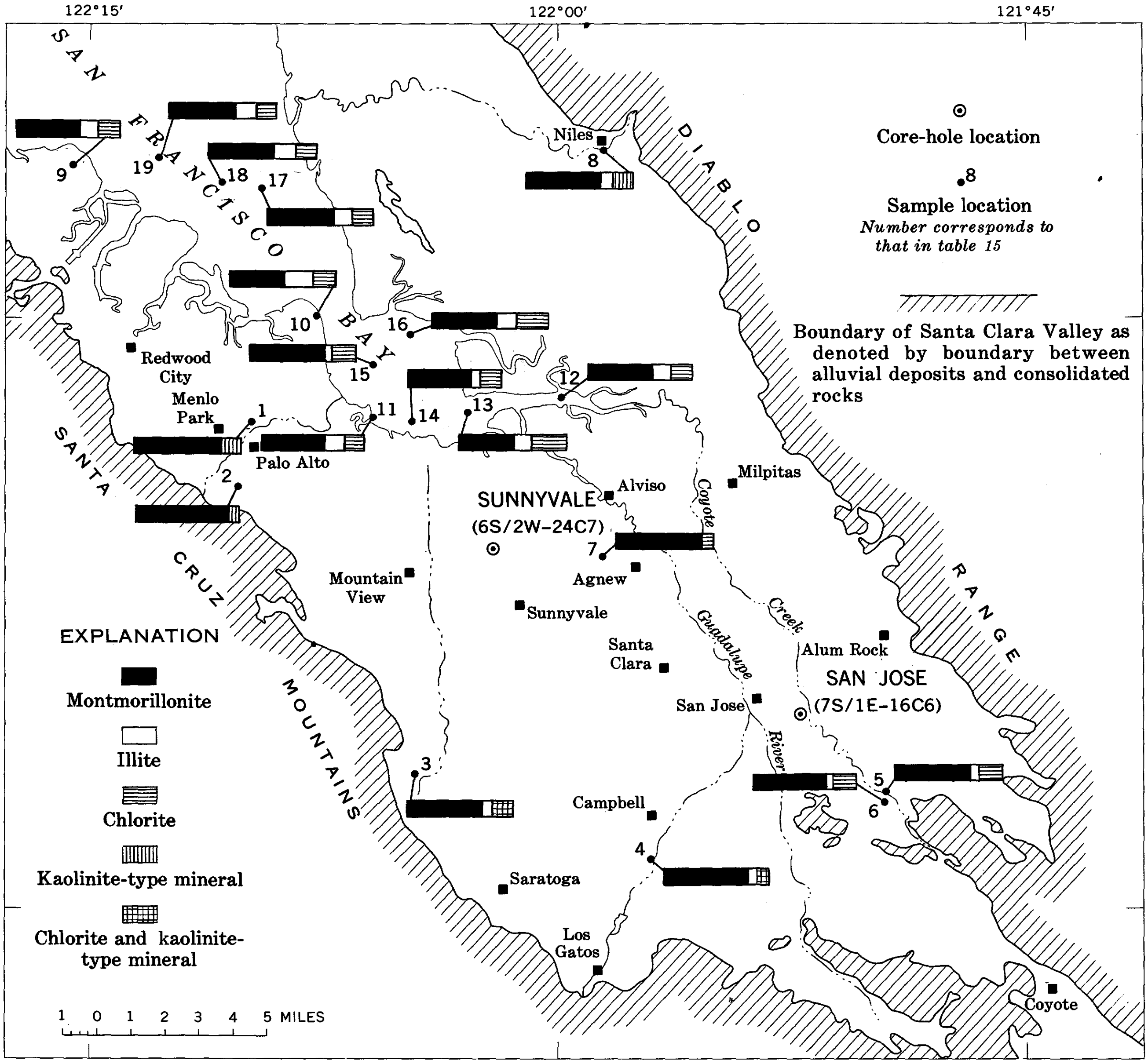

Figure 34.—Location of core holes and sampling sites for clay minerals in Recent surface alluvial and bay-bottom sediments, Santa Clara Valley. Minerals in samples 1–11 determined with assistance of J. B. Corliss, T. J. Conomos, and J. O. Berkland. Samples 12–19 collected and analyzed by T. J. Conomos.

depth interval as the core, and which is perhaps in near chemical equilibrium with the fine-grained sediments, has approximately the following chemical characteristics:

Total dissolved solids ppm	400
Na (percent of total cation equivalents)	25
Ca/Mg ratio (of equivalents)	1.5–2.0

These data are summarized from the more complete analyses listed in tables 16 and 17. Because the wells in the Sunnyvale area produce ground water from large depth intervals, rather than from selected smaller depth intervals, one cannot tell whether the increase in exchangeable sodium in the sediments near the bottom of the Sunnyvale core hole is related to a downward increase in the dissolved sodium or to a downward increase in the total disssolved solids in the ground water.

CLAY MINERALS IN THE ARVIN-MARICOPA AREA

The treatment that the sediments of the Arvin-Maricopa area are given in this report is very brief, for it is based on only eight samples from a test hole drilled near Lakeview in Kern County (location shown in fig. 36). The main purpose of this hole was not to obtain core, and only a few samples were taken (table 1). The

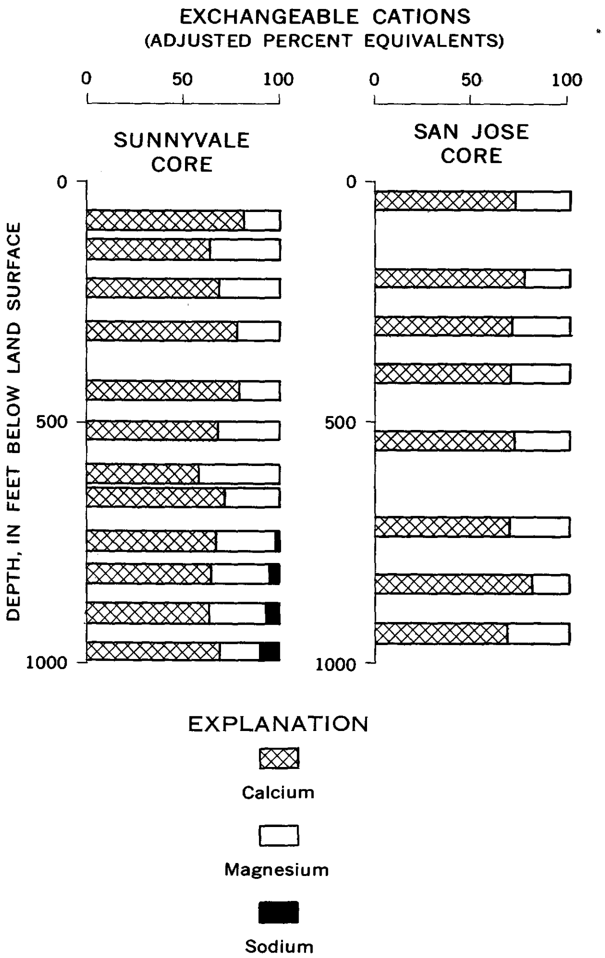

FIGURE 35.—Cations adsorbed by clay minerals in cored sediment, Santa Clara Valley. Determined by H. C. Starkey and Toribio Manzanares, Jr.

geology of the area and of the drilled deposits are summarized by Wood and Dale (1964). The land subsidence in the area is described by Lofgren (1963). Only the clay minerals are described here.

Montmorillonite is the principal clay mineral in the fresh-water-bearing sediments of the Arvin-Maricopa area. Subsidiary clay minerals are illite, chlorite, and a kaolinite-type mineral. Clay minerals in the sediments cored in the Lakeview test hole are represented in figure 37. Details are given in table 18. Assuming that these eight samples are representative, the average clay-mineral composition of the water-bearing sediments is—

Clay minerals	*Percent*
Montmorillonite	75
Illite	10
Chlorite	10
Kaolinite-type mineral	5

The sediments that were pierced by the Lake view test hole, and presumably the included clay minerals, seem to have been derived from a metamorphic and silicic-igneous terrane. The nearest and most likely such terrane is in the San Emigdio Mountains, to the south of the Arvin-Maricopa area. However, as only 37 feet of core (from 65 ft of cored interval, see table 1) was recovered from the test hole, the source can be identified on a tentative basis only. The main constituents of the gravels and the lithic grains in the sands recovered from this hole are fragments of metamorphic (schistose rocks, marble, hornfels, quartzite, serpentine) and megascopically crystalline silicic igneous rocks (mainly diorite). The sands are light colored. Biotite and hornblende grains are present but only amount to a percent or so of the sands.

Because so little core was taken from the Lakeview hole, no estimate was made of the total clay-mineral material in the sediments. Neither were the exchangeable cations determined.

SUMMARY OF RESULTS OF PETROLOGIC STUDY

The fresh-water-bearing sediments, mostly Pliocene to Recent in age, that lie beneath the three major areas of land subsidence in the San Joaquin and Santa Clara Valleys of California consist of detritus from the Sierra Nevada and the Coast Ranges. They are mostly alluvial, having been deposited on alluvial fans or on the flood plains of perennial streams. The sediments also include shallow-marine, lacustrine, and deltaic deposits, but these are less abundant than the alluvial deposits.

Because the particle sizes are so diverse, they are not easily summarized in a few sentences. Numerical averages, although they give some general impression of the sizes of the particles, are of limited significance. The geometric-mean particle size of all the sediments is probably in the coarse-silt range, 30μ to 60μ. The most abundant sediment type, according to the Shepard classification, is clayey silt; other abundant types are sand-silt-clay and silty sand.

The alluvial sediments, as well as being the most abundant sediment types, are also the most diverse in their size characteristics. They range from gravels to silty clays. The alluvial sediments in the Los Banos-Kettleman City area have a mean particle size between 30μ and 60μ and a modal size between 125μ and 250μ. Those in the Tulare-Wasco area have a mean size between 40μ and 80μ and a modal size between 30μ and 60μ. Note that although the Los Banos-Kettleman City sediments have a finer mean size than the Tulare-Wasco sediments, their modal size is coarser. The mean sizes of the alluvial sediments in the Santa Clara Valley range from rather coarse (500μ to 1,000μ) beneath the major streams to rather fine (5μ to 10μ) away from the axis of the valley. The general degree of sorting of all the alluvial sediments is fair to poor

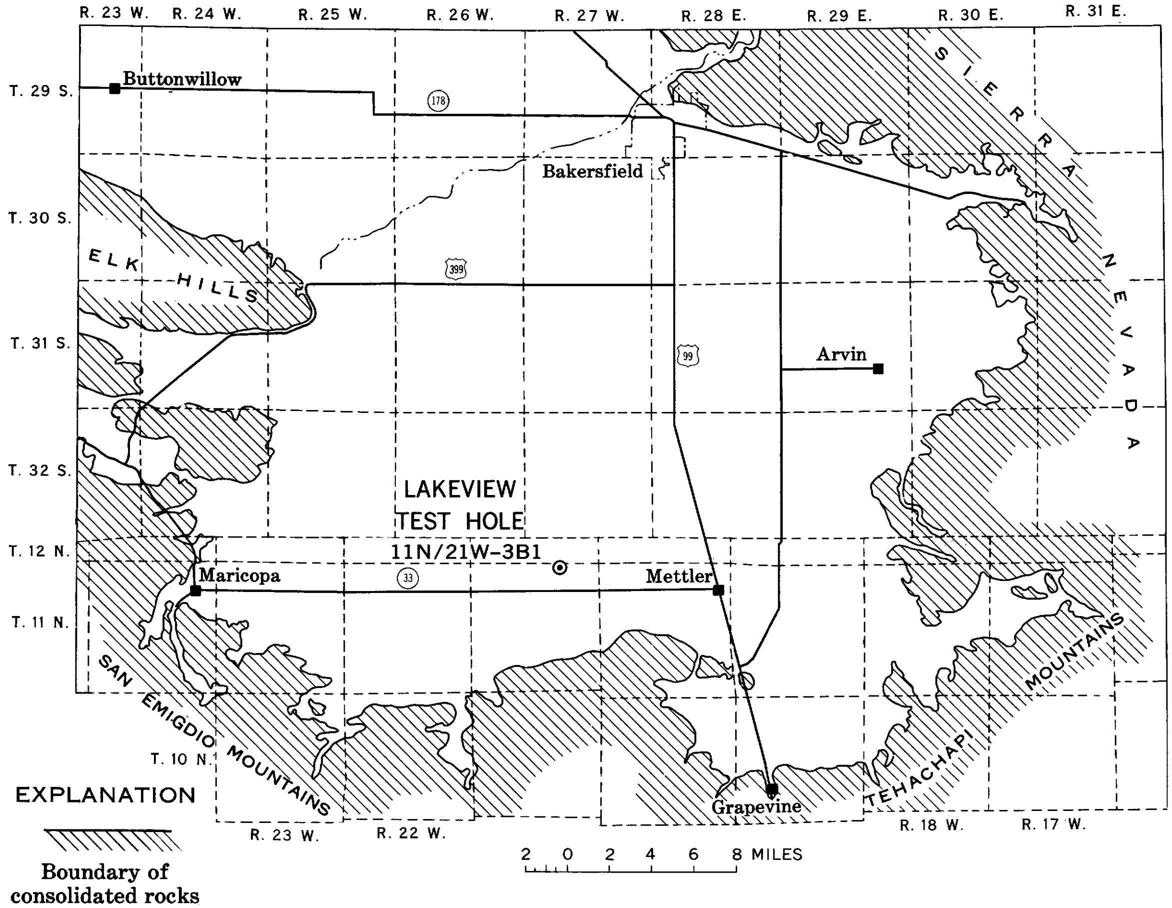

FIGURE 36.—Arvin-Maricopa area showing location of Lakeview test hole.

(average QD_ϕ near 2.0). Skewness measures indicate a disproportionately large admixture of finer particles. The interrelations of the particle-size measures (median diameter versus sorting, skewness, and the coarsest percentile) provide some insights into depositional processes, but they do not provide a unique means of interpreting the histories of alluvial sediments.

Montmorillonite is the predominant clay mineral in nearly all the sediments, regardless of their source terranes or their environments of deposition. It comprises 60–80 percent of the clay-mineral assemblages and 5–25 percent of the different sections of sediments whose compaction accounts for the observed land subsidence. The uniform preponderance of montmorillonite in clay-mineral assemblages derived from diverse source terranes (Sierra Nevada, Coast Ranges, and, in the Arvin-Maricopa area, the Transverse Ranges) and deposited in diverse environments (marine as well as nonmarine) implies some sort of pervasive influence on the clay-mineral assemblages. The identity and nature of this influence, however, await further study.

Calcium is the principal exchangeable cation adsorbed by the clay minerals. Other adsorbed cations are magnesium, sodium, and hydrogen. The proportion of adsorbed sodium increases with increasing depth, probably reflecting a corresponding downward increase in the sodium content of the associated interstitial waters. In some of the marine siltstones of the Tulare-Wasco area, calcium is replaced in the exchange positions by the other cations, under the influence of locally acid conditions accompanying high concentrations of sulfate.

Four petrologic characteristics are probably the most important to the understanding of the compaction behavior of these sediments: (1) the general fineness of the particle sizes, (2) the diverse juxtaposition of coarser and finer deposits, (3) the large proportion of montmorillonite, and (4) the downward increase in the proportion of adsorbed sodium relative to adsorbed calcium. As shown by studies reviewed in an earlier report in this series (Meade, 1964, fig. 3), finer sediments are more porous under a given load and more compressible under a given change in load than coarser sediments. The interbedding of coarser layers with the finer deposits provides permeable avenues of escape for the water squeezed from the finer deposits. Laboratory studies

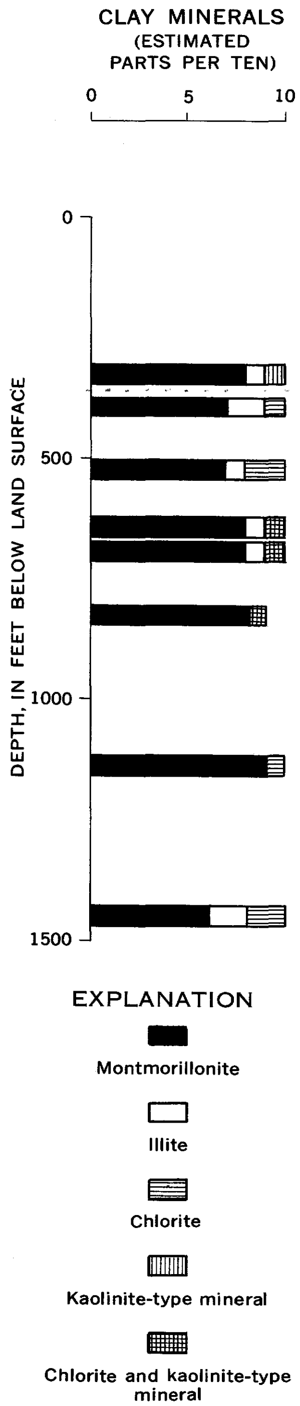

FIGURE 37.—Clay minerals in cored sediments from Lakeview test hole, Arvin-Maricopa area. Trace amounts not illustrated. Determined with the assistance of F. P. Naugler and J. B. Corliss.

by several workers, summarized earlier (Meade, 1964, fig. 4), show that clays rich in montmorillonite are more porous and more compressible under a given load or change in load than clays that consist mainly of the other clay minerals. And, finally, other laboratory studies (Meade, 1964, fig. 11) show that montmorillonite which has adsorbed sodium as its exchangeable cation is more porous under a given load than montmorillonite whose exchange positions are saturated with calcium. The next report in this series (Meade, R. H., Compaction of sediments underlying areas of land subsidence in central California, in preparation for publication as Prof. Paper 497–D) considers in more detail the relations of the petrologic characteristics to the observed compaction of the sediments.

DETERMINATION AND DESCRIPTION OF PARTICLE SIZES

SAMPLING AND PARTICLE-SIZE ANALYSIS

Samples for particle-size analysis were taken, wherever possible, from each 10 feet of cored interval. A consistent attempt was made to take "average" samples—that is, the sample from each 10-foot interval that seemed to be the most representative of material in the interval. Sampling, as a result, was not random, but was biased toward the visually estimated "average" sediment.

The sampling was also biased toward the finer sediments in the sections. The coring apparatus was unable to recover much of the loose gravel and well-sorted coarser sands, whereas it recovered easily the more cohesive clays, silts, fine sands, and poorly sorted sands. Not all the coarser material was lost, however—some well-sorted coarse sand and even a little loose gravel was recovered—and not all the unrecovered material was coarse grained. Some of the lost material was fine sediment that was not recovered because of occasional lapses in the efficiency of the coring procedure.

The two sources of sample bias—selectivity in coring and selectivity in sampling of the recovered core materials—limit the statistical use that can be made of the data on particle-size distribution. For example, one can estimate the mean particle size of the sediments as a whole only within widely spaced limits. On the other hand, the particle-size data can be used in a descriptive way and can be helpful in understanding the history and properties of the sediments—as long as one keeps in mind that the samples were not taken at random and that sampling of the coarsest and very finest sediments was especially inadequate.

Particle-size analyses of the samples were made in the Hydrologic Laboratory of the Geological Survey by standard wet sieve and hydrometer methods. The procedures and results are given in the report by A. I. Johnson, R. P. Moston, and D. A. Morris (1967).

DESCRIPTION OF PARTICLE SIZES

Because most of the sediments treated in this report are fairly fine, the particle sizes are expressed in microns (μ). The size-grade intervals used to express median and modal diameters in figures 6–12, 20–23, and 30–32 are those suggested by the National Research Council (Lane and others, 1947, p. 937), as given in the following table.

Grade [1]	μ	ϕ
	32, 000	−5
Coarse gravel		
	16, 000	−4
Medium gravel		
	8, 000	−3
Fine gravel		
	4, 000	−2
Very fine gravel		
	2, 000	−1
Very coarse sand		
	1, 000	0
Coarse sand		
	500	1
Medium sand		
	250	2
Fine sand		
	125	3
Very fine sand		
	62	4
Coarse silt		
	31	5
Medium silt		
	16	6
Fine silt		
	8	7
Very fine silt		
	4	8
Coarse clay		
	2	9
Medium clay		
	1	10
Fine clay		
	.5	11

[1] Lane, E. W., chm., and others, 1947, p. 937.

The phi-notation system for particle sizes was used to compute some of the measures of sorting and skewness. Phi (ϕ), as defined by its originator Krumbein (1934), is the negative logarithm to the base 2 of the grain diameter:

$$\phi = -\log_2 N,$$

where N is the grain diameter in millimeters. The advantages of this system are that it converts a geometric grade scale to an arithmetic one and "permits the application of common statistical procedures to the data" (Krumbein, 1936a, p. 35). The system and its advantages are discussed further by Krumbein (1934, 1936a, b). Phi values are included in the table above. Note that one whole ϕ interval corresponds to one grade in the National Research Council classification.

Selected percentiles, mean sizes, and measures of sorting and skewness, derived graphically from the cumulative curves or interpolated from particle-size data by a digital computer are given in tables 5–9. (Cumulative curves of some of the samples are given by Johnson and others, 1967.) Inman (1952, p. 125) suggests the inclusion of the following percentiles in a description of grain-size distributions: 5th, 16th, 50th (the median diameter, *Md*), 84th, and 95th. These are given in the tables, along with the 1st percentile (C, used in an interpretive method devised by Passega, 1957) and the 25th and 75th percentiles (the 1st and 3d quartiles, used in well-known measures of sorting and skewness devised by Trask, 1930, and Krumbein, 1936b). Percentiles are given in microns and phi units. The following measures, computed from the percentiles, are also tabulated for the benefit of those interested in specific numerical data.

Measure	Symbol	Formula	Reference
Median	Md	50th percentile, taken directly from the distribution curve and expressed either in μ, mm, or ϕ.	
Means	M_ϕ	$\frac{1}{2}(\phi_{16}+\phi_{84})$	Inman (1952, p. 133–134).
	QM_ϕ	$\frac{1}{2}(\phi_{25}+\phi_{75})$	
Deviations (sorting indexes).	σ_ϕ	$\frac{1}{2}(\phi_{84}-\phi_{16})$	Inman (1952, p. 135–136).
	QD_ϕ	$\frac{1}{2}(\phi_{75}-\phi_{25})$	Krumbein (1936b, p. 102–103).
Skewness measures	α_ϕ	$\frac{M_\phi-Md_\phi}{\sigma_\phi}$	Inman (1952, p. 137).
	Skq_ϕ	$QM_\phi-Md_\phi$	Krumbein (1936b, p. 107–110).
	Skq_ϕ/QD_ϕ	$\frac{QM_\phi-Md_\phi}{QD_\phi}$	Waugh (1952, p. 202–203).
	Sk	$P_{25}P_{75}/Md^2$	Trask (1930, p. 594).

The quartile measures of sorting and skewness, QD_ϕ and Skq_ϕ/QD_ϕ, are used in describing these sediments. The measures σ_ϕ and α_ϕ are recommended over quartile measures by Inman (1952, p. 126), among others, because they describe more of the sample—two-thirds instead of half—and because they are analogous to the moments of the normal frequency distribution generally used in statistics. Unfortunately, the sediments described in this report were so fine that the 84th percentile, necessary to the computation of σ_ϕ and α_ϕ, was not determined in many samples. The finest grain size determined in the hydrometer analyses was 1.0μ. In many of the sediments, especially those from the Los Banos-Kettleman City area and the Santa Clara Valley, the 84th percentile was below 1.0μ. Because the third quartile (75th percentile) was 1.0μ or larger in many more of the sediments and could be used to compute sorting and skewness measures, quartile measures were used.

Although a digital computer and a program were available to compute the actual moments of the size distributions, rather than such graphical analogues of the moments as σ_ϕ and QD_ϕ, the moments were not computed. Because the finer parts of the size distributions were not determined in detail, the graphical measures based on measured percentiles are probably as accurate a portrayal of sorting and skewness as moments calculated from size distributions whose finer parts have to be assumed.

$SKQ\phi/QD\phi$, OR BOWLEY'S MEASURE OF SKEWNESS

Because Bowley's measure of skewness, Skq_ϕ/QD_ϕ, has not been applied to sediments before, as far as I know, an expanded discussion is given here to relate it to the measures of skewness that are already established in the literature of sedimentology.

In spite of the fact that the particle-size distributions of most sediments do not follow the normal or log-normal probability law (Pettijohn, 1957, p. 40–42), the distribution parameters derived from probability theory are valuable for describing particle-size distributions and for comparing one distribution with another. This is particularly true of skewness measures. They "are used mainly in descriptive statistics; in experimental work, if a distribution is found to be skew, it is better to seek a transformation of the variable which will yield a nearly symmetrical distribution and carry out the necessary calculations in terms of the new variable" (Davies, 1957, p. 37). Because their use is mainly descriptive, measures of skewness can be designed to show different characteristics of frequency distributions. Some skewness measures, for instance, show the absolute difference between two measures of central tendency; other relative measures show more clearly the asymmetry of the distribution. Bowley's measure of skewness is a measure of asymmetry.

Waugh (1952, p. 203) gives the formula for Bowley's measure of skewness:

$$\frac{Q_3+Q_1-2\text{ median}}{Q_3-Q_1}.$$

Substituting phi notation and dividing numerator and denominator by 2, we have

$$\frac{\tfrac{1}{2}(\phi_{75}+\phi_{25})-Md_\phi}{\tfrac{1}{2}(\phi_{75}-\phi_{25})},$$

which is

$$\frac{QM_\phi-Md_\phi}{QD_\phi},\text{ or }\frac{Skq_\phi}{QD_\phi}.$$

Rather than introduce a new symbol, I prefer to express it as a fraction of two well-known symbols introduced by Krumbein (1936b, p. 102–103, 107–110). All the possible values of Skq_ϕ/QD_ϕ fall between -1.0 and $+1.0$.

Skq_ϕ/QD_ϕ gives a clearer impression than Skq_ϕ of the asymmetry of a particle-size distribution. Skq_ϕ is the difference between the quartile mean (QM_ϕ) and the median diameter (Md_ϕ). In using Skq_ϕ, one can assign equal skewness values to a slightly asymmetrical poorly sorted sediment and a strongly asymmetrical well-sorted sediment. Dividing Skq_ϕ by QD_ϕ makes it a simple measure of asymmetry and less dependent on the spread of the distribution.

The relation of Skq_ϕ/QD_ϕ to another established measure of skewness, Sk (Trask, 1930, p. 594), is shown in figure 38. Positive values of Skq_ϕ/QD_ϕ are associated with negative values of the logarithm to the base 10 of Sk. The numerical relation between the two measures varies with changes in the value of QD_ϕ. In a sediment for which $QD_\phi=1.67$, $Skq_\phi/QD_\phi=-\log_{10}Sk$. This is confirmed in a conversion chart given by Krumbein and Pettijohn (1938, p. 237) in which $Skq_\phi=-1.67\log_{10}Sk$.

Waugh (1952, p. 203) points out that Bowley's measure of skewness can be extended to include more of the distribution curve by using any two percentiles equidistant from the median. Inman (1952, p. 137) has done essentially this in his measure of skewness, α_ϕ, which is expressed as

$$\frac{\phi_{84}+\phi_{16}-2Md_\phi}{\phi_{84}-\phi_{16}}.$$

The relation between Skq_ϕ/QD_ϕ and α_ϕ is very close. In fact, in a particle-size distribution in which the asymmetry is not progressive toward the extremes of the distribution, Skq_ϕ/QD_ϕ and α_ϕ are numerically equal.

TABLES OF PARTICLE-SIZE-DISTRIBUTION DATA AND DERIVED MEASURES

The remainder of this part of the report consists of five tables, 5–9. Table 5 contains selected particle-size data for 305 samples from the Mendota, Cantua Creek, and Huron cores of the Los Banos-Kettleman City area. Table 6 contains particle-size data for a group of fine sediments from the Los Banos-Kettleman City area in which the exchangeable cations and soluble anions were determined. (See tables 11, 12.) Table 8 contains particle-size data for 157 core-hole samples from the Tulare-Wasco area. Table 9 contains data for 87 core-hole samples from the Santa Clara Valley. Particle sizes in these samples were determined in the Hydrologic Laboratory of the U.S. Geological Survey; the sample numbers are those assigned by the laboratory. Table 7 contains the results of sieve analyses (finest sieve 0.062 mm) of selected well-sorted sands.

Although the samples in tables 5–7 were all from the Los Banos-Kettleman City area, they were not combined

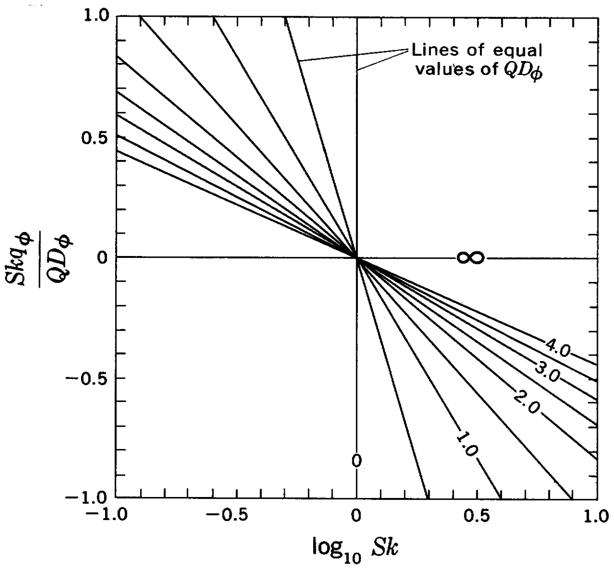

FIGURE 38.—Relation between Skq_ϕ/QD_ϕ and $\log_{10} Sk$.

into one table because they represent three different groups of sediments that were sampled for three different purposes. That is, the samples in each group are biased in different ways.

The percentiles in tables 5–7 were interpolated by eye from the smoothed cumulative curve drawn from the particle-size data. The other measures in tables 5–7 were computed from the percentiles, using a desk calculator. The percentiles in tables 8 and 9 were interpolated from particle-size data by a digital computer. The other measures in tables 8 and 9 (except for the percent finer than 3μ) were also calculated by the computer.

The measures reported in tables 8 and 9 may be different from corresponding measures in the same samples as reported by the Hydrologic Laboratory (Johnson and others, 1967). The differences reflect the fact that Johnson and his coworkers determined the measures by eye from the smoothed cumulative curves.

TABLE 5.—*Particle-size data for sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*

Sample	Depth below land surface (feet)	Percentiles (microns / ϕ)								Means		Deviations		Skewness				Finer than 3 microns (percent)
		1 (C)	5	16	25	50 (*Md*)	75	84	95	M_ϕ	QM_ϕ	σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	*Sk*	
Mendota core																		
57 CAL 1	77	220 2.2	150	85 3.6	61 4.0	24 5.4	3.8 8.0	1.5 9.4	------	6.5	6.0	2.9	2.0	0.37	0.33	0.66	0.40	23
57 CAL 2	111	410 1.3	130	35	19	3.4 8.2	------	------	------	------	------	------	------	------	------	------	------	48
57 CAL 3	153	720 0.47	460	320 1.6	280 1.8	230 2.1	140 2.8	89 3.5	------	2.6	2.3	.9	.5	.48	.44	.22	.74	9
57 CAL 4	192	220 2.2	150	91	69 3.9	27 5.2	4.5 7.8	------	------	------	5.8	------	2.0	------	.31	.62	.43	22
57 CAL 5a	233	320 1.6	210	100	45	4.6 7.8	------	------	------	------	------	------	------	------	------	------	------	45
57 CAL 5b	233	390 1.4	260	170 2.6	150 2.7	91 3.5	14 6.2	1.8 9.1	------	5.8	4.4	3.3	1.7	.73	.58	.99	.25	18
57 CAL 6	277	2,500 −1.3	740	530 0.92	430 1.2	250 2.0	170 2.6	140 2.8	------	1.9	1.9	1.0	.7	−.12	−.16	−.11	1.17	8
57 CAL 7	314	240 2.1	160	92	56 4.2	19 5.7	3.3 8.2	------		------	6.2	------	2.0	------	.24	.48	.51	24
57 CAL 8	353	410 1.3	260	170 2.6	130 2.9	60 4.1	11 6.5	1.7 9.2	------	5.9	4.7	3.3	1.8	.55	.37	.66	.40	18
57 CAL 9	398	49 4.4	22	9.6	6.3	1.1 9.8	------	------	------	------	------	------	------	------	------	------	------	61
57 CAL 10	432	290 1.8	91	22	9.5	2.0 9.0	------	------	------	------	------	------	------	------	------	------	------	57
57 CAL 11	472	230 2.1	170	120 3.1	97 3.4	58 4.1	24 5.4	8.3 6.9	------	5.0	4.4	1.9	1.0	.45	.26	.26	.69	12
57 CAL 12	511	1,100 −0.13	250	14	5.3	0.8 10.3	------	------	------	------	------	------	------	------	------	------	------	67
57 CAL 13	553	340 1.6	200	93	49	6.1 7.4	------		------	------	------	------	------	------	------	------	------	41
57 CAL 14	594	310 1.7	130	15	5.0	1.2 9.7	------	------	------	------	------	------	------	------	------	------	------	67
57 CAL 15	631	370 1.4	240	92	30 5.1	5.7 7.5	0.9 10.1	------	------	------	7.6	------	2.5	------	.06	.14	.83	40
57 CAL 16	647	60 4.1	35	19	13	3.6 8.1	------	------	------	------	------	------	------	------	------	------	------	47
57 CAL 17	653	380 1.4	280	140	49 4.4	9.6 6.7	1.8 9.1	------	------	------	6.7	------	2.4	------	.01	.03	.96	32
57 CAL 18	662	62 4.0	33	22	17 5.9	5.8 7.4	1.5 9.4	------	------	------	7.6	------	1.7	------	.11	.20	.76	37
57 CAL 19	674	68 3.9	35	19 5.7	14 6.2	6.8 7.2	2.0 9.0	1.2 9.7	------	7.7	7.6	2.0	1.4	.26	.26	.36	.61	32
57 CAL 20	683	440 1.2	310	150 2.7	81 3.6	13 6.3	3.2 8.3	1.2 9.7	------	6.2	6.0	3.5	2.3	−.01	−.13	−.31	1.53	24
57 CAL 21	697	62 4.0	33	21 5.6	17 5.9	8.2 6.9	2.7 8.5	1.4 9.5	------	7.5	7.2	2.0	1.3	.30	.20	.27	.68	26
57 CAL 22	707	440 1.2	390	330 1.6	310 1.7	250 2.0	110 3.2	42 4.6	6.4	3.1	2.4	1.5	.7	.73	.58	.43	.55	3
57 CAL 23	713	50 4.3	31	22 5.5	18 5.8	10 6.6	4.5 7.8	2.3 8.8	------	7.1	6.8	1.6	1.0	.30	.16	.16	.81	19
57 CAL 24	722	120 3.1	50	23 5.4	18 5.8	12 6.4	8.2 6.9	6.0 7.4	------	6.4	6.4	1.0	.6	.03	−.04	−.02	1.02	8
57 CAL 25	731	78 3.7	37	23 5.4	17 5.9	6.6 7.2	1.9 9.0	1.0 10.0	------	7.7	7.5	2.3	1.6	.20	.14	.22	.74	34

TABLE 5.—*Particle-size data for sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / ϕ)								Means		Deviations		Skewness				Finer than 3 microns (percent)
		1 (C)	5	16	25	50 (*Md*)	75	84	95	M_ϕ	QM_ϕ	σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	Sk	
Mendota core—Continued																		
57 CAL 26	743	180 2.5	71	40 4.6	29 5.1	13 6.3	4.3 7.9	1.8 9.1	------	6.9	6.5	2.2	1.4	0.27	0.15	0.21	0.74	21
57 CAL 27	757	430 1.2	340	200 2.3	140 2.8	62 4.0	15 6.1	6.5 7.3	------	4.8	4.4	2.5	1.6	.32	.27	.44	.55	10
57 CAL 28	765	1,200 −0.26	750	550 0.86	490 1.0	320 1.6	86 3.5	25 5.3	------	3.1	2.3	2.2	1.3	.65	.51	.64	.41	8
57 CAL 29	773	110 3.2	93	80 3.6	73 3.8	51 4.3	15 6.1	5.8 7.4	------	5.5	4.9	1.9	1.1	.66	.55	.63	.42	13
57 CAL 30	785	110 3.2	90	62 4.0	45 4.5	20 5.6	5.2 7.6	1.9 9.0	------	6.5	6.0	2.5	1.6	.35	.25	.39	.58	19
57 CAL 31	791	210 2.3	130	82	63 4.0	26 5.3	1.8 9.1	------	------	------	6.6	------	2.6	------	.50	1.28	.15	28
57 CAL 32	802	200 2.3	140	91 3.5	75 3.7	40 4.6	6.0 7.4	1.9 9.0	------	6.2	5.6	2.8	1.8	.58	.51	.92	.28	19
57 CAL 33	812	1,500 −0.58	1,000	630 0.67	480 1.1	250 2.0	85 3.6	45 4.5	------	2.6	2.3	1.9	1.2	.30	.25	.31	.65	8
57 CAL 34	813	1,100 −0.13	510	330 1.6	280 1.8	210 2.3	170 2.6	150 2.7	------	2.2	2.2	.6	.4	−.14	−.14	−.05	1.08	7
57 CAL 35	826	65 3.9	23	13	8.8 6.8	3.3 8.2	1.2 9.7	------	------	------	8.3	------	1.4	------	.01	.02	.97	48
57 CAL 36	832	200 2.3	110	53 4.2	42 4.6	20 5.6	3.5 8.2	1.1 9.8	------	7.0	6.4	2.8	1.8	.50	.40	.72	.37	24
57 CAL 37	844	230 2.1	180	150 2.7	140 2.8	110 3.2	37 4.8	14 6.2	------	4.4	3.8	1.7	1.0	.74	.65	.62	.43	10
57 CAL 38	853	350 1.5	250	170 2.6	150 2.7	110 3.2	87 3.5	59 4.1	1.7	3.3	3.1	.8	.4	.18	−.13	−.05	1.08	6
57 CAL 39	860	76 3.7	55	37 4.8	29 5.2	14 6.2	3.2 8.3	1.1 9.8	------	7.3	6.7	2.5	1.6	.45	.36	.56	.46	24
57 CAL 40	867	350 1.5	260	180 2.5	140 2.8	77 3.7	10 6.6	2.2 8.8	------	5.6	4.7	3.2	1.9	.61	.55	1.04	.24	17
57 CAL 41	871	640 0.64	300	180 2.5	150 2.7	98 3.4	50 4.3	22 5.5	------	4.0	3.5	1.5	.8	.42	.23	.18	.78	10
57 CAL 42	877	120 3.1	63	29	18 5.8	5.0 7.6	1.0 10.0	------	------	------	7.9	------	2.1	------	.12	.24	.72	41
57 CAL 43	888	54 4.2	22	12	9.0 6.8	4.1 7.9	0.9 10.1	------	------	------	8.5	------	1.7	------	.32	.53	.48	44
57 CAL 44	901	200 2.3	90	38 4.7	25 5.3	11 6.5	2.9 8.4	1.6 9.3	------	7.0	6.9	2.3	1.6	.21	.23	.36	.60	26
57 CAL 45	912	450 1.2	320	200 2.3	150 2.7	56 4.2	13 6.3	2.5 8.6	------	5.5	4.5	3.2	1.8	.42	.19	.34	.62	16
57 CAL 46	917	500 1.0	350	280 1.8	250 2.0	210 2.3	100 3.3	39 4.7	------	3.3	2.7	1.4	.7	.71	.62	.41	.57	7
57 CAL 47	932	330 1.6	80	40	27	6.4 7.3	------	------	------	------	------	------	------	------	------	------	------	41
57 CAL 48	937	160 2.6	100	50 4.3	33 4.9	16 6.0	4.9 7.7	2.3 8.8	------	6.5	6.3	2.2	1.4	.26	.23	.32	.63	19
57 CAL 49	951	210 2.3	58	35	25 5.3	8.2 6.9	1.0 10.0	------	------	------	7.6	------	2.3	------	.31	.71	.37	37
57 CAL 50	958	250 2.0	180	120 3.1	89 3.5	44 4.5	16 6.0	6.7 7.2	------	5.1	4.7	2.1	1.2	.30	.18	.22	.74	12
57 CAL 51	969	170 2.6	70	39 4.7	31 5.0	16 6.0	3.9 8.0	1.0 10.0	------	7.3	6.5	2.6	1.5	.51	.36	.53	.47	23
57 CAL 52	984	150 2.7	27	7.3	4.0	1.5 9.4	------	------	------	------	------	------	------	------	------	------	------	68
57 CAL 53	988	390 1.4	280	150	84 3.6	25 5.3	1.8 9.1	------	------	------	6.3	------	2.8	------	.37	1.02	0.24	28
57 CAL 54	1,001	240 2.1	60	27	19 5.7	6.8 7.2	1.0 10.0	------	------	------	7.8	------	2.1	------	.30	.64	.41	36
57 CAL 55	1,005	140 2.8	39	25	20 5.6	8.9 6.8	2.5 8.6	------	------	------	7.1	------	1.5	------	.22	.33	.63	27
57 CAL 56	1,021	200 2.3	89	52 4.3	40 4.6	23 5.4	5.0 7.6	1.9 9.0	------	6.7	6.1	2.4	1.5	.51	.47	.70	.38	20
57 CAL 57	1,034	750 0.41	500	350 1.5	260 1.9	71 3.8	14 6.2	4.0 8.0	------	4.7	4.0	3.2	2.1	.28	.11	.23	.72	15
57 CAL 58	1,040	170 2.6	29	17	12	4.9 7.7	------	------	------	------	------	------	------	------	------	------	------	41
57 CAL 59	1,051	140 2.8	84	55 4.2	44 4.5	25 5.3	7.1 7.1	2.2 8.8	------	6.5	5.8	2.3	1.3	.51	.38	.50	.50	18
57 CAL 60	1,064	400 1.3	300	230 2.1	170 2.6	26 5.3	4.5 7.8	0.9 10.1	------	6.1	5.2	4.0	2.6	.21	−.03	−.09	1.13	22
57 CAL 61	1,071	310 1.7	180	81 3.6	47 4.4	20 5.6	3.6 8.1	1.0 10.0	------	6.8	6.3	3.2	1.9	.37	.33	.62	.42	24
57 CAL 62	1,075	400 1.3	300	200 2.3	160 2.6	79 3.7	17 5.9	3.0 8.4	------	5.3	4.3	3.0	1.6	.56	.37	.60	.44	16
57 CAL 63	1,089	480 1.1	360	280 1.8	250 2.0	180 2.5	90 3.5	51 4.3	------	3.1	2.7	1.2	0.7	.48	.36	.26	.69	9
57 CAL 64	1,092	1,100 −0.13	730	370 1.4	150 2.7	42 4.6	15 6.1	4.8 7.7	------	4.6	4.4	3.1	1.7	.00	−.10	−.17	1.28	14
57 CAL 65	1,105	1,200 −0.26	750	270 1.9	120 3.1	37 4.8	9.4 6.7	2.4 8.7	------	5.3	4.9	3.4	1.8	.16	.07	.13	.82	17
57 CAL 66	1,114	440 1.2	360	290 1.8	270 1.9	230 2.1	180 2.5	130 2.9	------	2.4	2.2	0.6	.3	.42	.21	.06	.92	7
57 CAL 67	1,124	450 1.2	340	250 2.0	220 2.2	160 2.6	110 3.2	65 3.9	------	3.0	2.7	1.0	.5	.34	.08	.04	.95	7
57 CAL 68	1,133	110 3.2	66	33	23 5.4	10 6.6	2.3 8.8	------	------	------	7.1	------	1.7	------	.28	.46	.53	28
57 CAL 69	1,160	3,800 −1.9	870	440 1.2	350 1.5	250 2.0	150 2.7	78 3.7	------	2.4	2.1	1.2	.6	.34	.20	.12	.84	8
57 CAL 70	1,174	7,500 −2.9	1,900	950 .07	750 .41	520 .94	270 1.9	140 2.8	------	1.5	1.1	1.4	.7	.37	.28	.21	.75	7
57 CAL 71	1,207	25,500 −4.7	16,000	6,700 −2.7	2,600 −1.4	520 .94	240 2.1	120 3.1	1.3	.2	.3	2.9	1.7	−.27	−.35	−.60	2.31	7

TABLE 5.—*Particle-size data for sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / φ)								Means		Deviations		Skewness				Finer than 3 microns (percent)
		1 (C)	5	16	25	50 (*Md*)	75	84	95	M_ϕ	QM_ϕ	σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	*Sk*	
Mendota core—Continued																		
57 CAL 72	1,219	6,600 −2.7	1,400	460 1.1	360 1.5	250 2.0	110 3.2	24 5.4	------	3.2	2.3	2.1	0.9	0.59	0.38	0.32	0.63	9
57 CAL 73	1,221	4,100 −2.0	2,200	1,100 −.13	770 .38	350 1.5	130 2.9	7.4 7.1	------	3.5	1.7	3.6	1.3	.54	.12	.15	.82	13
57 CAL 74	1,232	6,300 −2.7	2,900	1,400 −.49	770 .38	370 1.4	190 2.4	100 3.3	5.1	1.4	1.4	1.9	1.0	−.01	−.04	−.04	1.07	4
57 CAL 75	1,242	150 2.7	100	58 4.1	40 4.6	20 5.6	7.2 7.1	3.1 8.3	------	6.2	5.9	2.1	1.2	.27	.19	.24	.72	16
57 CAL 76	1,252	400 1.3	300	210 2.3	170 2.6	130 2.9	56 4.2	18 5.8	------	4.0	3.4	1.8	.8	.61	.52	.42	.56	8
57 CAL 77	1,257	860 .22	600	350 1.5	250 2.0	160 2.6	73 3.8	16 6.0	------	3.7	2.9	2.2	.9	.49	.28	.25	.71	11
57 CAL 78	1,270	1,100 −.13	600	310	220 2.2	82 3.6	5.4 7.5	------	------	------	4.9	------	2.7	------	.46	1.24	.18	24
57 CAL 79	1,271	440 1.2	350	270 1.9	240 2.1	180 2.5	30 5.1	3.6 8.1	------	5.0	3.6	3.1	1.5	.81	.73	1.09	.22	15
57 CAL 80	1,284	410 1.3	310	240 2.1	210 2.3	170 2.6	130 2.9	85 3.6	------	2.8	2.6	.7	.3	.33	.09	.03	.95	8
57 CAL 81	1,293	410 1.3	320	220 2.2	180 2.5	81 3.6	8.3 6.9	1.0 10.0	------	6.1	4.7	3.9	2.2	.63	.48	1.06	.23	20
57 CAL 82	1,300	400 1.3	320	240 2.1	210 2.3	120 3.1	11 6.5	1.3 9.6	------	5.8	4.4	3.8	2.1	.73	.62	1.32	.16	20
57 CAL 83	1,312	460 1.1	310	170 2.6	65 3.9	22 5.5	3.7 8.1	1.0 10.0	------	6.3	6.0	3.7	2.1	.20	.24	.50	.50	23
57 CAL 84	1,320	440 1.2	340	270 1.9	240 2.1	170 2.6	14 6.2	2.5 8.6	------	5.3	4.1	3.4	2.0	.80	.76	1.55	.12	16
57 CAL 85	1,331	430 1.2	280	230 2.1	190 2.4	130 2.9	13 6.3	1.2 9.7	------	5.9	4.3	3.8	1.9	.78	.72	1.39	.15	18
57 CAL 86	1,340	220 2.2	120	67 3.9	48 4.4	22 5.5	5.5 7.5	2.0 9.0	------	6.4	5.9	2.5	1.6	.36	.28	.43	.55	19
57 CAL 87	1,348	8,800 −3.1	4,300	1,000 0.0	780 0.36	480 1.1	220 2.2	130 2.9	------	1.5	1.3	1.5	.9	.28	.23	.21	.75	7
57 CAL 88	1,357	180 2.5	96	33	20 5.6	5.8 7.4	1.2 9.7	------	------	------	7.7	------	2.0	------	.12	.24	.71	39
57 CAL 89	1,363	250 2.0	150	95	70 3.8	30 5.1	5.2 7.6	------	------	------	5.7	------	1.9	------	.35	.65	.40	21
57 CAL 90	1,374	360 1.5	260	190 2.4	160 2.6	64 4.0	6.9 7.2	1.4 9.5	------	5.9	4.9	3.5	2.3	.56	.41	.94	.27	19
57 CAL 91	1,385	360 1.5	230	100 3.3	45 4.5	16 6.0	4.2 7.9	1.9 9.0	------	6.2	6.2	2.9	1.7	.07	.12	.21	.74	21
57 CAL 92	1,397	450 1.2	290	29	8.7	2.3 8.8	------	------	------	------	------	------	------	------	------	------	------	56
57 CAL 93	1,406	420 1.3	330	250 2.0	210 2.3	110 3.2	9.0 6.8	2.1 8.9	------	5.4	4.5	3.4	2.3	.66	.59	1.34	.16	18
57 CAL 94	1,415	530 0.92	380	260 1.9	200 2.3	91 3.5	21 5.6	4.6 7.8	------	4.8	3.9	2.9	1.6	.48	.30	.48	.51	15
57 CAL 95	1,424	390 1.4	240	160 2.6	130 2.9	85 3.6	20 5.6	5.0 7.6	------	5.1	4.3	2.5	1.3	.63	.54	.78	.36	14
57 CAL 96	1,433	94 3.4	55	30	22 5.5	9.0 6.8	1.7 9.2	------	------	------	7.4	------	1.8	------	.30	.55	.46	31
57 CAL 97	1,446	50 4.3	33	18	12	4.8 7.7	------	------	------	------	------	------	------	------	------	------	------	40
57 CAL 98	1,455	350 1.5	220	120 3.1	73 3.8	20 5.6	4.2 7.9	1.4 9.5	------	6.3	5.8	3.2	2.1	.20	.10	.20	.77	22
57 CAL 99	1,465	280 1.8	35	11	6.8	2.3 8.8	------	------	------	------	------	------	------	------	------	------	------	56
57 CAL 100	1,474	410 1.3	250	180 2.5	160 2.6	120 3.1	48 4.4	26 5.3	------	3.9	3.5	1.4	.9	.58	.52	.45	.53	10
57 CAL 101	1,481	2,500 −1.3	800	410 1.3	270 1.9	74 3.8	13 6.3	4.3 7.9	------	4.6	4.1	3.3	2.2	.25	.15	.32	.64	13
57 CAL 102	1,487	580 0.79	420	340 1.6	300 1.7	220 2.2	130 2.9	39 4.7	------	3.1	2.3	1.6	.6	.60	.27	.16	.81	8
57 CAL 103	1,495	430 1.2	280	210 2.3	180 2.5	87 3.5	14 6.2	5.9 7.4	------	4.8	4.3	2.6	1.8	.51	.43	.79	.33	12
Cantua Creek core																		
58 CAL 1	250	3,800 −1.9	950	340 1.6	250 2.0	120 3.1	41 4.6	11 6.5	------	4.0	3.3	2.5	1.3	0.39	0.18	0.24	0.71	12
58 CAL 2	298	520 0.94	220	92	57 4.1	17 5.9	3.0 8.4	------	------	------	6.3	------	2.1	------	.17	.37	.59	25
58 CAL 3	333	500 1.0	290	140	70 3.8	10 6.6	1.5 9.4	------	------	------	6.6	------	2.8	------	−.01	−.03	1.05	32
58 CAL 4	372	740 0.43	510	370 1.4	310 1.7	140 2.8	52 4.3	8.7 6.8	------	4.1	3.0	2.7	1.3	.48	.11	.14	.82	13
58 CAL 5	419	240 2.1	130	61 4.0	37 4.8	8.5 6.9	2.3 8.8	1.4 9.5	------	6.8	6.8	2.7	2.0	−.04	−.06	−.12	1.18	31
58 CAL 6	455	330 1.6	130	71	42	5.0 7.6	------	------	------	------	------	------	------	------	------	------	------	46
58 CAL 7	497	700 0.51	370	260 1.9	230 2.1	150 2.7	49 4.4	14 6.2	------	4.0	3.2	2.1	1.1	.62	.44	.49	.50	13
58 CAL 8	508	2,200 −1.1	170	38	22 5.5	7.5 7.1	1.5 9.4	------	------	------	7.4	------	1.9	------	.20	.38	.59	34
58 CAL 9	510	110 3.2	60	32	22 5.5	9.7 6.7	3.3 8.2	------	------	------	6.9	------	1.4	------	.13	.18	.77	24
58 CAL 10	526	100 3.3	38	16	11 6.5	5.7 7.5	1.8 9.1	------	------	------	7.8	------	1.3	------	.28	.36	.61	34
58 CAL 11	533	580 0.79	360	210	140 2.8	28 5.2	2.3 8.8	------	------	------	5.8	------	3.0	------	.22	.64	.41	27
58 CAL 12	553	300 1.7	170	78 3.7	47 4.4	16 6.0	2.3 8.8	1.3 9.6	------	6.6	6.6	3.0	2.2	.22	.28	.61	.42	28

TABLE 5.—*Particle-size data for sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / φ)								Means		Deviations		Skewness				Finer than 3 microns (percent)
		1 (C)	5	16	25	50 (*Md*)	75	84	95	M_ϕ	QM_ϕ	σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	*Sk*	
Cantua Creek core—Continued																		
58 CAL 13	564	310 1.7	140	63 4.0	38 4.7	9.3 6.7	2.0 9.0	1.0 10.0	-----	7.0	6.8	3.0	2.1	0.08	0.04	0.09	0.88	31
58 CAL 14	571	350 1.5	83	38	23 5.4	5.5 7.5	1.0 10.0	-----	-----	-----	7.7	-----	2.3	-----	.08	.19	.76	40
58 CAL 15	581	480 1.1	360	280 1.8	260 1.9	200 2.3	140 2.8	97 3.4	27	2.6	2.4	.8	.4	.37	.16	.07	.91	3
58 CAL 16	592	800 0.32	510	370 1.4	330 1.6	270 1.9	210 2.3	190 2.4	120	1.9	1.9	.5	.3	.04	.09	.03	.95	0
58 CAL 17	602	780 .36	590	450 1.2	390 1.4	300 1.7	230 2.1	180 2.5	46	1.8	1.7	.7	.4	.11	.00	.00	1.00	1
58 CAL 18	623	790 .34	460	310 1.7	260 1.9	180 2.5	99 3.3	65 3.9	4.3	2.8	2.6	1.1	.7	.30	.24	.17	.79	4
58 CAL 19	637	400 1.3	220	97 3.4	63 4.0	21 5.6	4.4 7.8	2.0 9.0	-----	6.2	5.9	2.8	1.9	.21	.18	.34	.63	21
58 CAL 20	643	370 1.4	200	100 3.3	73 3.8	29 5.1	6.5 7.3	1.2 9.7	-----	6.5	5.5	3.2	1.7	.44	.24	.41	.56	20
58 CAL 21	653	630 .67	360	200 2.3	140 2.8	37 4.8	3.4 8.2	1.0 10.0	-----	6.1	5.5	3.8	2.7	.36	.28	.76	.35	24
58 CAL 22	666	200 2.3	52	13	8.8 6.8	4.4 7.8	0.9 10.1	-----	-----	-----	8.5	-----	1.6	-----	.39	.64	.41	42
58 CAL 23	674	290 1.8	41	8.1	4.7	1.5 9.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	65
58 CAL 24	684	170 2.6	110	70 3.8	56 4.2	30 5.1	5.7 7.5	1.0 10.0	-----	6.9	5.8	3.1	1.6	.60	.45	.75	.35	21
58 CAL 25	697	160 2.6	38	12	7.0	2.0 9.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	58
58 CAL 26	702	260 1.9	100	49	34 4.9	15 6.1	3.0 8.4	-----	-----	-----	6.6	-----	1.7	-----	.33	.57	.45	25
58 CAL 27	714	200 2.3	58	23 5.4	14 6.2	5.0 7.6	2.0 9.0	1.4 9.5	-----	7.5	7.6	2.0	1.4	−.09	−.06	−.08	1.12	37
58 CAL 28	722	430 1.2	260	170 2.6	120 3.1	55 4.2	12 6.4	1.0 10.0	-----	6.3	4.7	3.7	1.7	.56	.33	.54	.48	17
58 CAL 29	732	320 1.6	180	86	55 4.2	21 5.6	5.3 7.6	-----	-----	-----	5.9	-----	1.7	-----	.18	.30	.66	24
58 CAL 30	746	310 1.7	130	30	11	1.2 9.7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	58
58 CAL 31	754	190 2.4	86	37 4.8	25 5.3	12 6.4	2.4 8.7	1.0 10.0	-----	7.4	7.0	2.6	1.7	.38	.37	.63	.42	27
58 CAL 32	763	320 1.6	200	81	34 4.9	5.1 7.6	1.0 10.0	-----	-----	-----	7.4	-----	2.5	-----	−.08	−.20	1.31	42
58 CAL 33	774	340 1.6	220	130 2.9	95 3.4	33 4.9	4.3 7.9	1.0 10.0	-----	6.5	5.6	3.5	2.2	.44	.32	.71	.38	21
58 CAL 34	785	450 1.2	360	290 1.8	250 2.0	180 2.5	100 3.3	57 4.1	-----	3.0	2.7	1.2	.7	.42	.29	.19	.77	7
58 CAL 35	795	210 2.3	110	28	13	2.1 8.9	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	55
58 CAL 36	806	190 2.4	83	22	10	2.9 8.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	51
58 CAL 37	811	290 1.8	190	110 3.2	78 3.7	41 4.6	10 6.6	2.2 8.8	-----	6.0	5.2	2.8	1.5	.49	.37	.55	.46	17
58 CAL 38	822	600 0.74	260	98	43	3.2 8.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	49
58 CAL 39	828	350 1.5	240	120	70	8.2 6.9	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	39
58 CAL 40	838	150 2.7	59	21	11 6.5	3.6 8.1	0.9 10.1	-----	-----	-----	8.3	-----	1.8	-----	.11	.19	.76	46
58 CAL 41	852	420 1.3	340	220 2.2	160 2.6	64 4.0	6.6 7.2	1.2 9.7	-----	5.9	4.9	3.8	2.3	.52	.42	.97	.26	21
58 CAL 42	860	330 1.6	200	100	64 4.0	16 6.0	2.9 8.4	-----	-----	-----	6.2	-----	2.2	-----	.10	.23	.72	25
58 CAL 43	867	340 1.6	220	150	120 3.1	70 3.8	4.2 7.9	-----	-----	-----	5.5	-----	2.4	-----	.68	1.64	.10	24
58 CAL 44	877	450 1.2	390	310 1.7	270 1.9	190 2.4	88 3.5	32 5.0	-----	3.3	2.7	1.6	.8	.57	.37	.30	.66	9
58 CAL 45	892	340 1.6	200	81	40	5.4 7.5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	44
58 CAL 46	901	220 2.2	82	25	13	3.0 8.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	50
58 CAL 47	911	430 1.2	280	220 2.2	200 2.3	130 2.9	57 4.1	30 5.1	-----	3.6	3.2	1.4	.9	.47	.31	.28	.67	11
58 CAL 48	923	250 2.0	120	46	22	4.1 7.9	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	45
58 CAL 49	931	370 1.4	240	100	60 4.1	15 6.1	2.0 9.0	-----	-----	-----	6.5	-----	2.5	-----	.19	.45	.53	29
58 CAL 50	941	150 2.7	97	50	30	6.3 7.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	41
58 CAL 51	947	60 4.1	21	9.1	5.9	2.1 8.9	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	59
58 CAL 52	964	320 1.6	180	100 3.3	71 3.8	28 5.2	5.7 7.5	1.7 9.2	-----	6.3	5.6	2.9	1.8	.37	.26	.47	.52	20
58 CAL 53	972	96 3.4	47	26 5.3	19 5.7	8.7 6.8	2.2 8.8	1.0 10.0	-----	7.6	7.3	2.3	1.6	.33	.28	.43	.55	29
58 CAL 54	981	160 2.6	97	68 3.9	57 4.1	38 4.7	18 5.8	11 6.5	1.4	5.2	5.0	1.3	.8	.36	.29	.24	.71	8
58 CAL 55	999	1,300 −0.38	880	700 0.51	620 0.69	440 1.2	280 1.8	210 2.3	81	1.4	1.3	.9	.6	.23	.14	.08	.90	0
58 CAL 56	1,012	1,100 −0.13	710	440 1.2	340 1.6	210 2.3	130 2.9	91 3.5	18	2.3	2.2	1.1	.7	.06	.00	.00	1.00	3
58 CAL 57	1,037	280 1.8	61	26	15 6.1	3.8 8.0	1.2 9.7	-----	-----	-----	7.9	-----	1.8	-----	−.09	−.16	1.25	45

TABLE 5.—*Particle-size data for sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / φ)								Means		Deviations		Skewness				Finer than 3 microns (percent)
		1 (C)	5	16	25	50 (*Md*)	75	84	95	M_ϕ	QM_ϕ	σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	*Sk*	
Cantua Creek core—Continued																		
58 CAL 58	1,043	320 1.6	97	31	16	3.2 8.3	--	--	--	--	--	--	--	--	--	--	--	49
58 CAL 59	1,154	410 1.3	200	96 3.4	62 4.0	20 5.6	5.1 7.6	2.4 8.7	--	6.0	5.8	2.7	1.8	0.15	0.09	0.17	0.79	19
58 CAL 60	1,181	430 1.2	270	110	34	1.6 9.3	--	--	--	--	--	--	--	--	--	--	--	56
58 CAL 61	1,190	140 2.8	87	52	39 4.7	17 5.9	1.7 9.2	--	--	--	6.9	--	2.3	--	.47	1.06	.23	29
58 CAL 62	1,203	400 1.3	270	110	44	2.8 8.5	--	--	--	--	--	--	--	--	--	--	--	51
58 CAL 63	1,225	190 2.4	98	54 4.2	41 4.6	23 5.4	9.1 6.8	4.4 7.8	--	6.0	5.7	1.8	1.1	.32	.23	.25	.71	13
58 CAL 64	1,238	210 2.2	48	22 5.5	16 6.0	6.7 7.2	2.0 9.0	1.0 10.0	--	7.7	7.5	2.2	1.5	.23	.17	.25	.71	32
58 CAL 65	1,241	220 2.2	130	83 3.6	68 3.9	44 4.5	17 5.9	8.8 6.8	--	5.2	4.9	1.6	1.0	.43	.37	.37	.60	10
58 CAL 66	1,255	180 2.5	61	34 4.9	26 5.3	15 6.1	8.0 7.0	4.9 7.7	--	6.3	6.1	1.4	.8	.15	.07	.06	.92	12
58 CAL 67	1,280	100 3.3	52	37 4.8	31 5.0	15 6.1	3.4 8.2	1.6 9.3	--	7.0	6.6	2.3	1.6	.42	.34	.54	.47	23
58 CAL 68	1,326	290 1.8	140	26	15 6.1	4.4 7.8	1.3 9.6	--	--	--	7.8	--	1.8	--	−.01	−.01	1.01	43
58 CAL 69	1,332	350 1.5	220	150 2.7	130 2.9	99 3.3	70 3.8	49 4.4	1.0	3.5	3.4	.8	.4	.25	.11	.05	.93	6
58 CAL 70	1,352	350 1.5	160	84 3.6	63 4.0	30 5.1	10 6.6	1.8 9.1	--	6.3	5.3	2.8	1.3	.46	.19	.25	.70	17
58 CAL 71	1,364	280 1.8	220	180 2.5	160 2.6	110 3.2	63 4.0	46 4.4	18	3.5	3.3	1.0	.7	.28	.19	.13	.83	2
58 CAL 72	1,372	480 1.1	260	130 2.9	95 3.4	56 4.2	31 5.0	21 5.6	5.3	4.3	4.2	1.3	.8	.07	.05	.04	.94	4
58 CAL 73	1,392	260 1.9	200	150 2.7	110 3.2	38 4.7	8.7 6.8	4.5 7.8	1.3	5.3	5.0	2.5	1.8	.22	.16	.29	.66	11
58 CAL 74	1,402	450 1.1	370	290 1.8	240 2.1	140 2.8	51 4.3	23 5.4	--	3.6	3.2	1.8	1.1	.42	.30	.33	.62	9
58 CAL 75	1,414	1,600 −.68	800	330	190 2.4	61 4.0	3.5 8.2	--	--	--	5.3	--	2.9	--	.43	1.24	.18	24
58 CAL 76	1,422	450 1.1	340	200 2.3	140 2.8	65 3.9	14 6.2	3.6 8.1	--	5.2	4.5	2.9	1.7	.44	.34	.56	.46	15
58 CAL 77	1,432	570 .81	330	57	23 5.4	4.9 7.7	.9 10.1	--	--	--	7.8	--	2.3	--	.05	.11	.86	42
58 CAL 78	1,459	23 5.4	13	7.4	5.4 7.5	2.6 8.6	1.3 9.6	--	--	--	8.6	--	1.0	--	−.03	−.03	1.05	56
58 CAL 79	1,476	120 3.1	75	42	29 5.1	8.6 6.9	1.5 9.4	--	--	--	7.2	--	2.1	--	.18	.38	.57	32
58 CAL 80	1,483	100 3.3	58	38 4.7	29 5.1	12 6.4	3.0 8.4	1.0 10.0	--	7.3	6.7	2.6	1.6	.37	.22	.36	.60	25
58 CAL 81	1,496	480 1.1	380	240 2.1	160 2.6	51 4.3	12 6.4	1.5 9.4	--	5.7	4.5	3.7	1.9	.39	.12	.22	.74	18
58 CAL 82	1,507	360 1.5	250	180 2.5	140 2.8	59 4.1	16 6.0	3.8 8.0	--	5.3	4.4	2.8	1.6	.42	.21	.32	.64	15
58 CAL 83	1,507	460 1.1	260	150	100 3.3	14 6.2	1.0 10.0	--	--	--	6.6	--	3.3	--	.14	.48	.51	34
58 CAL 84	1,526	390 1.4	180	48	30 5.1	10 6.6	2.3 8.8	--	--	--	6.9	--	1.8	--	.15	.27	.69	28
58 CAL 85	1,551	870 .20	610	420 1.3	350 1.5	240 2.1	160 2.6	120 3.1	21	2.2	2.1	.9	.6	.10	.02	.01	.97	3
58 CAL 86	1,558	130 2.9	55	19	9.7 6.7	3.1 8.3	1.3 9.6	--	--	--	8.1	--	1.4	--	−.13	−.19	1.31	49
58 CAL 87	1,566	690 .54	400	210	150 2.7	66 3.9	13 6.3	--	--	--	4.5	--	1.8	--	.33	.58	.45	18
58 CAL 88	1,590	55 4.2	30	13	8.0 7.0	5.0 7.6	2.6 8.6	--	--	--	7.8	--	.8	--	.17	.14	.83	26
58 CAL 89	1,631	160 2.6	68	22	11 6.5	3.7 8.1	1.3 9.6	--	--	--	8.0	--	1.5	--	−.02	−.03	1.04	43
58 CAL 90	1,677	260 1.9	160	81	52 4.3	15 6.1	1.1 9.8	--	--	--	7.0	--	2.8	--	.36	.99	.25	34
58 CAL 91	1,714	400 1.3	270	120	77 3.7	20 5.6	1.4 9.5	--	--	--	6.6	--	2.9	--	.33	.95	.27	30
58 CAL 92	1,752	640 0.64	310	160	98	4.1 7.9	--	--	--	--	--	--	--	--	--	--	--	47
38 CAL 93	1,793	380 1.4	260	160 2.6	120 3.1	62 4.0	9.5 6.7	2.3 8.8	--	5.7	4.9	3.1	1.8	.55	.48	.88	.30	17
58 CAL 94	1,838	180 2.5	140	100 3.3	88 3.5	59 4.1	18 5.8	6.5 7.3	--	5.3	4.7	2.0	1.1	.61	.50	.57	.46	12
58 CAL 95	1,872	58 4.1	40	24 5.4	18 5.8	9.5 6.7	3.4 8.2	1.5 9.4	--	7.4	7.0	2.0	1.2	.33	.23	.28	.68	23
58 CAL 96	1,917	76 3.7	36	20	14 6.2	6.9 7.2	1.6 9.3	--	--	--	7.7	--	1.6	--	.35	.54	.47	34
58 CAL 97	1,953	240 2.1	190	130	75	6.8 7.2	--	--	--	--	--	--	--	--	--	--	--	42
58 CAL 98	1,990	1,700 −.77	1,300	740	460 1.1	86 3.5	1.6 9.3	--	--	--	5.2	--	4.1	--	.41	1.66	.10	30
Huron core																		
57 CAL 104	90	220 2.3	66	13	8.1	2.6 8.6	--	--	--	--	--	--	--	--	--	--	--	53
57 CAL 105	160	430 1.2	310	170	100 3.3	20 5.6	2.4 8.7	--	--	--	6.0	--	2.7	--	0.14	0.37	0.60	27

TABLE 5.—*Particle-size data for sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / φ)								Means		Deviations		Skewness				Finer than 3 microns (percent)
		1 (C)	5	16	25	50 (*Md*)	75	84	95	M_ϕ	QM_ϕ	σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	*Sk*	
Huron core—Continued																		
57 CAL 106	234	380 1.4	240	130 2.9	97 3.4	47 4.4	11 6.5	3.5 8.2	------	5.5	4.9	2.6	1.6	0.44	0.34	0.53	0.48	15
57 CAL 107	271	380 1.4	120	15	6.8	2.0 9.0	------	------	------	------	------	------	------	------	------	------	------	58
57 CAL 108	310	450 1.2	350	210	140 2.8	50 4.3	4.4 7.8	------	------	------	5.3	------	2.5	------	.41	1.01	.25	23
57 CAL 109	351	260 1.9	89	26	14	3.6 8.1	------	------	------	------	------	------	------	------	------	------	------	46
57 CAL 110	400	450 1.2	390	320 1.6	290 1.8	240 2.1	150 2.7	83 3.6	------	2.6	2.3	1.0	.5	.57	.42	.20	.76	7
57 CAL 111	431	390 1.4	190	51	26	5.9 7.4	------	------	------	------	------	------	------	------	------	------	------	43
57 CAL 112	476	55 4.2	16	8.8	6.5 7.3	3.2 8.3	1.0 10.0	------	------	------	8.6	------	1.3	------	.24	.33	.63	48
57 CAL 113	510	380 1.4	280	190 2.4	170 2.6	130 2.9	48 4.4	10 6.6	------	4.5	3.5	2.1	.9	.75	.58	.53	.48	12
57 CAL 114	553	320 1.6	140	50	30 5.1	10 6.6	2.4 8.7	------	------	------	6.9	------	1.8	------	.13	.24	.72	27
57 CAL 115	594	350 1.5	180	130 2.9	100 3.3	58 4.1	29 5.1	13 6.3	------	4.6	4.2	1.7	.9	.30	.11	.10	.86	9
57 CAL 116	631	350 1.5	230	170 2.6	140 2.8	72 3.8	21 5.6	10 6.6	------	4.6	4.2	2.0	1.4	.39	.29	.40	.57	9
57 CAL 117	676	440 1.2	350	290 1.8	260 1.9	200 2.3	130 2.9	100 3.3	1.5	2.6	2.4	.8	.5	.30	.24	.12	.84	6
57 CAL 118	713	360 1.5	250	190 2.4	170 2.6	150 2.7	110 3.2	75 3.7	------	3.1	2.9	.7	.3	.49	.42	.13	.83	6
57 CAL 119	727	240 2.1	200	160 2.6	140 2.8	100 3.3	64 4.0	34 4.9	------	3.8	3.4	1.1	.6	.39	.14	.08	.90	9
57 CAL 120	732	280 1.8	120	41	27 5.2	13 6.3	2.7 8.5	------	------	------	6.9	------	1.7	------	.36	.60	.43	26
57 CAL 121	746	470 1.1	180	91	66 3.9	23 5.4	2.1 8.9	------	------	------	6.4	------	2.5	------	.39	.97	.26	27
57 CAL 122	767	880 0.18	650	480 1.1	420 1.3	320 1.6	230 2.1	170 2.6	------	1.8	1.7	.7	.4	.23	.09	.04	.94	7
57 CAL 123	779	250 2.0	120	50 4.3	35 4.8	15 6.1	3.3 8.2	1.3 9.6	------	7.0	6.5	2.6	1.7	.34	.28	.48	.51	24
57 CAL 124	789	320 1.6	83	56 4.2	46 4.4	30 5.1	15 6.1	6.1 7.4	------	5.8	5.2	1.6	.8	.44	.23	.19	.77	12
57 CAL 125	800	160 2.6	37	22 5.5	15 6.1	6.5 7.3	2.6 8.6	1.6 9.3	------	7.4	7.3	1.9	1.3	.07	.04	.05	.92	28
57 CAL 126	810	260 1.9	160	79 3.7	49 4.4	18 5.8	3.1 8.3	1.3 9.6	------	6.6	6.3	3.0	2.0	.28	.27	.54	.47	24
57 CAL 127	831	260 1.9	160	81	51 4.3	12 6.4	1.8 9.1	------	------	------	6.7	------	2.4	------	.13	.32	.64	30
57 CAL 128	861	220 2.2	120	59 4.1	42 4.6	21 5.6	7.9 7.0	3.4 8.2	------	6.1	5.8	2.1	1.2	.28	.16	.20	.75	15
57 CAL 129	870	330 1.6	210	140 2.8	100 3.3	45 4.5	16 6.0	6.9 7.2	------	5.0	4.6	2.2	1.3	.25	.13	.17	.79	11
57 CAL 130	870	410 1.3	240	120 3.1	71 3.8	21 5.6	4.3 7.9	1.6 9.3	------	6.2	5.8	3.1	2.0	.19	.13	.27	.69	22
57 CAL 131	889	210 2.3	33	11	6.7	2.0 9.0	------	------	------	------	------	------	------	------	------	------	------	59
57 CAL 132	906	450 1.1	320	160 2.6	90 3.5	8.5 6.9	1.5 9.4	1.0 10.0	------	6.3	6.4	3.7	3.0	−.16	−.16	−.46	1.87	37
57 CAL 133	937	230 2.1	140	81 3.6	61 4.0	23 5.4	5.7 7.5	2.2 8.8	------	6.2	5.7	2.6	1.7	.30	.18	.30	.66	18
57 CAL 134	946	210 2.3	48	15 6.1	11 6.5	5.5 7.5	2.5 8.6	1.7 9.2	------	7.6	7.6	1.6	1.1	.08	.06	.06	.91	31
57 CAL 135	948	290 1.8	120	28	14 6.2	3.4 8.2	1.1 9.8	------	------	------	8.0	------	1.8	------	−.11	−.21	1.33	47
57 CAL 136	958	1,200 −0.26	510	320 1.6	250 2.0	120 3.1	17 5.9	4.2 7.9	------	4.8	3.9	3.1	1.9	.55	.45	.88	.30	14
57 CAL 137	972	300 1.7	150	27	12 6.4	3.9 8.0	1.4 9.5	------	------	------	7.9	------	1.5	------	−.05	−.07	1.10	43
57 CAL 138	983	280 1.8	98	35	21 5.6	8.1 6.9	2.4 8.7	------	------	------	7.1	------	1.6	------	.12	.18	.77	28
57 CAL 139	994	310 1.7	180	120 3.1	100 3.3	60 4.1	20 5.6	10 6.6	1.2	4.8	4.5	1.8	1.2	.44	.36	.42	.56	7
57 CAL 140	1,003	450 1.2	340	240 2.1	180 2.5	72 3.8	12 6.4	3.0 8.4	------	5.2	4.4	3.2	2.0	.45	.32	.62	.42	16
57 CAL 141	1,028	220 2.2	84	25	14 6.2	4.6 7.8	1.3 9.6	------	------	------	7.9	------	1.7	------	.06	.11	.86	40
57 CAL 142	1,032	380 1.4	280	180 2.5	130 2.9	58 4.1	7.6 7.0	2.5 8.6	------	5.6	5.0	3.1	2.0	.47	.43	.88	.29	17
57 CAL 143	1,042	460 1.1	360	270 1.9	240 2.1	180 2.5	110 3.2	76 3.7	4.0	2.8	2.6	.9	.6	.36	.27	.15	.81	5
57 CAL 144	1,094	270 1.9	120	49	29 5.1	82 6.9	2.1 8.9	------	------	------	7.0	------	1.9	------	.04	.07	.91	20
57 CAL 145	1,105	310 1.7	140	38	17 5.9	5.2 7.6	1.4 9.5	------	------	------	7.7	------	1.8	------	.05	.09	.88	38
57 CAL 146	1,120	240 2.1	85	21	13 6.3	4.8 7.7	1.4 9.5	------	------	------	7.9	------	1.6	------	.11	.17	.79	38
57 CAL 147	1,132	420 1.3	280	90	41 4.6	9.9 6.7	1.3 9.6	------	------	------	7.1	------	2.5	------	.18	.44	.54	33
57 CAL 148	1,144	300 1.7	150	16	9.6 6.7	3.5 8.2	1.4 9.5	------	------	------	8.1	------	1.4	------	−.05	−.07	1.10	46
57 CAL 149	1,145	320 1.6	160	81 3.6	57 4.1	28 5.2	11 6.5	4.8 7.7	------	5.7	5.3	2.0	1.2	.25	.13	.16	.80	14
57 CAL 150	1,160	170 2.6	100	62 4.0	48 4.4	26 5.3	10 6.6	4.9 7.7	------	5.8	5.5	1.8	1.1	.31	.21	.24	.71	12

TABLE 5.—*Particle-size data for sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / ϕ)								Means		Deviations		Skewness				Finer than 3 microns (percent)
		1 (C)	5	16	25	50 (*Md*)	75	84	95	M_ϕ	QM_ϕ	σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	Sk	
Huron core—Continued																		
57 CAL 151	1,180	470 1.1	220	17	5.3	1.6 9.3	------	------	------	------	------	------	------	------	------	------	------	66
57 CAL 152	1,199	440 1.2	340	200 2.3	140 2.8	37 4.8	5.4 7.5	1.9 9.0	------	5.7	5.2	3.4	2.3	0.27	0.18	0.42	0.55	20
57 CAL 153	1,209	250 2.0	140	50 4.3	33 4.9	15 6.1	6.5 7.3	4.0 8.0	1.1	6.1	6.1	1.8	1.2	.04	.03	.03	.95	13
57 CAL 154	1,216	640 0.64	310	170 2.6	120 3.1	36 4.8	7.4 7.1	3.5 8.2	------	5.4	5.1	2.8	2.0	.20	.13	.27	.69	14
57 CAL 155	1,232	270 1.9	170	130 2.9	100 3.3	54 4.2	14 6.2	3.7 8.1	------	5.5	4.7	2.6	1.4	.51	.37	.53	.48	14
57 CAL 156	1,248	4,900 −2.3	1,100	600 0.7	510 1.0	290 1.8	100 3.3	30 5.1	------	2.9	2.1	2.2	1.2	.51	.30	.35	.61	9
57 CAL 157	1,263	270 1.9	110	20	12	4.3 7.9	------	------	------	------	------	------	------	------	------	------	------	42
57 CAL 158	1,284	340 1.6	200	92	40 4.6	5.4 7.5	1.4 9.5	------	------	------	7.1	------	2.4	------	−.19	−.47	1.92	38
57 CAL 159	1,291	200 2.3	71	22	14 6.2	5.1 7.6	1.4 9.5	------	------	------	7.8	------	1.7	------	.12	.20	.75	38
57 CAL 160	1,306	450 1.2	290	160	110 3.2	14 6.2	1.6 9.3	------	------	------	6.2	------	3.1	------	.02	.07	.90	33
57 CAL 161	1,321	340 1.6	150	58	30 5.1	9.0 6.8	1.8 9.1	------	------	------	7.1	------	2.0	------	.14	.29	.67	31
57 CAL 162	1,347	420 1.3	280	170 2.6	120 3.1	28 5.2	3.7 8.1	2.0 9.0	------	5.8	5.6	3.2	2.5	.19	.16	.41	.57	22
57 CAL 163	1,357	370 1.4	130	28	16 6.0	4.1 7.9	1.0 10.0	------	------	------	8.0	------	2.0	------	.02	.04	.95	44
57 CAL 164	1,376	260 1.9	120	39	26 5.3	10 6.6	2.8 8.5	------	------	------	6.9	------	1.6	------	.14	.23	.73	26
57 CAL 165	1,392	450 1.2	150	32	15 6.1	4.2 7.9	1.2 9.7	------	------	------	7.9	------	1.8	------	−.01	−.02	1.02	43
57 CAL 166	1,417	310 1.7	210	100 3.3	49 4.4	14 6.2	3.3 8.2	1.5 9.4	------	6.3	6.3	3.0	1.9	.06	.07	.13	.82	24
57 CAL 167	1,428	330 1.6	180	70	38 4.7	9.2 6.8	1.7 9.2	------	------	------	7.0	------	2.2	------	.09	.20	.76	32
57 CAL 168	1,433	380 1.4	270	140 2.8	87 3.5	23 5.4	5.1 7.6	1.8 9.1	------	6.0	5.6	3.1	2.0	.17	.06	.13	.84	19
57 CAL 169	1,454	390 1.4	260	110 3.2	43 4.5	10 6.6	2.8 8.5	1.0 10.0	------	6.6	6.5	3.4	2.0	−.02	−.07	−.13	1.20	26
57 CAL 170	1,480	350 1.5	190	68	36 4.8	9.4 6.7	2.5 8.6	------	------	------	6.7	------	1.9	------	−.01	−.01	1.02	27
57 CAL 171	1,484	260 1.9	73	30 5.1	23 5.4	12 6.4	5.1 7.6	2.6 8.6	------	6.8	6.5	1.8	1.1	.25	.14	.15	.81	17
57 CAL 172	1,498	370 1.4	260	130 2.9	75 3.7	14 6.2	2.6 8.6	1.0 10.0	------	6.5	6.2	3.5	2.4	.08	.00	.00	.99	27
57 CAL 173	1,518	320 1.6	130	60 4.1	41 4.6	14 6.2	3.6 8.1	1.3 9.6	------	6.8	6.4	2.8	1.8	.24	.11	.20	.75	23
57 CAL 174	1,528	410 1.3	300	180 2.5	120 3.1	39 4.7	7.1 7.1	1.9 9.0	------	5.8	5.1	3.3	2.0	.33	.21	.42	.56	18
57 CAL 175	1,539	270 1.9	160	50	26 5.3	6.4 7.3	1.4 9.5	------	------	------	7.4	------	2.1	------	.04	.08	.89	36
57 CAL 176	1,544	340 1.6	200	130 2.9	100 3.3	48 4.4	14 6.2	3.1 8.3	------	5.6	4.7	2.7	1.4	.46	.25	.36	.61	16
57 CAL 177	1,551	410 1.3	300	210 2.3	170 2.6	110 3.2	44 4.5	20 5.6	------	3.9	3.5	1.7	1.0	.45	.36	.35	.62	10
57 CAL 178	1,575	380 1.4	270	150	97 3.4	27 5.2	6.9 7.2	------	------	------	5.3	------	1.9	------	.03	.06	.92	20
57 CAL 179	1,590	330 1.6	190	85 3.6	55 4.2	20 5.6	5.1 7.6	1.9 9.0	------	6.3	5.9	2.7	1.7	.24	.15	.26	.70	19
57 CAL 180	1,605	370 1.4	240	110 3.2	59 4.1	30 5.1	7.0 7.2	2.5 8.6	------	5.9	5.6	2.7	1.5	.31	.36	.56	.46	17
57 CAL 181	1,615	340 1.6	220	130 2.9	77 3.7	16 6.0	3.2 8.3	1.3 9.6	------	6.3	6.0	3.3	2.3	.09	.01	.02	.96	24
57 CAL 182	1,642	370 1.4	240	140 2.8	97 3.4	30 5.1	4.8 7.7	1.2 9.7	------	6.3	5.5	3.4	2.2	.35	.22	.47	.52	21
57 CAL 183	1,650	380 1.4	250	86	19	3.6 8.1	------	------	------	------	------	------	------	------	------	------	------	39
57 CAL 184	1,669	350 1.5	200	61 4.0	33 4.9	13 6.3	2.9 8.4	1.3 9.6	------	6.8	6.7	2.8	1.8	.19	.23	.40	.57	25
57 CAL 185	1,678	220 2.2	86	38	24 5.4	6.8 7.2	1.3 9.6	------	------	------	7.5	------	2.1	------	.13	.28	.67	36
57 CAL 186	1,699	320 1.6	210	150 2.7	120 3.1	47 4.4	6.4 7.3	1.6 9.3	------	6.0	5.2	3.3	2.1	.49	.36	.76	.35	19
57 CAL 187	1,719	350 1.5	120	35	22 5.5	6.4 7.3	1.4 9.5	------	------	------	7.5	------	2.0	------	.10	.20	.75	35
57 CAL 188	1,728	300 1.7	180	66	39 4.7	13 6.3	2.5 8.6	------	------	------	6.7	------	2.0	------	.20	.39	.58	27
57 CAL 189	1,748	300 1.7	130	27 5.2	15 6.1	5.2 7.6	1.8 9.1	1.0 10.0	------	7.6	7.6	2.4	1.5	.00	.00	.00	1.00	37
57 CAL 190	1,780	290 1.8	88	40	28 5.2	9.5 6.7	2.0 9.0	------	------	------	7.1	------	1.9	------	.18	.34	.62	30
57 CAL 191	1,800	410 1.3	290	150	88	13 6.3	------	------	------	------	------	------	------	------	------	------	------	37
57 CAL 192	1,805	400 1.3	270	150 2.7	100 3.3	37 4.8	8.9 6.8	5.0 7.6	2.3	5.2	5.1	2.4	1.7	.18	.17	.30	.65	8
57 CAL 193	1,831	230 2.1	54	18 5.8	13 6.3	7.5 7.1	3.6 8.1	2.3 8.8	------	7.3	7.2	1.5	.9	.15	.14	.13	.83	21
57 CAL 194	1,842	280 1.8	170	61	34 4.9	8.9 6.8	1.5 9.4	------	------	------	7.1	------	2.2	------	.14	.32	.64	34
57 CAL 195	1,868	410 1.3	360	270 1.9	200 2.3	51 4.3	10 6.6	5.7 7.5	2.3	4.7	4.5	2.8	2.2	.14	.09	.19	.77	7
57 CAL 196	1,873	290 1.8	150	85 3.6	71 3.8	50 4.3	12 6.4	3.4 8.2	------	5.9	5.1	2.3	1.3	.67	.61	.78	.34	15

TABLE 5.—*Particle-size data for sediments from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*—Continued

Sample	Depth below land surface (feet)	Percentiles $\left(\frac{\text{microns}}{\phi}\right)$ 1 (C)	5	16	25	50 (*Md*)	75	84	95	Means M_ϕ	QM_ϕ	Deviations σ_ϕ	QD_ϕ	Skewness α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	Sk	Finer than 3 microns (percent)
						Huron core—Continued												
57 CAL 197	1,900	230 2.1	65	22	14 6.2	5.0 7.6	1.2 9.7	----	----	----	7.9	----	1.8	----	0.16	0.29	0.67	39
57 CAL 198	1,913	300 1.74	160	61	32 5.0	7.2 7.1	1.3 9.6	----	----	----	7.3	----	2.3	----	.07	.16	0.80	37
57 CAL 199	1,937	420 1.3	310	200	120 3.1	9.1 6.8	1.2 9.7	----	----	----	6.4	----	3.3	----	−.12	−.40	1.74	35
57 CAL 200	1,957	420 1.3	280	190	150 2.7	49 4.4	1.2 9.7	----	----	----	6.2	----	3.5	----	.54	1.87	0.07	29
57 CAL 201	1,976	390 1.4	290	190	130	7.3 7.1	----	----	----	----	----	----	----	----	----	----	----	41
57 CAL 202	1,993	340 1.6	170	19	5.5	1.9 9.0	----	----	----	----	----	----	----	----	----	----	----	62
57 CAL 203	2,020	370 1.4	220	65	23 5.4	6.6 7.2	2.0 9.0	----	----	----	7.2	----	1.8	----	−.02	−.04	1.06	31
57 CAL 204	2,050	320 1.6	150	61 4.0	37 4.8	13 6.3	4.7 7.7	3.3 8.2	1.6	6.1	6.2	2.1	1.5	−0.06	−.02	−.03	1.03	14
57 CAL 205	2,064	330 1.6	140	29	10	2.0 9.0	----	----	----	----	----	----	----	----	----	----	----	56
57 CAL 206	2,092	410 1.3	220	37	7.7 7.0	2.9 8.4	1.4 9.5	----	----	----	8.2	----	1.2	----	−.15	−.18	1.28	51

TABLE 6.—*Particle-size data for selected fine-grained sediments from cores and streams, Los Banos-Kettleman City area*

[Particle-size analyses made by the Hydrologic Laboratory of the U.S. Geological Survey, Denver, Colo.]

Sample	Depth below land surface (feet)	Percentiles (microns) 1	5	16	25	50	75	84	Sand (>62μ) (percent)	Silt (4μ–62μ) (percent)	Clay (<4μ) (percent)
					Oro Loma core						
59 CAL 279	154	220	120	51	27	3.8	----	----	13.2	36.5	50.3
59 CAL 280	472	60	30	14	10	5.7	2.4	1.3	.8	61.2	38.0
59 CAL 281	724	110	48	36	19	3.0	----	----	1.6	45.6	52.8
59 CAL 282	823	120	47	25	14	3.0	----	----	2.2	43.4	54.4
					Mendota core						
59 CAL 283	75	100	74	53	45	14	----	----	9.2	51.5	39.3
59 CAL 285	746	60	43	32	25	11	2.8	1.6	.8	68.2	31.0
59 CAL 286	981	55	34	16	6.6	1.1	----	----	.4	31.6	68.0
59 CAL 287	1,443	60	32	16	9.8	2.7	----	----	.4	43.3	56.3
					Cantua Creek core						
59 CAL 288	418	80	50	31	17	1.9	----	----	2.0	41.0	57.0
59 CAL 289	572	58	43	20	8.2	1.3	----	----	.4	33.2	66.4
59 CAL 290	902	120	80	47	21	1.5	----	----	10.0	26.0	64.0
59 CAL 291	1,238	40	20	7.1	3.7	1.0	----	----	.0	24.0	76.0
59 CAL 292	1,632	43	23	11	7.1	3.3	1.5	----	.0	43.0	57.0
59 CAL 293	1,952	60	40	15	5.9	1.3	----	----	.8	28.8	70.4

TABLE 6.—*Particle-size data for selected fine-grained sediments from cores and streams, Los Banos-Kettleman City area*—Con.

Sample	Depth below land surface (feet)	Percentiles (microns) 1	5	16	25	50	75	84	Sand (>62μ) (percent)	Silt (4μ–62μ) (percent)	Clay (<4μ) (percent)
					Huron core						
59 CAL 294	313	27	12	6.3	4.6	2.2	----	----	0.0	29.6	70.4
59 CAL 295	735	59	48	42	36	18	1.3	----	.4	67.7	31.9
59 CAL 296	905	100	60	22	11	2.6	----	----	4.8	37.4	57.8
59 CAL 297	1,387	55	43	25	15	2.9	----	----	.0	46.3	53.7
59 CAL 298	1,801	110	72	50	43	12	1.5	----	8.5	53.5	38.0
59 CAL 299	2,093	100	55	27	15	4.2	1.9	----	3.2	48.3	48.5
					Bed sediment, Little Panoche Creek						
59 CAL 278	0	240	160	120	110	63	19	6.7	50.4	37.8	11.8
					Bank sediment, Panoche Creek						
59 CAL 277	0	180	120	90	72	31	4.1	1.2	30.2	44.8	25.0

TABLE 7.—*Particle-size data for selected well-sorted sands from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*

[Sieve analyses made by R. H. Meade]

Depth below land surface (feet)	Percentiles $\left(\frac{\text{microns}}{\phi}\right)$ 1 (C)	5	16	25	50 (*Md*)	75	84	95	Deviation σ_ϕ	QD_ϕ	Skewness α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ
						Mendota core							
232	370 1.4	240	180 2.5	160 2.6	140 2.8	110 3.2	88 3.5	47	0.5	0.3	0.54	0.26	0.07
472	350 1.5	250	190 2.4	170 2.6	160 2.6	80 3.6	25 5.3	----	1.5	.5	.84	.85	.46
833	440 1.2	290	220 2.2	200 2.3	150 2.7	100 3.3	67 3.9	----	.9	.5	.43	.16	.08

TABLE 7.—*Particle-size data for selected well-sorted sands from Mendota, Cantua Creek, and Huron cores, Los Banos-Kettleman City area*—Continued

Depth below land surface (feet)	Percentiles (microns / ϕ)								Deviation		Skewness		
	1 (C)	5	16	25	50 (*Md*)	75	84	95	σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ
Mendota core—Continued													
880	430 1.2	330	260 1.9	230 2.1	170 2.6	120 3.1	80 3.6	------	0.8	0.5	0.27	0.06	0.03
1,077	700 0.51	320	240 2.1	210 2.3	150 2.7	97 3.4	60 4.1	------	1.0	.6	.32	.12	.07
1,127	1,200 −0.26	750	410 1.3	310 1.7	210 2.3	160 2.6	120 3.1	73	.9	.5	−.09	−.19	−.09
1,251	2,100 −1.1	1,200	870 0.2	720 0.47	430 1.2	260 1.9	190 2.4	50	1.3	.7	−.09	−.03	−.02
1,347	590 0.76	390	300 1.7	280 1.8	210 2.3	150 2.7	110 3.2	------	.7	.5	.29	.09	.04
Cantua Creek core													
581	1,700 −0.77	1,000	500 1.0	410 1.3	300 1.7	220 2.2	180 2.5	100	0.7	0.4	−0.01	−0.02	−0.01
590	690 0.54	400	260 1.9	220 2.2	160 2.6	100 3.3	87 3.5	54	.8	.6	.11	.19	.11
633	620 0.69	220	170 2.6	150 2.7	110 3.2	76 3.7	65 3.9	38	.7	.5	.10	.10	.05
774	420 1.3	310	220 2.2	190 2.4	150 2.7	94 3.4	68 3.9	------	.8	.5	.34	.32	.16
824	520 0.94	230	170 2.6	150 2.7	130 2.9	85 3.6	57 4.1	------	.8	.4	.51	.47	.19
997	1,100 −0.13	760	490 1.0	440 1.2	330 1.6	250 2.0	210 2.3	110	.6	.4	.02	−.02	−.01
1,034	1,100 −0.13	580	340 1.6	300 1.7	250 2.0	200 2.3	170 2.6	74	.5	.3	.03	.10	.03
1,228	1,400 −0.49	830	480 1.1	370 1.4	190 2.4	110 3.2	98 3.4	60	1.1	.9	−.18	−.11	−.10
1,363	500 1.0	310	230 2.1	210 2.3	170 2.6	140 2.8	120 3.1	55	.5	.3	.06	−.07	−.02
1,420	2,100 −1.07	980	530 0.9	400 1.3	210 2.3	130 2.9	110 3.2	53	1.1	.8	−.18	−.15	−.12
1,550	1,100 −0.13	780	490 1.0	420 1.3	310 1.7	240 2.1	200 2.3	110	.6	.4	−.03	−.10	−.04
1,950	890 0.17	510	340 1.6	290 1.8	270 1.9	230 2.1	190 2.4	97	.4	.2	.21	.37	.06
Huron core													
632	370 1.4	230	180 2.5	160 2.6	110 3.2	56 4.2	35 4.8	------	1.2	0.8	0.40	0.29	0.22
721	260 1.9	160	120 3.1	110 3.2	85 3.6	62 4.0	47 4.4	------	.7	.4	.25	.07	.03
960	1,300 −0.38	860	460 1.1	280 1.8	140 2.8	110 3.2	92 3.4	55	1.2	.7	−.48	−.49	−.33

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TABLE 8.—*Particle-size data for cored sediments, Tulare-Wasco area*

[Particle-size analyses made by Hydrologic Laboratory of the U.S. Geological Survey, Denver, Colo.]

Sample	Depth below land surface (feet)	Percentiles (microns / φ)									Mode (microns / φ)	M_ϕ	Deviations		Skewness			Finer than 3 microns (percent)
		1 (C)	2	5	16	25	50 (Md)	75	84	95			σ_ϕ	QD_ϕ	α_ϕ	Skq_ϕ / QD_ϕ	Skq_ϕ	
Pixley core																		
58 CAL 99	31	1,700	1,500	950	440	280	43	6.5	------	------	------	------	------	2.7	------	0.01	0.01	21
		−0.8	−0.6	0.1	1.2	1.9	4.5	7.3										
58 CAL 100	70	360	280	170	80	54	20	6.1	2.5	------	34	6.1	2.5	1.6	0.21	.11	.17	18
		1.5	1.8	2.5	3.6	4.2	5.6	7.4	8.6		4.9							
58 CAL 101	119	1,800	1,600	1,200	530	280	49	8.2	3.1	------	36	4.6	3.7	2.5	.08	.02	.04	16
		−0.9	−0.7	−0.3	0.9	1.8	4.3	6.9	8.3		4.8							
58 CAL 102	155	610	470	280	160	130	65	23	9.9	------	52	4.6	2.0	1.2	.34	.20	.25	13
		0.7	1.1	1.8	2.6	3.0	4.0	5.4	6.7		4.3							
58 CAL 103	194	1,400	1,000	630	300	210	74	20	4.6	------	42	4.7	3.0	1.7	.33	.12	.20	15
		−0.5	0.0	0.7	1.7	2.3	3.8	5.7	7.8		4.6							
58 CAL 104	236	1,000	700	400	170	110	37	5.1	1.6	------	38	5.9	3.4	2.2	.35	.28	.62	21
		0.0	0.5	1.3	2.6	3.2	4.8	7.6	9.3		4.7							
58 CAL 105	269	1,300	920	630	300	180	30	3.7	2.0	------	35	5.4	3.6	2.8	.08	.08	.23	22
		−0.4	0.1	0.7	1.7	2.5	5.1	8.1	9.0		4.8							
58 CAL 106	287	125	68	48	30	24	13	3.6	1.2	------	28	7.4	2.3	1.4	.49	.37	.51	23
		3.0	3.9	4.4	5.0	5.4	6.2	8.1	9.7		5.2							
58 CAL 107	295	45	39	31	21	18	8.4	1.7	------	------	------	------	------	1.7	------	.37	.63	32
		4.5	4.7	5.0	5.6	5.8	6.9	9.2										
58 CAL 108	305	790	650	490	360	310	220	150	130	36	230	2.2	.8	.5	.09	.08	.04	1
		0.3	0.6	1.0	1.5	1.7	2.2	2.7	3.0	4.8	2.1							
58 CAL 109	317	610	400	210	83	57	27	7.5	1.3	------	36	6.6	3.0	1.5	.46	.26	.38	19
		0.7	1.3	2.3	3.6	4.1	5.2	7.1	9.6		4.8							
58 CAL 110	321	500	430	350	240	160	40	5.0	1.2	------	38	5.9	3.8	2.5	.32	.21	.51	22
		1.0	1.2	1.5	2.1	2.7	4.6	7.6	9.7		4.7							
58 CAL 111	336	1,600	1,300	830	340	150	16	1.6	------	------	------	------	------	3.3	------	.02	.05	30
		−0.7	−0.4	0.3	1.5	2.8	6.0	9.3										
58 CAL 112	343	400	290	140	37	22	6.9	1.9	1.0	------	------	7.4	2.6	1.7	.09	.05	.08	31
		1.3	1.8	2.8	4.8	5.5	7.2	9.0	10.0									
58 CAL 113	353	360	270	180	88	59	21	2.3	------	------	35	------	------	2.3	------	.37	.85	26
		1.5	1.9	2.5	3.5	4.1	5.6	8.7			4.8							
58 CAL 114	363	1,400	950	600	260	160	53	10	3.1	------	42	5.1	3.2	2.0	.28	.19	.39	16
		−0.4	0.1	0.7	1.9	2.6	4.2	6.6	8.3		4.6							
58 CAL 115	371	700	580	310	71	47	21	5.5	1.1	------	32	6.9	3.0	1.5	.42	.25	.39	20
		0.5	0.8	1.7	3.8	4.4	5.6	7.5	9.9		4.9							
58 CAL 116	418	560	390	230	74	42	13	1.7	------	------	------	------	------	2.3	------	.24	.57	31
		0.8	1.4	2.1	3.8	4.6	6.3	9.2										
58 CAL 117	427	190	160	110	48	31	11	------	------	------	31	------	------	------	------	------	------	32
		2.4	2.7	3.2	4.4	5.0	6.5				5.0							
58 CAL 118	443	750	560	250	34	18	5.1	------	------	------	------	------	------	------	------	------	------	40
		0.4	0.8	2.0	4.9	5.8	7.6											
58 CAL 119	451	125	79	49	27	20	9.9	2.8	1.1	------	24	7.5	2.3	1.4	.37	.28	.41	26
		3.0	3.7	4.4	5.2	5.6	6.7	8.5	9.8		5.4							
58 CAL 120	465	300	200	110	51	38	20	6.0	1.7	------	32	6.7	2.5	1.3	.46	.32	.43	20
		1.7	2.3	3.1	4.3	4.7	5.6	7.4	9.2		5.0							
58 CAL 121	476	380	280	190	120	83	32	7.1	2.8	------	42	5.8	2.7	1.8	.32	.23	.41	16
		1.4	1.8	2.4	3.1	3.6	4.9	7.1	8.5		4.6							
58 CAL 122	482	300	200	110	25	12	3.5	------	------	------	------	------	------	------	------	------	------	46
		1.7	2.3	3.2	5.3	6.3	8.2											
58 CAL 123	496	610	440	320	150	88	25	3.0	------	------	36	------	------	2.4	------	.25	.60	24
		0.7	1.2	1.7	2.7	3.5	5.3	8.4			4.8							
58 CAL 124	509	910	660	370	140	88	32	7.8	2.2	------	37	5.8	3.0	1.7	.28	.16	.28	17
		0.1	0.6	1.4	2.8	3.5	5.0	7.0	8.8		4.8							
58 CAL 125	511	420	350	210	70	38	9.1	1.1	------	------	------	------	------	2.5	------	.18	.46	35
		1.3	1.5	2.3	3.8	4.7	6.8	9.8										
58 CAL 126	523	420	360	240	150	120	27	2.3	------	------	------	------	------	2.8	------	.25	.71	27
		1.2	1.5	2.1	2.7	3.1	5.2	8.8										
58 CAL 127	534	300	230	180	120	94	54	22	10	1.1	52	4.8	1.8	1.0	.35	.23	.24	8
		1.7	2.1	2.5	3.1	3.4	4.2	5.5	6.6	9.8	4.3							
58 CAL 128	546	350	250	90	27	16	5.4	1.4	------	------	------	------	------	1.7	------	.10	.17	37
		1.5	2.0	3.5	5.2	6.0	7.5	9.5										
58 CAL 129	561	230	160	110	64	47	24	7.5	3.4	------	26	6.1	2.1	1.3	.33	.27	.36	15
		2.1	2.6	3.2	4.0	4.4	5.4	7.0	8.2		5.2							
58 CAL 130	582	1,700	1,400	930	640	540	300	140	81	------	420	2.1	1.5	1.0	.25	.13	.13	4
		−0.7	−0.5	0.1	0.6	0.9	1.8	2.9	3.6		1.2							
58 CAL 131	595	390	300	190	88	45	8.8	2.2	1.1	------	------	6.7	3.2	2.2	−.04	−.07	−.16	31
		1.4	1.7	2.4	3.5	4.5	6.8	8.9	9.9									
58 CAL 132	601	350	250	160	81	55	22	6.4	2.5	------	34	6.1	2.5	1.6	.25	.14	.22	17
		1.5	2.0	2.6	3.6	4.2	5.5	7.3	8.7		4.9							
58 CAL 133	616	1,000	810	590	170	62	11	1.8	------	------	------	------	------	2.6	------	.03	.07	31
		0.0	0.3	0.8	2.5	4.0	6.5	9.1										
58 CAL 134	622	410	350	270	150	110	52	20	11	------	44	4.6	1.9	1.2	.20	.13	.15	9
		1.3	1.5	1.9	2.8	3.2	4.3	5.6	6.5		4.5							
58 CAL 135	631	610	440	300	180	140	77	28	9.0	------	78	4.6	2.2	1.2	.43	.24	.28	11
		0.7	1.2	1.7	2.5	2.8	3.7	5.1	6.8		3.7							
58 CAL 136	644	560	420	300	180	140	68	19	6.0	------	80	4.9	2.4	1.4	.43	.28	.40	12
		0.8	1.3	1.8	2.5	2.8	3.9	5.7	7.4		3.6							
58 CAL 137	654	800	570	360	140	77	26	5.2	1.2	------	34	6.3	3.5	1.9	.29	.19	.37	20
		0.3	0.8	1.5	2.8	3.7	5.3	7.6	9.8		4.9							
58 CAL 138	660	420	360	290	190	140	72	27	11	------	51	4.4	2.0	1.2	.32	.17	.20	10
		1.3	1.5	1.8	2.4	2.8	3.8	5.2	6.5		4.3							
58 CAL 139	673	930	720	490	180	100	29	5.8	1.4	------	35	6.0	3.5	2.1	.24	.11	.23	20
		0.1	0.5	1.0	2.5	3.3	5.1	7.4	9.5		4.9							
58 CAL 140	683	220	150	100	59	44	24	10	5.2	------	33	5.8	1.8	1.1	.27	.18	.19	11
		2.2	2.7	3.3	4.1	4.5	5.4	6.6	7.6		4.9							
58 CAL 141	694	710	500	380	250	180	78	18	3.7	------	160	5.0	3.0	1.7	.44	.26	.43	15
		0.5	1.0	1.4	2.0	2.4	3.7	5.8	8.1		2.6							
58 CAL 142	705	400	310	210	125	92	45	20	10	1.7	40	4.8	1.8	1.1	.19	.06	.06	7
		1.3	1.7	2.3	3.0	3.4	4.5	5.6	6.6	9.2	4.6							
58 CAL 143	724	400	310	190	69	43	16	4.6	1.9	------	31	6.5	2.6	1.6	.19	.12	.20	20
		1.3	1.7	2.4	3.8	4.5	6.0	7.8	9.1		5.0							

TABLE 8.—*Particle-size data for cored sediments, Tulare-Wasco area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / ϕ)									Mode (microns / ϕ)	M_ϕ	Deviations		Skewness			Finer than 3 microns (percent)
		1 (C)	2	5	16	25	50 (Md)	75	84	95			σ_ϕ	QD_ϕ	α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	
Pixley core—Continued																		
58 CAL 144	731	320 1.6	210 2.2	94 3.4	34 4.9	23 5.4	11 6.6	3.9 8.0	1.9 9.0	------	23 5.4	7.0	2.1	1.3	.19	.13	.17	20
58 CAL 145	748	830 0.3	690 0.5	440 1.2	220 2.2	130 2.9	27 5.2	1.7 9.2	------	------	------	------	------	3.2	------	.27	.84	28
Richgrove core																		
59 CAL 310	55	3,400 −1.8	2,800 −1.5	2,100 −1.1	1,100 −0.2	760 0.4	250 2.0	28 5.2	5.5 7.5	------	670 0.6	3.7	3.8	2.4	0.44	0.33	0.79	15
59 CAL 311	64	6,400 −2.7	4,900 −2.3	3,500 −1.8	2,000 −1.0	1,200 −0.3	350 1.5	51 4.3	14 6.1	------	680 0.5	2.6	3.6	2.3	.30	.22	.51	11
59 CAL 312	85	3,700 −1.9	3,000 −1.6	2,100 −1.1	820 0.3	460 1.1	110 3.2	22 5.5	5.9 7.4	------	43 4.5	3.9	3.6	2.2	.18	.05	.10	12
59 CAL 313	93	2,500 −1.3	1,900 −0.9	1,300 −0.3	560 0.8	330 1.6	69 3.9	14 6.2	3.5 8.2	------	36 4.8	4.5	3.7	2.3	.18	.02	.04	15
59 CAL 314	103	4,900 −2.3	3,500 −1.8	2,500 −1.3	1,200 −0.2	690 0.5	170 2.6	20 5.6	4.6 7.8	------	------	3.8	4.0	2.5	.30	.21	.53	15
59 CAL 315	118	4,300 −2.1	3,300 −1.7	2,300 −1.2	970 0.0	590 0.8	130 2.9	10 6.6	2.2 8.9	------	------	4.4	4.4	2.9	.35	.27	.78	18
59 CAL 316	124	4,000 −2.0	2,400 −1.3	1,200 −0.2	320 1.6	180 2.5	51 4.3	7.5 7.1	1.6 9.3	------	40 4.7	5.5	3.8	2.3	.31	.21	.47	19
59 CAL 317	133	2,300 −1.2	1,900 −0.9	1,100 −0.2	310 1.7	160 2.7	50 4.3	12 6.4	3.2 8.3	------	40 4.6	5.0	3.3	1.9	.20	.11	.21	16
59 CAL 318	143	3,000 −1.6	2,400 −1.3	1,600 −0.7	620 0.7	360 1.5	50 4.3	3.4 8.2	1.0 9.9	------	------	5.3	4.6	3.4	.22	.16	.53	24
59 CAL 319	148	2,100 −1.1	1,500 −0.6	870 0.2	290 1.8	110 3.2	2.8 8.5	------	------	------	------	------	------	------	------	------	------	51
59 CAL 320	157	1,300 −0.4	1,000 0.0	620 0.7	250 2.0	150 2.8	31 5.0	1.8 9.2	------	------	------	------	------	3.2	------	.29	.94	30
59 CAL 321	173	2,300 −1.2	1,800 −0.8	1,100 −0.1	160 2.6	74 3.8	25 5.3	5.4 7.5	1.9 9.0	------	33 4.9	5.8	3.2	1.9	.16	.18	.34	19
59 CAL 322	177	2,900 −1.6	2,400 −1.3	1,600 −0.7	650 0.6	380 1.4	120 3.1	19 5.7	4.9 7.7	------	180 2.5	4.2	3.5	2.1	.30	.21	.45	13
59 CLA 323	187	6,900 −2.8	5,900 −2.6	3,900 −2.0	2,600 −1.4	2,100 −1.1	1,100 −0.1	420 1.3	220 2.2	3.2 8.3	1,900 −0.9	.4	1.8	1.2	.28	.16	.19	5
59 CAL 324	204	3,100 −1.6	2,600 −1.4	2,000 −1.0	970 0.0	580 0.8	74 3.8	2.9 8.4	------	------	------	------	------	3.8	------	.22	.85	25
59 CAL 325	210	1,900 −0.9	1,300 −0.4	700 0.51	220 2.2	130 2.9	35 4.8	9.0 6.8	3.6 8.1	------	34 4.9	5.1	3.0	1.9	.10	.01	.03	15
59 CAL 326	221	3,700 −1.9	3,000 −1.6	2,100 −1.1	810 0.30	400 1.3	52 4.3	8.3 6.9	2.4 8.7	------	36 4.8	4.5	4.2	2.8	.05	−.06	−.16	17
59 CAL 327	232	9,000 −3.2	3,400 −1.8	1,500 −0.5	410 1.3	190 2.4	38 4.7	6.1 7.4	1.9 9.0	------	36 4.8	5.2	3.9	2.5	.12	.07	.17	20
59 CAL 328	240	4,900 −2.3	3,500 −1.8	2,500 −1.3	890 0.2	490 1.0	100 3.3	12 6.3	3.4 8.2	------	38 4.7	4.2	4.0	2.7	.22	.16	.42	15
59 CAL 329	252	9,000 −3.2	6,800 −2.8	4,900 −2.3	3,000 −1.6	2,400 −1.3	1,300 −0.4	550 0.9	300 1.7	------	2,000 −1.0	.1	1.7	1.1	.26	.16	.17	5
59 CAL 330	260	3,700 −1.9	2,100 −1.1	580 0.8	210 2.3	150 2.7	72 3.8	24 5.4	12 6.4	------	60 4.1	4.4	2.1	1.3	.27	.20	.27	9
59 CAL 331	274	4,700 −2.2	3,500 −1.8	2,500 −1.3	1,200 −0.3	800 0.3	290 1.8	30 5.1	4.8 7.7	------	560 0.8	3.7	4.0	2.4	.48	.39	.93	14
59 CAL 332	285	1,100 −0.2	820 0.3	480 1.1	240 2.1	180 2.5	85 3.6	23 5.4	8.6 6.9	------	130 2.9	4.5	2.4	1.5	.38	.28	.42	11
59 CAL 333	290	690 0.5	500 1.0	250 2.0	110 3.2	64 4.0	26 5.3	7.6 7.0	3.4 8.2	------	34 4.9	5.7	2.5	1.5	.18	.14	.22	15
59 CAL 334	301	2,700 −1.4	1,700 −0.8	960 0.1	470 1.1	340 1.5	170 2.5	23 5.4	2.8 8.5	------	210 2.2	4.8	3.7	1.9	.61	.49	.96	16
59 CAL 335	316	2,200 −1.1	1,600 −0.7	910 0.1	310 1.7	200 2.3	82 3.6	19 5.7	6.1 7.4	------	110 3.2	4.5	2.8	1.7	.32	.24	.40	13
59 CAL 336	318	2,000 −1.0	1,400 −0.5	740 0.4	290 1.8	200 2.3	98 3.3	27 5.2	12 6.4	------	160 2.7	4.1	2.3	1.5	.33	.27	.40	8
59 CAL 337	329	2,500 −1.3	2,100 −1.1	1,300 −0.4	520 0.9	310 1.7	95 3.4	18 5.8	7.1 7.1	------	42 4.6	4.0	3.1	2.0	.20	.16	.32	12
59 CAL 338	338	1,400 −0.5	1,000 0.0	450 1.2	200 2.3	150 2.8	56 4.2	9.9 6.7	3.6 8.1	------	46 4.4	5.2	2.9	1.9	.36	.28	.55	15
59 CAL 339	357	2,300 −1.2	1,900 −0.9	920 0.1	270 1.9	160 2.7	55 4.2	16 6.0	6.2 7.3	------	40 4.6	4.6	2.7	1.7	.16	.09	.15	13
59 CAL 340	359	2,800 −1.5	2,300 −1.2	1,500 −0.6	640 0.6	430 1.2	170 2.6	30 5.0	7.5 7.1	1.2 9.7	290 1.8	3.9	3.2	1.9	.39	.29	.55	9
59 CAL 341	370	2,700 −1.4	2,200 −1.2	1,300 −0.4	560 0.8	320 1.7	64 4.0	5.1 7.6	2.0 9.0	------	200 2.3	4.9	4.1	3.0	.23	.23	.69	20
59 CAL 342	375	2,500 −1.3	2,200 −1.1	1,400 −0.5	630 0.7	390 1.4	110 3.2	19 5.7	3.9 8.0	------	40 4.6	4.3	3.7	2.2	.30	.14	.31	15
59 CAL 343	389	810 0.3	520 1.0	280 1.9	140 2.9	92 3.4	40 4.7	17 5.9	8.4 6.9	------	37 4.8	4.9	2.0	1.2	.12	.01	.01	9
59 CAL 344	399	2,600 −1.4	2,300 −1.2	1,600 −0.6	550 0.9	290 1.8	55 4.2	7.4 7.1	2.7 8.5	------	34 4.9	4.7	3.8	2.6	.14	.09	.25	17
59 CAL 345	403	1,500 −0.6	1,200 −0.2	720 0.5	310 1.7	210 2.3	63 4.0	5.1 7.6	1.8 9.1	------	------	5.4	3.7	2.7	.38	.35	.95	20
59 CAL 346	415	2,500 −1.3	2,100 −1.1	1,500 −0.6	840 0.2	600 0.7	230 2.1	52 4.3	17 5.9	------	550 0.8	3.0	2.8	1.8	.32	.20	.36	10
59 CAL 347	423	3,000 −1.6	2,500 −1.3	1,900 −0.9	900 0.1	590 0.8	210 2.3	39 4.7	11 6.5	1.0 9.9	380 1.4	3.3	3.2	2.0	.32	.22	.44	10
59 CAL 348	433	2,300 −1.2	1,600 −0.7	910 0.1	300 1.8	180 2.5	63 4.0	17 5.8	7.0 7.2	------	42 4.6	4.5	2.7	1.7	.18	.11	.18	12
59 CAL 349	443	1,700 −0.8	1,200 −0.2	700 0.5	260 1.9	160 2.7	30 5.0	5.4 7.5	2.7 8.5	------	35 4.9	5.2	3.3	2.4	.06	.02	.05	17
59 CAL 350	459	2,700 −1.4	2,300 −1.2	1,700 −0.7	670 0.6	390 1.3	100 3.3	21 5.6	8.3 6.9	------	43 4.5	3.7	3.2	2.1	.15	.09	.19	10

TABLE 8.—*Particle-size data for cored sediments, Tulare-Wasco area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / ϕ)									Mode (microns / ϕ)	M_ϕ	Deviations		Skewness			Finer than 3 microns (percent)
		1 (C)	2	5	16	25	50 (*Md*)	75	84	95			σ_ϕ	QD_ϕ	α_ϕ	Skq_ϕ / QD_ϕ	Skq_ϕ	
Richgrove core—Continued																		
59 CAL 351	468	2,800	2,000	1,300	500	300	70	12	4.9	------	35	4.3	3.3	2.3	.15	.10	.24	12
		−1.5	−1.0	−0.3	1.0	1.8	3.8	6.4	7.7		4.8							
59 CAL 352	475	2,900	2,100	1,100	330	170	35	4.4	1.5	------	36	5.5	3.9	2.6	.16	.13	.34	22
		−1.5	−1.1	−0.1	1.6	2.5	4.8	7.8	9.3		4.8							
59 CAL 353	488	1,600	1,200	620	160	110	51	15	6.5	1.3	46	5.0	2.3	1.4	.28	.20	.29	11
		−0.6	−0.2	0.7	2.7	3.2	4.3	6.0	7.3	9.6	4.4							
59 CAL 354	494	1,600	1,300	850	320	180	39	7.3	2.7	------	34	5.1	3.4	2.3	.12	.05	.11	17
		−0.7	−0.4	0.2	1.6	2.5	4.7	7.1	8.5		4.9							
59 CAL 355	507	1,700	1,200	570	150	96	34	6.5	1.7	------	40	6.0	3.2	1.9	.34	.23	.45	19
		−0.8	−0.2	0.8	2.7	3.4	4.9	7.3	9.2		4.7							
59 CAL 356	517	2,000	1,500	930	420	260	17	2.6	1.2	------	------	5.5	4.2	3.3	−.08	−.17	−.58	27
		−1.0	−0.6	.1	1.3	2.0	5.8	8.6	9.7									
59 CAL 357	531	1,500	1,200	770	280	140	53	12	3.7	------	45	5.0	3.1	1.8	.24	.20	.35	15
		−.6	−.3	.4	1.9	2.8	4.2	6.3	8.1		4.5							
59 CAL 358	533	5,100	3,700	2,500	1,100	690	240	54	17	1.3	350	2.9	3.0	1.8	.27	.17	.31	8
		−2.4	−1.9	−1.3	−.1	.5	2.1	4.2	5.9	9.6	1.5							
59 CAL 359	544	22,000	15,000	2,200	750	450	140	20	3.4	------	210	4.3	3.9	2.2	.37	.23	.52	16
		−4.5	−3.9	−1.2	.4	1.1	2.9	5.6	8.2		2.3							
59 CAL 360	553	3,200	2,600	2,000	1,000	720	240	76	23	------	690	2.7	2.7	1.6	.24	.03	.05	10
		−1.7	−1.4	−1.0	0	.5	2.1	3.7	5.4		.5							
59 CAL 361	565	2,700	2,200	920	240	130	59	15	5.8	------	52	4.7	2.7	1.5	.25	.26	.39	12
		−1.4	−1.1	.1	2.0	2.9	4.1	6.0	7.4		4.3							
59 CAL 362	575	2,500	2,000	1,300	450	130	22	5.6	2.3	------	28	5.0	3.8	2.2	−.15	−.13	−.29	18
		−1.3	−1.0	−.4	1.1	3.0	5.5	7.5	8.8		5.2							
59 CAL 363	583	5,100	3,400	2,200	180	84	21	4.9	2.2	------	31	5.7	3.2	2.0	.03	.02	.05	19
		−2.3	−1.8	−1.1	2.5	3.6	5.6	7.7	8.8		5.0							
59 CAL 364	595	2,200	1,600	930	230	150	45	8.2	3.7	------	40	5.1	3.0	2.1	.20	.18	.37	14
		−1.1	−.6	.1	2.1	2.8	4.5	6.9	8.1		4.6							
59 CAL 365	608	340	180	110	75	61	30	12	6.5	1.5	37	5.5	1.8	1.2	.25	.11	.12	9
		1.6	2.5	3.2	3.7	4.0	5.1	6.4	7.3	9.4	4.8							
59 CAL 366	614	1,300	900	340	120	82	34	10	3.1	------	38	5.7	2.6	1.5	.32	.15	.23	16
		−.4	.1	1.6	3.1	3.6	4.9	6.6	8.3		4.7							
59 CAL 367	623	2,200	690	240	130	80	18	2.6	------	------	------	------	------	2.5	------	.14	.35	27
		−1.1	.5	2.0	2.9	3.6	5.8	8.6										
59 CAL 368	631	1,600	1,300	930	360	170	16	1.9	------	------	------	------	------	3.2	------	−.04	−.14	30
		−0.7	−0.4	0.1	1.5	2.5	5.9	9.0										
59 CAL 369	648	1,300	1,000	560	130	45	7.1	1.5	------	------	------	------	------	2.5	------	−.09	−.21	36
		−0.4	0.0	0.8	3.0	4.5	7.1	9.4										
59 CAL 370	659	1,800	1,400	880	290	130	40	6.7	2.3	------	57	5.3	3.5	2.1	.18	.22	.46	18
		−0.8	−0.4	0.2	1.8	3.0	4.6	7.2	8.8	------	4.1							
59 CAL 371	669	2,100	1,600	1,000	410	270	90	11	3.4	------	190	4.7	3.5	2.3	.37	.31	.71	15
		−1.1	−0.7	0.0	1.3	1.9	3.5	6.5	8.2	------	2.4							
59 CAL 372	679	3,800	2,800	1,700	620	290	93	22	8.7	1.0	50	3.8	3.1	1.8	.11	.11	.20	9
		−1.9	−1.5	−0.8	.7	1.8	3.4	5.5	6.8	10.0	4.3							
59 CAL 373	687	1,400	1,100	660	170	81	14	1.7	------	------	------	------	------	2.8	------	.07	.20	33
		−0.5	−0.1	0.6	2.5	3.6	6.2	9.2										
59 CAL 374	698	270	230	190	140	120	72	28	15	1.2	76	4.4	1.6	1.0	.40	.30	.32	7
		1.9	2.1	2.4	2.8	3.1	3.8	5.1	6.1	9.6	3.7							
59 CAL 375	709	1,900	1,500	1,100	560	260	95	25	10	1.1	75	3.7	2.9	1.7	.11	.13	.21	8
		−0.9	−0.6	−0.2	.8	1.9	3.4	5.3	6.6	9.9	3.7							
59 CAL 376	720	910	680	420	190	120	42	12	6.4	1.0	37	4.9	2.4	1.7	.11	.06	.10	10
		0.1	0.6	1.2	2.4	3.0	4.6	6.3	7.3	10.0	4.8							
59 CAL 377	726	1,700	1,200	710	310	210	82	20	7.7	------	48	4.4	2.7	1.7	.28	.21	.36	9
		−0.8	−0.3	0.5	1.7	2.3	3.6	5.7	7.0		4.4							
59 CAL 378	736	2,500	1,800	1,300	710	510	170	28	11	------	410	3.5	3.0	2.1	.32	.25	.53	9
		−1.3	−0.9	−0.4	.5	1.0	2.6	5.2	6.6	------	1.3							
59 CAL 379	744	360	280	210	150	120	33	7.3	2.9	------	150	5.6	2.8	2.0	.23	.06	.12	16
		1.5	1.8	2.2	2.8	3.0	4.9	7.1	8.4		2.7							
59 CAL 380	757	230	220	180	90	55	7.2	3.0	2.4	1.5	------	6.1	2.6	2.1	−.39	−.40	−.84	37
		2.1	2.2	2.5	3.5	4.2	7.1	8.4	8.7	9.4								
59 CAL 381	763	760	670	540	270	150	5.3	------	------	------	------	------	------	------	------	------	------	45
		.4	.6	.9	1.9	2.7	7.6											
59 CAL 382	776	1,100	800	470	200	140	31	4.3	1.6	------	------	5.8	3.5	2.5	.23	.15	.37	22
		−.2	.3	1.1	2.3	2.9	5.0	7.9	9.3									
59 CAL 383	778	4,900	3,400	2,100	200	100	37	7.4	3.1	------	41	5.3	3.0	1.9	.19	.20	.39	16
		−2.3	−1.8	−1.1	2.3	3.3	4.8	7.1	8.3		4.6							
59 CAL 384	792	670	550	380	130	20	2.7	------	------	------	------	------	------	------	------	------	------	51
		.6	.9	1.4	2.9	5.6	8.5											
59 CAL 385	844	125	92	58	30	21	11	3.6	1.7	------	23	7.1	2.1	1.3	.27	.20	.26	22
		3.0	3.4	4.1	5.1	5.5	6.6	8.1	9.2		5.4							
59 CAL 386	852	140	110	81	50	38	22	9.1	4.7	------	32	6.0	1.7	1.0	.31	.23	.24	12
		2.9	3.2	3.6	4.3	4.7	5.5	6.8	7.7		4.9							
59 CAL 387	861	1,500	1,200	870	480	280	130	19	1.0	------	170	5.5	4.5	2.0	.57	.42	.82	19
		−.6	−.3	.2	1.1	1.8	3.0	5.8	10.0		2.6							
59 CAL 388	867	230	210	150	82	62	29	12	6.8	2.4	35	5.4	1.8	1.2	.16	.06	.08	8
		2.1	2.3	2.7	3.6	4.0	5.1	6.4	7.2	8.7	4.8							
59 CAL 389	917	220	130	71	32	22	10	3.6	1.7	------	22	7.1	2.1	1.3	.23	.17	.22	22
		2.2	2.9	3.8	5.0	5.5	6.6	8.1	9.2		5.5							
59 CAL 390	1,037	230	210	160	61	28	4.6	------	------	------	------	------	------	------	------	------	------	43
		2.1	2.3	2.7	4.0	5.2	7.8											
59 CAL 391	1,058	200	170	140	97	76	38	16	10	4.2	41	5.0	1.6	1.1	.15	.09	.10	4
		2.4	2.5	2.8	3.4	3.7	4.7	5.9	6.6	7.9	4.6							
59 CAL 392	1,099	7,300	6,100	4,600	2,700	2,100	680	270	130	2.7	630	.7	2.2	1.5	.08	−.09	−.14	5
		−2.9	−2.6	−2.2	−1.4	−1.0	.6	1.9	2.9	8.5	0.7							
59 CAL 393	1,117	1,200	880	550	240	170	36	2.5	------	------	170	------	------	3.0	------	.26	.78	25
		−0.3	.2	.9	2.1	2.6	4.8	8.6			2.5							
59 CAL 394	1,156	1,600	1,100	590	180	88	19	2.2	------	------	32	------	------	2.7	------	.17	.45	28
		−0.7	−0.1	0.8	2.5	3.5	5.7	8.8			4.9							
59 CAL 395	1,184	2,500	1,700	870	340	230	74	14	2.6	------	42	5.1	3.5	2.0	.38	.19	.39	16
		−1.3	−0.8	.2	1.5	2.1	3.8	6.2	8.6	------	4.6							
59 CAL 396	1,241	190	170	140	85	55	10	1.3	------	------	------	------	------	2.7	------	.08	.23	34
		2.4	2.5	2.8	3.6	4.2	6.6	9.6										

TABLE 8.—*Particle-size data for cored sediments, Tulare-Wasco area*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / φ) 1 (C)	2	5	16	25	50 (Md)	75	84	95	Mode (microns / φ)	M_ϕ	Deviations σ_ϕ	QD_ϕ	Skewness α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	Finer than 3 microns (percent)
Richgrove core—Continued																		
59 CAL 397	1,363	240 2.1	230 2.2	190 2.4	100 3.3	60 4.1	18 5.8	4.4 7.8	------	------	31 5.0	------	------	1.9	------	0.10	0.18	23
59 CAL 398	1,370	950 .1	650 .6	430 1.2	290 1.8	230 2.1	130 2.9	14 6.2	2.0 9.0	------	190 2.4	5.4	3.6	2.0	0.70	.62	1.27	17
59 CAL 399	1,421	1,300 −0.4	1,100 −0.1	870 .2	610 .7	520 1.0	220 2.2	4.7 7.7	------	------	530 0.9	------	------	3.4	------	.63	2.12	22
59 CAL 400	1,431	1,800 −0.9	1,600 −0.7	1,200 −0.3	680 .6	530 .9	150 2.7	6.2 7.3	1.1 9.8	------	680 0.5	5.2	4.6	3.2	.53	.43	1.38	21
59 CAL 401	1,447	200 2.3	180 2.5	150 2.7	100 3.3	56 4.2	15 6.0	2.2 8.8	------	------	33 4.9	------	------	2.3	------	.20	.47	28
59 CAL 402	1,492	1,400 −0.4	1,100 −0.1	690 .5	380 1.4	300 1.7	150 2.8	48 4.4	6.5 7.3	------	260 1.9	4.3	2.9	1.3	.53	.23	.30	15
59 CAL 403	1,527	240 2.1	230 2.1	190 2.4	100 3.3	56 4.1	14 6.2	1.8 9.1	------	------	31 5.0	------	------	2.5	------	.18	.45	28
59 CAL 404	1,688	230 2.1	210 2.3	170 2.5	130 2.9	85 3.6	10 6.6	1.3 9.6	------	------	------	------	------	3.0	------	.00	−.01	31
59 CAL 405	1,721	250 2.0	240 2.0	230 2.1	200 2.4	170 2.6	100 3.3	26 5.3	11 6.4	2.8 8.5	160 2.6	4.4	2.0	1.4	.54	.46	.63	5
59 CAL 406	1,752	6,600 −2.7	5,400 −2.4	3,800 −1.9	210 2.3	160 2.6	85 3.5	22 5.5	6.4 7.3	1.5 9.4	120 3.0	4.8	2.5	1.4	.49	.37	.53	10
59 CAL 407	1,785	760 .4	610 .7	430 1.2	240 2.0	200 2.4	110 3.1	29 5.1	16 6.0	4.3 7.9	180 2.5	4.0	2.0	1.4	.45	.44	.60	4
59 CAL 408	1,803	1,600 −.7	1,300 −.4	870 .2	370 1.4	220 2.2	96 3.4	33 4.9	14 6.1	------	83 3.6	3.8	2.3	1.4	.17	.13	.18	10
59 CAL 409	1,814	4,000 −2.0	3,200 −1.7	2,200 −1.2	1,100 −.1	670 .6	190 2.4	83 3.6	55 4.2	3.7 8.1	99 3.3	2.0	2.1	1.5	−.15	−.19	−.29	4
59 CAL 410	1,827	210 2.3	190 2.4	160 2.6	130 2.9	89 3.5	15 6.0	3.8 8.1	2.7 8.5	1.4 9.5	150 2.7	5.7	2.8	2.3	−.10	−.11	−.24	20
59 CAL 411	1,892	210 2.2	200 2.4	170 2.5	140 2.8	130 3.0	38 4.7	5.3 7.6	3.7 8.1	2.5 8.7	160 2.6	5.4	2.6	2.3	.27	.23	.53	20
59 CAL 412	1,912	540 .9	410 1.3	270 1.9	120 3.1	100 3.3	75 3.7	27 5.2	7.3 7.1	------	75 3.7	5.1	2.0	1.0	.66	.53	.51	13
59 CAL 413	1,943	420 1.2	370 1.4	300 1.7	220 2.2	200 2.3	150 2.7	110 3.2	83 3.6	51 4.3	170 2.6	2.9	.7	.4	.20	.13	.06	3
59 CAL 414	1,956	2,300 −1.2	1,900 −.9	1,500 −.6	990 .0	810 .3	540 .9	330 1.6	250 2.0	120 3.0	610 .7	1.0	1.0	.7	.11	.11	.07	1
59 CAL 415	1,964	3,200 −1.7	2,700 −1.4	2,100 −1.0	1,400 −.5	1,100 −.2	710 .5	360 1.5	210 2.3	65 3.9	820 .3	.9	1.4	.8	.30	.18	.15	1
59 CAL 416	2,010	2,500 −1.3	2,100 −1.1	1,700 −.8	1,200 −.3	1,100 −.1	730 .5	500 1.0	300 1.7	90 3.5	780 3.4	.7	1.0	.6	.25	.02	.01	1
59 CAL 417	2,051	3,500 −1.8	3,000 −1.6	2,300 −1.2	1,300 −.4	990 .0	330 1.6	180 2.4	150 2.8	67 3.9	210 2.3	1.2	1.6	1.2	−.27	−.31	−.37	1
59 CAL 418	2,102	14,000 −3.8	11,000 −3.5	7,300 −2.9	3,800 −1.9	2,800 −1.5	1,300 −.4	310 1.7	180 2.5	71 3.8	2,200 −1.1	.3	2.2	1.6	.30	.31	.49	1
59 CAL 419	2,174	1,400 −.5	1,200 −.3	930 .1	520 .9	410 1.3	250 2.0	150 2.7	110 3.2	35 4.8	270 1.9	2.1	1.1	.7	.09	.05	.04	1

TABLE 9.—*Particle-size data for cored sediments, Santa Clara Valley*

[Particle-size analyses made by the Hydrologic Laboratory of the U.S. Geological Survey, Denver, Colo.]

Sample	Depth below land surface (feet)	Percentiles (microns / φ) 1 (C)	2	5	16	25	50 (Md)	75	84	95	Mode (microns / φ)	M_ϕ	Deviations σ_ϕ	QD_ϕ	Skewness α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	Finer than 3 microns (percent)
Sunnyvale core																		
60 CAL 10	37	2,000 −1.0	620 0.7	290 1.8	130 3.0	88 3.5	33 4.9	7.7 7.0	2.2 8.9	------	40 4.7	5.9	2.9	1.8	0.34	0.20	0.35	17
60 CAL 11	50	4,000 −2.0	1,400 −0.5	200 2.3	69 3.9	39 4.7	11 6.5	1.0 10.0	------	------	------	------	------	2.6	------	.31	.81	33
60 CAL 12	72	210 2.3	180 2.5	150 2.8	75 3.7	44 4.5	12 6.3	1.8 9.1	------	------	32 5.0	------	------	2.3	------	.20	.47	28
60 CAL 13	91	200 2.3	140 2.8	79 3.7	21 5.6	11 6.4	3.1 8.4	------	------	------	------	------	------	------	------	------	------	51
60 CAL 14	101	150 2.8	98 3.3	45 4.5	19 5.7	13 6.3	4.8 7.7	1.2 9.7	------	------	------	------	------	1.7	------	.18	.30	40
60 CAL 15	113	140 2.9	70 3.8	28 5.2	7.0 7.2	4.6 7.8	1.9 9.1	------	------	------	------	------	------	------	------	------	------	63
60 CAL 16	121	42 4.6	30 5.1	18 5.8	9.3 6.7	6.6 7.2	2.9 8.4	1.0 9.9	------	------	------	------	------	1.3	------	.13	.17	49
60 CAL 17	131	170 2.6	140 2.9	94 3.4	46 4.4	31 5.0	14 6.2	4.6 7.8	1.9 9.1	------	29 5.1	6.8	2.3	1.4	.24	.12	.17	20
60 CAL 18	141	9,800 −3.3	4,900 −2.3	290 1.8	75 3.7	35 4.9	5.1 7.6	------	------	------	------	------	------	------	------	------	------	43
60 CAL 19	151	170 2.6	140 2.9	62 4.0	15 6.0	8.8 6.8	2.9 8.4	------	------	------	------	------	------	------	------	------	------	50
60 CAL 20	160	83 3.6	51 4.3	29 5.1	12 6.3	8.5 6.9	2.8 8.5	------	------	------	------	------	------	------	------	------	------	53
60 CAL 21	178	180 2.4	160 2.7	130 3.0	53 4.2	28 5.1	7.2 7.1	------	------	------	------	------	------	------	------	------	------	26

TABLE 9.—*Particle-size data for cored sediments, Santa Clara Valley*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / φ) 1 (C)	2	5	16	25	50 (Md)	75	84	95	Mode (microns / φ)	M_ϕ	Deviations σ_ϕ	QD_ϕ	Skewness α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	Finer than 3 microns (percent)
Sunnyvale Core—Continued																		
60 CAL 22	192	2,300 −1.2	880 1.8	230 2.1	82 3.6	40 4.6	7.6 7.0											39
60 CAL 23	210	220 2.2	190 2.4	120 3.0	77 3.7	61 4.0	27 5.2	7.7 7.0	3.0 8.4		37 4.8	6.0	2.3	1.5	0.35	0.21	0.31	16
60 CAL 24	223	75 3.7	48 4.4	28 5.2	13 6.3	9.0 6.8	3.7 8.1											44
60 CAL 25	229	2,800 −1.5	410 1.3	220 2.2	120 3.1	81 3.6	27 5.2	6.1 7.4	2.6 8.6		39 4.7	5.8	2.8	1.9	.23	.15	.28	17
60 CAL 26	236	2,900 −1.6	2,300 −1.2	320 1.6	130 2.9	79 3.7	21 5.5	4.6 7.8	1.8 9.1		33 4.9	6.0	3.1	2.1	.15	.09	.17	20
60 CAL 27	254	2,000 −1.0	250 2.0	170 2.5	93 3.4	66 3.9	27 5.2	6.7 7.2	3.1 8.3		37 4.8	5.9	2.5	1.7	.27	.21	.34	15
60 CAL 28	307	140 2.8	97 3.4	59 4.1	29 5.1	20 5.6	7.2 7.1											34
60 CAL 29	313	560 0.8	370 1.4	180 2.5	42 4.6	24 5.4	7.4 7.1	1.3 9.6						2.1		.19	.40	33
60 CAL 30	330	280 1.8	210 2.3	150 2.8	53 4.3	29 5.1	6.6 7.2	1.5 9.4			31 5.0			2.1		.00	.00	35
60 CAL 31	345	240 2.1	200 2.3	150 2.7	79 3.7	52 4.3	20 5.7	3.4 8.2	1.1 9.8		34 4.9	6.7	3.1	2.0	.35	.30	.59	24
60 CAL 32	362	4,700 −2.2	2,800 −1.5	420 1.2	130 3.0	43 4.6	8.5 6.9	1.6 9.3						2.4		.02	.04	33
60 CAL 33	409	340 1.6	190 2.4	110 3.2	39 4.7	22 5.4	6.9 7.2	1.0 10.0						2.3		.24	.55	37
60 CAL 34	420	830 0.3	470 1.1	260 2.0	150 2.7	110 3.2	33 4.9	5.9 7.4	1.5 9.4		44 4.5	6.1	3.3	2.1	.35	.19	.40	19
60 CAL 35	432	460 1.1	360 1.5	240 2.0	130 3.0	77 3.7	21 5.6	2.6 8.6						2.5		.22	.55	26
60 CAL 36	437	8,000 −3.0	1,500 −0.6	410 1.3	170 2.5	110 3.2	22 5.5	2.9 8.4						2.6		.13	.33	25
60 CAL 37	446	1,600 −0.6	1,200 −0.3	640 0.6	180 2.5	64 4.0	6.7 7.2	1.6 9.2						2.6		−.23	−.61	33
60 CAL 38	459	210 2.3	160 2.6	110 3.2	53 4.2	36 4.8	15 6.0	3.6 8.1			30 5.1			1.7		.26	.43	23
60 CAL 39	463	220 2.2	200 2.4	160 2.6	130 3.0	92 3.4	36 4.8	4.2 7.9	1.1 9.8		50 4.3	6.4	3.4	2.2	.47	.39	.86	23
60 CAL 40	523	810 0.3	640 0.6	410 1.3	130 2.9	57 4.1	11 6.5	1.4 9.4						2.7		.10	.27	31
60 CAL 41	545	160 2.6	130 2.9	86 3.5	37 4.7	24 5.4	8.9 6.8	1.7 9.2			27 5.2			1.9		.26	.49	31
60 CAL 42	555	1,700 −0.7	1,100 −0.2	330 1.6	140 2.8	97 3.4	33 4.9	4.7 7.7			41 4.6			2.2		.30	.65	23
60 CAL 43	563	460 1.1	330 1.6	200 2.3	60 4.1	32 5.0	7.9 7.0	1.2 9.7						2.4		.16	.37	35
60 CAL 44	575	220 2.2	150 2.8	80 3.6	33 4.9	22 5.5	8.0 7.0	1.7 9.2			27 5.2			1.8		.20	.37	33
60 CAL 45	606	2,400 −1.3	1,100 −1.0	390 1.4	140 2.9	80 3.6	16 5.9	1.3 9.6						3.0		.23	.69	31
60 CAL 46	634	370 1.4	280 1.8	210 2.3	140 2.8	110 3.2	28 5.1	2.9 8.4						2.6		.27	.69	25
60 CAL 47	657	380 1.4	280 1.8	200 2.3	120 3.0	68 3.9	8.7 6.8											37
60 CAL 48	666	8,000 −3.0	460 1.1	120 3.1	77 3.7	63 4.0	19 5.7	3.0 8.4			42 4.6			2.2		.23	.50	25
60 CAL 49	716	330 1.6	240 2.1	140 2.8	39 4.7	19 5.7	3.4 8.2											48
60 CAL 50	736	350 1.5	290 1.8	210 2.2	120 3.1	79 3.7	24 5.4	2.1 8.9			39 4.7			2.6		.35	.92	26
60 CAL 51	745	160 2.6	110 3.2	69 3.9	20 5.7	11 6.5	2.8 8.5											53
60 CAL 52	757	160 2.6	130 2.9	80 3.7	21 5.6	9.3 6.8	1.8 9.2											59
60 CAL 53	773	180 2.5	140 2.8	62 4.0	26 5.3	17 5.9	7.7 7.0	2.6 8.6	1.4 9.5		16 6.0	7.4	2.1	1.4	.16	.14	.19	27
60 CAL 54	790	250 2.0	100 3.3	63 4.0	17 6.0	10 6.6	3.7 8.1	1.1 9.9						1.6		.08	.13	45
60 CAL 55	797	240 2.1	210 2.2	180 2.5	130 2.9	110 3.2	66 3.9	25 5.3	12 6.3		68 3.9	4.6	1.7	1.1	.42	.33	.35	9
60 CAL 56	812	160 2.7	125 3.0	91 3.5	48 4.4	29 5.1	7.2 7.1	1.4 9.5			33 4.9			2.2		.08	.18	36
60 CAL 57	824	67 3.9	54 4.2	40 4.6	25 5.3	20 5.6	8.5 6.9	1.8 9.1			28 5.2			1.7		.29	.50	32
60 CAL 58	836	400 1.3	360 1.5	310 1.7	240 2.1	210 2.2	160 2.6	130 3.0	80 3.6	6.0 7.4	180 2.5	2.9	.8	.4	.30	.00	.00	4
60 CAL 59	842	40 4.6	32 5.0	23 5.4	13 6.2	9.7 6.7	4.1 7.9	1.1 9.8						1.6		.21	.34	41
60 CAL 60	854	140 2.8	84 3.6	28 5.1	8.5 6.9	5.2 7.6	1.9 9.1											63
60 CAL 61	866	62 4.0	32 5.0	13 6.2	6.4 7.3	4.4 7.8	1.8 9.2											64
60 CAL 62	874	190 2.4	170 2.6	140 2.9	72 3.8	44 4.5	10 6.6											36
60 CAL 63	883	310 1.7	250 2.0	170 2.6	70 3.8	43 4.5	15 6.1	1.2 9.7			33 4.9			2.6		.40	1.03	31
60 CAL 64	900	250 2.0	190 2.4	120 3.1	27 5.2	11 6.5	2.3 8.8											56
60 CAL 65	910	150 2.8	110 3.2	52 4.3	17 5.9	8.1 6.9	2.6 8.6											55
60 CAL 66	924	160 2.6	98 3.3	34 4.9	7.5 7.1	3.7 8.1	1.3 9.6											72
60 CAL 67	937	300 1.8	220 2.2	120 3.1	22 5.5	8.6 6.9	.8 10.3											65

TABLE 9.—*Particle-size data for cored sediments, Santa Clara Valley*—Continued

Sample	Depth below land surface (feet)	Percentiles (microns / φ) 1 (C)	2	5	16	25	50 (Md)	75	84	95	Mode (microns / φ)	M_ϕ	Deviations σ_ϕ	QD_ϕ	Skewness α_ϕ	$\frac{Skq_\phi}{QD_\phi}$	Skq_ϕ	Finer than 3 microns (percent)
Sunnyvale core—Continued																		
60 CAL 68	959	220	150	110	71	48	8.0	1.1						2.7		0.06	0.15	38
		2.2	2.7	3.2	3.8	4.4	7.0	9.9										
60 CAL 69	967	1,000	460	220	43	25	6.1											41
		.0	1.1	2.2	4.5	5.3	7.3											
San Jose core																		
60 CAL 70	197	430	320	220	120	60	6.2											45
		1.2	1.6	2.2	3.1	4.1	7.3											
60 CAL 71	207	120	110	92	70	61	21	5.6	2.1		42	6.3	2.5	1.7	0.31	0.10	0.18	19
		3.0	3.2	3.4	3.8	4.0	5.6	7.5	8.9		4.6							
60 CAL 72	233	170	125	66	26	17	5.4	1.3						1.8		.11	.21	37
		2.5	3.0	3.9	5.3	5.9	7.5	9.6										
60 CAL 73	258	12,000	8,300	400	78	48	12											33
		−3.5	−3.0	1.3	3.7	4.4	6.4											
60 CAL 74	276	470	320	180	70	44	16	3.5	1.0		30	6.9	3.1	1.8	.31	.20	.36	23
		1.1	1.6	2.5	3.8	4.5	6.0	8.2	10.0		5.0							
60 CAL 75	301	4,000	690	220	95	58	19	2.0			34			2.4		.34	.84	27
		−2.0	.5	2.2	3.4	4.1	5.7	9.0			4.9							
60 CAL 76	324	2,800	1,000	630	410	360	270	170	140	33	300	2.1	.8	.5	.21	.19	.10	4
		−1.5	.0	.7	1.3	1.5	1.9	2.5	2.9	4.9	1.7							
60 CAL 77	334	67	49	31	15	11	4.4	1.0						1.7		.27	.46	41
		3.9	4.3	5.0	6.0	6.5	7.8	10.0										
60 CAL 78	355	290	230	190	130	110	52	17	4.4		50	5.4	2.5	1.3	.45	.23	.30	14
		1.8	2.1	2.4	2.9	3.2	4.3	5.9	7.8		4.3							
60 CAL 79	402	42	34	26	16	10	3.4											47
		4.6	4.9	5.3	6.0	6.6	8.2											
60 CAL 80	430	560	390	240	120	71	18	2.2			34			2.5		.22	.54	27
		0.8	1.4	2.1	3.0	3.8	5.8	8.8			4.9							
60 CAL 81	441	740	540	390	250	200	130	63	25	1.1	170	3.7	1.7	.8	.46	.28	.24	7
		0.4	0.9	1.3	2.0	2.3	2.9	4.0	5.3	9.9	2.6							
60 CAL 82	510	8,500	6,000	2,900	190	110	24	1.8						3.0		.27	.79	28
		−3.1	−2.6	−1.5	2.4	3.2	5.4	9.1										
60 CAL 83	531	2,700	1,000	390	150	90	25	2.4			35			2.6		.30	.78	26
		−1.5	0.0	1.3	2.7	3.5	5.3	8.7			4.9							
60 CAL 84	555	1,400	830	420	200	140	39	6.6	1.1		37	6.1	3.8	2.2	.38	.16	.35	19
		−0.5	0.3	1.3	2.3	2.9	4.7	7.3	9.9		4.8							
60 CAL 85	570	500	370	240	130	89	32	7.1	1.5		37	6.1	3.2	1.8	.36	.19	.35	20
		1.0	1.4	2.1	2.9	3.5	5.0	7.1	9.4		4.8							
60 CAL 86	599	6,800	4,800	1,400	230	160	51	10	2.1		38	5.5	3.4	2.0	.36	.17	.33	17
		−2.8	−2.3	−0.5	2.1	2.6	4.3	6.6	8.9		4.7							
60 CAL 87	697	4,000	2,300	390	110	56	14	2.3			31			2.3		.14	.33	27
		−2.0	−1.2	1.4	3.2	4.2	6.1	8.8			5.0							
60 CAL 88	705	5,400	3,800	2,300	610	390	160	24	5.9		290	4.1	3.3	2.0	.41	.35	.70	12
		−2.4	−1.9	−1.2	0.7	1.4	2.7	5.4	7.4		1.8							
60 CAL 89	725	1,200	720	270	88	48	12											35
		−0.3	0.5	1.9	3.5	4.4	6.4											
60 CAL 90	750	27,000	23,000	15,000	8,500	5,700	1,500	470	310	51	640	−.7	2.4	1.8	−.03	−.05	−.09	2
		−4.8	−4.5	−3.9	−3.1	−2.5	−0.6	1.1	1.7	4.3	0.6							
60 CAL 91	791	1,200	410	220	100	69	22	3.6	1.4		37	6.4	3.1	2.1	.28	.22	.47	23
		−0.2	1.3	2.2	3.3	3.9	5.5	8.1	9.5		4.8							
60 CAL 92	812	170	140	110	61	44	22	7.8	3.3		33	6.1	2.1	1.3	.30	.20	.25	15
		2.5	2.8	3.2	4.0	4.5	5.5	7.0	8.2		4.9							
60 CAL 93	833	250	200	140	74	51	19	4.4	1.5		33	6.6	2.8	1.8	.29	.18	.32	22
		2.0	2.3	2.9	3.8	4.3	5.7	7.8	9.4		4.9							
60 CAL 94	848	220	180	140	74	52	23	6.5	2.2		34	6.3	2.5	1.5	.34	.22	.33	17
		2.2	2.5	2.9	3.7	4.3	5.4	7.3	8.8		4.9							
60 CAL 95	909	320	230	150	69	43	16	3.1	1.0		32	6.9	3.1	1.9	.30	.23	.43	25
		1.6	2.1	2.7	3.9	4.5	6.0	8.3	10.0		5.0							
60 CAL 96	938	470	330	190	62	37	11	1.5			30			2.3		.26	.60	31
		1.1	1.6	2.4	4.0	4.8	6.5	9.4			5.1							

ANALYTICAL PROCEDURES AND TABULATED RESULTS OF CLAY-MINERAL STUDY

CLAY-MINERAL SEPARATION

As an aid to the study of clay minerals, material coarser than 2μ is removed from a sediment in order that the characteristics of the clay minerals may be observed more clearly. Three different but similar procedures were used to separate the $<2\mu$ fractions of the sediments discussed in this report. The first procedure was used in the Sedimentary Petrology Laboratory of the Geological Survey to separate the clay minerals from 25 samples from the Mendota and Huron cores of the Los Banos-Kettleman City area. It is described by Hathaway (1956). The second procedure was used on the other 76 samples from the Los Banos-Kettleman City area. The third procedure, which improved on the second, was used to separate the clay minerals from sediments of the Tulare-Wasco, Santa Clara Valley, and Arvin-Maricopa areas.

The procedure used on most of the samples from the Los Banos-Kettleman City area is as follows. Twenty grams of air-dry fine sediment was—

1. Ground with a wooden pestle in a porcelain dish,
2. Placed in 200–300 ml of 0.05–0.1*N* sodium hexametaphosphate (Calgon) solution,

3. Stirred for 5–10 minutes with a glass rod and left standing for several days,
4. Stirred mechanically on a Hamilton Beach milkshake machine for 1 minute, and
5. Poured through a 230-mesh (U.S. Standard) sieve, and centrifuged to split off material coarser than 2μ.
6. The material finer than 2μ was centrifuged until all material coarser than 0.2μ had been removed from the suspension.
7. The concentrated 0.2μ–2.0μ fraction was placed on glass slides (26×45 mm) on which it dried at room temperature and formed oriented aggregates.
8. The aggregates were placed in the X-ray diffractometer for identification of the clay minerals.

The high concentration of sodium hexametaphosphate used in step 2 is not recommended for general use because in some samples (especially those from streams and near-surface alluvial-fan deposits) it provided enough sodium to replace the exchangeable calcium and magnesium that had been adsorbed by the clay minerals in their natural state. This made it impossible to draw inferences about the original adsorbed cations from the X-ray diffraction pattern. The dispersing effect of sodium hexametaphosphate seems to be time dependent: samples that were allowed to soak in the solution for a few days dispersed more readily than samples that had soaked in the solution for only a few hours. No dispersing agent was added to the samples from the Tulare-Wasco area, Arvin-Maricopa area, and Santa Clara Valley; these sediments were dispersed in an ultrasonic generator.

Material finer than 0.2μ usually was discarded without being analyzed. This did not seem to introduce significant error into the estimates of clay-mineral proportions because, as table 10 shows, the compositions of the 0.2μ–2.0μ fraction and a finer fraction, 0.1μ–0.2μ, in selected samples, do not differ significantly. More detailed study of the sediments in the Tulare-Wasco area and the Santa Clara Valley, however, indicates that the differences between the two size fractions may be significant—the principal difference being a slightly greater proportion of montmorillonite in the finer clay fraction. In spite of this, the proportion of the clay minerals in the 0.2μ–2.0μ fraction probably represents the proportions of the clay minerals in the sediments as a whole because (1) the bulk of the clay minerals is found in this size fraction and (2) the greater proportion of montmorillonite in the finest clay fraction (<0.2μ) is offset by the lesser proportion in the coarsest fraction (>2.0μ, which was analyzed in a few samples). Hathaway (1956, p. 9) and his associates at the Sedimentary Petrology Laboratory avoided the problem by recovering all the material finer than 2μ, using a filter candle under vacuum to remove water and concentrate the clay suspension.

TABLE 10.—*Proportions of clay minerals in two clay-size fractions of sediments from Los Banos-Kettleman City area*

Core hole	Depth below land surface (feet)	Size fraction (μ)	Clay minerals (estimated parts per ten)				
			Montmorillonite	Mixed-layer montmorillonite-illite	Illite	Low-grade illite-montmorillonite	Chlorite and kaolinite-type mineral[1]
Mendota	75	0.2–2.0	7	0	Tr.	Tr.	2 D
Do	75	.1–.2	6	0	1	1	2 D
Do	551	.2–2.0	6	0	1	Tr.	2 B
Do	551	.1–.2	6	0	1	1	2 D
Do	981	.2–2.0	6	0	1	1	2 D
Do	981	.1–.2	7	0	1	Tr.	2 D
Do	1,400	.2–2.0	8	0	Tr.	1	Tr.
Do	1,400	.1–.2	8	0	Tr.	1	Tr.
Cantua Creek	1,238	.2–2.0	6	0	1	Tr.	2 D
Do	1,238	.1–.2	7	0	2	Tr.	1 D
Huron	470	.2–2.0	6	0	2	Tr.	2 B
Do	470	.1–.2	6	0	1	Tr.	3 D
Stream	*Material sampled*						
Little Panoche	Suspended	0.2–2.0	2	2	4	0	1 A
Do	do	.1–.2	3	2	3	Tr.	2 D
Panoche	do	.2–2.0	7	0	1	0	2 C
Do	do	.1–.2	7	0	1	Tr.	2 C
Cantua	do	.2–2.0	7	0	1	0	2 D
Do	do	.1–.2	7	0	1	Tr.	2 D
Salt	do	.2–2.0	7	0	1	Tr.	2 D
Do	do	.1–.2	7	0	1	Tr.	2 D

[1] Letters refer to mineral types shown in fig. 40.

The procedure used on the samples from the Tulare-Wasco area, the Arvin-Maricopa area, and the Santa Clara Valley is as follows. About 5 grams of air-dry fine sediment was—

1. Ground with a wooden pestle in a porcelain dish and
2. Placed in about 100 ml of distilled water, stirred briefly, and left standing overnight.
3. The sediment was dispersed (no chemical dispersing agent was added) by an ultrasonic generator for ½–1 hr.
4. Concentrated slurries of two size fractions—0.2μ–2.0μ and 0.1μ–0.2μ—were separated by centrifuging.
5. Oriented aggregates of the size fractions were made on porous ceramic plates (26×45 mm), such as those described by Kinter and Diamond (1956). The slurries were placed on the plates with a dropper, and the water was sucked out of the slurry, through the pores of the plate, by a vacuum pump.
6. The aggregates, when dry, were placed in the X-ray diffractometer for identification of the clay minerals.

Several of the sediments from the Richgrove core and all the samples from San Francisco Bay, because they contained substantial amounts of soluble salts, flocculated during the centrifuging process. The salts were washed from these sediments by repeated decanting and centrifuging until the fine-grained material remained dispersed.

X-RAY DIFFRACTION

The clay minerals were identified by X-ray diffraction using a Norelco diffractometer and nickel-filtered copper radiation. The minimum angular aperture through which the X-ray beam was transmitted was 1°. The oriented clay aggregates were placed in the diffractometer in such a way that the maximum width of the sample intersected by the beam was 26 mm (in the Los Banos-Kettleman City sediments) or 45 mm (in the Tulare-Wasco, Arvin-Maricopa, and Santa Clara Valley sediments). Four diffraction patterns were made from oriented aggregates of most of the samples, as follows:

1. Air dry,
2. Treated with glycerol (most of the Los Banos-Kettleman City sediments) or ethylene glycol (Tulare-Wasco, Arvin-Maricopa, and Santa Clara Valley sediments),
3. Heated to 400° Celsius (centigrade) for 45–60 minutes, and
4. Heated to 525° C or 550° C for 45–60 minutes.

Diffraction patterns were also recorded from the 0.2μ–2.0μ fractions of samples from the Tulare-Wasco area and Santa Clara Valley that had been suspended in 2N $MgCl_2$ and 5–10 percent glycerol solution. This is the procedure suggested by Walker (1958; 1961, p. 314–317) for distinguishing between montmorillonite and vermiculite.

IDENTIFICATION OF CLAY MINERALS

MONTMORILLONITE AND VERMICULITE

Figure 39 shows X-ray diffraction patterns of two expanding-lattice minerals. The upper row of patterns shows a montmorillonite (shaded reflections) whose exchange positions are saturated with sodium. The pat-

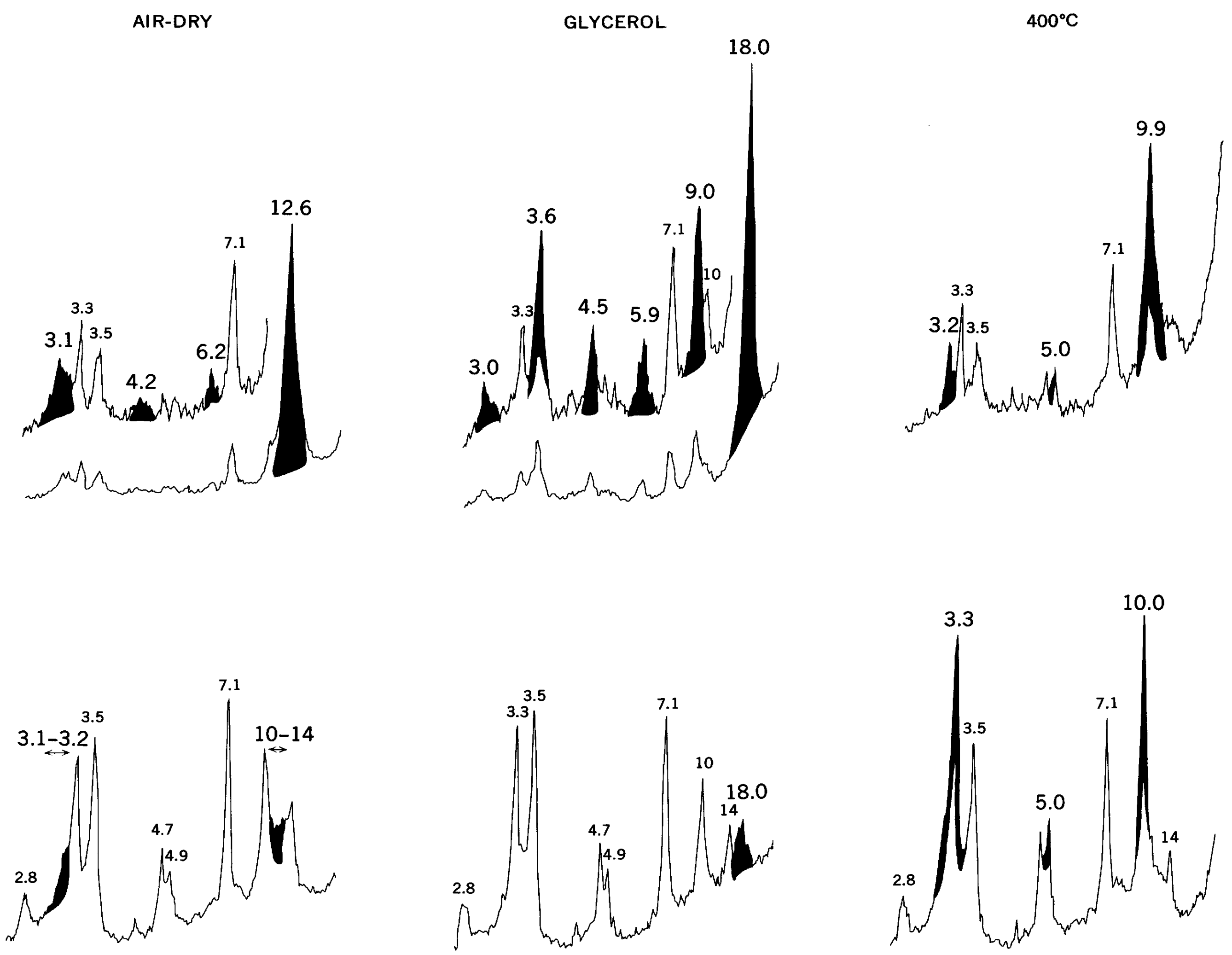

FIGURE 39.—X-ray diffraction patterns of oriented aggregates of expanding clay minerals. CuKα radiation: scanning speed 2° per minute. Locations of reflections given in Angstrom units. Ordinate is linear intensity. Upper row, Montmorillonite (shaded reflections) from sediment suspended in Cantua Creek. Saturated with sodium hexametaphosphate. Lower row, Mixed-layer montmorillonite-illite (shaded reflections) from depth of 154 feet in Oro Loma core hole. Saturated with soduim by treatment with dithionite and sodium citrate (Mehra and Jackson, 1960).

terns for air-dry and glycerol-treated montmorillonite were made at two different scales to show clearly the higher order basal reflections as well as the much stronger (001) reflection. The pattern for montmorillonite heated to 400°C was made at the same scale as the upper patterns for air-dry and glycerol-treated montmorillonite. The patterns in the upper row of figure 39 also contain reflections (unshaded) from type-B chlorite, a kaolinite-type mineral, illite, and quartz.

Montmorillonite was identified mainly on the basis of X-ray reflections it gave when expanded with organic liquids: an integral series of basal reflections related to 18 A [2] when treated with glycerol, or an integral series related to 17 A when treated with ethylene glycol. As recorded in the X-ray diffraction pattern (not corrected for 2θ angle, that is), the intensity (area) of the (001) reflection at 17 or 18 A is 20 or more times the intensity of the higher order basal reflections. Air-dry montmorillonite whose exchange positions are occupied by magnesium or calcium gives broad basal reflections at 15 and 5 A and a diffuse band of reflections in the region between 3.0 and 3.3 A. When its exchange positions are occupied by sodium, air-dry montmorillonite gives a nearly integral series of reflections related to 12.6 A. After the montmorillonite is heated to 400°C, its reflections enhance those of illite at 3.3 and 10 A; a broad and sometimes diffuse reflection appears in the region between 4.8 and 5.1 A, and a diffuse reflection appears near 3.2 A. After the mineral is heated to 525° or 550°C, the intensity of the reflection near 5 A is usually reduced, and the intensity of the 3.2-A reflection, relative to the reflection at 3.3 A, is usually enhanced.

Vermiculite was identified by a procedure recommended by Walker (1958; 1961, p. 314–317): combined treatment with glycerol and either magnesium chloride or sodium hexametaphosphate. According to Walker, the montmorillonite lattice will expand to 18 A after such a treatment, whereas the vermiculite lattice will not expand beyond 15 A. Otherwise, the X-ray diffraction pattern of vermiculite and the responses of vermiculite to treatment with ethylene glycol and heat are similar to those of montmorillonite. Vermiculite was positively identified in only one of the eight cores—the Pixley core from the Tulare-Wasco area.

MIXED-LAYER MONTMORILLONITE-ILLITE

Another expanding-lattice mineral found in a few of the sediments in the Los Banos-Kettleman City area is tentatively identified as mixed-layer montmorillonite-illite. X-ray diffraction patterns of a sample of this mineral are shown by the shaded reflections in the lower row of figure 39. This sample was saturated with sodium by treatment with dithionite and sodium citrate (Mehra and Jackson, 1960). The lower row of patterns also contains reflections (unshaded) from illite, type-A chlorite, and quartz.

[2] Angstrom unit=10^{-8}cm.

Mixed-layer montmorillonite-illite, when treated with glycerol, gives a diffuse basal reflection at 18 A without giving any detectable higher order basal reflections. When heated to 400° C, the mineral gives an integral series of sharp basal reflections related to 9.9 or 10.0 A. The intensity of the 10–A reflection from the heated mineral is several times greater than one would expect from the intensity of the reflection from the 001 plane of the mineral when it is expanded to 18 A. The diffuse band of reflections in the 10- to 14-A region is typical of the material when it is air dry and saturated with sodium. When the air-dry mineral is saturated with calcium and magnesium, the reflections are somewhat sharper and closer to 14 or 15 A.

Although this mineral expands to 18 A when treated with glycerol, the broadness of the 18–A reflection and the sharp X-ray diffraction pattern from the heated specimen indicate that the mineral is very different from the type of montmorillonite illustrated in the upper row of figure 39. In contrast to the montmorillonite, it exhibits the greatest degree of structural order in the collapsed rather than in the expanded state. A mineral with similar X-ray diffraction characteristics has been found in the Pierre Shale and identified as a mixed-layer montmorillonite-illite (L. G. Schultz, 1961, oral commun.).

ILLITE

Illite is identified on the basis of the following characteristic series of reflections.

Reflection	Air-dry	Glycerol or ethylene-glycol treated	Heated to 400° C
(001)----	10. 0–10. 2 A	9. 8–10. 0 A	Masked by (001) reflection from collapsed montmorillonite.
(002)-----	4. 98A	4. 93–4. 98A	4.98 A.
(003)-----	3. 33A	3. 35A	3.33 A.

The slight shifts in the basal spacings of illite when treated with glycerol or ethylene glycol seem to indicate the presence of small amounts of expanding material. The intensities of the (001) and (003) reflections are always several times the intensity of the (002) reflection.

LOW-GRADE ILLITE-MONTMORILLONITE MIXTURE

Many samples contained small amounts of a material that is interpreted as a poorly crystalline mixture, not necessarily interlayered, of illite and montmorillonite. It gives a diffuse band of reflections between 9.0 and 10.0 A when treated with glycerol, or between 8.5 and 10 A when treated with ethylene glycol. When heated to 400° C, it gives a diffuse band of reflections between 3.1 and 3.3 A and another between 4.8 and 5.0 A.

CHLORITE

At least two types of chlorite, distinguished from one another on the basis of their crystallinity as inferred from their X-ray diffraction patterns, were found in these sediments. These two are designated arbitrarily "type A" and "type B." Type A (fig. 40, sample *A*) gives an integral series of sharp basal reflections related to 14 A that is not changed by heating the mineral to 400° C. Type-B chlorite gives an integral series of reflections related to 14 A of which the (003) reflection at 4.7 A, poorly developed in air-dry specimens, is enhanced by heating to 400° C (fig. 40, sample *B*). This is presumably also true of the (001) reflection, which is masked by the (001) reflection of montmorillonite in X-ray patterns of air-dry samples. Heating both types of chlorite to 525° or 550° C strengthens the (001) reflection and destroys the higher order reflections. Heating to 650° C (patterns not shown in fig. 40) decreases the intensity of the (001) reflection by about half.

In figure 40, the apparent decrease in the intensity of the reflections from chlorites *A* and *B* after heating to 400° C was not a result of the heat treatment, but came about during an intermediate treatment with ethylene glycol. Although no decrease in the intensity of the reflections was noted between the glycol and heat treatments of these two samples, heating to 400° C did seem to reduce slightly the intensity of reflections from some chlorites.

The type-B chlorite in the Santa Clara Valley is different from the type-B chlorite found in the San Joaquin Valley. Its X-ray diffraction patterns are different from the ones given in figure 40B in that the odd-order reflections are more intense, relative to the even orders, and the reflections at 4.7 and 2.8 A are always clearly visible in patterns from air-dry specimens. The difference does not seem to be in the crystallinity of the chlorite in the Santa Clara Valley: the reflections are as diffuse as those of the type-B chlorite shown in figure 40, and the odd-order reflections are enhanced by heating the mineral to 400° C. The difference may be one of composition. As the odd-order reflections from magnesium-rich chlorites are more intense than the same reflections from iron-rich chlorites (Brindley and Gillery, 1956), perhaps the chlorite in the Santa Clara Valley contains more magnesium and less iron than the chlorites in the San Joaquin Valley.

KAOLINITE-TYPE MINERAL

A kaolinite-type mineral was recognized by its two basal reflections near 7.2 and 3.6 A (fig. 40, sample *C*). In air-dry samples, these reflections are broad, and their peaks are often diffuse—these facts suggest that the mineral is less well crystallized than the type-A and type-B chlorites. After treatment with glycerol or ethylene glycol, the peaks of the reflections may be shifted 0.1°–0.4° 2θ, or the reflections may become asymmetrical—the 7-A reflection toward lower 2θ angles (larger *d* spacings) and the 3.6-A reflection toward higher 2θ angles. In some samples the organic liquids have no apparent effect, whereas in other samples the 3.6-A reflection becomes so diffuse after glycerol or ethylene-glycol treatment that it is barely discernible. After the mineral is heated to 400° C, these reflections are found nearer their air-dry positions, sometimes retaining part of the asymmetry developed during glycerol or ethylene-glycol treatment. After the mineral is heated to 525° or 550° C, these reflections are no longer visible.

Although it has the appropriate 7-A structure, the mineral cannot be identified specifically as kaolinite. The mineral sample whose diffraction pattern is shown in figure 40*C* was also examined in the Sedimentary Petrology Laboratory of the Geological Survey: P. D. Blackmon (1961, written commun.) reported that the mineral did not behave as kaolinite when subjected to the intersalation procedure prescribed by Andrew and others (1960)—a reliable means of distinguishing between kaolinite and structurally similar minerals such as chamosite and antigorite. Neither were any hexagonal terminations seen in the sample under the electron microscope.

Because the identification of the kaolinite-type mineral or minerals was not pertinent to the aims of this study, other samples were not examined thoroughly. Where a mineral occurred whose X-ray diffraction pattern corresponded to figure 40*C*, it was reported as "kaolinite-type mineral" with the understanding that it could be either kaolinite, antigorite, chamosite, or another structurally similar mineral.

The kaolinite-type mineral and type-B chlorite commonly occur together in these sediments. The characteristic X-ray diffraction patterns of such a mixture are shown by sample *D* in figure 40. Double peaks appear at 7.1–7.2 A and at 3.5–3.6 A, and the odd-order reflections are less intense than those from pure type-B chlorite. Heating the mixture overnight in 6 *N* HCl destroys

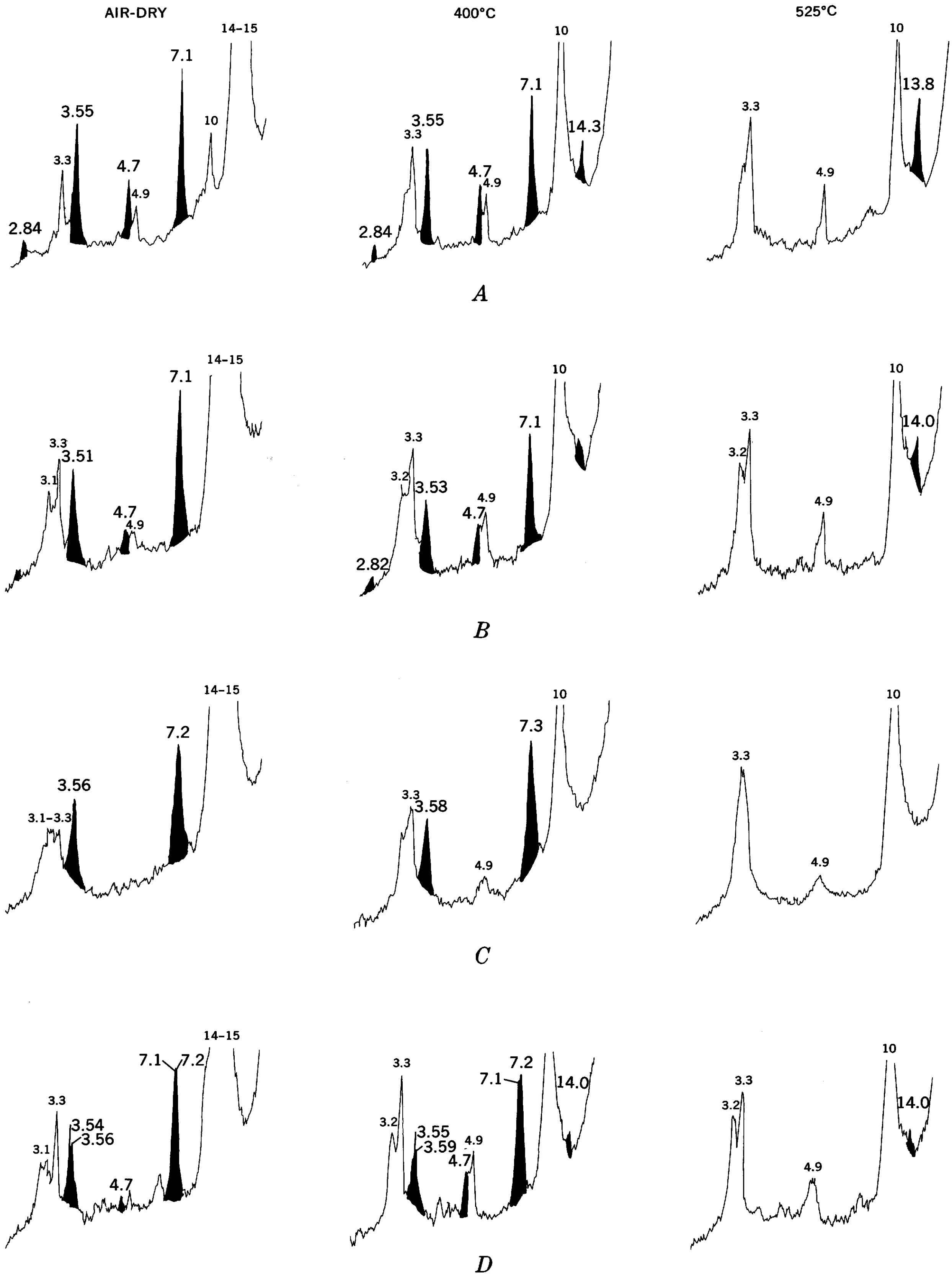

FIGURE 40.—X-ray diffraction patterns of oriented aggregates of chlorite and kaolinite-type minerals. CuKα radiation: scanning speed 2° per minute. Reflections from chlorite and kaolinite-type minerals shaded; locations given in Angstrom units. Ordinate is linear intensity. *A*, Chlorite, well crystallized, from depth of 1,134 feet, Mendota core hole. *B*, Chlorite, moderately well crystallized, from depth of 412 feet, Oro Loma core hole. *C*, Kaolinite-type mineral, from depth of 1,512 feet, Cantua Creek core hole. *D*, Mixture of chlorite (as in *B*) and kaolinite-type mineral from sediment suspended in Cantua Creek.

the chlorite reflections and leaves reflections at 7.2 and 3.6 A.

MINOR CHLORITIC MINERALS

Some of the sediments in the Santa Clara Valley contain a material that gives a small but broad reflection near 12 A when heated to 550° C. No other evidence of this mineral was seen in the X-ray diffraction pattern, and no evidence of it at all was seen at lower temperatures. It has been reported by Langston and others (1958, p. 225–227) from sediments in the vicinity of San Francisco Bay, and called by them "Chlorite, 12.3 A." This material may be a poorly crystallized interlayer mixture of chlorite and some expanding mineral such as montmorillonite. For lack of better information and understanding, the material is referred to in this report as the "the 12–A mineral."

A regular mixed-layer chlorite-illite was identified on the basis of the integral series of basal reflections, 24 A, 12 A, and 8 A. Higher order reflections may be present, but they are masked by reflections from other minerals, notably feldspar. The mineral was noted in only two samples, both of which came from a depth of 2,093 feet in the Huron core in the Los Banos-Kettleman City area. It is a minor constituent of these samples and is insignificant as a constituent of the sediments of the area. Its occurrence is reported here only as a matter of interest.

RELATIVE PROPORTIONS OF MINERAL SPECIES

Most estimates of the proportions of clay minerals in a sediment are, at best, qualitative and arbitrary. The problems involved in estimating the relative amounts of clay minerals in complex mixtures such as one finds in sediments have been discussed by von Engelhardt (1959), Glenn and Handy (1962), Harward and Theisen (1962), Hathaway and Carroll (1954, p. 266–269), Jarvis and others (1957), Johns and others (1954), Norrish and Taylor (1962), Oinuma and Kobayashi (1961), Schultz (1960, 1964), and Weaver (1958, p. 270–271), but no standard method of estimation has been adopted. Clay mineralogists generally adapt arbitrary systems to the particular clay-mineral assemblages with which they are working. The system used in this study is also arbitrary.

Proportions of montmorillonite, illite, mixed-layer montmorillonite-illite, and vermiculite were estimated by comparing the intensity of the reflection at 10 A before heat treatment to its intensity after heating the sample to 400° C. Illite and the expanding minerals were assumed to reflect X-rays with equal intensity at 10 A. The amount of low-grade illite-montmorillonite mixture was estimated from the intensity of the band of reflections between 9.0 and 10.0 A in glycerol-treated samples or between 8.5 and 10.0 A in ethylene glycol-treated samples.

Proportions of chlorite and kaolinite-type minerals were estimated by a method based on work by Schultz (1960). Type-A chlorite, because of its high degree of crystallinity, was assumed to reflect X-rays at 7 A with twice the intensity that illite reflects X-rays at 10 A. The intensity of the 7-A reflection, therefore, was multiplied by 0.5 and compared with the 10-A reflection. The intensity of the 7-A reflection of type-B chlorite, less well crystallized than type A, was multiplied by 0.75 and compared with the illite reflection The kaolinite-type mineral, less well crystallized than the chlorites, was assumed to reflect X-rays at 7 A with the same intensity that illite reflects X-rays at 10 A. Where chlorite and the kaolinite-type mineral occurred in approximately equivalent amounts (as in sample *D*, fig. 40), the intensity of the 7-A reflection was compared directly with the reflection at 10 A.

Because the 12–A reflection is weak and because I have no basis for estimating its abundance, the 12-A mineral is reported as a trace where it is present.

Estimated proportions of the clay minerals are expressed in parts per ten and given in tables 11 through 15 and in table 18. Where a small amount of mixed-layer montmorillonite-illite or vermiculite is present with an overwhelming abundance of montmorillonite, it is noted in the tables as a trace and included in the figure for montmorillonite. The reverse is reported for samples in which mixed-layer montmorillonite-illite is much more abundant than montmorillonite. Chlorite and the kaolinite-type mineral are reported in tables 11–13 as "A," "B," "C," or "D," according to the X–ray diffraction patterns illustrated in figure 40 that approximate the patterns for the sample most closely. Chlorite and the kaolinite-type mineral probably never occur to the complete exclusion of one another, but samples that contain considerably more chlorite than kaolinite-type minerals are reported as pure chlorite with no kaolinite-type mineral, and vice versa. Where the proportions of the two minerals approach equality, the mixture is reported as "D."

EXCHANGEABLE-CATION AND SOLUBLE-ANION ANALYSES

Exchangeable cations were determined by H. C. Starkey and T. Manzanares, of the Sedimentary Petrology Laboratory, by the following procedure. One-gram samples of sediment finer than 2 mm were leached with 1 *N* neutral NH_4Cl. Sodium and potassium in the leachates were determined by flame photometry, calcium and magnesium by versene titration. Exchangeable hydrogen was measured by Brown's (1943) method, in samples that registered pH values of less than 7.0. The samples were then washed with alcohol, and the cation-exchange capacities were determined by ammonia distillation. The figures for cations in tables 11 through 15 are the averages of duplicate analyses.

Soluble anions were extracted by leaching 10 grams of dry sediment with 500 ml of hot water (temperature near boiling). Anions in the leachate were determined by Claude Huffman, A. J. Bartell, H. H. Lipp, and I. C. Frost, of the Sedimentary Petrology Laboratory. Chloride, bicarbonate, and carbonate were determined volumetrically; sulfate was determined gravimetrically. Where the sum of the anions in the leachate was less than 50 ppm (about 3 milliequivalents per 100 g of sediment), the individual anions were not determined but the total anions were estimated from the specific conductance of the leachate. The total dissolved salts in the leachate was also estimated from the specific conductance.

The cations given in tables 11 through 15 are mostly exchangeable; that is, they represent approximately the ions adsorbed to the basal surfaces of the clay minerals. Exact quantitative evaluation of the amounts of each exchangeable cation species and the relations between species is impossible, however, because the sediments also contain calcite, gypsum, and perhaps other soluble salts. As a first approximation of the true sum of exchangeable cations, the measured sum has been adjusted for soluble salts by subtracting the total equivalents of the anions determined in the hot-water leach. This is only an adjustment in the right direction. It is not a correction, mainly because of the differences in the solubilities of calcite and gypsum in hot water and 1*N* NH_4Cl.

MEASUREMENT OF pH

Several types of pH measurements were made, two of them in the Sedimentary Petrology Laboratory. The pH of a mixture, that had been allowed at least half an hour to reach equilibrium, of 1 gram of dry sediment and 10 ml of distilled water was determined in samples from the Tulare-Wasco and Santa Clara Valley cores. Also determined was the pH of the hot water leachates in which the soluble anions were identified. These pH values are listed in tables 11 through 15.

In addition to the laboratory determinations, a few measurements were made on selected fine sediments while coring operations were in progress at the Mendota and Cantua Creek holes in the Los Banos-Kettleman City area. Because the sediments were too hard for direct insertion of the pH electrodes, the clay had to be disaggregated and dispersed in water before measurements could be made. As soon as it was extracted from the core barrel, a sample of clay was mixed with distilled water (that had been allowed to come to equilibrium with the atmosphere) in proportions of approximately 1 part of clay to 3 parts water by volume. Measurements of pH were made as follows:

Depth below land surface (feet)	pH of water before clay was added	pH of clay-water suspension		Temperature of suspension (° C.)
		Within a few minutes of mixing	1 hour after mixing	
Mendota core [1]				
435	----------	7.9	----------	----------
600	----------	8.4	----------	----------
980	----------	8.7	----------	----------
Cantua Creek core				
821	5.8	8.9	----------	12
942	5.7	8.6	----------	14
1156	5.6	9.6	10	----------
1327	5.7	9.1	9.2	16
1475	5.7	8.7	9.3	15
1836	5.8	9.9	9.6	14
1952	5.9	8.3	8.7	17

[1] Measurements in Mendota core made by Nikola Prokopovich, U.S. Bur. Reclamation.

Although this is a common procedure for measuring the pH of clays (see, for example, Bassett, 1950), precisely what is measured by placing an electrode into a mixture of clay minerals, nonclay minerals, distilled water, and interstitial water containing dissolved salts is obscure. The numerical values given in the table certainly are not to be interpreted rigorously because they are subject to many influences, intrinsic and extraneous. Vigorous stirring of the mixture, for instance, caused the pH meter to register increases of as much as 0.7 pH unit.

TABLES OF DATA ON CLAY MINERALS AND CHEMICAL ANALYSES

Tables 11 through 15 contain the results of the clay-mineral, exchangeable-cation, and soluble-anion analyses of samples from the Los Banos-Kettleman City area, Tulare-Wasco area, and Santa Clara Valley. Unless otherwise indicated, the clay-mineral proportions reported are those in the 0.2μ–2.0μ fraction. Because the estimated clay-mineral proportions were rounded off to the nearest part in ten, the total of the parts do not add up to 10 in all samples. The cations, cation-exchange capacity, soluble anions, and pH of 10:1 water–sediment mixture were determined using the unfractionated sample ground to pass a 2-mm sieve.

Tables 16 and 17 contain data not published elsewhere on the chemical quality of water being pumped from wells near the Sunnyvale and San Jose core holes in the Santa Clara Valley.

TABLE 11.—*Clay minerals and associated ions in fine-grained sediments from cores in the Los Banos-Kettleman City area*

[Cations and cation-exchange capacity determined by H. C. Starkey; anions and pH of hot-water leachate by H. H. Lipp, I. C. Frost, and Claude Huffman]

Depth below land surface (feet)	Clay minerals (estimated parts per ten)					Cations (meq/100 g)							Anions (meq/100 g)						
	Montmorillonite	Mixed-layer montmorillonite-illite	Illite	Low-grade illite-montmorillonite	Chlorite and kaolinite-type mineral [1]	Ca	Mg	Na	K	Adjusted sum [2]	Cation exchange capacity (meq/100 g)	Clay-mineral fraction (percent of total sample)	SO_4	HCO_3	CO_3	Cl	Sum	Total dissolved solids in hot-water leachate (ppm)	pH of hot-water leachate
Oro Loma core																			
85	2	1	5	0	2 A														
154	Tr.	5	3	0	2 A	21.1	4.7	0.0	0.0	22.5	21.9		2.0	1.0	0.0	0.3	3.3	51	7.2
231	Tr.	5	2	0	3 A														
375	8	0	1	Tr.	Tr.														
412	8	0	Tr.	Tr.	1 B														
423	8	0	Tr.	Tr.	2 D														
472	7	Tr.	1	Tr.	2 D	14.2	4.3	5.1	.0	21.1	18.7	20					2.5	40	8.2
575	8	0	Tr.	Tr.	2 D														
625	7	0	1	Tr.	2 B														
675	7	0	1	Tr.	2 B														
719	7	Tr.	Tr.	Tr.	2 B														
724	7	Tr.	1	0	2 D	21.6	5.6	9.3	.0	34.6	29.3	50					1.9	30	7.7
823	9	0	Tr.	Tr.	Tr.	26.3	11.0	11.3	.5	46.7	40.8	55					2.4	38	7.5
Mean: 85–231	1	4	3	0	2 A														
Mean: 375–823	7½	0	½	Tr.	1½ BD														
Mendota core																			
75	7	0	Tr.	Tr.	2 D	25.1	11.6	4.7	0.0	35.2	19.6	35	1.4	4.3	0.0	0.5	6.2	99	7.6
230	6	0	1	Tr.	3 D														
315 [3]	6	Tr.	1	Tr.	3 B														
399	6	0	1	1	2 D	37.1	19.7	2.0	.5	54.0	35.0	50	.8	4.4	.0	.1	5.3	88	8.0
551	6	0	1	Tr.	2 B														
554 [3]	6	0	2	Tr.	2 B														
631	7	0	2	0	1 D														
642 [3]	8	0	Tr.	Tr.	1 D														
693	6	0	2	Tr.	2 D														
699 [3]	7	0	1	Tr.	2 B														
746	6	Tr.	2	Tr.	2 D	16.2	3.9	3.6	.0	21.2	18.9	25					2.5	40	7.9
746 [3]	7	0	Tr.	Tr.	2 D														
780	7	0	1	Tr.	2 B														
831	6	0	3	Tr.	1 B														
833	6	0	2	Tr.	2 D														
932	7	0	2	Tr.	1 D														
981	6	0	1	1	2 D	28.0	4.7	6.8	.0	38.2	35.5	65					1.3	20	7.7
984 [3]	7	0	1	Tr.	2 A														
1,030	4	3	1	0	2 A														
1,076 [3]	7	0	1	0	2 B														
1,134	7	Tr.	2	0	1 A														
1,280	7	0	2	0	1 B														
1,351 [3]	8	0	Tr.	0	1 B														
1,395 [3]	8	Tr.	Tr.	0	2 B														
1,400	8	0	Tr.	1	Tr.														
1,443	7	Tr.	1	1	1 D	25.7	4.3	9.0	.0	37.0	35.6	55					2.0	31	7.2
1,450 [3]	8	0	Tr.	0	1 B														
Mean	6½	Tr.	1	Tr.	1½ BD														
Cantua Creek core																			
299	6	0	1	0	3 D														
418	8	0	1	Tr.	1 D	22.3	23.6	2.3	0.0	42.4	36.0	45	0.8	2.1	0.0	2.9	5.8	105	7.6
540	7	0	1	Tr.	2 D														
572	7	0	1	Tr.	1 B	22.8	23.3	2.0	.0	47.1	45.7	70					1.0	16	7.2
652	8	0	Tr.	0	1 B														
746	8	0	Tr.	Tr.	2 C														
828	7	Tr.	Tr.	Tr.	2 D														
902	7	0	Tr.	Tr.	2 D	29.6	18.6	2.0	.0	48.0	37.8	55					2.2	35	7.4
973	8	0	Tr.	0	1 D														
1,043	6	0	2	Tr.	2 D														
1,154	6	0	2	Tr.	2 D														
1,238	6	0	1	Tr.	2 D	35.8	1.2	8.0	.0	42.2	40.4	70					2.8	44	7.7
1,327	9	0	Tr.	Tr.	Tr.														
1,414	8	0	1	Tr.	1 D														
1,512	7	0	Tr.	Tr.	2 C														
1,632	7	0	1	0	2 D	12.2	1.3	5.7	.0	16.7	15.0	30					2.5	41	7.8
1,717	7	0	2	Tr.	1 D														
1,792	7	0	2	0	1 D														
1,871	5	0	2	1	2 B														
1,952	6	0	3	Tr.	Tr.	37.1	2.1	16.4	.0	51.4	49.5	80	.8	3.4	.02	<.20	4.2	69	8.5
Mean	7	0	1	Tr.	1½ D														

See footnotes at end of table.

TABLE 11.—*Clay minerals and associated ions in fine-grained sediments from cores in the Los Banos-Kettleman City area*—Continued

Depth below land surface (feet)	Clay minerals (estimated parts per ten): Montmorillonite	Mixed-layer montmorillonite-illite	Illite	Low-grade illite-montmorillonite	Chlorite and kaolinite-type mineral[1]	Cations (meq/100 g): Ca	Mg	Na	K	Adjusted sum[2]	Cation exchange capacity (meq/100 g)	Clay-mineral fraction (percent of total sample)	Anions (meq/100 g): SO_4	HCO_3	CO_3	Cl	Sum	Total dissolved solids in hot-water leachate (ppm)	pH of hot-water leachate
Huron core																			
165	8	0	1	Tr.	1 B														
312[3]	8	0	Tr.	Tr.	1 B														
313	8	0	Tr.	Tr.	1 B	25.3	21.4	2.0	0.0	46.2	41.8	55					2.5	41	7.7
470	6	0	2	Tr.	2 B														
555[3]	8	0	Tr.	Tr.	1 B														
735	7	Tr.	1	Tr.	2 B	13.5	11.9	2.7	.0	25.3	21.7	30					2.8	45	7.4
735[3]	7	Tr.	1	Tr.	2 B														
905	8	0	Tr.	0	1 B	43.2	21.2	4.2	.0	65.2	39.8	50	0.4	3.0	0.0	<0.2	3.4	53	7.9
905[3]	8	0	Tr.	0	1 B														
1,030	8	0	1	0	1 B														
1,094[3]	8	0	Tr.	0	1 B														
1,179	7	0	1	Tr.	2 D														
1,251[3]	8	0	Tr.	Tr.	1 B														
1,345[3]	9	0	Tr.	Tr.	1 B														
1,387	8	0	Tr.	Tr.	2 B	41.5	6.5	3.6	.0	47.5	41.1	50	.5	3.6	.0	<0.2	4.1	63	8.2
1,524[3]	9	0	Tr.	Tr.	Tr.														
1,601[3]	8	Tr.	1	Tr.	1 B														
1,651	7	0	1	1	1 D														
1,750[3]	9	0	Tr.	Tr.	1 D														
1,801	7	0	1	1	1 D	26.1	2.2	5.3	.0	19.9	22.9	30	13.6	.1	.0	<.2	13.7	240	6.7
1,899	8	0	1	Tr.	1 D														
1,956[3]	8	Tr.	1	Tr.	1 D														
2,021[3]	8	Tr.	1	Tr.	1 B														
2,093	5	Tr.	3	0	2 D	12.9	6.6	9.2	.0	24.5	18.4	55?	.6	3.2	.0	.4	4.2	75	8.0
2,093[3]	6	Tr.	2	0	2 D														
Mean	7½	0	1	Tr.	1½ B D														

[1] Letters refer to mineral types shown in figure 40.
[2] Sum of cations minus sum of anions.
[3] X-ray analysis made in Sedimentary Petrology Laboratory of the U.S. Geological Survey by J. C. Hathaway, H. C. Starkey, and G. W. Chloe; <2μ fraction.

TABLE 12.—*Clay minerals and associated ions in surface and near-surface alluvial sediments, Los Banos-Kettleman City area*

[Cations and cation-exchange capacity determined by H. C. Starkey; anions and pH of hot-water leachate determined by H. H. Lipp, I. C. Frost, and Claude Huffman]

Sample No., fig. 14	Stream or fan	Material sampled	Depth below surface (feet)	Clay minerals (estimated parts per ten): Montmorillonite	Mixed-layer montmorillonite-illite	Illite	Low-grade illite-montmorillonite	Chlorite and kaolinite-type mineral[1]	Cations (meq/100 g): Ca	Mg	Na	K	Adjusted sum[2]	Cation exchange capacity (meq/100 g)	Clay-mineral fraction (percent of total sample)	Anions (meq/100 g): SO_4	HCO_3	CO_3	Cl	Sum	Total dissolved solids in hot-water leachate (ppm)	pH of hot-water leachate
Surface and near-surface sediments																						
1	Little Panoche.	Suspended	0	Tr.	3	6	0	1 A														
2	do	Bed	0	2	2	4	0	1 A	15.6	2.9	0.0	0.0	9.9	6.8	10	0.5	4.0	0.0	4.1	8.6	140	8.2
3	Moreno Gulch.[3]	Fan	0	7	Tr.	1	Tr.	2 D														
	do.[3]	do	55	4	Tr.	3	Tr.	3 B														
4	Unnamed[3 4]	do	0	8	Tr.	Tr.	Tr.	1 D														
	do.[3 4]	do	24	9	0	Tr.	0	Tr.														
5	Panoche	Suspended	0	7	0	1	Tr.	2 D														
6	do	Bank	0	7	0	1	Tr.	2 C	42.6	5.1	.0	.0	31.5	26.7	23	14.8	.8	.0	.6	16.2	240	6.9
7	Arroyo Ciervo.[3]	Fan	0	8	0	Tr.	Tr.	1 D														
	do.[3]	do	33	8	0	1	Tr.	1														
8	Cantua	Suspended	0	7	0	1	Tr.	2 D														
9	do	Flood plain	0	7	0	1	Tr.	2 D	17.7	6.6	.0	.0	21.6	9.3	15					2.7	43	7.5
10	Salt[5]	Suspended	0	7	0	1	Tr.	2 D														
11	Martinez[3]	Fan	0	7	0	2	0	1 D														
	do	do	71	8	0	1	Tr.	1 D														
12	Los Gatos	Bed	0	6	0	1	Tr.	2 D	16.8	8.6	.5	.0	23.9	16.9	14					2.0	33	7.3

[1] Letters refer to mineral types shown in figure 40.
[2] Sum of cations minus sum of anions.
[3] Samples collected by W. B. Bull.
[4] First unnamed stream south of Capita Canyon.
[5] Sample represents mixture of Salt and Cantua Creeks; Salt Creek contaminated at time of sampling.

TABLE 13.—*Clay minerals and associated ions in fine-grained sediments from cores in Tulare-Wasco area*

[Cations, cation-exchange capacity and pH of 10:1 water-sediment mixtures determined by H. C. Starkey; anions and pH of hot-water leachate determined by Claude Huffman and A. J. Bartell]

Depth below land surface (feet)	Clay-mineral size fraction [1] (microns)	Clay minerals (estimated parts per ten): Montmorillonite [2]	Illite	Low-grade illite-montmorillonite	Kaolinite-type mineral and chlorite [3]	Cations (meq/100 g): Ca	Mg	Na	K	H	Adjusted sum [4]	Cation-exchange capacity (meq/100 g)	Anions (meq/100 g): SO_4	HCO_3	CO_3	Cl	Sum	Total dissolved solids in hot-water leachate/(ppm)	pH: Hot-water leachate	10:1 water-sediment mixture
Pixley core																				
70	0.2-2.0	9	Tr.	0	1C	13.3	4.5	0.0	0.0	----	16.8	14.5	----	----	----	----	1.0	16	7.3	8.9
268	.2-2.0	6	2	0	1C	20.4	2.5	1.2	.0	----	23.4	21.3	----	----	----	----	.7	11	7.3	8.7
288	.2-2.0	9	Tr.	0	Tr.	36.3	1.3	.0	.0	----	35.6	32.8	----	----	----	----	2.0	32	7.5	8.8
451	.2-2.0	7	1	0	2C	21.3	3.1	1.8	.0	----	24.9	21.6	----	----	----	----	1.3	21	8.4	8.7
601	.2-2.0	5	2	0	3C	20.0	1.1	1.5	.0	----	21.5	18.8	----	----	----	----	1.1	18	7.8	8.8
724	.2-2.0	6	2	0	2C	22.4	2.5	1.2	.0	----	25.1	22.5	----	----	----	----	1.0	15	7.8	8.9
Mean	.2-2.0	7	1	0	1½C															
Richgrove core																				
148	0.2-2.0	7	2	0	1 C	22.9	9.4	1.1	0.0	----	32.6	30.3	----	----	----	----	0.8	13	7.5	8.4
	.1-.2	7	2	0	1 C															
232	.2-2.0	5	3	Tr.	1 C	20.0	3.8	.6	.0	----	23.7	22.1	----	----	----	----	.7	11	7.6	8.7
	.1-.2	7	2	0	1 C															
290	.2-2.0	6	3	0	1 C	27.6	3.1	2.4	.0	----	31.6	31.6	----	----	----	----	1.5	24	6.7	8.7
	.1-.2	7	2	0	2 C															
371	.2-2.0	6	3	0	1 C	22.9	3.8	.0	.0	----	26.1	22.2	----	----	----	----	.6	9	7.3	8.9
	.1-.2	6	2	0	2 C															
444	.2-2.0	5	4	0	1 C	14.1	3.4	.0	.0	----	17.1	14.8	----	----	----	----	.4	6	7.0	8.7
	.1-.2	6	2	0	2 C															
517	.2-2.0	6	3	0	1 C	40.7	4.4	.0	.0	----	43.6	16.7	----	----	----	----	1.5	24	7.2	9.1
	.1-.2	6	2	0	2 C															
583	.2-2.0	7	2	Tr.	1 C	26.3	4.9	.0	.0	----	30.5	29.0	----	----	----	----	.7	12	6.7	8.6
	.1-.2	8	1	0	1 C															
649	.2-2.0	6	3	0	Tr.	22.0	4.5	.0	.0	----	25.2	25.3	----	----	----	----	1.3	21	7.1	8.7
	.1-.2	6	3	0	1 C															
764	.2-2.0	7	3	0	Tr.	36.8	9.4	4.2	.6	----	44.8	40.7	1.4	3.7	0.0	0.5	5.6	74	7.7	8.4
	.1-.2	8	2	0	Tr.															
844	.2-2.0	9	Tr.	0	Tr.	32.1	4.0	3.9	.0	----	37.3	29.1	----	----	----	----	2.7	43	7.3	8.7
	.1-.2	9	Tr.	Tr.	Tr.															
917	.2-2.0	8	Tr.	0	1 D	28.3	6.3	5.7	.0	----	35.6	31.9	2.6	2.1	.0	.0	4.7	62	7.7	8.5
	.1-.2	9	Tr.	Tr.	1 C															
	<.1	10	0	0	Tr.															
1,036	<2 [5]	8	1	0	1 D	24.3	9.0	6.6	.5	----	33.2	35.4	4.0	2.7	.0	.0	6.7	94	7.8	8.5
	.2-2.0	7	1	Tr.	2 D															
	.1-.2	8	1	Tr.	1 C															
1,156	.2-2.0	8	Tr.	Tr.	1 D	12.6	6.3	3.8	.0	----	20.1	21.1	----	----	----	----	2.6	41	6.8	8.6
	.1-.2	8	Tr.	Tr.	1 C															
1,240	<5 [5]	8	Tr.	0	1 D	9.4	13.3	6.6	.0	7.5	26.1	36.3	10.4	.4	.0	.0	10.8	170	6.5	4.5
	.2-2.0	8	1	0	1 C															
	.1-.2	9	Tr.	0	Tr.															
1,364	.2-2.0	8	Tr.	0	1 D	16.0	6.0	5.7	.0	----	24.8	24.5	----	----	----	----	2.9	47	7.5	8.7
	.1-.2	8	Tr.	Tr.	1 C															
1,447	<10 [5]	7	1	0	2 D	17.5	12.6	7.4	.0	7.1	25.0	28.7	18.9	.6	.0	.0	19.5	290	6.2	4.0
	.2-2.0	9	Tr.	0	1 C															
	.1-.2	9	Tr.	0	Tr.															
1,527	<10 [5]	6	2	0	2 D	11.7	13.2	7.5	.0	10.9	23.0	31.4	19.7	.6	.0	.0	20.3	300	6.2	4.0
	0.2-2.0	8	Tr.	Tr.	1 C															
	.1-.2	9	Tr.	Tr.	Tr.															
1,689	.2-2.0	9	1	Tr.	Tr.	29.0	6.7	10.7	.0	----	41.2	37.8	3.3	1.9	.0	.0	5.2	69	7.4	7.5
	.1-.2	9	Tr.	0	Tr.															
1,827	<10 [5]	9	Tr.	0	Tr.	8.0	17.5	11.1	.0	13.0	35.1	43.5	13.7	.7	.0	.0	14.4	230	6.7	4.1
	.2-2.0	9	Tr.	0	Tr.															
	.1-.2	9	Tr.	Tr.	Tr.															
1,912	<10 [5]	7	2	0	1 C	10.6	3.6	2.7	.0	4.0	14.9	11.6	5.2	.7	.0	.0	5.9	98	6.9	5.3
	.2-2.0	8	Tr.	Tr.	1 C															
	.1-.2	8	Tr.	Tr.	2 C															
Mean: 148-649	.2-2.0	6	3	Tr.	1 C															
Mean: 764-1,827	.2-2.0	8	½	Tr.	1 D C															

[1] Refers to clay-mineral determinations only; chemical determinations were made on unfractionated sediment.
[2] Includes some vermiculite in samples from Pixley core.
[3] Letters refer to type of X-ray-diffraction pattern shown in figure 40.
[4] Sum of cations minus sum of anions.
[5] Sediment flocculated during centrifuging.

TABLE 14.—*Clay minerals and associated ions in fine-grained sediments from cores in Santa Clara Valley*

[Clay-minerals determined with assistance of J. B. Corliss; cations, cation-exchange capacity, and pH of 10:1 water-sediment mixture determined by H. C. Starkey and Toribio Manzanares, Jr.; anions and pH of hot-water leachate determined by A. J. Bartel]

Depth below land surface (feet)	Clay-mineral size fraction [1] (microns)	Clay minerals (estimated parts per ten)				Cations (meq/100 g)					Cation-exchange capacity (meq/100 g)	Anions (meq/100 g)					Total dissolved solids in hot-water leachate (ppm)	pH	
		Montmorillonite	Illite	Low-grade illite-montmorillonite	Chlorite (type B)	Ca	Mg	Na	K	Adjusted sum [2]		SO_4	HCO_3	CO_3	Cl	Sum		Hot-water leachate	10:1 water-sediment mixture
								Sunnyvale core											
80	0.2-2.0	5	2	0	3	43.9	9.4	0.0	0.0	51.2	10.4	----	----	----	----	2.1	34	6.8	8.6
	.1-.2	7	1	0	2														
142	.2-2.0	7	Tr.	0	2	16.6	8.0	.0	.0	21.7	19.3	----	----	----	----	2.9	46	6.6	7.9
	.1-.2	9	Tr.	Tr.	1														
222	.2-2.0	8	Tr.	Tr.	2	29.4	12.8	.0	.0	40.6	33.8	----	----	----	----	1.6	25	6.8	8.7
	.1-.2	9	Tr.	Tr.	1														
313	.2-2.0	7	1	0	1	13.1	3.5	.0	.0	16.1	19.4	----	----	----	----	.5	8	6.8	8.5
	.1-.2	8	Tr.	0	1														
437	.2-2.0	7	Tr.	0	2	29.8	6.8	.0	.0	34.3	15.6	----	----	----	----	2.3	36	7.2	8.9
	.1-.2	9	Tr.	Tr.	1														
526	.2-2.0	8	1	0	1	49.0	21.5	.0	.0	67.7	17.2	----	----	----	----	2.8	45	7.3	9.1
	.1-.2	9	Tr.	Tr.	Tr.														
606	.2-2.0	8	Tr.	0	2	38.3	23.4	.0	.0	57.3	17.3	0.0	4.4	0.0	0.0	4.4	62	8.3	9.2
	.1-.2	9	Tr.	Tr.	1														
656	.2-2.0	9	Tr.	Tr.	1	67.2	25.9	.0	.0	89.6	21.8	.0	3.5	.0	.0	3.5	51	7.6	9.4
	.1-.2	9	Tr.	Tr.	Tr.														
746	.2-2.0	8	Tr.	Tr.	2	46.0	18.8	1.3	.0	61.5	33.6	.6	4.0	.0	.0	4.6	66	7.5	9.1
	.1-.2	9	Tr.	Tr.	1														
813	.2-2.0	7	Tr.	0	2	16.9	7.1	1.1	.0	23.5	23.4	----	----	----	----	1.6	27	7.0	9.4
	.1-.2	7	Tr.	Tr.	2														
901	.2-2.0	6	1	0	3	20.9	8.5	1.6	.0	28.2	24.0	----	----	----	----	2.8	46	7.5	9.3
	.1-.2	8	Tr.	0	2														
983	.2-2.0	9	Tr.	0	1	29.8	9.4	3.7	.0	41.7	40.6	----	----	----	----	1.2	19	6.7	9.2
	.1-.2	9	Tr.	0	Tr.														
Mean	.2-2.0	7½	½	Tr.	2 B														
								San Jose core											
40	0.2-2.0	5	2	0	3	24.2	8.6	0.0	0.0	29.4	28.0	0.7	2.7	0.0	0.0	3.4	49	7.3	8.5
	.1-.2	7	2	0	2														
207	.2-2.0	6	1	0	3	21.2	6.2	.0	.0	25.4	27.7	----	----	----	----	2.0	32	7.1	8.6
	.1-.2	7	1	0	2														
302	.2-2.0	8	1	0	1	11.9	5.1	.0	.0	16.2	16.4	----	----	----	----	.8	13	6.9	8.5
	.1-.2	9	Tr.	0	1														
402	.2-2.0	6	1	0	3	21.9	8.3	.0	.0	27.5	26.9	----	----	----	----	2.7	44	7.0	8.5
	.1-.2	8	Tr.	0	1														
542	.2-2.0	7	1	Tr.	2	20.5	7.6	.0	.0	26.7	20.1	----	----	----	----	1.4	23	7.1	9.1
	.1-.2	8	Tr.	Tr.	1														
727	.2-2.0	7	1	0	2	15.1	6.1	.0	.0	19.6	17.6	----	----	----	----	1.6	25	7.1	8.9
	.1-.2	8	Tr.	0	2														
833	.2-2.0	8	Tr.	0	2	43.3	9.5	.0	.0	50.5	21.9	----	----	----	----	2.3	37	7.3	9.2
	.1-.2	8	Tr.	0	1														
937	.2-2.0	7	Tr.	Tr.	2	19.6	8.6	.0	.0	26.6	22.0	----	----	----	----	1.6	26	7.3	9.1
	.1-.2	8	Tr.	Tr.	2														
Mean	.2-2.0	7	1	Tr.	2 B														

[1] Refers to clay-mineral determinations only; chemical determinations were made on unfractionated sediments.

[2] Sum of cations minus sum of anions.

TABLE 15.—*Clay minerals and associated ions in fine-grained surficial sediments from Santa Clara Valley and southern San Francisco Bay*

[Clay minerals in samples 1-11 determined with assistance of J. B. Corliss, T. J. Conomos, and J. O. Berkland. Samples 12-19 are grab samples, collected and analyzed by Conomos. Cations, cation-exchange capacity, and pH of 10:1 water-sediment mixtures determined by H.C. Starkey and Toribio Manzanares, Jr.; anions and pH of hot-water leachates determined by A. J. Bartel]

Sample No. in fig. 34	Sediment type and location	Clay minerals (estimated parts per ten)				Cations (meq/100 g)						Cation-exchange capacity (meq/100g)	Anions (meq/100 g)					Total dissolved solids in hot-water leachate (ppm)	pH	
		Montmorillonite	Illite	Chlorite and kaolinite-type minerals [1]	12-A mineral	Ca	Mg	Na	K	H	Sum		SO_4	HCO_3	CO_3	Cl	Sum		Hot-water leachate	10:1 water-sediment mixture
	Alluvial																			
1	San Francisquito Creek fan.	8	Tr.	2 C	0	27.6	10.2	0.0	0.0	-----	37.8	36.6	-----	-----	-----	-----	1.0	16	7.0	8.5
2	do	9	Tr.	1 C	0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	Stevens Creek bank.	7	1	2 D	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	Los Gatos Creek terrace.	8	1	1 D	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	Coyote Creek terrace.	7	1	2 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	do	7	1	2 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	Agnew [2]	8	Tr.	1 B	0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	Alameda Creek bottom.	7	1	2 C	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Bay bottom																			
9	Brewer Island [3]	6	2	2 B	Tr.	23.2	18.1	44.2	1.2	-----	86.7	32.9	8.3	4.5	0.0	40.7	53.6	810	7.4	8.3
10	San Francisco Bay.	5	3	2 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
11	Mayfield Slough	6	2	2 B	Tr.	16.1	32.8	55.9	1.2	8.0	114.0	36.2	49.7	.0	.0	58.2	107.9	1,500	4.6	4.0
12	Coyote Slough	6	2	2 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
13	San Francisco Bay.	5	2	3 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
14	do	6	1	2 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
15	do	7	1	2 B	0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
16	do	6	2	3 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
17	do	6	2	2 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
18	do	6	2	2 B	0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
19	do	6	2	2 B	Tr.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[1] Letters refer to type of X-ray diffraction pattern shown in figure 40.
[2] Slight soil profile developed.
[3] Reclaimed bay-bottom sediments.

TABLE 16.—*Partial chemical analyses of water from selected wells within about 3 miles of Sunnyvale core hole*

[Analyses by W. C. Pollard, B. H. Geib, Edelle Hansen, and Ignacio Sokula]

Well location (T/R-Sec)	Distance from Sunnyvale core hole (mile)	Total depth (feet)	Perforated interval (feet)		Day water sample collected	Total dissolved solids (ppm)	Parts per million (upper number) and equivalents per million (lower number) for indicated cations and anions								SiO_2 (ppm)	Percent Na
			Top	Bottom			Ca	Mg	Na	K	SO_4	HCO_3	CO_3	Cl		
6S/1W-19	1.3	550	-----	-----	8/14/57	354	58	18	41	1.6	35	268	0.0	26	30	29
							2.9	1.5	1.8	0.04	0.7	4.4	-----	0.7	-----	-----
6S/1W-29	2.7	300	-----	-----	8/17/54	288	42	18	31	1.0	34	220	.0	15	33	27
							2.1	1.5	1.3	0.03	0.7	3.6	-----	0.4	-----	-----
6S/2W-9	3.1	202	163	185	8/14/57	355	46	15	60	2.0	27	272	.0	39	32	42
							2.3	1.2	2.6	0.05	0.6	4.4	-----	1.1	-----	-----
6S/2W-14	.4	868	-----	-----	do	311	46	14	47	1.4	27	262	.0	20	26	37
							2.3	1.1	2.0	0.04	0.6	4.3	-----	0.6	-----	-----
6S/2W-16	2.8	500	-----	-----	do	542	103	31	38	1.6	127	327	.0	45	30	18
							5.1	2.6	1.6	0.04	2.6	5.4	-----	1.3	-----	-----
6S/2W-21	2.7	264	-----	-----	8/18/54	539	83	30	48	1.5	150	249	.0	50	49	24
							4.1	2.5	2.1	0.04	3.1	4.1	-----	1.4	-----	-----
6S/2W-24	.6	550	150	535	8/11/53	324	50	18	40	1.2	32	268	.0	20	30	30
							2.5	1.5	1.7	0.03	0.7	4.4	-----	0.6	-----	-----
6S/2W-28	3.1	320	190	316	8/15/57	361	75	23	22	1.3	22	315	.0	29	30	15
							3.7	1.9	1.0	0.03	0.5	5.2	-----	0.8	-----	-----
6S/2W-34	3.3	660	-----	-----	do	294	53	19	21	1.2	15	249	.0	20	30	18
							2.6	1.6	0.9	0.03	0.3	4.1	-----	0.6	-----	-----
6S/2W-36	2.5	480	-----	-----	do	444	95	21	33	1.9	41	322	.0	50	28	18
							4.7	1.7	1.4	0.05	0.8	5.3	-----	1.4	-----	-----

TABLE 17.—*Partial chemical analyses of water from wells within 200 yards of San Jose core hole*

[All wells in 12th Street Station of San Jose Water Works; samples collected and analyzed by Water Works: analyst, Primo Villarruz. Well numbers are those assigned by Water Works]

Well	Total depth (feet)	Perforated interval (feet)		Day water sample collected	Total dissolved solids (ppm)	Parts per million (upper number) and equivalents per million (lower number) for indicated cations and anions								SiO_2	Percent Na
		Top	Bottom			Ca	Mg	Na	K	SO_4	HCO_3	CO_3	Cl		
4	800	605	780	1/31/62	336	52	19	39	2.4	40	271	1.2	18	22	28
						2.6	1.6	1.7	0.06	0.8	4.4	0.04	0.5		
5	800	454	778	do	427	72	34	31	2.0	60	351	1.5	23	22	17
						3.6	2.8	1.3	0.05	1.2	5.7	0.05	0.6		
6	794	276	772	2/15/62	387	63	26	36	3.6	50	311	1.8	22	21	23
						3.1	2.1	1.6	0.09	1.0	5.1	0.06	0.6		
7	725	278	682	1/31/62	396	74	24	34	2.0	53	315	1.2	23	21	21
						3.7	2.0	1.5	0.05	1.1	5.2	0.04	0.6		
8	716	280	697	2/3/62	390	59	32	33	2.1	52	321	1.5	22	21	20
						3.0	2.7	1.4	0.05	1.1	5.3	0.05	0.6		
9	800	270	746	4/4/62	408	72	29	32	1.5	55	329	1.5	23	23	19
						3.6	2.4	1.4	0.04	1.1	5.4	0.05	0.6		
11	870	306	842	1/22/62	355	47	16	58	2.5	44	274	2.1	26	20	40
						2.4	1.3	2.5	0.06	0.9	4.5	0.07	0.7		

Table 18 contains the results of clay-mineral analyses of sediments from the Lakeview test hole in the Arvin-Maricopa area. No chemical analyses were made on samples from this hole.

TABLE 18.—*Clay minerals in fine-grained sediments from Lakeview test hole, Arvin-Maricopa area*

[Determined with the assistance of F. P. Naugler and J. B. Corliss]

Depth below land surface (feet)	Clay minerals (estimated parts per ten)		
	Montmorillonite	Illite	Chlorite and kaolinite-type mineral [1]
336	8	1	1 C
400	7	2	1 B
533	7	1	2 B
664	8	1	1 D
688	8	1	1 D
831	8	Trace	1 D
1,150	9	Trace	1 B
1,459	6	2	2 B
Mean	7½	1¼	1¼

[1] Letters refer to type of X-ray diffraction pattern shown in fig. 40.

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