Place of Origin of the Salinian Block, California, as Based on Clast Compositions of Upper Cretaceous and Lower Tertiary Conglomerates

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Place of Origin of the Salinian Block, California, as Based on Clast Compositions of Upper Cretaceous and Lower Tertiary Conglomerates

By VICTOR M. SEIDERS *and* BRETT F. COX

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1526

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1992

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., *Secretary*

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

Library of Congress Cataloging in Publication Data

Seiders, Victor M.
Place of origin of the Salinian block, California, as based on clast compositions of Upper Cretaceous and Lower Tertiary conglomerates / by Victor M. Seiders and Brett F. Cox.
p. cm.—(U.S. Geological Survey professional paper ; 1526)
Includes bibliographical references
Supt. of Docs. no.: I 19.16:1526
1. Conglomerate—California. 2. Conglomerate—Mexico—Baja California. 3. Conglomerate—Arizona.
I. Cox, Brett F. II. Title. III. Series.
QE471.15.C6S45 1993
552'.5—dc20 92-12530
CIP

For sale by the Book and Open-File Report Sales, U.S. Geological Survey,
Federal Center, Box 25286, Denver, CO 80225

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By VICTOR M. SEIDERS and BRETT F. COX

ABSTRACT

More than 250 pebble counts were done on conglomerates from the Salinian block and nearby terrane in California, Baja California, and Arizona. The regional pattern of conglomerate compositions suggests that the Salinian block originated adjacent to the Mojave block and is not an exotic terrane as interpreted from paleomagnetic results.

Upper Cretaceous, Paleocene, and Eocene conglomerates in the Salinian block consist of two remotely derived detrital suites. The principal suite is rich in clasts of felsic volcanic rocks with subordinate amounts of granitic rocks and quartz sandstone. Granitic rocks are more abundant in lower Tertiary conglomerates of this suite. The second suite, only found locally near the base of the sequence, is rich in quartz sandstone. Both suites are very poor in chert.

Conglomerates of the Salinian block contrast with those in regions which were located to the north and south before San Andreas fault displacement. Cretaceous and lower Tertiary conglomerates in the Diablo and Temblor Ranges to the north and Cretaceous conglomerates in the Peninsular Ranges to the south are richer in chert than are Salinian block conglomerates. Lower Tertiary conglomerates both to the north and south are poorer in granitic rocks than are Salinian conglomerates.

Salinian conglomerates are compositionally similar to conglomerates in native North America in areas bordering directly on the western part of the Mojave block. Although there are no remotely derived Upper Cretaceous conglomerates in the western Mojave region—instead only locally derived basal conglomerates—conglomerates in the overlying and onlapping Paleocene sequence are similar to the principal Cretaceous conglomerate suite of the Salinian block. Paleocene conglomerates in the Tehachapi and El Paso Mountains and in the San Gabriel Mountains are very similar to Paleocene conglomerates of the Salinian block. An Eocene conglomerate in the San Emigdio Mountains, located at the south end of the San Joaquin Valley and near the western Mojave, is similar to Eocene conglomerates in the Salinian block.

Jurassic or Cretaceous conglomerates composed of volcanic rocks and chert in the lower half of the McCoy Mountains Formation of southeastern California and adjacent Arizona are very similar to conglomerates in the Winterhaven Formation in extreme southeastern California. This supports other evidence indicating that the edge of the proposed Santa Lucia-Orocopia allochthon, which includes the Salinian block, does not lie between these two areas. Upper Cretaceous conglomerates rich in quartz sandstone clasts in the middle part of the McCoy Mountains Formation are similar to an areally restricted second suite of Cretaceous Salinian block conglomerates. Stratigraphically higher Cretaceous conglomerates in the McCoy Mountains Formation are rich in quartz sandstone, volcanic rocks, and granite and are similar to Upper Cretaceous conglomerates in the southwestern Transverse Ranges. Other conglomerates in the southwestern Transverse Ranges are rich in volcanic rocks and are similar to conglomerate in the northern Santa Ana Mountains of the Peninsular Ranges just to the south, with which there are close stratigraphic ties. These observations suggest a link between the Peninsular and southwestern Transverse Ranges and the Mojave block.

The geographic pattern in conglomerate compositions suggests a palinspastic reconstruction with the Salinian block restored adjacent to the western Mojave block by backslipping the San Andreas fault system. The restored Salinian block formed an interior part of the Cordilleran magmatic arc that may have become exposed to the ocean when hypothesized mid-Cretaceous left slip on the Nacimiento fault displaced southward the adjacent western part of the arc. Streams flowing westward off the magmatic arc north and south of the Salinian block transported gravel containing volcanic rocks derived from the magmatic arc and chert derived from prebatholithic rocks in the western part of the arc. In the Salinian block, volcanic-rich gravel with little chert may have been derived from the segment of the magmatic arc where the western belt of pre-batholithic rocks was absent because of Nacimiento fault displacement. Gravel rich in quartz sandstone and relatively poor in volcanic rocks was probably derived from the eastern Mojave area and transported southward to the southwestern Transverse Ranges, crossing the magmatic arc where it was most narrow. Volcanic-rich gravel in the northern Santa Ana Mountains may have been transported northward along the magmatic arc by streams following the trace of the Nacimiento fault. The abundance of granitic rocks in conglomerate of the Salinian block may have resulted from uplift and deep erosion attending Late Cretaceous and Paleogene subduction of oceanic crust beneath the thick continental crust of the breached arc.

The detailed comparison of conglomerate pairs separated by the San Gregorio, Rinconada, and San Andreas faults generally supports previously determined magnitudes of displacement. Some pairs, most notably the Eocene Butano Sandstone and the Point of Rocks Sandstone Member of the Kreyenhagen Formation,

Manuscript approved for publication February 19, 1992.

are found to be compositional mismatches and on this basis should no longer be used as reference points in estimating fault displacements.

INTRODUCTION

The Salinian block (fig. 1) is one of many Cordilleran suspect terranes (Coney and others, 1980) for which an exotic place of origin relative to North America has been suggested based on the low inclinations determined from paleomagnetic analyses of Upper Cretaceous and Paleocene strata (Champion and others, 1984). The Salinian block consists of high-grade metamorphic and deep-seated granitic rocks (Ross, 1977, 1978, 1984; James and Mattinson, 1988) overlain by Upper Cretaceous and Tertiary sedimentary rocks (Howell and others, 1977; Vedder and others, 1983). In this report, conglomerate compositions in Upper Cretaceous and lower Tertiary rocks of the Salinian block are examined and compared with those of nearby regions as a way of evaluating the place of origin of the Salinian block.

Neogene displacement on the San Andreas fault system has moved the Salinian block from a position in southern California adjacent to the Mojave block (fig. 1). If the Salinian block is allochthonous, it may have docked with North America in southern California during the Eocene as the Santa Lucia-Orocopia allochthon of Vedder and others (1983). Therefore, we evaluate our data in terms of the Salinian block's location with San Andreas displacement restored, using the reconstruction of Powell (in press; fig. 2). Paleocurrent directions for the Late Cretaceous, Paleocene, and Eocene, largely from the literature, are plotted on the same reconstruction (figs. 3, 4, and 5). We also use Powell's (in press) terms for geographic areas in the region.

Although the southern limit of the Salinian block is commonly taken at the Big Pine fault (Ross, 1978), for convenience of discussion we include the Frazier Mountain block just to the south (fig. 1), which includes Eocene conglomerates compositionally similar to those of the Salinian block. The Nacimiento block, located west of the Salinian block and with a basement composed of the Franciscan assemblage, was joined to Salinia at least by Late Cretaceous time (Vedder and others, 1983), and we include with the Salinian data a few Upper Cretaceous conglomerate compositions from the Nacimiento block. The Golden Gate-Gilroy block of the San Francisco Bay area, also with a Franciscan basement, also has some Upper Cretaceous conglomerate that we include with the Salinian block data.

METHODS AND DEFINITIONS

METHODS

We chose pebble counts as a method of evaluating the place of origin of suspect terrane because conglomerate compositions have been shown to be geographically distinctive (Seiders and Blome, 1988). Although conglomerate contains actual pieces of rock from the source area, rather than disaggregated mineral grains as in sandstone, it nonetheless can be a very difficult task to find a unique bedrock source for a given suite of conglomerate clasts. The problem is compounded when the potential source area is large and the conglomerate is old. Instead, we have chosen to study the clast compositions of conglomerates in suspect terranes and to compare them with the compositions of conglomerates in known paleogeographic settings.

Pebbles were counted in the size range 0.4-6.0 cm, mainly 0.4-3.0 cm. It is important that pebble counts be restricted to a limited size range because the clast compositions can vary greatly with size within the same conglomerate. In particular, the abundance of granitic rocks is commonly greater in the cobble and boulder sizes than in pebbles. Although we have not systematically tested for compositional variation as a function of size, the internal consistency of our results suggests that the variation is generally small within the range of sampled clast sizes.

Small pebbles were selected partly to reduce the volume of material to be processed, but as an added advantage they include fewer locally derived clasts. The resulting systematic bias in favor of remotely derived siliceous- resistate clast suites facilitates large-scale regional correlation.

Pebbles were collected from the outcrop by disaggregating and collecting all pebbles within the selected size range until an appropriate number, usually about 350, was obtained. Outcrops with more than a few decomposed pebbles were not sampled. Conglomerate that would not disaggregate was sawed.

Pebbles or sawed slabs were etched overnight in five percent hydrofluoric acid solution. Usually the sample was first placed in dilute hydrochloric acid to dissolve away any attached calcite and to test for clasts of limestone or marble, which were removed and counted. After etching in hydrofluoric acid, the sample was placed overnight in 3 percent hydrochloric acid solution to remove a white crust, probably calcium fluoride, that forms on some pebbles. Identifications were done in reflected light using a low-power microscope. The etched surface has a low relief and little reflectivity, which facilitates identification. The

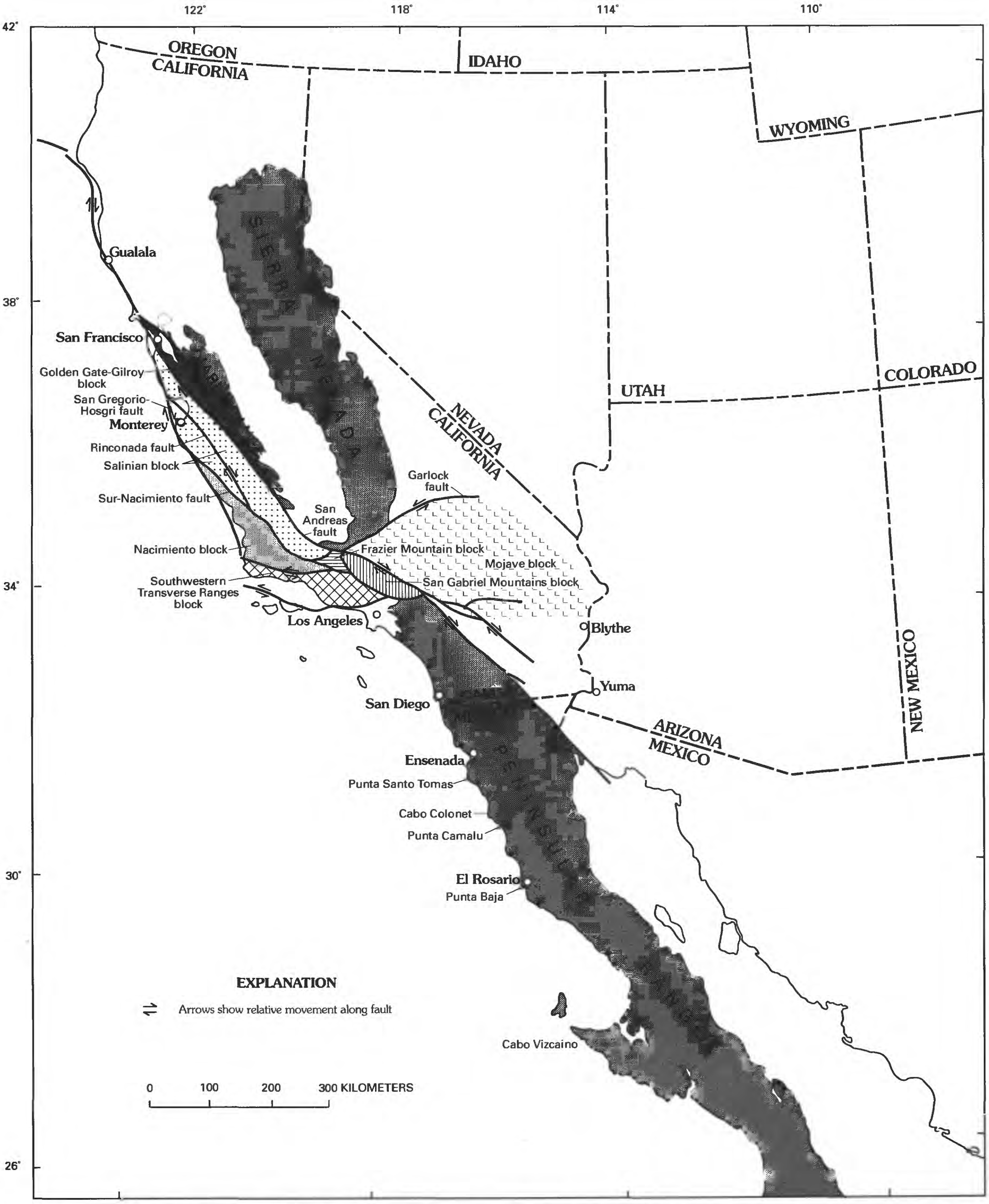


FIGURE 1.—Map of the southwestern United States and northwestern Mexico showing geologic provinces, some major faults, and selected localities mentioned in the text.

method is at least as fast and is more accurate than identifications done on the outcrop with a hand lens.

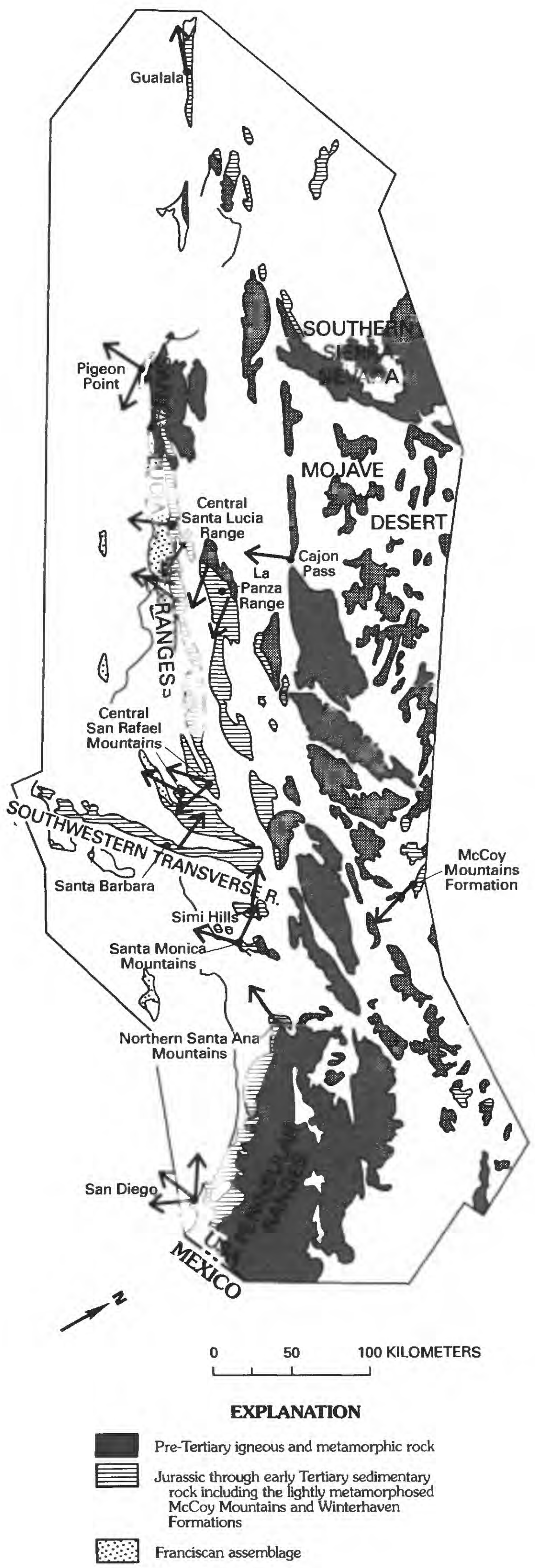
The pebble counts are presented in tables 1-8 and the data are presented graphically in triangular diagrams (figs. 6-20). The diagrams are of two types representing the compositions in terms of their most significant constituents, either quartz sandstone, chert, and all igneous rocks (Q-C-I) or quartz sandstone, volcanic rocks, and granitic rocks (Q-V-G). Following a method applied by Ingersoll and others (1977) to sandstone petrology, the diagrams show for each conglomerate group the mean composition and an envelope or dispersion field produced by the standard deviations of each of the three constituents. Although such diagrams contain some inherent distortion (Philip and Watson, 1988) and cannot be used as tests of statistical probability (Philip and others, 1987) they are, nevertheless, a convenient way to visually compare the compositions of conglomerate suites.

DEFINITIONS

Mudstone as used in this report includes both gray argillite that is gradational to chert, and tan, commonly silty mudstone of possible intraformational origin. Quartz sandstone is taken to mean sandstone with quartz grains making up more than about 80 percent of the framework grains. Other sandstone contains more than 20 percent of other constituents, including mineral grains, as well as chert and other rock fragments. Siltstone and fine conglomerate are included with sandstone. Metamorphic quartzite is included in quartz sandstone only if there is relict texture or some other indication that it formed from a detrital sedimentary rock rather than from chert. Otherwise, it is included in "other," a category that includes other metamorphic and unidentified rocks, usually in small abundance.

The line between felsic and other volcanic rocks is arbitrary and probably inaccurate because of the difficulty in making this distinction in small pieces of rock. We include diabase, usually rare or absent, with other volcanic rocks. Likewise, minor diorite and gabbro are included with granitic rocks. For a few samples where these rocks are abundant, dia-

◄ FIGURE 2.—Pre-late Cenozoic palinspastic reconstruction of western California (after Powell, in press) showing study areas described in the text. Other study areas are shown on figure 1 and detailed sample locations are given in the "Supplemental Information." About 90° of clockwise rotation of the southwestern Transverse Ranges, which we would restore, is not fully restored in this reconstruction.



base as well as combined diorite and gabbro are listed separately.

In describing conglomerate compositions, we have characterized component abundances with words such as "rich," "poor," and "abundant." These terms are used to describe the abundance relative to other samples of this study. Thus, a conglomerate with 30 percent granitic rocks or 20 percent quartz sandstone, components generally present in smaller abundance, would be described as rich in these rocks, whereas a conglomerate with 20 percent felsic volcanic rocks, usually the most abundant kind of clast, would be characterized as poor in this component.

CONGLOMERATE FROM THE SALINIAN AND NACIMIENTO BLOCKS

GUALALA

A thick sequence of turbidites of Late Cretaceous and early Tertiary age crops out west of the San Andreas fault in a narrow, 50-km-long coastal strip near Gualala (figs. 1 and 2; Wentworth, 1966, 1968; Ross and others, 1972). The basement is a spilite of uncertain affinities. Wentworth (1966, 1968) divided the Upper Cretaceous rocks into two interfingering facies based on the kind of contained detritus. The strata of Stewarts Point, mainly exposed to the south, include K-feldspar arkose and conglomerate in which the plutonic clasts are largely granitic. The strata of Anchor Bay to the north contain plagioclase arkose and conglomerate with relatively abundant mafic plutonic clasts. Overlying lower Tertiary rocks include both Paleocene and lower to middle Eocene strata. Paleocurrent directions in both Cretaceous and Tertiary rocks are mainly to the northwest (Wentworth, 1966, 1968; figs 3-5).

Kanter and Debiche (1985) interpreted paleomagnetic determinations on lower Tertiary rocks of the area to indicate about 1,800 km of northward translation.

CONGLOMERATE COMPOSITION

Pebble counts from Upper Cretaceous rocks are shown in table 1 and are represented graphically in

◀ FIGURE 3.—Pre-late Cenozoic palinspastic reconstruction of western California (after Powell, in press) showing generalized Late Cretaceous paleocurrent directions. See text for sources of information. Note that about 90° of clockwise rotation of the southwestern Transverse Ranges, which we would restore, is not fully restored in this reconstruction.

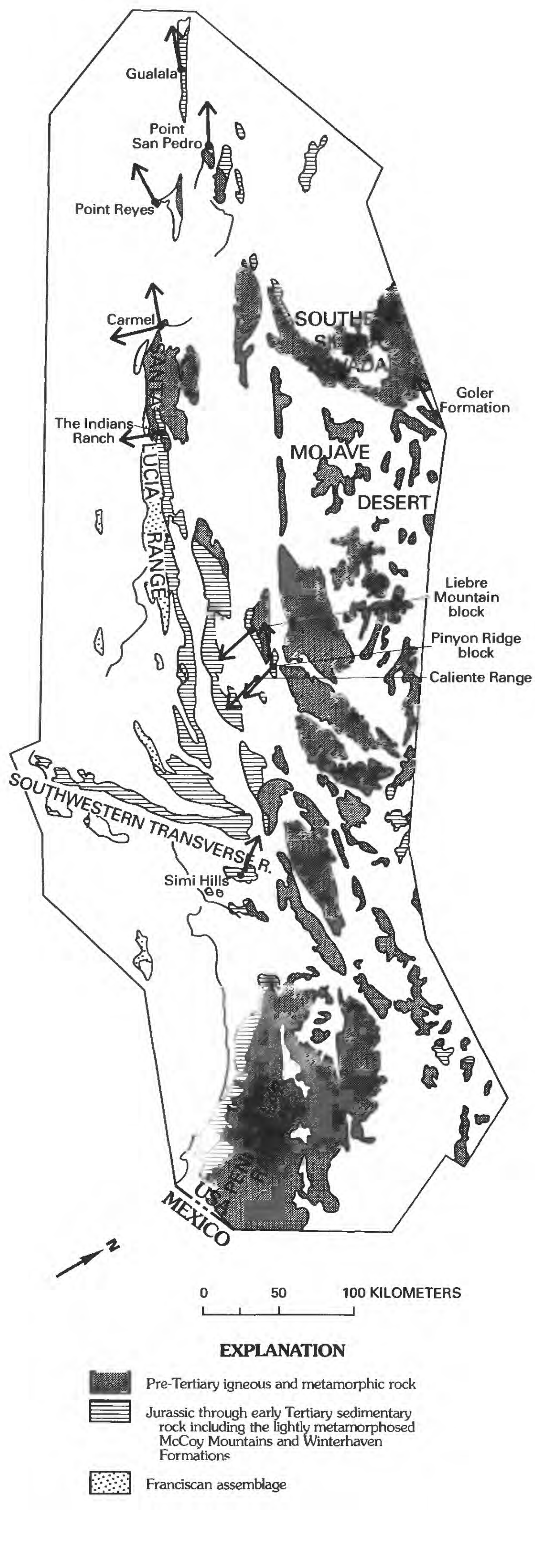
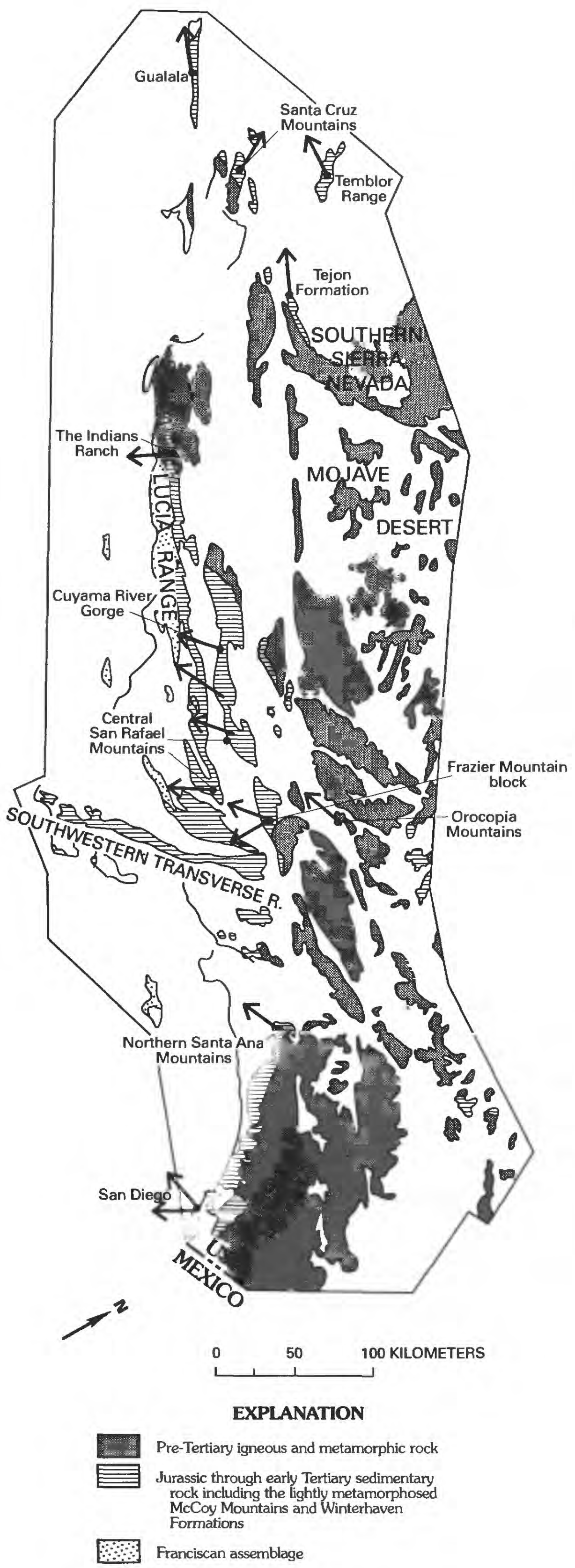


figure 6. Five silicic conglomerates from the strata of Stewarts Point, like most other Salinian block conglomerates, are composed mainly of felsic volcanic rocks (mean 61.5 percent). Relative to other Salinian block conglomerates, this suite is richer in quartz sandstone (mean 15.6 percent). The two stratigraphically lowest conglomerates are richest in quartz sandstone (29.2 and 19.6 percent; in table 1 the suite is arranged in ascending stratigraphic order). In figure 6 the variation in quartz sandstone is shown in the elongation of the dispersion field parallel to the Q-V (quartz sandstone-volcanic rock) side of the triangle. Granitic rock content (mean, 10.0 percent) is low, as in most other Cretaceous suites of the Salinian block. This contrasts with Wentworth's (1968) description of abundant granite. His observations probably reflect a greater abundance of granite among cobble and boulder-size clasts, which are excluded here.

Three pebble counts from the Cretaceous strata of Anchor Bay show less abundant felsic volcanic rocks than the Stewarts Point suite (mean 41.0 versus 61.5 percent) and are much richer in intermediate to mafic volcanic rocks and diabase (mean 25.7 versus 1.3 percent). Plutonic rocks of granitic (mean 16.9 percent) and mafic (mean 5.6 percent) composition are more abundant than in the Stewarts Point suite (means 10.0 and 0 percent, respectively) and quartz sandstone is lower (mean 2.0 versus 15.6 percent). The Anchor Bay suite is unusual for its abundance of intermediate to mafic volcanic and plutonic rocks. It shows some similarity with a conglomerate from an unnamed formation in the Golden Gate-Gilroy block (table 1, locality WO-268).

The basal Paleocene conglomerate is approximately similar to the underlying Cretaceous conglomerate in the strata of Stewarts Point, but stratigraphically higher Paleocene conglomerates show an abrupt increase in granite content (mean 29.3 versus 11.7 percent; table 4 and fig. 13). These rocks also contain a mean of 3.3 percent chert, which is unusually high for the Salinian block. Eocene conglomerates are similar to the youngest Paleocene conglomerates, but are somewhat more variable in composition and not rich in chert (mean 0.9 percent; table 6 and fig. 15).

◄ FIGURE 4.—Pre-late Cenozoic palinspastic reconstruction of western California (after Powell, in press) showing generalized Paleocene paleocurrent directions. See text for sources of information. Note that about 90° of clockwise rotation of the southwestern Transverse Ranges, which we would restore, is not fully restored in this reconstruction.



POINT SAN PEDRO

A sequence of Paleocene turbidites perhaps 900 m thick rests on granitic basement at Point San Pedro, just south of San Francisco (figs. 1 and 2; Morgan, 1981; Nilsen and Yount, 1981, 1987). Paleocurrent indicators point west-northwest (Nilsen and Yount, 1981; fig. 4). Champion and others (1984) reported paleomagnetic determinations and interpreted about 2,000 km of northward displacement for these rocks.

CONGLOMERATE COMPOSITION

Three pebble counts from the sequence at Point San Pedro (table 4 and fig. 13) show abundant felsic volcanic (mean 42.6 percent) and granitic (mean 25.7 percent) rocks, with moderately abundant quartz sandstone (mean 14.2 percent), and a slight enrichment in chert (mean 2.0 percent). The composition is similar to the granite-rich conglomerate occurring low in the Paleocene sequence, but not at the base, at Gualala (fig. 13). Coarse-grained conglomerate that is well exposed in a highway roadcut at Point San Pedro contains abundant granite boulders. We sampled only the pebble-size clasts in the interstices between the boulders at this locality (BP-73-1D).

SANTA CRUZ MOUNTAINS

In the Santa Cruz Mountains south of San Francisco (fig. 2) the Eocene Butano Sandstone is widely distributed (Clark, 1981; Brabb and Pampayan, 1983; Brabb, 1989). The formation is as much as 3,000 m thick and consists of turbidites of deep-sea fan facies with mainly north-directed paleocurrent indicators (Nilsen and Simoni, 1973; Nilsen, 1985). The Butano overlies the Locatelli Formation of Paleocene age, which consists of about 270 m of siltstone resting on granitic basement (Clark, 1981).

Clark (1981) gave the age of the Butano Sandstone as ranging from Penutian (early Eocene) to Narizian (middle and late Eocene), but he noted that the lower part of the formation is not well dated and could be older. Kanter (1988) discussed new data supporting

◀ FIGURE 5.—Pre-late Cenozoic palinspastic reconstruction of western California (after Powell, in press) showing generalized Eocene paleocurrent directions. See text for sources of information. Note that about 90° of clockwise rotation of the southwestern Transverse Ranges, which we would restore, is not fully restored in this reconstruction.

an early and middle Eocene age for the formation. In an effort to better date the lower part of the Butano, we collected foraminiferal mudstone from a locality (grid 4,110,800N, 572,040E) stratigraphically just below two of our conglomerate localities near the base of the formation (BP-80-1 and BP-78-1D). R. Z. Poore (written commun., 1989) identified planktic foraminifers and calcareous nannofossils of early Eocene age (foraminiferal zones P7-P9, nannofossil zone NP11), which confirms the previous age assignments of the lower part of the Butano.

Paleomagnetic determinations on the Butano Sandstone are interpreted by Kanter and Debiche (1985) and Kanter (1988) to indicate that, aside from San Andreas fault displacement, no large northward translation is required.

CONGLOMERATE COMPOSITION

The mean of five pebble counts of conglomerate in the Butano Sandstone (table 6 and fig. 15) shows abundant felsic volcanic rocks (57.0 percent), quartz sandstone (19.1 percent), and granitic rocks (14.5 percent). Relative to other Eocene conglomerate of the Salinian block, conglomerate in the Butano Sandstone is relatively rich in quartz sandstone and poor in granitic rocks.

We also present sandstone petrology from the Butano Sandstone (table 9 and figs. 19 and 20). This is discussed in a later section.

POINT REYES

In a small area on the tip of Point Reyes (fig. 2) about 200 m of graded sandstone, conglomerate, and minor siltstone of Paleocene age overlies granitic basement (Galloway, 1977; Clark and others, 1984). West to northwest sediment transport (fig. 4) is suggested by channel orientations and paleocurrent data (Clark and others, 1984).

CONGLOMERATE COMPOSITION

Three pebble counts from the Point Reyes Conglomerate of Galloway (1977; table 4 and fig. 13) show abundant felsic volcanic rocks (mean 69.6 percent) and modest amounts of quartz sandstone (mean 8.4 percent) and granitic rocks (mean 14.4 percent). Compared with the Paleocene conglomerate at Gualala, the conglomerate at Point Reyes is more like the granite-poor conglomerate at the base of the Paleocene section than the granite-rich conglomerate higher up.

CARMEL

Paleocene rocks of the Carmelo Formation of Bowen (1965) are well exposed near Carmel, just south of Monterey, where they rest on granitic basement (figs. 1 and 2; Clark and others, 1974; Clifton and Hill, 1987). Good exposures are found both in the Point Lobos State Reserve south of Carmel Bay and at the north edge of the bay along the Pebble Beach Golf Course. The formation is about 220 m thick (Clark and others, 1984) and consists of turbidites interpreted as the fill of a submarine canyon (Clifton, 1981; Clifton and Hill, 1987). Paleocurrent directions both to the northwest and to the southwest are reported (Clifton, 1981; fig. 4).

The few fossils that have been found in the Carmelo Formation of Bowen (1965) indicate a Paleocene age (Nili-Esfahani, 1965; Bowen, 1965). We sampled a microfossiliferous calcareous concretion from the beach at the south end of the Point Lobos Reserve (grid location, 4,040,530N, 595,090E). N. L. Frederiksen examined the sample and reported the following palynomorphs, which indicate a Paleocene to earliest Eocene age (written commun., 1989):

Betulaepollenites sp.
Momipites aff. *M. microfoveolatus*
Momipites coryloides group

CONGLOMERATE COMPOSITION

Seven pebble counts from the Carmelo Formation of Bowen (1965; table 4 and fig. 13) are very rich in felsic volcanic rocks (mean 82.6 percent) with little quartz sandstone (mean 3.2 percent) or granite (mean 9.9 percent). A basal boulder conglomerate, exposed on the north edge of Carmel Bay, is very rich in granite clasts; however, the size range is largely above the range used in this study, and a count was not done. The volcanic-rich conglomerate, because it is so low in granite, is more typical of Cretaceous rather than Paleocene conglomerate in the Salinian block. Similar conglomerate of Cretaceous age is exposed nearby on the Big Sur coast, and there is also a granite-rich basal conglomerate not far to the south. Because of this similarity with Cretaceous conglomerate, we collected more fossils, but, as noted above, the Tertiary age was confirmed.

PIGEON POINT

Upper Cretaceous rocks of the Pigeon Point Formation are well exposed along a 16-km stretch of the coast near Pigeon Point, west of the San Gregorio-Hosgri fault, south of San Francisco (figs. 1 and 2). It is not clear if the basement under the Pigeon Point consists of granitic rocks of the Salinian block or of the Franciscan assemblage (subduction complex) of the Nacimiento block (Howell and Joyce, 1981). Fossils of Campanian or Maestrichtian age have been reported (Hall and others, 1959; Saul and Popenoe, 1962; Saul, 1983; Elder, 1989). Most recently, the sequence was considered upper Campanian (Elder, 1991a). The sedimentary rocks are about 3,300 m thick and are of deep-sea fan facies passing up into slope and shelf facies (Howell and Joyce, 1981). Paleocurrent directions (Howell and Joyce, 1981), corrected for rotations suggested by paleomagnetic observations (Champion and others, 1984), are both to the west and to the south (fig. 3). Paleomagnetic observations are interpreted by Champion and others (1984) to indicate 2,500 km of northward translation.

CONGLOMERATE COMPOSITION

Like most Cretaceous conglomerates of the Salinian block (table 1 and fig. 6), four samples counted from the Pigeon Point Formation are rich in felsic volcanic rocks (mean 80.7 percent) and low in quartz sandstone (mean 1.5 percent) and granitic rocks (mean 11.7 percent). Like other Cretaceous conglomerates they are also low in chert (mean 1.5 percent). Some chert pebbles, however, have well-preserved radiolarians, whereas the chert in most Cretaceous conglomerate is typically recrystallized and lacks identifiable radiolarians. Grove (1989) reported that radiolarians in two pebbles in the Pigeon Point are Late Jurassic in age. This contrasts with the Triassic age of most chert in upper Mesozoic conglomerate in California (Seiders and others, 1979; Seiders and Blome, 1988). The Late Jurassic age, coupled with the observation that some pebbles are red, suggests a source in the Franciscan assemblage. The recycling of Franciscan rocks, including chert, into Upper Cretaceous rocks of the Franciscan itself is well documented (Cowan and Page, 1975; Seiders and others, 1979), but reports of Franciscan detritus in other Cretaceous sedimentary rock units are rare. The apparent absence of other distinctive Franciscan detritus, such as blueschist, casts doubt on the source of the chert.

BIG SUR COAST

Upper Cretaceous sedimentary rocks resting on Salinian basement and including conglomerate have been mapped along the Big Sur coast south of Monterey (figs. 1 and 2; Trask, 1926; Reiche, 1937; Howell and others, 1977; Seiders and others, 1983). The rocks have not been studied in detail but Upper Cretaceous fossils have been reported from them (Trask, 1926; Nomland and Schenck, 1932).

CONGLOMERATE COMPOSITION

The most northern of two conglomerates sampled from this area (table 1 and fig. 6) is typical of the Salinian block Cretaceous conglomerates, with abundant felsic volcanic clasts (82.0 percent) and relatively little quartz sandstone (3.8 percent) and granite (12.5 percent). The other conglomerate is a basal conglomerate rich in locally derived granite (39.9 percent) and metamorphic rocks (29.9 percent, included in "other" in table 1), with few felsic volcanic rocks (13.4 percent).

ARROYO SECO

A small area of Paleocene rocks is exposed near Arroyo Seco, inland from the Big Sur coastal area (fig. 2; Dickinson, 1965; Seiders and others, 1983). The sequence contains Paleocene megafossils and consists of about 30 m of conglomerate overlying about 250 m of mudstone, siltstone, and sandstone resting on crystalline basement (Dickinson, 1965).

CONGLOMERATE COMPOSITION

Two pebble counts from the conglomerate near Arroyo Seco (table 4 and fig. 13) are very rich in quartz sandstone (mean 55.4 percent) with moderately abundant granitic rocks (mean 20.7 percent) and unusually few felsic volcanic clasts (mean 19.3 percent). This is not a basal conglomerate and the unusual composition does not result from the local derivation of quartz sandstone clasts. The pebbles are well rounded and include quartz sandstone with well-preserved clastic textures, unlike the highly tectonized metasandstone found in the basement of the Salinian block.

THE INDIANS RANCH

Near the Indians Ranch, in the northern Santa Lucia Range (fig. 2; Seiders and others, 1983), a lenticular conglomerate body about 300 m thick is incised into proximal turbidites of the Reliz Canyon Formation (Graham, 1979a, b). The conglomerate represents a slope channel complex with southwest-directed paleocurrent indicators (fig. 5) and middle Eocene fossils. Graham (1979a) assigned the conglomerate to the Church Creek Formation, but Seiders and Joyce (1984) considered it part of the Reliz Canyon Formation. Underlying Paleocene beds (not sampled) show southwest-directed paleocurrents (fig. 4; Reutz, 1979).

CONGLOMERATE COMPOSITION

The mean of three pebble counts from conglomerate near the Indians Ranch (table 6 and fig. 15) is similar to other Eocene conglomerates of the Salinian block, with abundant felsic volcanic (54.9 percent) and granitic (25.6 percent) rocks and moderately abundant quartz sandstone (12.2 percent). In outcrop, large boulders of locally derived basement rocks are conspicuous.

CENTRAL SANTA LUCIA RANGE

Upper Cretaceous strata are widely exposed in the central Santa Lucia Range (fig. 2; Jennings, 1958), where they occur both depositionally above Salinian block basement and as tectonic klippe on Franciscan assemblage rocks of the Nacimiento block (Page, 1970). The stratigraphy in the Burnett Peak quadrangle (Seiders, 1989) is the basis for the stratigraphic assignment of most of the conglomerates studied in this area. This stratigraphy has been carried beyond that quadrangle through mapping by one of us (Seiders) and by correlation with rocks in other areas (Durham, 1968a, b; Howell and others, 1977; Seiders, 1982; Grove, 1986, 1989).

In the Burnett Peak quadrangle (Seiders, 1989), two slightly different stratigraphic sequences are exposed on opposite flanks of a faulted syncline. On the southwestern flank, the Steve Creek, Italian Flat, and Shut-in Formations, listed in ascending order, comprise about 2,500 m of turbidites, with abundant conglomerate in the Steve Creek and the Shut-in. The Steve Creek is not well dated and could be as old as Campanian, but the two overlying formations have yielded foraminifers, pollen, and dinoflagellates of late Maestrichtian age. On the northeast limb of the syncline, the El Piojo Formation is about 1,300 m thick and contains both microfossils and megafossils of Maestrichtian, largely late Maestrichtian, age (Saul, 1986; Seiders, 1986; Sliter, 1986). The upper part of the El Piojo consists of deep-water turbidites and the lower part is shallow-marine facies rocks (Grove, 1986; Seiders, 1986).

Paleocurrent indicators in Cretaceous rocks (fig. 3) in the western part of Lake Nacimiento point southwest (Seiders, unpub. data) and in the eastern part of the lake point mainly south (Howell and others, 1977; Grove, 1986). South of Lake Nacimiento some paleocurrent indicators are directed west (McClure, 1969).

In the eastern part of Lake Nacimiento, strata of late Maestrichtian age are succeeded without interruption by beds with Paleocene fossils (Durham, 1968b; Grove, 1986; Saul, 1986). We tentatively assign three conglomerate exposures in this area to the Paleocene based on along-strike projection from a Paleocene fossil locality.

CONGLOMERATE COMPOSITION

The Steve Creek and Shut-in Formations, units exposed on the southwest limb of the syncline mentioned above, have similar clast compositions and are like many other Cretaceous conglomerates of the Salinian block (table 1 and fig. 6). Conglomerate from the El Piojo Formation on the northeast side of the syncline, however, is more like Paleocene conglomerates of the Salinian block. Compared with the mean of 16 pebble counts from the Steve Creek and Shut-in Formations, the mean of 12 counts from the El Piojo is lower in felsic volcanic rocks (66.4 versus 84.6 percent) and is higher in quartz sandstone (7.8 versus 2.9 percent) and granitic rocks (20.4 versus 6.8 percent). The reason for this difference is not known with certainty, but it could be that the El Piojo, although also Maestrichtian in age, is nevertheless slightly younger than the Shut-in Formation. The deposition of granite-rich gravel, which in other areas started in the Paleocene, began in the El Piojo just before the end of the Cretaceous.

A geographic variation in the composition of conglomerates from the El Piojo Formation is shown in table 1, where the localities are listed in order from northwest to southeast. The seven more northwestern conglomerates are richer in granitic rocks than the five southeastern ones, exposed in the eastern part of Lake Nacimiento. The latter are closer in composition to Cretaceous conglomerate in the La Panza Range, with which they are juxtaposed when 45 km of displacement on the Rinconada fault is restored as suggested by Graham (1978).

The one Upper Cretacous conglomerate from the Atascadero Formation in the southern part of the region (table 1, locality Y-160) is unusual because it is composed entirely of volcanic and plutonic rock clasts with no sedimentary rock clasts at all. The reason for this is unclear.

The three conglomerates of questionable Paleocene age from the central Santa Lucia Range (table 4 and fig. 13) have abundant felsic volcanic rocks (mean 53.7 percent), quartz sandstone (mean 17.5 percent), and granitic rocks (mean 24.0).

LA PANZA RANGE

East of the Rinconada fault, a thick and extensive sequence of Upper Cretaceous and lower Tertiary sedimentary rocks overlies granitic basement of the La Panza Range (figs. 1 and 2). These rocks have been mapped by Vedder and others (1986a, b, c) and the sedimentary rocks are discussed by Howell and others (1977) and Grove (1989). The Cretaceous sequence probably is late Campanian and (or) Maestrichtian in age (J.G. Vedder, written commun., 1991) and begins with fluvial deposits, succeeded by shallow-marine facies rocks, and then deep-water turbidites. The overlying lower Tertiary rocks are of undifferentiated Paleocene or Eocene age and are a deep-sea fan facies. Paleocurrent indicators in the Cretaceous beds (fig. 3) are mainly south directed. Paleomagnetic observations on basal Upper Cretaceous strata are interpreted by Whidden and others (1991) to indicate formation within five degrees of the expected position as part of North America.

CONGLOMERATE COMPOSITION

In the northeastern part of this area, on Pozo grade and in American Canyon (Howell and others, 1977), three Cretaceous conglomerates from the lower 300 m of the section have a mean composition (table 1 and fig. 6) unusually rich in quartz sandstone (59.9 percent), very low in felsic volcanic rocks (2.7 percent), and moderately low in granitic rocks (12.4 percent). A basal conglomerate to the west, north of Santa Margarita Lake (Vedder and others, 1986a), and one to the southeast, on Chimineas Ranch (Vedder and others, 1986c), are compositionally similar but not quite so poor in felsic volcanic rocks (23 and 12.7 percent). The abundant quartz sandstone clasts in these conglomerates, like those in the Paleocene conglomerate at Arroyo Seco, are not of local derivation. The clasts are well rounded and many quartz sandstone clasts have well-preserved clastic textures, unlike the highly deformed, generally feldspathic metasandstones in the basement of the Salinian block. Both gray and pink quartz sandstone clasts are present.

The mean composition of six samples of Cretaceous conglomerates higher in the section (table 1 and fig. 6) are typical of Salinian block Cretaceous rocks, with abundant volcanic clasts (80.8 percent) and small amounts of quartz sandstone (7.5 percent) and granite (8.2 percent). A conglomerate of probable Cretaceous age in the southeastern part of this region is compositionally similar but richer in granitic clasts (25.9 percent).

Five conglomerates of early Tertiary age, either Paleocene or Eocene, fall into two suites (table 8 and fig. 18), one relatively low in quartz sandstone (mean of three, 8.2 percent) and the other higher in quartz sandstone (mean of two, 20.5 percent). Felsic volcanic rocks (mean 59.0 and 50.1 percent) and granitic rocks (mean 29.2 and 26.3 percent) are present in amounts typical of the lower Tertiary rocks of the Salinian block. Plotted on the geologic map of Vedder and others (1986a), the low quartz-sandstone suite is seen to underlie the high quartz-sandstone suite.

CUYAMA RIVER GORGE

Lower Tertiary turbidites are widely exposed in the region lying east of the Sur-Nacimiento fault zone north and south of the Cuyama River (Vedder and others, 1988, 1989b). These rocks are continuous with beds that form the upper part of the Upper Cretaceous and lower Tertiary sequence that rests on La Panza Range basement farther north. Some rocks are early Eocene in age and others can be dated no more precisely than either Paleocene or Eocene (J.G. Vedder, oral cummun., 1990). Near the Cuyama River and southward through the Sierra Madre Mountains, paleocurrent indicators point mainly to the west and west-southwest (fig. 5; Chipping, 1972).

CONGLOMERATE COMPOSITION

Two conglomerate suites, one early Eocene in age and one Paleocene or Eocene in age (tables 6 and 8 and figs. 15 and 18), are found in the area. Eight pebble counts from the Eocene suite have a mean composition that is low in quartz sandstone (5.3 percent) and rich in felsic volcanic (64.3 percent) and granitic (25.0 percent) rocks. The mean of four pebble counts from the Paleocene or Eocene suite is much richer in quartz sandstone (32.1 percent) and relatively lower in felsic volcanic (45.5 percent) and granitic (16.8 percent) rocks. Locally, conglomerate of the high quartz-sandstone suite appears to overlie the low quartz-sandstone suite, but this relationship is not certain.

CALIENTE RANGE

In the southeastern Caliente Range (fig. 2), as much as 1,000 m of Paleocene siltstone, sandstone, and conglomerate were mapped as the Pattiway Formation by Vedder and Repenning (1975). The base of the unit is not exposed. Paleocurrent measurements by Sage (1973) indicate south-directed currents.

CONGLOMERATE COMPOSITION

Three pebble counts from the Pattiway Formation (table 4 and fig. 13) have a mean clast composition that is rich in felsic volcanic (59.9 percent) and granitic (22.2 percent) rocks with moderate amounts of quartz sandstone (13.0 percent).

STANLEY MOUNTAIN AREA

West of the Sur-Nacimiento fault zone, near Stanley Mountain and close to the Cuyama River (Vedder and others, 1989a), and in the northwestern San Rafael Mountains 25 km to the southeast (Vedder and others, 1967; fig. 2), conglomerate occurs in beds of Late Cretaceous age. The precise age of the rocks near Stanley Mountain is not known (Hall and Corbató, 1967), but the conglomerate to the southeast is Campanian or Maestrichtian in age and a shallow-marine to nonmarine facies (Vedder and others, 1983). Underlying mid-Cretaceous (Cenomanian to Santonian) sedimentary rocks, together with an ophiolite at the base of the section, have paleomagnetic signatures interpreted by McWilliams and Howell (1982) to indicate formation near the equator.

CONGLOMERATE COMPOSITION

Three pebble counts of conglomerates from this area (table 1 and fig. 6) have a mean composition showing 15.4 percent quartz sandstone, 64.1 percent felsic volcanic rocks, and 8.3 percent granite. Relative to Cretaceous conglomerates of the Salinian block, this composition is only slightly high in quartz sandstone and slightly low in volcanic rocks. The granite content of the southeastern conglomerate (10.1 percent), like the others, is low. This contrasts with mention of abundant granite by Vedder and others (1977, 1983), which probably stems from observations on larger clasts.

CENTRAL SAN RAFAEL MOUNTAINS

A thick sequence of Upper Jurassic through lower Tertiary rocks was mapped in the central San Rafael Mountains (fig. 2) by Vedder and others (1967). The sampled Upper Cretaceous rocks are west of the Sur-Nacimiento fault zone and come from a sequence of beds that contain late(?) Campanian and Maestrichtian fossils (J.G. Vedder, written commun., 1991). Two samples (BP-597 and BP-598) are from the upper 500 m of the Mesozoic section, just below a depositional contact with lower Tertiary rocks. Paleocurrent indicators in some Upper Cretaceous rocks of the area point west and south-southwest (Howell and others, 1977).

The lower Tertiary samples are from just east of the Sur-Nacimiento fault zone and are early Eocene in age (J.G. Vedder, oral commun., 1990). These rocks are a southward continuation of the Eocene beds in the Cuyama River area to the north.

CONGLOMERATE COMPOSITION

One Cretaceous conglomerate from the San Rafael Mountains (table 1 and fig. 6), like most Salinian block conglomerates, is rich in felsic volcanic rocks (78.7 percent), with subordinate quartz sandstone (5.5 percent) and granitic rocks (13.9 percent). Two other samples taken high in the stratigraphic section are unusually rich in granitic rocks (mean 48.1 percent), with subordinate felsic volcanic rocks (mean 39.7 percent) and minor quartz sandstone (mean 4.8 percent). The richness in granitic rocks does not reflect a local source, because the pebbles are small and well rounded.

Two lower Eocene samples are compositionally similar to the lower Eocene conglomerate in the Cuyama River area (table 6 and fig. 15), with a mean composition rich in felsic volcanic rocks (65.9 percent) and granite (28.6 percent), with minor quartz sandstone (3.0 percent).

FRAZIER MOUNTAIN BLOCK

In the Frazier Mountain block, situated between the Big Pine and Pine Mountain faults (figs. 1 and 2), about 4,300 m of Eocene nonmarine to shallow-marine facies sedimentary rocks overlie a basement of granitic and metamorphic rocks (Givins, 1974). Conglomerate occurs abundantly in the Juncal Formation of early and middle Eocene age, the thick basal unit of the sequence. Sedimentary structures were interpreted by Jestes (1963) and Howell (1975) to indicate sediment transport to the south and southwest.

CONGLOMERATE COMPOSITION

The mean of six pebble counts from the Juncal Formation (table 6 and fig.15) shows abundant felsic volcanic (51.1 percent) and granitic (39.2 percent) rocks with minor quartz sandstone (4.8 percent).

CONGLOMERATE FROM THE GOLDEN GATE - GILROY BLOCK

Upper Cretaceous sedimentary rocks with mappable bodies of conglomerate occur in the Santa Cruz Mountains about 80 km southeast of San Francisco (fig. 1; McLaughlin and others, 1988; Brabb, 1989). Late Campanian fossils are reported from these rocks (Elder and Miller, 1989; Elder, 1991b). The Cretaceous rocks structurally overlie the Franciscan assemblage.

Farther north, 24 km south of San Francisco, adjacent to the Pilarcitos fault where it is crossed by Highway 92, pebbly sandstone occurs in rocks mapped as the Franciscan assemblage by Brabb and Pampayan (1983). These rocks contain rudistid fragments but have not yet been dated paleontologically. The assignment of these rocks to the Franciscan assemblage seems uncertain.

CONGLOMERATE COMPOSITION

The mean composition of three samples of conglomerate from the area 80 km southeast of San Francisco (table 1 and fig. 6) is similar to Cretaceous conglomerates of the Salinian block, with abundant felsic volcanic rocks (70.5 percent) and little quartz sandstone (2.8 percent) or granite (3.1 percent). The abundance of mafic and andesitic volcanic rocks in two of the three samples (mean 12.5 percent) is exceptional.

The composition of the more northern locality of uncertain stratigraphic assignment (table 1, locality WO-268) is unusual for the large abundance of other than felsic volcanic rocks (39.9 percent), including 16.7 percent diabase, and for the scarcity of all but igneous rock clasts. This shows some similarity with conglomerate of the Anchor Bay strata of the Gualala area and with the sample from the Atascadero Formation of the central Santa Lucia Range (table 1).

CONGLOMERATE FROM THE DIABLO AND TEMBLOR RANGES

CRETACEOUS CONGLOMERATE

Upper Cretaceous sedimentary rocks in this area belong to the Great Valley sequence, the thick and extensive deposits of Late Jurassic through Cretaceous age that accumulated largely as turbidites in an elongate forearc basin (Ingersoll, 1978, 1988). In order to make comparison with Cretaceous conglomerates of the Salinian block, only Campanian and Maestrichtian rocks were sampled, although conglomerate of that age range is not abundant in this region. We sampled widely along nearly 200 km of strike, wherever we found reference in the literature to accessible conglomerate. In the northern part of the Diablo Range (fig. 1), Schilling (1962) mapped conglomerate of Maestrichtian age near Pacheco Pass. Not far to the south, Saul (1983) noted two conglomerate localities with Maestrichtian fossils and one other is described by Bennison and others (1991). In the southern Diablo Range, conglomerate was mapped by Marsh (1960) and Tamesis (1966) in the Red Man Sandstone of Marsh (1960) of Campanian or Maestrichtian age.

CONGLOMERATE COMPOSITION

Six pebble counts yield a mean composition (table 2 and figs. 7 and 8) that is rich in felsic volcanic rocks (50.1 percent), with moderate chert (16.2 percent) and little quartz sandstone (6.8 percent) or granite (4.9 percent). This composition is similar to the composition of conglomerate in underlying, mainly Albian through Santonian beds of the Great Valley sequence (Seiders and Blome, 1988, and unpub. data), and indicates no major change in the source area throughout Late Cretaceous time. The composition differs from Cretaceous conglomerates of the Salinian block in the much higher abundance of chert and the slightly fewer granitic rocks.

PALEOCENE CONGLOMERATE

Lower Tertiary sedimentary rocks of the Diablo and Temblor Ranges occur widely and comprise both shallow-marine and deep-sea turbidite facies. Regional sedimentology and tectonics are discussed by Dickinson and others (1979).

We found only one Paleocene conglomerate, in the Meganos Formation near Mount Diablo east of San Francisco, in the extreme northern part of the region, at a locality described by Cherven and Bodden (1983).

CONGLOMERATE COMPOSITION

A pebble count from the conglomerate in the Meganos Formation (table 5 and fig. 14) shows abundant chert (41.8 percent) and quartz sandstone (19.8 percent) with few felsic volcanic rocks (7.0 percent) and no granite. The composition is exceptional for the abundance of vein quartz pebbles (24.0 percent).

EOCENE CONGLOMERATE

CANTUA SANDSTONE MEMBER

The Cantua Sandstone Member of the Lodo Formation is a deep-sea fan deposit of the central Diablo Range (Nilsen and others, 1974; Dibblee, 1979) of early Eocene age according to Stinemeyer (1974). Paleocurrent indicators are mainly to the north (Nilsen and others, 1974). The sediment was apparently derived from the Sierra Nevada and reached the area through a submarine canyon located to the southeast (Graham and Berry, 1979). Nilsen and others (1974) thought that the Cantua Sandstone Member and the Eocene rocks of the Gualala area (fig. 1) were deposited on the same submarine fan, the two units becoming separated by movement on the San Andreas fault. Graham and Berry (1979), however, argued that facies relations and contrasts in sandstone petrology indicate that the Cantua is unrelated to the Eocene rocks at Gualala.

Conglomerate Composition

The mean composition of two collections of small pebbles from pebbly sandstone in the Cantua Sandstone Member is relatively rich in chert (31.2 percent) and quartz sandstone (14.5 percent), with few volcanic (8.1 percent) or granitic (7.1 percent) rocks. The chert pebbles are dark gray and are gradational to argillite, which is abundant, making up most of the mudstone fraction (mean 28.3 percent). The composition contrasts sharply with Eocene conglomerate at Gualala, which lacks chert and is rich in volcanic and granitic rocks (table 6 and fig. 15), supporting Graham and Berry's (1979) conclusion that the two units are unrelated.

SHALLOW-WATER MARINE DEPOSITS

In the Diablo Range, conglomerate occurs in lower to middle Eocene rocks of shallow-water marine facies in the Domengine Sandstone and Avenal Sandstone and in the lower part of the Los Muertos Creek Formation of Wilson (1943). We sampled the Domengine Formation near Mount Diablo (Bodden, 1983), at the north end of the Diablo Range, and in the Vallecitos area of the central Diablo Range, where it was mapped undivided with the Yokut Sandstone of White (1940) by Dibblee (1979) and Nilsen and Dibblee (1979). The Los Muertos Creek Formation was sampled northwest of this area, where it was mapped by Wilson (1943) and Dibblee (1979), and discussed by Nilsen and Clarke (1975) and Nilsen (1979). We sampled the Avenal Formation in the southern Diablo Range where it was recently studied by Morelan (1988) and at Devils Den at the south end of the range, where its rocks were mapped as the Mabury Formation by Van Couvering and Allen (1943).

Conglomerate Compositions

Three pebble counts from the Domengine Sandstone have a mean composition (table 7 and figs. 16 and 17) rich in chert (73.3 percent) and poor in quartz sandstone (4.2 percent), volcanic rocks (6.7 percent), and granitic rocks (0.4 percent). Mudstone (mean 10.4 percent), consisting mainly of dark-gray argillite, is abundant in one sample (27.8 percent). Chert is commonly dark gray, gradational to siliceous argillite, but at one locality (PN-478, table 7) red and pale-green chert are common. The occurrence of red and green chert pebbles in conglomerate, like the presence of blue amphibole in sandstone, suggests a Franciscan assemblage source (Dickinson and others, 1979). The gray chert, and probably also the dark-gray argillite as well, were derived from the Sierra Nevada region.

Pebbles from the Los Muertos Creek Formation (locality GZ-479, table 7) are mainly chert (24 percent), mudstone (29 percent), and quartz sandstone (29 percent). One pebble of blueschist was found in this sample. The Avenal Sandstone from the southern Diablo Range (locality TD-437, table 7) is much richer in felsic volcanic rocks (42.6 percent), with subordinate chert (23.9 percent) and quartz sandstone (18.2 percent). The Avenal at Devels Den (locality SR-444) is unusual, with abundant felsic volcanic rocks (78.8 percent) and little chert (3.2 percent), quartz sandstone (3.2 percent), or granitic rocks (4.0 percent).

POINT OF ROCKS SANDSTONE MEMBER OF THE KREYENHAGEN FORMATION

As much as 900 m of lower and middle Eocene turbidites assigned to the Point of Rocks Sandstone member of the Kreyenhagen Formation crop out in the Temblor Range and southernmost Diablo Range (fig. 1), where they were studied by Clarke (1973). Paleocurrent indicators point mainly to the west-northwest. Clark and Nilsen (1973) proposed that the Point of Rocks formed as part of the same deep-sea fan as the Butano Sandstone of the Santa Cruz Mountains near San Francisco (figs. 1 and 2), the two units becoming separated by later San Andreas fault movement.

Conglomerate Composition

Three samples from the Point of Rocks Sandstone Member were obtained from the basal part of the unit. The mean composition (table 7 and figs. 16 and 17) is rich in chert (34.8 percent) and mudstone, largely argillite (34.3 percent), with subordinate quartz sandstone (10.5 percent) and minor felsic volcanic (6.5 percent) and granitic (1.6 percent) rocks. One sample with a very small pebble size (location CR-466, table 7) is also rich in vein quartz (19.5 percent). The chert is light to dark gray, gradational to dark-gray siliceous argillite. The clast assemblage contrasts with that of the Butano Sandstone, which has little chert (mean 1.8 percent) and is rich in volcanic (mean 57.0 percent) and granitic (mean 14.5 percent) rocks (table 6). The implications of this for the determination of San Andreas fault movement is discussed in a later section.

CONGLOMERATE OF THE PENINSULAR RANGES

NORTHERN SANTA ANA MOUNTAINS

The stratigraphy of this geologically important region at the northern tip of the Peninsular Ranges (figs. 1 and 2) has been described in detail by Schoellhamer and others (1981). The basement consists of low-grade metasedimentary rocks of the Middle Jurassic Bedford Canyon Formation. The basement is overlain by the Santiago Peak Volcanics of Late Jurassic(?) and Early(?) Cretaceous age, representative of the late Mesozoic Cordilleran magmatic arc.

The overlying Cretaceous sedimentary rocks correspond to the Great Valley sequence of the Great Valley of California but represent a more eastern basin-margin facies. Whereas the Great Valley sequence in the Diablo Range begins with Tithonian (Upper Jurassic) marine deposits, here the sea did not transgress eastward into the area until the Late Cretaceous. The oldest deposits are conglomerates assigned to the Trabuco Formation (nonmarine) and the Baker Canyon Conglomerate Member of the Ladd Formation (marine) of Turonian (Late Cretaceous) age. The overlying Holz Shale Member of the Ladd ranges from Turonian to Campanian in age and includes conglomerate called the Mustang Spring Conglomerate Lens by Blake and Colburn (1982), of Santonian or Campanian age (Almgren, 1982; Saul, 1982). The next higher unit, the Williams Formation of Campanian age, contains conglomerate in its lower member, the Schulz Ranch Sandstone Member. The Cretaceous rocks were deposited in nonmarine to shallow-water marine environments, with some deeper water outer-shelf and slope deposits, including some turbidites (Link and Bottjer, 1982; Saul, 1982). Paleocurrent indicators are mainly west directed (Blake and Colburn, 1982; Link and Bottjer, 1982).

Paleocene beds of the Silverado Formation overlie the Cretaceous rocks with angular unconformity. Conglomerate occurs at the base and near the top of the formation. Most of the Silverado is nonmarine but the upper part is marine in the northeastern part of the area. Paleocurrent directions determined by Sage (1973) and Davis (1978) vary widely.

The Santiago Formation of early to middle Eocene age overlies the Silverado Formation with apparent conformity and includes conglomerate at the base. The lower part of the formation is marine and the upper part may be nonmarine. West-directed paleocurrent indicators were measured by Davis (1978).

CONGLOMERATE COMPOSITION

Conglomerates in the Bedford Canyon Formation, the Santiago Peak Volcanics, and the basal Upper Cretaceous sedimentary rocks were studied by Seiders and Blome (1988). The compositional similarity of these conglomerates with Upper Jurassic through mid-Cretaceous conglomerate suites in the Golden Gate-Gilroy and Nacimiento blocks contributed to the conclusion that these blocks originated in southern California rather than farther to the south, as suggested by paleomagnetic observations.

The oldest conglomerate bearing directly upon the present study is in the Mustang Spring Conglomerate Lens of Blake and Colburn (1982) of the Holz Shale Member of the Ladd Formation. Two samples of this conglomerate have an unusual composition rich in sedimentary rock types (table 2 and figs. 9 and 10). The relative angularity of many clasts as well as their lithology points to a local source. This is also the conclusion of Colburn and Blake's (1982) more detailed study.

Two samples of conglomerate from the Schulz Ranch Sandstone Member of the Williams Formation have a mean composition rich in felsic volcanic rocks (72.5 percent) with moderately abundant quartz sandstone (11.8 percent). The composition is similar to Cretaceous conglomerate of the Salinian block, but the chert content (2.4 percent) is slightly high and the granite content (4.0 percent) slightly low.

The volcanic rock suite in conglomerate of the Schulz Ranch Sandstone Member is exceptional because a large number of the volcanic pebbles (mean 15.8 percent of all volcanic pebbles) contains xenoliths of quartz sandstone, chiefly as exotic clasts in volcaniclastic rock. Another stratigraphic unit that contains similar pebbles is a middle member of the Tuna Canyon Formation of the Santa Monica Mountains, described in a later section, where such rocks constitute a mean of 15.5 percent of the volcanic pebbles. Rocks of this kind are rare elsewhere and their abundance in both these areas demonstrates strong ties between the Santa Monica and northern Santa Ana Mountains during the Late Cretaceous.

Conglomerate in the basal part of the Silverado Formation of Paleocene age (table 5 and fig. 14), like Cretaceous conglomerate in the Holz Shale Member of the Ladd Formation, has relatively angular clasts and is composed mainly of sedimentary rocks of apparently local derivation. Conglomerate in the upper part of the Silverado, however, has well-rounded pebbles and a composition with abundant felsic volcanic (69.9 percent) and granitic (23.0 percent) rocks, little quartz sandstone (4.5 percent), and no chert. The composition is similar to that of some Paleocene conglomerates in the Coal Canyon Formation of the Santa Monica Mountains and to most Paleocene conglomerates in the Salinian block. It differs from Paleocene conglomerates in the Sepultura Formation farther south in the Peninsular Ranges, which have more chert (mean 3.5 versus 0 percent) and fewer granitic rocks (mean 3.4 versus 23.0 percent).

Conglomerates in the Eocene Santiago Formation (table 7 and figs. 16 and 17) are compositionally similar to those in the upper part of the Silverado Formation. They are similar to Eocene conglomerates in the Salinian block and contrast with Eocene conglomerates farther south in the Peninsular Ranges, which, in large part, are much poorer in granitic rocks.

SAN DIEGO

The geology of the San Diego area has been mapped by Kennedy (1975) and Kennedy and Peterson (1975). The basement consists of plutonic rocks of the southern California batholith and the Santiago Peak Volcanics, the latter in this area containing Tithonian fossils (Fife and others, 1967). Overlying Upper Cretaceous sedimentary rocks consist of a basal nonmarine conglomerate, the Lusardi Formation, medial sandstone and mudstone of the Point Loma Formation, and an upper unit of sandstone and conglomerate, the Cabrillo Formation. Both magnetostratigraphy and megafossils suggest that the Campanian-Maestrichtian boundary lies within the Point Loma and that the Cabrillo is entirely Maestrichtian in age (Bannon and others, 1989). We sampled the Cabrillo Formation at localities described by Nilsen and others (1984a, b). The Cretaceous rocks are mainly turbidites with shallow-water marine and nonmarine deposits in the lower part (Nilsen and Abbott, 1984). Paleocurrents were to the west, northwest, and southwest (Maytum and Elliott, 1970; Arthur and others, 1984).

Eocene rocks in the area are assigned to the La Jolla and Poway Groups of Kennedy (1975) and Kennedy and Peterson (1975) and the Ballena Gravel of Miller (1935). The rocks are of early to late Eocene age and show a progression of facies from marine on the west to fluvial in the east. Paleocurrent indicators point southwest and west (Minch, 1972; Howell and Link, 1979).

CONGLOMERATE COMPOSITION

Three samples of conglomerate from the Cabrillo Formation have a mean composition (table 2 and figs. 9 and 10) that is rich in felsic volcanic rocks (58.2 percent) with moderately abundant quartz sandstone (15.1 percent) and few granitic rocks (6.9 percent). The low chert content is slightly greater than that in the Upper Cretaceous rocks of the northern Santa Ana Mountains (3.3 versus 2.4 percent) and higher than that in the Salinian and Nacimiento blocks (0.5 percent).

Seven samples of Eocene conglomerate have a mean composition (table 7 and figs. 16 and 17) rich in felsic volcanic rocks (89.6 percent) and low in quartz sandstone (4.0 percent) and granitic rocks (4.6 percent). The low granite content contrasts sharply with Eocene conglomerates in the northern Santa Ana Mountains (fig. 17) and in the Salinian block (fig. 15).

UPPER CRETACEOUS CONGLOMERATE IN BAJA CALIFORNIA

Upper Cretaceous marine sedimentary rocks are widely distributed along the west coast of Baja California, where they are mainly assigned to the Rosario Formation of Campanian and Maestrichtian age (Morris and Busby-Spera, 1990). The marine rocks commonly overlie unfossiliferous nonmarine Upper Cretaceous sedimentary rocks, which in turn lie on upper Mesozoic volcanic rocks of the Alisitos Formation. The core of the peninsula consists of late Mesozoic batholithic rocks and Paleozoic and Mesozoic metamorphic rocks (Gastil and others, 1975). On Cabo Vizcaino (fig. 1), Upper Cretaceous sedimentary rocks occur at the top of a thick sequence that ranges down to the Upper Jurassic and overlies an ophiolite (Frizzell, 1984).

BAJA CALIFORNIA NORTH OF ENSENADA

Cretaceous rocks in this area (fig. 1) were studied by Yeo (1984a, b). Reddish nonmarine conglomerate of the Redondo Formation, correlative with the Lusardi Formation of the San Diego area, is overlain by the shallow-water marine to deep-sea turbidite facies Rosario Formation of Campanian and Maestrichtian age. We collected at localities in the Rosario suggested by Yeo's (1984b) stratigraphic sections. Some of the localities may be in rocks considered to be the Redondo Formation by Yeo (1984a, b), but none are red in color.

Conglomerate Composition

The mean of six pebble counts (table 2 and figs. 9 and 10) shows abundant felsic volcanic rocks (41.3 percent) and quartz sandstone (20.8 percent) with subordinate granitic rocks (8.3 percent). Chert (11.3 percent) is more abundant than at localities farther north in the Peninsular Ranges.

PUNTA BANDA AND PUNTA SANTO TOMAS

Conglomerate occurs in the Rosario Formation on Punta Banda, just southwest of Ensenada, and on Punta Santo Tomas, a little farther south (fig. 1), where it was studied by Acosta (1970). The Rosario overlies the Alisitos Formation and consists of shallow-water marine deposits of late Campanian age.

Conglomerate Composition

Conglomerate in this area is unusual because it is composed almost entirely of igneous rock clasts. The mean of four pebble counts (table 2 and figs. 9 and 10) shows 88.8 percent felsic volcanic rocks and 6.2 percent granitic rocks. Acosta (1970) pointed to the underlying Alisitos Formation as the source of the volcanic rocks. Many pebbles are poorly rounded, suggesting that the unusual composition results from local derivation in a small drainage basin that did not extend eastward much beyond the Alisitos Formation.

PUNTA CAMALU

Near Punta Camalu (fig. 1) the Rosario Formation is of shallow-water marine to submarine fan facies and is early Maestrichtian in age (Miller and Abbott, 1989).

Conglomerate Composition

The mean of two pebble counts from the Rosario Formation (table 2 and figs. 9 and 10) shows abundant felsic volcanic rocks (63.5 percent) with a moderate amount of chert (8.6 percent) and little quartz sandstone (3.8 percent) or granitic rocks (2.1 percent).

PUNTA BAJA

On Punta Baja, near El Rosario (fig. 1), the Punta Baja Formation of Kilmer (1963) is up to 140 m thick and contains early Campanian fossils. It shows south and southwest sediment transport directions and is interpreted as a deep-water submarine canyon fill (Boehlke and Abbott, 1986).

Conglomerate Composition

The mean of three pebble counts from Punta Baja (table 2 and figs. 9 and 10) is rich in chert (31.6 percent), dark-gray argillite (24.1 percent), and felsic volcanic rocks (23.9 percent), with less abundant quartz sandstone (8.3 percent) and few granitic rocks (1.8 percent).

CABO VIZCAINO

One conglomerate sample was collected from the Valle Formation, from beds considered to be Campanian in age by Rangin (1982).

Conglomerate Composition

This conglomerate (table 2 and figs. 9 and 10) is rich in felsic volcanic rocks (61.5 percent), with moderately abundant chert (14.6 percent) and quartz sandstone (12.1 percent) and few granitic rocks (6.7 percent).

PALEOCENE CONGLOMERATE IN BAJA CALIFORNIA

We sampled conglomerate in the Sepultura Formation near Cabo Colonet (fig. 1), where it was studied by Miller and Abbott (1988). The formation contains Paleocene megafossils, is of shallow-water marine to nonmarine facies, and shows west-directed paleocurrent indicators. We also sampled compositionally similar conglomerate on the highway north of El Rosario which we tentatively assign to the Sepultura.

CONGLOMERATE COMPOSITION

Three pebble counts from the Sepultura Formation (table 5 and fig. 14) have a mean composition rich in felsic volcanic rocks (67.6 percent), with small amounts of chert (3.5 percent), quartz sandstone (3.2 percent), and granitic rocks (3.4 percent).

EOCENE CONGLOMERATE IN BAJA CALIFORNIA

Extensive deposits of river gravels, at least partly of Eocene age, occur in inland areas of northern Baja California, where they were studied by Minch (1972). These systems are comparable to the Ballena Gravel which formed part of the distributary system that fed sediment to the La Jolla and Poway Groups in the San Diego area. We sampled the Las Palmas gravels 70 km north of Ensenada (fig. 1). The Las Palmas gravels appear to correlate with the Buenos Aires Formation near Tijuana and on this basis were considered Eocene by Minch (1972). We also sampled the Table Mountain Gravels of Minch and Abbott (1973) on the California-Baja California border 90 km east of San Diego. These gravels are undated and may be older than the Las Palmas gravels, possibly Cretaceous in age (Minch, 1972; Minch and Abbott, 1973).

CONGLOMERATE COMPOSITION

Two samples of the Las Palmas gravels have a mean composition (table 7 and figs. 16 and 17) rich in felsic volcanic rocks (75.7 percent) with little granite (3.7 percent). The composition is similar to that of Eocene conglomerate in the San Diego area, except that quartz sandstone (8.0 versus 4.0 percent) and other sandstone (9.0 versus 0.3 percent) are more abundant. Minch's (1972) more numerous (18) pebble counts of the Las Palmas gravels are also similar, except that he found a higher abundance of quartz sandstone (mean 25.7 percent).

The two samples of the Table Mountain Gravels (table 7 and fig. 17) are rich in felsic volcanic rocks (60 and 58 percent), but also contain abundant granitic rocks (34 and 16 percent). Because of the uncertainty in the age of these gravels, their significance is unclear.

CONGLOMERATE OF THE SOUTHWESTERN TRANSVERSE RANGES

This block is bounded on the north by the Santa Ynez and Santa Ynez River faults, on the south by the Malibu coast fault, and on the east by the San Gabriel fault. Paleomagnetic data indicate that the block has undergone Neogene clockwise rotation of about 90° (Luyendyk and others, 1980; Hornafius and others, 1986). Conglomerates of Late Cretaceous, Paleocene, and Eocene age are exceptional for their richness in quartz sandstone or granitic rocks or both.

CRETACEOUS CONGLOMERATE

SANTA BARBARA

North of Santa Barbara (fig. 2), a sequence of conglomerate-bearing strata about 620 m thick was assigned to the Upper Cretaceous Jalama Formation of Dibblee (1950) by Dibblee (1966), although no fossils were found. The Jalama is faulted against the Franciscan assemblage and the base is not exposed. The Jalama is overlain by the Matilija Sandstone of Eocene age. Paleocurrent indicators, after correction for tectonic rotation, point west (Reed and Campbell, 1991).

Conglomerate Composition

Two samples of conglomerate have a mean composition (table 2 and figs. 7 and 8) rich in felsic volcanic rocks (46.6 percent) and quartz sandstone (33.5 percent), with moderately abundant granitic rocks (14.9 percent).

WHEELER GORGE

A sequence of turbidites with layers of conglomerate is exposed near Wheeler gorge (fig. 2), where it was mapped unnamed but tentatively correlated with the Jalama Formation by Dibblee (1985, 1987a). About 1,400 m of these rocks crop out and their base is not exposed. These rocks are overlain by the Eocene Juncal Formation. Rust (1966) reported late Campanian or Maestrichtian fossils from these strata. At Wheeler gorge the conglomerate-bearing rocks are cut off on the north by the Santa Ynez fault. Four kilometers to the west, on Matilija Creek, conglomerate reappears beneath Eocene beds, but its correlation with the beds at Wheeler gorge is not certain (Rust, 1966). The Cretaceous rocks are well exposed at Wheeler gorge and have received considerable attention by sedimentologists (see Dibblee, 1987b). Rust (1966) and Walker (1975) reported paleocurrent indicators which point, when corrected for tectonic rotation (fig. 3), to the south and south-southwest; Howell and others' (1977) adjusted indicators also point to the south and west.

Conglomerate Composition

Two samples of conglomerate from this area have a mean composition (table 2 and figs. 7 and 8) that is rich in quartz sandstone (23.2 percent), felsic volcanic rocks (34.6 percent), and granitic rocks (34.8 percent). The more western sample from Matilija Creek (WH-517) differs from the Wheeler gorge sample (WH-518) in that it is poorer in quartz sandstone (9.5 versus 37.0 percent) and richer in felsic volcanic rocks (49.8 versus 19.3 percent).

SIMI HILLS

About 1,830 m of thick-bedded sandstone exposed in the Simi Hills was named the Chatsworth Formation by Colburn and others (1981a; see also several related papers in the same volume). The Chatsworth is overlain by the Simi Conglomerate of Paleocene age; the base is not exposed. Megafossils give a late middle Campanian to early Maestrichtian age (Saul and Alderson, 1981). The deposits are interpreted as a sand-rich deep-sea fan facies (Link, 1981). Paleocurrent indicators (Trembly and Kraemer, 1981), corrected for tectonic rotation (fig. 3), suggest sediment transport mainly to the west. Pebbly sandstone and conglomerate (Colburn and others, 1981b) constitute a small part of the formation.

Conglomerate Composition

The mean of three pebble counts (table 2 and figs. 7 and 8) shows abundant quartz sandstone (38.4 percent), felsic volcanic rocks (22.8 percent), and granitic rocks (23.8 percent), with considerable variation between samples. Granite makes up 42.6 percent of one sample of very small pebbles. This is remarkable because granitic rocks, although often concentrated in the cobble and boulder size range, are seldom so abundant in small sizes.

SANTA MONICA MOUNTAINS

A thick sequence of structurally complex Upper Cretaceous turbidites has been mapped as the Tuna Canyon Formation in the east-central Santa Monica Mountains (Yerkes and Campbell, 1979, 1980) and farther east as unnamed strata by Dibblee (1991a, b). The turbidites rest on nonmarine red conglomerate, called the Trabuco Formation by Durrell (1954) because of its similarity with the formation of that name in the northern Santa Ana Mountains. The Trabuco overlies the Upper Jurassic Santa Monica Slate. The oldest marine fossils in the Upper Cretaceous beds are Turonian (Popenoe, 1973). We sampled conglomerate mainly in the area near Carey and Colburn's (1978, fig. 4) stratigraphic section D, in a 1,000-m-thick conglomerate unit (member D of Wilson, 1942; cited by Popenoe, 1973). This conglomerate is underlain by beds with Coniacian fossils (Alderson, 1988) and is overlain by upper Campanian fossiliferous strata (Popenoe, 1973). The strata are of deep-sea fan facies (Carey and Colburn, 1978). Sedimentary structures were interpreted by Carey and Colburn (1978) to indicate that the fan sloped, when corrected for tectonic rotation, west and south and received sediment from the east (fig. 3).

Conglomerate Composition

The mean of six pebble counts (table 2 and figs. 7 and 8) shows abundant felsic volcanic rocks (52.9 percent) and quartz sandstone (27.9 percent). Granitic rocks are generally low (mean 7.5 percent) and are only moderately abundant in the most eastern sample (HW-552, 16.9 percent), which also contains relatively abundant chert (5.9 percent versus a mean of 1.6 percent). As noted earlier, the felsic volcanic rocks in the five samples from the middle part of the Tuna Canyon Formation include 15.5 percent pebbles with xenoliths of quartz sandstone, a close similarity with conglomerate in the Schulz Ranch Sandstone Member of the Williams Formation of the northern Santa Ana Mountains.

PALEOCENE CONGLOMERATE

SIMI HILLS

The Simi Conglomerate has been mapped by Squires (1983a) in and near the Simi Hills, where it unconformably overlies the Upper Cretaceous Chatsworth Formation of Colburn and others (1981a). The Simi locally is overlain by the Paleocene Las Virgenes Sandstone of Nelson (1925) and locally is overlain and interfingers with the Paleocene and lower Eocene Santa Susana Formation of Clark (1924). The Simi Conglomerate ranges in thickness from a few meters up to about 440 m and varies from nonmarine in the west to deep-water marine in the east, where it contains Paleocene fossils (Parker, 1983; see also related papers in the same volume). Paleocurrent indicators show much variability but have a vector-mean near north (Parker, 1983), which corrected for tectonic rotation suggest westward sediment transport (fig. 4).

Conglomerate Composition

The Simi Conglomerate in the Simi Hills is rich in quartz sandstone and felsic volcanic and granitic rocks. The mean of three samples from low in the section, compared with two samples stratigraphically higher (table 5 and fig. 14), is richer in quartz sandstone (52.3 versus 18.9 percent), poorer in felsic volcanic rocks (16.7 versus 51.4 percent), and about equal in granitic rocks (22.7 versus 23.5 percent).

SANTA MONICA MOUNTAINS AND GOLD CREEK

In the central Santa Monica Mountains (fig. 2) Yerkes and Campbell (1979) mapped a thin unit of nonmarine conglomerate as the Simi(?) Conglomerate. The Simi(?) overlies the Upper Cretaceous Tuna Canyon Formation and is overlain conformably by the marine Coal Canyon Formation of Paleocene and Eocene age. The Coal Canyon is as thick as 450 m and includes conglomerate. The Coal Canyon is overlain by the Llajas(?) Formation of Eocene age.

Colburn and others (1988) and Colburn and Novak (1989) studied the Paleocene rocks in the eastern Santa Monica Mountains and presented several detailed stratigraphic columns and over a dozen pebble counts. They mapped all of the dominantly conglomeratic beds at the base of the Tertiary sequence as the Simi Conglomerate. Overlying sandstone with lenses of conglomerate were mapped as the Las Virgenes Sandstone. The overlying and interfingering Santa Susana Formation has marine fossils, whereas the two lower units were considered nonmarine. The Paleocene rocks are overlain unconformably by what Colburn and others (1988, fig. 6) show as the Eocene Las Llajas Formation and Colburn and Novak (1989, fig. 12) show as the Eocene(?) Las Llajas(?) Formation. Colburn and Novak (1989) noted that conglomerate in the lower part of the Simi Conglomerate is very rich in reddish quartz sandstone clasts, conglomerate higher in the Simi is rich in felsic volcanic rocks, and conglomerate in the Las Virgenes Sandstone is rich in granitic clasts.

In the northeastern part of the area, near the San Gabriel fault, Oakeshott (1958) noted conglomerate in Paleocene rocks mapped near Gold Creek (fig. 2).

Conglomerate Composition

Nine pebble counts were done on Paleocene conglomerates from the combined Santa Monica-Gold Creek region. Two pebble counts (table 5 and fig. 14), one from the Simi(?) Conglomerate of Yerkes and Campbell (1979) and one from the base of the Simi Conglomerate of Colburn and others (1988), have a mean composition very rich in quartz sandstone (90.5 percent), with few felsic volcanic (4.0 percent) or granitic (2.6 percent) rocks. This composition is even richer in quartz sandstone than beds in the lower part of the Simi Conglomerate in the Simi Hills (mean 52.3 percent). Quartz sandstone clasts are a mixture of gray and red varieties.

One sample of conglomerate from the lower part of the Coal Canyon Formation is only moderately rich in quartz sandstone (12.9 percent), with abundant felsic volcanic (53.4 percent) and granitic (28.9 percent) rocks. This composition resembles that of conglomerate in the upper part of the Simi Conglomerate of the Simi Hills.

Five samples of conglomerate from higher beds of the Coal Canyon Formation and in the upper part of the Simi Conglomerate of Colburn and others (1988), together with one sample from the Paleocene of the Gold Creek area, have a mean composition that is low in quartz sandstone (2.0 percent), with abundant felsic volcanic (61.2 percent) and granitic (32.7 percent) rocks. This is similar to conglomerate in the upper part of the Silverado Formation of the northern Santa Ana Mountains. It is like most Salinian block conglomerate except that it is relatively low in quartz sandstone.

We did not sample the granite-rich conglomerate described by Colburn and Novak (1989) from the upper part of the Paleocene section, but the very high granite content reported by them (mean of four, 76 percent) does not seem inconsistent with the wide swings in composition noted in other units from the region.

EOCENE CONGLOMERATE

SANTA YNEZ

Dibblee (1950) mapped conglomerate in the Matilija Sandstone on San Lucas Creek (Wons Creek of Dibblee, 1950), 7 km southeast of Santa Ynez (fig. 2). Dibblee (1988) later mapped the Eocene rocks in this area as unnamed marine strata of early(?) to middle Eocene age, tentatively correlated with the Anita Shale and Matilija Sandstone. These units in this area overlie unconformably the Espada Formation of Dibblee (1950) of Late Jurassic and Early Cretaceous age and are overlain unconformably by the Monterey Shale of Miocene age.

Conglomerate Composition

One pebble count from the Eocene conglomerate near Santa Ynez (table 7 and figs. 16 and 17) is rich in quartz sandstone (31 percent) and felsic volcanic rocks (51 percent), with moderately abundant granitic rocks (14 percent).

SAN MARCOS PASS

Northwest of Santa Barbara (fig. 2), Dibblee (1966, 1987c) mapped a lens of conglomerate in the marine Cozy Dell Shale of late Eocene age. The Cozy Dell overlies the Matilija Sandstone of middle to late Eocene age and is overlain by other upper Eocene marine deposits.

Conglomerate Composition

Two samples of conglomerate from the Cozy Dell Shale have a mean composition (table 7 and figs. 16 and 17) with abundant chert (28.2 percent), quartz sandstone (19.7 percent), and felsic volcanic rocks (39.8 percent), with few granitic rocks (8.0 percent). The abundant chert, unlike that found as sparse clasts in older conglomerate of the region, is little recrystallized and contains moderately well preserved radiolarians. This could indicate a source in either the Franciscan assemblage or in the chert at the top of the Coast Range ophiolite (Hopson and others, 1981). Few chert pebbles are red, as would be expected if the chert were derived from the Franciscan. Granitic and dioritic rocks, although not abundant in the size range counted, are common as cobbles and boulders. The source of these coarse clasts is enigmatic.

SIMI VALLEY

On the north edge of the Simi Valley, just north of the Simi Hills (fig. 2), Squires (1981, 1983a, b) mapped conglomerate at the base of the Llajas Formation of late early through early middle Eocene age. The Llajas is about 545 m thick and disconformably overlies the Santa Susana Formation. It is overlain by the nonmarine Sespe Formation. The Llajas includes a basal nonmarine conglomerate overlain by shallow-water marine sandstone and some deeper water sandstone and siltstone.

Conglomerate Composition

One pebble count from the Llajas Formation (table 7 and figs. 16 and 17) shows abundant quartz sandstone (54.3 percent) and felsic volcanic rocks (29.3 percent), with less abundant granitic rocks (11.0 percent).

NEWHALL

In Elsmere Canyon, southeast of Newhall (fig. 2), Oakeshott (1958) mapped about 200 m of middle Eocene pebbly to cobbly sandstone as the Domengine Formation. The base of the unit is not exposed and it is overlain by Pliocene deposits.

Conglomerate Composition

A pebble count from this unit (table 7 and figs. 16 and 17) shows abundant granitic rocks (67.3 percent), with fewer felsic volcanic rocks (23.6 percent) and very little quartz sandstone (0.9 percent).

CONGLOMERATE IN AND NEAR THE MOJAVE BLOCK

SOUTHERN END OF THE SIERRA NEVADA

TEJON FORMATION

In the San Emigdio Mountains, near the San Andreas fault (figs. 1 and 2), the basal part of the Tejon Formation is occupied by the Uvas Conglomerate

Member, a nearshore marine deposit as much as 122 m thick (Nilsen, 1987). The Uvas rests on basement rocks and in the western part of the area, where we obtained a sample, is of "Capay" or early Eocene age. Paleocurrent indicators have a vector-mean direction to the west-northwest (fig. 5).

Conglomerate Composition

One sample from a pebbly sandstone in the Uvas Conglomerate Member of the Tejon Formation (table 7 and fig. 17) is rich in felsic volcanic (56 percent) and granitic (32 percent) rocks, with a modest amount of quartz sandstone (7 percent). The composition is similar to Eocene conglomerates in the Salinian block.

WITNET FORMATION

The Witnet Formation crops out in the southernmost Sierra Nevada near Tehachapi, where it was mapped by Dibblee and Louke (1970). The Witnet rests on granitic rocks and consists of about 1200 m of nonmarine sandstone and siltstone with some conglomerate and pebbly sandstone. It is unconformably overlain by the Miocene Kinnick Formation. The Witnet is unfossiliferous. Dibblee and Louke (1970) suggested an early Tertiary age based on correlation with the Goler Formation of Paleocene age (see below).

Conglomerate Composition

Three pebble counts from the Witnet Formation have a mean composition (table 5 and fig. 14) rich in felsic volcanic (54.2 percent) and granitic rocks (24.3 percent) with moderately abundant quartz sandstone (11.5 percent). It is compositionally similar to conglomerates in the upper part of the Goler Formation, but is relatively richer in granitic rocks (24.3 versus 14.4 percent) and chert (3.0 versus 0.1 percent). It is also similar to Paleocene conglomerates in the Salinian block.

GOLER FORMATION

The Paleocene Goler Formation crops out in the El Paso Mountains just north of the Garlock fault and east of the southernmost Sierra Nevada (figs. 1 and 2). It thus lies in the extreme southwestern part of the Basin and Range Province. The Goler was named and mapped by Dibblee (1952) and more recently has been mapped and studied by Cox and Diggles (1986) and Cox (1987). The Goler is composed of as much as 4 km of largely fluviatile deposits, divisible into two main sequences. The lower part of the formation consists of locally derived canyon fill and alluvial fan and plain deposits lain down by southward-flowing streams. The upper sequence consists mainly of deposits laid down by west-flowing streams in a deep sedimentary basin with marine beds in the upper part. Most detritus in the upper sequence is remotely derived. Vertebrates and nonmarine mollusks date the lower part of the upper sequence as early or late Paleocene (McKenna and others, 1987). Dinoflagellates, foraminifers, and mollusks occur in recently discovered marine beds in the upper part of the sequence (Cox and Edwards, 1984; McDougall, 1987; Squires and others, 1988). The marine deposits, initially thought to be early Eocene, are now known to be latest Paleocene (nannofossil zone CP8) based on coccoliths (Reid and Cox, 1989).

Conglomerate Composition

Sixteen pebble counts were done on conglomerates in the Goler Formation. Three pebble counts from the lower stratigraphic sequence (table 5 and fig. 14), combined with several previous counts by Cox (1982), contain widely variable proportions of granitic rocks, felsic volcanic rocks, and quartzose sandstone, reflecting local derivation of clasts from the heterogeneous basement terrane of the El Paso Mountains region.

By contrast, thirteen pebble counts from the upper sequence of the Goler Formation show limited compositional variation, all being dominated by felsic volcanic rocks. These counts are divided into three compositional suites in table 5 and figure 14). The oldest suite, assigned to an informal "middle" stratigraphic level, comprises seven samples including one from the lower part of the 300- to 1,130-m-thick lower sandstone and siltstone member of Cox and Diggles (1986) and six others from the overlying 650-m-thick conglomerate and sandstone unit of Sheep Spring of Cox and Diggles (1986). The seven samples have a mean composition rich in felsic volcanic rocks (78.4 percent), with moderately abundant granitic rocks (13.5 percent) and little quartz sandstone (2.5 percent). Although the samples span a thick stratigraphic interval, there is remarkably little compositional variation. Similar to other suites from the upper sequence of the Goler Formation, there is little chert (mean 0.6 percent) or mudstone (mean 0.9 percent), although these rock types are abundant in the locally derived conglomerate of the lower sequence and in the underlying basement rocks.

One sample, designated as from a "middle-upper" stratigraphic level in table 5, comes from the 760-m-thick upper sandstone and siltstone member of Cox and Diggles (1986). The composition is rich in both felsic volcanic (59.3 percent) and granitic (34.1 percent) rocks, with little quartz sandstone (2.2 percent).

A suite of five samples from an "upper" stratigraphic level comes from the 240-m-thick conglomerate unit of Black Hills of Cox and Diggles (1986), which includes a marine mudstone member. The mean composition is rich in felsic volcanic rocks (65.4 percent), with moderately abundant quartz sandstone (13.5 percent) and granitic rocks (14.4 percent).

The three suites of conglomerate in the upper sequence of the Goler Formation span a range of compositions that overlaps strongly with that found in the Upper Cretaceous and lower Tertiary conglomerates of the Salinian block.

EASTERN TRANSVERSE RANGES

CAJON PASS

A thin sequence of sedimentary rocks overlying crystalline basement in Cajon Pass, just northeast of the San Andreas fault (fig. 2), has been mapped as the San Francisquito(?) Formation by Woodburne and Golz (1972). Koozer (1980) reported about 125 m of section, ranging from alluvial fan facies at the base to turbidites in the upper part. Paleocurrent indicators are mainly directed southwest. Koozer (1980) noted that a Cretaceous plesiosaur vertebra has been preserved for study, whereas a previously reported collection of early Tertiary mollusks is now lost and conceivably was misidentified.

Conglomerate Composition

One sample collected from the basal conglomerate strongly reflects local bedrock. It contains 63.1 percent granitic rocks, 27.7 percent quartz sandstone, and only 3.3 percent felsic volcanic rocks (table 2).

LIEBRE MOUNTAIN BLOCK

About 4 km of largely marine sandstone, mudstone, and conglomerate assigned to the San Francisquito Formation are widely exposed in the Liebre Mountain block (fig. 2) centered on Warm Springs Mountain. The formation rests on crystalline basement rocks and includes a thin sequence of nonmarine and shallow-water marine deposits near the base. The bulk of the San Francisquito is of deep-sea fan facies with a complex set of paleocurrent directions interpreted by Koozer (1980) to indicate a shoreline located to the north. Marine fossils (Koozer, 1980; Saul, 1983) show that the basal part of the formation is as old as late Maestrichtian and that most of the sequence is Paleocene, no younger than middle Paleocene.

Conglomerate Composition

One sample collected from Upper Cretaceous beds just above granitic basement has a composition (table 2) that strongly reflects a local source. It contains 59.1 percent granitic rocks, 12.4 percent quartz sandstone, negligible volcanic rocks (0.3 percent), and unusually abundant vein quartz pebbles (25.6 percent).

Seven samples of Paleocene conglomerate from the main part of the San Francisquito Formation have a mean composition (table 5 and fig. 14) rich in felsic volcanic rocks (62.0 percent) and granitic rocks (24.2 percent) with moderately abundant quartz sandstone (9.4 percent). The composition is similar to that of the Witnet Formation, the upper part of the Goler Formation, and most Paleocene conglomerates of the Salinian block.

PINYON RIDGE BLOCK

A sequence of marine Paleocene beds about one kilometer thick, assigned by Dibblee (1967) to the San Francisquito Formation, crops out in the narrow, fault-bounded Pinyon Ridge block (fig. 2) southwest of the San Andreas fault near Valyermo. The formation here overlies granodiorite and is overlain by the upper Tertiary Punchbowl Formation (Noble, 1954). The deposits are of deep-sea fan facies and have paleocurrent indicators pointing southward in the lower part of the formation and northwestward higher in the unit (Koozer, 1980). Koozer (1980) reported that the San Francisquito Formation in this area is mainly late middle through late Paleocene in age and overlaps in time little, if at all, with the San Francisquito of the Liebre Mountain block.

Conglomerate Composition

The mean of three pebble counts (table 5 and fig. 14) is very rich in granitic rocks (71.6 percent) with little quartz sandstone (3.0 percent) or felsic volcanic rocks (7.7 percent). The composition is unusually rich in vein quartz (8.3 percent). The granite-rich composition is like some basal conglomerate in other areas, yet the samples are from well up within a thick turbidite sequence. As noted by Koozer (1980), the composition contrasts sharply with that of conglomerate in the San Francisquito Formation of the Liebre Mountain block. It is similar to that of conglomerate in the Eocene Maniobra Formation of the Orocopia Mountains (see below).

OROCOPIA MOUNTAINS

A sequence of Eocene marine beds resting on granitic basement was named the Maniobra Formation by Crowell and Susuki (1959). The name comes from Maniobra Valley, named by them to commemorate the site of World War II maneuvers by troops under the command of General George S. Patton, Jr. In keeping with California tradition, Crowell and Susuki (1959) translated *maneuver* into the Spanish *maniobra*. The formation has been studied by Advocate (1983) and Advocate and others (1988), who interpreted the deposits as submarine canyon fill deposited by turbidity currents and other gravity flows with west-directed paleocurrents. The Maniobra is 1,460 m thick, contains early Eocene fossils, and is unconformably overlain by Miocene nonmarine beds.

Conglomerate Composition

The mean of five pebble counts from the Maniobra Formation (table 7 and fig. 17) is very rich in granitic rocks (65.3 percent). The composition and the poor rounding of most clasts suggests a relatively local source, in spite of the occurrence in a thick sequence of turbidites. The mean composition compares closely with that of Paleocene conglomerate from the San Francisquito Formation in the Pinyon Ridge block.

SOUTHEASTERN CALIFORNIA AND ADJACENT ARIZONA

McCOY MOUNTAINS FORMATION

The McCoy Mountains Formation of Harding and Coney (1985) is a very thick sequence of lightly metamorphosed nonmarine sedimentary rocks widely exposed in southeastern California and adjacent parts of Arizona (figs. 1 and 2; Harding and Coney, 1985; Stone and others, 1987). In the McCoy Mountains, the McCoy Mountains Formation is at least 7 km thick and rests on volcanic rocks of Early or Middle Jurassic age. Fossil wood in the upper part of the formation is Cretaceous in age (Stone and others, 1987), and in the Dome Rock Mountains a tuff bed in the upper part of the sequence has been dated radiometrically at 78±2 Ma by Tosdal (1988). Thus, the upper part of the formation is at least partly Upper Cretaceous and the lower part could be as old as Jurassic. The formation consists largely of fluvial deposits with some alluvial fan and lacustrine deposits (Harding and Coney, 1985). Paleocurrent indicators point mainly to the south.

Harding and Coney (1985) divided the McCoy Mountains Formation into six informal members, each named for a characteristic lithology. These members, in ascending order, are basal sandstone member 1, basal sandstone member 2, mudstone member, conglomerate member, sandstone member, and siltstone member. Conglomerate is found in all six members.

Most of our samples are from the McCoy Mountains near Blythe, California (Stone and Pelka, 1989), but we also obtained material from the Coxcomb Mountains (Calzia and others, 1983) and the Palen Mountains (Stone and Pelka, 1989) in California, and from the Dome Rock Mountains (Stone, 1990), the southern Plomosa Mountains (Miller, 1970), the Granite Wash Mountains (Laubach and others, 1987), the Little Harquahala Mountains (Richard and others, 1987), and the New Water Mountains (Sherrod and Koch, 1987) in Arizona. Correlation of samples from these other areas with the informal members of the McCoy described by Harding (1982) and Harding and Coney (1985) in the McCoy Mountains are largely those suggested by the respective authors based on stratigraphy and petrology. However, locality CU- 234 (table 3) in the Dome Rock Mountains was correlated by Tosdal (1988) and Stone (1990) with Harding and Coney's (1985) conglomerate member, whereas we have included it with the sandstone and siltstone members based on the composition of the conglomerate.

Conglomerate Composition

Conglomerates in the basal part of the McCoy Mountains Formation, in basal sandstone member 1, are rich in either chert or quartz sandstone (table 3 and figs. 11 and 12). Two samples have a mean composition rich in chert (90.3 percent), with little quartz sandstone (6.5 percent), very few felsic volcanic rocks (0.5 percent), and no granite. Three other samples have a mean composition with a moderate amount of chert (13.8 percent), abundant quartz sandstone (83.4 percent), and little else.

Six samples of conglomerate from the overlying basal sandstone member 2 have a mean composition with abundant felsic volcanic rocks (58.8 percent) and moderate amounts of chert (19.8 percent) and quartz sandstone (10.5 percent) with few granitic rocks (1.2 percent).

Conglomerates in the overlying mudstone member, like those in the basal sandstone member 1, are composed chiefly of chert and quartz sandstone but the mixture is different. Whereas either chert or quartz sandstone is dominant in conglomerate from basal sandstone member 1, in two samples from the mudstone member both chert and quartz sandstone are abundant in each sample (chert 23.6 and 58.3 percent; quartz sandstone 75.9 and 39.6 percent). There are few felsic volcanic (mean 1.1 percent) or granitic (mean 0.1 percent) rocks.

A major compositional change is seen in the conglomerate member, where the mean of four samples shows for the first time abundant granitic rocks (18.9 percent) and little chert (2.7 percent). The principal component is quartz sandstone (74.8 percent) and there are few felsic volcanic rocks (0.7 percent). Both gray and pink quartz sandstone clasts are present.

Conglomerates in the overlying sandstone and siltstone members also contain abundant granitic rocks but differs in the presence of abundant felsic volcanic rocks in most samples. The mean of five pebble counts shows abundant quartz sandstone (32.4 percent), felsic volcanic rocks (31.4 percent), and granitic rocks (25.8 percent) with little chert (2.6 percent). The compositions vary widely and occupy broad fields in figures 11 and 12.

Conglomerates in the basal sandstone member 1 and in the mudstone member are roughly similar in composition to conglomerates in some of the older strata of the Great Valley sequence and Franciscan assemblage of the California Coast Ranges. In the northern California Coast Ranges, Great Valley and Franciscan conglomerates of Tithonian (Late Jurassic) to Valanginian (Early Cretaceous) age have an average composition of 84.7 percent chert and 0.8 percent quartz sandstone (mean of 72; Seiders, 1991). In the Golden Gate-Gilroy and Nacimiento blocks of central California, correlative rocks contain two suites rich in both chert (46.2 and 64.6 percent) and quartz sandstone (35.7 and 19.8 percent; means of 7 and 37, respectively; Seiders and Blome, 1988, and unpub. data). These compositions compare with conglomerate in the basal sandstone member 1 and the mudstone member in that they consist chiefly of chert and quartz sandstone, but there is little similarity in detail.

Conglomerates in the stratigraphically intervening basal sandstone member 2, which are much richer in felsic volcanic rocks, compare more closely to younger conglomerates found at mid-Cretaceous levels of the Great Valley sequence and Franciscan assemblage. In the northern California Coast Ranges the mean of 134 pebble counts is 37.4 percent chert, 5.2 percent quartz sandstone, and 32.9 percent felsic volcanic rocks (Seiders, 1991). In the Diablo Range a suite of 68 samples has a mean composition with 16.5 percent chert, 6.6 percent quartz sandstone, and 50.2 percent felsic volcanic rocks (Seiders and Blome, 1988, and unpub. data). A suite of seven samples from the Golden Gate-Gilroy and Nacimiento blocks, together with five compositionally similar samples from the northern Santa Ana Mountains, have a mean composition with 37.5 percent chert, 19.1 percent quartz sandstone, and 26.5 percent felsic volcanic rocks (Seiders and Blome, 1988). Each of these suites compares roughly with the suite from the basal sandstone member 2 of the McCoy Mountains Formation but the similarity with the Diablo Range suite is closest. In the northern Coast Ranges there is also a small suite (23 samples) of largely Lower Cretaceous conglomerate composed chiefly of volcanic rocks (Seiders, 1991).

In summary, conglomerate composed mainly of chert and quartz sandstone occurs in both the basal sandstone member 1 of the McCoy Mountains Formation and in the California Coast Ranges in the lower part of the Great Valley sequence and the oldest Franciscan rocks, but the similarities in detail are not close. In both sequences this kind of conglomerate is succeeded by conglomerate that is a mixture of chert, quartz sandstone, and felsic volcanic rocks. The change back to compositions dominated by chert and quartz sandstone, such as occurs in the mudstone member of the McCoy Mountains Formation, has no parallel in the Coast Ranges sequence.

Conglomerates in the basal sandstone member 2 of Harding and Coney (1985) are very similar to conglomerates in the Winterhaven Formation near Yuma, Arizona (see below).

Conglomerates composed of quartz sandstone and granitic rocks in the conglomerate member of the McCoy Mountains Formation are compositionally similar to conglomerates in the basal part of the Upper Cretaceous sequence of the La Panza Range of the Salinian block. Conglomerates in the sandstone and siltstone members, composed of abundant quartz sandstone and felsic volcanic and granitic rocks, are similar to Upper Cretaceous conglomerates of the southwestern Transverse Ranges.

WINTERHAVEN FORMATION

Exposed in the Picacho area of extreme southeastern California, near Yuma, Arizona (figs. 1 and 2), the type section of the Winterhaven Formation consists of about 450 m of metamorphosed volcanic and sedimentary rocks. As defined by Haxel and others (1985), the Winterhaven comprises an 80-m-thick lower dacite member, a 60-m-thick middle quartz arenite member, and an upper argillitic siltstone member unit, composed of at least 300 m of argillaceous siltstone with some sandstone and conglomerate. We sampled conglomerate at the base of the quartz arenite member and at two localities in the upper member. The Winterhaven was assigned a Jurassic(?) age by Haxel and others (1985). This age assignment depends upon interpretation of an equivocal basal contact of the dacite member and upon the lithologic correlation of the underlying volcanic rocks with isotopically dated rocks elsewhere. It is not clear that the age of the dacite member is necessarily the same as that of the overlying rocks, since the base of the quartz arenite member, which is marked by a basal conglomerate, might be an unconformity.

Conglomerate Composition

The mean of three pebble counts (table 3 and figs. 11 and 12) is rich in felsic volcanic rocks (57.1 percent), with less abundant chert (20.4 percent) and quartz sandstone (10.7 percent). This is very similar to conglomerates in the basal sandstone member 2 of the McCoy Mountains Formation, as shown by the overlap of dispersion fields in figures 11 and 12. It also is roughly similar to mid-Cretaceous conglomerates in the California Coast Ranges (see discussion under "McCoy Mountains Formation").

CONGLOMERATE COMPARISONS ACROSS FAULTS

The geographic distinctiveness of conglomerate compositions provides a tool for evaluating fault displacements. Our purpose here is to comment on the merits of some proposed fault displacements based on comparison of conglomerate compositions across the restored faults. No attempt is made at a more comprehensive review involving other lines of evidence. This section deals with the detailed comparison of conglomerate located close to the disrupting faults. Broader compositional patterns bearing on the place of origin of the Salinian block are treated in a later section. Our starting point for this discussion is the reconstruction of Powell (in press; fig. 2).

SAN GREGORIO FAULT

The San Gregorio fault is the northern segment of the San Gregorio-Hosgri fault zone (fig. 1). The reconstruction in figure 2 (Powell, in press) is based upon the restoration of 150 km of right slip on the San Gregorio fault north of Monterey Bay (Clark and others, 1984) and 105 km of right slip south of the bay (Graham and Dickinson, 1978a, b; Nagle and Mullins, 1983). The difference in displacement is accommodated by restoration of 45 km of right slip on the Rinconada fault (Graham, 1978), assuming that this fault meets the San Gregorio fault at a low angle just north of Monterey Bay (Ross and Brabb, 1973). In order to achieve a better fit of the granitic rocks at Montara Mountain (just south of Point San Pedro in fig. 2), Powell (in press) apportioned the 150-km San Gregorio displacement into about 80 km of slip on an early strand east of Montara Mountain and the rest on the present fault to the west. Otherwise, the granitic rocks at Montara Mountain are left standing seemingly too far to the north of similar rocks in the Santa Cruz Mountains (see also Champion, 1989).

CONGLOMERATE COMPARISON

The Paleocene conglomerate at Point San Pedro is similar in composition to conglomerate at Gualala low in the Paleocene section, but not at the base (table 4 and fig. 13). Since both areas have northwesterly directed paleocurrent indicators (fig. 4), the conglomerate compositions are fully compatible with the reconstruction of Powell (in press). A more northerly location of the Point San Pedro Paleocene rocks, one that does not depend on the apportionment of movement on both sides of Montara Mountain, is also compatible.

The 900-m-thick conglomerate-bearing Paleocene sequence of Point San Pedro compares poorly with the Paleocene Locatelli Formation of the Santa Cruz Mountains, against which it is juxtaposed in the reconstruction (fig. 2). The Locatelli consists of about 270 m of deep-water siltstone, with a thin basal shallow-water marine sandstone, and no conglomerate (Clark, 1981). Conglomerate in the overlying Eocene Butano Sandstone contains fewer granitic pebbles than the Paleocene conglomerate of Point San Pedro (compare tables 4 and 6 and figs. 13 and 15).

Clark and others (1984) restored Point Reyes 45 km farther south relative to Carmel than is shown in figure 2. They compared the Paleocene sedimentary rocks at Point Reyes with those at Carmel, suggesting that they may have been deposited in the same embayment and had the same source. Conglomerates at Point Reyes and Carmel are significantly different in composition (table 4 and fig. 13) and do not support that interpretation.

The reconstruction shown in figure 2 places Cretaceous rocks at Pigeon Point next to Cretaceous rocks on the Big Sur coast south of Carmel. In harmony with the reconstruction, the conglomerate at Pigeon Point is similar in composition to that at Big Sur and also to Paleocene conglomerate nearby at Carmel (tables 1 and 4 and fig. 19).

RINCONADA FAULT

Restoration of 45 km of right slip on the Rinconada fault (Graham, 1978) places Cretaceous and lower Tertiary sedimentary rocks of the central Santa Lucia Range adjacent to the northwest end of the sedimentary sequence of the La Panza Range (fig. 2).

CONGLOMERATE COMPARISON

The base of the Cretaceous sequence in the central Santa Lucia Range is not exposed and no conglomerate was found comparable to the quartz-sandstone-rich conglomerate near the base of the Cretaceous section in the La Panza Range (table 1). The Cretaceous conglomerate in the central Santa Lucia Range geographically closest to the restored La Panza Range is in the El Piojo Formation. The mean composition of 12 samples of conglomerate from the El Piojo is significantly richer in granitic rocks than Cretaceous conglomerate of the main part of the La Panza Range sequence (table 1 and fig. 6). In the El Piojo, however, granitic rock content decreases toward the southeast (see p. 10). When only the three southeasternmost El Piojo conglomerates are compared with six samples from the La Panza Range, the compositions are seen to be very similar (fig. 20).

Lower Tertiary conglomerate, for which the precise age is not known in either the Santa Lucia or La Panza Ranges, compares less closely than does Cretaceous conglomerate (fig. 20 and tables 4 and 8). Two of the three samples from the southeastern part of the central Santa Lucia Range are rich in quartz sandstone (18.5 and 22.1 percent), similar to the high quartz-sandstone suite of the La Panza Range (20.5 percent). The third Santa Lucia sample is lower in quartz sandstone (11.9 percent), closer to the mean of

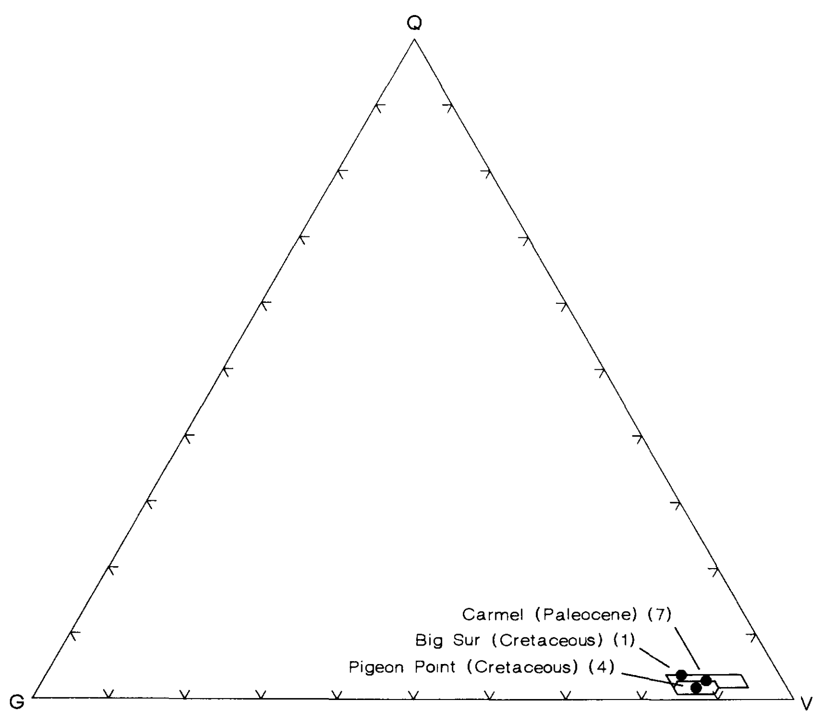


FIGURE 19.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of selected conglomerate suites juxtaposed by restoration of San Gregorio fault displacement as shown in figure 2 (after Powell, in press). Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

the low quartz- sandstone suite of the La Panza Range (8.2 percent). The dispersion field of the three Santa Lucia samples lies between the compositions of the two La Panza suites but does not overlap either. The comparison, nevertheless, is considered compatible with the restoration (fig. 2).

SAN ANDREAS FAULT, NORTHERN PART

Clarke and Nilsen (1973) proposed that the Eocene Butano Sandstone in the Santa Cruz Mountains was deposited upon the same deep-sea fan as the presumed more distal Point of Rocks Sandstone Member of the Kreyenhagen Formation of the Temblor Range (fig. 2). The proposed match between these rock units was taken as evidence of about 305 km of displacement on the San Andreas fault (compared with 295 km in fig. 2). Clarke and Nilsen's (1973) conclusion has not been challenged, notwithstanding compositional differences between the sandstones of the two areas (Clarke, 1973), and despite the fact that paleocurrent directions (fig. 5) are different, mainly north in the Butano (Nilsen and Simoni, 1973) and west-northwest in the Point of Rocks (Clarke, 1973).

CONGLOMERATE COMPARISON

The mean of five samples from the Butano Sandstone compares poorly with that of three samples from the basal part of the Point of Rocks Sandstone Member (tables 6 and 7 and figs. 15, 16, and 17). The samples from the Butano are much richer in felsic volcanic rocks (57.0 versus 6.5 percent) and granite (14.5 percent versus 1.6 percent) whereas those from the Point of Rocks Sandstone are richer in chert (34.8 versus 1.8 percent).

SANDSTONE PETROLOGY

Because pebbles were only obtained from the basal part of the Point of Rocks Sandstone Member, the sandstone petrology of the two units is also compared. Modal analyses using the Gazzi-Dickinson method (Ingersoll and others, 1984) and counting about 425 points per sample were done on 19 samples from the Butano Sandstone (table 9). The results, combined with eight point counts by Nilsen (*in* Clarke, 1973), are compared in figures 21 and 22 with 46 point counts from the Point of Rocks Sandstone Member by Clarke (1973). In both the QFL and

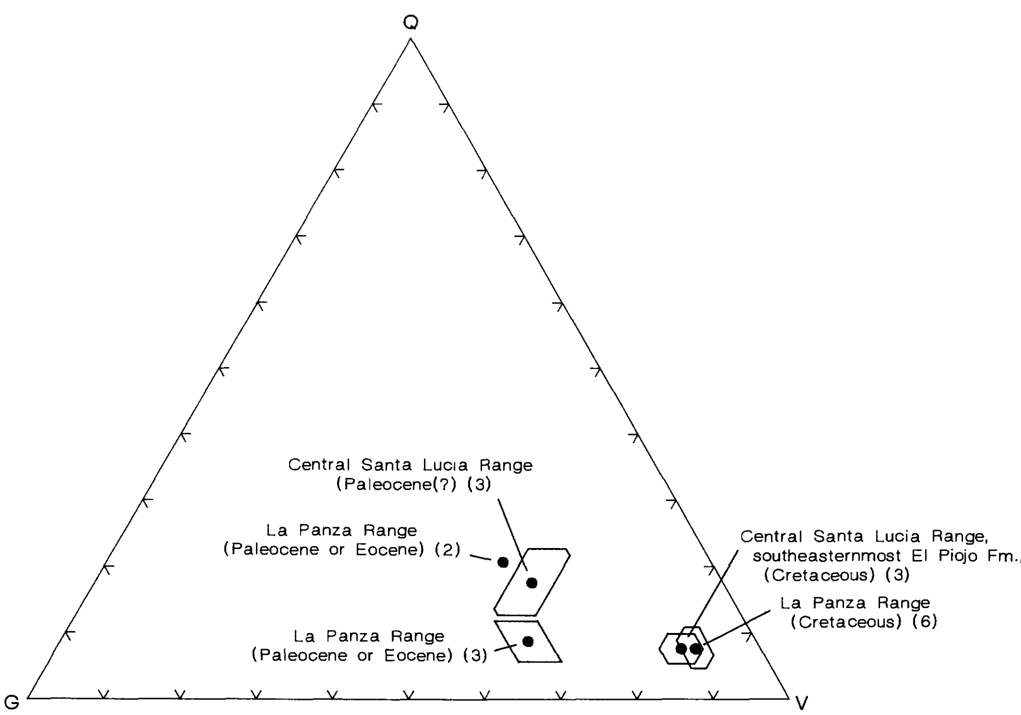


FIGURE 20.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of selected conglomerate suites juxtaposed by restoration of Rinconada fault displacement as shown in figure 2 (after Powell, in press). Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

the QKP diagrams the Butano and Point of Rocks samples occupy distinct fields, with the Point of Rocks samples being comparatively rich in quartz and poor in feldspar.

These data for the Butano Sandstone and the Point of Rocks Sandstone Member are comparable to results obtained by Graham and Berry (1979) on the German Rancho Formation of Wentworth (1966) of the Gualala area and the Cantua Sandstone Member of the Lodo Formation of the central Diablo Range. Graham and Berry (1979) showed that subsurface facies relations indicate that the Cantua was derived from the Sierra Nevada to the southeast and they disputed the interpretation of Nilsen and others (1974) that the Cantua was linked to the German Rancho across the San Andreas fault. The petrology of the Point of Rocks Sandstone Member is similar to that of the Cantua (figs. 21 and 22) and, taken together with the west-northwest paleocurrent directions in the Point of Rocks, suggests a source in the Sierra Nevada. The Butano Sandstone is compositionally similar to the German Rancho and, like it, had a different source.

INTERPRETATION

The restoration shown in figure 2 (Powell, in press) and similar reconstructions (see Graham and others, 1989) are derived by matching several geologic pairs and do not depend alone upon restoration of a single Butano-Point of Rocks deep-sea fan. The distinct detrital compositions of the Butano Sandstone and the Point of Rocks Sandstone Member do not invalidate the restorations, because the paleocurrent directions show that the two detrital suites were derived from different directions and thus may have been coincidentally deposited side-by-side. The two units apparently were not united within a single depositional system, however, and they should no longer be construed as an offset pair fixing San Andreas fault displacement.

SAN ANDREAS AND RELATED FAULTS, SOUTHERN CALIFORNIA

We will not review here the complex history of fault movement that Powell (in press) interpreted to produce the reconstruction shown in figure 2.

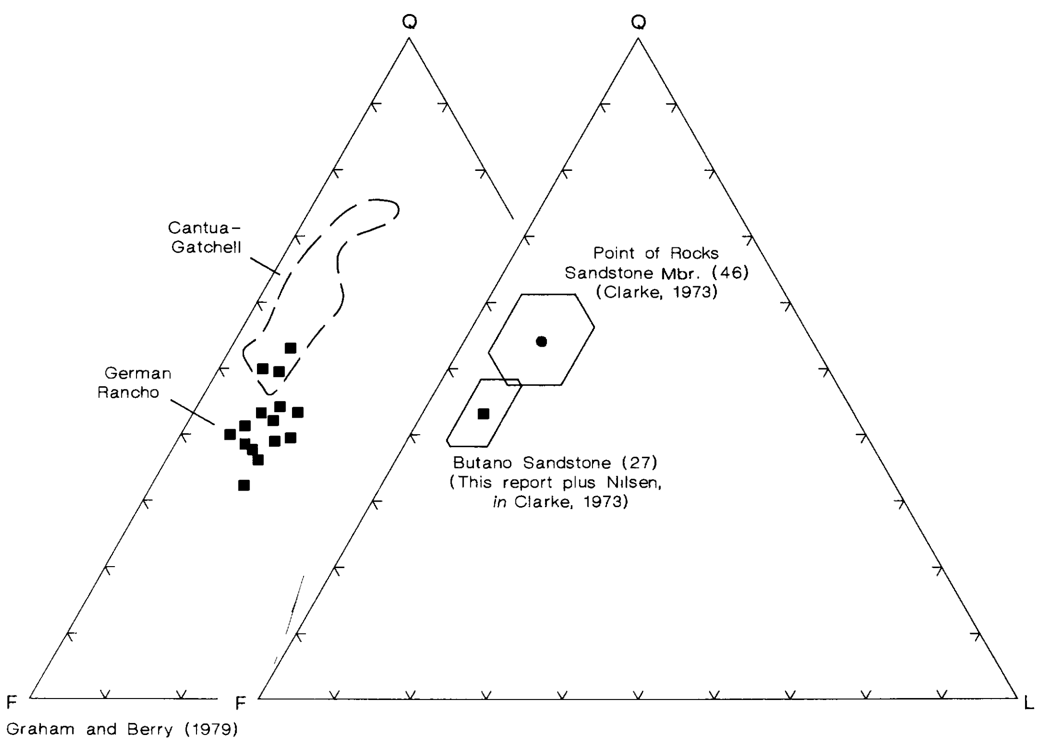


FIGURE 21.—QFL diagram showing the mean compositions and dispersion fields at one standard deviation of sandstone of the Butano Sandstone and the Point of Rocks Sandstone Member of the Kreyenhagen Formation. See table 9 for point counts. Shown for comparison is sandstone petrology of the German Rancho Formation of Wentworth (1968) and the combined Cantua Sandstone Member of the Lodo Formation and the Gatchell Sandstone of Ryall (1974) from Graham and Berry (1979). Q = quartz, F = feldspar, L = lithic grains.

Instead, we will simply test the end product by comparing the composition of juxtaposed conglomerate.

LIEBRE MOUNTAIN BLOCK

The Liebre Mountain block at present occupies the northern part of the San Gabriel Mountains block (fig. 1). It is bounded by the San Gabriel, San Francisquito, and San Andreas faults.

CONGLOMERATE COMPOSITION

A basal conglomerate of Late Cretaceous age in the San Francisquito Formation is full of locally derived detritus (table 2) and compares poorly with conglomerate at the base of a seemingly thicker Cretaceous section in the southeastern La Panza Range, located close by to the west in the reconstruction (fig. 2). The latter is rich in remotely derived quartz sandstone (table 1). These relations are consistent, however, with the general eastward transgression that characterizes the Upper Cretaceous to lower Tertiary sequence.

The major part of the San Francisquito Formation is Paleocene in age and contains conglomerate rich in felsic volcanic and granitic rocks. One sample from beds well above the base of an unnamed Cretaceous formation in the southeastern La Panza Range is compositionally similar to the Paleocene conglomerates of the San Francisquito (fig. 23). This conglomerate differs from other Cretaceous conglomerates of the La Panza Range in that it is richer in granitic rocks (25.9 versus 8.2 percent; table 1). The age of the sample is not known but Vedder and others (1986c) note that the unit may include Paleocene rocks. The Paleocene conglomerates of the San Francisquito compare well with Paleocene conglomerates in the Pattiway Formation of the Caliente Range (fig. 23), located not far to the southeast in figure 2. It is also similar to lower Eocene conglomerates in the Cuyama gorge area, located to the southwest in the reconstruction. Another suite of conglomerate in the Cuyama gorge area, of either Paleocene or Eocene age, is richer in quartz sandstone and has no counterpart in the San Francisquito (fig. 23). Except for this last suite, conglomerate compositions harmonize

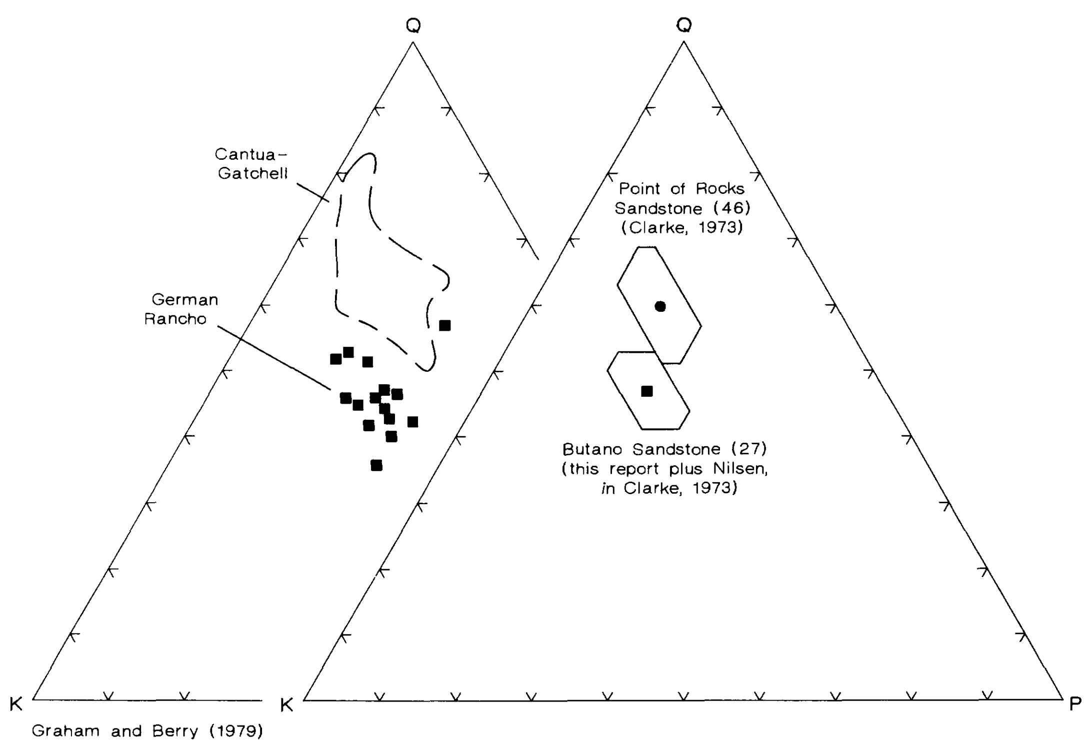


FIGURE 22.—QKP diagram showing the mean compositions and dispersion fields at one standard deviation of sandstone of the Butano Sandstone and the Point of Rocks Sandstone Member of the Kreyenhagen Formation. See table 9 for point counts. Shown for comparison is sandstone petrology of the German Rancho Formation of Wentworth (1968) and the combined Cantua Sandstone Member of the Lodo Formation and the Gatchell Sandstone of Ryall (1974) from Graham and Berry (1979). Q = quartz, K = potassium feldspar, P = plagioclase.

TABLE 9.—*Sandstone petrology, in percent, of the Butano Sandstone and the Point of Rocks Sandstone Member of the Kreyenhagen Formation*

[Q=quartz, both monocrystalline and polycrystalline, F=feldspar, L=lithic grains, except quartzose lithic grains (chert and quartzite), Qm=monocrystalline quartz; P=plagioclase; K=potash feldspar, -=not present].

	Butano Sandstone (this report)																				
Locality	BP-78-1A	70-CB-851	83-A	EB-203	EB-355	WO-481	WO-482	FE-483	FE-484	CR-485	CR-486	CR-487	CR-488	CR-489	BB-490	BB-491	BB-492	WO-493	WO-494	mean of 19	std. dev.
Quartz	30.2	26.2	30.2	30.9	30.6	27.0	31.2	27.1	30.4	21.7	22.5	39.1	26.5	28.3	34.2	24.4	36.3	35.5	32.2	29.8	4.5
Potassium feldspar	18.1	26.9	25.2	17.7	25.7	20.0	19.3	23.4	18.8	17.2	17.6	22.0	23.8	18.1	24.0	19.8	17.8	27.1	16.7	21.0	3.6
Plagioclase	15.0	11.6	22.4	8.1	15.7	13.8	14.8	12.4	13.3	27.9	19.0	17.2	13.7	21.3	6.3	12.0	23.2	17.4	18.2	16.0	5.3
Lithic, volcanic	6.3	3.1	4.8	2.6	4.6	2.3	5.2	5.0	5.5	1.7	1.4	3.2	6.3	8.0	5.3	5.1	5.9	5.1	4.6	4.5	1.7
Lithic, sedimentary	-	-	.2	-	-	.2	-	-	-	.2	-	-	.2	-	.2	.7	-	.7	1.5	.2	.4
Lithic, metamorphic	.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.7	-	.0	.2
Chert	-	-	.5	-	-	-	.2	-	.2	-	-	-	2.3	-	-	-	-	-	-	.2	.5
Fine quartzite	-	-	-	-	-	-	-	-	.2	-	-	-	-	-	.7	-	-	.2	-	.1	.2
White mica	.2	.2	1.2	.5	.5	.7	.7	.5	.2	1.3	.9	.7	-	-	-	-	.5	-	-	.4	.4
Chlorite	.5	.5	2.1	.7	1.4	1.6	.5	1.7	.5	1.7	3.0	2.3	.2	1.0	1.2	.2	.9	.7	.5	1.1	.8
Other phyllosilicate	1.0	1.0	1.7	1.9	4.6	3.7	2.4	.5	.7	8.9	4.2	7.3	1.6	1.9	1.5	1.0	5.9	2.7	.2	2.8	2.4
Heavy minerals	.7	.2	-	.2	.2	-	-	-	-	-	-	-	1.4	.2	-	.2	-	-	-	.2	.3
Opaque	1.2	1.2	1.0	1.7	2.1	3.2	.7	1.2	2.2	4.5	2.1	.5	1.2	1.4	.2	.2	-	1.4	1.7	1.5	1.1
Calcite	15.2	20.1	6.4	27.0	2.3	17.3	15.0	18.7	20.7	-	16.2	-	17.4	14.0	17.5	33.5	-	1.4	19.4	13.8	9.6
Unknown	3.9	2.9	1.4	4.8	3.5	3.5	.7	1.2	.7	3.2	4.2	.7	1.2	.7	1.0	1.0	1.2	1.2	1.9	2.1	1.4
Matrix	7.5	5.6	2.6	3.8	8.8	6.7	8.6	8.2	6.5	11.7	8.8	7.1	2.3	5.1	7.5	1.3	8.4	5.8	3.1	6.3	2.7
Total	100.0	100.0	99.9	99.9	100.0	100.0	100.0	99.9	99.9	100.0	99.9	100.1	100.1	100.0	99.8	99.8	100.1	99.9	100.0	100.0	
Q	43	38	37	52	40	42	44	40	45	31	37	48	41	37	49	40	44	41	44	42	5
F	48	57	57	44	54	54	48	53	47	66	61	48	50	52	43	51	49	51	48	51	6
L	9	5	6	4	6	4	8	7	8	3	2	4	9	11	8	9	7	8	8	7	2
Qm	48	40	39	54	42	44	48	43	49	32	38	50	43	41	53	44	47	44	48	45	5
P	24	18	29	15	22	23	22	20	21	42	32	22	21	31	10	21	30	22	27	24	7
K	28	42	32	31	36	33	30	37	30	26	30	28	36	27	37	35	23	34	25	31	5

	Butano Sandstone (Nilsen, in Clarke, 1973)		Butano Sandstone (this report plus Nilsen, in Clarke, 1973)		Point of Rocks Sandstone Mbr. (Clarke, 1973)	
	Mean of 8	Std. dev.	Mean of 27	Std. dev.	Mean of 46	Std. dev.
Q	46	5	43	5	54	7
F	43	6	49	7	36	8
L	11	3	8	3	10	6
Qm	52	6	47	6	60	9
P	17	5	22	7	17	7
K	31	3	31	4	23	4

well with the restored location of the Liebre Mountain block (fig. 2).

PINYON RIDGE BLOCK

This narrow sliver is restored to a position just east of the Leibre Mountain block in figure 2.

CONGLOMERATE COMPOSITION

Paleocene conglomerates of the San Francisquito Formation of the Pinyon Ridge block are very rich in granitic rocks (mean 71.6 percent) and, as previously noted by Kooser (1980), contrast sharply with volcanic-rich conglomerate of the San Francisquito Formation of the Liebre Mountain block. They are also quite different from Paleocene conglomerates in the Caliente Range, restored not far to the south, and seem out of place in the reconstruction. The composition is very similar to that of lower Eocene conglomerates of the Orocopia Mountains (see below).

OROCOPIA MOUNTAINS

Eocene sedimentary rocks in the Orocopia Mountains are restored relatively far from other sedimentary rocks of similar age and this makes detailed conglomerate comparison difficult. Their nearest comparable neighbors are in the Frazier Mountain block, restored 37 km to the southeast, and near Newhall, restored 55 km to the south-southeast (fig. 2).

CONGLOMERATE COMPOSITION

Conglomerate in the lower Eocene Maniobra Formation is very rich in granitic rocks (mean 65.3 percent, table 7). It compares poorly with Eocene conglomerate from the Frazier Mountain block (fig. 24), although this pair has long been considered a factor in estimating San Andreas displacement (Crowell, 1962). It is closer in composition, but still significantly different from Eocene conglomerate near Newhall. The distances between the Orocopia Mountains and the restored positions of these areas, however, are so large that it is difficult to draw con-

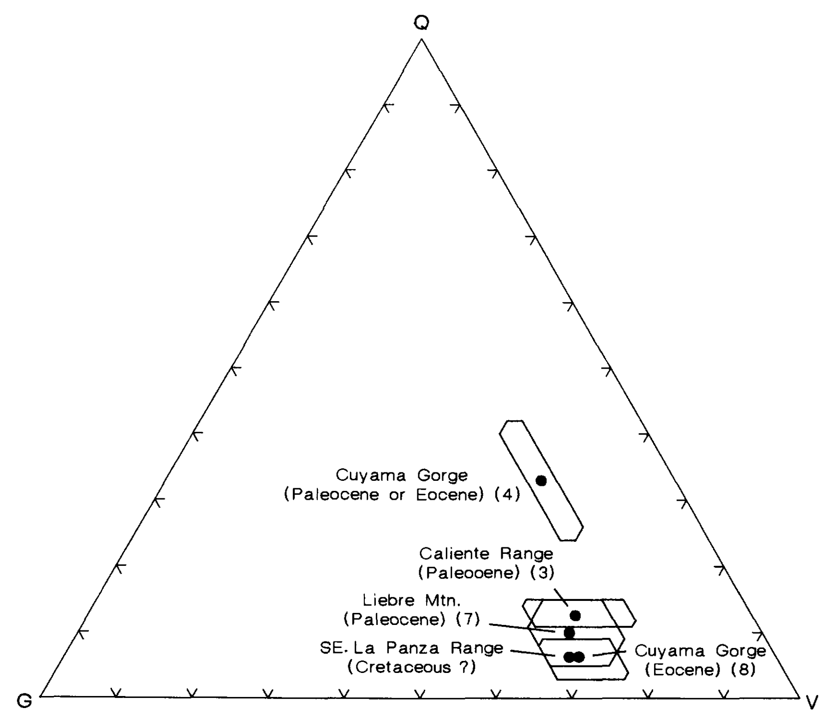


FIGURE 23.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of selected conglomerate suites juxtaposed by restoration of San Andreas fault displacement as shown in figure 2 (after Powell, in press). Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

clusions regarding the compatibility of the conglomerate compositions.

The composition of the Eocene conglomerates in the Orocopia Mountains is very similar to that of Paleocene conglomerates in the Pinyon Ridge block. Not only are the major components similarly abundant, as evidenced by the overlapping dispersion fields in figure 24, but as noted earlier, vein quartz is unusually high in both suites (mean 8.5 and 8.3 percent, tables 5 and 7). Restoration of the Pinyon Ridge block conglomerates, which are compositionally mismatched as restored in figure 2, to a location near the Orocopia Mountains is, therefore, tempting. However, in this location the Paleocene turbidites of the Pinyon Ridge block are placed between two areas, the Frazier Mountain block and the Orocopia Mountains, where the oldest sedimentary rocks above basement are Eocene in age. An alternative interpretation is to consider the two granite-rich suites as local anomalies, coincidentally similar in composition. This composition, in spite of its occurrence in thick turbidite sections, strongly reflects local bedrock and may not have been as widely distributed as the volcanic-rich suites. The granite-rich conglomerate may have been deposited in isolated small basins close to remotely derived conglomerate suites with contrasting composition.

PLACE OF ORIGIN OF THE SALINIAN BLOCK AND RELATED TERRANE

INTRODUCTION

In this section the composition of conglomerate from broad regions will be compared to test its bearing on the place of origin of the Salinian block. The conglomerate suites are divided into Upper Cretaceous, Paleocene, and Eocene groups. These age groups within each region are then further divided into compositionally distinct suites as appropriate. For example, Upper Cretaceous conglomerate of the Salinian block is divisible into two suites, one of 59 samples rich in felsic volcanic rocks and one of five samples rich in quartz sandstone clasts. The compositions are represented in triangular diagrams (figs. 25-33) and the numerical parameters for constructing

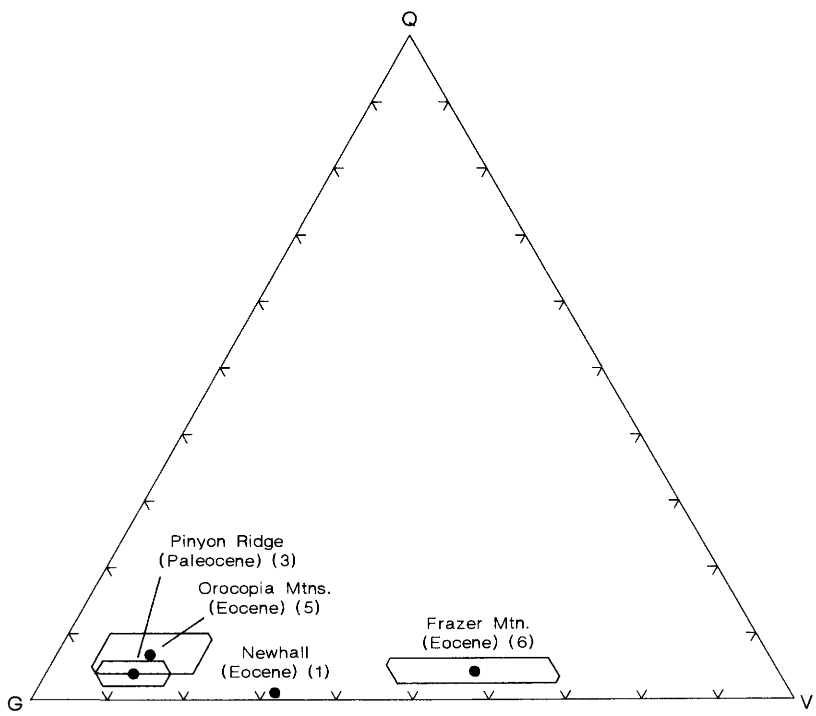


FIGURE 24.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of selected conglomerate suites juxtaposed by restoration of San Andreas and related fault displacements in southern California as shown in figure 2 (after Powell, in press). Pinyon Ridge Paleocene conglomerate, not juxtaposed with any of the others, added for comparison. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

the diagrams are given in table 10. A few basal conglomerates of obviously local origin are excluded from the diagrams. These include a Cretaceous conglomerate from the Big Sur coast (table 1, locality PS-399), Cretaceous conglomerate at the base of the San Francisquito Formation in the Liebre Mountain block (table 2, locality WM-450) and at Cajon Pass (table 2, locality CJ-498), and three Paleocene conglomerates from the lower sequence of the Goler Formation (table 5, localities SD-617, SD-618, and SD-619).

For purposes of discussion, we treat the Salinian block, the southwestern Transverse Ranges, and the Peninsular Ranges as suspect terranes, possibly derived from remote places. A few conglomerates from the Nacimiento block are included with the Salinian block data because the Salinian and Nacimiento blocks may have been united before the end of the Cretaceous (Vedder and others, 1983). Because of close affinities between the Golden Gate-Gilroy and Nacimiento blocks (Seiders and Blome, 1988), four samples from the former area are also included with the Salinian block group. Conglomerate suites from the northern Santa Ana Mountains, a part of the Peninsular Ranges, are treated separately because they are compositionally distinct.

The Diablo and Temblor Ranges, the southernmost Sierra Nevada, the southwestern Basin and Range Province, and the southeastern Mojave Desert area and adjacent parts of southeastern California and western Arizona are considered part of North America. Although the Liebre Mountain block of the San Gabriel Mountains was placed within the Santa Lucia-Orocopia allochthon by Vedder and others (1983), we consider it to be an autochthonous part of North America because of a chain of correlations involving basement rocks. Frizzell and others (1986) correlated a distinctive Triassic megaporphyritic monzogranite in the Liebre Mountain block with lithologically similar rock in the San Bernardino Mountains, proposing that the monzogranite once formed a single body now offset 160 km along the San Andreas fault. In the San Bernardino Mountains, the megaporphyritic monzogranite is mapped by Dibblee (1964) and Frizzell and others (1986) to within 2 kilometers, without intervening faults, of distinctive Proterozoic and Paleozoic metasedimentary rocks correlated by Stewart and Poole (1975) with the miogeosynclinal sequence of the southern Great Basin. Because of these relations, we include the Paleocene conglomerate of the Liebre Mountain block with the suites native to North America.

We also include as part of native North America the Eocene Maniobra Formation of the Orocopia Mountains. Although this area is also within Vedder and others' (1983) allochthon, both Hamilton (1988) and Powell (1991) argue that faults inboard of the Orocopia Mountains that could have accommodated the docking of the allochthon do not exist. This conclusion is also supported by the close similarity of conglomerate in the Winterhaven Formation with that in the lower part of the McCoy Mountains Formation (see p. 26), since this lithologic tie spans the Mule Mountains thrust, considered a possible strand of the docking fault system (the Vincent-Orocopia-Chocolate Mountains thrust) by Vedder and others (1983).

REGIONAL CONGLOMERATE COMPARISONS

CRETACEOUS CONGLOMERATE

The principal suite of Cretaceous conglomerates from the Salinian block and related terrane (59 samples) differs from correlative conglomerates in the Diablo Range (6 samples) and in the main suite from the Peninsular Ranges (15 samples) in that chert is very sparse in the Salinian block conglomerates, whereas it is moderately abundant in conglomerate from the Diablo and Peninsular Ranges (fig. 25). A suite of two samples from the northern Santa Ana Mountains overlaps the Salinian block and Peninsular Ranges fields. A suite of four samples from the Peninsular Ranges near Punta Banda is poor in chert and plots near the Salinian block suite (fig. 25). In detail, however, this suite differs from Salinian conglomerates in that it is composed almost entirely of igneous clasts (compare tables 1 and 2) and probably had a local source.

A suite of 13 samples from the southwestern Transverse Ranges is low in chert, like the main Salinian block suite, but is richer in quartz sandstone (fig. 25). A second Salinian suite of five samples from the basal part of the La Panza Range sequence is still richer in quartz sandstone and plots far from all the other conglomerates.

The same conglomerate suites are shown in figure 26, which presents quartz sandstone, volcanic rocks, and granitic rocks as end members. The main Salinian block suite lies near the volcanic rock corner. It partly overlaps the fields of the northern Santa Ana Mountains and the Diablo and Peninsular Ranges, but extends to more granite-rich compositions. The suite from the southwestern Transverse Ranges partly overlaps the Peninsular Range field, but is mainly richer in granitic rocks and quartz sandstone.

Conglomerates from the upper part (conglomerate, sandstone, and siltstone members) of the McCoy Mountains Formation of Harding and Coney (1985) are poor in chert, like those of the Salinian block, the northern Santa Ana Mountains, and the southwestern Transverse Ranges (fig. 27). In both figures 27 and 28, although the dispersion fields are large, the compositions of the suites from the conglomerate member and the combined sandstone and siltstone members of the McCoy Mountains Formation are similar, respectively, to those from the basal part of the La Panza Range section and the southwestern Transverse Ranges. Relative to conglomerates of the main Salinian block suite and the northern Santa Ana Mountains, these rocks are richer in quartz sandstone.

PALEOCENE CONGLOMERATE

One conglomerate from the Diablo Range is very rich in chert. All other Paleocene conglomerate lies close to the Q-I side of the triangle in figure 29, although three samples from the Peninsular Ranges with a small amount of chert stand out from the rest. Two samples from the Salinian block and five samples from the lower part of the Paleocene section in the southwestern Transverse Ranges (Simi Hills and Santa Monica Mountains) are rich in quartz sandstone. All the rest, including 23 samples from the Salinian block, plot near the igneous rock corner of the diagram.

Greater differentiation of conglomerate suites is seen in figure 30, representing quartz sandstone, volcanic rocks, and granitic rocks. The Diablo and Peninsular Ranges suites both are distinctly poor in granitic rocks. The main Salinian block field is richer in granitic rocks and is broadly overlapped by the field of the combined Goler and Witnet Formations of the southernmost Sierra Nevada and the San Francisquito Formation of the Liebre Mountain block. Conglomerate suites from the southwestern Transverse Ranges are diverse. Two suites are very rich in quartz sandstone, one of them very similar to the minor Salinian suite. Two other suites are similar to the main Salinian block suite, but are marginally richer in quartz sandstone and granitic rocks. Another suite, from the upper part of the Paleocene section in the Santa Monica Mountains, is poor in quartz sandstone but relatively rich in granitic rocks. One sample from the northern Santa Ana Mountains plots within the main Salinian block dispersion field but is poor in quartz sandstone and lies near the quartz-sandstone-poor Santa Monica Mountains suite. Three samples from the Pinyon Ridge block are very rich in granitic rocks.

EOCENE CONGLOMERATE

Eocene conglomerate from the Diablo and Temblor Ranges is chert rich (fig. 31). Some chert may have been derived from the Franciscan assemblage which was uplifted to the west. Most chert was derived from the Sierra Nevada area, as inferred from paleocurrent directions and the lithologic character of the chert. Two samples of upper Eocene conglomerate from the San Marcos Pass area are also rich in chert, probably derived from the underlying Franciscan assemblage or the Coast Range ophiolite. All other Eocene conglomerates are chert poor. In figure 31 most samples, including 28 from the Salinian block and 9 from the Peninsular Ranges, cluster near the igneous rock corner. Two samples from the southwestern Transverse Ranges are richer in quartz sandstone.

Figure 32, representing quartz sandstone, volcanic rocks, and granitic rocks, shows a clear distinction between Salinian block conglomerates and those of the Diablo, Temblor, and Peninsular Ranges. The Salinian block conglomerates are rich in both volcanic and granitic rocks, whereas the other suites are poorer in granitic rocks. Significantly, conglomerates from the San Emigdio Mountains and from the northern Santa Ana Mountains plot within the Salinian block dispersion field. Conglomerate from the Orocopia Mountains and from the southwestern Transverse Ranges near Newhall is richer in granitic rocks. Two other samples from the southwestern Transverse Ranges are rich in quartz sandstone.

SUMMARY AND INTERPRETATION

SALINIAN BLOCK RELATIONSHIPS

Conglomerate compositions in the Salinian block contrast sharply with those in the Diablo and Temblor Ranges and in the Peninsular Ranges. For the Late Cretaceous this difference lies mainly in the greater abundance of chert in conglomerate of the Diablo and Peninsular Ranges, but there is also a trend toward more granite-rich compositions in the Salinian block (figs. 25 and 26). For the Paleocene and Eocene, Salinian block conglomerates differ mainly in the greater abundance of granitic rocks (figs. 30 and 32), although the lack of chert also continues to distinguish them from conglomerates of the Diablo and Temblor Ranges (figs. 29 and 31). In the Peninsular Ranges, chert only slightly exceeds Salinian abundance in Paleocene conglomerates and it is nearly absent in the Eocene.

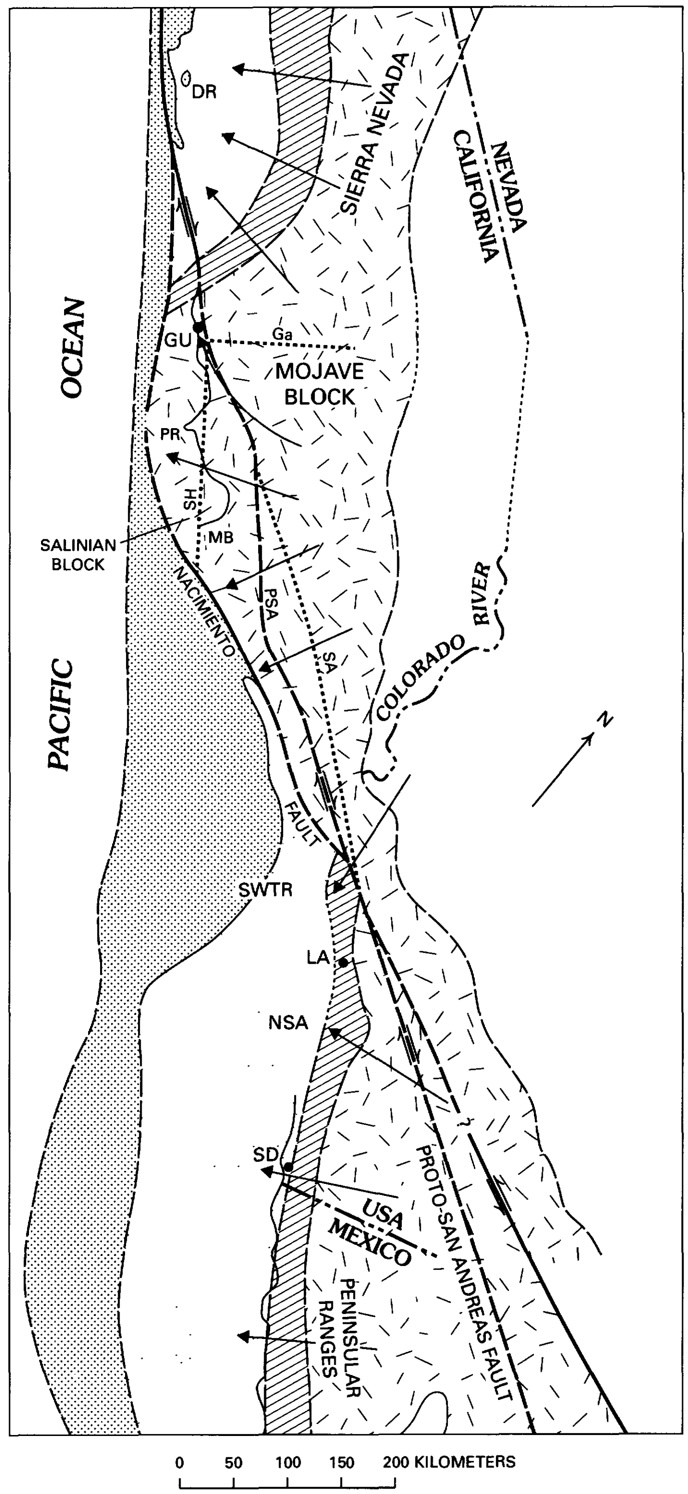
Salinian block Paleocene conglomerates with abundant volcanic rocks and moderately abundant granitic rocks are very similar to Paleocene conglomerates around the margin of the western Mojave Desert (figs. 29 and 30). Eocene conglomerates from the Salinian block are compositionally similar to those in the Paleocene and compare well with the one sample of Eocene conglomerate found adjacent to the western Mojave area in the San Emigdio Mountains (fig. 32). The only Cretaceous sedimentary rocks around the western Mojave are basal conglomerates with locally derived detritus. The sequence is onlapping, however, and Paleocene conglomerates of the western Mojave margin are similar to Cretaceous conglomerates of Salinia (fig. 33).

These conglomerate compositional patterns are interpreted by plotting inferred gross sediment distribution paths for the Late Cretaceous and early Tertiary on paleogeographic base maps (figs. 34 and 35) modified from Dickinson (1983). The Late Cretaceous configuration (fig. 34) includes reversal of 195 km of dextral slip on a proto-San Andreas fault (Dickinson, 1983), a restoration that is not included in Powell's (in press; fig. 2) reconstruction. A proto-San Andreas fault seems necessary in order to restore basement rocks in the northern part of the Salinian block (Dickinson, 1983), but its existence is not critical to our interpretation. Dickinson (1983) thought that the proto-San Andreas fault may have existed in latest Cretaceous time and that the Cretaceous sedimentary rocks near Gualala (figs. 2 and 34) may have been deposited in a linear trough developed along the fault zone. This interpretation is consistent with northwest-directed paleocurrent indicators at Gualala (Wentworth, 1966; fig. 3).

The key component of these maps (figs. 34 and 35) is the interpretation of 560 km of left-slip on the Nacimiento fault in mid-Cretaceous time (Dickinson, 1983). The Salinian block, in its restored pre-San Andreas position adjacent to the Mojave block, is an interior part of the magmatic arc that became exposed to the sea as a result of the displacement. Two matching belts in the Sierra Nevada and the Peninsular Ranges are displaced by the Nacimiento fault. The western belt consists of pre-batholithic rocks, which includes chert-bearing rocks in the Sierra Nevada in the Shoo Fly Complex and the Calaveras Complex of Schweickert and others (1977; see for example Schweickert and Snyder, 1981) and in the Peninsular Ranges in various rock units (see for example Gastil and Miller, 1984). The eastern belt consists of batholithic rocks, probably covered by a thick cap of volcanic rocks, especially during Late Cretaceous time.

Sediment distribution paths (figs. 34 and 35) in the Sierra Nevada leading to the Diablo Range cross both the belt of pre-batholithic rocks as well as the batholithic belt. Consequently, Upper Cretaceous and lower Tertiary conglomerates in the Diablo Range contain both abundant chert and volcanic rocks. Sediment distribution paths reaching the Salinian block do not cross the belt of pre-batholithic rocks and Salinian conglomerates are poor in chert but rich in volcanic rocks derived from the magmatic arc.

The abundance of granite in Salinian block conglomerates and those found on the fringe of the west-



ern Mojave may result from deep erosion of a rapidly uplifted Mojave block. The deep erosion, evidenced by the wide exposure of granulite and amphibolite facies rocks around the margin of the Mojave block (see Ross, 1984, 1989; James and Mattinson, 1988), began in Late Cretaceous time, possibly as a consequence of the shallowing of the inclination of the subduction zone that occurred at that time (Burchfiel and Davis, 1975). Uplift may have been greatest in this region because, in the model of Dickinson (1983), it was a place where a more interior and thicker part of the continent had been exposed to the Pacific through left-slip on the Nacimiento fault.

Salinian block conglomerates rich in quartz sandstone, such as that found at the base of the Cretaceous sequence of the La Panza Range and low in the Paleocene section at Arroyo Seco, compare well both in overall composition and clast lithology with Upper Cretaceous conglomerate in the McCoy Mountains Formation near the southern Mojave area. The quartz-sandstone rich gravel of the Salinian block, like that of the McCoy Mountains, was probably derived from the Mojave area (figs. 28 and 30). In the Salinian block this kind of conglomerate only occurs locally in basal deposits and was soon replaced by volcanic-rich conglomerate.

SOUTHWESTERN TRANSVERSE RANGES AND PENINSULAR RANGES RELATIONSHIPS

The northern Santa Ana Mountains, a part of the Peninsular Ranges, have strong stratigraphic links and conglomerate compositional similarities with the Santa Monica Mountains across the Los Angeles basin. These ties are important because they establish past connections between the Peninsular Ranges and the southwestern Transverse Ranges and, in turn, with the Mojave and Salinian blocks.

Cretaceous rocks show close stratigraphic similarities between the northern Santa Ana Mountains and the Santa Monica Mountains. In each area the sedimentary sequence begins with a nonmarine conglomerate overlain by marine beds with Turonian (Late Cretaceous) fossils. There is no parallel in the Santa Monica Mountains to the locally derived conglomerates of the Holz Shale Member of the Ladd Formation in the Santa Ana Mountains. Conglomerates in the overlying Schulz Ranch Sandstone Member of the Williams Formation are compositionally similar to

◄ FIGURE 34. Late Cretaceous distribution of Mesozoic lithotectonic belts (from Dickinson, 1983, fig. 7) showing generalized sediment distribution paths (arrows). Dense stipples, Franciscan assemblage belt; open stipples, Great Valley sequence belt; diagonal lines, pre-batholithic belt; cross hatched, batholithic belt. DR, Diablo Range; Ga, Garlock fault; GU, Gualala; LA, Los Angeles; MB, Monterey Bay; NSA, northern Santa Ana Mountains; PR, Point Reyes; PSA, proto-San Andreas fault; SA, San Andreas fault; SH, San Gregorio-Hosgri fault; SWTR, southwestern Transverse Ranges. Lines representing modern shorelines are shown.

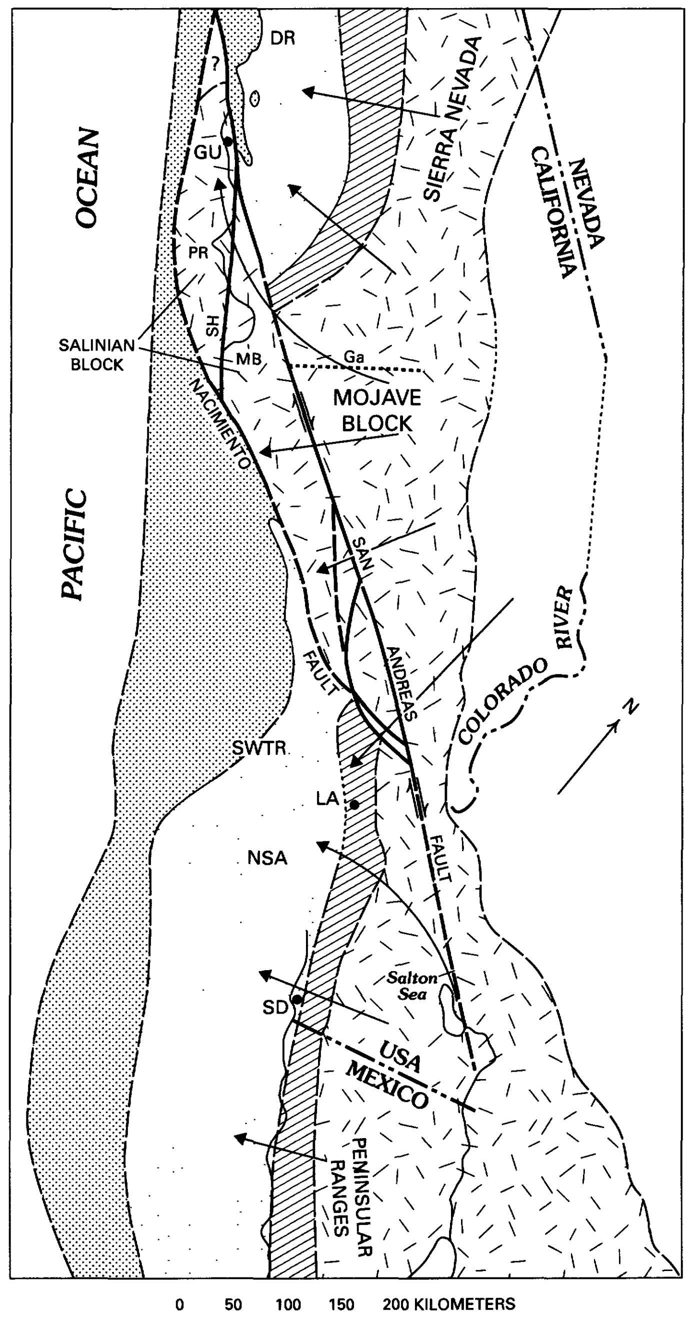


FIGURE 35.—Early Tertiary distribution of Mesozoic lithotectonic belts (from Dickinson, 1983, fig. 8) showing generalized sediment distribution paths. See figure 34 for explanation.

those in the middle part of the Tuna Canyon Formation of the Santa Monicas. The conglomerates in these two units are uniquely rich in volcanic pebbles with xenoliths of quartz sandstone. Conglomerates of the Santa Ana Mountains, however, are richer overall in felsic volcanic rocks and lower in quartz sandstone (72.5 versus 52.9 percent and 11.8 versus 27.9 percent; table 2).

In both the Santa Ana and Santa Monica Mountains the base of the Paleocene is marked by an unconformity. In the Santa Anas the lower part of the Paleocene section contains conglomerates with locally derived detritus, whereas the lower Paleocene deposits in the Santa Monicas are rich in remotely derived quartz sandstone. Conglomerates higher in the Paleocene section are similarly rich in volcanic and granitic rocks in both areas (table 5 and fig. 14). Conglomerates farther north in the southwestern Transverse Ranges, in the upper part of the Simi Conglomerate in the Simi Hills, are richer in quartz sandstone relative to those in the higher part of the Paleocene sequence in the Santa Monica Mountains (18.9 versus 2.0 percent; table 5).

Eocene conglomerates in the northern Santa Ana Mountains, like the underlying Paleocene conglomerates, are rich in volcanic and granitic rocks. Eocene conglomerates in the southwestern Transverse ranges are more diverse. Some are quite rich in quartz sandstone and others are rich in granitic rocks (table 7 and fig. 17).

Conglomerate compositions in the southwestern Transverse Ranges and the northern Santa Ana Mountains accord well with the paleogeographic models (figs. 34 and 35). Gravel deposits in the southwestern Transverse Ranges were fed by streams crossing the magmatic arc at its narrowest point. Much conglomerate there is relatively poor in volcanic rocks and rich in quartz sandstone, like conglomerate directly upstream in Upper Cretaceous beds of the McCoy Mountains Formation of the lower Colorado River area. Conglomerates in the northern Santa Ana Mountains are relatively richer in volcanic rocks, possibly because the sediment distribution system was oriented along the trace of the Nacimiento fault, subparallel to the magmatic arc. At times the north-flowing sediment distribution system of the Santa Ana Mountains may have migrated northward, and the effect is seen in some volcanic-rich conglomerates in the Santa Monica Mountains, especially in the higher Paleocene deposits. Abundant granite clasts in both the southwestern Transverse Ranges and the northern Santa Ana Mountains came from the deeply eroded margin of the nearby Mojave block.

Conglomerate deposited in the Cretaceous on the west side of the Peninsular Ranges south of the northern Santa Ana Mountains is rich in both chert and volcanic rocks because the sediment distribution systems had access to both prebatholithic rocks and the volcanic arc. It is not clear why chert disappeared from conglomerate in the early Tertiary, but it may be that the source area became covered with sediments or had a low relief. The sediment distribution systems had no access to the rapidly uplifted Mojave block and granitic rocks therefore are not abundant.

GOLDEN GATE-GILROY BLOCK RELATIONSHIPS

Upper Cretaceous rocks in the Golden Gate-Gilroy block south and southeast of San Francisco (fig. 1) overlie a basement composed of the Franciscan assemblage. Conglomerates in the Franciscan assemblage and in older parts of the overlying Great Valley sequence are very similar in composition to those in the Nacimiento block of the central California coastal area (fig. 36). Seiders and Blome (1988) interpreted this similarity to indicate that the Golden Gate-Gilroy block originated close to the Nacimiento block. The compositional similarity of some conglomerates of the Golden Gate-Gilroy and Nacimiento blocks with mid-Cretaceous conglomerates of the northern Santa Ana Mountains (fig. 36), along with other considerations, led Seiders and Blome (1988) to suggest that these two blocks originated in southern California. Following Dickinson's (1983) proposal of 560 km of mid-Cretaceous left slip on the Nacimiento fault, Seiders and Blome (1988) argued that this displacement may have separated the Golden Gate-Gilroy and Nacimiento blocks. In this reconstruction the Nacimiento block was displaced southward and juxtaposed against the Salinian block, whereas the Golden Gate-Gilroy block was located east of the Nacimiento fault and held a position south of the Mesozoic deposits of the Diablo Range, with which there is a contrast in conglomerate composition.

Conglomerate compositions in Upper Cretaceous rocks of the Golden Gate-Gilroy block have a bearing on their place of formation. The lack of chert in four samples from this area (table 1) indicates that the gravel probably was transported by a sediment distribution system that passed south of the source of the chert-bearing Cretaceous conglomerates of the Diablo Range (figs. 1 and 34). The richness in some of the samples of intermediate and mafic volcanic rocks is a similarity with the Upper Cretaceous strata of Anchor Bay in the Gualala area, but the similarity is not close enough as to demand the correlation. The Cretaceous rocks at Gualala overlie a basement of spilitic basalt of uncertain affinities. The basalt contains epidote but metamorphic minerals typical of the Franciscan assemblage, such as pumpellyite, lawsonite, and blue amphibole, are not reported (Wentworth, 1966), and we doubt that the basalt is part of the Franciscan. It is lithologically similar to some Jurassic rocks in the foothills of the northern Sierra Nevada (see Duffield and Sharp, 1975), and correlative rocks might be concealed under Quaternary deposits farther south. The presence of pre-Cretaceous metasedimentary rocks in the subsurface near Gualala (Hoskins and Griffiths, 1971) suggested to Dickinson (1983) affinities with the Sierran foothills belt. If the basement at Gualala corresponds to the Sierran foothills, then the Golden Gate-Gilroy block, with a Franciscan basement, by analogy with the expected distribution of rocks underneath the San Joaquin Valley, originated farther northwest. It seems likely that the Golden Gate-Gilroy block formed somewhere between this buried foothill belt and the exposed upper Mesozoic deposits of the Diablo Range to the north. A similar location with respect to the Diablo Range was indicated by Elder (1991a) based on paleogeographic interpretation of molluscan faunas in the Golden Gate-Gilroy block.

Right slip on the San Andreas fault system, and possibly also on a Late Cretaceous or early Tertiary precursor (Suppe, 1970), moved the Salinian and Nacimiento blocks northward together. The Golden Gate-Gilroy block, originally north of the Salinian block, was also displaced northward but by a smaller distance. When it reached its present position, the San Andreas fault may have stepped to the left, allowing the Salinian block to move northward to the west.

CONCLUSION

Restoration of San Andreas fault displacement puts the Salinian block adjacent to the Mojave block

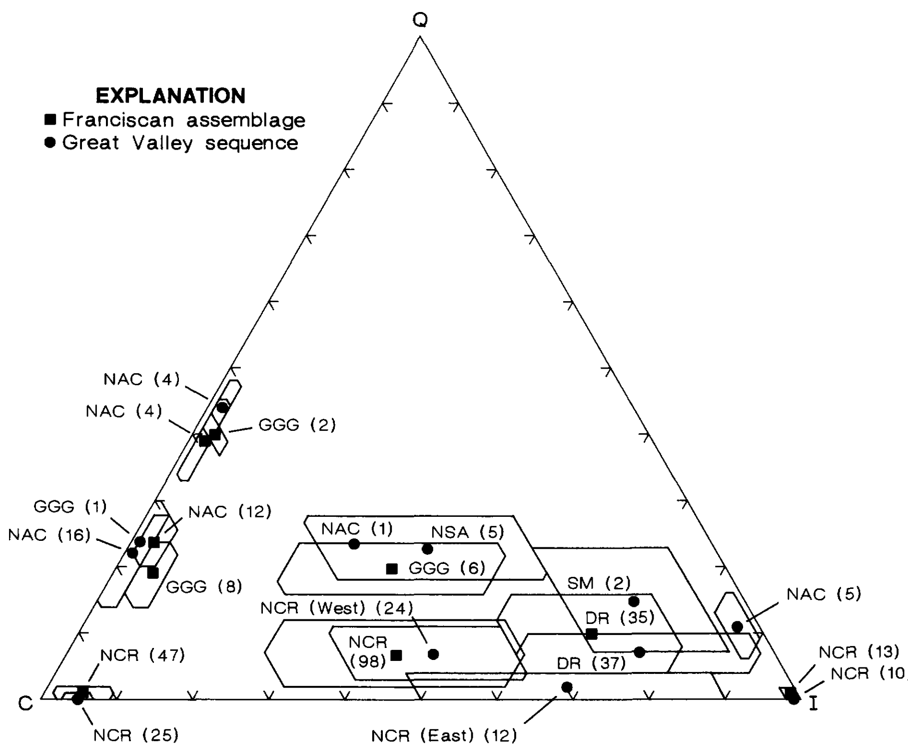


FIGURE 36.—Summary QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Jurassic through mid-Cretaceous (largely Turonian and older) conglomerate suites (364 conglomerates) from the Franciscan assemblage and Great Valley sequence in California and from correlative rocks in southwestern Oregon. Multiple suites in some regions reflect conglomerate of different ages. Data from Seiders and Blome (1988), Seiders (1991), and unpublished data. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert. DR, Diablo Range; GGG, Golden Gate-Gilroy block; NAC, Nacimiento block; NCR, northern California Coast Ranges; NSA, northern Santa Ana Mountains; SM, Santa Monica Mountains.

where Upper Cretaceous to Eocene conglomerate compositions compare closely with those in the Salinian block. Salinian conglomerates contrast sharply with conglomerates found for long distances to the north and south of the Mojave block. If the Salinian block is an exotic terrane derived 2,500 km to the south, as interpreted from paleomagnetic results (Champion and others, 1984), we are driven to the unlikely conclusion that it must have docked at just the place along the coast where matching conglomerate compositions occur.

The suggested time of docking of the Salinian block in latest Paleocene or earliest Eocene time (Vedder and others, 1983) is no longer constrained by the reconstruction of an early and middle Eocene Butano-Point of Rocks deep-sea fan (Nilsen and Clarke, 1975), because we have shown that the Butano Sandstone and Point of Rocks Sandstone Member of the Kreyenhagen Formation are compositionally different and were not part of the same fan; nevertheless, the same time of docking is indicated by interpretation of paleomagnetic data (Kanter and Debiche, 1985; Kanter, 1988). However, Paleocene and lower Eocene conglomerates in the Salinian block are compositionally alike, giving no hint of an intervening tectonic event such as the docking of a large exotic terrane.

The case made here based on conglomerate compositions for an origin of the Salinian block near the Mojave region is only one of several studies of diverse kinds pointing to the same conclusion (Dickinson, 1983; Ross, 1984; Silver and Mattinson, 1986; Hamilton, 1988; James and Mattinson, 1988; Powell, 1991). Butler and others (1991) have argued that the low paleomagnetic inclinations determined on marine sedimentary rocks of the Salinian block may have resulted from compactional shallowing. If they are correct, the strong and varied evidence for a local origin of the Salinian block is left without arguments to the contrary.

Several paleomagnetic studies have suggested large northward translation of the Peninsular Ranges as well (see Butler and others, 1991, for a review). Other paleomagnetic data, however, indicate no significant post-early Eocene northward translation (Flynn and others, 1989), and Butler and others (1991) reinterpret the low paleomagnetic inclinations as resulting from the tilting of the Peninsular Ranges batholith and compactional shallowing of inclinations in marine sedimentary rocks. The pattern of conglomerate compositions reported here indicates a Late Cretaceous position of the Peninsular Range near the southwestern Transverse Ranges and the Mojave block, although the evidence is less direct than that bearing on the Salinian block.

ACKNOWLEDGMENTS

We are grateful to many people who provided information about conglomerate localities. These include P.L. Abbott, J.M. Alderson, T.H. Anderson, A.P. Bennison, E.E. Brabb, J.P. Calzia, J.C. Clark, S.H. Clarke, I.P. Colburn, M.X. Kirby, R.D. Koch, S.M. Richard, J.E. Spencer, R.L. Squires, R.M. Tosdal, J.G. Vedder, John Wakabayashi, C.M. Wentworth, Jr., and R.F. Yerkes. T.J. Seiders collected two conglomerate samples from the beach in Baja California. We thank Paul Stone for helpful discussion of the McCoy Mountains Formation and for assistance in collecting several samples. R.E. Powell contributed valuable information on San Andreas fault restorations and provided advanced copies of a paper on that subject.

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SUPPLEMENTAL INFORMATION

SUPPLEMENTAL INFORMATION.—LOCATIONS OF SAMPLED CONGLOMERATES IN TABLES 1-8

[Except as noted, locations are given by 7.5-minute quadrangle and 1,000- meter Universal Transverse Mercator grid]

Table 1. SP-405 - Stewarts Point, 4,281,400N, 462,390E. SP-462 - Stewarts Point, 4,281,260N, 462,490E. SP-406 - Stewarts Point, 4,281,040N, 462,500E. SP-343 - Stewarts Point, 4,280,910N, 462,820E. SP-496 - Stewarts Point, 4,277,390N, 465,550E. GU-461 - Gualala, 4,297,110N, 447,990E. GU-412 - Gualala, 4,294,760N, 449,400E. SP-411 - Stewarts Point, 4,286,330N, 485,280E. PG-344 - Pigeon Point, 4,115,000N, 554,000E. PG-345 - Pigeon Point, 4,115,410N, 553,650E. PG-346 - Pigeon Point, 4,116,500N, 553,000E. PG-347, Pigeon Point, 4,118,550N, 552,580E. PS-399 - Point Sur, 4,023,250N, 599,020E. PT-400 - Partington Ridge, 4,000,650N, 620,960E. BP-508 - Burnett Peak, 3,967,020N, 662,080E. PS- 2427 - Pebblestone Shut-in, 3,957,570N, 672,940E. PS-2430 - Pebblestone Shut-in, 3,956,100N, 672,170E. Y-158 - York Mountain, 3,938,970N, 695,520E. BP-431 - Burnett Peak, 3,969,990N, 661,190E. BP-430 - Burnett Peak, 3,968,200N, 662,250E. BP-402 - Burnett Peak, 3,967,260N, 665,570E. BY-2382 - Bryson, 3,959,520N, 674,440E. BY-2386 - Bryson, 3,959,050N, 674,410E. BY-2852 - Bryson, 3,958,370N, 675,180E. BY-2853 - Bryson, 3,957,990N, 675,880E. BY-2366 - Bryson, 3,957,890N, 676,310E. PS-2848 - Pebblestone Shut-in, 3,957,260N, 675,000E. PS-2850 - Pebblestone Shut-in, 3,956,500N, 675,370E. PS-2372 - Pebblestone Shut-in, 3,956,880N, 675,660E. PS-2767 - Pebblestone Shut-in, 3,957,400N, 677,220E. Y-160 - York Mountain, 3,938,700N, 693,890E. AP-432 - Alder Peak, 3,977,210N, 657,550E. JO-403 - Bryson 15′, 3,971,670N, 661,180E. BP-401 - Burnett Peak, 3,968,450N, 666,900E. PSI-1104 - Pebblestone Shut-in, 3,956,930N, 676,360E. PS-2765 - same as PSI-1104. PS-2766 - Pebblestone Shut-in, 3,956,830N, 677,120E. LM-510 - Lime Mountain, 3,957,140N, 684,720E. LM- 511 - Lime Mountain, 3,956,990N, 684,800E. LM-512 - Lime Mountain, 3,957,520N, 688,810E. TR-514 - Tierra Redonda Mtn., 3,959,420N, 689,310E. TR-513 - Tierra Redonda Mtn., 3,958,560N, 689,570E. AD-593 - Adelaida, 3,953,860N, 696,010E. SL-472 - Santa Margarita Lake, 3,915,510N, 729,070E. PZ-440 - Pozo Summit, 3,913,900N, 745,070E. PZ-443 - Pozo Summit, 3,908,800N, 749,190E. PZ-441 - Pozo Summit, 3,913,040N, 744,600E. CR-558 - Chimineas Ranch, 3,896,570N,228,030E. PZ-442 - Pozo Summit, 3,911,890N, 744,330E. LM-456 - Lopez Mountain, 3,912,430N, 726,440E. SL-455 - Santa Margarita Lake, 3,913,090N, 728,790E. SL-454 - Santa Margarita Lake, 3,912,300N, 729,860E. SL-453 - Santa Margarita Lake, 3,912,660N, 731,200E. SL-471 - Santa Margarita Lake, 3,911,590N, 734,690E. CR-559 - Chimineas Ranch, 3,895,210N, 228,080E. LM-521 - Los Machos Hills, 3,892,180N, 755,010E. CC-606 - Chimney Canyon, 3,879,240N, 752,550E. BC-592 - Bates Canyon, 3,864,880N, 227,220E. BP-599 - Big Pine Mtn., 3,837,070N, 252,630E. BP-597 - Big Pine Mtn., 3,841,220N, 257,280E. BP-598 - Big Pine Mtn., 3,840,300N, 256,860E. LP-372 - Loma Prieta, 4,108,190N, 603,580E. 131 - Laurel, 4,107,310N, 598,300E. 132 - Loma Prieta, 4,105,790N, 602,860E. WO-268 - Woodside, 4,149,080N, 555,710E.

Table 2. BW-139-2 - Howard Ranch, 4,122,300N, 666,990E. VO-585 - Volta, 4,097,080N, 683,210E. OP-632 - Ortigalita Peak NW, composite sample, 4,095,890N, 684,030E and 4,095,520N, 684,300E. LS-563 - Laguna Seca Ranch, 4,082,750N, 694,250E. GP-438 - Garza Peak, 3,979,320N, 754,300E. TH-439 - Tent Hills, 3,967,150N, 758,000E. 159 - Black Star Canyon, 3,738,960N, 438,640E. BS-600 - Black Star Canyon, 3,735,390N, 440,220E. 160 - Black Star Canyon, 3,735,520N, 438,940E. BS-601 - Black Star Canyon, 3,735,190N, 439,630E. 161 - La Jolla, 3,629,820N, 475,190E. PL-629 - Point Loma, 3,614,790N, 477,300E. PL-474 - Point Loma, 3,615,170N, 477,240E. BJ-567 - North side of Arroyo El Morro, 0.6 miles east of route 1-D. PT-628 - Primo Tapia 1:50,000, 63,410N, 08,400E, Route 1, 750 m north of Cañon El Descanso. PT-627 - Primo Tapia 1:50,000, 62,720N, 08,400E, Route 1 at Canon El Descanso. BJ-568 - Route 1-D, 2.5 miles by road south of Salsipuedes. BJ-569 - Route 1-D, 2.7 miles by road south of Salsipuedes. BJ-570 - Gravel pit just east of route 1 at El Junco, 4.6 miles by road north of route 1-D. BJ-571 - Sea cliff about 120 meters north of El Rincon, where first sea cliffs occur going out east coast of Punta Banda. BJ-578 - Road to Punta China, 1.1 miles by road from junction with road to Punta Santo Tomas. BJ-579 - 0.9 miles by road east of same road junction. BJ-580 - 4.6 miles by road east of same road junction. 4C - Camalu (H11B53) 1:50,000, 22,350N, 73,040E, on beach at Heroes de Chapultepec, east of Punta San Telmo. CLU - Camalu (H11B53) 1:50,000, 09,790N, 870,070E, on Punta Camalu. BJ-573 - On beach just northwest of main fish camp. BJ-572 - On beach just southeast of main fish camp. BJ-574 - Tip of Punta Baja. 162 - On main highway about 9 miles east of San Miguel (a place near San Jose de Castro). CP-626 - Carpinteria, 3,818,230N, 261,920E. CP-625 - Carpinteria, 3,818,000N, 262,580E. WH-517 - Wheeler Springs, 3,820,100N, 284,450E. WH-518 - Wheeler Springs, 3,820,590N, 291,140E. 157 - Calabasas, 3,789,520N, 347,400E. OM-630 - Oat Mountain, 3,792,380N, 351,300E. SS-413 - Santa Susana, 3,792,580N, 346,000E. TG-419 - Topanga Canyon, 3,770,990N, 360,550E. TG-370 - Topanga, 3,770,160N, 361,200E. TP-394 - Topanga, 3,769,690N, 360,660E. TG-377, Topanga, 3,769,630N, 358,850E. TG-515 - Topanga, 3,767,510N, 355,560E. HW-552 - Hollywood, 3,775,620N, 375,260E. WM-450 - Warm Springs Mountain, 3,831,700N, 351,470E. CJ-498 - Cajon, 4,792,760N, 458,120E.

Table 3. MP-251 - McCoy Peak, 3,725,570N, 698,590E. MP-253 - McCoy Peak, 3,725,480N, 701,110E. MC-225 - McCoy Peak, 3,723,850N, 704,810E. RO-231 - Roosevelt Mine, 3,721,340N, 707,410E. CU-234 - Cunningham Mtn., 3,714,800N, 751,420E. MS-249 - McCoy Spring, 3,735,970N, 694,670E. MS-250 - McCoy Spring, 3,735,750N, 694,820E. MS-229 - McCoy Springs, 3,731,360N, 696,220E. MS-252 - McCoy Spring, 3,731,900N, 696,530E. AR-247 - Arlington Mine, 3,737,390N, 693,790E. AR-248 - Arlington Mine, 3,736,900N, 693,950E. CX-226 - Coxcomb Mountains 15′, 3,744,300N, 659,980E. AM-154 Arlington Mine, 3,738,410N, 694,280E, stream boulder. AR-246 - Arlington Mine, 3,738,090N, 694,200E. AM-155 - Arlington Mine, 3,738,000N, 694,140E. VK-236 - Vicksburg 15′, 3,722,120N, 225,150E. UT-239 - Utting 15′, 3,743,200N, 245,350E. PM-227 - Palen Mtns. 15′, 3,744,400N, 679,530E. QZ-235 - Quartzite 15′, 3,713,400N, 768,510E. AR-230 - Arlington Mine, 3,739,740N, 694,340E. HO-238 - Hope 15′, 3,730,890N, 253,970E. HO-237 - Hope 15′, 3,720,000N, 255,380E. PS-240 - Picacho SW, 3,654,140N, 721,560E. PS-242 - Picacho SW, 3,660,720N, 710,620E. PS-241 - Picacho SW, 3,654,820N, 721,270E.

Table 4. SP-339 - Stewarts Point, 4,276,830N, 465,670E. SP-342 - Stewarts Point, 4,276,320N, 466,300E. SP-340 - Stewarts Point, 4.276,290N, 466,050E. SP-341 - Stewarts Point, 4,276,140N, 466,160E. BW-89-1 - Point Reyes 19′ X 15′, 4,205,350N, 499,150E. BW-90-2 - Point Reyes 19′ X 15′,4,205,250N, 498,900E. BW-91-1 - Point Reyes 19′ X 15′, 4,205,150N, 500,850E. MM-497 - Montera Mountain, 4,161,170N, 542,950E. BW-84-1A - Montera Mountain, 4,160,600N,

543,110E. BP-73-1D - Montera Mountain, 4,159,700N, 543,600E. BW-149-1 - Monterey, 4,047,070N, 593,950E. BW-148-2 - Monterey, 4,046,980N, 594,490E. BW-135-2 - Monterey, 4,042,150N, 595,370E. BW-134-1 - Monterey, 4,041,720N, 593,770E. BW-133-2 - Monterey, 4,041,090N, 594,780E. BW-133-1 - Monterey, 4,040,930N, 594,860E. BW-147-1 - Monterey, 4,040,530N, 595,090E. TS-457 - Tassajara Hot Springs, 4,008,990N, 634,790E. JS-473 - Junipero Serra, 4,009,150N, 635,150E. AD- 562 - Adelaida, 3,949,750N, 694,710E. AD-594 - Adelaida, 3,949,670N, 696,390E. AD-634 - Adelaida, 3,951,580N, 699,550E. CU-520 - Cuyama, 3,871,280N, 269,270E. CU-519 - Cuyama, 3,870,840N, 270,090E. CU-560 - Cuyama, 3,871,690N, 271,420E.

Table 5. AS-621 - Antioch South, 4,199,110N, 602,140E. ET-417 - El Toro, 3,734,050N, 349,850E. ET-418 - El Toro, 3,729,390N, 441,090E. BS-416 - Black Star Canyon, 3,747,090N, 436,060E. BJ-577 - On road that runs southwest from Colonet to fish camp at Cabo Colonet, 4.6 miles from route 1. BJ-576 - Sea cliffs just west of fish camp at Cabo Colonet. BJ-575 - Route 1, 6.3 miles by road north of center of El Rosario. SS-415 - Santa Susana, 3,795,500N, 347,300E. CB-536 - Calabasas, 3,788,810N, 340,960E. SS-620 - Santa Susana, 3,792,650N, 345,790E. SS-414 - Santa Susana, 3,794,290N, 346,180E. CB-537 - Calabasas, 3,789,070N, 340,510E. PD-550 - Point Dume, 3,770,660N, 337,650E. HW-551 - Hollywood, 3,775,650N, 375,340E. MB-396 - Malibu Beach, 3,769,200N, 347,680E. TG-516 - Topanga, 3,771,060N, 353,590E. TP-395 - Topanga, 3,770,520N, 353,660E. TP-378 - Topanga, 3,769,190N, 356,700E. BH-554 - Beverly Hills, 3,776,410N, 372,530E. HW-553 - Hollywood, 3,775,770N, 375,370E. SU-555 - Sunland, 3,799,890N, 376,620E. BW-75-1A - Tehachapi, 3,887,620N, 379,060E. TC-614 - Tehachapi NE, 3,887,780N, 379,260E. TC-615 - Tehachapi NE, 3,890,140N, 381,800E. SD-617 - Saltdale NW, 3,917,080N, 416,190E. SD-618 - Saltdale NW, 3,917,760N, 416,780E. SW-619 - Saltdale NE, 3,920,690N, 419,490E. GK- 616 - Garlock, 3,923,380N, 425,110E. BW-104-2 - Garlock, 3,925,000N, 429,310E. BW-105-1 - Garlock, 3,925,310N, 429,200E. BX-136-1 - Garlock, 3,927,190N, 427,110E. BX-136-2 - Garlock, 3,927,490N, 427,000E. BX-136-3 - Garlock, 3,927,850N, 427,000E. BX-136-4 - Inyokern SE, 3,928,700N, 428,120E. BX-136-6 - 3,929,780N, 428,110E. BX-136-5 - Inyokern SE, 3,930,160N, 427,980E. BX-137-1 - Inyokern SE, 3,932,000N, 426,920E. BX- 137-2 - Inyokern SE, 3,930,850N, 428,080E. BX-137-3 - Inyokern SE, 3,932,810N, 423,800E. BX-137-4 - Inyokern SE, 3,933,430N, 423,620E. WP-464 - Whitaker Peak, 3,831,940N, 350,680E. WM-465 - Warm Springs Mountain, 3,831,670N, 352,890E. WM-449 - Warm Springs Mountain, 3,830,590N, 353,490E. WM-451 - Warm Springs Mountain, 3,827,270N, 357,430E. WM-448 - Warm Springs Mountain, 3,826,050N, 357,220E. GV-469 - Green Valley, 3,827,830N, 366,570E. GV-468 - Green Valley, 3,827,220N, 366,230E. VY-557 - Valyermo, 3,808,830N, 422,990E. VY-556 - Valyermo, 3,808,810N, 423,030E. VY-470 - Valyermo, 3,808,580N, 422,980E.

Table 6. PL-407 - Plantation, 4,270,160N, 470,820E. PL-495 - Plantation, 4,268,620N, 471,340E. PL-408 - Plantation, 4,267,350N, 473,580E. PL-409 - Plantation, 4,266,330N, 474,190E. BP-80-1 - Big Basin, 4,110,730N, 572,230E. BP-78-1D - Big Basin, 4,110,810N, 571,950E. FP-460 - Franklin Point, 4,111,670N, 566,580E. CR-488 - Castle Rock Ridge, 4,109,290N, 578,160E. FE-436 - Felton, 4,105,410N, 588,390E. JS-458 - Junipero Serra Peak, 4,000,000N, 636,580E. CP-459 - Cone Peak, 3,998,590N, 637,720E. CP-433 - Cone Peak, 3,998,210N, 637,950E. LM-522 - Los Machos Hills, 3,892,230N, 756,700E. MP-561 - Miranda Pine Mtn., 3,890,250N, 764,300E. MP-529 - Miranda Pine Mtn., 3,888,560N, 768,090E. MP-527 - Miranda Pine Mtn., 3,885,600N, 767,850E. MP-526 - Miranda Pine Mtn., 3,884,390N, 768,610E. MP-525 - Miranda Pine Mtn., 3,880,550N, 770,580E. MD-602 - Miranda Pine Mtn., 3,880,090N, 770,030E. MD-603 - Miranda Pine Mtn., 3,879,360N, 769,160E. MD-596 - Madulce Peak, 3,843,340N, 259,680E. MD-595 - Madulce Peak, 3,843,360N, 259,800E. LV-504 - Lockwood Valley, 3,836,240N, 310,820E. LV-505 - Lockwood Valley, 3,836,280N, 310,710E. LV- 507 - Lockwood Valley, 3,834,850N, 309,570E. LV-506 - Lockwood Valley, 3,835,100N, 309,270E. LV-508 - Lockwood Valley, 3,838,610N, 306,170E. LV- 509 - Lockwood Valley, 3,839,060N, 306,050E.

Table 7. ID-476 - Idria, 4.033,500N, 709,020E. ID-475 - Idria, 4,033,170N, 709,220E. CL-622 - Clayton, 4,200,350N, 597,370E. PN-478 - Panoche, 4,044,040N, 694,070E. ID-477 - Idria, 4,035,320N, 709,780E. GZ-479 - Gonzales 15', 4,066,710N, 656,140E. TD-437 - The Dark Hole, 3,983,290N, 747,490E. SR-444 - Sawtooth Ridge, 3,955,900N, 768,660E. PW-445 Packwood Creek, 3,937,690N, 768,240E. SP-467 - Shale Point, 3,933,400N, 228,970E. CR-466 - Carneros Rocks, 3,920,020N, 241,600E. BS-565 - Black Star Canyon, 3,748,060N, 435,700E. BS-566 - Black Star Canyon, 3,748,050N, 435,580E. DM-530 - Del Mar, 3,637,560N, 476,730E. LJ-531 - La Jolla, 3,636,480N, 476,350E. LM-533 - La Mesa, 3,629,710N, 489,080E. LM-591 - La Mesa, 3,626,300N,493,810E. LM-532 - La Mesa, 3,625,870N, 495,880E. VR-534 - San Vicente Reservoir, 3,641,160N, 505,520E. VR-535 - 3,646,750N, 508,590E. BJ-582 - Route 3, 2.7 miles by road north of El Testerazo. BJ-581 - Route 3, 1.8 miles by road north of El Testerazo. JC-584 - Jacumba, 3,610,930N, 575,450E. BJ-583 - Route 2, west of La Rumorosa, 1.5 miles by road east of El Condor. LC-623 - Lake Cachuma, 3,823,510N, 232,970E. LC-624 - Lake Cachuma, 3,823,510N, 233,190E. SY-538 - Santa Ynez, 3,830,210N, 773,940E. SS-549 - Santa Susana, 3,797,630N, 344,290E. SF-631 - San Fernando, 3,801,930N, 362,800E. ST-446 - Santiago Creek, 3,867,110N, 290,510E. RC-500 - Red Canyon, 3,720,690N, 621,180E. RC-499 - Red Canyon, 3,720,190N, 621,830E. RC-502 - Red Canyon, 3,719,860N, 620,690E. RC-501 - Red Canyon, 3,719,830N, 620,800E. RC-503 - Red Canyon, 3,718,840N, 621,200E.

Table 8. PZ-539 - Pozo Summit, 3,905,200N, 746,690E. SL-543 - Santa Margarita Lake, 3,907,210N, 736,290E. SL-542 - Santa Margarita Lake, 3,906,280N, 736,160E. SL-541 - Santa Margarita Lake, 3,905,690N, 736,080E. SL-540 - Santa Margarita Lake, 3,905,390N, 735,760E. LM-523 - Los Machos Hills, 3,892,870N, 756,690E. MP-524 - Miranda Pine Mtn., 3,888,290N, 763,870E. MP-528 - Miranda Pine Mtn., 3,887,470N, 766,730E. MD-604 - Miranda Pine Mtn., 3,884,610N, 766,300E.

FIGURES 6–18, 25–33; TABLES 1–8 and 10

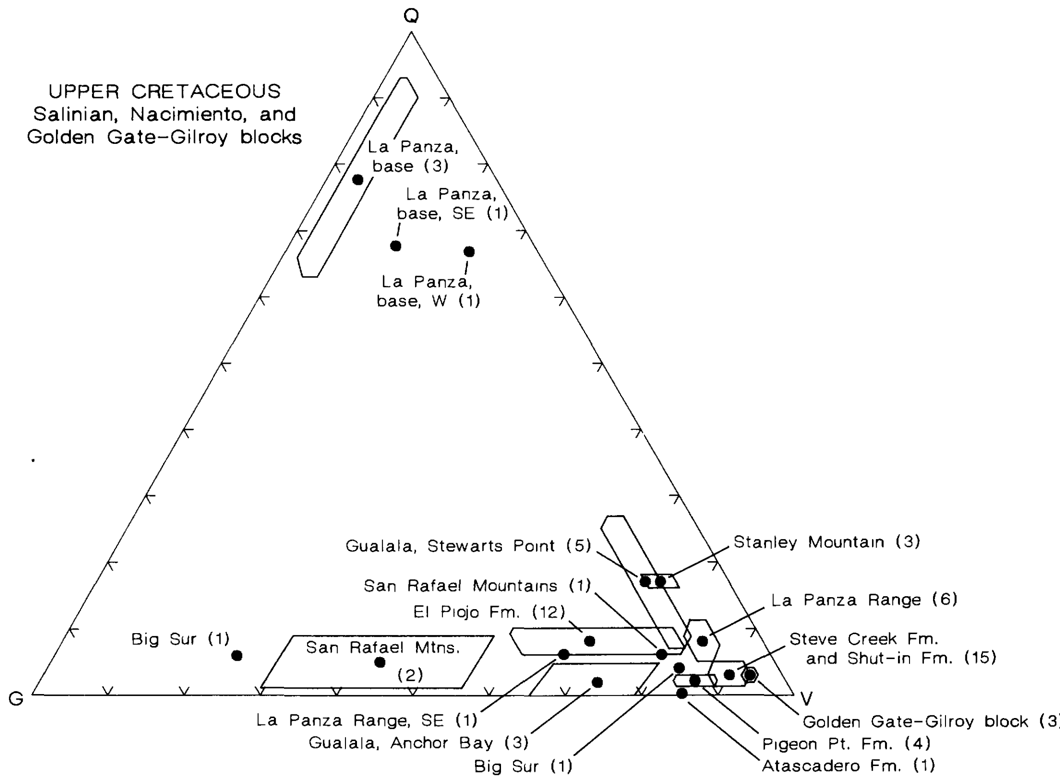

FIGURE 6.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites (61 conglomerates) from the Salinian, Nacimiento, and Golden Gate-Gilroy blocks. See table 1 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

TABLE 1.—*Pebble counts, in percent, of Upper Cretaceous conglomerates of the Salinian, Nacimiento, and Golden Gate-Gilroy blocks*

[C=chert, G=granitic rocks, I=igneous rocks, Q=quartz sandstone, V=volcanic rocks, -=not present].

Area ------------	Gualala											
Unit -------------	Strata of Stewarts Point							Strata of Anchor Bay				
Locality ----------	SP-405	SP-462	SP-406	SP-343	SP-496	Mean of 5	Std. dev.	GU-461	GU-412	SP-411	Mean of 3	Std. dev.
Chert	0.3	0.6	0.8	0.8	0.8	0.7	0.2	-	-	0.3	0.1	0.2
Mudstone	2.1	3.5	3.6	4.5	4.9	3.7	1.1	-	0.3	2.4	.9	1.3
Quartz sandstone	29.2	19.6	13.1	6.1	10.0	15.6	9.1	0.6	.3	5.0	2.0	2.6
Other sandstone	3.8	4.1	2.8	10.0	1.1	4.4	3.4	1.7	.9	3.2	1.9	1.2
Vein quartz	.3	.3	-	.5	.5	.3	.2	-	-	-	-	-
Felsic volcanic rocks	52.2	61.5	62.5	63.7	67.5	61.5	5.7	44.9	34.7	43.5	41.0	5.5
Other volcanic rocks	-	.3	1.9	4.2	-	1.3	1.8	11.4	16.9	18.3	15.5	3.6
Diabase[1]	-	-	-	-	-	-	-	10.0	10.8	9.8	10.2	.5
Granitic rocks	10.6	8.5	10.6	7.4	12.7	10.0	2.1	20.2	18.4	12.2	16.9	4.2
Diorite and gabbro[1]	-	-	-	-	-	-	-	1.4	13.4	1.9	5.6	6.8
Other	1.5	1.6	4.7	2.9	2.4	2.6	1.3	10.0	4.4	3.4	5.9	3.6
Total	100.0	100.0	100.0	100.1	99.9	100.1		100.2	100.1	100.0	100.0	
Pebbles counted	339	317	360	360	369	353		361	343	377	360	
Q	32	21	15	7	11	17	10	1	0	6	2	3
I	68	78	84	92	88	82	9	99	100	94	98	3
C	0	1	1	1	1	1	0	0	0	0	0	0
Q	32	22	15	7	11	17	10	1	0	6	2	3
V	57	69	73	84	75	72	10	75	66	79	73	7
G	11	9	12	9	14	11	2	24	34	15	25	10
Age	Campanian to Maestrichtian							Campanian to Maestrichtian				

Area ------------	Pigeon Point						Big Sur coast		Central Santa Lucia Range					
Unit -------------	Pigeon Point Formation						Unnamed strata		Steve Creek Formation					
Locality ----------	PG-344	PG-345	PG-346	PG-347	Mean of 4	Std. dev.	PS-399	PT-400	BP-508	PS-2427	PS-2430	Y-158	Mean of 4	Std. dev.
Chert	-	1.7	2.0	2.4	1.5	1.1	0.5	4.7	2.2	-	0.3	4.8	1.8	2.2
Mudstone	0.3	1.1	-	.2	.4	.5	.3	5.0	.6	0.5	2.7	2.4	1.6	1.2
Quartz sandstone	2.2	.3	.9	2.4	1.5	1.0	3.8	3.4	1.0	.3	6.6	.9	2.9	2.9
Other sandstone	.3	2.0	2.3	1.9	1.6	.9	-	.6	4.5	1.6	3.9	6.0	4.0	1.8
Vein quartz	.3	-	-	.2	.1	.1	.5	.3	1.9	-	-	.3	.6	.9
Felsic volcanic rocks	80.7	80.7	81.0	80.2	80.7	.3	82.0	13.4	82.2	79.8	61.3	78.0	75.3	9.5
Other volcanic rocks	.6	2.1	.9	3.1	1.7	1.1	-	.3	1.6	4.9	16.0	2.4	6.2	6.7
Granitic rocks	15.5	11.0	11.6	6.7	11.7	2.8	12.5	39.9	2.9	12.0	8.5	2.4	6.4	4.6
Other	.3	.3	1.4	.7	.7	.5	.3	32.4	3.2	.8	.6	-	1.2	1.4
Total	100.2	99.9	100.1	99.8	99.9		99.9	100.0	100.1	99.9	99.9	100.2	100.0	
Pebbles counted	362	353	352	414	370		367	321	314	367	331	336	337	
Q	2	0	1	3	2	1	4	6	1	0	7	4	3	3
I	98	96	97	95	97	1	96	67	97	100	93	91	95	4
C	0	2	2	2	1	1	0	7	2	0	0	5	2	2
Q	2	0	1	3	2	1	4	6	1	0	7	4	3	3
V	82	88	87	88	86	3	83	24	96	88	84	93	90	5
G	16	12	12	9	12	3	13	70	3	12	9	3	7	4
Age	Campanian to Maestrichtian						Late Cret.		Campanian to Maestrichtian					

Area ------------	Central Santa Lucia Range--con.													
Unit -------------	Shut-in Formation													
Locality ----------	BP-431	BP-430	BP-402	BY-2382	BY-2386	BY-2852	BY-2653	BY-2366	PS-2848	PS-2850	PS-2372	PS-2767	Mean of 12	Std. dev.
Chert	-	-	0.3	-	-	0.6	0.5	-	-	-	-	0.3	0.1	0.2
Mudstone	-	0.8	0.3	0.3	-	0.3	0.3	-	0.3	2.9	0.3	-	.5	.8
Quartz sandstone	3.0	3.1	3.5	3.6	0.6	.8	4.6	1.6	4.2	2.6	1.2	2.5	2.9	1.3
Other sandstone	-	1.7	.5	-	.3	.3	1.6	.3	-	.3	.6	-	.5	.6
Vein quartz	-	-	-	.3	-	-	.3	-	-	-	-	-	.0	.1
Felsic volcanic rocks	91.7	87.9	84.8	85.8	93.2	85.7	84.8	86.9	86.0	86.1	89.3	89.9	87.7	2.8
Other volcanic rocks	.8	-	.8	2.5	1.1	.8	.3	1.1	.3	-	1.2	.6	.6	.7
Granitic rocks	4.3	6.2	8.9	7.2	4.5	6.7	7.1	9.5	8.7	7.5	5.5	6.3	6.9	1.6
Other	.3	.3	.8	.3	.3	.8	.5	.5	.6	.6	2.0	.3	.6	.5
Total	100.1	100.0	99.9	100.0	100.0	100.0	100.0	99.9	100.1	100.0	100.1	100.1	100.0	
Pebbles counted	372	354	369	359	353	357	368	367	358	345	345	365	359	
Q	3	3	4	4	1	5	5	2	4	3	1	2	3	1
I	97	97	96	96	99	94	95	98	96	97	99	96	97	2
C	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Q	3	3	4	4	1	5	5	2	4	3	1	3	3	1
V	93	91	87	89	95	88	68	89	97	89	93	91	90	3
G	4	6	9	7	4	7	7	9	9	8	6	6	7	2
Age	Late Maestrichtian													

TABLE 1.—*Pebble counts, in percent, of Upper Cretaceous conglomerates of the Salinian, Nacimiento, and Golden Gate-Gilroy blocks*—Continued

Area	Central Santa Lucia R.- - con.		
Unit	Steve Creek & Shut-in Fms.		Atascadero Formation
Locality	Mean of 16	Std. dev.	Y-160
Chert	0.6	1.3	-
Mudstone	.7	1.0	-
Quartz sandstone	2.9	1.7	-
Other sandstone	1.3	1.7	-
Vein quartz	.2	.5	-
Felsic volcanics	84.6	7.4	69.6
Other volcanics	2.2	3.9	14.6
Granitic rocks	6.6	2.5	14.6
Other	.7	.8	1.3
Total	100.0		100.1
Pebbles counted	354		316
Q	3	2	0
I	96	2	100
C	1	1	0
Q	3	2	0
V	90	3	65
G	7	3	15
Age	Camp. to Maest.		Campanian

Area	Central Santa Lucia Range--con.													
Unit	El Piojo Formation													
Locality	AP-432	JO-403	BP-401	PSI-1104	PS-2765	PS-2766	LM-510	LM-511	LM-512	TR-514	TR-513	AD-593	Mean of 12	Std. dev.
Chert	-	-	-	1.4	0.3	-	-	-	-	-	-	-	0.2	0.4
Mudstone	0.8	0.3	0.3	-	0.6	0.8	-	0.6	0.8	0.9	0.6	-	.5	.3
Quartz sandstone	4.2	4.7	8.0	9.9	9.6	11.2	6.9	7.2	8.2	9.3	5.2	8.8	7.8	2.2
Other sandstone	.8	-	1.4	.3	.6	.6	.3	.6	.5	.3	1.4	2.1	.8	.6
Vein quartz	2.0	2.2	5.5	2.0	2.0	-	3.7	1.4	1.9	1.5	2.6	2.1	2.3	1.3
Felsic volcanic rocks	72.5	64.8	68.2	53.7	39.7	54.8	62.5	74.3	72.2	79.9	80.2	74.0	66.4	12.0
Other volcanic rocks	-	-	-	.3	.3	.5	.6	-	-	-	-	.3	.2	.2
Granitic rocks	18.0	27.7	14.6	27.9	43.4	27.8	25.2	15.2	15.5	7.4	9.6	12.4	20.4	10.2
Other	1.7	.3	1.9	4.4	3.4	4.0	.9	.6	.8	.6	.3	.3	1.6	1.5
Total	100.0	100.0	99.9	99.9	100.1	99.9	100.1	100.1	99.9	99.9	100.1	100.0	100.1	
Pebbles counted	356	361	362	294	355	374	349	362	367	323	363	339	350	
Q	4	5	9	11	10	12	7	7	9	10	6	9	8	2
I	96	95	91	88	90	88	93	93	91	90	94	91	92	3
C	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Q	4	5	9	11	10	12	7	7	9	9	6	9	8	2
V	77	67	75	59	43	59	66	77	75	83	84	78	70	12
G	19	28	16	30	47	29	27	16	16	8	10	13	22	11
Age	Late Maestrichtian													

Area	La Panza Range					
Part of area	West	East				Southeast
Unit	Unnamed strata, basal part					
Locality	SL-472	PZ-440	PZ-443	PZ-441	Mean of 3	Std. dev.	CR-558
Chert	1	-	0.3	-	0.1	0.2	-
Mudstone	-	-	2.7	1.1	1.3	1.4	-
Quartz sandstone	63	36.8	59.9	62.9	59.9	23.0	61.3
Other sandstone	4	35.6	20.9	3.5	2.0[2]	16.1	4.6
Vein quartz	1	1.8	.9	2.7	1.8	.9	3.4
Felsic volcanic rocks	23	2.9	3.2	1.9	2.7	.7	12.7
Other volcanic rocks	-	-	-	-	-		-
Granitic rocks	8	20.6	9.4	7.3	12.4	7.1	15.8
Other	-	2.4	2.7	.5	1.9	1.2	2.0
Total	100	100.1	100.0	99.9	100.1		100.0
Pebbles counted	100	340	339	369	349		354
Q	66	61	82	90	78	15	68
I	33	39	17	10	22	15	32
C	1	0	1	0	0	1	0
Q	67	61	83	90	78	15	68
V	24	5	4	2	4	2	14
G	9	34	13	8	18	14	18
Age	Campanian to Maestrichtian						

TABLE 1.—*Pebble counts, in percent, of Upper Cretaceous conglomerates of the Salinian, Nacimiento, and Golden Gate-Gilroy blocks*—Continued

Area	La Panza Range--con.								
Part of area	North								Southeast
Unit	Unnamed strata, above basal part								
Locality	PZ-442	LM-456	SL-455	SL-454	SL-453	SL-471	Mean of 6	Std. dev.	CR-559
Chert	-	-	-	-	-	-	-	-	0.3
Mudstone	-	0.6	1.1	0.8	0.3	0.8	0.6	0.4	-
Quartz sandstone	10.7	3.9	9.5	7.2	6.1	7.3	7.5	2.4	5.7
Other sandstone	1.6	.3	.3	1.1	1.7	1.3	1.0	.6	1.4
Vein quartz	1.4	1.8	.3	-	1.7	1.9	1.2	.6	1.1
Felsic volcanic rocks	78.6	83.4	77.4	85.6	81.1	79.0	80.8	3.1	64.5
Other volcanic rocks	-	-	-	-	-	-	-	-	-
Granitic rocks	7.7	10.1	10.1	4.4	8.4	8.4	8.2	2.1	25.9
Other	-	-	1.4	.8	.8	1.3	.7	.6	1.1
Total	100.0	100.1	100.1	99.9	100.1	100.0	100.0		100.0
Pebbles counted	365	337	358	362	359	371	359		352
Q	11	4	10	7	6	8	8	3	6
I	89	96	90	93	94	92	92	3	94
C	0	0	0	0	0	0	0	0	0
Q	11	4	10	7	6	8	8	3	6
V	81	86	80	88	85	83	84	3	67
G	8	10	10	5	9	9	8	2	27
Age	Campanian to Maestrichtian								?

Area	Stanley Mountain area					San Rafael Mountains				
Unit	Unnamed strata					Unnamed strata				
Locality	LM-521	CC-606	BC-592	Mean of 3	Std. dev.	BP-599	BP-597	BP-598	Mean of 2	Std. dev.
Chert	0.3	0.6	0.3	0.4	0.2	0.3	-	-	-	-
Mudstone	5.0	3.2	3.4	3.9	1.0	.5	-	2.3	1.1	1.6
Quartz sandstone	15.2	14.6	16.3	15.4	.9	5.5	7.6	2.0	4.8	4.0
Other sandstone	6.6	2.3	4.5	4.5	2.1	.5	.9	1.4	1.2	.4
Vein quartz	-	-	-	-	-	-	3.0	.9	1.9	1.5
Felsic volcanic rocks	64.8	69.6	57.9	64.1	5.9	78.7	50.0	29.3	39.7	14.6
Other volcanic rocks	.3	1.1	4.5	2.0	2.2	.5	-	2.0	1.0	1.4
Granitic rocks	7.2	7.7	10.1	8.3	1.5	13.9	36.4	59.8	48.1	16.5
Other	.6	.9	3.1	1.5	1.4	-	2.1	2.3	2.2	.2
Total	100.0	100.0	100.1	100.1		99.9	100.0	100.0	100.0	
Pebbles counted	361	349	356	355		366	330	348	339	
Q	18	15	18	17	2	6	8	2	5	4
I	82	84	82	83	1	94	92	98	95	4
C	0	1	0	0	1	0	0	0	0	0
Q	18	16	18	17	1	6	8	2	5	4
V	74	76	70	74	3	80	53	34	43	13
G	8	8	12	9	2	14	39	64	52	18
Age	?	?	Camp. to Maest.			Campanian to Maestrichtian				

Area	Golden Gate-Gilroy block					
Unit	Unnamed strata					
Locality	LP-372	131	132	Mean of 3	Std. dev.	WO-268
Chert	3.1	0.4	-	1.2	1.7	-
Mudstone	2.2	7.2	4.1	4.5	2.5	2.5
Quartz sandstone	2.8	3.2	2.3	2.8	.5	-
Other sandstone	5.8	3.6	3.3	4.2	1.4	-
Vein quartz	.8	.8	-	.5	.5	-
Felsic volcanic rocks	79.7	71.3	60.4	70.5	9.7	39.5
Other volcanic rocks	1.1	10.4	26.0	12.5	12.6	39.9
Granitic rocks	3.3	2.8	3.3	3.1	.3	13.4
Other	1.1	.4	.5	.7	.4	4.7
Total	99.9	100.1	99.9	100.0		100.0
Pebbles counted	359	251	389	333		276
Q	3	4	3	3	1	0
I	94	96	97	96	2	100
C	3	0	0	1	2	0
Q	3	4	2	3	1	0
V	93	93	94	93	1	86
G	4	3	4	4	1	14
Age	Campanian					?

[1] Except where listed separately, diabase, diorite, and gabbro, usually scarse or absent, are included with other volcanic rocks (diabase) or with granitic rocks (diorite and gabbro).

[2] Most other sandstone in these samples is feldspathic but quartz-rich, gradational in composition, and similar in texture to quartz sandstone in the same samples.

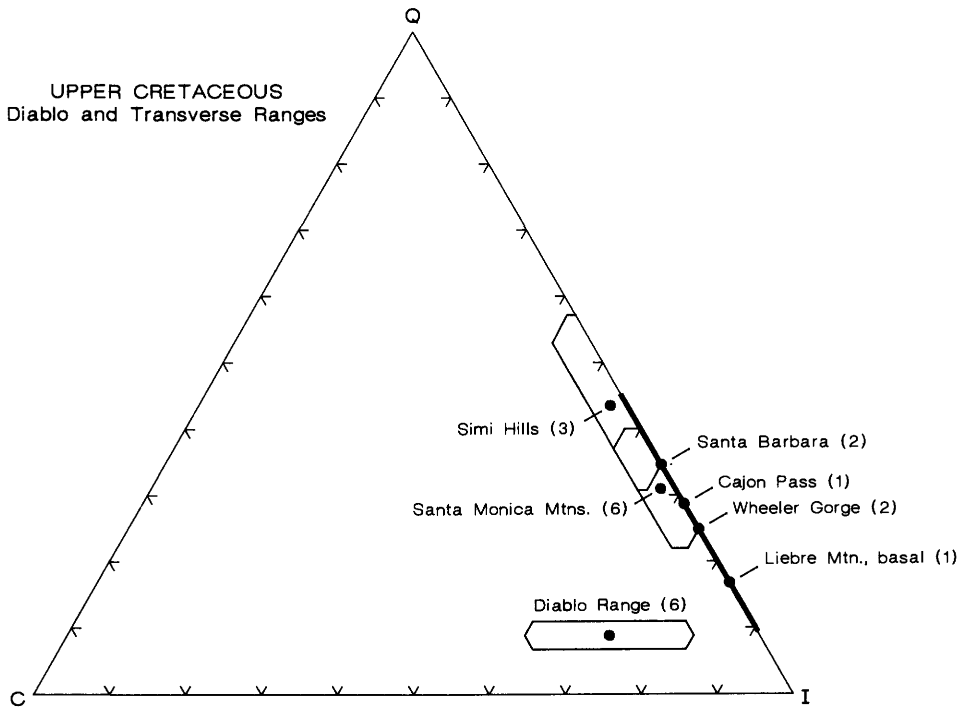

FIGURE 7.—QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites (21 conglomerates) from the Diablo and Transverse Ranges. See table 2 for pebble counts. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert.

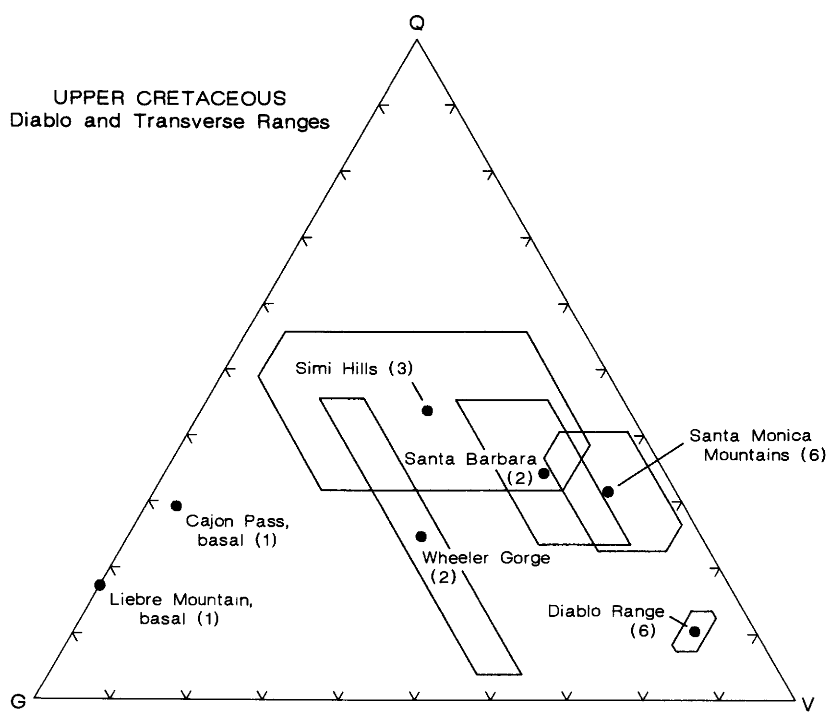

FIGURE 8.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites (21 conglomerates) from the Diablo and Transverse Ranges. See table 2 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

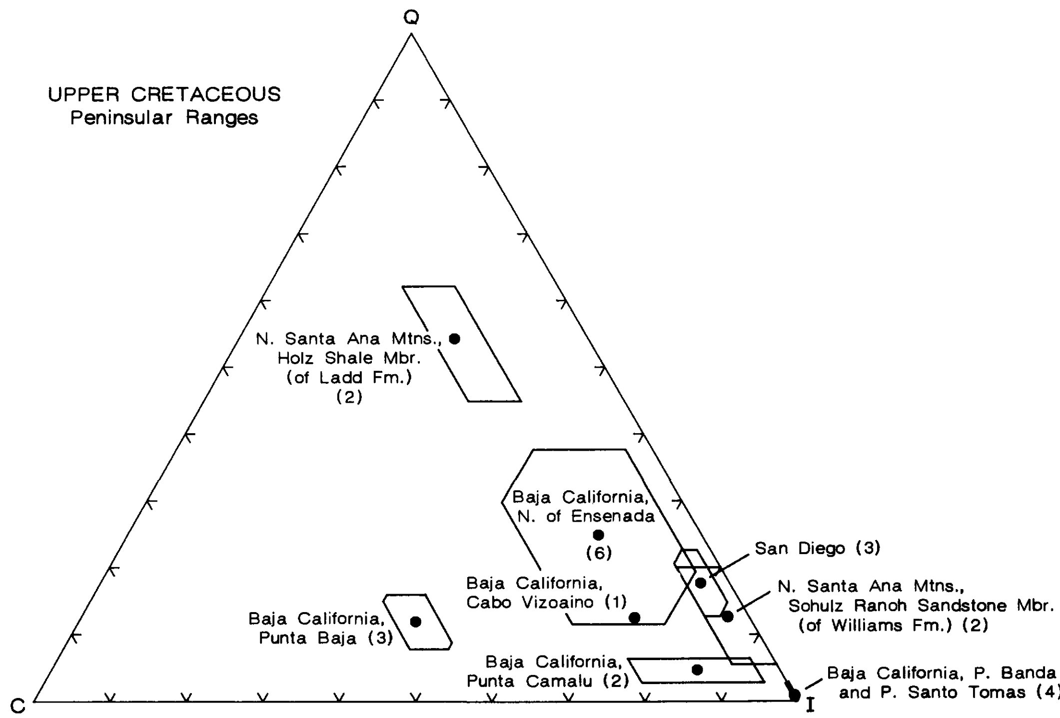

FIGURE 9.—QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites (23 conglomerates) from the Peninsular Ranges. See table 2 for pebble counts. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert.

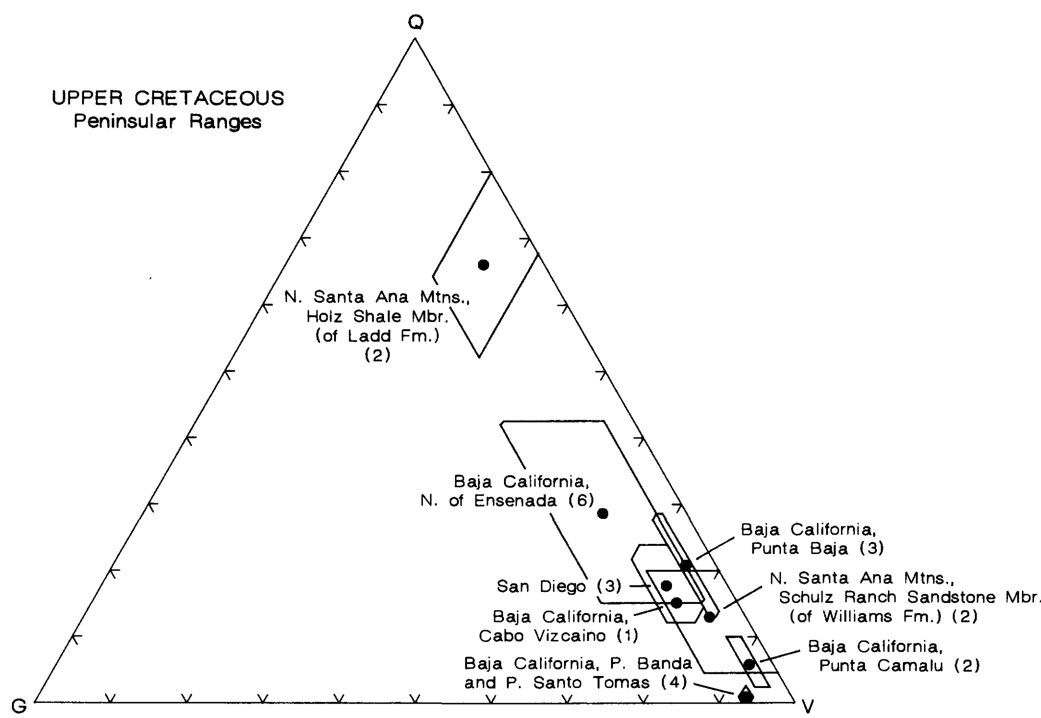

FIGURE 10.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites (23 conglomerates) from the Peninsular Ranges. See table 2 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

TABLE 2.—*Pebble counts, in percent, of Upper Cretaceous conglomerate of the Diablo Range and southern and Baja California*

[C=chert, G=granitic rocks, I=volcanic and granitic rocks, Q=quartz sandstone, V=volcanic rocks, -=not present].

Region	Diablo Range							
Unit	Great Valley sequence							
Locality	BW-139-2	VO-585	OP-632	LS-563	GP-438	TH-439	Mean of 6	Std. dev.
Chert	10.9	18.7	11.7	0.5	9.1	37.4	16.2	10.9
Mudstone	.4	1.4	63	3.0	1.0	2.0	6.4	13.0
Quartz sandstone	5.8	6.	5.3	3.9	10.8	8.1	6.8	2.4
Other sandstone	.9	1.6	.6	15.4	3.0	2.0	4.4	5.5
Vein quartz	6.6	10.5	9.4	-	1.0	1.2	4.8	4.6
Felsic volcanic rocks	63.2	46.3	56.4	29.1	60.9	44.9	50.1	12.7
Other volcanic rocks	-	.5	1.7	-	.7	.6	.6	.6
Granitic rocks	8.4	7.2	7.5	2.8	2.4	1.2	4.9	3.1
Limestone	-	2.6	1.1	5.0	9.4	2.0	3.3	3.4
Other	3.8	5.1	3.9	1.4	1.7	.6	2.6	1.7
Total	100.0	100.0	100.1	100.0	100.0	100.0	100.0	
Pebbles counted	797	428	360	358	297	345	431	
Q	7	8	6	9	13	9	9	2
I	81	68	80	70	76	51	71	11
C	12	24	14	21	11	40	20	11
Q	7	10	7	11	14	15	11	3
V	82	78	82	81	83	83	81	2
G	11	12	11	8	3	2	8	4
Age	Maest.	Maest.	Maest.	Maest.	Camp. to Maest.	Camp. to Maest.		

Region	Peninsular Ranges												
Area	Northern Santa Ana Mountains								San Diego				
Unit	Ladd Formation, Holz Shale Mbr.				Williams Formation, Schulz Ranch Sandstone Mbr.				Cabrillo Formation				
Locality no.	159	BS-600	Mean of 2	Std. dev.	160	BS-601	Mean of 2	Std. dev.	161	PL-629	PL-474	Mean of 3	Std. dev.
Chert	12.7	9.1	10.9	2.5	0.6	4.1	2.4	2.5	5.9	3.1	1.4	3.3	2.3
Mudstone	11.2	13.4	12.3	1.6	5.2	5.1	5.1	.1	5.4	3.1	9.3	5.9	3.1
Quartz sandstone	36.4	28.5	32.5	5.6	7.4	16.2	11.8	6.2	15.3	11.6	18.4	15.1	3.4
Other sandstone	21.8	22.3	22.0	.4	2.4	1.9	2.1	.4	.5	3.1	4.9	2.8	2.2
Vein quartz	.9	1.1	1.0	.1	.3	1.4	.8	.8	-	-	.3	.1	.2
Felsic volcanic rocks	10.3	15.3	12.8	3.5	81.8	63.2	72.5	13.2	56.3	67.9	50.5	58.2	8.9
Other volcanic rocks	-	-	-	-	.3	-	.2	.2	9.0	2.0	1.4	4.1	4.2
Granitic rocks	1.5	7.0	4.3	3.9	1.2	6.8	4.0	4.0	4.5	8.2	8.0	6.9	2.1
Other	5.2	3.2	4.2	1.4	.9	1.4	1.1	.4	3.2	.9	5.8	3.3	2.4
Total	100.0	99.9	100.0		100.0	100.1	100.0		100.1	99.9	100.0	99.9	
Pebbles counted	330	372	351		330	370	350		222	352	364	313	
Q	60	48	54	8	8	18	13	7	17	13	23	18	5
I	19	37	28	13	91	77	84	10	77	84	75	78	5
C	21	15	18	4	1	5	3	3	6	3	2	4	2
Q	76	56	66	14	8	19	13	8	18	13	24	18	6
V	21	30	26	6	91	73	82	13	77	78	66	74	7
G	3	14	8	8	1	8	5	5	5	9	10	8	3
Age	Santonian to Campanian				Campanian				Maestrichtian				

Region	Peninsular Ranges--con.													
Area	Baja California north of Ensenada								Punta Banda and Punta Santo Tomas, B.C.					
Unit	Redondo(?) and Rosario Formations								Rosario Formation					
	BJ-567	PT-628	PT-627	BJ-568	BJ-569	BJ-570	Mean of 6	Std. dev.	BJ-571	BJ-578	BJ-579	BJ-580	Mean of 4	Std. dev.
Chert	13.6	27.0	7.6	4.2	8.9	6.7	11.3	8.3	-	-	-	0.3	0.1	0.1
Mudstone	10.0	9.1	.3	9.3	3.0	4.5	7.7	4.5	-	-	0.3	3.6	1.0	1.8
Quartz sandstone	20.3	16.2	1.4	27.9	23.0	36.1	20.8	11.7	-	0.3	-	3.3	.9	1.6
Other sandstone	3.5	2.0	.8	4.8	7.5	6.4	4.2	2.6	-	-	-	1.2	.3	.6
Vein quartz	-	-	.3	.3	-	.3	.1	.2	-	-	-	-	-	-
Felsic volcanic rocks	39.0	30.1	78.7	38.0	33.5	28.3	41.3	18.8	87.6	92.3	91.3	84.1	88.8	3.7
Other volcanic rocks	6.2	3.1	3.6	.6	4.2	.3	3.0	2.2	4.3	1.1	2.5	2.1	2.5	1.3
Granitic rocks	2.7	6.3	3.1	13.8	8.6	15.4	8.3	5.3	8.1	6.0	5.7	5.1	6.2	1.3
Other	4.6	6.3	4.2	1.1	1.4	2.0	3.3	1.1	-	.3	.3	.3	.2	.1
Total	99.9	100.1	100.0	100.0	100.1	100.0	100.0		100.0	100.0	100.1	100.0	100.0	
Pebbles counted	369	352	357	355	361	357	358		258	365	366	333	331	
Q	25	20	2	33	30	41	25	13	0	0	0	4	1	2
I	58	48	90	62	59	51	61	15	100	100	100	96	99	2
C	17	32	8	5	11	8	14	10	0	0	0	0	0	0
Q	30	29	2	35	33	45	29	14	0	0	0	4	1	2
V	66	60	95	48	54	36	60	20	92	94	94	91	93	1
G	4	11	3	17	13	19	11	7	8	6	6	5	6	1
Age	Campanian to Maestrichtian								Campanian to Maestrichtian					

TABLE 2.—*Pebble counts, in percent, of Upper Cretaceous conglomerate of the Diablo Range and southern and Baja California*—Continued

Region	Peninsular Ranges--con.									
Area	Punta Camalu, B.C.				Punta Baja, B.C.					Cabo Vizcaino, B.C.
Unit	Rosario Formation				Punta Baja Formation					Valle Fm.
Locality	4C	CLU	Mean of 2	Std. dev.	BJ-573	BJ-572	BJ-574	Mean of 3	Std. dev.	162
Chert	4.1	13.1	8.6	6.4	29.2	33.1	32.6	31.6	2.1	14.6
Mudstone	5.7	12.0	8.9	4.4	23.7	26.4	22.1	24.1	2.2	1.1
Quartz sandstone	2.7	5.0	3.8	1.6	5.6	7.6	11.6	8.3	3.1	12.1
Other sandstone	3.3	8.6	6.0	3.7	3.6	.6	3.7	2.6	1.8	1.3
Vein quartz	.3	-	.1	.2	-	-	-	-	-	.8
Felsic volcanic rocks	77.3	49.6	63.5	19.6	25.9	23.3	22.4	23.9	1.8	61.5
Other volcanic rocks	3.8	8.1	5.9	3.0	8.1	5.1	4.0	5.7	2.1	-
Granitic rocks	1.6	2.5	2.1	.6	1.9	2.0	1.4	1.8	.3	6.7
Other	1.1	1.1	1.1	.0	1.9	2.0	2.3	2.1	.2	1.9
Total	99.9	100.0	100.0		99.9	100.1	100.1	100.1		100.0
Pebbles counted	366	359	362		359	356	353	356		371
Q	3	6	5	2	8	11	16	12	4	13
I	92	77	84	11	51	43	39	44	6	72
C	5	17	11	8	41	46	45	44	3	15
Q	3	8	6	4	13	20	29	21	8	15
V	95	88	91	5	82	75	67	75	8	77
G	2	4	3	1	5	5	4	4	18	8
Age	Early Maestrichtian				Early Campanian					Camp.

Region	Southwestern Transverse Ranges												
Area	Santa Barbara				Wheeler Gorge				Simi Hills				
Unit	Jalama Formation				Jalama(?) Formation				Chatsworth Formation				
Locality no.	CP-626	CP-625	Mean of 2	Std. dev.	WH-517	WH-518	Mean of 2	Std. dev.	157	OM-630	SS-413	Mean of 3	Std. dev.
Chert	-	-	-	-	-	0.3	0.2	0.2	4.5	0.9	0.3	1.9	2.3
Mudstone	-	0.9	0.4	0.6	1.0	1.8	1.4	.6	7.2	2.3	1.4	3.6	3.1
Quartz sandstone	26.3	40.6	33.5	10.1	9.5	37.0	23.2	19.4	27.8	49.9	37.8	38.4	11.1
Other sandstone	2.8	4.3	3.5	1.1	3.9	2.7	3.3	.8	3.3	4.9	1.1	3.1	1.9
Vein quartz	-	-	-	-	1.6	1.2	1.4	.3	-	.6	-	.2	.3
Felsic volcanic rocks	58.5	34.6	46.6	16.9	49.8	19.3	34.6	21.6	43.0	14.9	10.6	22.8	17.6
Other volcanic rocks	.3	.6	.4	.2	.7	-	.3	.5	3.3	.6	-	1.1	1.9
Granitic rocks	11.3	18.4	14.9	5.0	32.8	36.7	34.8	9.6	8.1	20.6	42.6	23.8	17.5
Other	.8	.6	.7	.1	.7	.9	.8	.1	3.0	6.2	6.2	5.1	1.8
Total	100.0	100.0	100.0		100.0	99.9	100.0		100.2	100.1	100.0	100.0	
Pebbles counted	354	347	351		305	332	319		335	349	357	347	
Q	27	43	35	11	10	40	25	21	32	58	42	44	13
I	73	57	65	11	90	60	75	21	63	41	58	54	12
C	0	0	0	0	0	0	0	0	5	1	0	2	3
Q	27	43	35	11	10	40	25	21	34	58	41	44	12
V	61	37	49	17	55	21	38	24	56	18	12	29	24
G	12	20	16	6	35	39	37	3	10	24	47	27	19
Age	Late Cretaceous				Late Campanian to Maestrichtian				Campanian to Maestrichtian				

Region	Southwestern Transverse Ranges--con.								E. Transverse Ranges	
Area	Santa Monica Mountains								Liebre Mtn. block	Cajon Pass
Unit	Tuna Canyon Fm., middle part					Tuna Canyon Fm.			San Francisquito Fm.	
Locality	TG-419	TG-370	TP-394	TG 377	TG-515	HW-552	Mean of 6	Std. dev.	WM-450	CJ-498
Chert	2.4	0.3	0.8	0.3	-	5.9	1.6	2.3	-	-
Mudstone	2.1	.5	1.9	.8	0.3	7.0	2.1	2.5	-	-
Quartz sandstone	23.2	40.0	33.5	16.7	27.6	26.6	27.9	8.1	12.4	27.7
Other sandstone	4.2	1.4	5.8	3.9	1.8	.8	3.0	1.9	2.4	1.5
Vein quartz	2.6	1.1	1.9	1.6	2.4	.8	1.7	.7	25.6	2.6
Felsic volcanic rocks	53.0	47.0	52.5	69.8	61.5	33.3	52.9	12.5	.3	3.3
Other volcanic rocks	-	.3	-	-	-	-	.1	.1	-	.7
Granitic rocks	8.4	5.7	3.0	5.5	5.6	16.9	7.5	4.9	59.1	63.1
Other	4.0	3.8	.5	1.6	.9	8.6	3.2	3.0	.3	1.1
Total	99.9	100.1	99.9	100.0	100.1	99.9	100.0		100.1	100.0
Pebbles counted	379	370	364	381	340	372	368		340	274
Q	27	43	37	18	29	32	31	9	17	29
I	70	57	62	82	71	61	67	9	83	71
C	3	0	1	0	0	7	2	3	0	0
Q	27	43	38	18	29	35	32	9	17	29
V	63	51	59	76	65	43	59	11	0	4
G	10	6	3	6	6	22	9	7	83	67
Age	Coniacian to Campanian								Maest.	Cret.(?)

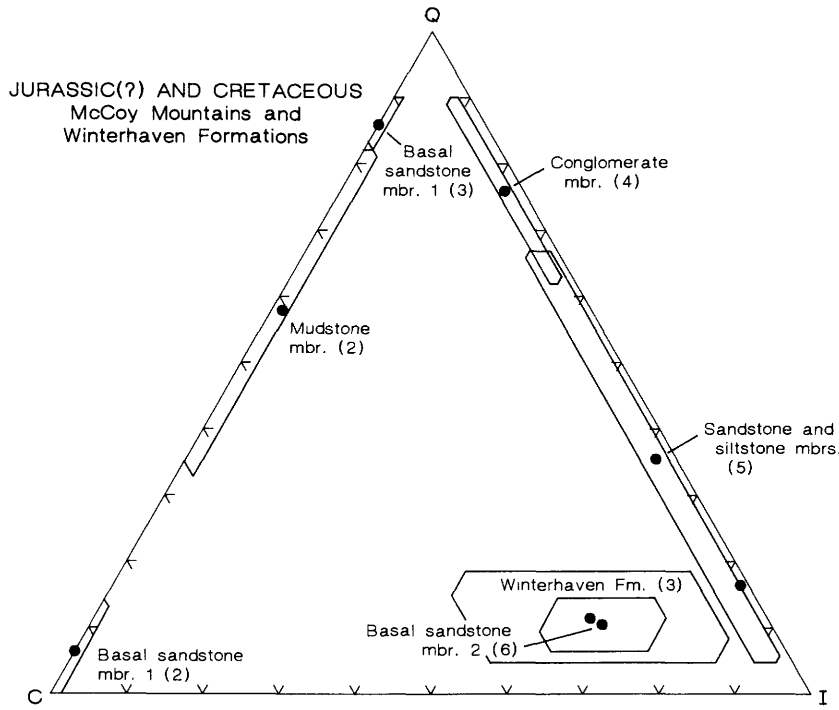

FIGURE 11.—QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Jurassic(?) and Cretaceous conglomerate suites (25 conglomerates) from the Winterhaven Formation and from informal members of the McCoy Mountains Formation of Harding and Coney (1985). See table 3 for pebble counts. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert.

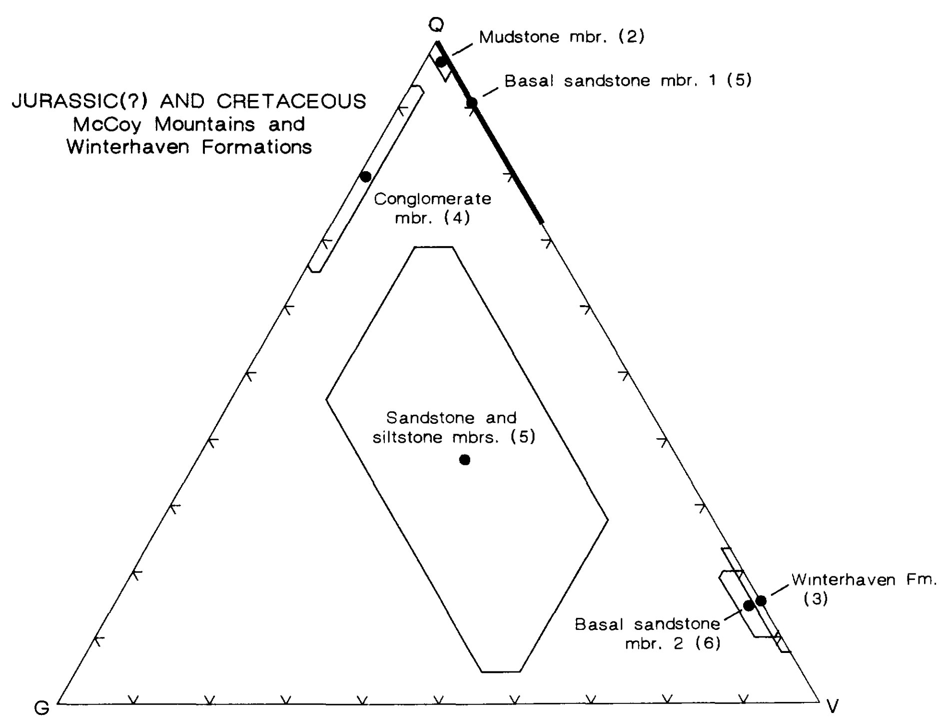

FIGURE 12.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Jurassic(?) and Cretaceous conglomerate suites (25 conglomerates) from the Winterhaven Formation and from informal members of the McCoy Mountains Formation of Harding and Coney (1985). See table 3 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

TABLE 3.—*Pebble counts, in percent, from the McCoy Mountains and Winterhaven Formations*

[C=chert, G=granitic rocks, I=volcanic and granitic rocks, Q=quartz sandstone, V=volcanic rocks, -= not present CX=Coxcomb Mountains; DR=Dome Rock Mountains; GW=Granite Wash Mountains; LH=Little Harquahala Mountains; Mc=McCoy Mountains; NW=New Water Mountains; PA=Palen Mountains; PC=Picacho area; SP=Southern Pomosa Mountains. *In MP- 253, 48 fragments of intraformational sandstone were excluded].

Unit	McCoy Mountains Formation												
Subunit	Siltstone and sandstone members							Conglomerate member					
Mountain Range	Mc	Mc	Mc	Mc	DR			Mc	Mc	Mc	Mc		
Locality	MP-251	MP-253	MC-225	RO-231	CU-234	Mean of 5	Std. dev.	MS-249	MS-250	MS-229	MS-252	Mean of 4	Std. dev.
Chert	1.6	2.6	1.4	5.5	1.7	2.6	1.7	3.9	0.8	2.0	4.3	2.7	1.6
Mudstone	-	-	-	-	.7	.1	.3	-	.3	-	-	.1	.1
Quartz sandstone	27.2	75.6	8.5	42.8	7.7	32.4	28.2	77.4	54.2	87.3	80.4	74.8	14.4
Other sandstone	.8	2.6*	1.7	3.2	1.0	1.9	1.0	2.0	3.0	.3	.8	1.5	1.2
Vein quartz	1.9	.3	1.1	1.7	.3	1.1	.8	-	1.1	.3	.3	.4	.5
Felsic volcanic rocks	23.7	4.2	55.8	23.6	49.8	31.4	21.2	.3	.5	.3	1.6	.7	.6
Other volcanic rocks	-	-	.3	-	-	.1	.1	.3	-	-	-	.1	.1
Granitic rocks	40.3	9.0	26.8	16.1	36.8	25.8	13.3	15.4	38.8	9.6	11.8	18.9	13.5
Limestone	-	4.8	-	-	-	1.0	2.1	-	-	-	-	-	-
Other	4.4	1.0	4.3	7.2	2.0	3.8	2.6	.7	1.4	.3	.8	.8	.5
Total	99.9	100.1	99.9	100.1	100.0	100.2		100.0	100.1	100.0	100.0	100.0	
Pebbles counted	367	311	351	348	299	335		305	369	354	373	350	
Q	29	83	9	49	8	36	31	79	57	88	82	76	14
I	69	14	89	45	90	61	32	17	42	10	14	21	14
C	2	3	1	6	2	3	2	4	1	2	4	3	1
Q	30	85	9	52	8	37	32	83	58	90	86	79	14
V	26	5	62	29	53	35	23	1	1	0	2	1	1
G	44	10	29	19	39	28	14	16	41	10	12	20	14

Unit	McCoy Mountains Formation--con.											
Subunit	Mudstone member				Basal sandstone member 2							
Mountain range	Mc	Mc			CX	Mc	Mc	Mc	NW	GW		
Locality	AR-247	AR-248	Mean of 2	Std. dev.	CX-226	AM-154	AR-246	AM-155	VK-236	UT-239	Mean of 6	Std. dev.
Chert	23.6	58.3	40.9	24.5	6.8	26.8	17.4	28.0	28.3	11.7	19.8	9.3
Mudstone	-	-	-	-	.3	-	-	-	-	6.4	1.1	2.6
Quartz sandstone	75.9	39.6	57.8	25.7	10.8	12.5	11.3	10.4	3.9	13.8	10.5	3.4
Other sandstone	-	-	-	-	.9	1.5	5.5	1.0	.3	2.1	1.9	2.6
Vein quartz	-	-	-	-	.9	-	.8	.5	.3	1.1	.6	.4
Felsic volcanic rocks	.5	1.6	1.1	.8	75.2	55.1	57.5	53.4	63.3	48.2	58.8	9.4
Other volcanic rocks	-	-	-	-	1.9	-	-	-	.6	3.2	.9	1.3
Granitic rocks	-	.3	.1	.2	.3	.4	.3	.8	1.2	3.9	1.2	1.4
Limestone	-	-	-	-	.3	-	-	-	-	-	.0	.1
Other	-.3	.1	.2	2.5	3.7	7.2	6.0	2.1	9.6	5.2	2.9	
Total	100.0	100.1	100.0		99.9	100.0	100.0	100.1	100.0	100.0	100.0	
Pebbles counted	406	384	395		323	463	362	386	332	282	358	
Q	76	40	58	25	12	13	13	11	4	17	11	4
I	0	2	1	1	81	59	67	59	67	68	67	8
C	24	58	41	24	7	29	20	30	29	15	22	9
Q	99	95	97	3	12	18	16	16	6	20	15	5
V	1	4	2	2	87	81	83	83	92	74	83	6
G	0	1	1	1	1	1	1	1	2	6	2	2

Unit	McCoy Mountains Formation--con.									Winterhaven Formation				
Subunit	Basal sandstone member 1									Basal part	Lower part	Upper part		
Mountain Range	PA	SP			Mc	LH	LH			PC	PC	PC		
Locality	PM-227	QZ-235	Mean of 2	Std. dev.	AR-230	HO-238	HO-237	Mean of 3	Std. dev.	PS-240	PS-242	PS-241	Mean of 3	Std. dev.
Chert	92.6	87.9	90.3	3.3	15.1	9.0	17.3	13.8	4.3	5.9	16.9	38.5	20.4	16.6
Mudstone	-	-	-	-	.6	-	-	.2	.3	3.3	.4	.5	1.4	1.6
Quartz sandstone	1.3	11.8	6.5	7.4	81.3	87.9	80.9	83.4	3.9	5.6	16.5	10.1	10.7	5.5
Other sandstone	-	-	-	-	2.4	.3	-	.9	1.3	1.6	.4	.3	.8	.7
Vein quartz	.6	-	.3	.4	.3	.3	1.5	.7	.7	-	.4	.3	.2	.2
Felsic volcanics	1.0	-	.5	.7	-	.6	-	.2	.4	77.5	52.3	41.5	57.1	18.5
Other volcanics	-	-	-	-	-	-	-	-	-	-	2.5	2.7	1.7	1.5
Granitic rocks	-	-	-	-	-	-	-	-	-	.3	-	.3	.2	.2
Limestone	1.9	-	1.0	1.3	-	-	-	-	-	-	-	-	-	-
Other	2.6	.3	1.4	1.6	.3	2.0	.3	.9	1.0	5.9	10.5	5.7	7.4	2.7
Total	100.0	100.0	100.0		100.0	100.1	100.0	100.1		100.1	99.9	99.9	99.9	
Pebbles counted	312	338	325		332	354	341	342		306	237	366	303	
Q	1	12	7	8	84	90	82	86	4	6	19	11	12	7
I	1	0	0	1	0	1	0	0	1	87	62	48	65	20
C	98	88	93	7	16	9	18	14	5	7	19	41	23	17
Q	57	100	79	30	100	99	100	100	1	7	23	19	16	8
V	43	0	21	30	0	1	0	0	1	93	77	80	84	9
G	0	0	0	0	0	0	0	0	0	0	0	1	0	1

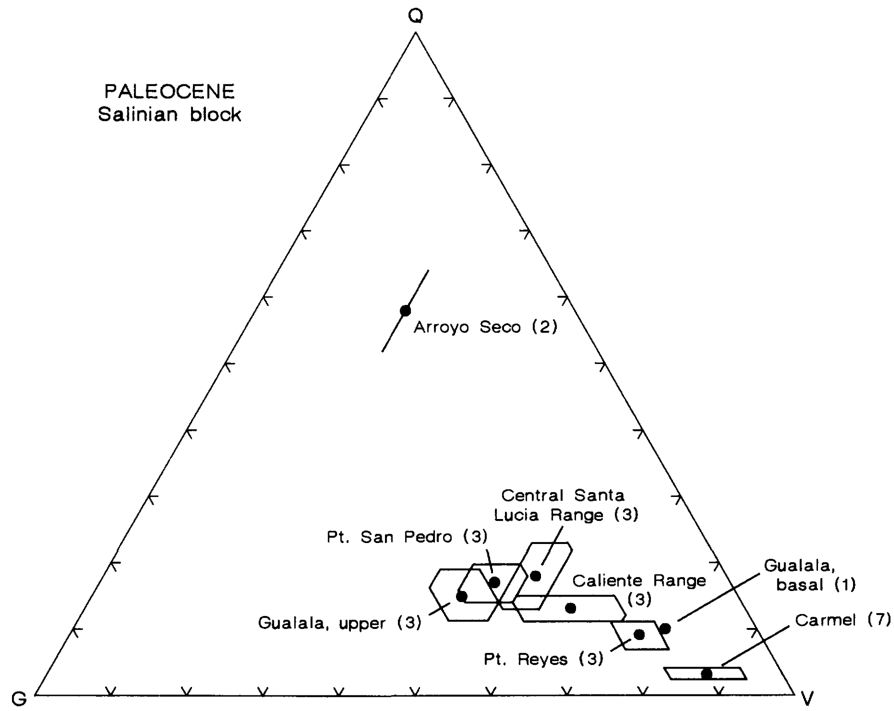

FIGURE 13.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Paleocene conglomerate suites (25 conglomerates) from the Salinian block. See table 4 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

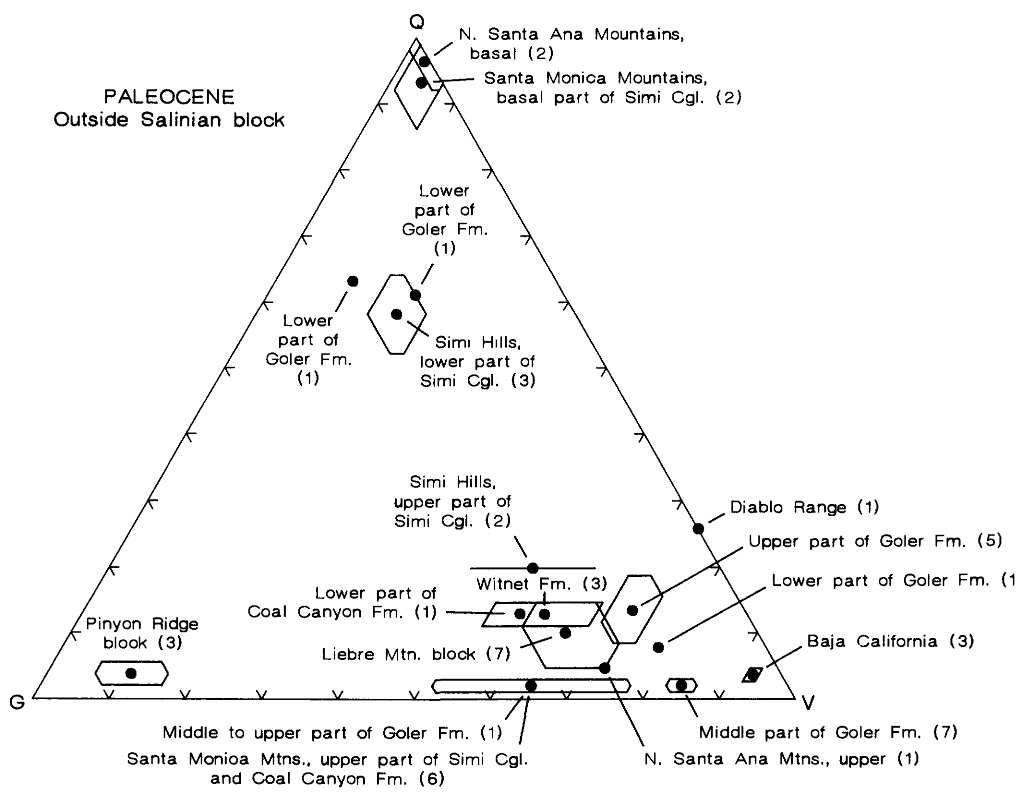

FIGURE 14.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Paleocene conglomerate suites (51 conglomerates) from outside the Salinian block. See table 5 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

TABLE 4.—*Pebble counts, in percent, of Paleocene conglomerates from the Salinian block*

[C=chert, G=granitic rocks, I=volcanic and granitic rocks, Q=quartz sandstone, V=volcanic rocks, -=not present].

Area	Gualala						Point Reyes				
Unit	German Rancho Formation						Point Reyes Conglomerate				
Stratigraphic position	Basal part	Lower part					Near base				
Locality	SP-339	SP-342	SP-340	SP-341	Mean of 3	Std. dev.	BW-89-1	BW-90-2	BW-91-1	Mean of 3	Std. dev.
Chert	0.6	3.5	2.7	3.6	3.3	0.5	2.0	0.5	2.0	1.5	0.9
Mudstone	1.7	3.5	5.2	8.1	5.6	2.3	.6	.5	1.1	.7	.3
Quartz sandstone	9.4	16.0	8.7	12.4	12.4	3.6	9.6	8.9	6.7	8.4	1.5
Other sandstone	.6	2.0	.5	3.3	1.9	1.4	.6	.3	-	.3	.3
Vein quartz	.8	1.2	4.6	3.3	3.0	1.7	5.6	2.2	3.4	3.7	1.7
Felsic volcanic rocks	74.2	37.2	41.8	42.7	40.6	2.9	64.6	69.6	74.5	69.6	4.9
Other volcanic rocks	.6	.6	-	-	.2	.3	-	.3	-	.1	.2
Granitic rocks	11.7	31.1	32.5	24.4	29.3	4.3	14.9	17.1	11.2	14.4	3.0
Other	.6	4.9	3.8	2.3	3.7	1.3	2.2	.5	1.1	1.3	.9
Total	100.2	100.0	99.8	100.1	100.0		100.1	99.9	100.0	100.0	
Pebbles counted	360	344	366	307	339		356	369	357	361	
Q	10	18	10	15	14	4	11	9	7	9	2
I	89	78	87	81	82	5	87	90	91	89	2
C	1	4	3	4	4	1	2	1	2	2	1
Q	10	19	11	15	15	4	11	9	7	9	2
V	78	44	50	54	49	5	72	73	81	75	5
G	12	37	39	31	36	4	17	18	12	16	3

Area	Point San Pedro					Carmel								
Unit	Unnamed strata					Carmelo Formation								
Locality	MM-497	BW-84-1A	BP-73-1D	Mean of 3	Std. dev.	BW-149-1	BW-148-2	BW-135-2	BW-134-1	BW-133-2	BW-133-1	BW-147-1	Mean of 7	Std. dev.
Chert	0.6	2.6	2.8	2.0	1.2	0.3	0.5	0.5	0.5	1.1	0.5	.08	0.6	0.3
Mudstone	9.5	5.7	5.7	7.0	2.2	.5	.8	2.3	2.9	3.5	.3	.5	1.5	1.3
Quartz sandstone	11.7	14.5	16.4	14.2	2.4	3.5	3.5	3.4	3.9	2.1	4.1	1.6	3.2	.9
Other sandstone	.8	.9	.8	.8	.1	.3	.3	.3	1.1	.3	.3	.3	.4	.3
Vein quartz	.6	5.4	4.2	3.4	2.5	.3	.3	.5	.8	.3	2.5	3.2	1.1	1.2
Felsic volcanic rocks	45.1	37.6	45.0	42.6	4.3	84.0	72.9	82.7	79.3	88.0	82.5	89.0	82.6	5.4
Other volcanic rocks	-	-	.6	.2	.3	-	-	-	.3	-	-	.5	.1	.2
Granitic rocks	28.7	27.9	20.4	25.7	4.6	10.7	20.5	10.1	10.4	4.5	9.3	3.8	9.9	5.5
Other	3.1	5.4	4.0	4.2	1.2	.5	1.3	.3	1.0	.3	.5	.3	.6	.4
Total	100.1	100.0	99.9	100.1		100.1	100.1	100.1	100.2	100.1	100.0	100.0	100.0	
Pebbles counted	359	351	353	354		375	376	387	1151	376	366	372	485	
Q	13	18	19	17	3	4	4	4	4	2	4	2	3	1
I	86	79	78	81	4	96	96	96	95	97	95	97	96	1
C	1	3	3	2	1	0	0	0	1	1	1	1	1	1
Q	14	18	20	17	3	3	4	4	4	2	4	2	3	1
V	53	47	55	52	4	86	75	86	85	93	86	94	87	6
G	33	35	25	31	5	11	21	10	11	5	10	4	10	5

Area	Arroyo Seco				Central Santa Lucia Range					Caliente Range				
Unit	Unnamed strata				Unnamed strata					Pattiway Formation				
Locality	TS-457	JS-473	Mean of 2	Std. dev.	AD-562	AD-594	AD-634	Mean of 3	Std. dev.	CU-520	CU-519	CU-560	Mean of 3	Std. dev.
Chert	-	-	-	-	0.3	-	-	0.1	0.2	-	0.3	0.3	0.2	0.2
Mudstone	0.8	-	0.4	0.6	.3	0.6	1.2	.7	.5	-	.3	.6	.3	.3
Quartz sandstone	51.3	59.4	55.4	5.7	18.5	22.1	11.9	17.5	5.2	14.2	11.7	13.0	13.0	1.2
Other sandstone	.8	1.7	1.2	.6	1.0	1.4	3.5	2.0	1.3	1.1	1.1	.3	.8	.5
Vein quartz	2.9	1.9	2.4	.7	1.0	1.4	-	.8	.7	1.1	2.6	.8	1.5	1.0
Felsic volcanic rocks	19.1	19.4	19.3	.2	57.4	53.9	49.9	53.7	3.7	51.4	63.3	65.0	59.9	7.4
Other volcanic rocks	-	-	-	-	-	-	1.2	.4	.7	1.1	2.8	.3	1.4	1.3
Granitic rocks	24.6	16.7	20.7	5.6	20.6	20.1	31.3	24.0	6.0	29.8	17.7	19.2	22.2	6.6
Other	.5	.8	.6	.2	1.0	.6	1.2	.9	.3	1.1	.3	.6	.7	.4
Total	100.0	99.9	100.0		100.1	100.1	100.2	100.1		99.8	100.0	100.1	100.0	
Pebbles counted	382	360	371		394	358	345	366		352	351	354	352	
Q	54	62	58	6	19	23	13	18	5	15	12	13	13	2
I	46	38	42	6	81	77	87	82	5	85	88	87	87	2
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q	54	62	58	6	19	23	13	18	5	15	12	13	13	2
V	20	20	20	0	60	56	54	57	3	54	69	67	64	8
G	26	18	22	6	21	21	33	25	7	31	19	20	23	7

TABLE 5.—*Pebble counts, in percent, of Paleocene conglomerates outside the Salinian block*

[C=chert, G=granitic rocks, I=volcanic and granitic rocks, Q=quartzite, V=volcanic rocks, -=not present].

Region	Diablo Range	Peninsular Ranges									
Area		Northern Santa Ana Mountains					Cabo Colonet		El Rosario		
Unit	Maganos Fm.	Silverado Formation					Sepultura Formation				
Stratigraphic level		Basal part				Upper part					
Locality	AS-621	ET-417	ET-418	Mean of 2	Std. dev.	BS-416	BJ-577	BJ-576	BJ-575	Mean of 3	Std. dev.
Chert	41.8	16.3	29.4	22.9	9.3	-	2.6	4.4	3.6	3.5	0.9
Mudstone	4.2	19.5	16.6	18.0	2.1	0.3	2.0	.9	5.6	3.8	1.8
Quartz sandstone	19.8	44.4	33.4	38.9	7.8	4.5	3.4	3.9	2.2	3.2	.9
Other sandstone	.8	8.9	6.3	12.6	5.2	.9	2.0	7.2	10.8	6.7	4.4
Vein quartz	24.0	4.1	.8	2.5	2.3	.6	-	-	-	-	-
Felsic volcanic rocks	7.0	.3	2.1	.2	1.2	69.9	73.4	67.8	61.7	67.6	5.9
Other volcanic rocks	-	-	-	-	-	-	10.3	7.	9.2	8.9	1.6
Granitic rocks	-	-	.5	.2	.4	23.0	3.4	2.2	4.7	3.4	1.2
Other	2.5	6.5	.8	3.7	4.0	.9	2.9	3.3	2.2	2.8	.6
Total	100.1	100.0	99.9	100.0		100.1	100.0	99.9	100.0	99.9	
Pebbles counted	359	369	374	372		352	349	360	360	356	
Q	29	73	51	62	16	5	4	5	3	4	1
I	10	0	4	2	3	95	93	90	93	92	2
C	61	27	45	36	13	0	3	5	4	4	1
Q	74	99	93	96	4	5	4	5	3	4	1
V	26	1	6	3	4	72	92	92	91	92	1
G	0	0	1	1	1	23	4	3	6	4	2

Region	Southwestern Transverse Ranges												
Area	Simi Hills									Santa Monica Mountains			
Unit	Simi Conglomerate					Simi Conglomerate				Simi Conglomerate			
Stratigraphic level	Lower part					Upper part				Basal part			
Locality	SS-415	CB-536	SS-620	Mean of 3	Std. dev.	SS-414	CB-537	Mean of 2	Std. dev.	PD-550	HW-551	Mean of 2	Std. dev.
Chert	0.8	0.6	-	0.5	0.4	0.3	0.6	0.4	0.2	0.9	-	0.4	0.6
Mudstone	1.1	2.8	-	1.3	1.4	-	-	-	-	-	0.3	.2	.2
Quartz sandstone	57.8	49.6	49.6	52.3	4.7	18.9	18.9	18.9	.0	96.0	85.1	90.5	7.7
Other sandstone	1.7	6.8	.6	3.0	3.3	2.5	2.9	2.7	.3	-	2.5	1.3	1.8
Vein quartz	-	-	-	-	-	.8	.9	.8	.1	.3	.3	.3	.0
Felsic volcanic rocks	17.0	12.0	21.1	16.7	4.6	56.9	45.8	51.4	7.8	2.0	6.1	4.0	2.9
Other volcanic rocks	.3	1.1	.6	.7	.4	-	-	-	-	-	-	-	-
Granitic rocks	19.3	22.2	26.5	22.7	3.6	18.6	28.4	23.5	6.9	-	5.2	2.6	3.7
Other	2.0	4.8	1.7	2.8	1.7	2.0	2.6	2.3	.4	.9	.6	.8	.2
Total	100.0	99.9	100.1	100.0		100.0	100.1	100.0		100.1	100.1	100.1	
Pebbles counted	353	351	355	353		355	349	352		352	363	358	
Q	61	58	51	57	5	20	20	20	0	97	88	93	6
I	38	41	49	43	6	80	79	79	1	2	12	7	7
C	1	1	0	0	1	0	1	1	1	1	0	0	1
Q	62	59	51	58	6	20	20	20	0	98	88	93	7
V	18	15	22	18	4	60	49	55	8	2	6	4	3
G	20	26	27	24	4	20	31	25	8	0	6	3	4

Region	Southwestern Transverse Ranges--con.									Southernmost Sierra Nevada				
Area	Santa Monica Mountains--con.						Gold Cr.							
Unit	Coal Canyon Fm.	Simi Conglomerate and Coal Canyon Formation					Unnamed strata			Witnet Formation				
Stratigraphic level	Lower part	All except lower part												
Locality no.	MB-396	TG-516	TP-395	TP-378	BH 554	HW 553	SU-555	Mean of 6	Std. dev.	BW-75-1A	TC-614	TC-615	Mean of 3	Std. dev.
Chert	0.3	-	-	0.3	-	-	-	0.1	0.1	3.5	3.3	2.1	3.0	0.8
Mudstone	-	-	-	-	-	-	6	1.0	2.4	2.1	1.9	2.1	2.0	.1
Quartz sandstone	12.9	1.9	1.8	1.1	1.9	2.2	3	2.0	.6	9.4	2.4	12.6	11.5	1.8
Other sandstone	2.9	.3	.3	1.1	1.0	-	1	.6	.5	.9	.8	1.6	1.1	.4
Vein quartz	-	.3	.9	.6	-	1.9	-	.6	.7	.6	1.7	.8	1.0	.6
Felsic volcanic rocks	53.4	78.9	48.2	62.0	69.0	62.8	46	61.2	12.5	47.6	55.9	59.2	54.2	6.0
Other volcanic rocks	1.1	3.3	.6	.3	-	-	-	.7	1.3	-	1.9	.3	.7	1.0
Granitic rocks	28.9	14.2	46.6	33.2	26.5	32.8	43	32.7	11.7	33.5	19.8	19.6	24.3	8.0
Other	.5	1.1	1.5	1.4	1.3	.3	1	1.1	.4	2.4	2.2	1.6	2.1	.4
Total	100.0	100.0	99.9	100.0	100.0	100.0	100	100.0		100.0	99.9	99.9	99.9	
Pebbles counted	380	360	326	355	309	360	100	302		340	363	373	359	
Q	13	2	2	1	2	2	3	2	1	10	13	14	12	2
I	87	98	98	99	98	98	97	98	1	86	83	84	85	2
C	0	0	0	0	0	0	0	0	0	4	4	2	3	1
Q	13	2	2	1	2	2	3	2	1	10	14	14	13	2
V	57	84	50	65	71	64	50	64	13	53	64	65	60	7
G	30	14	48	34	27	34	47	34	13	37	22	21	27	9

TABLE 5.—*Pebble counts, in percent, of Paleocene conglomerates outside the Salinian block*—Continued

Region	Southernmost Sierra Nevada--con.												
Unit	Goler Formation												
Stratigraphic level	Lower part			Middle part									Middle-upper part
Locality	SD-617	SD-618	SD-619	GK-616	BW-104-2	BW-105-1	BX-136-1	BX-136-2	BX-136-3	BX-136-4	Mean of 7	Std. dev.	BX-136-6
Chert	8.5	13.6	24.2	0.3	0.3	0.3	-	1.5	1.1	0.8	0.6	0.5	0.3
Mudstone	11.3	8.6	40.6	3.1	.3	.3	-	2.0	.3	.5	.9	1.2	-
Quartz sandstone	45.1	5.3	13.9	3.3	1.1	2.2	1.4	4.1	3.3	2.1	2.5	1.1	2.2
Other sandstone	1.4	2.8	.6	-	1.7	.3	-	.3	-	.8	.4	.6	.5
Vein quartz	.6	.8	1.9	-	-	-	-	-	-	-	-	-	-
Felsic volcanic rocks	13.5	47.2	1.9	73.3	77.3	82.6	81.6	75.1	79.5	79.5	78.4	3.4	59.3
Other volcanic rocks	.8	6.4	.3	7.2	1.4	1.4	2.8	1.2	2.7	4.8	3.1	2.2	3.6
Granitic rocks	14.9	9.4	5.8	11.7	17.4	12.4	14.2	15.2	12.6	11.2	13.5	2.2	34.1
Other	3.9	5.8	10.8	1.1	.6	.6	-	.6	.5	.3	.5	.3	-
Total	100.0	99.9	100.0	100.0	100.1	100.1	100.0	100.0	100.0	100.0	99.9		100.0
Pebbles counted	355	360	360	360	357	362	353	342	366	376	359		364
Q	55	6	30	4	1	2	1	4	3	2	2	1	2
I	35	77	18	96	99	98	99	94	98	97	97	2	98
C	10	17	52	0	0	0	0	2	1	1	1	1	0
Q	61	8	63	4	1	2	1	4	3	2	2	1	2
V	19	78	10	84	81	85	85	80	84	86	84	2	64
G	20	14	27	12	18	13	14	16	13	12	14	2	34

Region	Southernmost Sierra Nevada--con.							Liebre Mountain block								
Unit	Goler Formation--con.							San Francisquito Formation								
Stratigraphic level	Upper part															
Locality	BX-136-5	BX-137-1	BX-137-2	BX-137-3	BX-137-4	Mean of 5	Std. dev.	WP-464	WM-465	WM-449	WM-451	WM-448	GV-469	GV-468	Mean of 7	Std. dev.
Chert	0.3	-	-	0.3	-	0.1	0.2	-	-	0.3	-	-	-	-	0.0	.1
Mudstone	1.4	0.3	2.0	-	-	.7	.9	-	-	.3	-	-	4.4	0.8	.8	1.6
Quartz sandstone	15.0	13.7	20.5	10.2	7.9	13.5	4.8	9.1	12.7	8.2	18.1	6.2	6.1	4.8	9.4	4.9
Other sandstone	.6	.8	.6	-	.3	.5	.3	1.8	1.1	1.4	.6	2.5	1.1	.5	1.3	.7
Vein quartz	-	-	-	-	-	-	-	.3	1.1	1.4	2.5	1.1	1.4	.5	1.2	.7
Felsic volcanic rocks	67.7	67.0	59.0	67.5	64.8	65.4	3.8	64.6	53.2	69.1	56.7	66.9	52.9	70.7	62.0	7.6
Other volcanic rocks	5.0	2.8	3.7	2.3	6.8	4.1	1.8	.6	-	-	.3	.3	.8	-	.3	.3
Granitic rocks	8.6	13.7	10.7	19.5	19.4	14.4	5.0	22.0	31.0	18.7	20.9	23.0	32.0	22.1	24.2	5.1
Limestone	.3	-	3.1	-	-	.7	1.4	-	-	-	-	-	-	-	-	-
Other	1.1	.8	.6	.3	.8	.7	.3	1.5	.8	.6	.9	.3	1.4	.5	.9	.4
Total	100.0	100.0	100.2	100.1	100.0	100.1		99.9	99.9	100.0	100.0	100.0	100.0	99.9	100.1	
Pebbles counted	359	358	356	354	355	356		328	355	353	321	356	362	376	350	
Q	16	14	22	10	8	14	5	9	13	9	19	6	7	5	10	5
I	84	86	78	90	92	86	5	91	87	91	81	94	93	95	90	5
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q	16	14	22	10	8	14	5	9	13	9	19	7	7	5	10	5
V	75	72	67	70	72	71	3	68	55	72	59	69	58	72	65	7
G	9	14	11	20	20	15	5	23	32	19	22	24	35	23	25	6

Area	Pinyon Ridge block				
Unit	San Francisquito Formation				
Locality	VY-557	VY-556	VY-470	Mean of 3	Std. dev.
Chert	-	0.3	-	0.1	0.2
Mudstone	1.2	.6	0.3	.7	.5
Quartz sandstone	2.1	3.1	3.7	3.0	.8
Other sandstone	.9	.9	1.4	1.1	.3
Vein quartz	7.9	8.0	9.1	8.3	.7
Felsic volcanics	7.9	4.6	10.5	7.7	3.0
Other volcanics	1.2	.9	1.1	1.1	.2
Granitic rocks	73.7	78.2	62.8	71.6	7.9
Other	5.1	3.4	11.1	6.5	4.0
Total	100.0	100.0	100.0	100.1	
Pebbles counted	331	326	352	336	
Q	2	4	5	4	2
I	98	96	95	96	2
C	0	0	0	0	0
Q	2	4	5	4	2
V	11	6	15	11	5
G	87	90	80	85	5

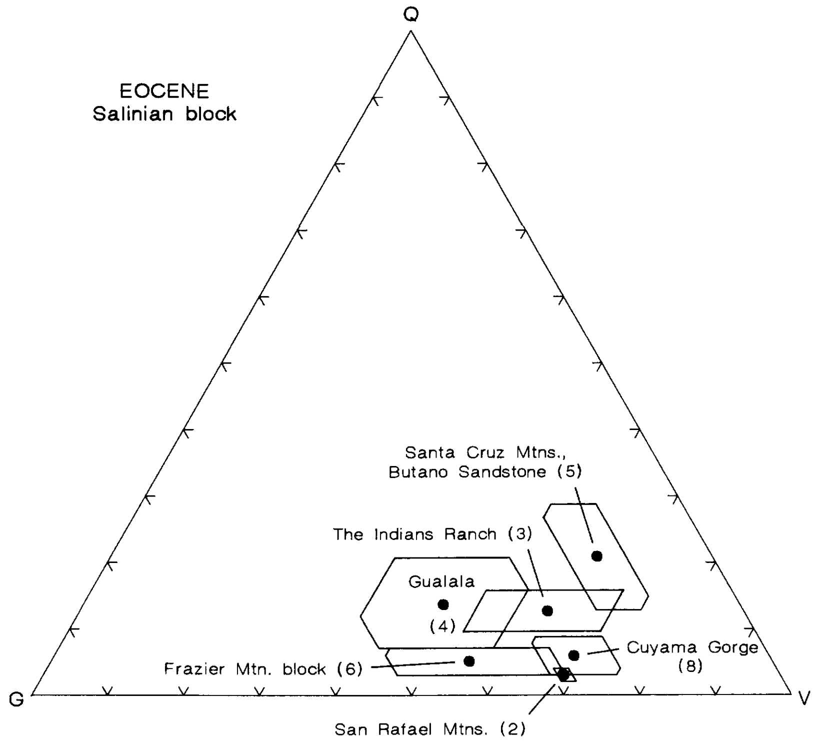

FIGURE 15.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Eocene conglomerate suites (28 conglomerates) from the Salinian block. See table 6 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

TABLE 6.—*Pebble counts, in percent, of Eocene conglomerates from the Salinian block and the Frazier Mountain block*

[C=chert, G=granitic rocks, I=igneous rocks, Q=quartz sandstone, V=volcanic rocks, -=not present. *Some granitic clasts were lost in collecting].

Area	Gualala						Santa Cruz Mountains						
Unit	German Rancho Formation						Butano Sandstone						
Locality	PL-407	PL-495	PL-408	PL-409	Mean of 4	Std. dev.	BP-80-1	BP-78-1D	FP-460	CR-488	FE-436	Mean of 5	Std. dev.
Chert	0.8	0.9	1.3	0.6	0.9	0.3	1.0	3.4	0.9	1.9	1.7	1.8	1.0
Mudstone	3.6	2.6	8.6	3.2	4.5	2.8	2.0	3.1	5.4	1.4	3.4	3.1	1.5
Quartz sandstone	12.9	22.0	8.9	6.1	12.8	6.9	30.7	21.7	12.7	12.4	17.8	19.1	7.6
Other sandstone	1.1	-	1.6	.6	.8	.7	.8	.3	.3	1.1	2.0	.9	.7
Vein quartz	5.0	2.6	2.1	1.9	2.9	1.4	2.0	.9	2.8	2.5	.6	1.8	1.0
Felsic volcanic rocks	53.8	37.4	38.4	34.9	41.1	8.6	48.6	49.6	60.4	69.7	56.8	57.0	8.6
Other volcanic rocks	-	-	.8	1.0	.5	.5	-	.6	-	-	-	.1	.3
Granitic rocks	21.8	31.7	36.6	48.4	34.6	11.1	13.3	18.5	16.5	8.0	16.1*	14.5*	4.1
Other	.8	2.9	1.8	3.2	2.2	1.1	1.5	2.0	.9	3.0	1.7	1.8	.8
Total	99.8	100.1	100.1	99.9	100.0		99.9	100.1	99.9	100.0	100.1	100.1	
Pebbles counted	357	350	383	312	350		391	351	316	363	354	355	
Q	14	24	10	7	14	7	33	23	14	14	19	21	8
I	85	75	88	92	85	7	66	73	85	84	79	77	8
C	1	1	2	1	1	1	1	4	1	2	2	2	1
Q	14	24	11	7	14	7	33	24	14	14	20	21	8
V	61	41	46	40	47	10	53	56	68	77	62	63	10
G	25	35	43	53	39	12	14	20	18	9	18	16	4
Age	Early or middle Eocene						Early and middle Eocene						

Area	The Indians Ranch					Cuyama River gorge									
Unit	Reliz Canyon Formation					Unnamed strata									
Locality	JS-458	CP-459	CP-433	Mean of 3	Std. dev.	LM-522	MP-561	MP-529	MP-527	MP-526	MP-525	MD-602	MD-603	Mean of 8	Std. dev.
Chert	0.3	0.3	0.6	0.4	0.2	-	0.3	-	-	-	-	0.3	-	0.1	0.1
Mudstone	.3	.3	-	.2	.2	2.2	-	1.1	0.3	-	-	-	-	.4	.8
Quartz sandstone	12.7	9.3	14.6	12.2	2.7	2.5	2.8	5.7	8.0	1.7	7.3	2.8	11.2	5.3	3.4
Other sandstone	.3	.3	2.2	.9	1.1	3.4	.8	3.1	1.7	.9	.8	.8	1.0	1.6	1.1
Vein quartz	4.9	4.1	4.5	4.5	.4	.3	.6	2.0	.9	1.1	.3	-	1.4	.8	.7
Felsic volcanic rocks	60.5	46.7	57.6	54.9	7.3	73.1	59.8	64.8	59.5	69.4	68.0	66.0	54.0	64.3	6.2
Other volcanic rocks	-	-	.6	.2	.3	.9	3.9	.9	1.4	2.3	1.7	.6	1.4	1.6	1.1
Granitic rocks	20.0	38.5	18.3	25.6	11.2	15.7	29.4	22.4	27.6	24.0	21.3	29.2	30.0	25.0	5.0
Other	1.1	.5	1.7	1.1	.6	1.9	2.5	-	.6	.6	.6	.3	1.0	.9	.8
Total	100.1	100.0	100.1	100.0		100.0	100.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Pebbles counted	370	366	356	364		324	361	352	351	350	356	356	420	359	
Q	14	10	16	13	3	3	3	6	8	2	7	3	12	6	3
I	86	90	83	86	4	97	97	94	92	98	93	97	88	94	3
C	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Q	14	10	16	13	3	3	3	6	8	2	7	3	12	6	3
V	65	49	64	60	9	80	66	70	63	73	71	67	57	68	7
G	21	41	20	27	12	17	31	24	29	25	22	30	31	26	5
Age	Middle Eocene					Early Eocene									

Area	San Rafael Mountains				Frazier Mountain block							
Unit	Unnamed strata				Juncal Formation							
Locality	MD-596	MD-595	Mean of 2	Std. dev.	LV-504	LV-505	LV-507	LV-506	LV-508	LV-509	Mean of 6	Std. dev.
Chert	-	-	-	-	0.3	-	-	-	-	-	0.0	0.1
Mudstone	-	-	-	-	.3	-	-	-	-	-	.0	.1
Quartz sandstone	2.3	3.7	3.0	1.0	5.3	2.5	5.1	9.2	2.2	4.5	4.8	2.5
Other sandstone	.3	.6	.4	.2	.6	.5	-	1.0	1.1	.6	.6	.4
Vein quartz	.3	.3	.3	.0	-	-	.3	1.0	.3	-	.3	.4
Felsic volcanic rocks	66.8	64.9	65.9	1.3	64.5	61.7	41.4	40.1	50.1	48.7	51.1	10.1
Other volcanic rocks	1.4	-	.7	1.0	5.8	3.0	1.1	.6	6.0	2.6	3.2	2.3
Granitic rocks	27.8	29.4	28.6	1.1	22.7	31.7	51.0	47.8	39.8	41.9	39.2	10.5
Other	1.1	1.1	1.1	.0	.6	.5	1.1	.3	.5	1.6	.8	.5
Total	100.0	100.0	100.0		100.1	99.9	100.0	100.0	100.0	99.9	100.0	
Pebbles counted	352	350	351		361	366	353	314	369	310	346	
Q	2	4	3	1	5	3	5	9	2	5	5	2
I	98	96	97	1	95	97	95	91	98	95	95	2
C	0	0	0	0	0	0	0	0	0	0	0	0
Q	2	4	3	1	5	3	5	9	2	5	5	2
V	70	66	68	3	72	65	43	42	57	52	55	12
G	28	30	29	1	23	32	52	49	41	43	40	11
Age	Early Eocene				Early or middle Eocene							

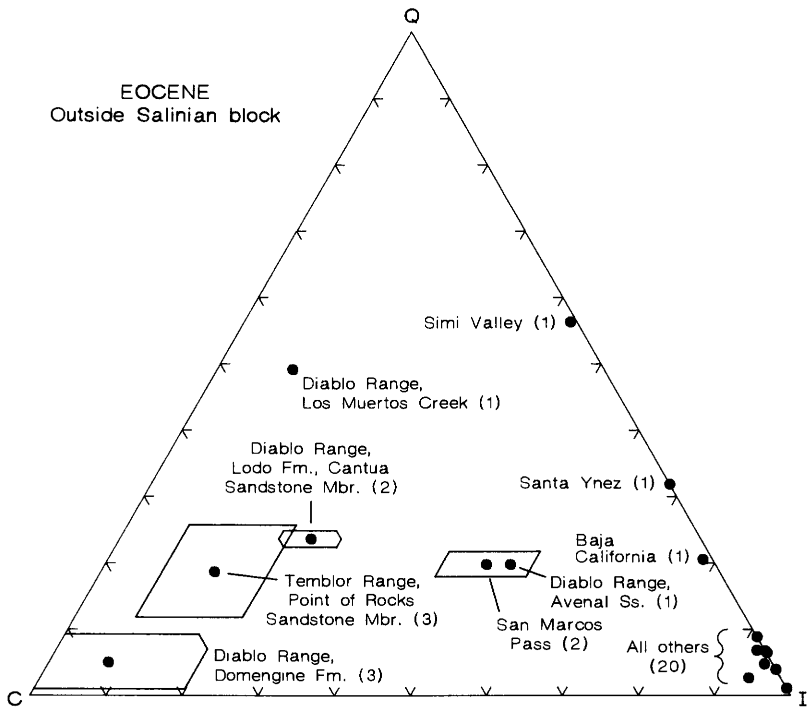

FIGURE 16.—QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Eocene conglomerate suites (35 conglomerates) from outside the Salinian block. See table 7 for pebble counts. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert.

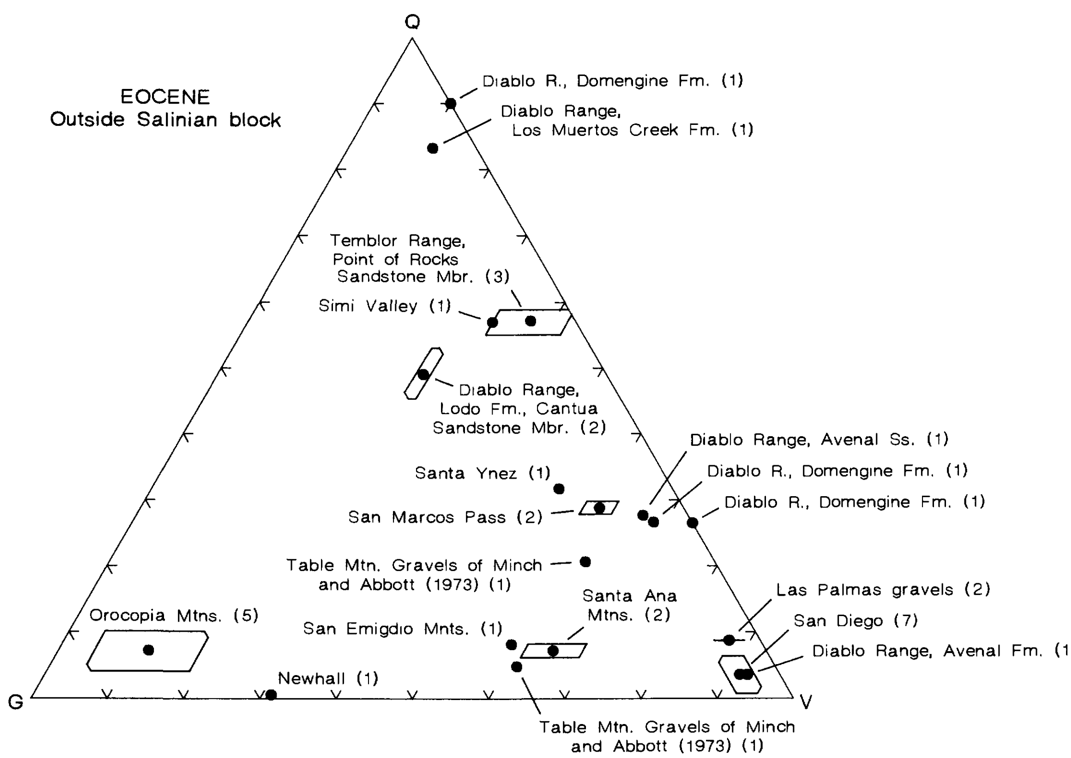

FIGURE 17.—QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Eocene conglomerate suites (35 conglomerates) from outside the Salinian block. See table 7 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

TABLE 7.—*Pebble counts, in percent, of Eocene conglomerates from outside the Salinian block*

[C=chert, G=granitic rocks, I= gneous rocks, Q=quartz sandstone, V=volcanic rocks, -=not present].

Region	Diablo Range											
Unit	Lodo Formation, Cantua Sandstone Member				Domengine Formation					Los Muertos Creek Fm.	Avenal Sandstone	
Locality	ID-476	ID-475	Mean of 2	Std. dev.	CL-622	PN-478	ID-477	Mean of 3	Std. dev.	GZ-479	TD-437	SR-444
Chert	28	34.4	31.2	4.5	63.6	90.7	65.6	73.3	15.1	24	23.9	3.2
Mudstone	32	24.6	28.3	5.2	2.2	1.1	27.8	10.4	15.1	29	1.6	.4
Quartz sandstone	14	14.9	14.5	.6	6.7	.8	5.1	4.2	3.1	29	18.2	3.2
Other sandstone	1	1.5	1.2	.4	.3	1.1	-	.5	.6	-	4.6	2.2
Vein quartz	3	4.6	3.8	1.1	7.0	.6	.3	2.7	3.7	8	1.9	2.5
Felsic volcanic rocks	8	8.2	8.1	.1	17.3	2.2	.6	6.7	9.2	4	42.6	78.8
Other volcanic rocks	-	-	-	-	-	-	-	-	-	-	-	1.4
Granitic rocks	8	6.2	7.1	1.3	1.3	-	-	.4	.8	2	4.0	4.0
Limestone	-	-	-	-	-	-	-	-	-	-	-	3.2
Other	6	5.6	5.8	.3	1.6	3.3	.6	1.8	1.4	4	3.2	1.1
Total	100	100.0	100.0		100.0	100.0	100.0	100.0		100	100.0	100.0
Pebbles counted	100	195	148		371	365	352	363		133	373	278
Q	24	23	24	1	8	1	7	5	4	49	20	3
I	28	23	25	4	21	2	1	8	11	10	53	93
C	48	54	51	4	71	97	92	87	14	41	27	4
Q	46	51	49	4	27	27	90	46	36	83	28	4
V	27	28	27	1	68	73	10	50	35	11	66	92
G	27	21	24	4	5	0	0	2	3	6	6	4
Age	Early Eocene				Early to middle Eocene					Early or middle Eocene		

Region	Temblor Range					Peninsular Ranges			
Area						Northern Santa Ana Mtns.			
Unit	Kreyenhagen Formation Point of Rocks Sandstone Mbr.					Santiago Formation			
Locality	PW-445	SP-467	CR-466	Mean of 3	Std. dev.	BS-565	BS-566	Mean of 2	Std. dev.
Chert	35.7	39.4	29.4	34.8	5.1	-	-	-	-
Mudstone	41.2	46.0	15.8	34.3	16.3	-	-	-	-
Quartz sandstone	10.4	6.1	15.0	10.5	4.5	5.5	8.2	6.8	1.9
Other sandstone	1.1	.2	.6	.6	.5	.9	.8	.9	.1
Vein quartz	2.2	2.6	19.5	8.1	9.9	.3	.8	.5	.4
Felsic volcanic rocks	6.6	4.4	8.5	6.5	2.1	60.2	62.2	61.2	1.3
Other volcanic rocks	.5	-	-	.2	.3	1.2	4.5	2.8	2.3
Granitic rocks	.5	.2	4.0	1.6	2.1	31.7	23.4	27.6	5.9
Limestone	.5	-	-	.2	.3	-	-	-	-
Other	1.1	1.1	7.3	3.2	3.6	.3	.3	.3	.0
Total	99.8	100.0	100.1	100.0		100.1	100.1	100.1	
Pebbles counted	364	459	354	392		347	380	363	
Q	20	12	26	19	7	6	8	7	1
I	14	9	22	15	7	94	92	93	1
C	66	79	52	66	14	0	0	0	0
Q	58	57	55	57	2	6	8	7	1
V	39	41	31	37	5	62	68	65	4
G	3	2	14	6	7	32	24	28	6
Age	Early to middle Eocene					Early or middle Eocene			

Region	Peninsular Ranges--con.								
Area	San Diego								
Unit	La Jolla and Poway Groups and Ballena Gravels								
Locality	DM-530	LJ-531	LM-533	LM-591	LM-532	VR-534	VR-535	Mean of 7	Std. dev.
Chert	-	0.3	-	0.3	-	-	0.3	0.1	0.2
Mudstone	0.3	-	-	-	-	-	.3	.1	.2
Quartz sandstone	2.3	3.3	5.6	1.7	4.2	9.6	1.1	4.0	3.0
Other sandstone	.9	.8	.6	-	.6	.6	1.1	.7	.4
Vein quartz	-	-	-	-	-	-	-	-	-
Felsic volcanic rocks	93.4	91.2	89.6	95.1	89.8	80.6	87.6	89.6	4.7
Other volcanic rocks	.3	-	.3	-	.8	1.1	-	.4	.4
Granitic rocks	2.8	3.9	3.7	2.3	4.5	7.0	7.9	4.6	2.1
Other	-	.6	.3	.6	-	.8	1.4	.5	.5
Total	100.0	100.1	100.1	100.0	99.9	99.9	99.9	100.0	
Pebbles counted	351	362	355	350	353	356	353	354	
Q	2	3	6	2	4	10	1	4	3
I	98	97	94	98	96	90	99	96	3
C	0	0	0	0	0	0	0	0	0
Q	2	3	6	2	4	10	1	4	3
V	95	93	90	96	91	83	91	91	4
G	3	4	4	2	5	7	8	5	2
Age	Early to late Eocene								

TABLE 7.—*Pebble counts, in percent, of Eocene conglomerates from outside the Salinian block*—Continued

Region	Peninsular Ranges--con.					
Area	Southernmost California and adjacent Baja California					
Unit	Las Palmas gravels				Table Mountain Gravels	
Locality	BJ-582	BJ-581	Mean of 2	Std. dev.	JC-584	BJ-583
Chert	0.3	0.3	0.3	.0	1	1
Mudstone	2.0	.3	1.1	1.2	-	1
Quartz sandstone	7.8	8.2	8.0	.3	5	20
Other sandstone	9.5	8.5	9.0	.7	-	9
Vein quartz	-	-	-	-	-	-
Felsic volcanics	75.9	75.4	75.7	.4	60	58
Other volcanics	1.7	1.5	1.6	.1	-	2
Granitic rocks	2.3	5.2	3.7	2.1	34	16
Other	.6	.6	.6	.0	-	3
Total	100.1	100.0	100.0		100	100
Pebbles counted	348	329	339		100	100
Q	9	9	9	0	5	21
I	91	91	91	0	94	78
C	0	0	0	0	1	1
Q	9	9	9	0	5	21
V	88	85	87	2	34	17
Age	Eocene(?)				Unknown	

Region	Southwestern Transverse Ranges--con.						
Area	San Marcos Pass				Santa Ynez	Simi Valley	Newhall
Unit	Cozy Dell Shale				Matilija Ss.	Llajas Fm.	Domengine Fm.
Locality	LC-623	LC-624	Mean of 2	Std. dev.	SY-538	SS-549	SF-631
Chert	33.0	23.4	28.2	6.8	-	1.1	-
Mudstone	1.1	1.2	1.1	.1	-	-	0.3
Quartz sandstone	18.6	20.8	19.7	1.6	31	54.3	.9
Other sandstone	.3	1.2	.8	.8	-	.3	-
Vein quartz	2.0	.6	1.3	1.0	1	.3	.6
Felsic volcanic rocks	37.2	42.5	39.8	3.7	51	29.3	23.6
Other volcanic rocks	.6	-	.3	.4	-	1.1	3.8
Granitic rocks	5.9	10.1	8.0	3.0	14	11.0	67.3
Other	1.4	.3	.8	.8	3	2.7	.9
Total	100.1	100.1	100.0		100	100.1	100.1
Pebbles counted	355	346	350		100	372	342
Q	19	22	20	2	32	56	1
I	46	54	50	6	68	43	99
C	35	24	30	8	0	1	0
Q	30	28	29	1	32	57	1
V	61	58	60	2	53	32	31
G	9	14	11	4	15	11	68
Age	Late Eocene				Eocene	Early Eocene	Middle Eocene

Region	San Emigdio Mtns.	Orocopia Mountains						
Unit	Tejon Fm.	Maniobra Formation						
Locality	ST-446	RC-500	RC-499	RC-502	RC-501	RC-503	Mean of 5	Std. dev.
Chert	1	-	-	1	-	-	0.2	0.4
Mudstone	2	-	-	-	-	-	-	-
Quartz sandstone	7	9	3.0	7	6.5	3.1	5.7	2.6
Other sandstone	1	2	-	1	.3	.3	.7	.8
Vein quartz	-	10	3.0	3	13.6	12.7	8.5	5.2
Felsic volcanic rocks	56	14	3.7	6	15.1	8.8	9.5	4.9
Other volcanic rocks	-	-	1.0	-	.6	.3	.4	.4
Granitic rocks	32	61	63.4	78	49.4	74.6	65.3	11.4
Limestone	-	3	24.6	1	1.4	-	6.0	10.5
Other	-	1	1.0	3	13.1	.3	3.7	5.4
Total	99	100	99.9	100	100.0	100.1	100.0	
Pebbles counted	84	100	298	100	352	354	241	
Q	7	11	4	8	9	4	7	3
I	92	89	96	91	91	96	93	3
C	1	0	0	1	0	0	0	0
Q	7	11	4	8	9	4	7	3
V	59	17	7	6	22	10	12	7
G	34	72	89	96	69	86	81	9
Age	Early Eocene	Early Eocene						

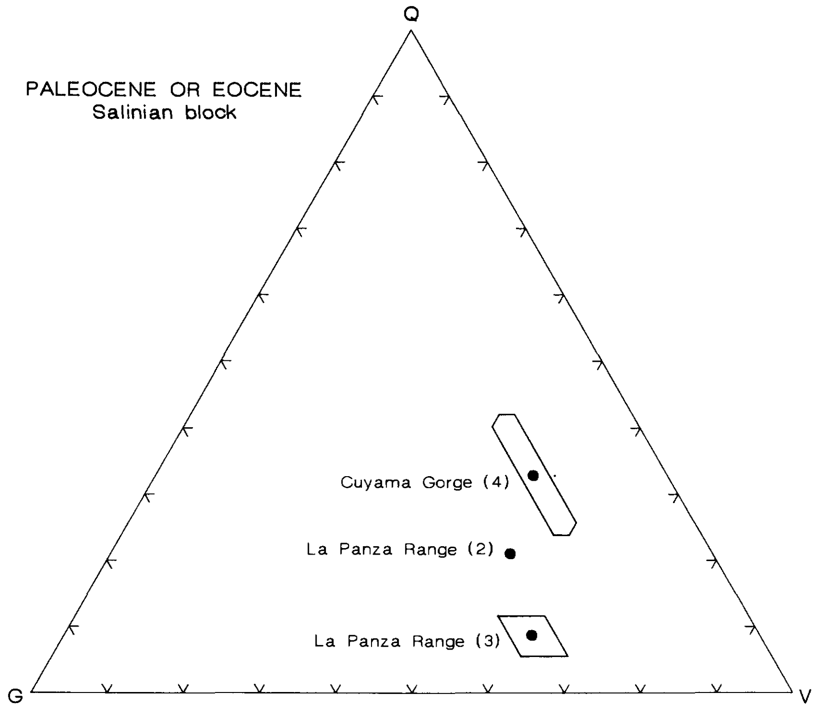

FIGURE 18.—QVQ diagram showing the mean compositions and dispersion fields at one standard deviation of conglomerate suites (9 conglomerates) of uncertain Tertiary (Paleocene or Eocene) age from the Salinian block. See table 8 for pebble counts. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

TABLE 8.—*Pebble counts, in percent, of conglomerates of uncertain Tertiary age (Paleocene or Eocene) from the Salinian block*

[C=chert, G=granitic rocks, I=igneous rocks, Q=quartz sandstone, V=volcanic rocks, -=not present].

Region	La Panza Range										
Unit	Unnamed strata										
Conglomerate type	Low quartz-sandstone					High quartz-sandstone				Both types	
Locality	PZ-539	SL-543	SL-542	Mean of 3	Std. dev.	SL-541	SL-540	Mean of 2	Std. dev.	Mean of 5	Std. dev.
Chert	-	-	-	-	-	-	-	-	-	-	-
Mudstone	0.3	0.6	-	0.3	0.3	0.9	-	0.4	0.6	0.4	0.4
Quartz sandstone	11.5	6.3	6.7	8.2	2.9	20.5	20.5	20.5	.0	13.1	7.1
Other sandstone	1.1	1.4	1.1	1.2	.2	.6	1.0	.8	.2	1.0	.3
Vein quartz	1.1	2.2	1.3	1.5	.6	.6	.8	.7	.1	1.2	.6
Felsic volcanic rocks	53.6	59.8	63.7	59.0	5.1	50.1	50.0	50.1	.1	55.4	6.1
Other volcanic rocks	.3	-	1.1	.5	.6	.6	.8	.7	.1	.6	.4
Granitic rocks	32.1	29.5	26.1	29.2	3.0	26.2	26.4	26.3	.1	28.1	2.7
Other	-	.3	-	.1	.2	.6	.5	.5	.1	.3	.3
Total	100.0	100.1	100.0	100.0		100.1	100.0	100.0		100.1	
Pebbles counted	364	363	375	367		351	386	368		368	
Q	12	7	7	9	3	21	21	21	0	14	7
I	88	93	93	91	3	79	79	79	0	86	7
C	0	0	0	0	0	0	0	0	0	0	0
Q	12	7	7	9	3	21	21	21	0	14	7
V	55	62	66	61	6	52	52	52	0	57	6
G	33	31	27	30	3	27	27	27	0	29	3

Region	Cuyama gorge					
Unit	Unnamed strata					
Conglomerate type	High quartz-sandstone					
Locality	LM-523	MP-524	MP-528	MD-604	Mean of 4	Std. dev.
Chert	-	-	-	0.3	0.1	0.1
Mudstone	1.4	-	3.4	-	1.2	1.6
Quartz sandstone	43.7	30.2	23.6	30.8	32.1	8.4
Other sandstone	2.3	1.4	.9	1.4	1.5	.6
Vein quartz	.9	.3	.9	.9	.8	.3
Felsic volcanic rocks	32.9	48.9	49.9	50.4	45.5	8.4
Other volcanic rocks	.9	1.1	2.0	.9	1.2	.5
Granitic rocks	17.4	17.4	18.2	14.4	16.8	1.7
Other	.6	.8	1.1	.9	.8	.2
Total	100.1	100.1	100.0	100.0	100.0	
Pebbles counted	350	368	351	347	354	
Q	46	31	25	32	34	9
I	54	69	75	68	66	9
C	0	0	0	0	0	0
Q	46	31	25	32	33	9
V	36	51	55	53	49	9
G	18	18	20	15	18	2

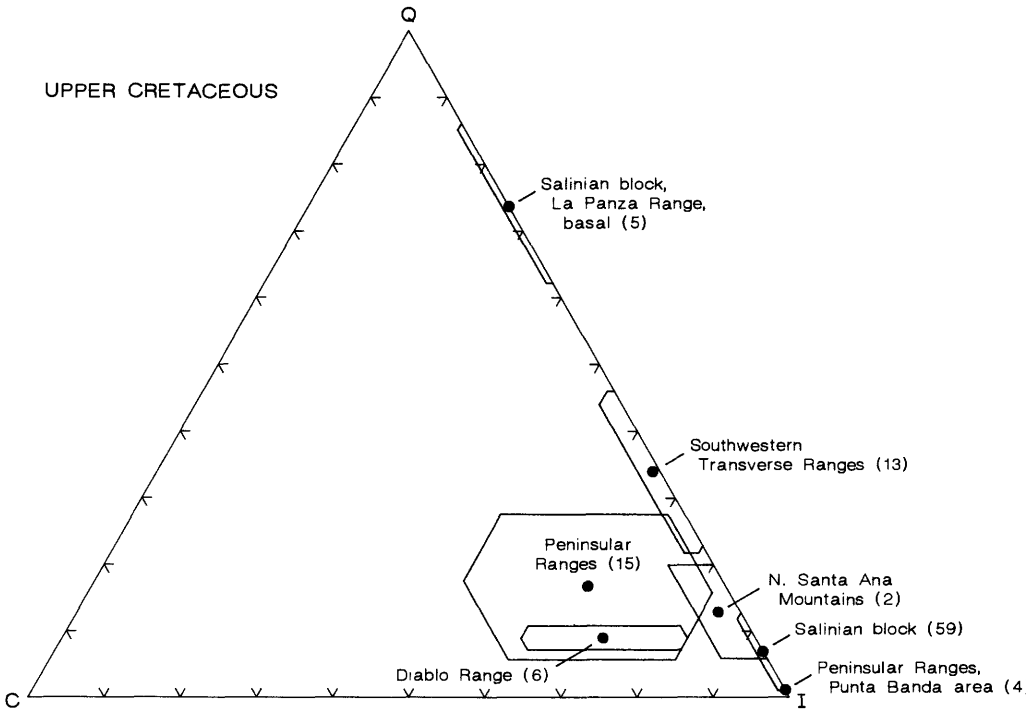

FIGURE 25.—Summary QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites from the Diablo and Peninsular Ranges, Salinian block, and nearby regions. Numerical values are given in table 10. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert.

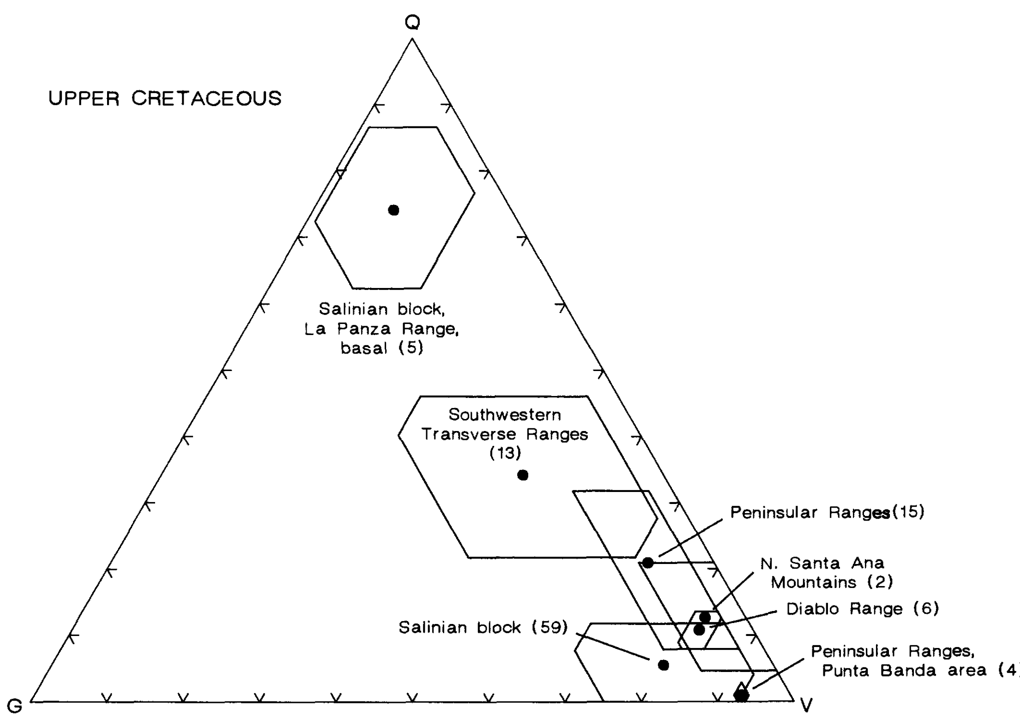

FIGURE 26.—Summary QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites from the Diablo and Peninsular Ranges, the Salinian block, and nearby regions. Numerical values are given in table 10. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

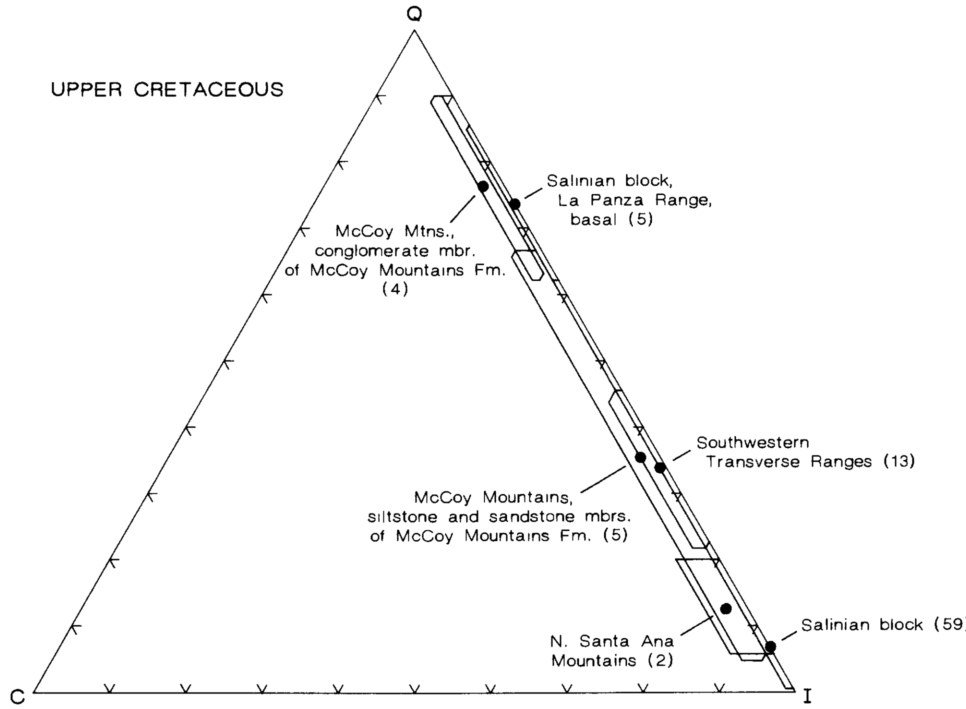

FIGURE 27.—Summary QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites from the McCoy Mountains Formation of Harding and Coney (1985), the Salinian block, and nearby regions. Numerical values are given in table 10. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert.

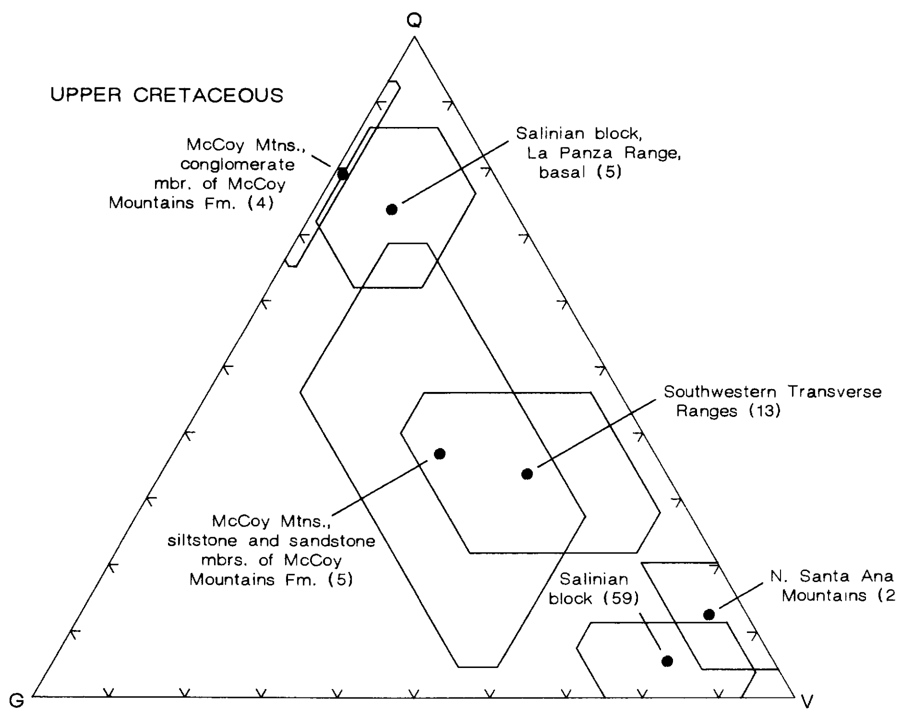

FIGURE 28.—Summary QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Upper Cretaceous conglomerate suites from the McCoy Mountains Formation of Harding and Coney (1985), the Salinian block, and nearby regions. Numerical values are given in table 10. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

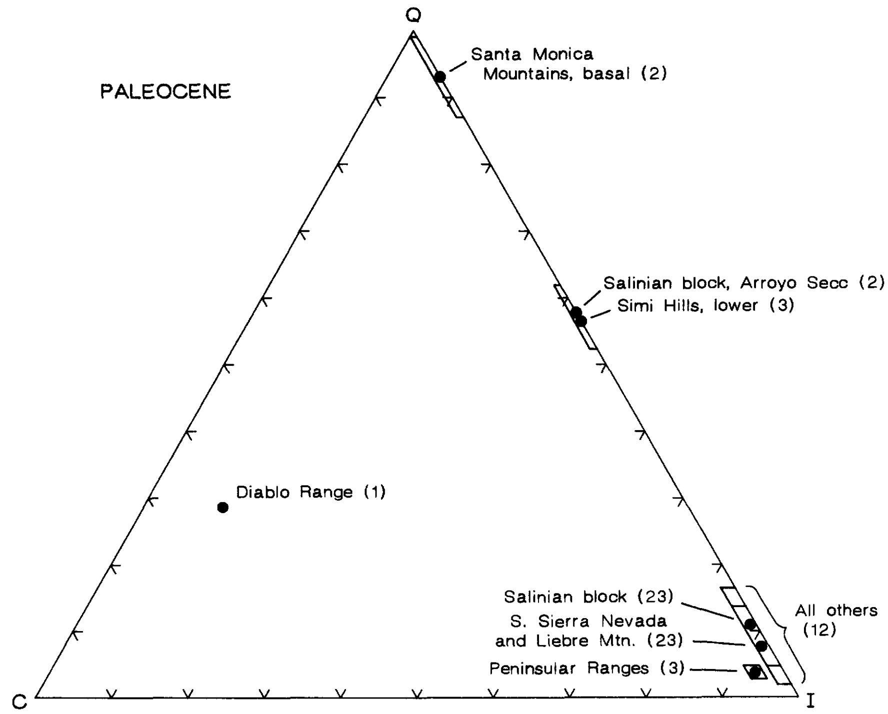

FIGURE 29.—Summary QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Paleocene conglomerate suites from the Salinian block and nearby regions. Numerical values are given in table 10. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert.

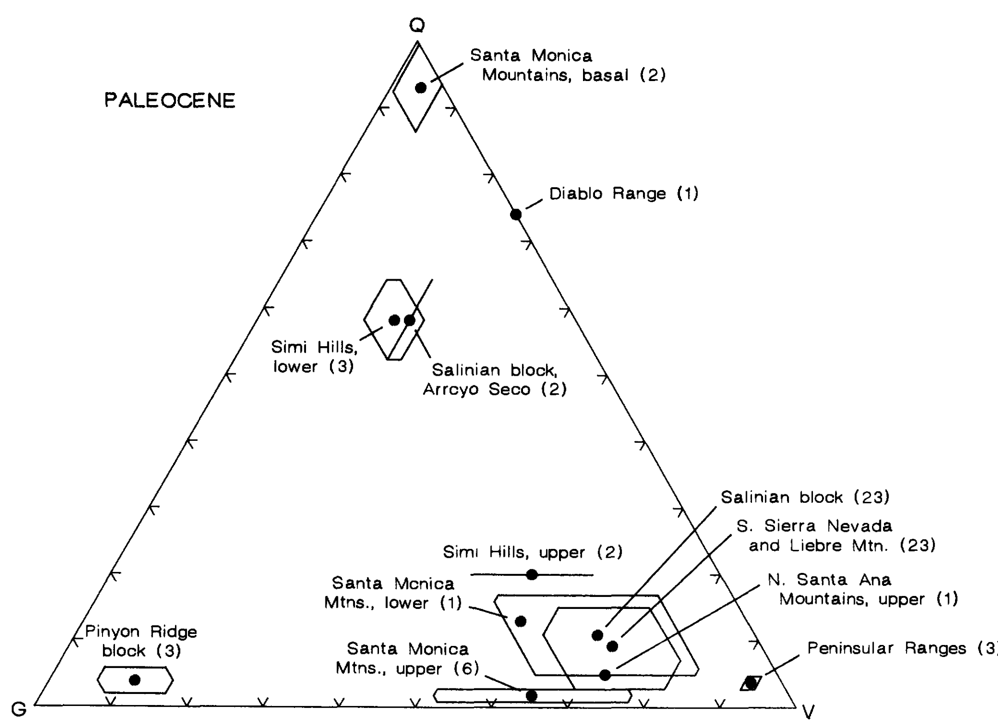

FIGURE 30.—Summary QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Paleocene conglomerate suites from the Salinian block and nearby regions. Numerical values are given in table 10. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

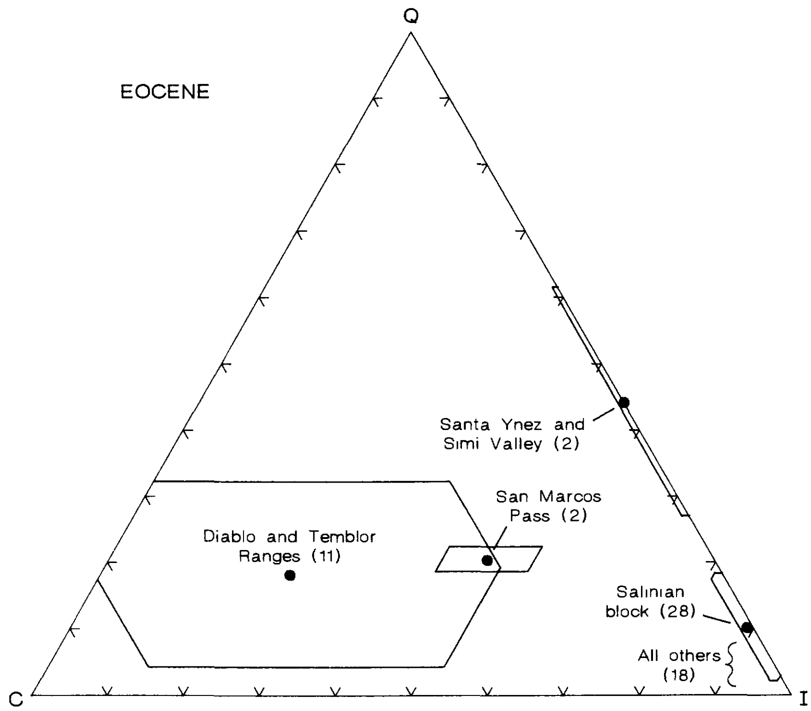

FIGURE 31.—Summary QIC diagram showing the mean compositions and dispersion fields at one standard deviation of Eocene conglomerate suites from the Salinian block and nearby regions. Numerical values are given in table 10. Q = quartz sandstone, I = volcanic and granitic rocks, C = chert.

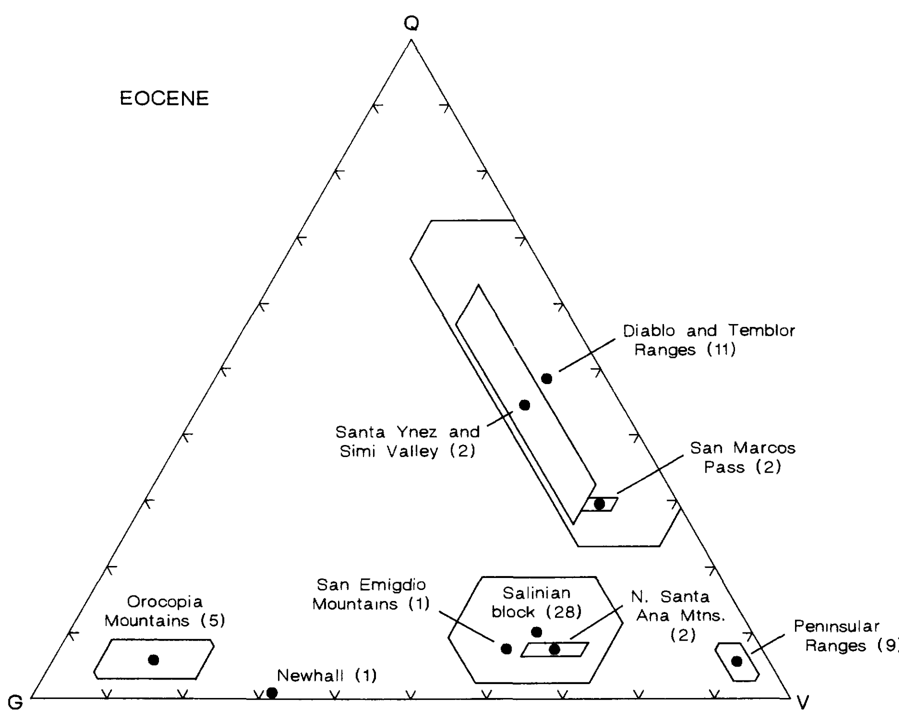

FIGURE 32.—Summary QVG diagram showing the mean compositions and dispersion fields at one standard deviation of Eocene conglomerate suites from the Salinian block and nearby regions. Numerical values are given in table 10. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

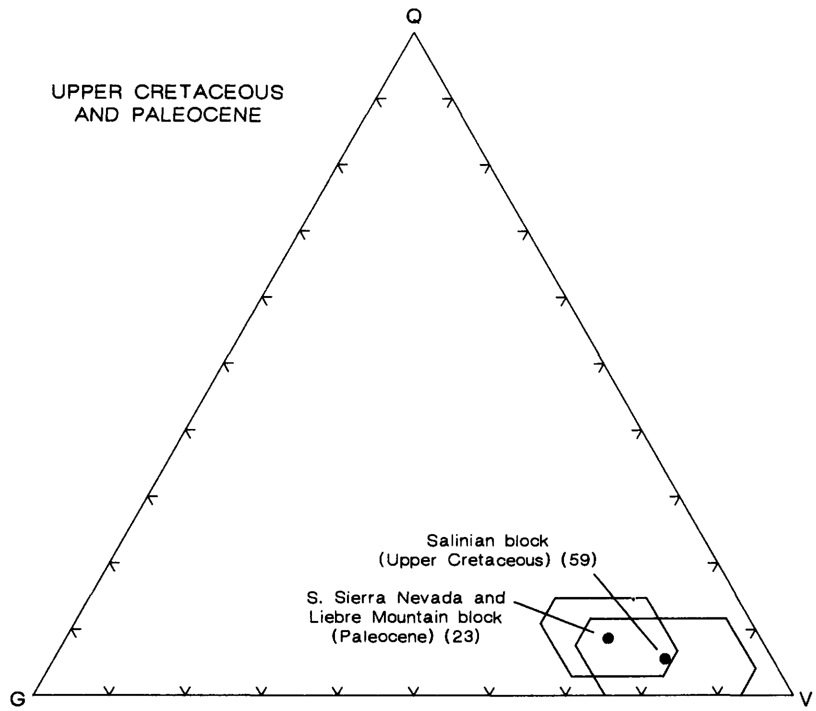

FIGURE 33.—Summary QVG diagram showing the mean compositions and dispersion fields at one standard deviation of the Upper Cretaceous conglomerate suite from the Salinian block and the Paleocene suite from the southernmost Sierra Nevada and the Liebre Mountain block (Witnet, Goler, and San Francisquito Formations). Numerical values are given in table 10. Q = quartz sandstone, V = volcanic rocks, G = granitic rocks.

TABLE 10.—*Summary of conglomerate clast compositions, in percent*

[Numerical values for constructing figures 25-33. Q, quartz sandstone; I, volcanic and granitic rocks; C, chert; V, volcanic rocks; G, granitic rocks; n, number of samples]

	Q- I- C (std. dev.)	Q- V- G (std. dev.)	n
CRETACEOUS			
SALINIAN BLOCK, except basal La Panza R.	7-93- 0 (6-6-1)	6-80-14 (6-13-11)	59
SALINIAN BLOCK, basal La Panza Range	74-26- 0 (12-12-1)	74-10-16 (12-0-11)	5
DIABLO RANGE	9-71-20 (2-11-11)	11-81- 8 (3-2-4)	6
PENINSULAR RANGES			
all but two areas below	17-65-18 (11-17-16)	21-71- 8 (12-17-5)	15
northern Santa Ana Mountains	13-84- 3 (7-10-3)	13-82- 5 (8-13-5)	2
Punta Banda area, Baja California	1-99- 0 (2-2-0)	1-93- 6 (2-1-1)	4
SOUTHWESTERN TRANSVERSE RANGES	34-65- 1 (12-12-2)	34-48-18 (12-20-14)	13
McCOY MOUNTAINS FORMATION			
siltstone and sandstone members	36-61- 3 (31-32-2)	37-35-28 (32-23-14)	5
conglomerate member	76-21-14 (14-14-1)	79- 1-20 (14-1-14)	5
PALEOCENE			
SALINIAN BLOCK, except Arroyo Seco area	11-88- 1 (6-7-1)	11-68-21 (6-16-11)	23
SALINIAN BLOCK, Arroyo Seco area	58-42- 0 (6-6-0)	58-20-22 (6-0-6)	2
DIABLO RANGE	29-10-61	74-26- 0	1
PENINSULAR RANGES			
Baja California	4-92- 4 (1-2-1)	4-92- 4 (1-1-2)	3
northern Santa Ana Mountains	5-95- 0	5-72-23	1
SOUTHWESTERN TRANSVERSE RANGES			
Simi Hills, upper part of section	20-79- 1 (0-1-1)	20-55-25 (0-8-8)	2
Simi Hills, lower part of section	57-43- 0 (5-6-1)	58-18-24 (6-4-4)	3
Santa Monica Mtns., upper part of section	2-98- 0 (1-1-0)	2-64-34 (1-13-13)	6
Santa Monica Mtns., lower part of section	13-87- 0	13-57-30	1
Santa Monica Mtns., basal part of section	93- 7- 0 (6-7-1)	93- 4- 3 (7-3-4)	2
S. SIERRA NEVADA AND LIEBRE MTN. BLOCK			
Witnet, Goler, and San Francisquito Formations	8-91- 1 (6-6-1)	9-71-20 (6-10-8)	23
PINYON RIDGE BLOCK	4-96- 0 (2-2-0)	4-11-85 (2-5-5)	3
EOCENE			
SALINIAN BLOCK	10-89- 1 (8-8-1)	10-61-29 (8-11-12)	28
DIABLO AND TEMBLOR RANGES	18-25-57 (14-27-28)	48-44- 8 (25-27-9)	11
PENINSULAR RANGES			
all but northern Santa Ana Mountains	5-95- 0 (3-3-0)	5-90- 5 (3-4-2)	9
northern Santa Ana Mountains	7-93- 0 (1-1-0)	7-65-28 (1-4-6)	2
SOUTHWESTERN TRANSVERSE RANGES			
Santa Ynez and Simi Valley	44-56- 0 (17-18-1)	44-43-13 (18-15-3)	2
Newhall	1-99- 0	1-31-68	1
San Marcos Pass	20-50-30 (2-6-8)	29-60-11 (1-2-4)	2
SAN EMIGDIO MOUNTAINS	7-92- 1	7-59-34	1
OROCOPIA MOUNTAINS	7-93- 0 (3-3-0)	7-12-81 (3-7-9)	5

SELECTED SERIES OF U.S. GEOLOGICAL SURVEY PUBLICATIONS

Periodicals

Earthquakes & Volcanoes (issued bimonthly).
Preliminary Determination of Epicenters (issued monthly).

Technical Books and Reports

Professional Papers are mainly comprehensive scientific reports of wide and lasting interest and importance to professional scientists and engineers. Included are reports on the results of resource studies and of topographic, hydrologic, and geologic investigations. They also include collections of related papers addressing different aspects of a single scientific topic.

Bulletins contain significant data and interpretations that are of lasting scientific interest but are generally more limited in scope or geographic coverage than Professional Papers. They include the results of resource studies and of geologic and topographic investigations; as well as collections of short papers related to a specific topic.

Water-Supply Papers are comprehensive reports that present significant interpretive results of hydrologic investigations of wide interest to professional geologists, hydrologists, and engineers. The series covers investigations in all phases of hydrology, including hydrogeology, availability of water, quality of water, and use of water.

Circulars present administrative information or important scientific information of wide popular interest in a format designed for distribution at no cost to the public. Information is usually of short-term interest.

Water-Resources Investigations Reports are papers of an interpretive nature made available to the public outside the formal USGS publications series. Copies are reproduced on request unlike formal USGS publications, and they are also available for public inspection at depositories indicated in USGS catalogs.

Open-File Reports include unpublished manuscript reports, maps, and other material that are made available for public consultation at depositories. They are a nonpermanent form of publication that may be cited in other publications as sources of information.

Maps

Geologic Quadrangle Maps are multicolor geologic maps on topographic bases in 7 1/2- or 15-minute quadrangle formats (scales mainly 1:24,000 or 1:62,500) showing bedrock, surficial, or engineering geology. Maps generally include brief texts; some maps include structure and columnar sections only.

Geophysical Investigations Maps are on topographic or planimetric bases at various scales; they show results of surveys using geophysical techniques, such as gravity, magnetic, seismic, or radioactivity, which reflect subsurface structures that are of economic or geologic significance. Many maps include correlations with the geology.

Miscellaneous Investigations Series Maps are on planimetric or topographic bases of regular and irregular areas at various scales; they present a wide variety of format and subject matter. The series also includes 7 1/2-minute quadrangle photogeologic maps on planimetric bases which show geology as interpreted from aerial photographs. Series also includes maps of Mars and the Moon.

Coal Investigations Maps are geologic maps on topographic or planimetric bases at various scales showing bedrock or surficial geology, stratigraphy, and structural relations in certain coal-resource areas.

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Miscellaneous Field Studies Maps are multicolor or black-and-white maps on topographic or planimetric bases on quadrangle or irregular areas at various scales. Pre-1971 maps show bedrock geology in relation to specific mining or mineral-deposit problems; post-1971 maps are primarily black-and-white maps on various subjects such as environmental studies or wilderness mineral investigations.

Hydrologic Investigations Atlases are multicolored or black-and-white maps on topographic or planimetric bases presenting a wide range of geohydrologic data of both regular and irregular areas; principal scale is 1:24,000 and regional studies are at 1:250,000 scale or smaller.

Catalogs

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