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CONGLOMERATE STRATIGRAPHY AND TECTONICS IN THE FRANCISCAN ASSEMBLAGE OF NORTHERN CALIFORNIA AND IMPLICATIONS FOR CORDILLERAN TECTONICS

by

VICTOR M. SEIDERS[1]

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[1]Menlo Park, California

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Victor M. Seiders
U.S. Geological Survey, MS-975
345 Middlefield Road
Menlo Park, California 94025

ABSTRACT

The reconnaissance mapping of conglomerate types in the Franciscan assemblage gives an orderly pattern of distribution that can be interpreted in the same way as an ordinary geologic map. Three types of conglomerate in the Franciscan (chert-rich, volcanic-rich, and mixed-clast) are similar to types exposed nearby in the Great Valley sequence. They were accreted to the front and base of the Franciscan accretionary wedge in the same sequence as they were deposited in the trench and in the Great Valley forearc basin. The three types of conglomerate, including three varieties of the mixed-clast type, have been mapped widely in the northern California Coast Ranges. The resulting map pattern reveals little evidence of strike-slip faulting and refutes proposals calling for 100s to 1000s of kms of strike-slip displacement within or between the central and eastern belts of the Franciscan. Hypotheses suggesting the strike-slip dispersal of fragments of Franciscan and Great Valley rocks to distant parts of the Cordillera are not compatible with the evidence pointing to little dispersal within northern California and are found to have little merit on other grounds.

INTRODUCTION

The accretionary-wedge Franciscan assemblage consists primarily of shale-matrix melange complexly interwoven with incomplete and poorly dated packages of relatively coherent strata. The inherent difficulty in interpreting the larger scale structure of such a terrane led Suppe (1973) to preface his report on the Leech Lake Mountain-Ball Mountain region with this pun made from a passage in an architectural journal: "Elaborateness of effect conceals the paucity of tectonic design in California . . ." Recent work with conglomerate clast compositions provides a tool that helps us see through this "elaborateness of effect" and to interpret the underlying megastructural features. It has been shown previously that conglomerate types in the Franciscan assemblage are the same as in the nearby, stratigraphically intact, Great Valley sequence (Seiders and Blome, 1988; Seiders, 1988). Moreover, as a probable consequence of the sequence of trench deposition and subsequent accretion, conglomerate types within the Franciscan are ordered in a sequence corresponding to that found in the Great Valley sequence (Seiders, 1988). Thus, the conglomerates serve like stratigraphic markers. The present study maps and interprets the distribution of conglomerate types in wide areas of the Franciscan of the northern California Coast Ranges (Figs. 1-2). The maps have implications for the late Mesozoic geology of northern California, because they suggest little lateral tectonic transport of the conglomerate-bearing Franciscan rocks north of San Francisco and east of the San Andreas fault.

THE ACCRETIONARY MODEL

The presence of distinctively similar conglomerate types in both the Franciscan assemblage and the Great Valley sequence led Seiders and Blome (1988) to conclude that Franciscan conglomerates represent sediment that bypassed the Great Valley forearc basin and accumulated in the trench. Preliminary mapping showed that conglomerate types in the Franciscan are geographically arranged in a sequence similar to the order in which they occur stratigraphically in the Great Valley sequence. The oldest Franciscan type was found in the eastern part of the area at the highest structural level. Younger types were found progressively westward and at lower structural levels. Following the imbricate-thrust model for prism accretion of Seely and others (1974) and Karig and Sharman (1975) and the familiar regional tectonic model developed by Ingersoll and others (1977), Ingersoll (1978), and Dickinson and Seely (1979), Seiders (1988) suggested that the Franciscan conglomerates and associated strata had been sequentially accreted to the front and base of the accretionary wedge in the order they were deposited, thus producing an upside-down facsimile of conglomerate stratigraphy in the Great Valley sequence.

CONGLOMERATE CLAST COMPOSITIONS

This study is based upon pebble counts at 231 localities (158 in the Franciscan assemblage, 73 in the Great Valley sequence), of which 114, almost all from the Franciscan, are presented for the first time. The rest were given by Seiders and Blome (1988) and Seiders (1988). Most localities are in the area of Figure 1, but a few are as far north as southwest Oregon and a few are as much as 170 km south of the map area. Most localities in the Franciscan assemblage are plotted on Figure 1 and most other localities are shown by Seiders and Blome (1988) and Seiders (1988).

Conglomerate clast compositions were determined by counting pebbles in the size range 0.4-6.0 cm, mainly 0.4-3.0 cm. Friable conglomerates were disaggregated and all pebbles within the size range were collected until an appropriate number, usually about 350, was obtained. Other conglomerates were sawed. The loose pebbles or cut slabs were prepared by etching overnight in 5% hydrofluoric acid solution, followed by overnight treatment in 3.5% hydrochloric acid solution to remove any newly-formed calcium fluoride precipitate. Etching cleans the pebbles of mineral stains and produces a surface with some relief and little reflectivity. Identifications were made with a low-power microscope and are believed to be better than any done on the outcrop.

The mean clast compositions of both Franciscan and Great Valley conglomerate types are given in Table 1 and individual pebble counts are shown in Appendix Tables A-G. The data are presented graphically in triangular diagrams (Figs. 3-5) representing the compositions in terms of their most significant constituents, chert, igneous (mainly volcanic) rocks, quartz sandstone, and vein quartz. Following a method employed by Ingersoll and others (1977) with sandstone petrology, the diagrams show for each conglomerate group the mean composition and an envelope produced by the standard deviations of each component of the group. 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

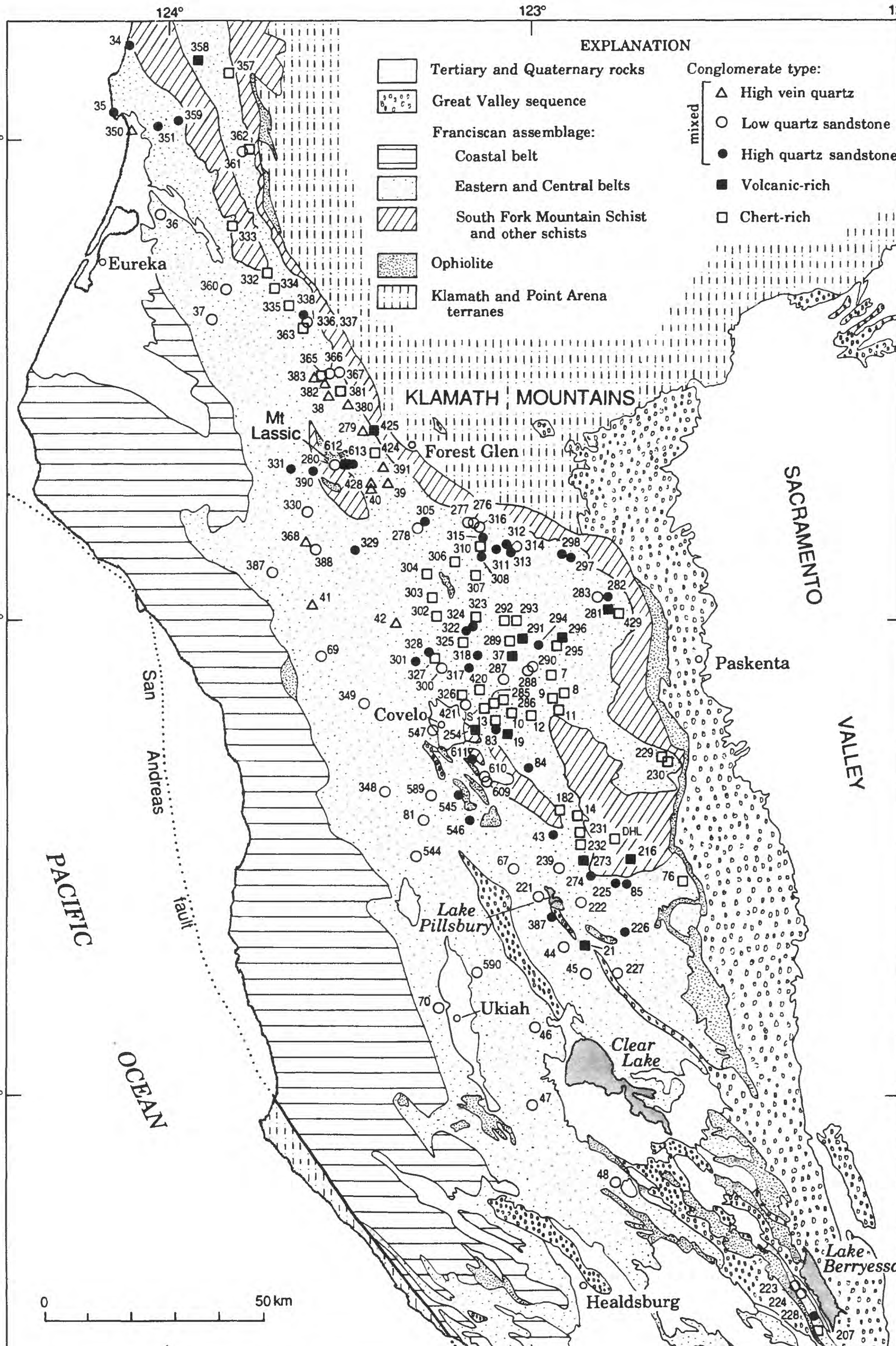

124°
123°
122°
41°
40°
39°
EXPLANATION
Tertiary and Quaternary rocks
Great Valley sequence
Franciscan assemblage:
Coastal belt
Eastern and Central belts
South Fork Mountain Schist and other schists
Ophiolite
Klamath and Point Arena terranes
Conglomerate type:
mixed
High vein quartz
Low quartz sandstone
High quartz sandstone
Volcanic-rich
Chert-rich
KLAMATH MOUNTAINS
SACRAMENTO
VALLEY
PACIFIC
OCEAN
San Andreas fault
Eureka
Mt Lassic
Forest Glen
Paskenta
Covelo
Lake Pillsbury
Ukiah
Clear Lake
Lake Berryessa
Healdsburg
0
50 km

TABLE 1. MEAN CLAST COMPOSITIONS OF CONGLOMERATES IN THE NORTHERN CALIFIRNIA COAST RANGES AND SW OREGON

Age	Tithonian to Valanginian				Valan-ginian	Valanginian and younger				
Conglomerate type	chert-rich		volc.-rich		mixed-clast					
Stratigraphic unit	GVs	F	GVs	F	GVs, west	F, all	F, high-Q	F, low-Q	F, high-VQ	GVs, east
Chert	87.5	82.4	.6	1.2	37.6	39.2	39.2	37.5	46.0	22.6
Mudstone	6.1	8.9	1.1	4.0	6.3	10.3	10.0	11.0	8.6	7.7
Quartz sandstone	.3	.9	.1	.7	5.9	5.5	8.9	3.0	2.1	1.9
Other sandstone	.5	1.0	.4	3.1	3.9	4.5	5.0	4.7	4.9	5.5
Vein quartz	.5	.3	.2	.2	2.3	2.7	2.2	1.6	7.8	1.9
Felsic volcanic rocks	4.2	4.5	71.3	71.6	34.8	30.3	27.1	34.3	25.1	50.1
Other volcanic rocks	.1	.1	8.6	4.5	3.6	1.6	1.2	2.3	.4	2.7
Granitic rocks	.3	.1	15.4	7.0	2.3	1.8	1.7	1.8	1.5	3.2
Blueschist	-	-	-	5.8	-	.3	-	.5	-	-
Limestone	-	-	-	-	-	.1	-	.0	.6	1.5
Other	.5	2.0	2.4	1.8	3.2	3.8	4.7	3.3	3.1	2.9
Total (percent)	100.0	100.2	100.1	100.0	99.9	100.1	100.0	100.0	100.1	100.0
Pebbles counted (mean)	343	355	327	307	344	373	383	362	380	297
Q	0(1)	1(1)	0(0)	1(1)	7(4)	7(5)	12(4)	4(2)	3(2)	3(2)
I	5(2)	5(4)	99(1)	98(2)	48(15)	43(17)	38(16)	48(16)	36(14)	68(22)
C	95(2)	94(4)	1(1)	1(1)	45(12)	50(17)	50(17)	48(16)	61(13)	29(20)
Q/C	.00	.01	.17	.56	.16	.14	.23	.08	.05	.08
VQ	1(1)	0(1)	0(0)	0(0)	3(3)	4(4)	3(3)	2(2)	10(4)	3(3)
I	5(2)	6(4)	99(1)	99(2)	50(14)	44(17)	42(18)	49(16)	33(13)	68(23)
C	94(2)	94(4)	1(1)	1(1)	47(14)	52(16)	55(18)	49(16)	57(11)	29(20)
No. of localities	25	47	10	13	24	98	37	48	13	12

Note: GVs, Great Valley sequence and correlative rocks in Oregon (GVs, west, refers to western outliers and GVs, east, refers to west side of Sacramento Valley); F, Franciscan assemblage and correlative rocks in Oregon; Q, quartz sandstone; I, volcanic and granitic rocks and blueschist; C, chert; VQ, vein quartz. Numbers in parentheses are standard deviations.

compositions of corresponding Franciscan and Great Valley conglomerate types (Fig. 3) and to visually evaluate the compositional distinctiveness of conglomerate types within the Franciscan (Figures 4-5).

Conglomerate types rich in 1) chert, 2) volcanic rocks, and 3) mixed chert and volcanic clasts occur in both the Franciscan assemblage and the Great Valley sequence. In Figure 3, the chert-rich and volcanic-rich groups occupy fields near the chert and igneous rock apices. Franciscan and Great Valley means of these two conglomerate types differ by no more than 1% and the small dispersion fields are distinct from those of other conglomerate types. Franciscan mixed-clast conglomerates from 98 localities occupy a broader field midway between the chert and igneous corners. The Franciscan field overlaps almost all of the field of 24 conglomerates from western outliers of the Great Valley sequence north and east of San Francisco, although the means differ by as much as 5%. The Franciscan group compares more poorly with a group of 12 conglomerates from the Great Valley sequence of the Sacramento Valley, which are richer in igneous clasts and poorer in chert and quartz sandstone. Seiders (1989) interpreted these data to suggest

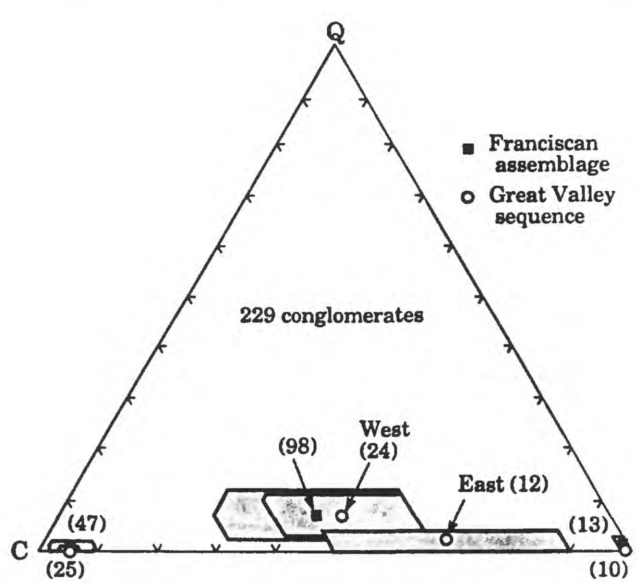
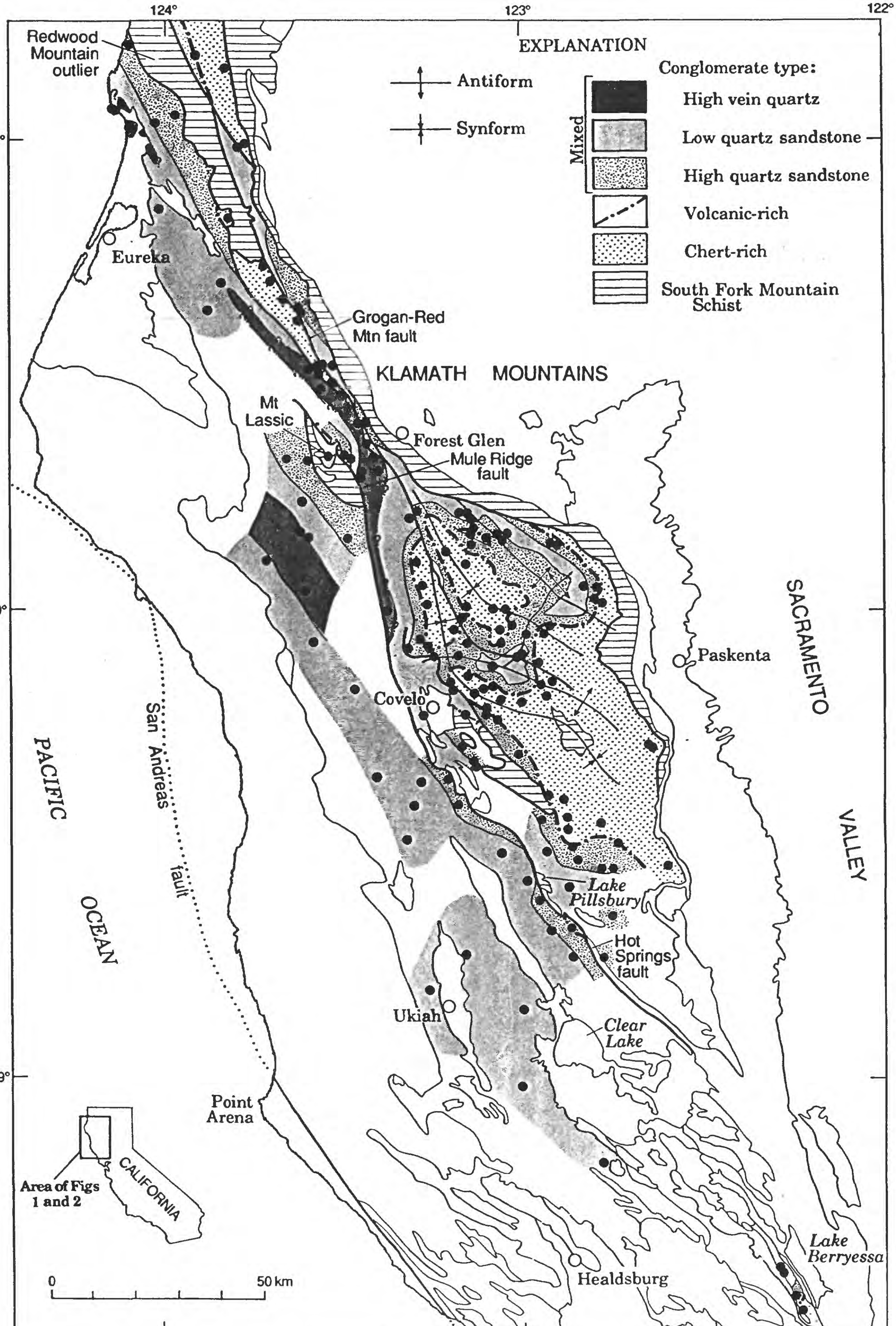


Figure 3. Q-C-I diagram showing the mean clast compositions and standard deviations of conglomerates of the Franciscan assemblage and the Great Valley sequence from the northern California Coast Ranges. Q, quartz sandstone; C, chert; I, volcanic and granitic rocks and blueschist. Numbers in parentheses are the number of conglomerate samples.

Figure 1. Geologic sketch map of northwestern California, modified from Jennings (1977), Lehman (1974), Maxwell (1974), Etter (1977), and Blake and others (1988), showing conglomerate localities. Localities JS and DHL are taken, respectively, from descriptions by Suppe (1973) and Lehman (1974).


124°
123°
122°
41°
40°
39°
Redwood Mountain outlier
EXPLANATION
Antiform
Synform
Conglomerate type:
Mixed
High vein quartz
Low quartz sandstone
High quartz sandstone
Volcanic-rich
Chert-rich
South Fork Mountain Schist
Eureka
Grogan-Red Mtn fault
KLAMATH MOUNTAINS
Mt Lassic
Forest Glen
Mule Ridge fault
SACRAMENTO
VALLEY
Paskenta
Covelo
San Andreas fault
PACIFIC
OCEAN
Lake Pillsbury
Hot Springs fault
Ukiah
Clear Lake
Point Arena
Area of Figs 1 and 2
CALIFORNIA
Lake Berryessa
Healdsburg
0
50 km

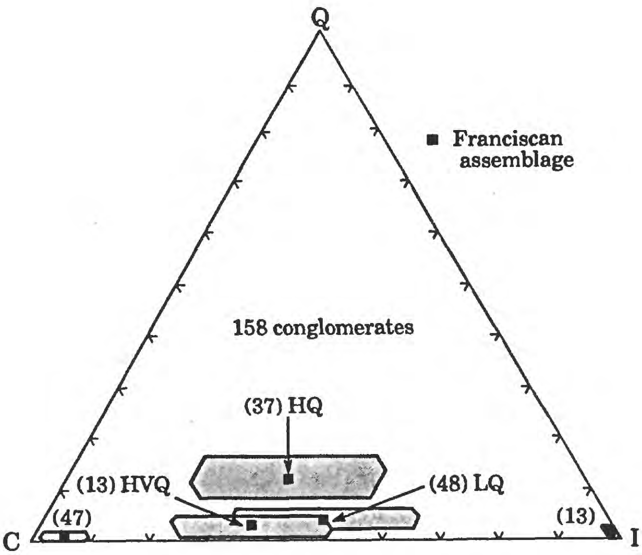


Figure 4. Q-C-I diagram showing the mean clast compositions and standard deviations of conglomerates of the Franciscan assemblage from the northern California Coast Ranges. Q, quartz sandstone; C, chert; I, volcanic and granitic rocks and blueschist; HQ, high quartz-sandstone; LQ, low quartz-sandstone; HVQ, high vein-quartz. Numbers in parentheses are the number of conglomerate samples.

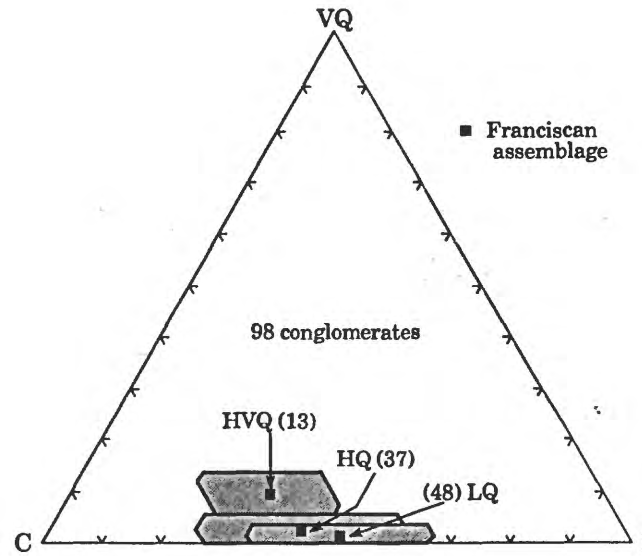


Figure 5. VQ-C-I diagram showing the mean clast compositions and standard deviations of mixed-clast conglomerates of the Franciscan assemblage from the northern California Coast Ranges. VQ, vein quartz; C, chert; I, volcanic and granitic rocks and blueschist; HQ, high quartz-sandstone; LQ, low quartz-sandstone; HVQ, high vein-quartz. Numbers in parentheses are the number of conglomerate samples.

that the Franciscan mixed-clast gravel was derived from the south and transported northward through that part of the Great Valley forearc basin represented by the western outliers, then westward down a submarine canyon to the Franciscan trench. The small compositional difference Franciscan and Great Valley conglomerates could indicate that the Franciscan had more than one source.

Three varieties of mixed-clast conglomerate are recognized in the northern California Franciscan assemblage (Table 1; Figs. 4-5). One variety is relatively rich in quartz sandstone clasts (mean 8.9% versus 3.0% and 2.1%), another is rich in vein quartz (mean 7.8% versus 2.2% and 1.6%), and the third is low in both quartz sandstone and vein quartz (mean 3.0% and 1.6%, respectively). Comparing the data in both Figures 4 and 5, it is seen that all three of these varieties have mean compositions and dispersion fields that distinguish them from the other two. As noted above, their overall composition is similar to that of the western outliers, but there is not sufficient data to correlate the three varieties with stratigraphic levels in the Great Valley sequence.

Fossils in the Great Valley sequence show that chert-rich conglomerates are Tithonian (Late Jurassic) to Valanginian (Early Cretaceous) in age, most volcanic-rich conglomerates are Valanginian but some are older, and mixed-clast conglomerate are of Valanginian and younger age (Seiders and Blome, 1988; Seiders, 1988). Most Franciscan conglomerates cannot be directly dated by fossils.

Figure 2. Map of conglomerate stratigraphy in the Franciscan assemblage of northwestern California. Heavy lines are faults that disrupt conglomerate stratigraphy. Light lines are early faults that assembled conglomerate stratigraphy, other faults, and contacts.

It is important to note that the correlation of the three main conglomerate types in the Franciscan assemblage with corresponding types in the Great Valley sequence does not depend alone on the closeness of similarity in clast composition. Equally important is the observation that the three conglomerate types in the Franciscan occur in the same sequence structurally, but in reverse order, as corresponding conglomerate types occur stratigraphically in the Great Valley sequence (Seiders and Blome, 1988; Seiders, 1988). Since this is just what is predicted by the accretionary model, a strong case is made for the suggested correlation. That Franciscan and Great Valley conglomerates in other parts of California are distinctly different from those in the northern Coast Ranges (see below), further reduces the possibility that the northern California correlation results from the chance juxtaposition of similar but unrelated rocks.

A MAP OF CONGLOMERATE STRATIGRAPHY

Figures 1 and 2 show the distribution of five varieties of conglomerate in the Franciscan assemblage of the northern California Coast Ranges. Figure 1 is a simplified conventional geologic map showing conglomerate localities and types, with locality numbers keyed to pebbles counts in the tables. Figure 2 shows the conglomerate localities by dots and interprets the distribution of conglomerate types with map patterns. Figure 2 is not a conventional geologic map in that it portrays only the distribution of conglomerates, which are volumetrically small; a broad spectrum of other Franciscan rock types are also present. Yet, if the conglomerate types can be uniquely correlated with stratigraphy in the Great Valley sequence, the conglomerate localities provide chronologic information much like fossil localities on an ordinary geologic map. Conglomerates in the Franciscan occur both in stratally intact sandstone sequences and in melange, where they are associated with sandstone, mudstone, and oceanic rocks such as chert and greenstone.

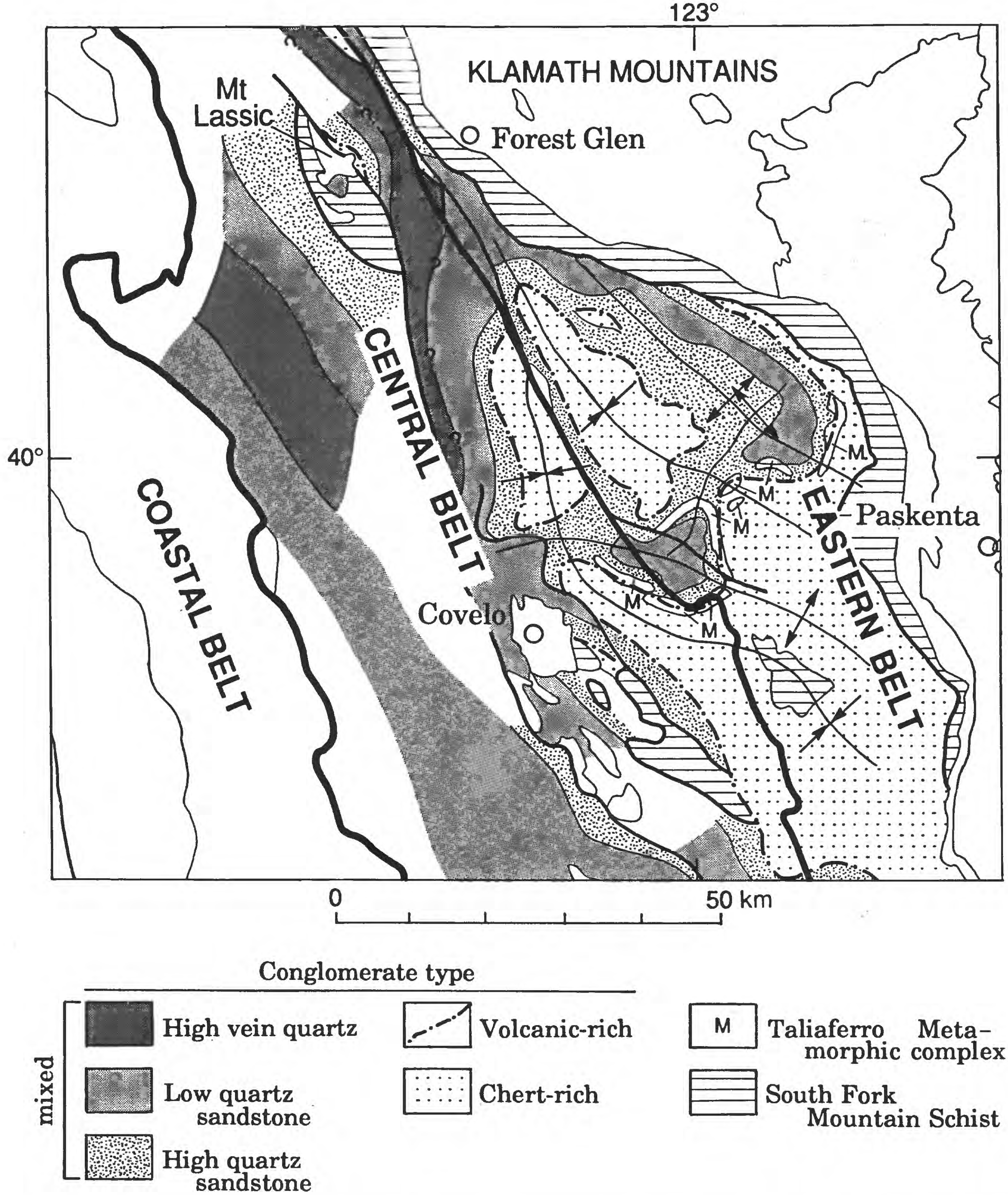


Figure 6. Map of conglomerate stratigraphy in the Franciscan assemblage between latitude 39°30' and 40°30', showing Franciscan belt boundaries from Blake and others (1988). Distribution of the Taliaferro Metamorphic Complex of Suppe (1973) after Suppe (1973) and Blake and others (1988).

Sparse fossil localities in the Franciscan assemblage (Blake and Jones, 1974; Jayko and others, 1989) show a greater geographic randomness in age than is seen in the distribution of conglomerate types. This is not fully understood but at least two factors may have contributed. Some fossils may have been reworked into trench sediments from topographically higher parts of the accretionary wedge and forearc basin. Others may have been deposited on remote parts of moving oceanic plates, thus arriving at the trench later, when younger sediment was being deposited. The latter case seems especially clear of fossils in Franciscan chert, some of which are as old as Early Jurassic (Rymer and others, 1989), yet the oldest detrital sedimentary rocks in the Franciscan are Tithonian (Late Jurassic).

The complete sequence of conglomerate types comprises, in order of descending tectonic level, chert-rich, volcanic-rich, and mixed-clast conglomerates; mixed-clast varieties descend from high quartz-sandstone, through low quartz-sandstone, to high vein-quartz types.

Area northeast and east of Covelo

The area of Franciscan assemblage exposed in the the central part of Figures 1 and 2, northeast and east of Covelo, is especially important because here the relationship is best seen between conglomerate stratigraphy and previously mapped structures and tectonostratigraphic units. The central part of Figure 2 is reproduced in Figure 6, with conglomerate localities removed and the boundaries between Franciscan belts from Blake and others (1988) added.

In the Franciscan eastern belt, 28 and 40 km northeast of Covelo, two northwest-trending folds, an antiform and a synform, are shown as previously mapped by Blake and Jayko (1983). Guided by their strikes and dips, I have added a northeast-trending antiformal cross fold extending northeast from a dome mapped by Suppe (1973) 20 km northeast of Covelo. On the maps of Blake and Jayko (1983) and Blake and others (1988) structural highs are generally occupied by the Chicago Rock melange, the highest unit of the Yolla Bolly terrane of Blake and others (1988). This unit corresponds closely to areas of chert-rich conglomerate in Figures 2 and 6. Volcanic-rich conglomerates lie near the lower contact of the Chicago Rock melange. Structural lows are occupied by two lower tectonostratigraphic units, the metagraywacke of Hammerhorn Ridge and the broken formation of Devils Hole Ridge, which correspond to areas of mixed-clast conglomerate on Figure 6. In some areas where there are both fairly close conglomerate samples and structural control, as for example in the eastern part of the area 25 km northwest of Paskenta (Worrall, 1981), it is seen that the sequence of conglomerate types descending structurally is chert-rich, volcanic-rich, followed by high and then low quartz-sandstone varieties of the mixed-clast type.

The dome 20 km east-northeast of Covelo contains the low quartz-sandstone variety of mixed-clast conglomerate, although part of this area is shown as Chicago Rock melange by Blake and others (1988). This dome was mapped by Suppe (1973), who noted that fossils found in the core, although not age diagnostic, are the same forms as occur in the Great Valley sequence just above the uppermost occurrence of the age diagnostic mollusk Buchia. This led Suppe (1973, p. 63) to conclude that the rocks in the core of the dome were younger than the Buchia-bearing rocks that surround it, a conclusion that is supported here by conglomerate stratigraphy.

The above observations show that northeast of Covelo evidence is widespread that the same sequence of conglomerate types as found in the Great Valley sequence is exposed in reverse structural order in the Franciscan, supporting Seiders' (1988) hypothesis about the accretionary origin of the Franciscan sequence. An exception occurs in the northeastern-most antiform (Figures 2 and 6) where the youngest conglomerate unit lies a few kilometers to the northeast of the crest of the fold. This and other potential anomalies may have resulted from out-of-sequence faulting or later structural reworking.

Northeast and east of Covelo, the boundary between Franciscan eastern and central belts, the Grogan-Red Mountain fault of Blake and others (1988), is crossed with little or no offset by mapped conglomerate units. Likewise, the Taliaferro Metamorphic Complex of Suppe (1973), a Franciscan unit mapped by both Suppe (1973) and by Jayko and others (1989), crosses the boundary without offset. I have also shown fold structures extending across the boundary without interruption, but this is less certain because the complexity in detail of Franciscan central belt structures is difficult to generalize and different workers interpret it in different ways (compare Suppe, 1973, and Jayko and others, 1989). The evidence presented here for continuity across the eastern-central belt boundary is important because the boundary has been interpreted as a major tectonic discontinuity showing large strike-slip displacement (Blake and others, 1988).

Redwood Mountain outlier and Grogan-Red Mountain fault

Midway between Covelo and Paskenta, chert-rich conglomerates of the Franciscan assemblage are locally overlain by highly recrystallized rocks of the South Fork Mountain Schist (Fig. 2). A continuous belt of this schist occurs on the eastern margin of the Franciscan in the northern half of the map area and a correlative unit, called the Redwood Mountain outlier by Irwin (1960), lies about 10 km west of the main schist belt at about 41° N. Following Irwin (1960), I believe the Redwood Mountain outlier is a body of South Fork Mountain Schist thrust westward over lower units of the Franciscan assemblage. The eastern boundary of the outlier, the Grogan fault, is a high-angle fault that I interpret as a dip-slip fault, down on the west, and thus responsible for the repetition of the South Fork Mountain Schist and underlying sequence of conglomerates to the west (Fig. 2). Along most of its length, the Grogan fault and its southward extension, the Red Mountain fault, is roughly coincident with the Franciscan eastern-central belt boundary (Blake and others, 1988).

Several previous workers have suggested that large-scale strike-slip displacement on the Grogan fault is required to explain the location of the Redwood Mountain outlier (Monson and Aalto, 1980; Kelsey and Hagens, 1982; Cashman and others, 1986), but the arguements are ambiguous and not compelling. Large strike-slip offset on the Grogan fault can be precluded by tracing the fault southward and showing that it does not appreciably offset map units (Fig. 2). At the south end of the Redwood Mountain body, a thin wedge of chert-rich conglomerate extends 40 km to the south. Because the east margin of this wedge can be accurately located, the Grogan fault can be traced this far south. Farther south near Forest Glen the location of the fault is constrained on the west by high vein-quartz conglomerate. South of here, I follow Blake and others (1988) in connecting the Grogan fault with the Red Mountain fault, which takes its name from the site of an ultramafic body 30 km north of Covelo (Figs. 1-2). Fifteen kilometers south of Red Mountain, I have shown the Grogan-Red Mountain fault turning southeast and connecting with a fault mapped by Suppe (1973) which produces little offset of rock units. As discussed in the previous section, in the region northeast of Covelo there is little possible offset along the line of the Grogan-Red Mountain fault.

Other observations

Figure 2 shows that in many places conglomerate types in the Franciscan assemblage are arranged geographically in the same sequence in which they occur structurally in the area northeast of Covelo. This suggests that the same sequence of conglomerate types was accreted widely in the northern Coast Ranges. The sequence is not everywhere complete, however. Along the main outcrop belt of South Fork Mountain Schist between Paskenta and Forest Glen (Fig. 2), the western contact of the schist cuts across conglomerate stratigraphy in the underlying Franciscan assemblage. Chert-rich conglomerate is largely absent adjacent to western outliers of the schist, as on the west side of the Redwood Mountain outlier and around the schist body at Mount Lassic and those southeast of Covelo. This indicates that the base of the schist is a plane of detachment along which the underlying sequence is faulted and folded.

Conglomerate stratigraphy is repeated across the Hot Springs fault zone near Lake Pillsbury (Fig. 2). This fault zone is marked by a line of outliers of the Great Valley sequence. A small body of South Fork Mountain Schist was mapped near the the fault zone southeast of Lake Pillsbury by Etter (1979). The repetition of stratigraphy across the Hot Springs fault zone suggests that it may be a more important fault than generally realized.

The high vein-quartz variety of mixed-clast conglomerate is most abundant near Mount Lassic (Fig. 2). The occurrence of this conglomerate both northeast and southwest of Mount Lassic, and its absence farther south, speaks against the existance of any large-scale strike-slip faults in this area.

TECTONIC IMPLICATIONS

Blake and others (1988) proposed that the boundary between Franciscan eastern and central belts is a major tectonic discontinuity with important implications for both California and the Pacific Northwest. They argued that the eastern belt underwent blueschist facies metamorphism in mid-Cretaceous time near the close of an episode of orthogonal plate convergence. Soon thereafter, when plate convergence became oblique, the eastern belt of the Franciscan was faulted to the surface and its western margin was truncated as blocks of eastern belt were entrained in the central belt melange and dispersed northward by oblique convergence and transform faulting. Blake and others (1988) suggested that some blocks were moved at least as far north as southwestern Oregon. Brown and Blake (1987), Jett and Heller (1988), and McLaughlin and others (1988) proposed that some rocks in Washington State were derived from this part of California.

The mapping of conglomerate stratigraphy in the Franciscan assemblage in the area north and east of Covelo shows that displacements of no more than a few kms are possible along the eastern-central belt boundary, not the 100s or 1000s of kms proposed by Blake and others (1988). Moreover, if fragments of the eastern belt had been dispersed randomly in the central belt, as mapped by Blake and others (1988), we should expect to also find the conglomerate types so dispersed but as discussed above, that is not the case (Fig. 2). Finally, if large-scale tectonic translations have occurred in the Franciscan of the northern Coast Ranges, it might be expected that conglomerate types characteristic of other parts of California would be found. In fact, Franciscan conglomerates in the northern Coast Ranges are quite similar to Great Valley conglomerate of the same area and differ from Franciscan conglomerates in all other areas of California (Fig. 7; Seiders and Blome, 1988; Seiders, 1988). Similar conclusions are suggested by sandstone petrology. Aalto (1989) found no significant differences between Franciscan eastern and central belt sandstones and, following Dickinson and others (1982), suggested that the source of both was the ancestral Sierran-Klamath arc.

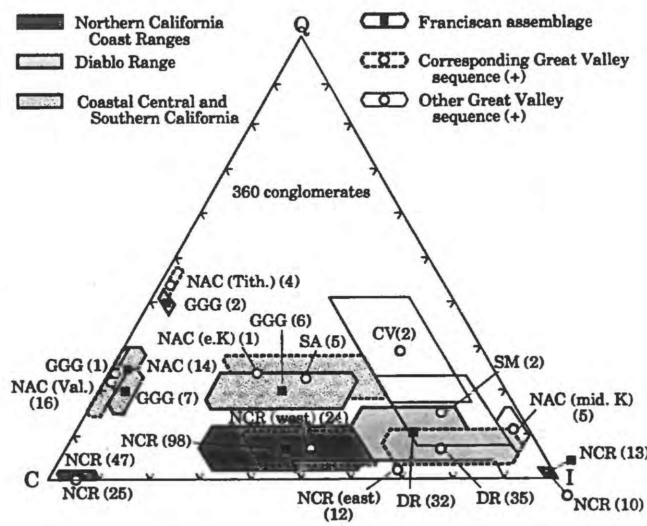


Figure 7. Q-C-I diagram showing the mean clast composition and standard deviations of Upper Jurassic through mid-Cretaceous (largely Turonian and older) conglomerate suites in western California, southwestern Oregon, and Baja California. Excluded are six conglomerates from the lower part of the Great Valley sequence of the Diablo Range, rich in detrital sedimentary and volcanic rocks. Data from Seiders and Blome (1988), this report, and unpublished data. Q, quartz sandstone; C, chert, I, volcanic and granitic rocks and blueschist; CV, Cape Vizcaino, Baja California; DR, Diablo Range of central California; GGG, Golden Gate-Gilroy block of the San Francisco Bay area; NAC, Nacimiento block of coastal central California; NCR, northern California Coast Ranges and adjacent southwestern Oregon; SA, Santa Ana Mountains of southern California; SM, Santa Monica Mountains of southern California. e.K, Early(?) Cretaceous; mid.K, middle(?) Cretaceous; Tith., Tithonian; Val., Valanginian. Numbers in parentheses are the number of conglomerate samples.

Oregon

Evidence presented here indicates that large tectonic displacements have not occurred within the northern California Coast Ranges. If this is correct, it is dificult to understand how proposals calling for the tectonic transport of interior parts of the northern Coast Ranges to remote places can succeed. This aside, the proposals remain unconvincing.

Blake and others (1988) wrote that parts of the northern Coast Ranges were transported at least as far north as southwestern Oregon but they gave no evidence in support. Conglomerates in southwestern Oregon are similar to those in northern California (Seiders and Blome, 1987, 1988) and, since the two areas are contiguous, there is no reason to doubt that the Oregon rocks are not simply a continuation of the same petrographic province.

Derivation of the Gold Beach terrane of southwestern Oregon from a more southerly site, possibly adjacent to central or southern California, was advocated by Bourgeois and Dott (1985) and Aalto (1989), but the interpretation is contradicted by conglomerate compositions and sandstone petrology (Seiders and Blome, 1987; Seiders, 1990). Chert-rich and volcanic-rich conglomerates in the Otter Point Formation (Tithonian) of the Gold Beach terrane compare closely with conglomerates in adjacent parts of Oregon and northern California and in Figure 7 are included in the northern Coast Ranges groups. The compositions contrast sharply with conglomerate compositions farther south in California and northern Mexico, which are much richer in quartz sandstone (Fig. 7). Bourgeois and Dott (1987) and Aalto (1990) believe that the conglomerate data is scant and inconclusive, but I think that is not the case. The robust contrast between northern and southern conglomerate suites is clearly shown in Figure 7.

Both Bourgeois and Dott (1987) and Aalto (1990) insist that paleomagnetic observations on sedimentary rocks of the Otter Point Formation have implications for long distance tectonic transport, yet the authors of the data clearly state that their results are preliminary and conclusions about precise paleolatitudes and rotations are precluded (Blake and others, 1985, p. 153). One of the uncertainties of Blake and others (1985) is in the location of the 150 m.y. pole of Irving and Irving (1982). Indeed, May and Butler (1986) have since proposed a different apparent polar wander path covering this time period, one that would place North America farther south, thus eliminating the need to call upon lateral motions to reconcile the paleomagnetic observations of some outboard terranes (Butler and others, in press). If firm paleomagnetic results are ever obtained from the Gold Beach terrane, comparison with the apparent polar wander path of May and Butler (1986) would be of interest.

Washington

Mclaughlin and others (1988), citing an abstract by Garver (1986), suggested that a fragment of the Coast Range ophiolite and overlying Great Valley sequence had been translated through the Franciscan central belt from northern California to northwest Washington as the Decatur terrane. Much of the evidence of McLaughlin and others (1988) for long distance transport is based on the distribution of different kinds of ophiolite in northern California. However, since the supposedly displaced ophiolite fragments are on the west edge of the central belt, they tell nothing about displacements within the central belt. Moreover, since no evidence is given to document the original distribution of ophiolite types within California, the observations have no bearing at all on tectonic displacements.

Garver (1988a) favored a point of origin for the Decatur terrane at the southern end of the central California Nacimiento block, possibly when this block was at equatorial lattitudes, as suggested by McWilliams and Howell (1982). Tithonian to Valanginian rocks in the Decatur terrane, however, contain conglomerate rich in ophiolite clasts with subordinate clasts of chert, felsic volcanic rocks, and argillite (Garver, 1988b), whereas such conglomerate is absent in California, although ophiolitic breccia and olistostromes occur in the northern Coast Ranges (Phipps, 1984). Conglomerate rich in chert, like that in northern California, or rich in chert and quartz sandstone, like that in the Nacimiento and Golden Gate-Gilroy blocks, or rich in volcanic rocks, quartz sandstone, and chert, like that in central Baja California (Fig. 7) is not reported in correlative rocks of the Decatur terrane (Garver, 1988b). Moreover, the sandstone petrology of Decatur rocks (Garver, 1988b) differs significantly from that of correlative rocks in northern California (Ingersoll, 1983), central California (MacKinnon, 1978; Seiders, 1983), and Baja California (Hickey, 1984). In a later report, Bogue and others (1989) interpret complex paleomagnetic observations to indicate that the Decatur terrane formed still farther to the south and not contiguous with California. This interpretation places the Decatur terrane beyond the scope of this paper and the suggested place of origin, like those of many Cordilleran terranes, is such that the paleomagnetic interpretation cannot be tested by other kinds of geologic observation. The statement of Bogue and others (1989, p. 10,426) that the geological setting of the place of origin was identical to that of the California Great Valley sequence, however, is not supported by the petrology discribed above.

Jett and Heller (1988) suggested that the western melange belt of northwestern Washington may be a displaced fragment of the Franciscan assemblage, partly from the central belt melange. Garver (1988c) has disputed this, pointing out that the trimodal sandstone petrology of the western melange belt finds only two points of comparison in the Franciscan, whereas all three sandstone types are found in apparently coeval units of the Methow-Tyaughton basin of nearby Washington and British Colombia. Moreover, as noted by Garver (1988c), the Franciscan contains many other sandstone suites that were ignored by Jett and Heller (1988) in their comparison. Heller and Jett (1988), assuming that all sandstones of the western melange belt are Jurassic, argue that one Methow-Tyaughton suite and the contrasting Franciscan suites should be excluded from consideration because they are Cretaceous. Plainly, the sparce Jurassic fossils in the western melange belt provide no basis for assuming that the whole melange is Jurassic. Indeed, the presence of Cretaceous chert in the melange (Frizzell and others, 1987) opens the door for the presence of Cretaceous sandstone as well. In addition, the occurrence in the western melange belt of Paleozoic marble and an Oxfordian Buchia concentrica, together with the rarity of serpentinite (Frizzell et al., 1987), are sharp points of contrast with the Franciscan. Correlation of the western melange belt with the Franciscan should not be seriously considered.

Brown and Blake (1987) reported close lithologic and age similarities between the Shuksan Metamorphic Suite of Misch (1966) of northwestern Washington and the South Fork Mountain Schist and other schists of California and southwestern Oregon. They concluded that either the various schists formed in remote places under the same conditions or, in their preferred interpretation, the schists formed in the same place and were later dispersed tectonically. The former alternative is suggested by the observation that subduction along the west edge of North America extended from Alaska to Mexico at the time (ca. 125 Ma) when the schists formed (Engebretson and others, 1985). In California, the South Fork Mountain Schist is intimately associated with melanges and other rocks of the Franciscan assemblage. A strong point against the latter interpretation is the absence with the Shuksan of rocks similar to these other units of the Franciscan.

CONCLUSION

The mapping of conglomerate types in the Franciscan assemblage of the northern California Coast Ranges produces a surprisingly regular pattern of distribution that has important implications for tectonics and promises to be a useful approach to other geologic problems. The most important conclusion from this work is that large lateral tectonic displacements have not been an important factor in Franciscan geology. This conclusion casts doubt on hypotheses calling for large northward dispersion of fragments derived from the Franciscan and the Great Valley sequence. Taken together with conclusions from prior work in California (Seiders and Blome, 1988; Abbott and Smith, 1989), and with cautionary notes from paleobiogeography (Saul, 1986; Newton, 1988) and from regional geology in other parts of the North American Cordillera (Csejtey and others, 1982; Price and Carmichael, 1986; Gardner and others, 1988; Butler and others, 1989; Miller, 1989), it suggests that the long distance northward transport of continental rocks should not be an a priori assumption about Pacific coast geology. The recent landmark reinterpretation of paleomagnetism of coastal California and Baja California (Butler and others, in press) should serve as a guide to those who would propose large movements based on paleomagnetism unsupported by other geologic observations.

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Appendix. Individual pebble counts and sample locations.

Location numbers with a two or three letter prefix are new and the others have been published previously. In Figure 1, the letter prefixes are omitted.

Table A. Pebble counts of chert-rich conglomerate in the Myrtle Group of southwestern Oregon and the Great Valley sequence of the northern California Coast Ranges, and of two anomalous mixed-clast conglomerates near Knoxville, California (locs. 208 and 209).

Area	southwestern Oreg.			northern California Coast Ranges						
Stratigraphic unit	Myrtle Group			Great Valley sequence						
Locality no.	181	74	75	1	2	72	PK-321	196	NV-320	EC-319
Chert	84.3	86.8	87.9	85.5	85.6	89.1	89.5	88.3	89.6	90.2
Mudstone	6.9	5.2	2.6	5.3	7.9	6.4	7.1	9.3	3.8	4.3
Quartz sandstone	-	-	.3	1.4	1.4	-	-	.3	.5	-
Other sandstone	.5	.6	-	.4	2.3	.3	.2	-	.5	1.1
Vein quartz	.5	1.1	-	1.8	.5	-	1.1	.3	.3	1.1
Felsic volcanic rocks	6.4	5.7	8.1	2.5	1.4	3.7	1.8	1.9	4.9	2.4
Other volcanic rocks	.7	-	-	-	-	.5	-	-	-	-
Granitic rocks	-	.6	.3	-	.5	-	-	-	-	.5
Other	.7	-	.9	3.2	.5	-	.2	-	.3	.5
Total (percent)	100.0	100.0	100.1	100.1	100.1	100.0	99.9	100.1	99.9	100.1
Pebbles counted	408	174	346	283	215	376	439	367	365	376
Q	0	0	0	2	2	0	0	0	1	0
I	8	7	9	3	2	5	2	2	5	3
C	92	93	91	95	96	95	98	98	94	97
Q/C	.00	.00	.00	.02	.02	.00	.00	.00	.01	.00
VQ	0	1	0	2	1	0	1	0	0	1
I	8	7	9	3	2	5	2	2	5	3
C	92	92	91	95	97	95	97	98	95	96
Age	Tith.	-	-	Val.	-	Tith.	Kim.-Tith.	Tith.	Tith.	Tith.

Area	northern California Coast Ranges (continued)									
Stratigraphic unit	Great Valley sequence (continued)									
Locality no.	3	73	4	5	197	198	199	200	201	202
Chert	84.1	89.1	89.6	90.5	89.8	84.2	87.8	83.1	85.9	89.2
Mudstone	9.3	5.2	6.8	2.2	5.6	7.2	7.0	9.2	6.1	4.5
Quartz sandstone	-	-	-	-	-	-	-	.5	.3	.5
Other sandstone	1.8	1.1	-	.4	.3	1.9	-	.3	.3	.5
Vein quartz	.3	.5	-	.4	.5	-	.2	.3	1.6	.3
Felsic volcanic rocks	3.9	3.8	3.6	5.6	3.1	5.6	3.6	5.6	4.2	4.0
Other volcanic rocks	-	-	-	-	.3	.6	-	-	.3	-
Granitic rocks	.3	.3	-	-	.3	.6	1.0	.5	-	.5
Other	.3	-	-	.9	.3	-	.5	.5	1.3	.5
Total (percent)	100.0	100.1	100.0	100.0	100.2	100.1	100.1	100.0	100.0	100.0
Pebbles counted	338	366	222	232	391	360	417	391	377	397
Q	0	0	0	0	0	0	0	1	0	0
I	5	4	4	6	4	7	5	7	5	5
C	95	96	96	94	96	93	95	92	95	95
Q/C	.00	.00	.00	.00	.00	.00	.00	.01	.00	.01
VQ	0	1	0	0	1	0	0	0	2	0
I	5	4	4	6	4	7	5	7	5	5
C	95	95	96	94	95	93	95	93	93	95
Age	Tith.	Tith.	Tith.	Berr.	Tith.	-	-	-	-	-

Area	N. Cal. Coast Ranges (cont.)					Or. & Cal.		Knoxville	
Stratigraphic unit	Great Valley sequence (cont.)					Myrtle Gp. & GVs		GVs	
Locality no.	203	204	205	206	6	mean of 25	std. dev.	208	209
Chert	82.1	87.8	88.4	82.3	95.6	87.5	3.1	62.1	13.3
Mudstone	7.7	7.8	5.8	6.7	2.8	6.1	2.0	7.1	4.5
Quartz sandstone	.3	-	-	.8	-	.3	.4	.3	.3
Other sandstone	-	-	-	1.1	-	.5	.7	1.3	2.0
Vein quartz	-	1.0	-	1.7	-	.5	.6	-	-
Felsic volcanic rocks	8.7	2.8	5.2	5.9	1.6	4.2	1.9	26.0	73.4
Other volcanic rocks	-	-	-	.3	-	.1	.2	.3	1.1
Granitic rocks	.8	.5	.3	.6	-	.3	.3	2.5	3.7
Other	.5	-	.3	.6	-	.5	.7	.5	1.7
Total (percent)	100.1	99.9	100.0	100.0	100.0	100.0		100.1	100.0
Pebbles counted	379	395	362	356	253	343		393	353
Q	0	0	0	1	0	0	1	0	0
I	10	4	6	7	2	5	2	32	85
C	90	96	94	92	98	95	2	68	15
Q/C	.00	.00	.00	.01	.00	.00		.00	.02
VQ	0	1	0	2	0	1	1	0	0
I	10	4	6	7	2	5	2	32	85
C	90	95	94	91	98	94	2	68	15
Age	Tith.	Tith.	Tith.	-	-			Tith.	Tith.

Q, quartz sandstone; I, volcanic and granitic rocks; C, chert; VQ, vein quartz.

Table B. Pebble counts of chert-rich conglomerate from the Franciscan assemblage of the northern California Coast Ranges and from partly correlative rocks in southwestern Oregon.

Area	southwestern Oregon				northern California Coast Ranges												
Stratigraphic unit	Otter Point Formation			Dothan Fm.	Franciscan assemblage												
Locality no.	77	78	79	80	FR-357	BL-362	MC-333	BC-332	BC-334	BC-335	SH-363	BK-365	DI-381	RR-424	BR-310	BR-306	FC-307
Chert	84.8	85.1	91.2	82.3	79.2	81.5	79.6	86.5	86.3	79.3	84.2	82.1	82.1	82.4	79.0	77.0	77.6
Mudstone	7.7	8.0	4.0	8.7	10.4	9.8	9.7	6.6	10.5	12.4	8.6	10.3	11.0	10.3	15.9	12.3	10.5
Quartz sandstone	.8	.3	.3	.9	.5	2.2	.3	.8	.3	1.4	.8	1.4	-	.8	1.1	3.6	1.9
Other sandstone	.8	.3	-	.6	3.0	.8	1.1	.5	-	.6	.6	-	-	.3	1.1	1.9	1.1
Vein quartz	1.1	-	-	-	.3	-	.3	-	-	-	-	-	-	.6	-	.3	-
Felsic volcanic rocks	3.7	5.0	4.6	5.3	3.3	3.6	7.3	2.2	2.6	3.3	3.1	3.9	4.6	3.9	2.6	1.6	6.6
Other volcanic rocks	-	-	-	.6	.3	-	-	-	-	-	-	-	-	-	-	-	-
Granitic rocks	-	.5	-	-	-	-	-	.3	-	.3	-	-	.6	-	-	-	-
Other	1.1	.8	-	1.6	3.0	2.0	1.9	3.0	.3	2.8	2.8	2.2	1.7	1.7	.3	3.3	2.2
Total (percent)	100.0	100.0	100.1	100.0	100.0	99.9	100.2	99.9	100.0	100.1	100.1	99.9	100.0	100.0	100.0	100.0	99.9
Pebbles counted	376	377	328	322	365	357	372	364	351	362	360	358	347	358	352	365	362
Q	1	0	0	1	1	3	0	1	0	2	1	2	0	1	1	4	2
I	4	6	5	7	4	4	8	3	3	4	3	4	6	4	3	2	8
C	95	94	95	92	95	93	92	96	97	94	96	94	94	95	96	94	90
Q/C	.01	.00	.00	.01	.01	.03	.00	.01	.00	.02	.01	.02	.00	.01	.01	.05	.02
VQ	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
I	4	6	5	7	4	4	9	3	3	4	4	4	6	4	3	2	8
C	95	94	95	93	95	96	91	97	97	96	96	96	94	95	97	98	92

Area	northern California Coast Ranges (continued)															
Stratigraphic unit	Franciscan assemblage (continued)															
Locality no.	LR-304	LR-303	LR-302	FC-323	FC-292	FC-293	BN-325	LL-289	SY-429	BR-295	MI-327	7	8	CE-326	CE-420	NR-285
Chert	81.8	82.5	65.1	89.2	85.2	84.1	90.2	60.6	68.5	75.8	79.7	82.7	84.6	81.9	88.5	86.8
Mudstone	8.4	6.4	11.3	6.9	9.3	8.1	6.5	22.0	8.8	13.8	11.7	9.1	7.4	8.4	5.3	4.8
Quartz sandstone	.3	3.3	4.7	.5	.7	1.6	.5	1.0	.6	1.7	-	.4	-	.5	.3	1.3
Other sandstone	1.1	.8	.5	-	.2	1.1	-	8.7	-	1.9	1.4	3.7	-	1.0	.3	.5
Vein quartz	.3	-	-	.7	.5	-	1.2	-	.6	-	-	-	1.1	.5	-	-
Felsic volcanic rocks	6.5	5.3	13.2	1.5	3.0	4.1	.9	5.9	3.3	4.1	4.7	4.1	6.2	6.9	4.2	4.5
Other volcanic rocks	.3	-	.5	-	-	-	-	-	.6	-	-	-	-	-	-	-
Granitic rocks	.5	.8	.5	-	-	.3	-	-	-	-	-	-	-	.5	-	-
Other	.8	.8	4.2	1.2	1.2	.8	.7	1.8	17.7	2.8	2.5	-	.6	.3	1.4	2.1
Total (percent)	100.0	99.9	100.0	100.0	100.1	100.1	100.0	100.0	100.1	100.1	100.0	100.0	99.9	100.0	100.0	100.0
Pebbles counted	368	361	424	408	432	370	430	391	181	363	360	243	351	393	356	378
Q	0	4	6	0	1	2	0	1	1	2	0	0	0	1	0	1
I	8	6	17	2	3	5	1	9	5	5	6	5	7	8	5	5
C	92	90	77	98	96	93	99	90	94	93	94	95	93	91	95	94
Q/C	.00	.04	.07	.00	.01	.02	.00	.02	.01	.02	.00	.01	.00	.01	.00	.01
VQ	0	0	0	1	1	0	1	0	1	0	0	0	1	1	0	0
I	8	7	18	2	3	5	1	9	5	5	6	5	7	8	4	5
C	92	93	82	97	96	95	98	91	94	95	94	95	92	91	96	95

Area	northern California Coast Ranges (continued)														Or. & Cal.	
Stratigraphic unit	Franciscan assemblage (continued)														Otter Pt., Dothan, & Fran.	
Locality no.	NR-286	9	10	11	12	13	229	230	182	14	231	232	76	207	mean of 47	std. dev.
Chert	75.5	88.5	88.8	91.9	87.4	87.3	83.5	83.3	81.4	94.5	72.2	84.3	91.3	75.8	82.4	6.7
Mudstone	16.7	4.9	6.2	5.6	7.9	8.2	4.9	4.1	7.8	4.1	5.4	7.7	3.6	14.7	8.9	3.7
Quartz sandstone	1.1	-	-	1.1	-	.8	.3	.7	.3	.5	.3	.5	.2	-	.9	1.0
Other sandstone	.6	-	-	.7	-	.8	.8	1.0	1.6	-	.5	.5	-	4.7	1.0	1.5
Vein quartz	-	.5	3.7	-	.3	.3	-	.2	-	-	.5	.3	.5	-	.3	.6
Felsic volcanic rocks	4.1	5.6	1.3	.7	4.5	2.1	6.9	8.2	3.5	.5	17.0	3.6	3.6	2.2	4.5	2.9
Other volcanic rocks	-	-	-	-	-	-	-	-	-	-	.8	-	-	-	.1	.2
Granitic rocks	.3	.3	-	-	-	.3	.3	-	-	-	.8	-	-	-	.1	.2
Other	2.8	.3	-	-	-	.3	3.3	2.4	5.4	.5	2.4	3.0	.7	2.5	2.0	2.7
Total (percent)	100.1	100.1	100.0	100.0	100.1	100.1	100.0	99.9	100.0	100.1	99.9	99.9	99.9	99.9	100.2	
Pebbles counted	363	390	160	270	381	373	364	413	370	220	371	364	416	360	355	
Q	1	0	0	1	0	1	0	1	0	0	0	1	0	0	1	1
I	6	6	1	1	5	3	8	9	4	1	21	4	4	3	5	4
C	93	94	99	98	95	96	92	90	96	99	79	95	96	97	94	4
Q/C	.01	.00	.00	.01	.00	.01	.00	.01	.00	.00	.00	.01	.00	.00	.01	
VQ	0	1	4	0	0	0	0	0	0	0	1	0	0	0	0	1
I	5	6	1	1	5	3	8	9	4	1	20	4	4	3	6	4
C	95	93	95	99	95	97	92	91	96	99	79	96	96	97	94	4

Q, quartz sandstone; I, volcanic and granitic rocks; C, chert; VQ, vein quartz. Because of small pebble size and strong foliation, SY-429 is less accurate than others.

Table C. Pebble counts of conglomerates rich in volcanic clasts in the northern California Coast Ranges and southwestern Oregon.

Area	northern California Coast Ranges											
Stratigraphic unit	Great Valley sequence											
Locality no.	15	16	17	18	210	211	212	213	214	215	mean of 10	std. dev.
Chert	-	1.6	-	-	.5	1.1	2.9	-	-	-	.6	1.0
Mudstone	1.9	.6	-	1.2	.5	.5	1.3	1.8	-	3.3	1.1	1.0
Quartz sandstone	-	.3	-	-	-	-	-	-	.3	.8	.1	.3
Other sandstone	-	.3	-	-	-	-	.5	2.3	.3	.3	.4	.7
Vein quartz	.4	.3	-	-	.3	.3	.3	-	.3	.3	.2	.2
Felsic volcanic rocks	85.1	85.5	86	60.2	65.9	68.4	75.1	53.0	78.1	55.7	71.3	12.5
Other volcanic rocks	5.8	-	6	27.7	12.0	16.8	1.0	3.4	5.7	7.7	8.6	8.3
Granitic rocks	5.7	8.8	7	10.1	19.7	11.4	17.9	33.2	13.1	27.0	15.4	8.9
Other	1.1	2.5	1	.9	2.1	1.6	1.0	6.2	2.3	4.9	2.4	1.8
Total (percent)	100.0	99.9	100	100.1	100.0	100.1	100.0	99.9	100.1	100.0	100.1	
Pebbles counted	262	318	100	347	376	376	385	385	351	366	327	
Q	0	0	0	0	0	0	0	0	0	1	0	0
I	100	98	100	100	99	99	97	100	100	99	99	1
C	0	2	0	0	1	1	3	0	0	0	1	1
Q/C	.00	.19	.00	.00	.00	.00	.00	.00	-	-	.17	
VQ	0	0	0	0	0	0	0	0	0	0	0	0
I	100	98	100	100	99	99	97	100	100	100	99	1
C	0	2	0	0	1	1	3	0	0	0	1	1
Age	Val.	Val.	Val.	Val.	-	Val.	Tith.	Val.	Tith.	Val.		

Area	southwest Oregon	northern California Coast Ranges												Or. & Cal.	
Stratigraphic unit	Otter Point Formation	Franciscan assemblage												Otter Pt. & Franciscan	
Locality no.	183	BH-358	SH-425	BL-612	SY-281	BR-296	LL-291	LLM-37	CE-284	19	CK-273	216	217	mean of 13	std. dev.
Chert	-	1.4	2.8	.3	1.9	-	-	2.2	2.3	1.4	1.3	1.0	1.2	1.2	.9
Mudstone	4	.5	14.3	4.6	.8	-	1.4	-	5.3	.5	12.1	7.0	1.2	4.0	4.7
Quartz sandstone	-	-	1.4	-	1.6	-	1.1	.5	-	-	1.6	2.6	-	.7	.9
Other sandstone	-	.9	11.1	1.1	12.8	-	.3	-	2.3	-	3.2	9.1	-	3.1	4.6
Vein quartz	-	-	.5	.3	.3	-	-	-	.4	-	.3	-	.9	.2	.3
Felsic volcanic rocks	85	84.6	54.1	84.3	69.9	34.0	75.4	44.5	78.6	90.1	72.6	74.3	83.6	71.6	17.1
Other volcanic rocks	8	-	2.3	.9	4.8	26.0	.3	12.1	-	.5	1.6	2.3	.3	4.5	7.4
Granitic rocks	1	10.4	8.5	8.3	5.6	-	18.2	1.6	10.5	7.1	6.3	1.3	12.4	7.0	5.3
Blueschist	-	-	-	-	-	40.0	-	36.3	-	-	-	-	-	5.8	14.3
Other	2	2.3	5.1	.3	2.4	-	3.3	2.7	.8	.5	1.1	2.3	.6	1.8	1.4
Total (percent)	100	100.1	100.1	100.1	100.1	100.0	100.0	99.9	100.2	100.1	100.1	99.9	100.2	100.0	
Pebbles counted	129	221	434	350	376	350	362	182	266	212	380	385	347	307	
Q	0	0	2	0	2	0	1	1	0	0	2	3	0	1	1
I	100	99	94	100	96	100	99	97	98	99	96	96	99	98	2
C	0	1	4	0	2	0	0	2	2	1	2	1	1	1	1
Q/C	.00	.00	.50	-	.86	-	-	.25	.00	.00	1.2	2.50	.00	.56	
VQ	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0
I	100	99	95	100	97	100	100	98	97	99	98	99	98	99	2
C	0	1	4	0	2	0	0	2	3	1	2	1	1	1	1

Q, quartz sandstone ; I, volcanic and granitic rocks and blueschist; C, chert; VQ, vein quartz.

Table D. Pebble counts of mixed-clast conglomerates, mainly rich in chert and volcanic rocks, from the Great Valley sequence of the northern California Coast Ranges, and from mainly Valanginian conglomerates in western outliers of the Great Valley sequence both north and east to southeast of San Francisco.

Area: west side of Sacramento Valley and Middle Mountain area

Locality no.	21	22	20	27	23	28	25	24	26	LB-392	218	mean of 11	std. dev.
Chert	28.3	11.8	57.3	6.6	36.3	22.5	9.7	31.3	19.6	1.1	23.6	22.6	15.8
Mudstone	6.9	20.2	1.8	7.1	6.5	7.4	2.8	10.7	8.1	7.8	8.0	7.9	4.8
Quartz sandstone	1.7	1.3	3.7	-	3.1	.3	1.6	5.0	2.4	1.4	1.2	2.0	1.5
Other sandstone	6.9	6.3	2.8	3.1	14.6	5.2	1.2	6.7	7.8	2.5	4.7	5.6	3.6
Vein quartz	1.2	.8	4.6	-	4.3	1.8	1.2	3.5	2.4	-	2.1	2.0	1.6
Felsic volcanic rocks	45.1	54.6	16.5	69.9	29.2	59.4	78.2	22.9	58.1	60.3	58.4	50.2	19.6
Other volcanic rocks	.6	-	-	.9	.3	-	-	.5	-	16.7	.9	1.8	5.0
Granitic rocks	1.7	3.8	3.7	10.2	2.2	.9	4.0	1.7	1.7	7.8	.3	3.5	3.0
Limestone	-	-	-	-	-	-	-	17.4	-	-	-	1.6	5.2
Other	7.5	1.3	9.6	2.2	3.4	2.5	1.2	.2	-	2.5	.9	2.8	3.0
Total (percent)	99.9	100.1	100.0	100.0	99.9	100.0	99.9	99.9	100.1	100.1	100.1	100.0	
Pebbles counted	173	238	219	226	322	325	321	402	296	360	339	293	
Q	2	2	4	0	4	0	2	8	3	2	1	2	2
I	61	81	25	92	45	73	88	41	73	97	71	68	23
C	37	17	71	8	51	27	10	51	24	1	28	30	21
Q/C	.06	.11	.06	.00	.08	.01	.16	.16	.12	1.25	.05	.09	
VQ	2	1	6	0	6	2	1	6	3	0	2	2	2
I	61	82	22	92	44	71	88	42	73	99	70	68	24
C	37	17	72	8	50	27	11	52	24	1	28	30	21
Age	Haut.	Haut.-Barr.	Late Val.	Cen.	Haut.-Barr.	Tur.	Alb.	Apt.-Alb.	Cen.	Tur.	Early Cret.		

Area: western outliers, north of San Francisco

Locality no.	233	82	29	GV-548	219	234	30	DM-463	31	235	32	33	NO-384	PT-385	mean of 14	std. dev.
Chert	45.3	17.6	36	34.6	42.1	25.4	27.5	27.3	19.6	49.0	52.6	47.9	41.1	46.5	36.6	11.5
Mudstone	7.7	5.0	6	5.6	5.2	2.7	10.2	8.1	5.5	2.8	4.6	6.1	5.9	2.2	5.5	2.2
Quartz sandstone	1.9	2.9	4	5.6	2.7	1.5	3.9	3.4	1.8	7.0	3.0	9.6	9.6	11.1	4.9	3.2
Other sandstone	4.9	1.4	-	1.9	5.7	2.5	4.2	3.1	1.8	3.9	5.4	6.3	1.7	2.8	3.3	1.9
Vein quartz	1.1	1.4	-	1.1	.5	2.0	1.0	.3	3.6	.8	3.5	8.0	1.7	1.7	2.0	2.0
Felsic volcanic rocks	35.2	46.2	32	37.3	35.1	54.1	43.6	50.8	54.5	30.1	25.3	17.6	31.5	27.9	37.2	11.2
Other volcanic rocks	-	20.4	10	4.3	3.3	7.2	7.1	.3	6.2	1.6	1.1	.6	1.4	1.9	4.7	5.5
Granitic rocks	1.6	2.9	5	3.8	2.2	3.5	1.4	2.9	4.7	.8	2.5	1.7	3.9	1.1	2.7	1.3
Other	2.2	2.2	7	5.9	3.3	1.0	1.2	3.9	2.2	4.1	1.9	2.2	3.1	4.7	3.2	1.7
Total (percent)	99.9	100.0	100	100.1	100.1	99.9	100.1	100.1	99.9	100.1	99.9	100.0	99.9	99.9	100.1	
Pebbles counted	364	279	100	373	368	401	590	385	275	386	367	363	355	359	355	
Q	2	3	5	7	3	1	5	4	2	8	4	12	11	13	6	4
I	44	77	54	53	48	71	62	64	75	37	34	26	42	35	51	16
C	54	20	41	40	49	28	33	32	23	55	62	62	47	52	43	14
Q/C	.04	.16	.11	.16	.06	.06	.14	.12	.09	.14	.06	.20	.23	.24	.13	
VQ	1	2	0	1	1	2	1	0	4	1	4	11	2	2	2	3
I	44	78	57	56	49	70	65	66	74	39	34	26	46	39	53	16
C	55	20	43	43	50	28	34	34	22	60	62	63	52	59	45	15
Age	only Valanginian fossils reported															

Area: western outliers, east and southeast of San Francisco; western outliers

Locality no.	236	52	53	237	238	HA-398	NI-397	54	55	88	mean of 10	std. dev.	western outliers mean of 24	western outliers std. dev.
Chert	41.1	43.8	49	47.4	43.6	39.1	27.0	35.4	33.2	31.0	39.1	7.3	37.6	9.8
Mudstone	7.1	7.1	9	4.0	6.1	2.5	6.0	17.3	5.7	8.1	7.3	4.0	6.3	3.1
Quartz sandstone	5.1	11.1	12	7.7	7.3	7.2	7.5	6.3	3.3	6.7	7.4	2.6	5.9	3.2
Other sandstone	7.1	4.9	5	3.7	5.0	4.4	7.8	5.9	2.9	1.7	4.9	1.8	3.9	2.0
Vein quartz	5.1	4.0	1	3.4	3.6	4.1	4.9	.4	.4	1.4	2.8	1.8	2.3	2.0
Felsic volcanic rocks	28.0	22.7	17	28.0	26.0	34.4	37.9	28.7	47.1	44.9	31.5	11.1	34.8	10.7
Other volcanic rocks	1.4	.2	2	2.1	1.1	.3	4.0	4.3	4.1	1.9	2.1	1.5	3.6	4.4
Granitic rocks	2.8	2.0	-	1.6	3.1	3.3	1.7	-	-	2.4	1.7	1.3	2.3	1.4
Other	2.3	4.2	5	2.1	4.2	4.7	3.2	1.6	3.3	1.9	3.3	1.2	3.2	1.5
Total (percent)	100.0	100.0	100	100.0	100.0	100.0	100.0	99.9	100.0	100.0	100.0		99.9	
Pebbles counted	353	450	131	378	358	363	348	254	244	419	330		344	
Q	7	14	15	9	9	9	9	8	4	8	9	3	7	4
I	41	31	24	36	37	45	56	44	58	56	43	11	48	15
C	52	55	61	55	54	46	35	48	38	36	48	9	45	12
Q/C	.12	.25	.24	.16	.17	.18	.28	.18	.10	.21	.19		.16	
VQ	7	6	1	4	5	5	6	1	1	2	4	2	3	3
I	41	34	28	38	39	47	58	48	60	60	45	11	50	14
C	52	60	71	58	56	48	36	51	39	38	51	11	47	14
Age	only Valanginian fossils reported												Valanginian	

Q, quartz sandstone; I, volcanic and granitic rocks; C, chert; VQ, vein quartz.

Table E. Pebble counts of conglomerates with mixed chert and volcanic clasts, high in quartz sandstone, in the Franciscan assemblage of the northern California Coast Ranges.

Locality no.	34	CY-359	CN-351	BC-338	BB-331	BL-613	BL-390	ZN-329	SB-305	BR-315	BR-312	BR-311	BR-313
Chert	21.6	37.5	47.3	47.7	59.6	62.2	28.5	36.1	42.4	65.6	40.1	43.1	46.1
Mudstone	11.3	25.0	6.2	14.4	6.0	8.0	4.4	5.0	16.8	7.3	9.5*	9.5*	9.4
Quartz sandstone	5.6	8.2	12.2	9.1	6.9	6.7	9.7	6.6	5.6	8.7	9.3	7.5	8.9
Other sandstone	1.3	11.0	3.9	2.9	1.5	2.8	1.3	6.3	5.3	1.3	5.1*	5.1*	5.9
Vein quartz	3.0	1.8	3.4	6.5	5.5	4.1	8.6	5.3	.8	.5	.6	.4	.5
Felsic volcanic rocks	48.9	12.2	19.7	12.5	14.9	11.9	32.6	30.5	23.4	10.2	24.1	22.1	22.1
Other volcanic rocks	1.7	.3	1.0	-	.7	.3	7.8	2.9	1.5	-	-	2.1	.5
Granitic rocks	5.6	.8	2.1	1.2	1.5	.8	2.1	2.9	.8	1.3	3.6	2.5	1.0
Other	3.3	3.3	4.2	5.8	3.5	3.1	5.0	4.5	3.4	5.0	7.7	7.7	5.6
Total (percent)	99.9	100.1	100.0	100.1	100.1	99.9	100.0	100.1	100.0	99.9	99.9	100.0	100.0
Pebbles counted	231	392	385	417	403	386	383	380	394	381	407	409	393
Q	7	14	15	13	8	8	12	8	7	10	12	10	11
I	67	22	28	19	21	16	53	46	35	14	36	34	30
C	26	64	57	68	71	76	35	46	58	76	52	56	59
Q/C	.26	.22	.26	.19	.12	.11	.34	.18	.13	.13	.23	.17	.19
VQ	4	4	5	10	7	5	11	7	1	1	1	1	1
I	69	25	31	20	21	16	53	47	37	15	40	38	33
C	27	71	64	70	72	79	36	46	62	84	59	61	66

Locality no.	BR-308	NY-298	NY-297	SY-282	BN-322	BN-324	BR-294	MI-328	MI-301	BN-318	BN-317	83	JR-611
Chert	43.8	16.6	9.9	18.4	33.9	32.5	22.5	35.3	63.4	32.8	31.1	58.5	28.9
Mudstone	9.8	10.7	6.6	12.0	14.2	18.2	8.5	10.8	6.5	6.2	8.8	4.8	39.2
Quartz sandstone	8.5	15.9	6.6	12.2	7.8	7.5	13.9	8.5	6.8	10.3	8.8	9.0	8.9
Other sandstone	5.3	12.9	8.9	13.0	5.2	6.8	1.8	3.8	3.3	2.1	2.7	4.5	5.2
Vein quartz	1.0	1.2	.9	.3	-	.5	.3	-	.8	1.6	1.9	1.3	3.2
Felsic volcanic rocks	24.5	33.4	56.8	33.0	32.6	28.1	43.5	32.0	16.5	41.1	42.1	19.3	11.5
Other volcanic rocks	1.5	1.0	2.1	1.3	1.8	1.3	.8	1.0	-	1.0	.3	.3	.9
Granitic rocks	1.5	4.1	5.9	4.5	1.6	1.6	.3	1.5	.3	1.8	.8	.3	.2
Other	4.3	4.1	2.3	5.3	2.8	3.6	8.4	7.3	2.4	3.1	3.5	2.1	2.1
Total (percent)	100.2	99.9	100.0	100.0	99.9	100.1	100.1	100.2	100.0	100.0	100.0	100.1	100.1
Pebbles counted	400	410	426	376	386	385	395	400	369	387	373	378	655
Q	11	22	8	18	10	11	17	11	8	12	11	10	18
I	34	54	80	56	46	43	55	44	19	50	52	23	25
C	55	24	12	26	44	46	28	45	73	38	37	67	57
Q/C	.19	.96	.67	.67	.23	.23	.62	.24	.11	.31	.28	.15	.31
VQ	1	2	1	1	0	1	0	0	1	2	2	2	7
I	38	68	86	67	51	48	66	49	21	56	57	25	28
C	61	30	13	32	49	51	34	51	78	42	41	73	65

Location no.	84	BM-545	BM-546	43	CK-274	225	85	LP-386	226	227	228	mean of 37	std. dev.
Chert	62.2	62.3	37.4	25.2	31.0	34.9	39.4	33.8	36.5	31.4	52.9	39.2	14.2
Mudstone	7.4	3.7	8.2	4.3	6.6	6.3	4.7	8.3	19.6	5.7	7.8	10.0	6.8
Quartz sandstone	7.4	5.6	11.8	6.2	7.2	10.5	10.0	9.5	13.5	10.7	5.8	8.9	2.5
Other sandstone	2.6	3.9	5.8	-	5.6	4.7	3.3	3.5	15.6	7.5	2.4	5.0	3.5
Vein quartz	3.2	1.7	.5	1.9	6.0	1.0	7.6	1.5	2.6	-	2.2	2.2	2.2
Felsic volcanic rocks	13.5	15.8	28.3	57.6	35.7	33.1	28.2	33.3	8.2	28.2	21.1	27.1	12.5
Other volcanic rocks	-	-	1.4	-	-	.5	-	.3	.5	8.7	-	1.2	1.9
Granitic rocks	.6	1.7	1.6	1.9	1.6	.3	1.2	2.5	.3	.2	2.2	1.7	1.4
Limestone	-	-	-	-	-	-	-	-	-	-	*	-	-
Other	3.2	5.4	4.9	2.9	6.3	8.7	5.6	7.5	3.3	7.5	5.6	4.7	1.9
Total (percent)	100.1	100.1	99.9	100.0	100.0	100.0	99.9	100.2	100.1	99.9	100.0	100.0	
Pebbles counted	312	355	364	210	319	381	340	400	392	401	412	383	
Q	9	7	15	7	10	13	13	12	23	13	7	12	4
I	17	20	39	65	49	43	37	45	15	47	28	38	16
C	74	73	46	28	41	44	50	43	62	40	65	50	17
Q/C	.12	.09	.32	.24	.23	.30	.25	.29	.37	.34	.11	.23	
VQ	4	2	1	2	8	1	10	2	5	0	3	3	3
I	18	22	45	69	50	49	38	51	19	54	30	42	18
C	78	76	54	29	42	50	52	47	76	46	67	55	18

* Samples 8R-311 and BR-312 contained abundant clasts of intraformational mudstone, siltstone, and feldspathic sandstone, which were ignored to facilitate counting. The values given for mudstone and other sandstone in these samples are the approximate means from other samples of the group. Sample 228 contained a few limestone clasts that were lost in processing. Q, quartz sandstone; I, volcanic and granitic rocks; C, chert; VQ, vein quartz.

Table F. Pebble counts of conglomerates with both chert and volcanic clasts, low in quartzite, low in vein quartz, in the Franciscan assemblage of the northern California Coast Ranges and correlative rocks in southwestern Oregon.

Area	Oregon						northern California Coast Ranges									
Locality no.	184	35	BL-361	36	IB-360	37	BC-337	BC-336	BK-366	BK-367	BL-280	BL-280A	AP-330	AP-388	SB-278	BR-277
Chert	54.5	29.0	38.7	44.0	35.5	32.9	35.6	30.4	39.7	33.5	53.3	38.0	32.2	30.0	36.3	50.4
Mudstone	9.6	8.5	24.4	7.7	6.7	10.0	26.3	29.3	13.1	32.1	14.9	4.6	9.1	4.8	15.1	11.3
Quartz sandstone	1.7	2.4	1.3	3.4	5.1	4.6	4.6	2.3	3.9	3.1	1.6	.8	4.0	5.1	2.2	1.8
Other sandstone	3.6	1.6	8.7	3.7	3.2	5.9	8.0	8.4	10.9	9.6	2.4	.5	6.8	5.1	8.5	4.0
Vein quartz	2.4	.4	1.5	2.2	4.0	2.7	4.4	4.1	1.7	2.9	.5	-	3.1	2.9	2.0	.5
Felsic volcanic rocks	24.4	42.7	20.1	29.8	34.7	38.5	13.9	21.7	21.7	8.8	23.7	51.9	42.2	44.0	29.3	27.2
Other volcanic rocks	.2	6.0	1.5	1.2	3.8	2.2	-	.8	.5	-	.8	-	.9	2.9	1.7	.8
Granitic rocks	.2	6.5	.5	3.1	3.2	2.2	2.9	1.3	3.9	1.0	.3	2.2	.9	2.7	1.5	1.1
Other	3.3	2.8	3.3	4.9	3.8	1.0	4.1	1.8	4.6	9.0	2.4	1.9	.9	2.4	3.4	2.9
Total (percent)	99.9	99.9	100.0	100.0	100.0	100.0	99.8	100.1	100.0	100.0	99.9	99.9	100.1	99.9	100.0	100.0
Pebbles counted	418	248	393	325	372	410	410	392	411	511	375	366	351	373	410	379
Q	2	3	2	4	6	6	8	4	6	7	2	1	5	6	3	2
I	31	64	36	42	51	53	30	42	37	21	31	58	55	59	46	36
C	67	33	62	54	43	41	62	54	57	72	67	41	40	35	51	62
Q/C	.03	.08	.03	.08	.14	.14	.13	.08	.10	.09	.03	.02	.12	.17	.06	.04
VQ	3	1	2	3	5	3	8	7	2	6	1	0	4	4	3	1
I	30	65	36	42	51	55	29	41	39	21	31	59	55	60	46	36
C	67	34	62	55	44	42	63	52	59	73	68	41	41	36	51	63

Area	northern California Coast Ranges (continued)																
Locality no.	BR-276	BR-316	BR-314	SY-283	HR-387	69	BN-300	LL-287	LL-288	BR-290	CE-421	IP-349	CW-547	JR-610	JR-609	LY-348	DR-589
Chert	44.6	70.2	41.7	58.0	14.5	23.3	45.3	37.8	42.4	39.5	32.2	60.3	53.3	24.2	57.4	46.5	25.6
Mudstone	7.3	9.3	20.6	11.3	4.4	5.4	10.0	15.2	15.3	13.0	14.6	8.0	29.5	11.2	5.5	5.9	4.9
Quartz sandstone	2.6	4.1	2.4	2.1	3.6	4.1	2.4	3.1	2.0	2.0	4.1	1.3	.8	1.9	2.6	4.6	2.2
Other sandstone	1.8	1.8	5.3	2.1	4.1	2.4	2.6	5.7	3.2	6.4	3.5	2.3	2.1	7.8	1.1	5.1	3.5
Vein quartz	1.3	.3	.3	.3	1.1	1.1	-	1.0	.7	1.0	-	1.8	.2	2.2	2.1	2.7	1.6
Felsic volcanic rocks	35.0	9.6	25.3	21.1	65.8	52.6	36.6	28.5	29.1	32.7	40.9	19.1	9.7	49.4	26.1	31.1	38.0
Other volcanic rocks	2.8	1.0	.5	-	3.0	6.0	.5	1.0	2.7	.8	.6	2.1	.2	.6	1.6	-	17.3
Granitic rocks	1.3	.5	.8	2.4	2.2	1.1	.5	2.6	1.7	1.0	.6	-	-	1.2	1.8	1.6	3.2
Other	3.4	3.1	3.2	2.6	1.4	4.1	2.1	5.1	3.0	3.6	3.5	5.2	4.2	1.6	1.8	2.4	3.8
Total (percent)	100.1	99.9	100.1	99.9	100.1	100.1	100.0	100.0	100.1	100.0	100.0	100.1	100.0	100.1	100.0	99.9	100.1
Pebbles counted	386	386	379	379	366	369	380	389	406	392	342	388	475	322	380	370	371
Q	3	5	3	3	4	5	3	4	3	3	5	2	1	3	3	5	2
I	45	13	38	28	80	68	44	44	43	45	54	25	16	66	33	39	68
C	52	82	59	69	16	27	53	52	54	52	41	73	83	31	64	56	30
Q/C	.06	.06	.06	.04	.24	.17	.05	.05	.05	.08	.13	.02	.02	.08	.05	.10	.08
VQ	1	0	0	0	1	1	0	2	1	1	0	2	0	3	2	3	2
I	46	14	39	29	82	71	45	45	44	46	57	26	16	66	33	40	68
C	53	86	61	71	17	28	55	53	55	53	43	72	84	31	65	57	30

Area	northern California Coast Ranges (continued)															Or. & Cal.	
Locality no.	81	WR-544	67	239	221	222	PV-590	44	45	70	46	47	48	223	224	mean of 48	std. dev.
Chert	22.8	21.9	17.9	36.2	29.0	30.7	32.2	32.1	29.8	18.3	36	33.2	61.1	33.1	33.3	37.5	12.2
Mudstone	4.7	5.9	4.3	10.5	7.9	6.6	9.7	9.9	4.6	5.8	4	6.3	6.1	11.4	10.0	11.0	7.1
Quartz sandstone	.6	1.1	4.6	4.4	4.1	2.5	2.8	2.7	3.2	4.3	5	4.5	5.8	2.5	3.3	3.0	1.3
Other sandstone	4.1	1.4	3.7	23.8	2.5	4.7	2.8	4.2	2.8	3.0	3	7.2	3.3	3.9	3.6	4.7	3.7
Vein quartz	1.2	.8	.6	1.7	3.3	2.2	.9	3.1	2.8	1.3	1	.9	1.9	2.5	1.7	1.6	1.1
Felsic volcanic rocks	48.0	52.0	37.2	17.7	46.3	46.8	39.3	44.7	51.4	53.3	39	41.7	19.4	39.6	42.8	34.3	13.2
Other volcanic rocks	12.3	5.1	1.7	2.2	.5	1.7	5.7	-	.9	7.8	3	3.6	-	.3	1.7	2.3	3.2
Granitic rocks	2.3	3.4	.9	.6	2.7	.3	1.7	.4	1.4	2.0	9	.9	1.9	2.8	.8	1.8	1.6
Blueschist	-	-	25.6	-	-	-	-	-	-	-	-	-	-	-	-	.5	3.7
Limestone	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	.0	.2
Other	4.1	8.4	3.5	3.0	3.6	4.4	4.8	3.1	3.2	4.1	1	1.8	.3	2.8	2.8	3.3	1.6
Total (percent)	100.1	100.0	100.0	100.1	99.9	99.9	99.9	100.2	100.1	99.9	101	100.1	99.8	100.0	100.0	100.0	
Pebbles counted	342	356	347	362	365	361	351	262	218	394	107	223	360	359	360	362	
Q	1	2	5	7	5	3	4	3	4	5	5	5	7	3	4	4	2
I	73	72	75	34	60	60	57	57	62	74	56	55	24	55	55	48	16
C	28	26	20	59	35	37	39	40	34	21	39	40	69	42	41	48	16
Q/C	.03	.06	.26	.12	.14	.08	.09	.08	.11	.24	.13	.14	.09	.08	.10	.08	
VQ	1	1	1	3	4	3	1	4	3	2	1	1	2	3	2	2	2
I	72	73	68	35	60	60	59	56	62	76	58	58	25	55	56	49	16
C	27	26	31	62	36	37	40	40	35	22	41	41	73	42	42	49	16

Q, quartz sandstone; I, volcanic and granitic rocks and blueschist; C, chert; VQ, vein quartz.

Table G. Pebble counts of conglomerates with mixed chert and volcanic clasts, high in vein quartz, low in quartz sandstone, and the mean of all mixed-clast conglomerates in the Franciscan assemblage of the northern California Coast Ranges and correlative rocks in southsestern Oregon.

Locality no.	CN-350	BK-383	BK-382	38	DI-380	PP-279	RR-391
Chert	42.5	53.6	47.9	52.6	63.3	32.8	52.4
Mudstone	14.7	3.5	5.5	3.9	6.5	11.3	13.7
Quartz sandstone	.5	3.2	2.5	1.0	2.0	2.0	2.5
Other sandstone	7.4	6.2	5.0	5.6	1.5	5.6	4.0
Vein quartz	5.7	5.7	5.0	8.9	15.9	9.6	5.2
Felsic volcanic rocks	23.4	21.7	28.4	23.5	7.2	33.1	15.2
Other volcanic rocks	-	.7	.7	-	.5	-	.5
Granitic rocks	2.2	1.7	1.5	2.6	.7	2.5	1.5
Other	3.5	3.7	3.5	2.0	2.5	3.1	5.0
Total (percent)	99.9	100.0	100.0	100.0	100.1	100.0	100.0
Pebbles counted	367	405	401	306	403	354	401
Q	1	4	3	1	3	3	3
I	37	30	38	33	11	50	24
C	62	66	59	66	86	47	73
Q/C	.01	.06	.05	.02	.03	.06	.05
VQ	8	7	6	10	18	12	7
I	35	29	37	30	10	46	23
C	57	64	57	60	72	42	70

Locality no.	39	RR-423	40	AP-368	41	42	mean of 13	std. dev.
Chert	41.1	52.3	52.6	36.5	33.3	36.5	46.0	9.5
Mudstone	14.8	6.6	7.7	8.8	6.7	7.6	8.6	3.9
Quartz sandstone	1.4	1.9	4.5	4.1	.7	1.3	2.1	1.2
Other sandstone	6.9	6.6	2.1	5.0	5.2	2.0	4.9	1.9
Vein quartz	5.7	9.1	10.8	8.8	6.0	4.8	7.8	3.2
Felsic volcanic rocks	22.9	16.8	16.4	29.3	44.0	44.6	25.1	10.9
Other volcanic rocks	1.4	-	-	-	1.1	.3	.4	.5
Granitic rocks	2.2	.3	.5	1.4	2.2	.8	1.5	.8
Limestone	1.6	5.8	-	-	-	-	.6	1.6
Other	2.0	.3	5.6	6.1	.7	2.3	3.1	1.7
Total (percent)	100.0	100.0	99.9	100.0	99.9	100.2	100.1	
Pebbles counted	494	363	426	362	268	395	380	
Q	2	3	6	6	1	1	3	2
I	38	24	23	43	58	55	36	14
C	60	73	71	51	41	44	61	13
Q/C	.03	.04	.08	.11	.02	.03	.05	
VQ	8	11	14	12	7	6	10	4
I	36	22	20	40	55	52	33	13
C	56	67	66	48	38	42	57	11

	all mixed-clast conglomerates	
	mean of 98	std. dev.
Chert	39.2	12.9
Mudstone	10.3	6.6
Quartz sandstone	5.5	3.3
Other sandstone	4.5	3.5
Vein quartz	2.7	2.8
Felsic volcanic rocks	30.3	13.1
Other volcanic rocks	1.6	2.6
Granitic rocks	1.8	1.5
Blueschist	.3	2.6
Limestone	.1	.6
Other	3.8	1.9
Total (percent)	100.1	
Pebbles counted, mean	373	
Q	7	5
I	43	17
C	50	17
Q/C	.14	
VQ	4	4
I	44	17
C	52	16

Q, quartz sandstone; I, volcanic and granitic rocks; C, chert; VQ, vein quartz.

Locations of sampled conglomerates. Supersedes previously published locations, some of which are in error. Except as noted, locations are given by 7.5 minute quadrangle and 1000-meter Universal Transverse Mercator grid.

Table A. 181 - Marial 15', 4,724,470N, 420,100E. 74 - Collier Butte 15', 4,689,380N, 405,200E. 75 - Collier Butte 15', 4,690,290N, 405,840E. 1 - Naufus Creek, 4,472,550N, 478,490E. 2 - Blocksburg 15', 4,465,220N, 454,050E. 72 - Paskenta, 4,422,270N, 535,620E. PK-321 - Paskenta, 4,421,470N, 532,830E. 196 - Newville, 4,404,650N, 540,730E. NV-320 - Newville, 4,399,930N, 540,550E. EC-319 - Elk Creek 15', 4,395,360N, 536,000E. 3 - Elk Creek, 4,380,950N, 533,940E. 73 - Stonyford, 4,364,140N, 542,060E. 4 - Wilbur Springs 15', 4,339,850N, 546,920E. 5 - Wilbur Springs 15', 4,335,720N, 548,400E. 197 - Lake Pillsbury, 4,361,800N, 504,300E. 198 - Potato Hill, 4,352,800N, 518,200E. 199 - Clearlake Oaks 15', 4,334,410N, 529,150E. 200 - Wilbur Springs 15', 4,319,170N, 550,500E. 201 - Knoxville, 4,330,830N, 555,150E. 202 - Jericho Valley, 4,297,080N, 548,720E. 203 - St. Helena 15', 4,279,440N, 547,660E. 204 - Walter Springs, 4,280,250N, 563,050E. 205 - Walter Springs, 4,279,870N, 562,940E. 206 - Chiles Valley, 4,262,840N, 600,480E. 6 - Capell Valley, 4,255,370N, 571,350E. 208 - Knoxville, 4,300,690N, 554,910N. 209 - Knoxville, 4,300,730N, 554,950E.

Table B. 77 - Gold Beach 15', 4,705,670N, 383,220E. 78 - Gold Beach 15', 4,702,610N, 388,210E. 79 - Gold Beach 15', 4,699,800N, 387,400E. 80 - Cape Ferrelo 15', 4,658,180N, 391,190E. FR-357 - French Camp Ridge, 4,555,500N, 430,780E (approx.). BL-362 - Blue Lake 15', 4,537,800N, 434,500E. MC-333 - Maple Creek, 4,520,040N, 430,710E. BC-332 - Board Camp Mtn., 4,509,020N, 438,830E. BC-334 - Board Camp Mtn., 4,505,100N, 441,190E. BC-335 - Board Camp Mtn., 4,500,830N, 443,600E. SH-363 - Showers Mtn., 4,497,110N, 446,570E. BK-365 - Blake Mtn., 4,485,970N, 451,810E. DI-381 - Dinsmore, 4,481,340N, 455,160E. RR-424 - Ruth Reservoir, 4,466,800N, 463,430E. BR-310 - Black Rock Mtn. 7.5' X 15', 4,444,710N, 489,100E. BR-306 - Black Rock Mtn. 7.5' X 15', 4,442,000N, 481,070E. FC-307 - Four Corners Rock 7.5' X 15', 4,439,030N, 487,425E. LR-304 - Long Ridge, 4,437,470N, 475,830E. LR-303 - Long Ridge, 4,432,680N, 476,720E. LR-302 - Long Ridge, 4,428,600N, 477,860E. FC-323 - Four Corners Rock 7.5' X 15', 4,428,880N, 487,590E. FC-292 - Four Corners Rock 7.5' X15', 4,428,320N, 493,100E. FC-293 - Four Corners Rock 7.5' X 15', 4,428,680N, 496,225E. BN-325 - Bluenose Ridge, 4,423,940N, 484,730E. LL-289 - Leech Lake Mtn., 4,423,200N, 495,070E. SY-429 - South Yolla Bolly 7.5' X 15', 4,429,340N, 519,920E. BR-295 - Buck Rock, 4,422,380N, 505,060E. MI-327 - Mina, 4,419,550N, 477,420E. 7 - Buck Rock, 4,414,560N, 504,310E. 8 - Mendocino Pass, 4,411,000N, 507,740E. CE-326 - Covelo East, 4,410,490N, 484,140E. CE-420 - 4,411,620N, 487,540E. NR-285 - Newhouse Ridge, 4,408,550N, 491,210E. NR-286 - Newhouse Ridge, 4,409,370N, 492,820E. 9 - Mendocino Pass, 4,409,390N, 504,310E. 10 - Newhouse Ridge, 4,406,620N, 495,370E. 11 - Mendocino Pass, 4,406,390N, 506,300E. 12 - Mendocino Pass, 4,406,370N, 500,200E. 13 - Newhouse Ridge, 4,403,260N, 491,830E. 229 - Alder Springs, 4,395,630N, 530,710E. 230 - Alder Springs, 4,395,380N, 531,110E. 182 - Hull Mtn., 4,384,470N, 505,580E. 14 - Kneecap Ridge, 4,383,160N, 510,950E. 231 - Kneecap Ridge, 4,378,970N, 511,520E. 232 - Kneecap Ridge, 4,376,420N, 512,070E. 76 - Stonyford, 4,366,520N, 535,720E. 207 - Capell Valley, 4,261,320N, 566,370E.

Table C. 15 - Elk Creek, 4,384,560N, 540,540E. 16 - Lakeport 15', 4,335,500N, 507,210E. 17 - Lower Lake, 4,303,240N, 537,170E. 18 - Middletown, 4,300,500N, 541,010E. 210 - Jericho Valley, 4,289,880N, 550,540E. 211 - Jericho Valley, 4,289,710N, 550,540E. 212 - Knoxville, 4,302,040N, 554,390E. 213 - Knoxville, 4,301,620N, 555,830E. 214 - Walter Springs, 4,280,500N, 563,050E. 215 - Walter Springs, 4,280,920N, 563,080E. 183 - Cape Ferrelo 15', 4,667,870N, 387,290E. BH-358 - Bald Hills, 4,559,410N, 422,490E. SH-425 - Sportshaven, 4,472,170N, 462,930E. BL-612 - Black Lassic, 4,463,970N, 457,170E. SY-281 - South Yolla Bolly 7.5' X 15', 4,430,900N, 517,310E. BR-296 - Buck Rock, 4,424,610N, 506,350E. LL-291 - Leech Lake Mtn., 4,423,310N, 497,860E. LLM-37 - Leech Lake Mtn., 4,419,930, 495,325. CE-284 - Covelo East, 4,401,940N, 487,180E. 19 - Newhouse Ridge, 4,400,620N, 494,700E. CK-273 - Crockett Peak, 4,371,590N, 512,340E. 216 - St. John Mtn., 4,370,180N, 521,940E. 217 - Potato Hill, 4,352,510N, 512,190E.

Table D. 21 - Chanchelulla Peak 15' 4,463,940N, 513,570E. 22 - Colyear Springs 15', 4,450,630N, 526,400E. 20 - Lowrey, composite sample, 4,438,050N, 532,240E, and 4,437,750N, 532,320E. 27 - Lowrey, 4,438,820N, 538,180E. 23 - Lowrey, 4,436,770N, 535,500E. 28 - Lowrey, 4,430,320N, 541,750E. 25 - Potter Valley 15', 4,360,620N, 489,700E. 24 - Wilbur Springs 15', 4,334,310N, 550,540E. 26 - Wilbur Springs 15', 4,333,770N, 555,230E. LB-392 - Lake Berryessa 15', 4,262,800N, 578,080E. 218 - Chiles Valley, 4,261,970N, 563,010E. 233 - Cloverdale, 4,291,040N, 497,970E. 82 - Skaggs Springs, 38°44'07"N, 123°00'35"W. 29 - Geyserville, 4,287,800N, 501,320E. GV-548 - Geyserville, 4,284,300N, 506,610E. 219 - Geyserville, 4,279,740N, 510,700E. 234 - Healdsburg, 4,274,020N, 514,770E. 30 - Fort Ross, 4,265,130N, 488,120E. DM-463 - Duncans Mills, 4,254,900N, 491,400E. 31 - Duncans Mills, 4,252,310N, 491,720E. 235 - Novato, 4,218,480N, 541,610E. 32 - Novato, 4,217,450N, 542,850E. 33 - Novato, 4,217,400N, 542,250E. NO-384 - Novato, 4,217,400N, 543,260E. PT-385 - Petaluma Point, 4,217,930N, 544,720E. 236 - Oakland East, 4,178,940N, 576,520E. 52 - Hayward, 4,176,000N, 577,670E. 53 - Hayward, 4,173,800N, 579,280E. 237 - Hayward, 4,170,290N, 581,850E. 238 - Hayward, 4,165,620N, 586,210E. HA-398 - Hayward, 4,164,800N, 585,720E. NI-397 - Niles, 4,159,770N, 589,500E. 54 - Niles, 4,159,440N, 589,960E. 55 - Calaveras Reservoir, 4,139,230N, 604,120E. 88 - Lick Observatory, 4,126,810N, 612,790E.

Table E. 34 - Rodgers Peak, 4,561,240N, 406,940E. CY-359 - Coyote Peak 15', 4,544,890N, 418,500E, float boulder. CN-351 - Crannell, 4,542,140N, 413,180E. BC-338 - Board Camp Mtn., 4,498,520N, 446,430E (approx.). BB-331 - Blocksburg, 4,463,450N, 443,800E. BL-613 - Black Lassic, 4,463,943N, 457,360E. BL-390 - Black Lassic, 4,462,470N, 449,480E. ZN-329 - Zenia, 4,444,520N, 459,550E. SB-305 - Shannon Butte, 4,450,550N, 475,290E. BR-315 - Black Rock Mtn. 7.5' X 15', 4,447,010N, 489,280E. BR-312 - Black Rock Mtn. 7.5' X 15', 4,444,500N, 494,010E. BR-311 - Black Rock Mtn. 7.5' X 15', 4,443,575N, 492,070E. BR-313 - Black Rock Mtn. 7.5' X 15', 4,443,270N, 495,180E. BR-308 - Black Rock Mtn. 7.5' X 15', 4,443,080N, 488,860E. NY-298 - North Yolla Bolly 7.5' X 15', 4,442,920N, 506,980E. NY-297 - North Yolla Bolly 7.5' X 15', 4,442,430N, 508,670E. SY-282 -South Yolla Bolly 7.5' X 15', 4,432,975N, 517,210E. BN-322 - Bluenose Ridge, 4,426,450N, 485,800E. BN-324 - Bluenose Ridge, 4,427,010N, 486,440E. BR-294 - Buck Rock, 4,422,020N, 501,580E. MI-328 - Mina, 4,420,490N, 476,010E. MI-301 - Mina, 4,418,480N, 473,320E. BN-318 - Bluenose Ridge, 4,420,910N, 487,200E, stream boulder. BN-317 - Bluenose

Ridge, 4,417,180N, 485,040E. 83 - Newhouse Ridge, 4,402,260N, 491,800E. JR-611 - Jamison Ridge, 4,395,610N, 487,700E. 84 - Thatcher Ridge, 4,393,910N, 499,510E. BM-545 - Brushy Mtn., 4,385,300N, 483,420E. BM-546 - Brushy Mtn., 4,381,700N, 485,940E. 43 - Hull Mtn., 4,378,310N, 504,160E. CK-274 - Crockett Peak, 4,368,470N, 513,620E. 225 - Crockett Peak, 4,366,550N, 520,720E. 85 - St. Johns Mtn., 4,367,810N, 522,390E. LP-386 - Lake Pillsbury, 4,359,610N, 503,330E. 226 - Fouts Springs - 4,355,400N, 521,550E. 227 - Potato Hill, 4,345,000N, 520,060E, stream boulder, probably derived from large landslide to the east. 228 - Lake Berryessa, 4,265,660N, 565,690E.

Table F. 184 - Marial 15', 4,708,710N, 422,080E. 35 - Trinidad, 4,546,420N, 403,390E. BL-361 - Blue Lake 15', 4,537,180N, 433,330E. 36 - Arcata South, 4,520,910N, 413,860E. IB-360 - Iaqua Buttes 15', 4,503,930N, 429,310E. 37 - Iaqua Buttes 15', 4,498,390N, 425,800E. BC-337 - Board Camp Mtn., 4,497,660N, 446,810E (approx.). BC-336 - Board Camp Mtn., 4,497,530N, 446,750E (approx.). BK-366 - Blake Mtn., 4,485,800N, 452,900E (approx.). BK-367 - Blake Mtn., 4,484,970N, 455,940E (approx.). BL-280 - Black Lassic, 4,464,660N, 453,470E. BL-280A - Same as BL-280. AP-330 - Alderpoint, 4,453,050N, 448,100E. AP-388 - Alderpoint, 4,444,390N, 449,180E. SB-278 - Shannon Butte, 4,449,290N, 473,350E. BR-277 - Black Rock Mtn. 7.5' X 15', 4,451,050N, 485,900E. BR-276 - Black Rock Mtn. 7.5' X 15', 4,450,940N, 486,210E. BR-316 - Black Rock Mtn. 7.5' X 15', 4,449,125, 488,150E. BR-314 - Black Rock Mtn. 7.5' X 15', 4,446,010N, 496,440E. SY-283 - South Yolla Bolly 7.5' X 15', 4,433,520N, 515,450E. HR-387 - Harris, 4,439,360N, 439,840E. 69 - Legett 15', 4,421,000N, 450,800E. BN-300 - Bluenose Ridge, 4,417,300N, 478,910E. LL-287 - Leech Lake Mtn., 4,414,200N, 492,650E. LL-288 - Leech Lake Mtn., 4,416,460N, 498,580E, stream boulder. BR-290 - Buck Rock, 4,417,620N, 500,430E. CE-421 - Covelo East, 4,408,840N, 484,770E. IP-349 - Iron Peak, 4,408,500N, 461,430E. CW-547 - Covelo West, 4,403,400N, 477,290E. JR-610 - Jamison Ridge, 4,391,010N, 488,870E. JR-609 - 4,390,000N, 489,200E. LY-348 - Laytonville, 4,388,200N, 465,600E. DR-589 - Dos Rios, 4,386,520N, 476,800E. 81 - Willis Ridge, 4,381,340N, 474,300E. WR-544 - Willis Ridge, 4,373,100N, 472,190E. 67 - Potter Valley 15', 4,370,210N, 495,090E. 239 - Lake Pillsbury, 4,370,490N, 506,000E. 221 - Lake Pillsbury, 4,363,020N, 501,400E. 222 - Crockett Peak, 4,360,500N, 511,800N, stream boulder. PV-590 - Potter Valley 15', 4,345,440N, 487,630E. 44 - Lake Pillsbury 15', 4,351,560N, 507,500E. 45 - Lakeport 15', 4,344,300N, 512,740E. 70 - Ukiah 15', 4,336,840N, 478,800E. 46 - Lakeport 15', 4,333,450N, 500,150E. 47 - Hopland, 4,314,580N, 449,720E. 48 - The Geysers, 4,298,800N, 519,300E. 223 - Chiles Valley, 4,272,560N, 560,510E. 224 - Chiles Valley, 4,271,830N, 561,250E.

Table G. CN-350 - Crannell, 4,542,300N, 406,720E. BK-383 - Blake Mtn., 4,485,010N, 449,240E. BK-382 - Blake Mtn., 4,483,590N, 451,090E. 38 - Dinsmore, 4,480,020N, 452,870E. DI-380 - Dinsmore, 4,478,040N, 457,110E. PP-279 - Sportshaven, 4,471,900N, 461,170E. RR-391 - Ruth Reservoir, 4,463,670N, 465,950E. 39 - Ruth Reservoir, 4,459,580N, 466,610E. RR-423 - 4,458,850N, 423,090E. 40 - Ruth Reservoir, 4,456,700N, 462,170E AP-368 - Alderpoint, 4,445,750N, 447,740E. 41 - Jewett Rock, 4,431,580N, 448,530E. 42 - Updegraff Ridge, 4,427,550N, 467,760E.