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AGE AND CORRELATION OF THE CALERA LIMESTONE IN THE PERMANENTE TERRANE OF NORTHERN CALIFORNIA

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Abstract

Planktonic foraminifers indicate that outcrops of Calera Limestone from the Permanente terrane in the Franciscan Complex of northern California range in age from possibly as old as Barremian to late Turonian. Underlying black limestone, which is devoid of planktonic foraminifers, presumably is Barremian in age or older. The top of the sequence exposed in major quarries is always faulted. Improved biostratigraphic resolution shows two patterns of missing time intervals. The primary pattern, which is found at all localities and involves missing planktonic foraminiferal zones in the late Aptian to early Albian and the late Albian, is linked to paleoceanographic changes in the Cretaceous Pacific Ocean. The secondary pattern, which is found at the scattered outcrops outside the major quarries and involves missing zones in the Albian and Cenomanian, suggests the results of a common tectonic history related to the accretion of a large seamount.

Introduction

Limestone in the Franciscan Complex of northern California has received considerable attention despite its rare occurrence and limited distribution. Understanding the age and origin of the limestone has been critical to interpreting the tectonic history of Franciscan terranes, as the limestone represents an undisputed component of the oceanic suite that includes mafic volcanic rocks and chert. One such Franciscan terrane, the Permanente terrane of the San Francisco peninsula (Blake et al., 1982, 1984), contains the largest and most extensive exposures of limestone in the Franciscan Complex (Fig. 1). Referred to as the Calera Limestone (Lawson, 1902), the exposures consist of a series of isolated blocks and linear outcrops that generally parallel the northwest-southeast trend of the Permanente terrane from the coast at Rockaway Beach near Pacifica (Fig. 2) to the northern portion of the San Juan Bautista 15' Quadrangle about 100 km to the south (Allen, 1946; Walker, 1950; Bailey and Everhart, 1964). Numerous quarries located along the trend of the limestone, such as the Pacifica Quarry at the type locality of the Calera Limestone (Fig. 2, loc. 1), provide the most extensive exposures.

The Calera Limestone typically consists of light-grey to black micrite interbedded with replacement chert, although rare occurrences of pink micrite and oolitic to pelletal-bioclastic limestone also occur. Bailey et al. (1964) distinguished the white weathering, light to dark-grey "Calera-type" limestone from the less common pink to red "Laytonville-type" limestone named for exposures north of the San Francisco Bay area near Laytonville, California. Early studies based on planktonic foraminifers showed that the two limestone "types" are correlative in part (see Sliter, 1984, for review).

The origin of the limestone in the Franciscan Complex has received equal attention. Early studies recognized the oceanic character of the deposits but attributed their origin to chemical precipitation (Lawson, 1914; Bailey et al., 1964). Garrison and Bailey (1967) first demonstrated the pelagic origin of the micritic limestone in the Franciscan Complex based on the discovery of calcareous nannofossils and raised the possibility of a seamount origin. Paleomagnetic studies have added an important dimension in describing large-scale tectonic transport from low-latitude, mid-ocean sites of deposition (Alvarez et al., 1980; Courtillot et al., 1985; Tarduno et al., 1985; Tarduno et al., 1986). Accordingly, the Calera Limestone is thought to represent the obducted cap of one or more accreted oceanic plateaus that formed on the Farallon plate (Tarduno et al., 1985). As such, the Calera Limestone provides an exposed record of Cretaceous paleoceanography from the eastern North Pacific that otherwise was largely obliterated by plate motion and subduction processes.

Here we present a progress report on the dating of the Calera Limestone at 24 major outcrops within the Permanente terrane (Fig. 2) and correlate these outcrops by means of planktonic foraminifers. Field work was done as part of the San Jose-San Francisco Region Mapping Project in the Office of Regional Geology. The improved biostratigraphy substantiates or improves the age data in Sliter (1984) and provides a temporal framework for interpreting both local structural complexities and the tectonic history of these oceanic rocks.

Biochronology

The biozonation used is that of Sliter (1989a) which was developed for Cretaceous planktonic foraminifers examined in thin section (Fig. 3). Species identifications in thin section are based on an evolutionary sequence of morphologic criteria recognizable in axial (parallel to the axis of coiling) or transverse (perpendicular to the axis of coiling) sections. These criteria include test size and shape, the character of the test wall and periphery, chamber shape, number and arrangement, and the forms of ornamentation. The result is a zonal scheme based on the stratigraphic distribution of planktonic foraminifers that is correlated to the magneto-geochronology of Harland et al. (1982) and Kent and Gradstein (1985). Utilizing this technique, outcrops of Calera Limestone dated to stage or multistage level now have a mean stratigraphic resolution of 0.75 m.y. In specific time intervals the resolution is less than 0.5 m.y.

The zonation in Figure 3 incorporates new data from Leckie and Bralower (1991) and Coccioni et al. (1992) that revises the ages of Barremian and early Aptian planktonic foraminifers. As a consequence, the oldest outcrops previously dated as early Aptian (Sliter, 1989b) are now known to be Barremian in age.

Limestone Localities and Ages

Reported here are age determinations for the 24 measured sections and isolated outcrops shown in Figure 2 and listed in Table 1. The localities, numbered from north to south, are shown topographically in figures 4-13. The localities are grouped in three major areas within the Permanente terrane that is located adjacent to the San Andreas fault zone and bounded either to the east or west by subparallel faults (Fig. 2). The areas from north to south are: The Calera area, the Black Mountain area and the larger New Almaden-Gilroy area. Within these areas each locality is described in terms of its selected age-indicator species and correlative planktonic foraminiferal zones as shown in Figures 14-16. Larger outcrops and quarries were dated by means of numerous samples taken from measured sections. Smaller outcrops were dated by taking samples from the top and bottom of each outcrop and examining intervening samples by hand lens. For illustrations of the diagnostic species we refer the readers to Sliter (1984, 1989a, in press) and Sliter and Premoli Silva (1990).

Calera Area

Datable planktonic foraminifers are found at nine limestone localities (Fig. 2, locs. 1-9) exposed in two subparallel belts bounded by the San Mateo and Pilarcitos Faults from the Pacific coast, south to Highway 92. Planktonic foraminifers from this area range in age from early Aptian to late Cenomanian (Fig. 14).

Locality 1. The second largest exposure of limestone in the Permanente terrane occurs at Pacifica Quarry, just north of Rockaway Beach (Fig. 4). The quarry at the mouth of the Calera Valley is located at the type area of the Calera Limestone (Lawson, 1902; 1914). The dated section consists of 48 m of light-grey to black limestone and chert of early Aptian to late Cenomanian age that overlies 61.5 m of black limestone and chert devoid of planktonic foraminifers and that is presumably Barremian or older in age. Fourteen biozones and three subzones are identified based on the first and last occurrence of zonal index fossils (Fig. 14). The section extends from the early Aptian *Globigerinelloides blowi* Zone to the late Cenomanian *Dicarinella algeriana* Subzone of the *Rotalipora cushmani* Zone. All the primary indicator species described and illustrated by Sliter (1989a) are present. Missing from the section are the lower part of the late Aptian *Ticinella bejaouaensis* Zone, as well as, the late Albian *Rotalipora subticinensis* Subzone of the *Biticinella breggiensis* Zone, and the *Rotalipora ticinensis* Zone.

Locality 2. Massive light-grey to black limestone and black chert about 20 m thick cropping out on a knoll near the center of Rockaway Beach (Fig. 4) contains planktonic foraminifers from the middle Aptian *Globigerinelloides algerianus* Zone. The presence of *G. algerianus* together with *Planomalina cheniourensis* indicates the age of the outcrop is limited to the upper part of the zone (Fig. 14).

Locality 3. Light-grey, heavily-veined limestone and chert exposed in an 8 m section at Royce Quarry, less than a mile southwest of Pacifica Quarry (Fig. 4), ranges in age from middle Albian *Ticinella praeticinensis* Subzone of the *Biticinella breggiensis* Zone to the middle Cenomanian *Rotalipora greenhornensis* Subzone of the *Rotalipora cushmani* Zone (Fig. 14). Planktonic foraminifers are poorly preserved and often tectonically deformed.

Nevertheless, species present include the zonal indicators in addition to taxa such as *Ticinella roberti, Planomalina buxtorfi* and *Praeglobotruncana gibba.* Missing from the section are the late Albian *Rotalipora subticinensis* Subzone of the *Biticinella breggiensis* Zone and the *Rotalipora ticinensis* Zone.

Locality 4. East facing hillside exposure about 10 m thick of medium-grey, heavily veined limestone and black chert in the North Fork of San Pedro Creek (Fig. 4) along the trend of Pacifica and Royce Quarries contains middle Albian foraminifers from the *Ticinella praeticinensis* Subzone of the *Biticinella breggiensis* Zone (Fig. 14). Planktonic foraminifers are poorly preserved and tectonically deformed.

Locality 5. Light-grey, mostly recrystallized, heavily-veined limestone and light-grey chert exposed as small blocky patches about 2 to 5 m thick along the Middle Fork of San Pedro Creek (Fig. 4) in the lower limestone belt is assigned to the Late Albian *Rotalipora appenninica* Zone (Fig. 14). Species present include the nominal species and *Rotalipora ticinensis* and *Praeglobotruncana stephani.*

Locality 6. Three meter high exposure of medium-grey, mostly recrystallized, heavily-veined limestone and black chert exposed at the northwest end of Fifield Ridge in the northern belt (Fig. 4) is placed in the Aptian *Hedbergella gorbachikae* Zone (Fig. 14) on the presence of abundant *Hedbergella trocoidea* and rare *Globigerinelloides barri, Hedbergella gorbachikae* and *Planomalina cheniourensis,* and the lack of *Globigerinelloides algerianus.*

Locality 7. Two meter thick outcrop of medium-grey, heavily-veined limestone and black chert exposed on the southwest side of the road atop Spring Valley Ridge in the southern belt (Fig. 5) is assigned to the *Ticinella praeticinensis* Subzone of the *Biticinella breggiensis* Zone (Fig. 14). Present are the nominal species plus *Ticinella roberti.*

Locality 8. Several small (1-3 m square) outcrops of medium-grey, heavily-veined limestone exposed along the southwest side of the road atop Cahill Ridge in the southern belt (Fig. 5) is placed in the middle Aptian *Globigerinelloides algerianus* Zone (Fig. 14). Species present include the nominal species plus *Globigerinelloides barri, G. ferreolensis, Hedbergella trocoidea* and *Planomalina cheniourensis.*

Locality 9. Northeast facing wall in long abandoned quarry that exposes a 20 m thick section of deeply weathered and fractured, mostly recrystallized, medium-grey, heavily-veined limestone and black chert in the northern belt at Highway 92 (Fig 6) is late Albian in age. Planktonic foraminifers present indicate that the section includes the *Ticinella praeticinensis* Subzone of the *Biticinella breggiensis* Zone and the *Rotalipora appenninica* Zone (Fig. 14). Missing are the *Rotalipora subticinensis* Subzone of the *Biticinella breggiensis* Zone and the *Rotalipora ticinensis* Zone.

Black Mountain Area

Six limestone localities (Fig. 2, locs. 10-15) in the vicinity of Black Mountain near Cupertino contain datable planktonic foraminifers. The dated localities range in age from early Aptian to late Turonian (Fig. 15).

Locality 10. The southwest facing hillside of Black Mountain (Fig. 7) consists of a sequence of medium-grey limestone and chert overlying basalt that is repeated by at least three low-angle thrust faults. The age of the limestone ranges from late Aptian to middle Turonian. The oldest dated samples were recovered from the base of a prominent 4 m thick bed located in the middle of the hillside. These samples are assigned to the late Aptian *Ticinella bejaouaensis* Zone on the presence of the nominal species plus abundant *Hedbergella trocoidea,* and rare *Planomalina cheniourensis* (Fig. 15). Limestone samples of Albian age are assigned to the middle Albian *Ticinella praeticinensis* Subzone of the *Biticinella breggiensis* Zone and to the late Albian *Rotalipora appenninica* Zone. Again missing are the *Rotalipora subticinensis* Subzone of the *Biticinella breggiensis* Zone and the *Rotalipora ticinensis* Zone. Limestone of Cenomanian age is represented by the *Rotalipora greenhornensis* Subzone of the *Rotalipora cushmani* Zone. Samples of Turonian age, found both in narrow 2-3 meter beds at the base of the hillside and massive limestone at the crest of Black Mountain, are assigned to the middle Turonian *Helvetoglobotruncana helvetica* Zone. Ages of the Albian, Cenomanian, and Turonian limestone found both above and below the limestone of Aptian age are based on the presence of well preserved planktonic foraminifers that include the nominal species, as well as, characteristic secondary species. Missing from the sequence of repeated limestone and basalt, are planktonic foraminifers of late Aptian to middle Albian, late Albian, early Cenomanian, and late Cenomanian to early Turonian age.

Locality 11. Medium-grey, heavily-veined, limestone with black chert of Aptian and Albian age is exposed in a small 3 m outcrop on the northeastern hillside of Black Mountain (Fig. 7). Planktonic foraminifers of late Aptian age are assigned to the *Ticinella bejaouaensis* Zone (Fig. 15) on the presence of the nominal species plus abundant *Hedbergella trocoidea,* and rare *Planomalina cheniourensis.* Also present at the outcrop are planktonic foraminifers of late Albian age assigned to the *Rotalipora appenninica* Zone. The abundant and well preserved assemblage contains the nominal species plus *Biticinella breggiensis, Costellagerina libyca, Planomalina buxtorfi, Rotalipora balernaensis,* and *Ticinella roberti.*

Locality 12. Medium-grey, mostly recrystallized, heavily-veined limestone exposed as 2-3 m blocks and a 4 m section in the long abandoned Foothill Quarry in Los Altos Hills (Fig. 8) contains poorly preserved and tectonically deformed planktonic foraminifers assigned to the *Ticinella bejaouaensis* Zone (Fig. 15).

Locality 13. The largest exposure of limestone in the Permanente terrane occurs on the northeastern hillside of Monte Bello Ridge near Cupertino (Fig. 8). Extensive quarrying since 1900 has exposed over 206 meters of light-grey to black, faulted and sheared limestone and interbedded chert. The age of the dated limestone ranges from early Aptian to late Turonian. The dated section overlies black limestone devoid of foraminifers that presumably is Barremian in age or older. Fifteen biozones and three subzones are identified based on the first and last occurrence of zonal index species (Fig. 15). The section extends from the early Aptian *Globigerinelloides blowi* Zone to the late Turonian *Marginotruncana sigali* Zone. All the primary indicator species described and illustrated by Sliter (1989a) are present. Missing from the section are the upper part of the late Aptian *Ticinella bejaouaensis* Zone and the early Albian *Hedbergella planispira* Zone, as well as, the late Albian *Rotalipora subticinensis* Subzone of the *Biticinella breggiensis* Zone and the *Rotalipora ticinensis* Zone.

Locality 14. Medium-grey, heavily-veined limestone exposed in a 48 m roadcut on Monte Bello Road at the southern end of Monte Bello Ridge (Fig. 9) contains poorly to well preserved, often tectonically deformed, planktonic foraminifers of Albian and Cenomanian age (Fig. 15). Age assignments include the late Albian *Rotalipora appenninica* Zone and the middle Cenomanian *Rotalipora reicheli* Zone and *Rotalipora greenhornensis* Subzone of the *Rotalipora cushmani* Zone.

Locality 15. Medium-grey, heavily-veined limestone cropping out along the banks of Stevens Creek at the southern end of Monte Bello Ridge (Fig. 9) in a sequence 5 m thick contains poorly preserved, tectonically deformed planktonic foraminifers assigned to the late Albian *Rotalipora appenninica* Zone (Fig 15). Species present include *Biticinella breggiensis, Planomalina buxtorfi,* and *Rotalipora balernaensis.*

New Almaden-Gilroy Area

Nine limestone localities (Fig. 2, locs. 16-24) are dated in the structurally complex New Almaden-Gilroy area that extends from Highway 17 south to Gilroy. The dated localities range in age from questionable late Barremian to late Turonian (Fig. 16).

Locality 16. Several restricted 10 m outcrops of medium-grey, heavily-veined limestone and black chert exposed in a road cut on the western side of Highway 17 near Los Gatos (Fig. 10) contain planktonic foraminifers of Aptian and Albian age. Species present identify the following zones: the upper part of the middle Aptian *Globigerinelloides algerianus* Zone (Fig. 16) based on the presence of the nominal species plus *Globigerinelloides barri, Hedbergella trocoidea* and *Planomalina cheniourensis;* the middle Albian *Ticinella praeticinensis* Subzone of the *Biticinella breggiensis* Zone with the nominal species plus *Hedbergella rischi* and *Ticinella primula*; and the late Albian *Rotalipora appenninica* Zone with *Biticinella breggiensis, Rotalipora balernaensis* and *Planomalina buxtorfi.* Missing from the outcrops are planktonic foraminifers of late Aptian to middle Albian, and late Albian age.

Locality 17. Mostly recrystallized, medium-grey, heavily-veined limestone and black chert from a 4 m section in a small abandoned quarry on the eastern hillside of St. Josephs Hill near Los Gatos (Fig. 10) contains poorly preserved, tectonically deformed planktonic foraminifers assigned to the middle Cenomanian *Rotalipora greenhornensis* Subzone of the *Rotalipora cushmani* Zone (Fig. 16). Present are the nominal species plus *Praeglobotruncana delrioensis* and *P. stephani.*

Locality 18. Twenty-two meter section of light-grey limestone and interbedded medium-grey chert exposed in a roadcut on the western side of Kennedy Road east of Los Gatos (Fig. 10) is dated as Cenomanian to Turonian in age. Present are planktonic foraminifers assigned to the middle Cenomanian *Rotalipora greenhornensis* Subzone of the *Rotalipora cushmani* Zone (Fig. 16), the middle Turonian *Helvetoglobotruncana helvetica* Zone and the late Turonian *Marginotruncana sigali* Zone.

Locality 19. Fractured and heavily-veined limestone and chert cropping out in small 1-3 m exposures along Reynolds Stream southwest of Hicks Road (Fig. 11) in the Ben Trovato shear zone, contains foraminifers of middle Aptian age. Moderately well-preserved planktonic foraminifers indicate the upper part of the *Globigerinelloides algerianus* Zone based on the presence of the nominal species plus *Hedbergella trochoidea* and *Planomalina cheniourensis* (Fig. 16).

Locality 20. Light-grey, heavily-fractured limestone blocks 1-3 m thick exposed in a long abandoned quarry about 400 m due east of locality 19 (Fig. 11) in the Ben Trovato shear zone, contains poorly preserved planktonic foraminifers questionably assigned to the middle Aptian *Globigerinelloides algerianus* Zone (Fig. 16). The age of the limestone is based on the co-occurrence of *Hedbergella gorbachikae* and *H. praetrochoidea.*

Locality 21. Light-to-medium-grey limestone and black chert from an 11 m thick outcrop exposed on the northeastern hillside of Mt. El Sombroso in the Ben Trovato shear zone near the southern end of Guadalupe Reservoir (Fig. 11) contains planktonic foraminifers of Aptian and Albian age. Species present are assigned to the middle Aptian *Globigerinelloides algerianus* Zone (Fig. 16) on the basis of the nominal species in addition to *Globigerinelloides barri* and *Hedbergella trochoidea,* and to the middle Albian *Ticinella praeticinensis* Subzone of the *Biticinella breggiensis* Zone based on the nominal species plus *Ticinella roberti.* Missing are species of late Aptian to middle Albian age.

Locality 22. Limestone from Baldy Ryan Canyon west of Casa Loma Road in the Ben Trovato shear zone (Fig. 12) exposed in two 9 m sections is medium- to dark-grey in color, mostly recrystallized, heavily-veined and contains planktonic foraminifers from the *Globigerinelloides blowi* Zone. The poorly preserved assemblage includes the nominal species plus *Hedbergella sigali* and *H. similis* (Fig. 16).

Locality 23. Light- to dark-grey limestone and black chert about 10 m thick exposed in an abandoned quarry south of Calero Reservoir (Fig. 12) contains planktonic foraminifers of Aptian, Albian, and Cenomanian age. Aptian foraminifers are assigned to the lower part of the late Aptian *Ticinella bejaouaensis* Zone (Fig. 16) on the presence of the nominal species and *Hedbergella trochoidea* and *Planomalina cheniourensis.* Albian samples include the middle Albian *Ticinella praeticinensis* Subzone of the *Biticinella breggiensis* Zone with the nominal species plus *Hedbergella rischi, Ticinella primula,* and *T. roberti* and the late Albian *Rotalipora appenninica* Zone with poorly preserved *Biticinella breggiensis, Rotalipora balernaensis, Planomalina buxtorfi, Rotalipora appenninica,* and *R. ticinensis.* The Cenomanian samples are assigned to the middle Cenomanian *Rotalipora greenhornensis* Subzone of the *Rotalipora cushmani* Zone based on the presence of poorly preserved and tectonically deformed nominal species and *Praeglobotruncana gibba.* Missing from the section are planktonic foraminifers of late Aptian to middle Albian, late Albian, and early Cenomanian age.

Locality 24. Medium-grey limestone and black chert exposed in a 2 m thick section at the crest of a small hill at Uvas Reservoir (Fig. 13) and apparently lying conformably at the top of a pelagic sequence that overlies basaltic pillow flows and tuff is questionably placed in the late Barremian to early Aptian. The presence of minute, sparse, poorly preserved specimens that resemble *Globigerinelloides duboisi, Hedbergella sigali, H. similis,* and other rare hedbergellids suggest an age assignment within the *Hedbergella similis* to *Globigerinelloides blowi* Zones (Fig. 16).

Summary

Planktonic foraminifers collected from outcrops of the Calera Limestone found throughout the Permanente terrane of the Franciscan Complex range in age from possible Barremian to late Turonian. The improved biostratigraphic resolution for Cretaceous planktonic foraminifers examined in thin section allows the identification of seventeen zones and four subzones within this time frame. No samples younger than Turonian were found. Dating the base of the sequence remains a problem. Tens of meters of black limestone devoid of identifiable planktonic foraminifers due to recrystallization and chertification underlie the dated sequence and presumably are Barremian in age or older. Attempts to date the basal sequence by foraminifers, radiolarians, and calcareous nannofossils have as yet proved unsuccessful.

Within the dated sequence, specific planktonic foraminiferal zones are consistently missing. These are best noted in the two most complete sections at Pacifica Quarry (Fig. 14, loc. 1) and Permanente Quarry (Fig. 15, loc. 13). In these sections, zones are missing in the late Aptian to early Albian (KS 11-12) and late Albian (KS 14b and 15). Comparing these two sections to the other smaller and more discontinuous outcrops again shows that these two time intervals are consistently missing.

The smaller outcrops also show a pattern of additional missing zones that is not present at the two major quarries. These secondary missing intervals are seen by comparing Figures 14 to 16 and include the early to middle Albian (KS 12-13), the early Cenomanian (KS 17-18), and the late Cenomanian to early Turonian (KS 19b-20).

We believe that the primary pattern found at the major quarries is due to widespread paleoceanographic effects in the Cretaceous Pacific Ocean that caused a reduction in sedimentation and/or erosion. Similar unconformities are noted in the sedimentary record from topographic highs in the Pacific basin (Sliter, in press.).

The secondary pattern we relate to the tectonic history of the Calera Limestone. Following this hypothesis, portions of the pelagic cap were repeatedly sheared by thrust faults during the accretionary process into the sequence visible on the hillside at Black Mountain (Loc. 10). Subsequent northward translation of the sheared blocks resulted in their present dispersal throughout the Permanente terrane. Further, the secondary pattern of limestone ages supports the conclusion that the limestone bodies within the Permanente terrane were derived from a single seamount and a unique tectonic history.

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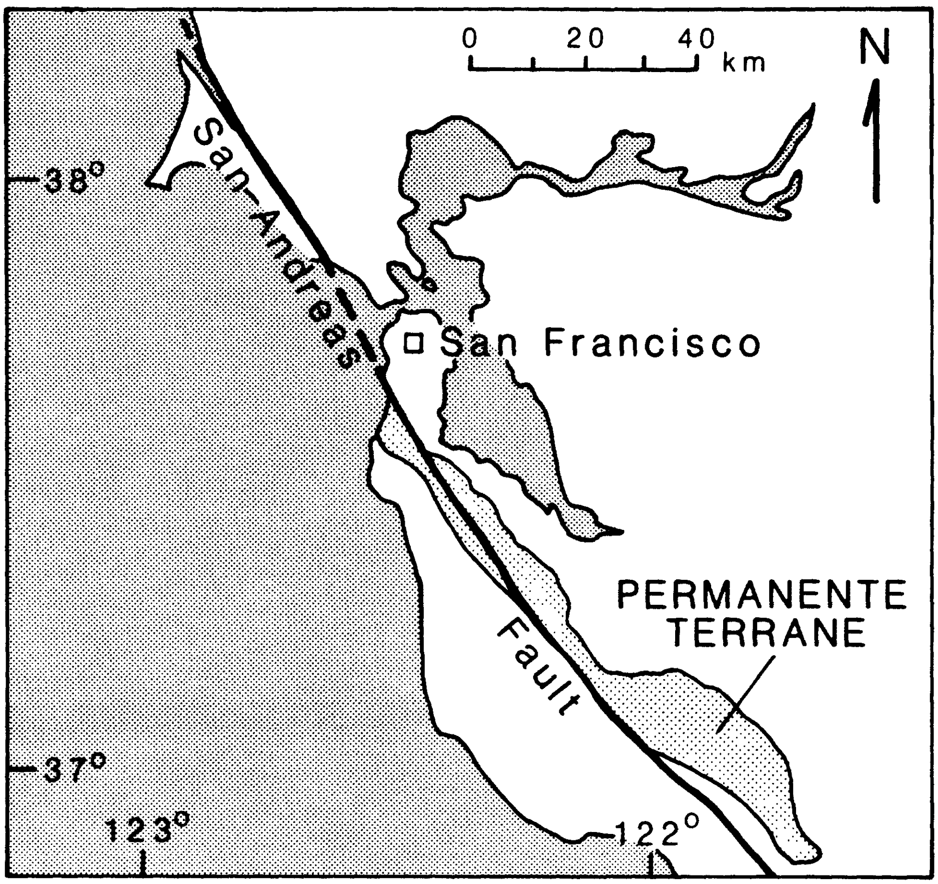


Figure 1. Map of the San Francisco Bay region showing the area of the Permanente terrane (stippled) adjacent to the San Andreas Fault zone.

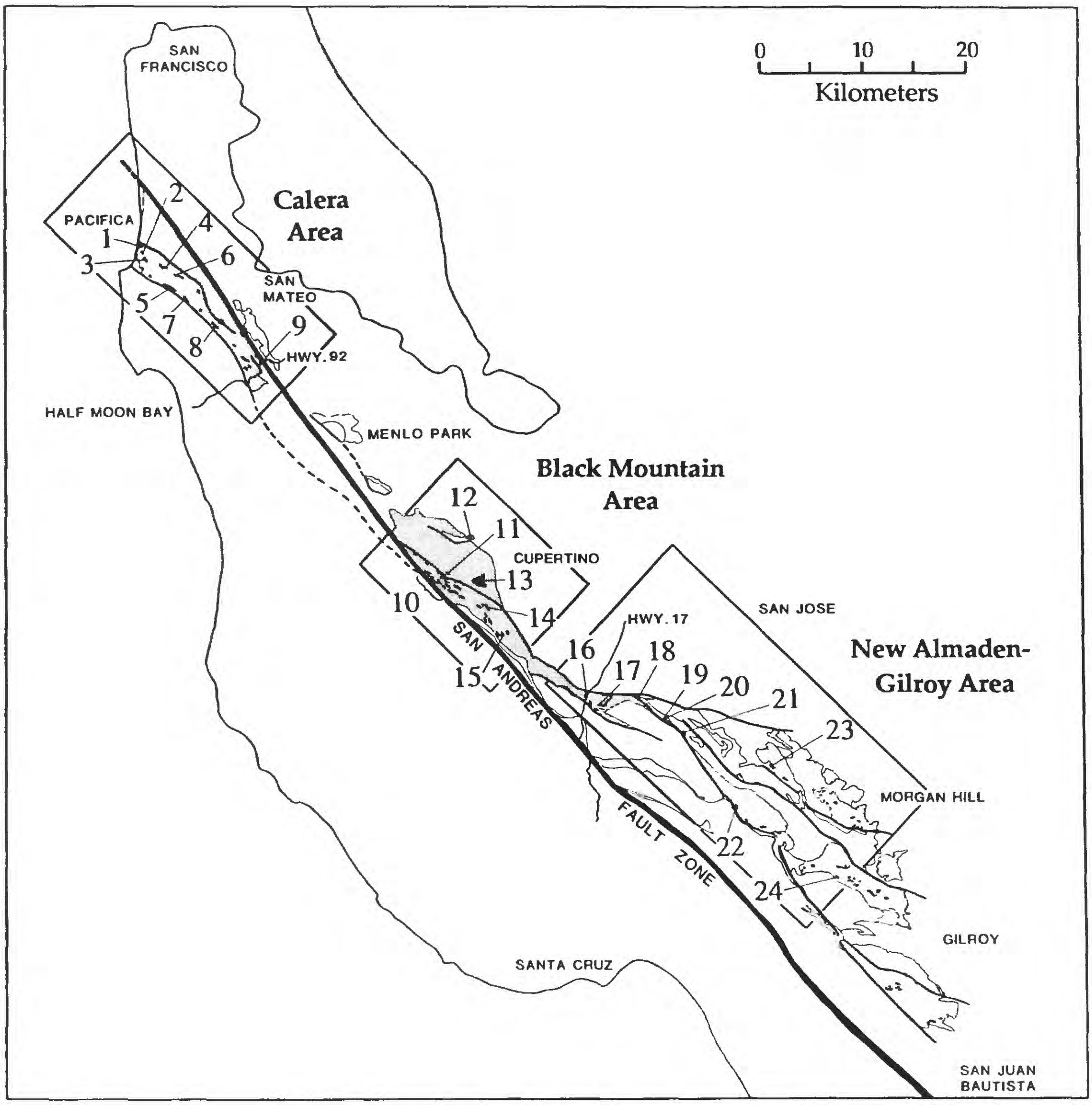


Figure 2. Distribution of the Permanente terrane (stippled) and secondary subparallel faults in the Franciscan Complex showing the location of the dated limestone outcrops, numbered from north to south, and undated or unfossiliferous outcrops (black without numbers).

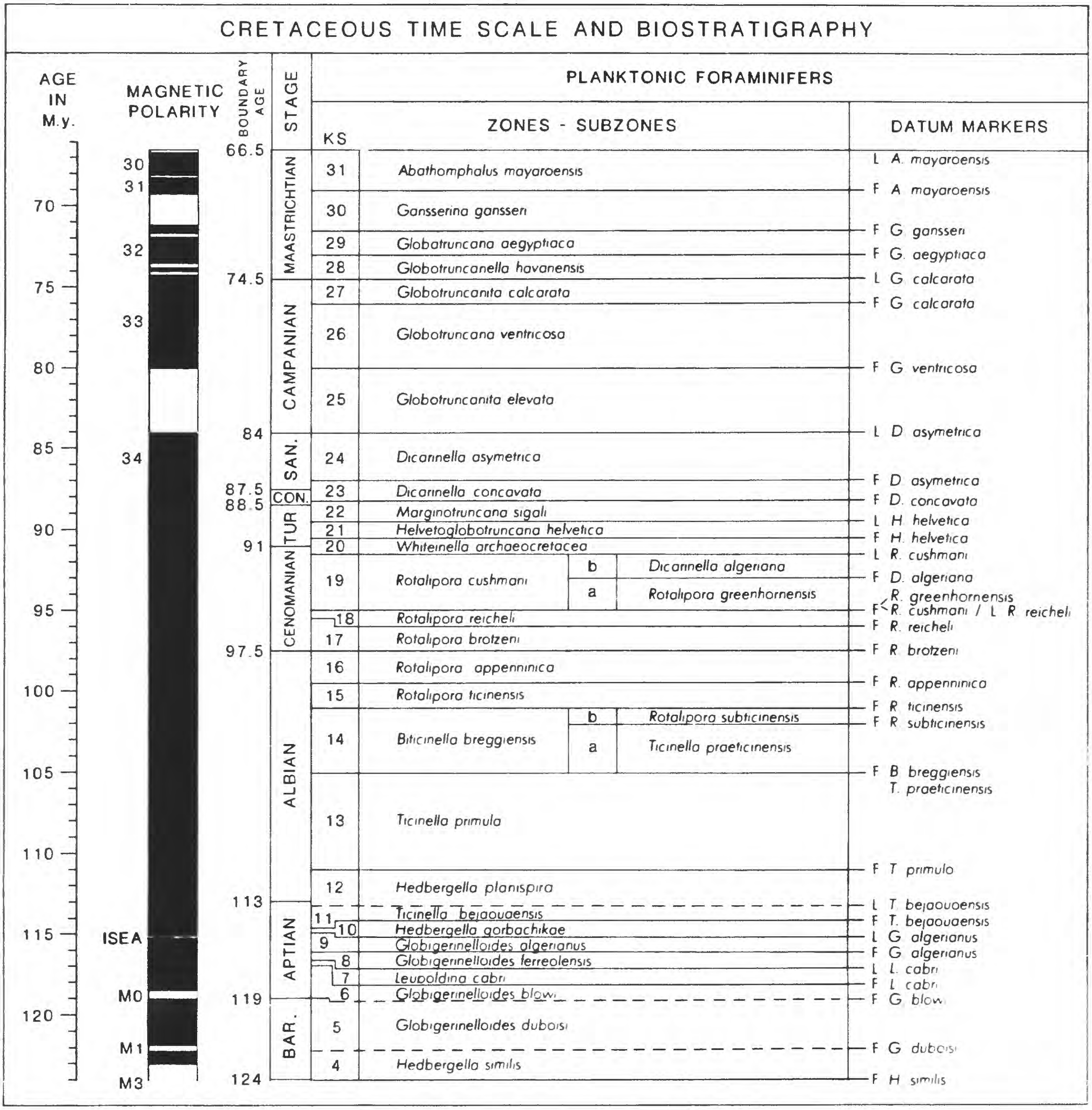
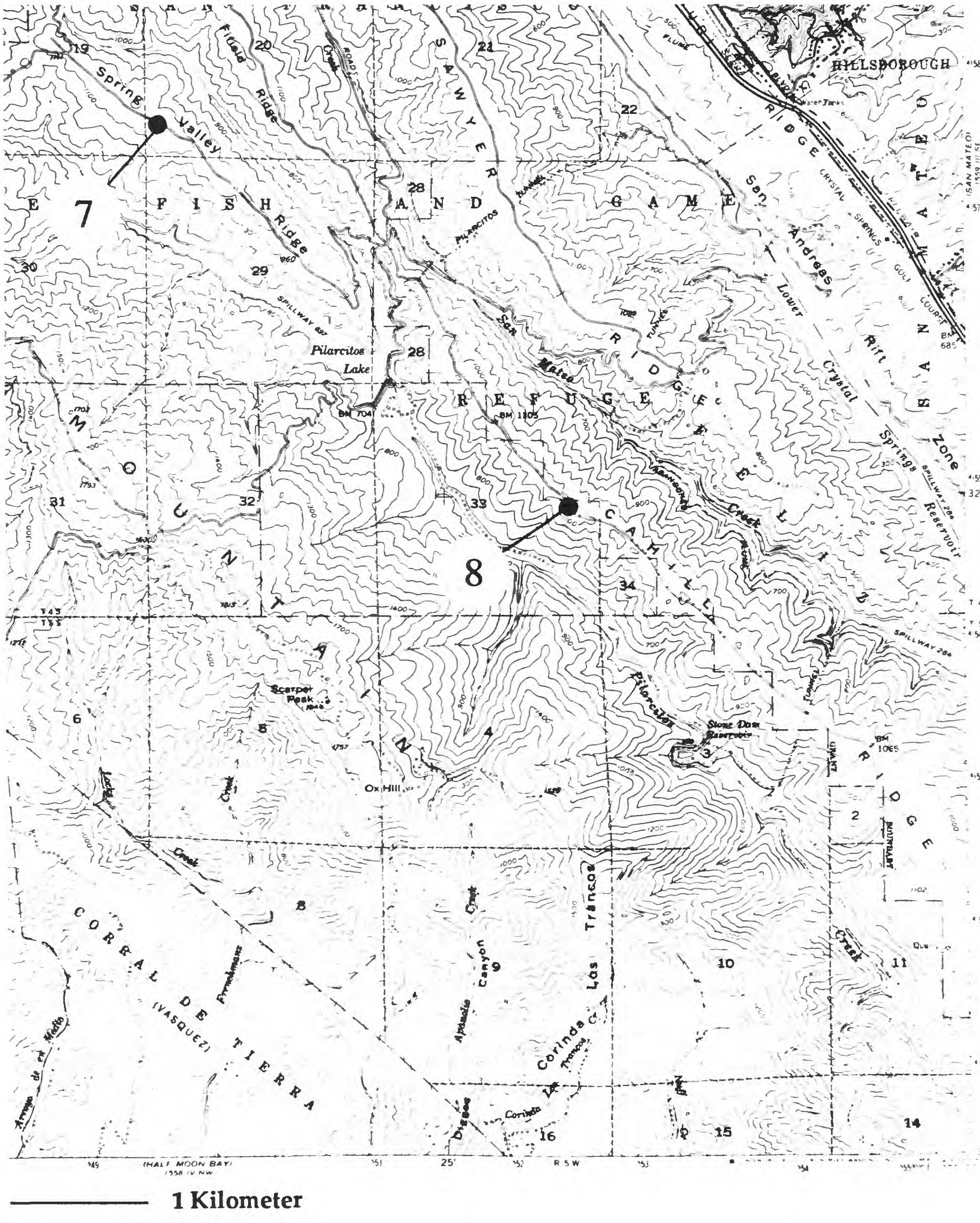


Figure 3. Zonation for Cretaceous planktonic foraminifers examined in thin section (modified from Sliter, 1989a). Magneto-geochronology after Harland et al., (1982) and Kent and Gradstein (1985). KS = Cretaceous zone notation. F = first occurrence; L = last occurrence.

1 Kilometer

Figure 4. Location of Calera Limestone localities 1-6 in the Calera area.

MONTARA MOUNTAIN QUADRANGLE
CALIFORNIA–SAN MATEO CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
SW/4 SAN MATEO 15 QUADRANGLE



——— 1 Kilometer

Figure 5. Location of Calera Limestone localities 7-8 in the Calera area.

Figure 6. Location of Calera Limestone locality 9 in the Calera area.

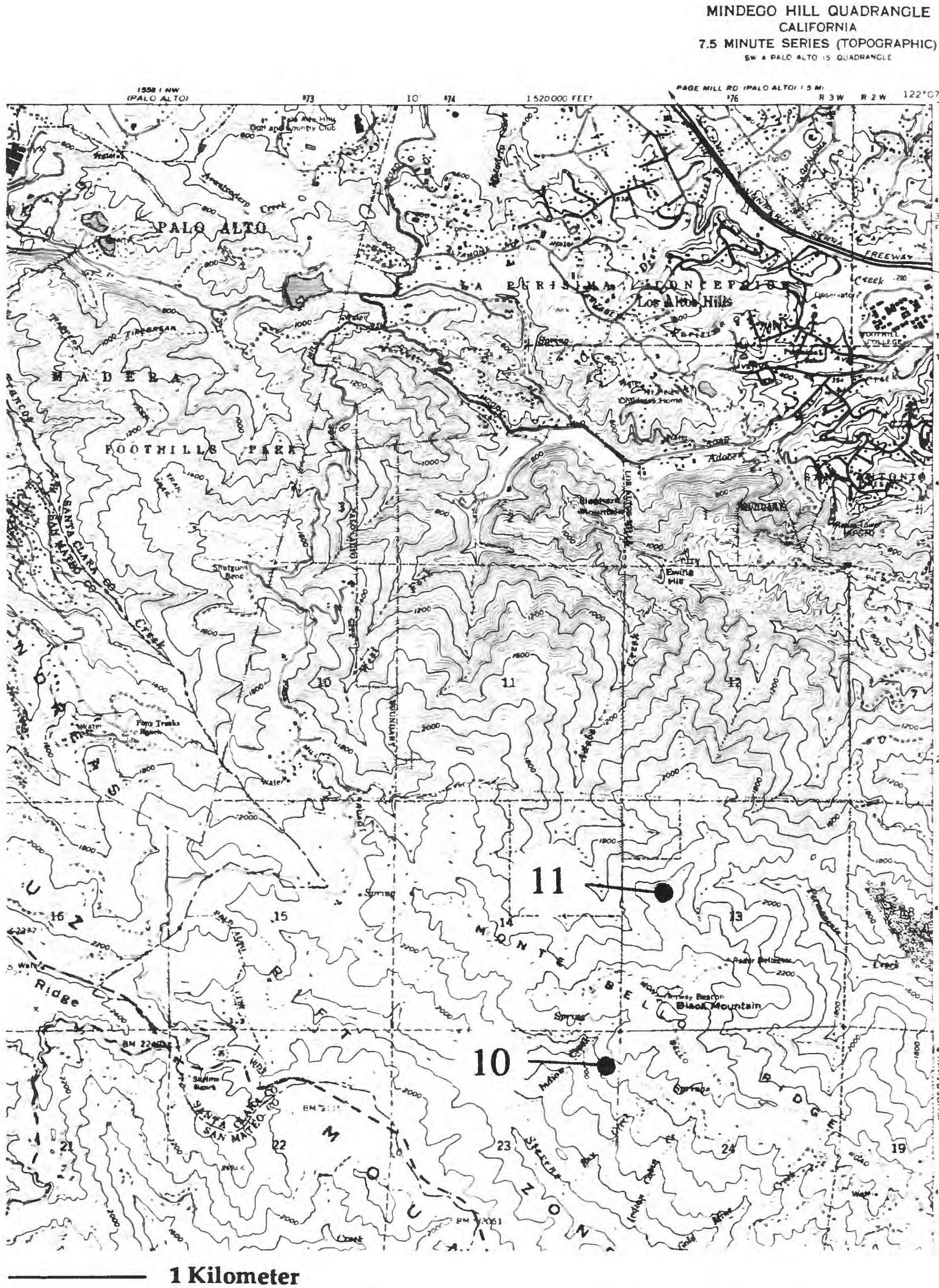


Figure 7. Location of Calera Limestone localities 10-11 in the Black Mountain area.

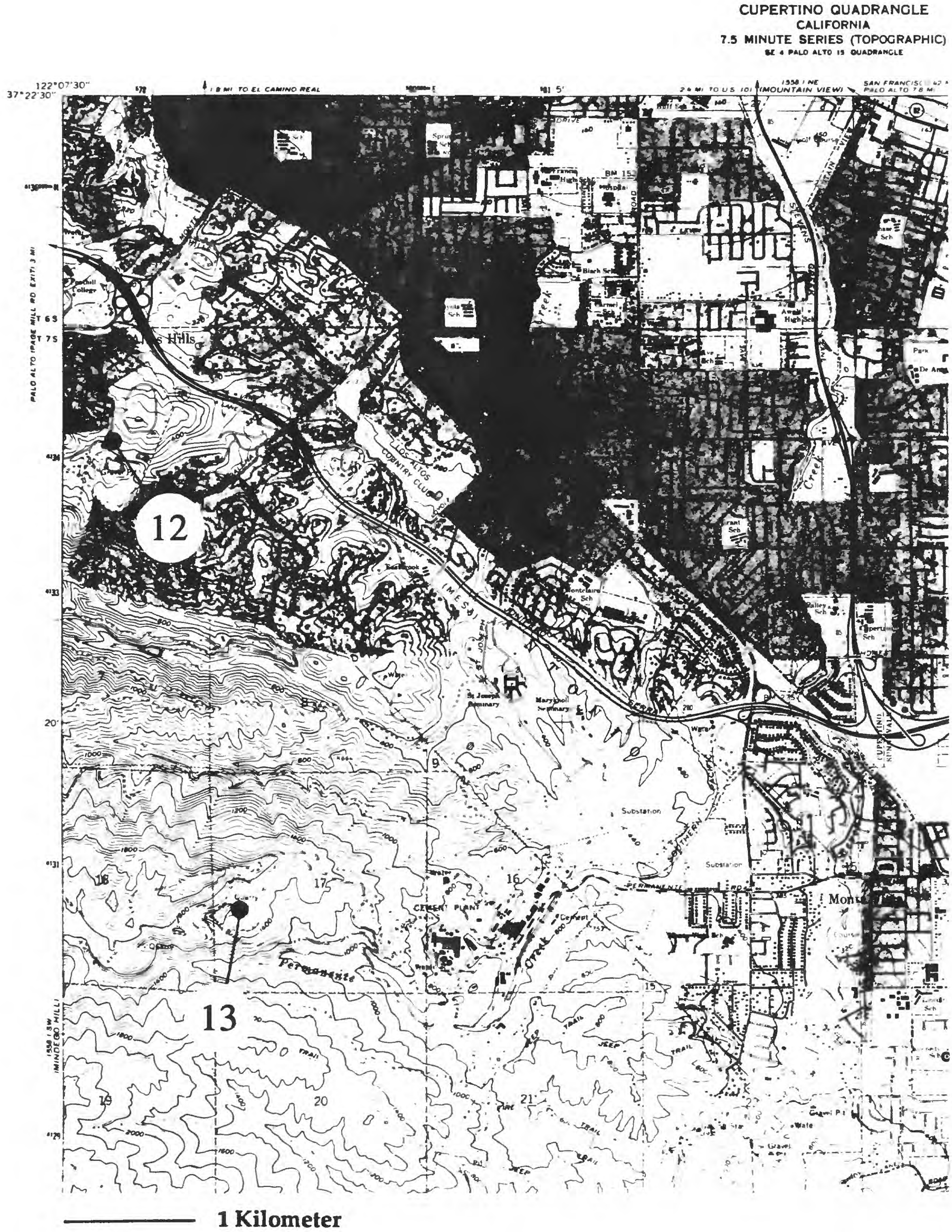


Figure 8. Location of Calera Limestone localities 12-13 in the Black Mountain area.

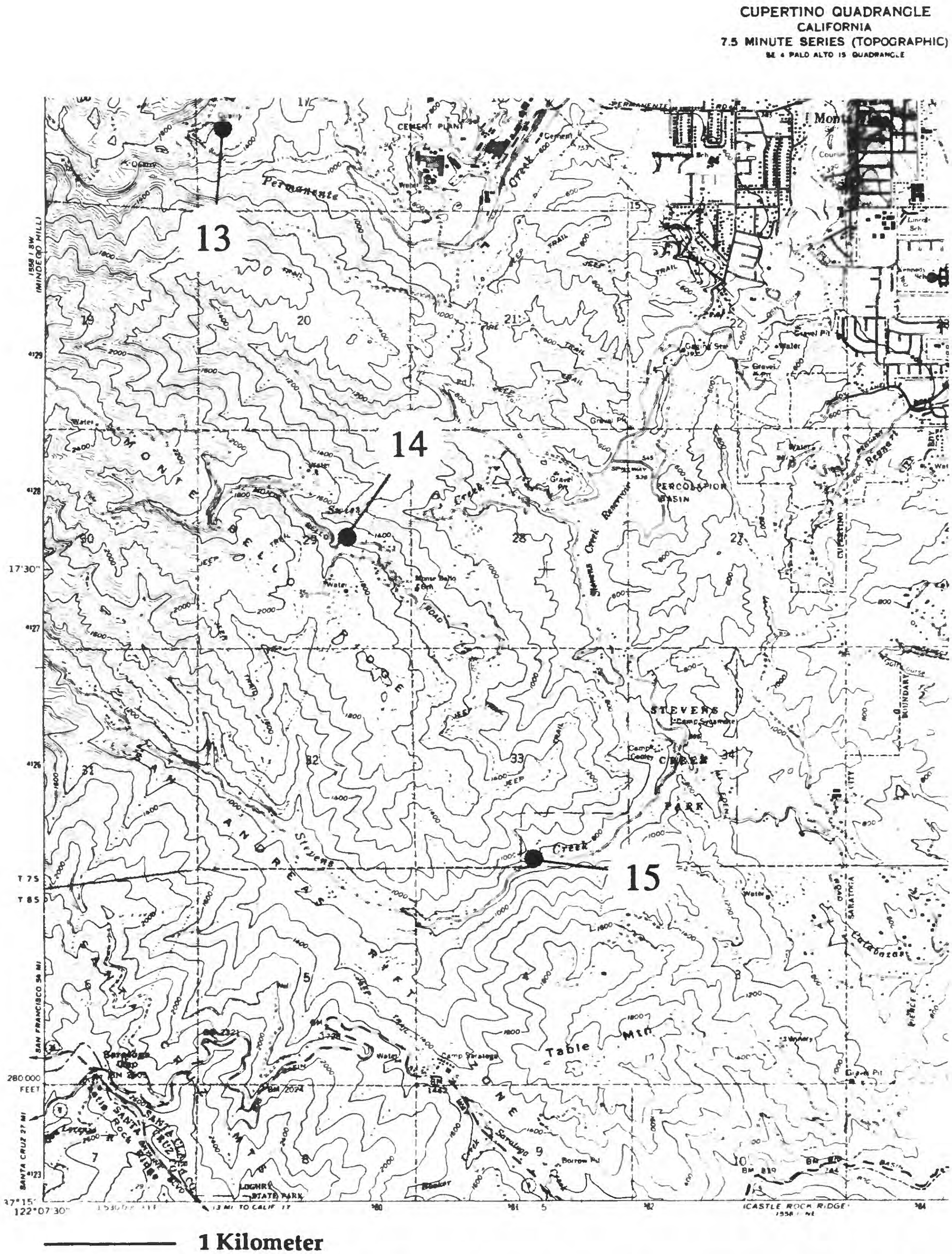


Figure 9. Location of Calera Limestone localities 13-15 in the Black Mountain area.

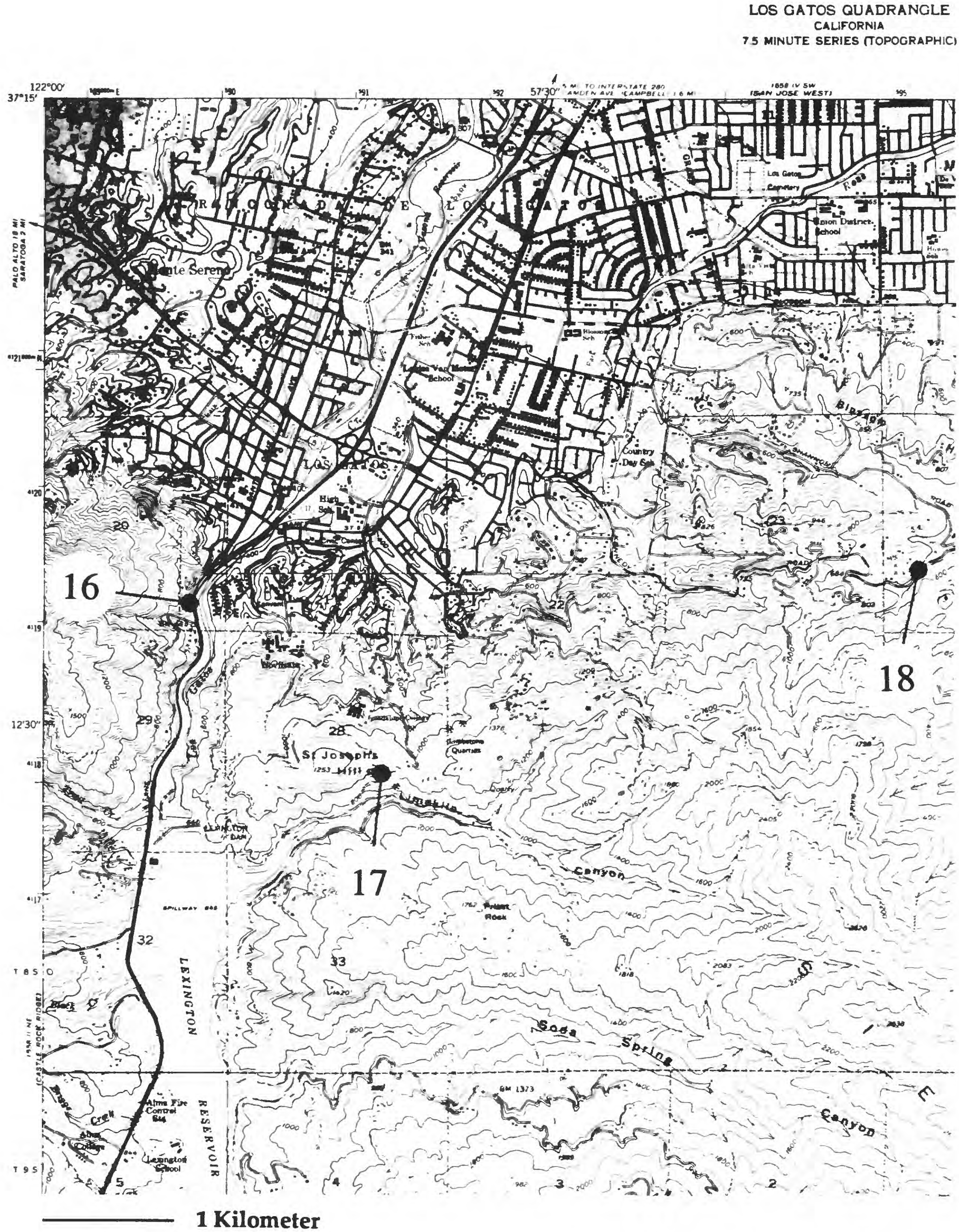
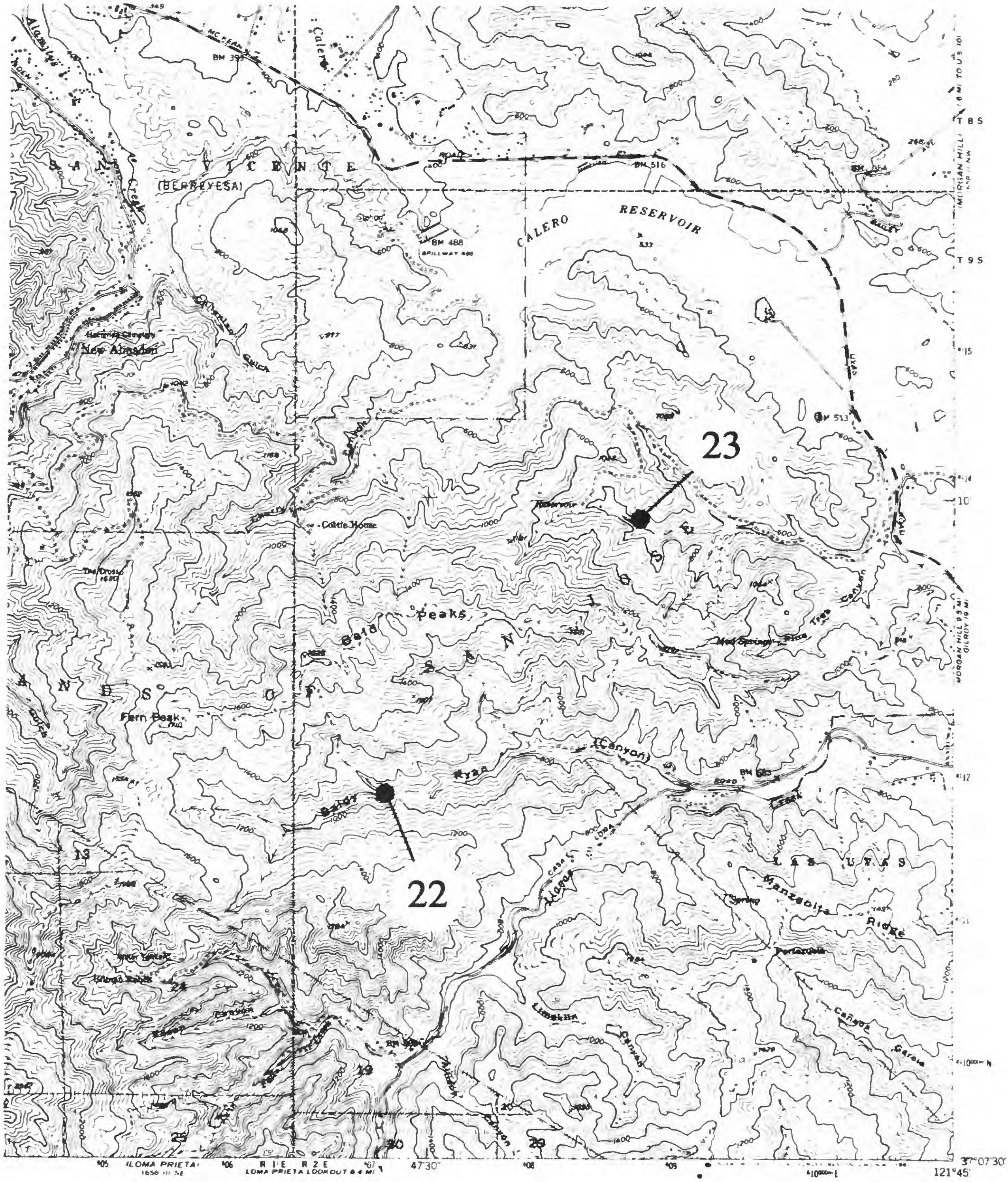


Figure 10. Location of Calera Limestone localities 16-18 in the New Almaden-Gilroy area.

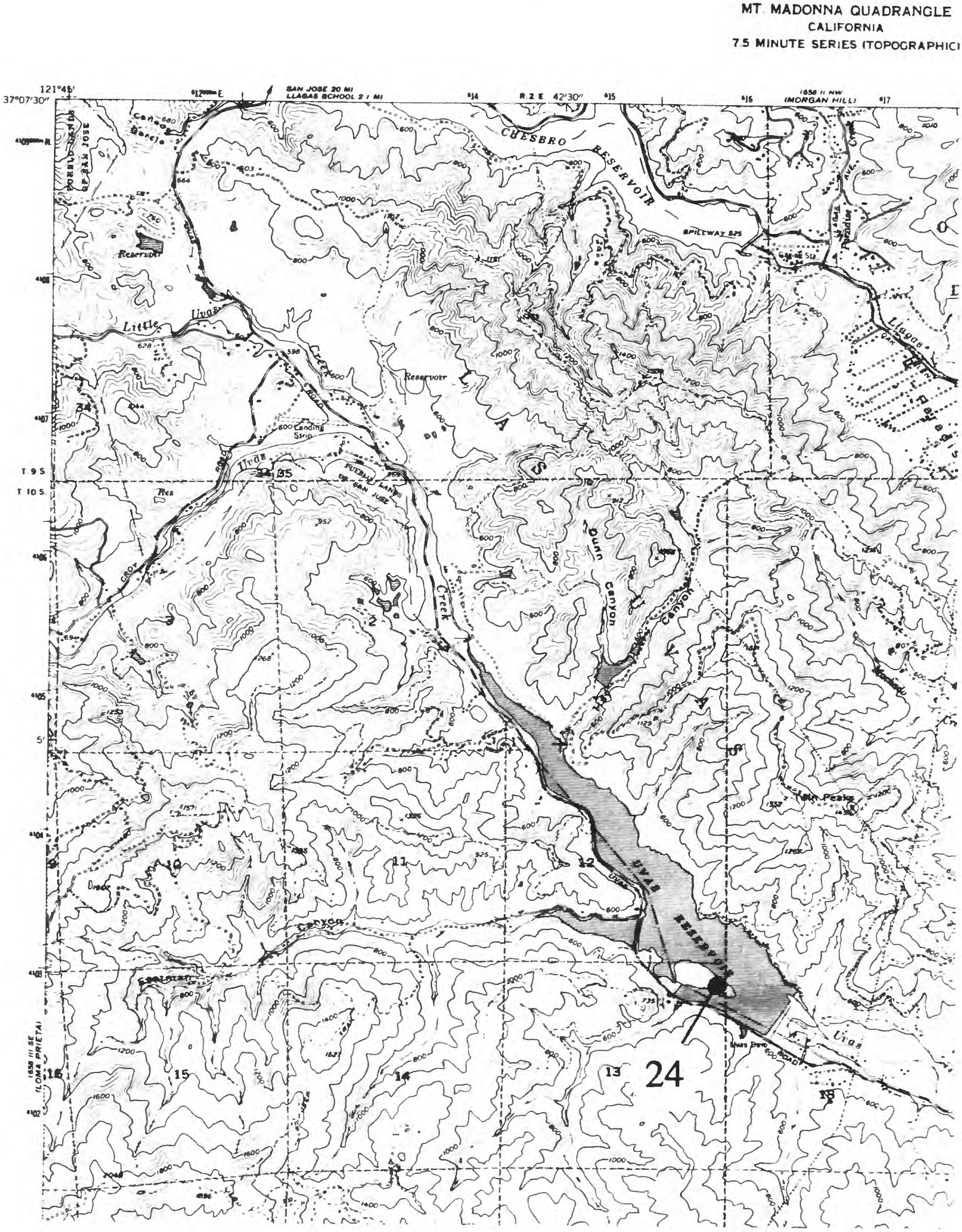
Figure 11. Location of Calera Limestone localities 18-21 in the New Almaden-Gilroy area.

SANTA TERESA HILLS QUADRANGLE
CALIFORNIA-SANTA CLARA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



1 Kilometer

Figure 12. Location of Calera Limestone localities 22-23 in the New Almaden-Gilroy area.



1 Kilometer

Figure 13. Location of Calera Limestone locality 24 in the New Almaden-Gilroy area.

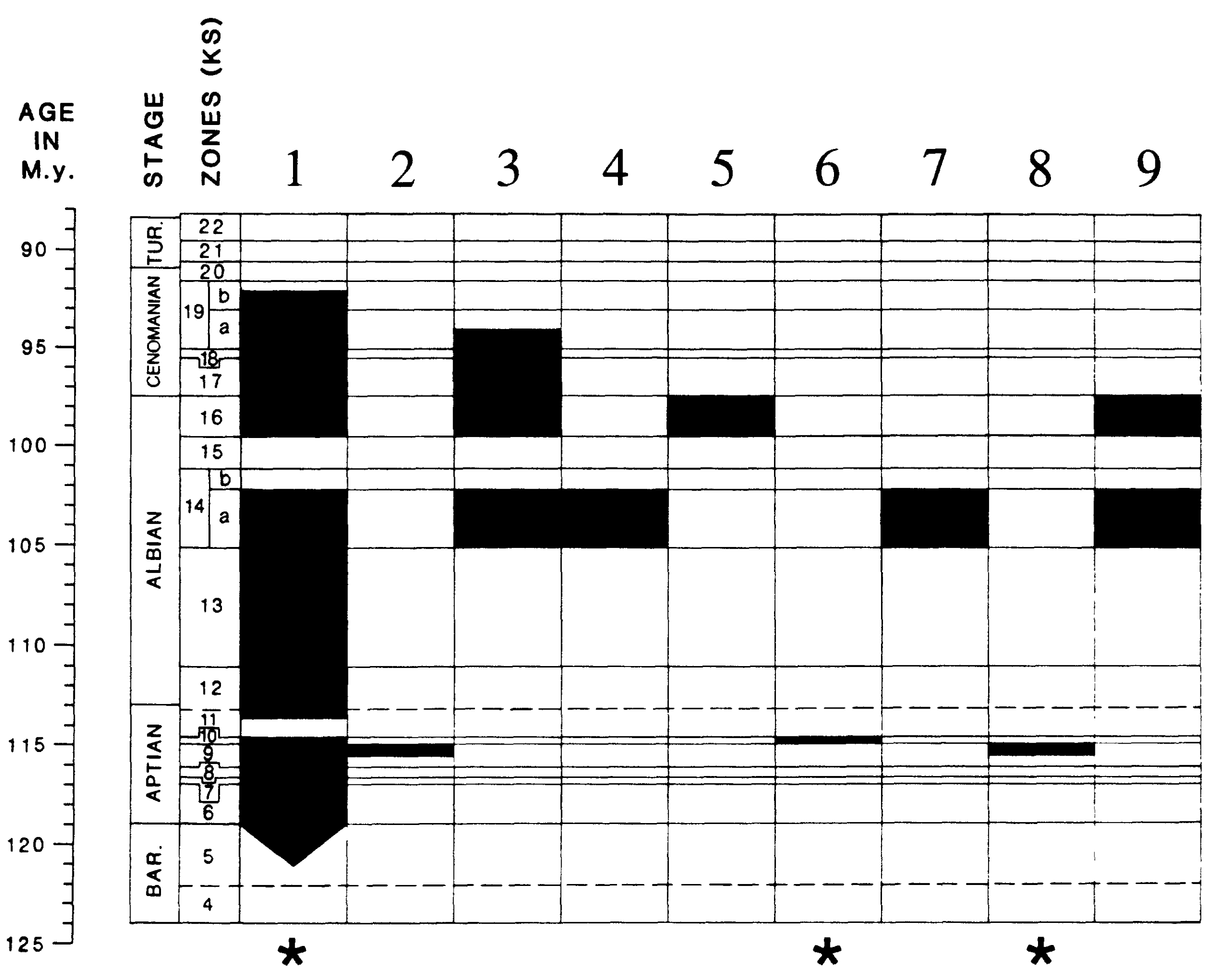


Figure 14. Age of Calera Limestone in the Calera area (locs. 1-9). Black areas show presence of all or part of planktonic foraminiferal zone as delineated by KS notation from Figure 3. Oldest age at locality 1 presumably Barremian or older. Asterisk = presence of black limestone.

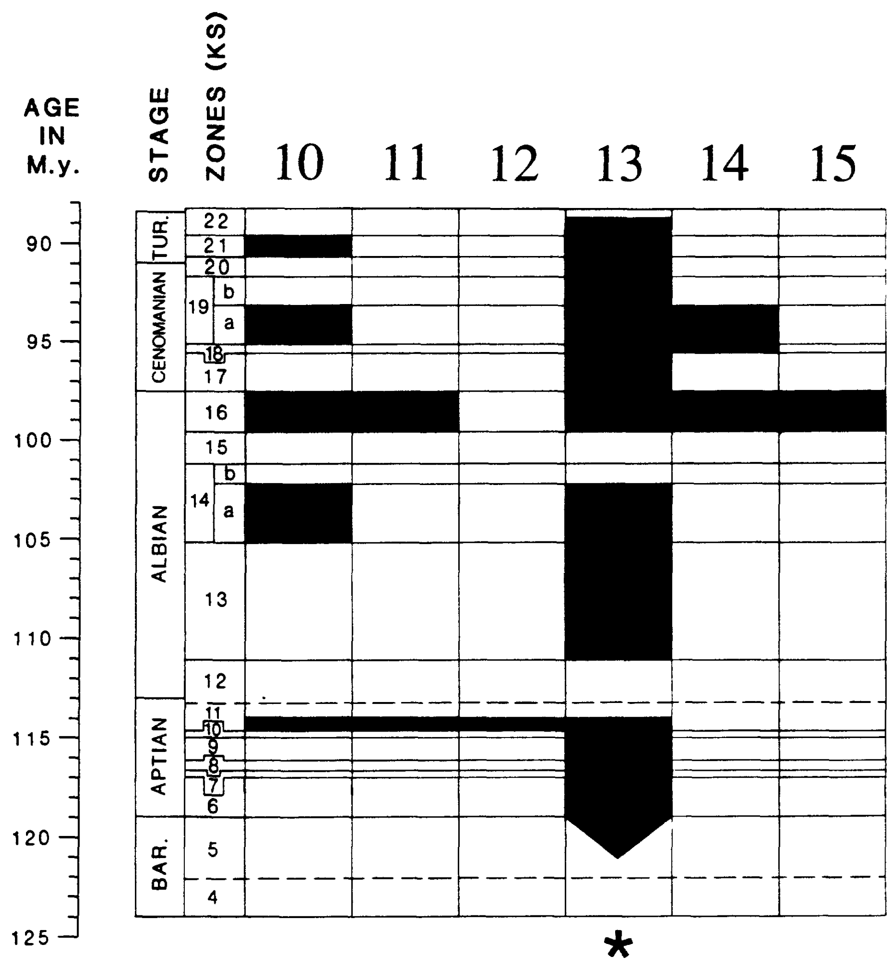


Figure 15. Age of Calera Limestone in the Black Mountainarea (locs. 10-15). Black areas show presence of all or part of planktonic foraminiferal zone as delineated by KS notation from Figure 3. Oldest age at locality 13 presumably Barremian or older. Asterisk = presence of black limestone.

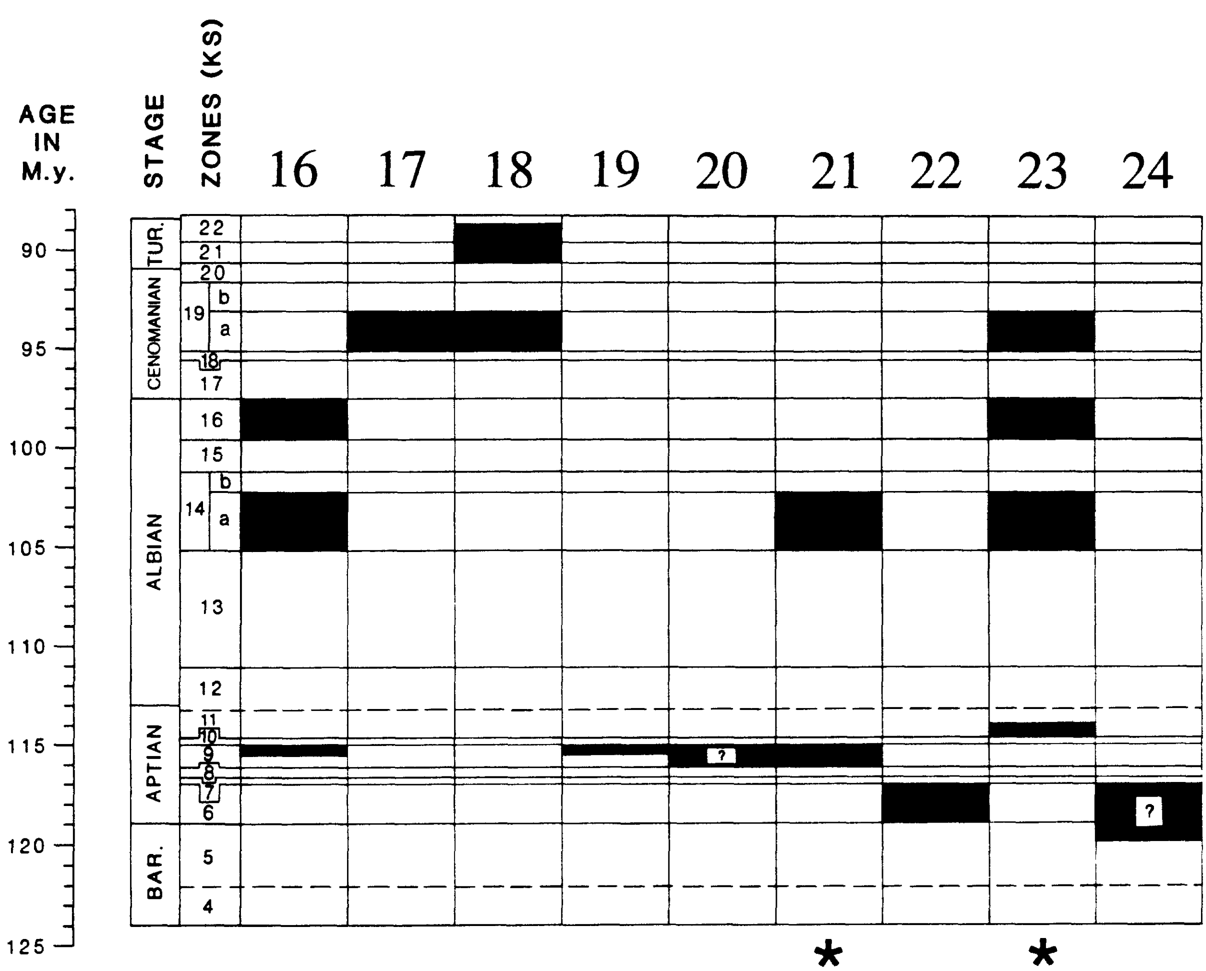


Figure 16. Age of Calera Limestone in the New Almaden-Gilroy area (locs. 16-24). Black areas show presence of all or part of planktonic foraminiferal zone as delineated by KS notation from Figure 3. ? = questionable zone assignment. Asterisk = presence of black limestone.

Table 1. Permanente Terrane limestone location data for localities shown on Figure 2.

Locality No.	Location	Latitude/Longitude	Quadrangle/Section, Township, Range
1	Pacifica Quarry	37°36.80'N 122°29.70'W	Montara Mountain 7 1/2' sec. [2], T. 4 S., R. 6 W.
2	Rockaway Knoll	37°36.47'N 122°29.68'W	Montara Mountain 7 1/2' sec. [2], T. 4 S., R. 6 W.
3	Royce Quarry	37°35.98'N 122°29.27'W	Montara Mountain 7 1/2' sec. [11], T. 4 S., R. 6 W.
4	North Fork	37°35.63'N 122°27.87'W	Montara Mountain 7 1/2' sec. [12], T. 4 S., R. 6 W.
5	Middle Fork Hill	37°34.50'N 122°27.48'W	Montara Mountain 7 1/2' sec. 19, T. 4 S., R. 5 W.
6	Fifield Ridge	37°35.10'N 122°26.92'W	Montara Mountain 7 1/2' sec. 18, T. 4 S., R. 5 W.
7	Spring Valley Ridge	37°33.92'N 122°26.37'W	Montara Mountain 7 1/2' sec. 20, T. 4 S., R. 5 W.
8	Cahill Ridge	37°32.45'N 122°24.43'W	Montara Mountain 7 1/2' sec. 33, T. 4 S., R. 5 W.
9	Skyline Quarry	37°30.32'N 122°21.60'W	San Mateo 7 1/2' sec. [12], T. 5 S., R. 5 W.
10	Black Mountain	37°18.85'N 122°09.13'W	Mindego Hill 7 1/2' sec. 23, T. 7 S., R. 3 W.
11	Black Mountain - North	37°19.50'N 122°08.80'W	Mindego Hill 7 1/2' sec. 13, T. 7 S., R. 3 W.
12	Foothill Quarry	37°21.12'N 122°07.27'W	Cupertino 7 1/2' sec. [6], T. 7 S., R. 2 W.
13	Permanente Quarry	37°19.13'N 122°06.58'W	Cupertino 7 1/2' sec. 17, T. 7 S., R. 2 W.
14	Montebello Road	37°17.65'N 122°05.98'W	Cupertino 7 1/2' sec. 29, T. 7 S., R. 2 W.
15	Stevens Creek	37°16.48'N 122°04.60'W	Cupertino 7 1/2' sec. 33, T. 7 S., R. 2 W.
16	Highway 17	37°13.00'N 121°59.25'W	Los Gatos 7 1/2' sec. 20, T. 8 S., R. 1 W.
17	St. Josephs Hill	37°12.30'N 121°58.33'W	Los Gatos 7 1/2' sec. 28, T. 8 S., R. 1 W.
18	Kennedy Road	37°13.15'N 121°55.58'W	Los Gatos 7 1/2' sec. [24], T. 8 S., R. 1 W.
19	Reynolds Stream	37°12.03'N 121°53.87'W	Los Gatos 7 1/2' sec. [30], T. 8 S., R. 1 E.
20	Guadalupe Quarry	37°12.05'N 121°53.47'W	Los Gatos 7 1/2' sec. [29], T. 8 S., R. 1 E.
21	Almaden Oval	37°11.25'N 121°52.50'W	Los Gatos 7 1/2' sec. [33], T. 8 S., R. 1 E.
22	Baldy Ryan	37°08.90'N 121°47.42'W	Santa Teresa Hills 7 1/2' sec. [18], T. 9 S., R. 2 E.
23	Calero Quarry	37°09.80'N 121°46.32'W	Santa Teresa Hills 7 1/2' sec. [8], T. 9 S., R. 2 E.
24	Uvas Reservoir	37°04.07'N 121°41.73'W	Mt. Madonna 7 1/2' sec. 13, T. 10 S., R. 2 E.