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Generalized geologic map of the basement rocks of the southern Sierra Nevada, California

by

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Generalized geologic map of the basement rocks of the southern Sierra Nevada, California

INTRODUCTION

The basement geology of the southern Sierra Nevada north to lat. 36°00' N. (plate 1) has generally been shown on previous compilations as basement rock undivided or as granitic rock containing some metamorphic bodies. Other maps have shown much more detail, but only for limited areas of the southern Sierra Nevada. This map, which encompasses some 4900 km^2 of basement exposures, is an attempt to present a somewhat standardized coverage of the basement rocks of this large area and, at the same time, to point out some of its petrographic complexity, and to a lesser extent, to show some of the variety in the metamorphic pendant rocks. Certainly more complexity in the geology is present than is grossly summarized here at a scale of 1:250,000.

Coverage of the area has been somewhat uneven as shown on Plate 2 that indicates all localities where samples or other data have been collected. For example, coverage is notably sparse in the northeast part of the map area and, in the northwest, is mostly limited to scattered road traverses. The geologic study has concentrated on granitic rocks and has focused more on their petrography than on their structure. Some of the granitic units shown on Plate 1 have been distinguished on other than geologic mapping evidence. For example, the Bear Valley Springs (Kbv), Poso Flat (Kpf), Alder Creek (Kal), and Dunlap Meadows (Kdm) granitic bodies are much alike in the field. All four bodies are texturally similar and have abundant hornblende and biotite. However, in the study of the thin sections and stained slabs there were distinguishable differences, principally in the amount of K-feldspar. Also, distinctions can be made on the basis of differences in $^{87}Sr/^{86}Sr$ ratios. Based on these factors, these units have been delineated on Plate 1, but it should be emphasized that no mappable contacts have been seen between them. Hence, the distinctions are strictly based on petrography and chemistry. The Poso Flat unit (Kpf) may be a relatively K-feldspar-rich facies of the Bear Valley Springs (Kbv) and the Alder Creek unit (Kal) may be similarly related to the Dunlap Meadows (Kdm) unit. Early in the geologic mapping the Dunlap Meadows body

(Kdm) was considered a correlative of the Bear Valley Springs (Kbv). Subsequent Rb/Sr studies showed that though both bodies have a considerable range of $^{87}Sr/^{86}Sr$ ratios, the Dunlap Meadows mass (Kdm) is somewhat higher (average of 0.07069) than the Bear Valley Springs (Kbv) (average of 0.7054) and the two units probably are not correlative. Nevertheless, neither field nor microscopic studies revealed any obvious textural or mineralogic differences between them. The showing of almost all geologic contacts as solid lines is more a convention for simplicity than it is a recognition of easily observable contacts. Seldom were geologic contacts obvious, except in very local areas. The intrusive relations shown on figure 1 for a limited number of granitic units are based mostly on diking relations and map pattern. Correlations (?) are based on mineralogic and petrographic similarities as well as textural resemblance in the field.

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Alluvial, sedimentary and volcanic rocks, undivided (Quaternary and Tertiary).

PLUTONIC ROCKS

GRANITE

(radiometric ages shown)

Knc GRANITE OF NONAME CANYON (LATE CRETACEOUS)--leucocratic alaskite with minor amounts of muscovite and garnet. K-Ar age on muscovite, 80.1 ± 5.3 Ma (Diggles, 1984). Rb/Sr on whole rock isochron on 4 samples is 80.5 ± 1.7 Ma (R.W. Kistler, written commun., 1986).

Kcc GRANITE OF CANNELL CREEK (LATE CRETACEOUS)--coarse-grained, strongly sheared rock. U-Pb age on zircon of 80 ± 2 Ma (Saleeby and Busby-Spera, 1986). Rb/Sr ages on whole rocks for 5 samples average 107.5 ± 5 Ma. K-Ar ages on biotite of 50.5 Ma (Evernden and Kistler, 1970) and 55 Ma (Jenkins, 1961--location uncertain).

Kkr GRANITE OF THE KERN RIVER (LATE CRETACEOUS)--relatively dark-colored hornblende and biotite-bearing rock with distinctive centimeter-sized dark clots. U-Pb age on zircon of 80 $\pm$ 3 Ma (Saleeby and Busby-Spera, 1986, p. 92). K-Ar ages on biotite of 86.8, 87.2, and 88.8 Ma (Evernden and Kistler, 1970). Rb/Sr whole rock isochron on 4 samples gives an age of 81.1 $\pm$ 11.1 Ma (R.W. Kistler, commun., 1986).

Kgo GRANITE OF ONYX (LATE CRETACEOUS)--fine grained sugary textured rock with about 4 percent biotite. K-Ar age on biotite, 80.7 Ma (Evernden and Kistler, 1970).

Ksp ALASKITE* OF SHERMAN PASS (CRETACEOUS)--coarse-grained with minor biotite and some hornblende. Rb-Sr whole rock age of 91 Ma from samples just to north of the map area in the Hockett Peak quadrangle (R.W. Kistler, written commun., 1987.) May be correlative with alaskite of Coyote Pass and/or alaskite of Hells Hole in the Golden Trout Wilderness Area to the north of the map area (du Bray and Dellinger. 1981).

Kbp GRANITE OF BAKER POINT (LATE CRETACEOUS)--fine-grained biotite bearing rock. Essentially a large dike into the granite of the Kern River. Questionable K-Ar age on biotite of ~92 Ma (Jenkins, 1961).

Ktj GRANITE OF TEJON LOOKOUT (LATE CRETACEOUS)--coarse-grained, forms craggy orange-to-yellow outcrops that weather to distinctive yellow grus. May be correlative to the similar granite of Brush Mountain. Rb/Sr determinations on 3 whole rock samples gives an age of 96.0 + 1.9 Ma (R.W. Kistler, written commun., 1986).

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*In the IUGS classification the term "alaskite" is restricted to rocks with a plagioclase fraction of An_{0-5}. This is unusually restrictive and virtually eliminates the term from the Cordilleran batholithic belt. I prefer the time-worn usage of "alaskite": felsic granitic rock with less than 5 percent mafic constituents, and normally subequal amounts of plagioclase, K-feldspar, and quartz.

Kbm GRANITE OF BRUSH MOUNTAIN (LATE CRETACEOUS)--relatively coarse-grained rock. Many outcrops extensively altered. U/pb age on zircon of 98 Ma (James, 1986). Rb/Sr date on whole rock gives age of 91.5 ± 1.1 Ma (R.W. Kistler, written commun., 1986).

Kpp GRANITE OF PORTUGUESE PASS (EARLY CRETACEOUS)--coarse-grained biotite-bearing rock with some hornblende. Rb/Sr determinations on whole rock samples gives an age of 105.6 ± 9.2 Ma (R.W. Kistler, written commun., 1986).

GRANITE

(no radiometric ages)

Kac GRANITE OF ARRASTRE CREEK (CRETACEOUS)--coarse-grained felsic rock.

Kba GRANITE OF BASKET PEAK (CRETACEOUS)--coarse-grained felsic rock that forms craggy orange-weathering outcrops on peak and sides of Basket Peak. Mapped outline very tentative.

Kbc GRANITE OF BEAN CANYON (CRETACEOUS)--five irregular shaped bodies south of the Garlock fault that may well be felsic differentiates of the granite of Tejon Lookout.

Kbr GRANITE OF BISHOP RANCH (CRETACEOUS)--contains only sparse biotite (alaskitic) and forms craggy orange to salmon-pink outcrops.

Kblm GRANITE OF BLACK MOUNTAIN (CRETACEOUS)--a small, nearly round plug of biotite granite intruded into the granite of the Kern River and the tonalite of Woffird Heights.

Kbra GRANITE OF BOB RABBIT CANYON (CRETACEOUS)--felsic, coarse-grained biotite bearing rock with minor hornblende. Intrudes granodiorite of Rabbit Island and probably granodiorite of Castle Rock.

Kbo GRANITE OF BODFISH CANYON (CRETACEOUS)--typically coarse-grained but some variation, contains a few percent of biotite and only local hornblende.

Kb GRANITE OF BROWN (CRETACEOUS)--small plug on east fron of the Sierra Nevada. Distinctly different from nearby felsic dikes and plugs. Has some textural resemblance to quartz diorite of Walker Pass.

Kgg OUARTZ SYENITE OF GRAPEVINE GRADE (CRETACEOUS)--small plug about 6 km east of White River that is surprisingly quartz-poor (13 percent).

Klm GRANITE OF LONG MEADOW (CRETACEOUS)--an ovoid pluton of fine- to medium-grained felsic rock containing a few percent of biotite. Intrudes the granodiorite of Castle Rock.

Kmf MISCELLANEOUS FELSIC BODIES IN GRANODIORITE OF SACATAR (CRETACEOUS)--vari-textured dikes and small stocks on east face of the Sierra Nevada. Granite of Brown and stock correlated with Granite of Onyx about 6 km to the northwest of Granite of Brown may be related to the small stocks and dikes. Some of these dikes may be part of the Jurassic Independence dike swarm of Moore and Hopson (1961).

Khs GRANITE OF THE OLD HOT SPRINGS ROAD (CRETACEOUS)--small medium-grained heart-shaped alaskitic stock with traces of garnet.

Kpd POLKA-DOT DIKES (CRETACEOUS)--conspicuous felsic dikes intruding tonalite of Bear Valley Springs. Dikes contain abundant spherical dark clots to several centimeters in diameter composed of biotite, muscovite, sodic plagioclase, quartz, and scattered pink garnet. Common white rims (haloes) around cores.

Krr ALASKITE OF ROBBERS ROOST (CRETACEOUS)--coarse-grained orange weathering craggy rock with small amounts of biotite, opaque minerals, and garnet.

Kss GRANITE OF SADDLE SPRINGS ROAD (CRETACEOUS)--fine-grained, vari-shades of gray, and characterized by small mafic clots and inclusions to several millimeters.

Ksc GRANITE OF SAND CANYON (CRETACEOUS)--low dipping fine-grained mass along eastern Sierra Nevada Sierra front; may be a dike-like offshoot of granodiorite of Castle Rock?.

Kta GRANITE OF TEHACHAPI AIRPORT (CRETACEOUS)--medium-grained felsic rock with minot biotite and common scattered pink garnet. Modally very similar to granite of Bishop Ranch, except for the common garnet.

GRANODIORITE
(radiometric ages shown)

Kk GRANODIORITE OF KEENE (LATE CRETACEOUS)--coarse-grained, felsic masses that occur only within the tonalite of Bear Valley Springs. Distinctly orange-weathered, and more quartz rich than tonalite of Bear Valley Springs. Local contacts seen that appear gradational. K-Ar age on biotite is 83.3 Ma (Evernden and Kistler, 1970).

Kas GRANODIORITE OF ALTA SIERRA (LATE CRETACEOUS)--fine-grained but sprinkled with coarser biotite. Dikes of this unit intrude the granodiorite of Wagy Flat, but textural gradation between these two masses suggest the Alta Sierra is a slightly younger, finer grained pulse of the Wagy Flat. K-Ar age on biotite of 89.0 ± 2.1 Ma (Evernden and Kistler, 1970).

Kcr GRANODIORITE OF CASTLE ROCK (LATE CRETACEOUS)--mostly porphyritic containing pink to salmon K-feldspar phenocrysts to 5 cm. Modal average very close to granite field. Probably correlative with granite of White Mountain to north (du Bray and Dellinger, 1981). K-Ar ages on biotite of 80.2, 80.7 Ma (Evernden and Kistler, 1970), 67.1 ± 2, 78.7 ± 2, 74.8 ± 2 Ma (Kistler and Peterman, 1978), and 81.1 ± 2

Ma (R.M. Tosdal in Bergquist and Nitkiewicz, 1982). K-Ar ages may reflect resetting by the younger Granite of Onyx. One Pb/U age of 90 ± 2 Ma from the Whiterock facies of the Granodiorite of Castle Rock suggests the entire body may have been intruded about 90 Ma.

Kcw WHITEROCK FACIES OF THE GRANODIORITE OF CASTLE ROCK (LATE CRETACEOUS) --generally somewhat similar petrographically to main Castle Rock type, but is non-porphyritic, has more dark minerals, and somewhat less K-feldspar. U-Pb age on zircon is 90 ± 2 Ma (Sams, 1986).

Kff GRANODIORITE OF FIVE FINGERS (LATE CRETACEOUS)--weathers into impressive light-colored spires. Noted for abundant small mafic inclusion and scattered hornblende, otherwise much similar to granodiorite of Castle Rock. Estimated age from Rb/Sr whole rock data of 90 Ma (R.W. Kistler, written commun., 1986).

Kbru GRANODIORITE OF BRUSH CREEK (LATE CRETACEOUS)--varied, but generally dark colored, in part contaminated rock containing abundant biotite hornblende. Dark, ovoid, inclusions common, as are centimeter-sized mafic clots which are reminiscent of the granite of Kern River. May correlate with granodiorite of Loggy Meadow to the north (du Bray and Dellinger, 1981). K-Ar age on biotite of 90.0 ± 2.0 Ma (Evernden and Kistler, 1970).

Kal GRANODIORITE OF ALDER CREEK (LATE CRETACEOUS)--facies of tonalite of Dunlap Meadow that contains more K-feldspar and less mafic minerals. Has higher measured $^{87}Sr/^{86}Sr$ (average of 6 samples = 0.7085) than Dunlap Meadow (average of 7 samples = 0.7069); both are higher than nearby Poso Flat unit (average of 4 samples = 0.7057), but no contact has been seen. Age of 91.4 ± 11.3 Ma (same as Dunlap Meadow) assumed. K-Ar ages on biotite from the above samples are 93.9 and 94.6 Ma (Evernden and Kistler, 1970).

Kpi GRANODIORITE OF PINE FLAT (LATE CRETACEOUS)--medium-grained relatively felsic rock with biotite and some hornblende. Dikes of Pine Flat intrude tonalite of Dunlap Meadow at several localities--no age-relevant contacts seen; however, Rb/Sr whole rock data indicate that this body has an age of 91.4 ± 11.3 Ma and cannot be distinguished from the tonalite of Dunlap Meadow on the basis of age (R.W. Kistler, written commun., 1986).

Kle GRANODIORITE OF LEBEC (LATE CRETACEOUS)--peppery textured biotite-bearing rock with minor hornblende. Locally porphyritic with stubby poikilitic K-feldspar; also contains rounded, "blue" quartz. Rb/Sr age on whole rock of 85 Ma (R.W. Kistler, written commun., 1981). Later data indicates an Rb/Sr whole rock age of 96.3 ± 8.7 Ma equivalent to granodiorite of Gato-Montes.

Kgm GRANODIORITE OF GATO-MONTES (LATE CRETACEOUS)--fine- to medium-grained peppery textured biotite-bearing rock with minor hornblende that closely resembles the granodiorite of Lebec both physically and chemically and may be correlative with it. Rb/Sr ages on whole rock of 4 samples about 85 Ma (R.W. Kistler, written commun., 1981). Recent reevaluation of these data and the addition of 5 more whole rock samples gives a Rb/Sr isochron of 96.3 ± 8.7 Ma (R.W. Kistler, written commun., 1986). On the basis of Rb/Sr data the Gato-Montes and Lebec may be correlative.

Kri GRANODIORITE OF RABBIT ISLAND (LATE CRETACEOUS)--medium-grained, relatively dark rock containing more biotite than hornblende. Mafic inclusions generally common. U-Pb age on zircon of 99 ± 2 Ma (Saleeby and Busby-Spera, 1986).

Kpf GRANODIORITE OF POSO FLAT (LATE CRETACEOUS)--texturally much like tonalite of Bear Valley Springs with abundant biotite and hornblende, but has abundant K-feldspar. These rocks may well be the same age as the tonalite of Bear Valley Springs, which is dated by U-Pb on zircon as 100 Ma (Sams, 1986).

Kpm GRANODIORITE OF PEPPERMINT MEADOW (EARLY CRETACEOUS)--medium grained, abundant biotite and some hornblende. Sprinkled with scattered coarser mafic minerals. Extends some distance north of the map area and may be correlative with the granodiorite of Pecks Canyon (du Bray and Dellinger, 1981). Rb/Sr whole rock data gives an age of 106.7 ± 21.1 Ma (R. W. Kistler, written commun., 1986).

Js GRANODIORITE OF SACATAR (JURASSIC)--dark rock of varied grain size, in part porphyritic--may well be a composite body. Abundant biotite and hornblende, surprising abundance of K-feldsapr in so dark a rock (about 15 percent average). Quartz quite variable, but generally relatively low (about 15 percent average). Examined in detail only along eastern Sierra Nevada front, where it is intruded by mafic lamprophyric dikes that probably belong to the Independence dike swarm of 148 Ma (Chen and Moore, 1982). K-Ar ages on hornblende of 146.3± 4.4, 145.3 ± 4.4, and 144.5 ± 4.3 Ma have been determined from samples of the Sacatar unit about 4 km north of the map area (R.M. Tosdal in Bergquist and Nitkiewicz, 1982). Biotite from this same sample gives a discordant K-Ar age of 88.2 ± 2.6 Ma and is probably a reset age (R. M. Tosdal in Bergquist and Nitkiewicz, 1982). R. W. Kistler (written commun., 1986) has determined an isochron of 177.4 ± 4.9 Ma from whole rock data for Rb/Sr for a large number of samples from the northeast part of the map and from north of the map area between Kennedy Meadows and Blackrock Mountain.

GRANODIORITE
(no radiometric ages)

Kcm GRANODIORITE OF CAMERON (CRETACEOUS)--an isolated pluton that is coarser grained than either the nearby Gato-Montes and the Whiterock facies of the Castle Rock pluton, both of which it modally resembles.

Kdc GRANODIORITE OF DEER CREEK (CRETACEOUS)--medium-grained gray rock with abundant biotite and varied amounts of hornblende. Seems to cut off foliation in nearby tonalite of Carver-Bowen and may be younger.

Kds GRANODIORITE OF DEMOCRAT SPRINGS (CRETACEOUS)--medium-grained, relatively felsic body that intrudes the tonalite of Bear Valley Springs (body of unknown size--not fully mapped--along State Highway 178).

Kef GRANODIORITE OF EVANS FLAT (CRETACEOUS)--peppered with abundant biotite crystals and weakly porphyritic with distinctive blue-gray anhedral quartz crystals to 1 cm in diameter--map pattern suggests Evans Flat intrudes the granodiorites of Alder Creek and Wagy Flat, but no age diagnostic contacts have been seen.

Khp GRANODIORITE OF HATCHET PEAK (CRETACEOUS)--coarse-grained with abundant biotite and some hornblende.

Kso GRANODIORITE OF SORRELL PEAK (CRETACEOUS)--several small, coarse-grained plugs west of Kelso Valley. Abundant associated aplite-alaskite-pegmatite dikes.

Kwf GRANODIORITE OF WAGY FLAT (CRETACEOUS)--medium-grained with abundant relatively coarse subhedral to euhedral biotite and hornblende crystals. Texturally similar to Mount Adelaide pluton, but contains about 10 percent of K-feldspar.

TONALITE

(radiometric ages shown)

Kwh TONALITE OF WOFFORD HEIGHTS (LATE CRETACEOUS?)--dark rocks with abundant biotite and hornblende that texturally and modally resemble the tonalite of Bear Valley Springs. K-Ar ages on biotite of 87.7 and on hornblende from the same sample of 89.9 Ma (Evernden and Kistler, 1970) are very close to the ages of a near coherent pair from the tonalite of Bear Valley Springs about 25 km south of Caliente. The latter samples have been presumed to have been reset, but their near concordance poses a problem.

Khc TONALITE OF HOFFMAN CANYON (LATE CRETACEOUS)--in outcrop appearance resembles tonalite of Bear Valley Springs with abundant anhedral biotite and hornblende and abundant mafic inclusions. Strontium isotopic data suggest the two tonalites are not related and that the Hoffman Canyon mass is more likely a contaminated phase of the granodiorite of facies of which has been dated at 90 Ma.

Kdm TONALITE OF DUNLAP MEADOW (LATE CRETACEOUS)--another medium-grained, fairly dark rock that is much like the Bear Valley Springs mass (perhaps the Dunlap has somewhat better formed mafic minerals and does not have noticeable gneissic patches and stringers). Rb/Sr whole rock data indicates an age of 91.4 ± 11.3 Ma, indistinguishable from the age of the granodiorite of Pine Flat (R.W. Kistler, written commun., 1986).

Kma TONALITE OF MOUNT ADELAIDE (EARLY CRETACEOUS)--distinctive medium-grained rock with abundant coarse biotite crystals, in part euhedral, and lesser subhedral to euhedral coarse hornblende crystals. Very small amounts of K-feldspar, but quite abundant quartz. Probably intrudes tonalite of Bear Velley Springs. U-Pb age on zircon of 100 ± 2 Ma (sams, 1986).

Kbv TONALITE OF BEAR VALLEY SPRINGS (EARLY CRETACEOUS)--dark gray medium-grained rock with abundant anhedral and patchy biotite and hornblende, characteristically foliated and containing abundant mafic inclusions and streaks and patches of gneiss. Grades westward into the mafic gneiss complex of the San Emigdio and Tehachapi Mountains. Six U-Pb zircon ages of 98 ± 2, 100 ± 2, 100 ± 2, 100 ± 2, 100 ± 2, and 100 + 2 Ma (Sams, 1986). K-Ar age on biotite of 85.9 ± 3 and on hornblende from the same sample of 88.1 ± 3 Ma (J.L. morton, written commun., 1979). The near concordance of this latter pair of ages in the midst of concordant and much older U-Pb ages is an enigma and requires very special conditions (such as very rapid cooling) to reset both biotite and hornblende at roughly the same time.

Kfs TONALITE OF FOUNTAIN SPRINGS (EARLY CRETACEOUS)--medium-grained, moderate gray tonalite with average of 11 percent biotite and 5 percent hornblende. U-Pb age on zircon of 102 Ma (Saleeby and Sharp, 1980).

Kwk TONALITE OF WALT KLEIN RANCH (EARLY CRETACEOUS)--medium-grained and texturally very similar to Mount Adelaide mass with abundant coarse, well-formed biotite and hornblende crystals. K/Ar ages on biotite of 105 Ma and hornblende from same sample 111 Ma (Evernden and Kistler, 1970). K-Ar age determination on biotite and hornblende of another sample yielded, respectively 100.4 and 105 Ma (Evernden and Kistler, 1970). These later two samples are the same ones that were samples for Rb/Sr. Another K-Ar determination on biotite gave an age of 100.6 Ma (Evernden and Kistler, 1970). More recent evaluation of the data of Evernden and Kistler (1970) indicates a K-Ar age on hornblende of 111 $\pm$ 2.5 Ma (R.W. Kistler, written commun., 1986).

KJap TONALITE OF ANTIMONY PEAK (EARLY CRETACEOUS OR LATE JURASSIC)--gray, medium-grained rock with a texture that features particularly blocky plagioclase ("corny texture"). Noticeable prehnite in several samples. U-Pb ages on zircon are very discordant but suggest an early Cretaceous or late Jurassic age (James, 1986).

TONALITE

(no radiometric ages)

Kcb TONALITE OF THE CARVER-BOWEN RANCH (EARLY CRETACEOUS)--medium-grained, very dark rock with more than 10 percent each of biotite and hornblende.

Kw TONALITE OF WOODY (CRETACEOUS)--rock of variable grain size, commonly fine-grained, seems to be a mixed body within the Walt Klein body.

Kzr TONALITE OF THE ZUMWALT RANCH (CRETACEOUS)--an incompletely mapped dark colored medium-grained body in the northwest corner of the map area that is much like the tonalite of Bear Valley Springs in texture and modal content.

Kbt BIOTITE TONALITE IN SAN JOAQUIN VALLEY SUBSURFACE (CRETACEOUS)--probably the least in part correlative with tonalite of Mount Adelaide.

Khbt HORNBLENDE-BIOTITE TONALITE IN SAN JOAQUIN VALLEY SUBSURFACE (CRETACEOUS)--probably correlative with tonalite of Bear Valley Springs.

QUARTZ DIORITE
(radiometric ages shown)

Kcf QUARTZ DIORITE OF CYRUS FLAT (EARLY CRETACEOUS)--medium-grained dark colored rock with abundant, but variable amounts of biotite and hornblende. Also a few percent of clinopyroxene (and) or orthopyroxene. On west side is a gabbro that is made up of mostly plagioclase and hornblende, with lesser amounts of biotite, clinopyrozene, orthopyroxene, and opaque minerals (unit "A" of Fox, 1981). U-Pb age on zircon of 100 $\pm$ 3 Ma (Saleeby and Busby-Spera, 1986).

Trfj QUARTZ DIORITE OF FREEMAN JUNCTION (TRIASSIC)--small dark gray body of varied grain size and texture. Some samples resemble the quartz diorite of Walker Pass. Rb/Sr whole rock determinations, on only 2 samples, give an age of about 222 Ma (R.W. Kistler, written commun., 1986).

Twrp QUARTZ DIORITE OF WALKER PASS (TRIASSIC)--medium-grained moderately dark gray rock that has distinctly coarser mafic minerals that are anhedral and patchy, giving rock a distinctive "fuzzy" texture. Almost no mafic inclusions, which is unusual here for so dark a rock. Strongly foliated margin shown by wiggly line pattern. Intruded by mafic lamprophyric dikes that are possibly related to the Independence dike swarm of 148 Ma (Chen and Moore, 1982). Rb/Sr on whole rock at 86 Ma has a relatively low Sr_i of 0.7049. K-Ar age on biotite and hornblende from the same sample is respectively 80 and 88 Ma. Preliminary Rb/Sr determinations on several other samples from this body indicates these ages are anomalously low, as recent determinations of Rb/Sr on whole rocks gives ages of 240.4 $\pm$ 14 Ma (R.W. Kistler, written commun., 1986).

QUARTZ DIORITE
(no radiometric ages)

Kca QUARTZ DIORITE OF CALIENTE (CRETACEOUS)--medium-grained, relatively mafic rock with abundant hornblende and much biotite; relatively low quartz content. Contains mafic, ultramafic, and gneiss patches, also mixed with tonalite of Bear Valley Springs.

Krc QUARTZ DIORITE OF RHYMES CAMPGROUND (CRETACEOUS)--a small dark gray body that is low in quartz and contains orthopyroxene enclosed in granodiorite of Alder Creek.

(?)Trlv QUARTZ DIORITE OF LONG VALLEY (TRIASSIC?)--only sparsely sampled; texture and mineral content compatible with some Sacatar samples, texture is unlike distinctive Walker Pass. Measured $^{87}Sr/^{86}Sr$ = 0.70558, much lower than Sacatar to the east (0.708-0.709) and higher than Walker Pass (0.7046). Some resembleance physically to quartz diorite of Freeman Junction that has a measured $^{87}Sr/^{86}Sr$ of 0.7051.

MAFIC AND ULTRAMAFIC ROCKS
(radiometric ages shown)

Kqm GABBRONORITE OF QUEDOW MOUNTAIN (EARLY CRETACEOUS)--a number of probably related bodies in the northwest part of the map area. Medium-to coarse-grained dark rocks composed of various mixtures of labradorite, orthopyroxene, clinopyroxene, and opaque minerals; also minor olivine. Associated hornblende gabbros developed from gabbronorite parent. U-Pb age on zircon of 115 Ma (Saleeby and Sharp, 1980).

Jer GABBRO, PYROXENITE, AND QUARTZ GABBRO OF EAGLE REST PEAK (LATE JURASSIC)--dark rocks of various grain size; most common is gabbro composed of calcic plagioclase, pale green amphibole, clinopyroxene, and minor orthopyroxene and metallic opaque grains. Pyroxenite, chiefly composed of clinopyroxene and partly serpentinized orthopyroxene (websterite). Hornblende quartz gabbro intrudes the gabbro-pyroxenite. K-Ar ages on hornblende are 137, 169, and 212 Ma from the hornblende quartz gabbro (Ross and others, 1973). U-Pb determination on zircon from the quartz gabbro gives age of 161 Ma (James and others , 1986).

Pzgm GABBRO-BASALT SERPENTINITE MELANGE OF SALEEBY AND SHARP (1980) (LATE PALEOZOIC?)--disrupted and internally mixed oceanic lithosphere exposed in far northwest corner of map area. U-Pb determinations on zircon from plagiogranite block gives widely discordant ages from 165 to 191 Ma (Saleeby and Sharp, 1980). They interpret these age data as suggesting a "safe age assignment" of 270 to 305 Ma (representing the age of the ocean-floor assemblage these blocks were originally a part of!)

MAFIC AND ULTRAMAFIC ROCK

(no radiometric ages)

KJbo OLIVINE GABBRO OF BODFISH (CRETACEOUS OR JURASSIC)--olivine gabbro, gabbro, anorthositic gabbro, and lesser dunite and wehrlite, in part serpentinized. Distinctive mantled olivines, gabbro commonly weathers to spheroided piles ("cannonballs"). May be cut by dark dikes of the Independence swarm?

KJbm GABBRONORITE OF BRECKENRIDGE MOUNTAIN (CRETACEOUS OR JURASSIC)--small remnants of strongly retrograded dark rocks in an intrusion breccia of tonalite and fine-grained granitic rock. Freshest samples are composed of well-twinned labradorite, and colorless to pale green amphibole, also liberally studded with pleochroic (pink to green) lamellar twinned orthopyroxene and altered olivine. Green spinel in reaction rims. Age uncertain but some resemblance to gabbronorite of Quedow Mountain of Early Cretaceous age.

KJlo GABBRO OF LIVE OAK (CRETACEOUS OR JURASSIC)--dark hornblende gabbro (and ampibolite?) with patches of remnant olivine norite with diffuse contacts with surrounding tonalite. Possibly correlative with Breckenridge remnants.

KJmsc MISCELLANEOUS GABBROIC BODIES (CRETACEOUS OR JURASSIC)--hornblende-gabbro and amphibolite in a number of small bodies at Freeman Canyon, Sage Canyon, Bull Run Basin, Horse Thief Flat, Tweedy Creek, Lone Tree Canyon, Comanche Point Road, and Granite School; and other small bodies.

KJp GABBRO OF PAMPA (CRETACEOUS OR JURASSIC)--mapped as "gabbro and gabbro-diorite" by Dibblee and Chesterman (1953). In addition to hornblende gabbro of various grain sizes also contains amphibolite(?), some porphyritic volcanic rocks, hypersthene-bearing tonalite, and retrograded rock of solely fibrous amphibole and chlorite that could have been an ultramafic rock.

KJsj GABBRO IN THE SAN JOAQUIN VALLEY SUBSURFACE (CRETACEOUS OR JURASSIC)--limited thin sections (no samples) reveal rocks composed of chiefly labradorite and clinopyroxene that is more or less altered to pale green fibrous amphibole. Relation to other map units unknown.

Trs SUMMIT GABBRO OF MILLER AND WEBB (1940) (TRIASSIC)?--commonly occurs as vari-sized patches of hornblende-gabbro in the granodorite of Sacatar; the largest of which are southwest of Big Pine Meadow and in Spanish Needle Creek area. Possibly intruded by quartz diorite of Walker Pass. Original definition of unit also included olivine gabbro of Bodfish (KJbo), quartz diorite of Cyrus Flat (Kcf), and tonalite of Wofford Heights (Kwh).

MIXED PLUTONIC AND METAMORPHIC ROCKS

Ktmg METAGABBRO OF TUNIS CREEK (EARLY CRETACEOUS)--two pyroxene, plagioclase hornblende gabbro with olivine remnants; intrusive into the mafic gneiss complex (Kset). Typically dark gray, massive, some compositional and cumulate layering. Associated hornblende-rich ultramafic rocks. U/Pb ziron age 102 $\pm$ 2 Ma (Sams, 1986). Rb/Sr whole-rock age 94.1 $\pm$ 12.5 Ma (R. W. Kistler, written commun., 1986).

Kset MAFIC GNEISS COMPLEX OF THE SAN EMIGDIO AND TEHACHAPI MOUNTAINS (EARLY CRETACEOUS)--a mostly metaigneous, hornblende-rich terrane of largely gneiss, amphibolite, quartzo-feldspathic gneiss, and diorite-tonalite. Coarse, haloed, red garnets are widespread and distinctive. Northeastern contact is gradational through wide zone with tonalite of Bear Valley Springs. Subdivided into diorite gneiss, tonalite gneiss, quartzo-feldspathic gneiss, and hypersthene tonalite map units in western Tehachapi Mountains by Sams (1986). U-Pb determinations on zircon from 13 samples give an age range of 110-120 Ma (Sams, 1986). Rb/Sr determinations on 13 whole rock samples give an isochron of 116.7 $\pm$ 2.45 Ma (R. W. Kistler, written commun., 1986).

Kjc AMPHIBOLITE OF JAWBONE CANYON AND MIXED PLUTONIC ROCKS (CRETACEOUS)--dark massive to foliated rocks much intruded by granite to tonalite bodies. Superficially resembles some of the mafic gneiss complex of the San Emigdio and Tehachapi Mountains, but $^{87}Sr/^{86}Sr$ ratios are much higher (0.708 $\pm$) than for the mafic gneiss complex (Kset) (0.704-0.705 $\pm$), suggesting these Jawbone Canyon rocks are more closely related to the granitic terrane they are immersed in.

Mzgm GRANITIC AND METAMORPHIC ROCKS, UNDIVIDED IN SAN JOAQUIN VALLEY SUBSURFACE (MESOZOIC)--for most of these rocks only data available are driller's log notations of either granite or schist.

METAMORPHIC ROCKS
(some age data)

Jbc BEAN CANYON FORMATION (JURASSIC?)--considerable variety of rock types including marble, calc-hornfels, dark schist and hornfels (with andalusite), quartzite, widespread but sparse metavolcanic and tuffaceous rocks, and minor ultramafic rocks. Rb/Sr determinations on whole rock samples of dacitic metavolcanic rocks at Bean Canyon suggest an age of volcanism (or period of metamorphism) of about 150 Ma (R.A. Fleck, written commun., 1976).

JTrlc LONG CANYON METASEDIMENTARY BELT (JURASSIC AND (OR) TRIASSIC)--irregular west-northwest-trending pendant and several correlative masses to the north, including one series of beds offset along, and west of the Kern Canyon fault. Mostly well-layered sequence of siliceous to pelitic schist (in part, coarse, containing andalusite and sillimanite), pure to impure quartzite, marble, and calc-hornfels. Main pendant contains one locality of bivalves that indicate a late Triassic or early Jurassic age (Saleeby and others, 1979).

Pzrb ROCKHOUSE BASIN METASEDIMENTARY BELT (PALEOZOIC?)--several isolated pendants of thin bedded mica schist, pure and impure quartzite, and calcareous beds. Age of belt possibly Paleozoic because of bedded barite in largest pendant (Taylor, 1984) and intrusion of belt by Triassic granitic rocks.

METAMORPHIC ROCKS
(no age data)

Mzbm BIG MEADOW METASEDIMENTARY BELT (MESOZOIC?)--a group of several northwest-trending pendants distinguished by gray to green calc-hornfels layers that have purplish spots that weather out ("fish eye holes")--otherwise much like Rockhouse Basin belt. From the north boundary of the map area the Big Meadow belt extends south-southeast for 50 km. This metasedimentary belt continues north of the map area and there contains barite, suggesting the Big Meadow belt may be, at least in part, Paleozoic. The easternmost pendants of the poorly studied Big Meadow Belt could as well be on-strike continuations of the Rockhouse Basin belt.

Mzfv FAIRVIEW METASEDIMENTARY BELT (MESOZOIC?)--consisting of numerous roof pendants, extends 55 km south-southeast from near the northern border of the map area, and is diagonally bisected by the White Wolf-Breckenridge-Kern Canyon fault. Pendants are composed of dark fine-grained to granular quartz-rich, thick-bedded to massive quartzite and lesser schist. Angular to subrounded clasts, largely unsorted, suggest rapid deposition (from turbidity currents?) for these beds. Tuffaceous layers and other metavolcanic types are present. Included is the probably related French Gulch metavolcanic pendant (Mzfg) which contains various felsic and intermediate volcanic rock and tuff types, including felsic layers with strong fluxion structure that probably represent ash flow tuff layers. The metavolcanic pendant also contains layers of coarse granular quartzite typical of the main Fairview belt. Fairview belt has offset counterparts on the east side of the Kern Canyon fault, including pendant that has both granular quartzite beds and metavolcanic layers and seems to form a tie between the main Fairview belt and the metavolcanic belt of French Gulch. French Gulch pendant contains ash flow tuff that has been dated by U-Pb on zircon at 98 ± 3 Ma (Saleeby and Busby-Spera, 1986). From the same locality Rb/Sr whole rock data indicates an age of 97.3 ± 0.5 Ma (R.W. Kistler, written commun., 1986). A rhyolite sill in Erskine Canyon has been dated by the U-Pb method on zircon at 105 ± 2 Ma (Saleeby and Busby Spera, 1986). An ash flow tuff, also in Erskine Canyon, has been dated by the U-Pb method on zircon at 102 ± 5 Ma (Saleeby and Busby-Spera, 1986). The relation of these mid-Cretaceous rocks to the much older fossiliferous pendant rocks to the east (Triassic or Jurassic) is not known.

Mzp PAMPA SCHIST (MESOZOIC?)--dominantly dark pelitic schist and quartzo-feldspathic hornfels; locally conspicuous coarse andalusite (chiastolitic) crystals and lesser sillimanite. Minor amphibolitic and chloritic schist suggest a metavolcanic fraction. Possibly related to greenschist and amphibolite in the subsurface (Mzsp) in the nearby San Joaquin Valley. Also possibly related to the dark schistose rocks, some with abundant carbonaceous material (Mzss) in the San Joaquin Valley subsurface. The White River and Fountain Springs pendants are possibly correlative with the Pampa Schist and are shown as Mzp?

Mzrs RAND SCHIST (MESOZOIC?)--exposed only as vari-sized slivers in the Garlock and Pastoria fault zones. Includes chlorite, amphibole, and mica schist, quartzite (at least in part metachert), serpentinite, and other metavolcanic rocks. Veins and dikes to several meters thick of white "bull" quartz are common and characteristic. All rock types resemble closely probable correlative schists in the Rand Mountains.

Mzsc SALT CREEK METASEDIMENTARY BELT (MESOZOIC?)--a series of pendants and inclusions in the granodiorite of Lebec (Kle) that consists of commonly red-weathering calcareous, siliceous, and pelitic schist and hornfels (commonly with sillimanite and red garnet).

Mzt TEHACHAPI METASEDIMENTARY BELT (MESOZOIC?)--one irregular, but generally north-trending pendant and several related masses to the south, northeast and northwest. Includes some bodies offset on the west side of the Kern Canyon fault. Also tentatively included with this belt are several, as yet poorly studied, pendants (Mzt?) to the northwest. This group includes a metavolcanic pendant that includes ash flow tuff (King George Ridge metavolcanic pendant--shown as "Mztv"). The Tehachapi belt contains the usual siliceous, pelitic, and calcareous thin beds (some rather massive marble). The Brite Valley quartzite-rich pendants west of the main Tehachapi pendant (Mztq) seem to contain more pure quartzite than the other parts of the belt.

Mztj TEJON CANYON PENDANT (MESOZOIC?)--dominantly thin-bedded calcareous, siliceous, and argillaceous beds (some with sillimanite and coarse red haloed garnets). Also contains gneissic beds and migmatite and may be transitional between the Tehachapi pendants and the paragneissic layers in the gneiss complex (Kset) to the north and west.

SUMMARY OF BASEMENT GEOLOGIC FEATURES

Nearly 100 units have been subdivided on the basement rock map of the southern Sierra Nevada. Most of these units are granite or granodiorite bodies that range from plutons covering only a few square kilometers to batholithic bodies many hundreds of square kilometers in extent. In addition, there are bodies of tonalite and quartz diorite. Generally, small remnants of retrograded mafic and ultramafic rocks are scattered through the granitic bodies. A fair sprinkling of radiometric ages by Pb-U, Rb/Sr, and K-Ar methods show that most of the granitic bodies are Cretaceous, but on the east side of the

Sierra some are of Jurassic age and some are Triassic. The mafic rocks on the west are considered Cretaceous on the basis of sparse radiometric data. One body in the central part of the map area may be Jurassic. An isolated gabbroic mass north of the San Emigdio Mountains is Jurassic also, but it is not certainly related to the other southern Sierra Nevada basement. Several mafic bodies to the east are at least as old as Traissic, and may be older.

The metamorphic framework rocks of the batholith are represented by a large gneissic complex in the southern Sierra Nevada tail, largely composed of tonalitic orthogneiss, that may be a part of the root zone of the batholith. In addition, there are widespread metasedimentary pendant rocks that have been somewhat arbitrarily grouped into mainly northwest-trending belts. Most of these rocks are probably part of the Kings Sequence of Jurassic and Triassic age, based on one fossil locality and lithologic similarities to metasedimentary rocks further north in the Sierra Nevada where the name Kings Sequence was derived (Saleeby and others, 1978). One belt of metasedimentary rocks in the eastern Sierra Nevada may, however, be Paleozoic based on the presence of bedded barite and lithologic similarities with known Paleozoic rocks to the north in the western Sierra foothills (Weber, 1963) and El Paso Mountains a short distance southeast of the Sierra Nevada. Metavolcanic rocks, mostly felsic to intermediate in composition, and including ash flow tuffs, are common in some metamorphic belts.

The southern Sierra Nevada basement is transected by the San Andreas fault, a right-lateral strike-slip fault of considerable movement (at least several hundred kilometers and possibly much more). The left lateral strike-slip Garlock fault cuts east-northeast near the south margin of the Sierra Nevada basement. Granitic rocks south of the Garlock fault are probably correlative with granitic rocks northwest across the fault, but the framework metamorphic rocks south of the Garlock fault have some marked dissimilarities with metasedimentary rocks to the northwest. Large exotic slivers of Rand Schist are exposed between branches of the Garlock fault and the east-west trending Pastoria fault. These two faults (possibly related) mark the southern extent of the gneiss complex; granitic rocks south of these faults appear to represent a much shallower crustal level than those to the north. Map patterns of some slivers of the Rand Schist (Mzrs) along both faults suggest the gneiss and accompanying granitic rocks are thrust over the Rand Schist.

The east border of the Sierra Nevada at this latitude is marked by the Sierra Nevada fault. Strong physiographic contrast of mountain-up on the west and valley-down to the east marks this dominantly dip-slip fault, probably the westernmost significant basin-and-range fault.

An impressive zone of faulting slices northward through the center of the basement outcrops. This fault, the White Wolf-Breckenridge-Kern Canyon fault, bends strongly west near its south end to almost parallel the Garlock fault trend, as the north end (which extends some distance north of the map area) parallels the Sierra Nevada fault. A fault of this magnitude cutting through batholithic rocks for about 200 km is unusual, if not unique, in the Sierra Nevada batholith. The fault offsets several basement rock units as much as 20 km in a right-lateral sense. The fault probably originated some 80-90 Ma during the latest pulse of the batholithic emplacement. The most recent movements along this fault have been north-directed thrusting on the southern part (White Wolf segment) as emphasized by a strong earthquake in 1952. Further north, particularly in the Walker Basin and Isabella Lake areas, the physiography suggests normal faulting with the east side down. This is in the area of undoubted right-lateral offset of the basement and suggests recent movements on this fault have a different sense than the original movements--possibly in reaction to differing stress patterns? There, the sense of movement and orientation of the fault mimics basin-and-range type movement, and may reflect the westernmost example of basin-and-range faulting.

An earthquake swarm in 1983-84 (Jones and others, 1984) and several earlier swarms define a north-trending zone only a few kilometers east of the Kern Canyon fault near Big Meadow. Focal mechanisms of some of these earthquakes indicate dip-slip displacement with the east side down. The swarms suggest the incipient development of another basin-and-range fault in this area.

The Pleito thrust trends more-or-less east-west and in present exposures, north of the San Emigdio Mountains it transects Cenozoic deposits. It is a north-directed thrust that may be related to the latest movement on the southern segment of the White Wolf-Breckenridge-Kern Canyon fault. Also, the Pleito thrust movement may be the cause of the surfacing of the isolated Eagle Rest Peak gabbroic rock north of the Sierran basement. The thrust movements of both faults could be evidence of strain release of stress placed on the southern Sierra Nevada because of northward shoving of the basement block west of the San Andreas fault.

A few other faults (surprisingly few) have been identified within the basement of the map area. Two northwest-trending normal faults with their southwest side down bound the basement against the valley floor at the point near where the Kern River emerges from the mountains and to the north. The fault evidence here is largely physiographic with sharp triangular facets on both sides of Kern Canyon. Similar northwest-trending relatively straight segments of the basement against valley deposits are present north of the mouth of Kern Canyon where no faults have been mapped, and are at least suggestive of similar faulting. A somewhat similar trending fault is the Edison fault to the south. It, however, is downthrown to the north and forms a grabenlike structure with the fault to the north that cuts across the mouth of the Kern River Canyon. The Edison fault displacement is more than 1500 m at its western end, based on data from oil wells. The eastern part of the fault dips steeply to gently to the north and is marked by zones of mylonite, gouge, and pulverized rock (Dibblee and Chesterman, 1953). Displacement on the fault decreases to the east and it may terminate against the White Wolf-Breckenridge-Kern Canyon fault zone.

REFERENCES CITED

Bergquist, J.R., and Nitkiewicz, A.M., 1982, Geologic map of the Domelands Wilderness and contiguous roadless areas, Kern and Tulare Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map, MF 1395-A, scale 1:48,000.

Chen J.H. and Moore, J.G., 1982, Uranium-lead isotopic ages from the Sierra Nevada batholith, California: Journal of Geophysical Research, v. 87, no. B6, p. 4761-4784.

Dibblee, T.W., Jr., and Chesterman, C.W., 1953, Geology of the Breckenridge Mountain quadrangle, California: California Division of Mines and Geology, Bulletin 168, 56 p.

Diggles, M.F., 1984, Peraluminous granite from the southern Sierra Nevada, California: Geological Society of America Abstracts with Programs, v. 16, no. 5, p. 278.

du Bray, E.A., and Dellinger, D.A., 1981, Geology of the Golden Trout Wilderness, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1231-A, scale 1:48,000.

Evernden, J.F., and Kistler, R.W., 1970, Chronology of emplacement of Mesozoic batholithic complexes in California and western Nevada: U.S. Geological Survey Professional Paper 623, 42 p.

Fox, L.K., 1981, Compositional variations and implications of petrogenesis of the Kernville pluton, southern Sierra Nevada, California: Princeton, N.J., Princeton University, senior thesis, 77 p.

James, E.W., 1986, U/Pb age of the Antimony Peak tonalite and its relation to Rand Schist in the San Emigdio Mountains, California: Geological Society of America Abstracts with Programs, v. 18, p. 121.

James, E.W., Kimbrough, David, and Mattinson, J.M., 1986, Evaluation of pre-Tertiary piercing points along the northern San Andreas fault using U/Pb zircon dating, initial Sr, and common Pb isotopic ratios: Geological Society of America Abstracts with Programs, v. 18, p. 121.

Jenkins, S.F., 1961, A structural study of a portion of the Kernville Series: unpublished thesis, University of California, Berkeley, 83 p.

Jones, M.L., Johnson, C., and Dollar, R.S., 1984, Swarms in the southern Sierra Nevada: Earthquake Notes, v. 55, p. 22.

Kistler, R.W., and Peterman, Z.E., 1978, Reconstruction of crustal blocks of California on the basis on initial strontium isotopic compositions of Mesozoic granitic rocks: U.S. Geological Survey Professional Paper 1071, 17 p.

MacKevett, E.M., Jr., 1960, Geology and ore deposits of the Kern River uranium area, California: U.S. Geological Survey Bulletin 1087-F, p. 169-222.

Miller, J.W., and Webb, R.W., 1940, Descriptive geology of the Kernville [30'] quadrangle, California: California Journal of Mines and Geology, v. 36, p. 343-378.

Moore, J.G., and Hopson, C.A., 1961, The Independence dike swarm in eastern California: American Journal of Science, v. 259, p. 241-259.

Ross, D.C., 1979, Summary of petrographic data of basement rock samples from oil wells in the southeastern San Joaquin Valley: U.S. Geological Survey Open-File Report 79-400, 11 p.

Ross, D.C., Wentworth, C.M., and McKee, E.H., 1973, Cretaceous mafic conglomerate near Gualala offset 350 miles by San Andreas fault from oceanic crustal source near Eagle Rest Peak, California: U.S. Geological Survey Journal Research, v. 1, no. 1, p. 45-52.

Saleeby, J.B., and Busby-Spera, Cathy, 1986, Field trip guide to the metamorphic framework rocks of the Lake Isabella area, southern Sierra Nevada, California, in Dunne, G.C., compiler, Mesozoic and Cenozoic structural evolution of selected areas, east-central California: guidebook prepared for 82nd Annual Meeting of the Cordilleran Section of the Geological Society of America, p. 81-94.

Saleeby, J.B., Goodin, S.E., Sharp, W.D., and Busby, C.J., 1978, Early Mesozoic paleotectonic-paleogeographic reconstruction of the southern Sierra Nevada region: in Howell, D.G., and McDougall, K.A., eds., Mesozoic paleogeography of the western United States; Society of Economic Paleontologists and Mineralogists, Pacific Section, Pacific Coast Paleogeography Symposium 2, p. 311-336.

Saleeby, J.B., and Sharp, W.D., 1980, Chronology of the structural and petrologic development of the southwest Sierra Nevada foothills, California: Geological Society of America Bulletin, v. 91, Pt. I, p. 317-320, Pt. II, p. 1416-1535.

Sams, D.B., 1986, U/Pb geochronology, petrology, and structural geology of the crystalline rocks of the southernmost Sierra Nevada and Tehachapi Mountains, Kern County, California: Pasadena, California Institute of Technology, Ph..D. Thesis, 315 p.

Taylor, G.C., 1984, Rockhouse Basin Wilderness Study Area, Kern and Tulare Counties: California Geology, v. 37, no. 12, p. 263-272.

Weber, H.F., Jr., 1963, Barite in California: Mineral Information Service, California Division of Mines and Geology, v. 16, no. 10, p. 1-10.

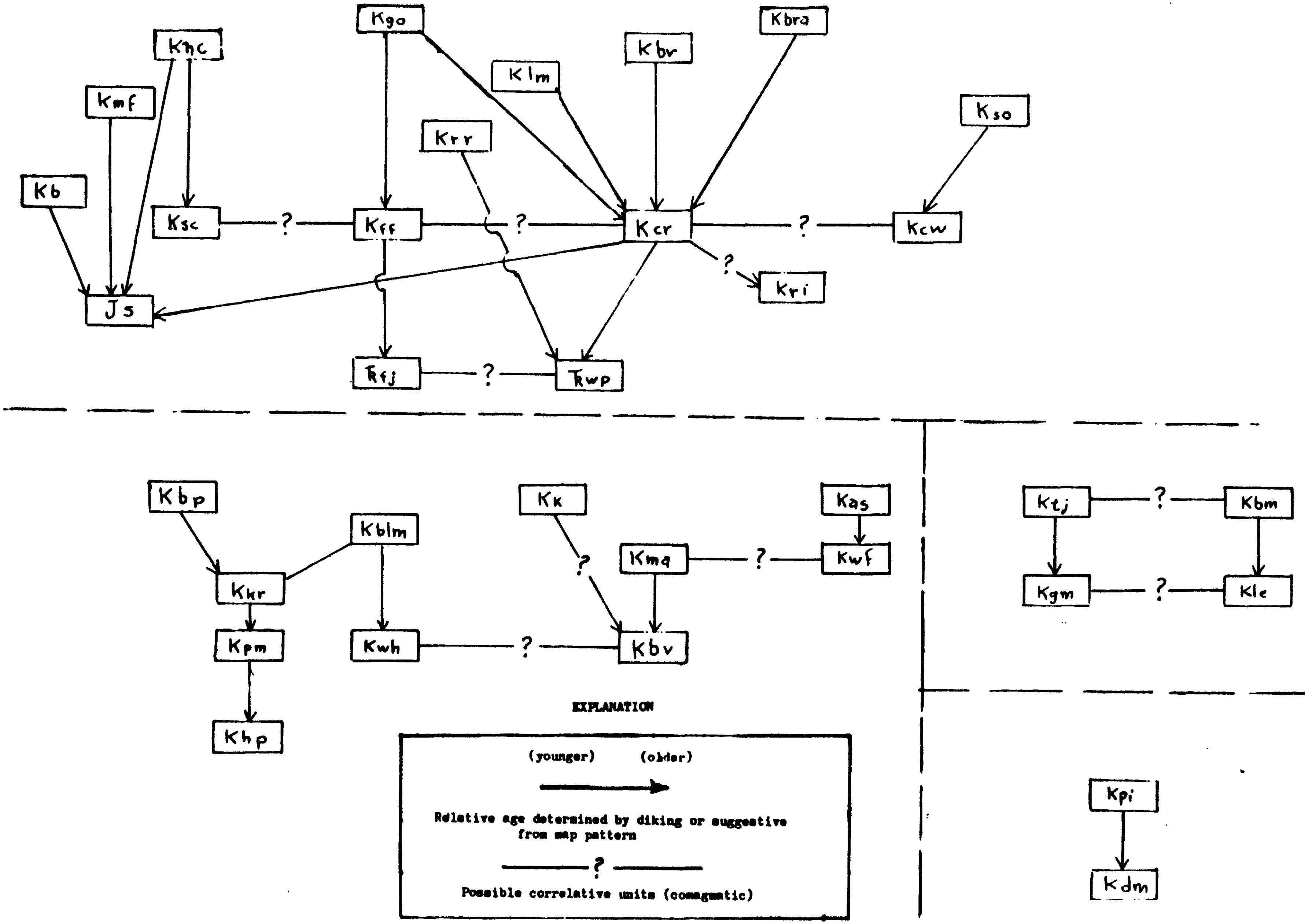

Figure 1. Intrusive relations for some granitic units of the southern Sierrs Nevada, California