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METAMORPHIC FRAMEWORK ROCKS OF THE SOUTHERN SIERRA NEVADA, CALIFORNIA

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ABSTRACT

The metamorphic-framework rocks of the southern Sierra Nevada consist primarily thin-bedded metasedimentary rocks including various proportions of micaceous to quartzofeldspathic schist, pure to impure quartzite, and calcareous beds including relatively pure marble. Notable exceptions are the immature granular quartzites of the Fairview pendant and probably related ash flow tuffs and other metavolcanic rocks of the French Gulch pendant. These two pendants together form a north-trending linear belt that is sharply in contrast to the pendant rocks to the east, west, and south, appearing to form a giant lens in an otherwise normal sequence of schist, quartzite, and marble.

Also somewhat anomalous is the Pampa Schist of Dibblee and Chesterman (1953), which is composed mainly of dark-colored micaceous rocks (commonly containing conspicuous chiastolite) and some metavolcanic rocks. Marble and quartzite are notably absent. In a large area immediately west of the Pampa Schist, the subsurface basement of the San Joaquin Valley is made up of largely greenschist and low grade amphibolite that commonly preserves a felty to trachytic texture--almost certainly metavolcanic rocks. Associated with these metavolcanic rocks are dark carbonaceous schistose rocks that are much like outcrops of Pampa Schist. Possibly the Pampa Schist extends west under the San Joaquin Valley, where it has a much larger proportion of metavolcanic layers.

The Bean Canyon Formation, limited in outcrop area to pendants in the plutonic rocks south of the Garlock fault, is in many respects a "normal" metasedimentary assemblage of marble, quartzite, and schist. However, this formation has significant dark micaceous schist (in part andalusite-bearing) and sparse but widespread metavolcanic layers (including ash flow tuff). In total the Bean Canyon Formation is not like any other sequence of metamorphic rocks in this part of the Sierra Nevada.

Exotic slivers of the Rand Schist are preserved in the Garlock and Pastoria fault zones. These dark colored schists and quartzites, metavolcanic rocks, metacherts, and minor serpentinites closely resemble the outcrops of Rand Schist some 50 km east in the Rand Mountains.

All the metasedimentary rocks, except the exotic Rand Schist slivers, have previously been considered part of the Jurassic-Triassic King sequence of Saleeby and others (1978). The only fossil locality (in the Long Canyon pendant) contains bivalves of Late Triassic or Early Jurassic. In addition, Rb/Sr data suggest a Jurassic age for the Bean Canyon Formation. The presence of bedded barite in the Rockhouse pendant, which is intruded by possibly Triassic granitic rocks, suggests that this pendant (and the related belt) may be Paleozoic.

INTRODUCTION

The metamorphic framework rocks of the southern Sierra Nevada consist of vari-sized pendants and the large mafic gneiss complex of the San Emigdio and Tehachapi Mountains (pl. 1). This mafic gneissic complex is not discussed here, but some of the metasedimentary rocks associated with the gneissic complex may be related to the pendant rocks discussed here. The vari-sized pendants are composed mainly of thin-bedded metasedimentary rocks, primarily of micaeous to quartzofeldspathic schist, pure to impure quartzite, and calcareous rocks including abundant relatively pure marble. These pendants can be grouped into a number of belts that may be equivalent to formations of an original stratigraphic section (fig. 1). Here, these belts are informally named after the largest pendant in each belt. Because of the small extent of most units, the strong deformation and relatively high metamorphic grade of the rocks, and the rarity of preserved fossils, these pendant rocks are not formally named at this time. A summary of the lithologic and petrographic character of each belt is shown on Table 1.

The age of these rocks is largely unknown. Only one fossil locality is known, that being south of Isabella Lake in the main body of the Long Canyon pendant where bivalves were found that are considered to be Late Jurassic or early Triassic by J.W. Durham and D.L. Jones (Saleeby and others, 1978). On the basis of this lithologic comparison with metasedimentary rocks in the central Sierra Nevada, and this fossil locality, most of the metasedimentary rocks are considered to be a part of the Kings Sequence of Triassic-Jurassic age (Saleeby and others, 1978).

ROCKHOUSE BASIN METASEDIMENTARY BELT

The Rockhouse Basin metasedimentary belt consists of the Hi-Peak, Owens Peak, and Rockhouse Basin pendants. The rocks in these pendants are dominantly thinly layered red-to brown-weathering siliceous, argillaceous, and calcareous beds; the Owens Peak pendant perhaps has a higher percentage of argillaceous beds than do the other pendants of this belt. Along the southwest side of the Owens Peak pendant are layers of metavolcanic rocks of intermediate composition. Minor metavolcanic layers are also reported from the Rockhouse Basin pendant (Taylor, 1984). Possibly these layers are ash flow or crystal tuff beds. Marble in all three pendants has been altered to scheelite-bearing tactite. These three pendants make up a "typical" thin bedded sequence of Sierran pendants, but lack much pure quartzite.

Hi-Peak Pendant

Thinly layered, red-to brown-weathering, siliceous, calcareous, and argillaceous rocks of the Hi-Peak pendant extend along the east front of the Sierra Nevada for about 10 km north of Indian Wells Canyon. The pendant is named for a small tungsten mine at the north end of the largest pendant body.

In the largest body, Bruce (1981) described four units: (1) thin bedded argillaceous and siliceous schist and hornfels, (2) calc-hornfels, (3) high silica marble, and (4) low silica marble. The argillaceous rocks range from schist to schistose hornfels in beds from 5 to 10 cm thick in units from tens to hundreds of meters thick. Quartz and feldspar are dominant; from 10 to 30 percent of calcite is present in most rocks. Variable amounts of biotite, amphibole, pyroxene, and epidote are also present. The dark green to dark reddish-brown calc-hornfels layers of unit 2 are hard to distinguish from the hornfels of unit 1, but have more clinopyroxene, grossularite garnet, and epidote, as well as traces of scheelite. Marble (units 3 and 4) is generally white to light gray, thinly bedded and interbedded with the calc-hornfels. Calcite is dominant, but some dolomite is present. Varying amounts of wollastonite, tremolite-actinolite, idocrase, epidote, and grossularite garnet dictate the distinction between the high and low silica units. In addition, the high silica unit is thicker bedded and darker. Small tactite masses are found in the low silica marble; they are generally pyroxene-rich, with minor epidote, grossularite garnet, quartz, and calcite. The locally scheelite-bearing tactites have had modest tungsten production (Bruce, 1981).

The smaller, disconnected bodies to the north are mostly red-to brown-weathering thinly layered quartzite, siliceous hornfels, and calc-hornfels. Marble is rare to absent, but the northernmost small occurrence is a small prospect pit that contains coarse garnet. The small body just south of Grapevine Canyon contains layers of quartzite and quartz schist with abundant graphite and muscovite, but no biotite, as well as "normal" red to brown-weathering siliceous rocks.

Owens Peak Pendant

The Owens Peak pendant is a 20-km-long, northwest-trending discontinuous belt of distinctive red-weathering metasedimentary rocks. A small outcrop area just northeast of Robbers Roost along the Sierra Nevada frontal fault is tentatively considered to be a disconnected piece of the Owens Peak pendant. Most of the Owens Peak pendant is composed of thinly-layered impure quartzite, siliceous hornfels, schist (in part coarse) and minor calc-hornfels and marble. Some dark carbonaceous quartzite may be metachert. Some layers are rich in colorless, tremolitic(?) amphibole.

The Owens Peak pendant is generally similar to the Hi-Peak pendant, but probably has a higher percentage of argillaceous layers, as typified by the presence of andalusite and fibrolitic to prismatic sillimanite. At the northwest end of the pendant, distinctively coarse spotted muscovite schist contains cordierite. These schist layers also contain abundant small euhedra of pale blue tourmaline.

Abundant red- to brown-weathering float from the northern part of the Owens Peak pendant is present in Cow Canyon. Most common in this float is spotted to streaky mica schist rich in poikilitic muscovite, and brown biotite in part altered to chlorite. Quartz and plagioclase form a generally finer grained matrix of these rocks. Some samples contain abundant lens-like bundles of fibrolitic sillimanite. Tiny crystals of magnetite are strikingly abundant. Gray-green tourmaline is sparse but widespread. Less abundant in the float is dense black quartz hornfels (metachert?) that contains well-aligned trains of opaque "dust."

On the Pacific Crest Trail about 1 km north of Morris Peak a dark, knobby schist layer contains subhedral twinned intermediate plagioclase cystals to 3 mm in a fine-grained granoblastic (quartz and feldspar) and nematoblastic (brown biotite) groundmass. Probably this is an intermediate metavolcanic rock. The setting suggests it is a thin sill, but the relations are not clear--in the field I assumed this was another metasedimentary rock type.

Just west of Spanish Needle Creek (Lamont Peak 15' quadrangle) [1/] near the north tip of the pendant, thinly layered dark schistose rocks are exposed that are may be metavolcanic. Some layers are thinly laminated and dominated by pale green hornblende and largely untwinned plagioclase. One schist layer is an interlocking mat of talc with scattered tremolite and chlorite; another is almost solely a mat of pale green chlorite. Tremolite and minor chlorite make up another layer. One plagioclase-hornblende schist also contains coarser plagioclase crystals to 0.6 mm that suggest phenocrysts or volcanic clasts. These schists could have been derived, at least in part, from dolomitic sediments, but a volcanic protolith seems likely. These schists and the intermediate volcanic layer suggest a volcanic component along the southwest side of the Owens Peak pendant.

[1/] Geographic localities that are referred to but not named on the Topographic base or on Plate 1, are indexed to specific 7-1/2 and 15 minute quadrangles. The location of these quadrangles are shown on figure 2.

The isolated Robbers Roost (Freeman Junction 7-1/2' quadrangle) body (about 3 km south of the south part of the Owens Peak pendant) is mostly made up of dark-colored, fine-grained, siliceous to argillaceous rocks, and minor blue-gray marble and epidote-rich tactite. The argillaceous rocks are schistose to slaty and rich in muscovite, brown biotite, and quartz. Some layers are spotted with pale green chlorite clots to 1 mm. Some layers of carbonaceous quartzite, probable metachert, are rich in opaque flakes of graphite and have some local lenses rich in tiny, low birefringent, high relief grains that are most likely apatite. These may reflect original phosphatic nodules in the chert.

Some tungsten has been produced from scheelite-bearing tactite zones in the pendant (Bruce, 1981). Also gold-bearing quartz veins within the pendant rocks have been modest producers. The veins also cut adjacent granitic rocks and are thus younger and unrelated to the metasedimentary rocks.

Rockhouse Basin Pendant

The Rockhouse Basin pendant is an irregular body about 16 km long and as wide as 4 km. A number of smaller nearby masses of metasedimentary rock are tentatively considered to be related. These pendant masses appear to be included within the large area occupied by the dark granitic rocks of the granodiorite of Sacatar. The Rockhouse Basin pendant bodies may well be the on-strike continuations of the Hi-Peak and Owens Peak pendants, judging from the map pattern.

The character of the largest pendant has been summarized by Taylor (1984) based on a mineral resource appraisal of the Rockhouse Basin wilderness study area. He reported two map units: (1) massive, light-gray to black quartzite that makes up the small bodies north of the main mass, and (2) an undifferentiated unit that consists of quartz-mica schist, quartzite, and phyllite, with minor amounts of marble, slate, hornfels, and metavolcanic rock.

The quartzite north of the main pendant mass is gray to black, ranging from massive to thinly laminated, and from coarsely crystalline to cryptocrystalline. Some quartzite is micaceous and interlayers of quartz-mica schist and phyllite are present.

The main pendant mass, best exposed along the Rockhouse Basin-Chimney Meadows Road (east of Rockhouse Basin), contains abundant light gray to bluish gray, thinly laminated pure to micaceous quartzite. Interbedded with the quartzite is well-foliated, greenish gray to dark gray, fine grained schist ranging from quartz-muscovite-biotite-garnet schist to quartz-mica schist. Several zones of calc-hornfels and marble as much as 30 m thick also occur in the main pendant. The white to bluish gray marble is thinly bedded, fine- to coarse-grained, and in part dolomitic. Near intrusive contacts the marble is locally altered to quartz-epidote-garnet tactite and has local scheelite zones that have been mined for tungsten. Interbeds of barite in the marble have also been exploited.

Metamorphosed volcanic rocks are also reported by Taylor (1984) from the main pendant as minor intercalated layers in the metasedimentary sequence. The presumed metavolcanic rocks are light gray and massive, and are interpreted as hypabyssal intrusions into the metasedimentary pile. Alternatively I suspect these metavolcanic rocks may represent ash flow or crystal tuff layers.

The only place where I have examined rocks of the Rockhouse Basin pendant is at a small unmapped body just south of the main mass. Micaceous schist is present there containing coarse muscovite, dark brown biotite, about 50 percent matrix quartz, and abundant opaque grains and bundles of fibrolitic sillimanite.

Except for the presence of the beds of barite the Rockhouse Basin pendant rocks are compatible with being the on-strike continuation of the Hi-Peak and Owens Peak pendants.

BIG MEADOW METASEDIMENTARY BELT

The Big Meadow metasedimentary belt consists of several pendants north of Big Meadow, some scattered scraps north of the South Fork of the Kern River and remnants on strike in the Scodie Mountains. This belt, at least at the north end, is characterized by "fish eye" beds that are distinctive white calc-hornfels beds that contain green to purple spots that weather out as holes. These "fish eye" beds prove to be composed chiefly of clinopyroxene with lesser plagioclase, quartz, and K-feldspar. Stretched out quartz clasts suggest some beds were sandy limestone.

Big Meadow pendants

The Big Meadow pendants comprise an arbitrary group of six north-to northwest-trending, probably related elongate pendants north of Big Meadow. The two easternmost, and less elongate pendants were first described by Miller and Webb (1940). They noted several thousand feet of phyllite and white, poorly bedded, "fish-eye" quartzite, surrounded by an aureole of gneiss. Bergquist and Nitkiewicz (1982) noted that the gneiss was a medium-grained, well-foliated hornblende gneiss composed of subequal amounts of quartz and plagioclase with hornblende and minor amounts of sphene, biotite, apatite, epidote, and metallic opaque minerals. They made no distinction between these two pendants and several others in the region which they characterize as mostly composed of quartzite, mica schist, phyllite, and marble. I have not examined these two pendants.

The easternmost, and largest (12 km long), of the western group of four pendants is characterized, particularly at its northern end, by white rocks with distinctive green to purple spots that weather out as holes. This is probably the same rock type that Miller and Webb (1940) called "fish-eye quartzite" in the two eastern pendants. These rocks are essentially clinopyroxene hornfels composed of a granoblastic mat of clinopyroxene, with lesser plagioclase, quartz, and K-feldspar. Some stretched out quartz lenses may be deformed original clasts suggesting these rocks were sandy limestones. Farther south the pendant also has abundant biotite-quartzofeldspathic schist that contains bundles of fibrolitic sillimanite, lesser amounts of coarser acicular sillimanite, and possible pinite after cordierite. Tactite, impure quartzite, and muscovite-quartz schist are also present.

The other three pendants on the west are composed of a mixture of generally thin-bedded, impure quartzite (some with pink garnet), biotite quartzofeldspathic schist containing fibrolite and prismatic sillimanite, lesser calc-hornfels, and minor tactite and marble.

The conspicuous white "fish-eye" layers in the eastern three pendants of the Big Meadow group have not been noted elsewhere in the metasedimentary rocks of the southern Sierra Nevada. As such, these suggest a tentative formational unit, pending further work.

Scodie remnants

In the Scodie Mountains and to the northwest are a number of inclusions or tiny pendants of metasedimentary rock awash in a sea of granitic material. Harner and others (1983) noted that the individual bodies were no more than 100 m across. Brief notes in Harner and others (1983), and a few thin sections, suggest that the dominant rock types are fine-grained calc-hornfels (variable amounts of plagioclase, clinopyroxene, epidote, hornblende, K-feldspar, and garnet), calcareous quartzite (alternating quartz-rich layers, and layers rich in clinopyroxene and hornblende), rather pure quartzite with minor of K-feldspar, plagioclase, biotite, and opaque grains, and lesser coarse marble and garnet-epidote tactite. Selective exposure of the more resistant calcareous rocks and quartzite on the poorly exposed uplands of the Scodie Mountains may account for the lack of mention by Harner and others (1983) of the less resistant schistose rocks. Also, Harner and others (1983), in their mineral resources appraisal, may have selectively examined and collected calcareous rocks, which have more economic interest than the schistose. Numerous small masses just north of the South Fork of the Kern River are possibly an on-strike continuation of the Scodie remnants. Here are exposed thinly layered reddish brown weathering siliceous mica schist, quartzite, calc-hornfels, and lesser garnet-epidote tactite. These rocks are lithologically compatible with those of the Scodie Mountains, and this whole remnant package could be related to the Big Meadow pendants.

Two small pendants of marble were delineated by Miller and Webb (1940) in Berts Canyon near Coyote Spring (Walker Pass 7-1/2' quadrangle) about halfway between the Owens Peak pendant and the belt of Scodie remnants. I have not examined these two bodies.

The small bodies north of the South Fork of the Kern River are essentially on-strike with the Scodie remnants and are considered related. These bodies are dominantly siliceous mica schist.

LONG CANYON METASEDIMENTARY BELT

The Long Canyon metasedimentary belt consists of the irregularly-shaped Long Canyon pendant (up to 3 km wide and about 20 km long) and a number of unnamed bodies of similar lithology both east of the main pendant, and stretching north of the pendant adjacent to the Kern Canyon fault. An offset body across the fault to the west, which extends for several kilometers north of the map area, is also considered part of the Long Canyon belt. Three lithologies typify this belt: (1) white, pure to impure quartzite that weathers reddish, (2) white to gray marble in thick units, and (3) dark colored micaceous schist commonly containing andalusite and sillimanite.

Gray to green thinly layered calc-hornfels is also common in this belt. Locally, quartzite and marble units are mappable (Best and Weiss, 1964, fig. 2). Dark micaceous schist and hornfels is probably the most abundant rock type in the Long Canyon pendant. All gradations exist between strongly schistose fabrics and massive granoblastic hornfelsic rocks. My observations suggest that foliated schistose rocks are more abundant. Best and Weiss (1964), on the other hand, believed hornfelsic textures were dominant, at least in the largest pendant mass. Many of these rocks that have a directional fabric in hand specimen are nevertheless dominantly granoblastic in detail in thin section, so worrying about dominance of schist or hornfels in this pendant may be largely an exercise in futility!

An examination of 40 thin sections of dark micaceous schist and hornfels from all parts of the Long Canyon metasedimentary belt shows that generally the most abundant minerals are quartz and brown to red brown biotite. Most samples also contain muscovite that is generally less abundant than biotite. Some samples contain more muscovite than biotite, but samples containing muscovite and no biotite are rare. Plagioclase, generally twinned andesine, is rare to abundant in most samples. K-feldspar is much less common, but is abundant in some layers. Andalusite, both as euhedral crystals and irregular anhedral masses, is common and widespread. Sillimanite is less abundant but widespread and occurs both as discrete prismatic crystals and as ropy fibrolitic bundles. Isotropic orange masses in some sections suggest the former presence of cordierite. Garnet is uncommon but locally abundant. Scattered tiny grains of tourmaline are present in many samples.

White to gray, thinly layered to massive, coarse to fine grained marble is abundant and in conspicuous beds throughout the Long Canyon belt. Associated with the marble are striped to massive dense layers of gray to green calc-hornfels. Most of these rocks are rich in clinopyroxene and plagioclase, with lesser amounts of quartz, K-feldspar, tremolitic amphibole, epidote, and biotite. Most layers also contain accessory sphene. Locally abundant are garnet, idocrase, and scapolite. Some coarse-grained garnet-epidote tactite is associated with the calc-hornfels and marble.

White to gray and tan orthoquartzite is locally conspicuous and commonly weathers to shades of dark red and brown. The quartzite is particularly well-exposed just southeast of South Lake and north of Sierra Way along the north side of Isabella Lake near Cane Spring (Lake Isabella North 7-1/2 quadrangle). Much more common are varieties of impure quartzite that have various admixtures of plagioclase, K-feldspar, biotite, hornblende, clinopyroxene, and epidote. Original clastic textures are only rarely preserved, but locally original rounded quartz grains from 0.4 to 0.8 mm are cushioned by recrystallized calcareous and argillaceous matrix material. One layer has preserved granules to 3 mm.

The marble, calc-hornfels, quartzite, and schist and hornfels of the Long Canyon belt are essentially end-member rock types of a wide variety of argillaceous, siliceous, and calcareous that made up the original sedimentary sequence of the pendant.

Small slivers of calc-hornfels, marble, quartzite, and biotite quartzofeldspathic schist are scattered through the quartz diorite of Cyrus Flat (a small dark-colored granitic body, just east of the north arm of Isabella Lake). Some of the marble has been converted to garnet-epidote-clinopyroxene-hornblende tactite and contains disseminated scheelite which has been modestly exploited for tungsten. These small metasedimentary slivers as well as some in the Rabbit Island body near the Cyrus Flat mass are most likely related to the rocks of the Long Canyon pendant.

FAIRVIEW METASEDIMENTARY BELT

The Fairview metasedimentary belt consists of the main Fairview pendant several correlative masses in the vicinity of Wofford Heights, small correlative bodies of siliceous metasediments east of the Kern Canyon fault near Bodfish, the French Gulch pendant of largely metavolcanic rocks, and the Cypress pendant. The distinctive rock types of this largely metasedimentary belt are summarized on figure 3. The Cypress pendant may be a slice of the Fairview pendant that has been separated by later igneous intrusions.

The Fairview belt rock types end rather abruptly to the south and only rock types compatible with the Tehachapi belt are seen further south. The distinction between the Long Canyon and Tehachapi belts would be difficult to make in the absence of the intervening Fairview belt. It is almost as if the Fairview belt is a gigantic lens of anomalous rock types in this region of "typical" thin bedded metasedimentary rocks.

Fairview pendant and correlative pendants near Bodfish

North of Kernville a distinctive, dark colored, irregularly-shaped pendant largely composed of quartzite extends along the west side of the Kern Canyon fault for about 22 km. The characterizing lithology is dark, granular to pebbly, virtually unsorted quartzite that is massive to poorly bedded (fig. 3A). To my knowledge, this rock type is unique in the southern Sierra Nevada, at least as far north as lat 36°00'N. The dark quartzite beds look like they have been dumped rapidly into a basin from a quartz-rich source.

Near Fairview, pebbly beds with clasts to 1 cm are present, but generally clasts do not exceed 2 to 3 mm. Most of the quartzite samples have sparse clasts of patch twinned plagioclase that is probably albite. K-feldspar clasts are present locally. Rounded, detrital zircon is also present. The groundmass of these coarser grains is largely finer-grained quartz with various admixtures of muscovite, red brown biotite, and pale green chlorite. Some samples lack muscovite, others lack biotite, but normally both are present. The chlorite is commonly widespread in small amounts, generally looks primary, and is not an obvious alteration product of biotite. Tourmaline is a widespread, scattered accessory mineral in the quartzite. Pale green hornblende has been seen in some samples. Siliceous to micaceous schist and phyllite make up a small proportion of the pendant. However, in the western tail of the stubby north end of the pendant, micaceous rocks dominate with abundant muscovite, red brown biotite, some coarse andalusite, and possible pinite after cordierite. However, marble is notably absent in the southern part of the main pendant and calc-hornfels layers are rare. Marble is abundant in mappable lenticular bodies in the center part of the stubby north end of the pendant. The marble is interlayered with dark granular quartzite and seems to belong to the pendant--the micaceous western tail, however, may be a separate mappable unit more compatible with the metasedimentary pendants to the west. Float from the Fairview pendant in a large landslide mass south of Johnsondale contains fragments of amphibolite consisting of a granoblastic mat of plagioclase and olive hornblende and abundant opaque grains. This rock is amphibolite-grade and probably is metavolcanic.

Jenkins (1961) noted a distinction between phyllite and hornfels in a segment of the main body of the Fairview pendant extending about 10 km north from Kernville. A western belt consists of fine-grained to aphanitic hornfels and includes calc-hornfels, agglomeratic hornfels, "meta-quartzite" and minor phyllite. Jenkins also noted the presence of pyroxene (presumably in the calc-hornfels) and andalusite in the hornfels unit. He distinguished a phyllite unit in the eastern part of the pendant adjacent to the Kern Canyon fault characterized by phyllite and "meta-quartzite." In my reconnaissance study of the Fairview pendant I was not convinced of an obvious stratigraphic or metamorphic-grade difference across the pendant at this latitude.

North and west of Wofford Heights dark metamorphic rocks are present that are almost certainly a southward continuation of the main Fairview pendant. The dominant rock type near Wofford Heights is tan to dark gray, poorly sorted and generally poorly bedded quartzite, with coarse quartz granules to 4 mm across. The quartz clasts are sheared and stretched, and commonly have sutured margins, but their form leaves no doubt that they are clastic fragments. Much less common are clasts of plagioclase and K-feldspar. With various admixtures of muscovite and biotite, these rocks grade to argillaceous quartzite, commonly with smaller quartz clasts that give a silty look to thin sections. Pale to moderate green hornblende is locally present. Some quartzite layers have a matrix of fine grained epidote, with lesser sphene and calcite suggesting original calcareous sandstone. Locally, layered calc-hornfels and garnet-epidote tactite are present along with gray marble. Mica schist is a minor part of the section, but locally knobby gray schist contains poikilitic andalusite crystals as long as 2 mm; one schist layer in addition contains small prismatic sillimanite crystals. Accessory tourmaline is widespread in these rocks. In one sample thin veinlets of prehnite were noted.

The dark metamorphic rocks east of the Kern Canyon fault near Bodfish contain distinctive unsorted quartzite layers with granules of quartz as large as 4 mm, as well as scattered patchily-twinned albite(?) clasts. The groundmass of these rocks is finer grained quartz and various amounts of muscovite and brown biotite. Green tourmaline grains are noticeable. Micaceous schist is also present, as are some calcite-garnet-quartz calc-hornfels and mappable marble layers. The overall character of these metamorphic rocks, particularly the coarse unsorted quartzite, suggests correlation with the Fairview pendant across the Kern Canyon fault to the north.

Metavolcanic rocks were identified in the main pendant mass north of Kernville and in the detached but correlative rocks near Wofford Heights. No definite metavolcanic rocks were seen in the pendant rocks near Bodfish, but this pendant was examined only briefly and mostly near its west end.

Just south of Kernville probable ash flow tuff layers that have fluxion structure, partially resorbed quartz clasts, and mica streaks and lenses that may represent glass or pumice shards are associated with quartzite and lesser argillaceous layers typical of the Fairview pendant. Farther south, andesite porphyry is present that has phenocrysts of andesine to 3 mm and lesser and somewhat smaller pseudomorphs of hornblende phenocrysts (now largely aggregates of amphibole, in part with clinopyroxene cores). Fragmental phenocrysts suggest alternatively that these rocks could be crystal tuff.

Present near Wofford Heights are fine-grained, somewhat schistose rocks rich in pale green to colorless, commonly acicular amphibole. These rocks also contain chlorite, plagioclase, quartz, and brown biotite. One sample has a diabasic matrix of felty well-twinned andesine crystals--a definite volcanic texture. Other samples do not show volcanic textures, but their composition suggests that they have volcanic parentage.

In the main Fairview pendant no good examples of ash flow tuff were identified. The most common suggestion of a volcanic component is the presence of patchily-twinned albitic plagioclase clasts, hornblende aggregates, and rare felty volcanic lapilli in the quartzite layers. Andesite-basalt porphyry with phenocrysts of andesine-labradorite and hornblende set in a lath-like plagioclase groundmass is not common, but distinctive. The texture suggests these porphyries may be intrusive, but field relations are not clear to me.

Low-grade amphibolite or greenschist layers are also present in the main pendant that are rich in nearly colorless amphibole and lesser chlorite, sodic plagioclase, brown biotite, and quartz. Some local layers are rich in muscovite and pale green chlorite, but have no obvious quartz or feldspar. These dark, fine-grained, partly schistose rocks have no volcanic textures, but again the composition suggests volcanic parentage. These rocks seem particularly common in the west tail of the stubby north end of the main pendant.

Mafic inclusions are abundant in the granodiorite of Brush Creek east of the Kern River. Some of these inclusions are porphyritic with plagioclase (calcic as An_{50}) and olive brown hornblende (some with skeletal clinopyroxene cores) crystals as large as 2 to 3 mm set in a sugary to bladed, somewhat altered fine-grained matrix. One inclusion is an altered hornblende gabbro with remnant hypoautomorphic granular crystals of brown hornblende (with clinopyroxene cores) and well-twinned sodic labradorite. Brown to reddish brown biotite is less common and scattered interstitial quartz is present. These inclusions are unlike the more common "normal" diorite and quartz diorite ovoid inclusions that are also present here that are so typical of Sierran granitic rocks. These mafic inclusions may be related to andesite porphyry plugs(?) in the Fairview pendant and the metavolcanic rocks of French Gulch.

The most distinctive rock type in the Fairview pendant is undoubtedly the virtually unsorted, granule-pebble quartzite. Similar quartzite layers have been identified within the metavolcanic rocks of the French Gulch pendant north and south of Isabella Lake and in Erskine Canyon. These distinctive quartzite layers emphasize the relation between these two pendants and at the same time point out their striking differences from most other pendants to the east and west.

French Gulch metavolcanic pendant

Adjacent to, and apparently concordant with, the Long Canyon pendant on the west is the elongate French Gulch pendant of dominantly metavolcanic rocks. The French Gulch pendant extends some 33 km from the French Gulch area (Emerald Mountain 15' quadrangle) in the Piute Mountains to where it is truncated by the Kern Canyon fault. The metavolcanic belt is generally about 2 km wide. No comparable belt of metavolcanic rocks has been found across the Kern Canyon fault to the west.

Busby-Spera (1983) has delineated the Piute Lookout ash flow tuff unit at the south end of the metavolcanic belt. Samples and thin sections that I have examined from that area show a strong fluxion structure as well as later shearing. Preserved clasts of plagioclase to 1-2 mm are common, and some deformed, elongated, mosaicked quartz clasts of about the same size are present. The hornfelsed groundmass of these rocks consists of admixtures of plagioclase, K-feldspar, and quartz. Brown to reddish brown biotite and lesser muscovite mimic the strong fluxion foliation in these rocks. Some dark lenses that are evident in hand specimens and that are rich in biotite may be pseudomorphs after pumice or glass shards. Locally green hornblende is present, and scattered crystals of tourmaline and garnet are also characteristic. One dark layer of dense mosaicked quartz with abundant carbonaceous impurities is presumed to have been chert.

North of the ash flow tuff unit, the volcanic rocks have about the same composition, but are less foliated and lack obvious fluxion structures. Some of the layers are liberally studded with small plagioclase megacrysts that could be either clasts from a crystal tuff or phenocrysts from a flow rock.

North along the French Gulch pendant from Erskine Canyon north to Paradise Cove on the south shore of Isabella Lake, as well as north of the lake, the pendant rocks are predominantly of volcanic parentage, though some tuffaceous sedimentary rocks and pebbly quartzite resembling quartzite from the Fairview pendant to the west also are present. Common through this segment of the pendant are fine-grained rocks with strong fluxion structures that were probably ash-flow tuffs. These rocks contain fragments and euhedral crystals of andesine to 2 mm and, less commonly, equant to elongate quartz crystals of about the same size. Both volcanic flow and later shearing is recorded in these rocks, but the preservation of coarser clasts of quartz indicates that these fluxion layers dominantly reflect volcanic flow rather than cataclastic deformation. Some of the flow layered rocks have wisps and lenses of biotite and muscovite concentrations that suggest former pumice or glass shards. Most of these ash flow tuff layers are most probably rhyolite or rhyodacite, as they are rich in quartz and K-feldspar, generally contain more muscovite than biotite and do not contain hornblende. The distinctive ash-flow tuff layers are common along the entire length of the French Gulch pendant. Figure 3B shows only a very minimum of distribution, showing only samples I have studied in thin section. The paucity of ash-flow tuff samples in most of the southern half of the pendant reflects lack of examination of these rocks, not necessarily a paucity of ash-flow tuff.

Other more massive layers in the volcanic sequence are of a more intermediate composition; some contain significant green hornblende, in part in aggregates mimicking former ferromagnesian phenocrysts. In many samples it is difficult to confidently decide whether the metamorphosed rocks were once flows, crystal tuffs, or volcanogenic sedimentary rocks. The volcanic textures shown by the presence of plagioclase phenocrysts or clasts in most rocks attests to the volcanic parentage of this pendant.

Thinly layered calc-hornfels containing variable amounts of pale green hornblende, K-feldspar, epidote, plagioclase, and quartz, as well as white marble, are locally present and make conspicuous layers in the dominantly dark colored pendant rocks in Erskine Canyon.

Small tourmaline crystals are common accessory minerals throughout the French Gulch pendant. Locally, particularly east of Cook Peak (Lake Isabella South 7-1/2' quadrangle), coarse black tourmaline (pleochroic in shades of gray and blue) forms large replacement masses and veins in the meta-volcanic rocks.

Thinly flow-banded gray dikes cut the granitic rocks of the Cyrus Flat body near the head of Cyrus Flat (Lake Isabella North 7-1/2' quadrangle). In thin section these dikes have a strong fluxion structure with rounded crystals of grid-twinned K-feldspar to 2 mm across. Smaller crystals of sodic plagioclase and quartz are also present. The groundmass is a microcrystalline mat that is rich in K-feldspar. These dikes of rhyolitic composition are certainly not part of an aplite-alaskite-pegmatite suite. Could they be related to the ash flow tuff of presumably mid-Cretaceous age? The Cyrus Flat pluton has been dated as 100±3 Ma. (Pb-U age from zircon, Saleeby and Busby-Spera, 1986) and 120 Ma. (Rb/Sr whole rock determination, R.W. Kistler, written commun., 1983).

Fox (1981) noted a swarm of northwest-trending, steeply-dipping "microgranodiorite" dikes in the northern part of the Cyrus Flat body that do not cut either the adjoining Rabbit Island or Cannell Creek granitic bodies. My field notes described "foliated felsic dikes" in this same area, but unfortunately no samples were collected. Possibly the flow banded rhyolite dikes are widespread in the Cyrus Flat body.

Significance of contact between the Long Canyon and French Gulch pendants

The metasedimentary rocks of the Long Canyon pendant are in contact with a thick belt of metavolcanic rocks on the west both north and south of Isabella Lake. South of the lake, in a saddle at the head of Lynch Canyon south of Squirrel Mountain Valley (Lake Isabella South 7-1/2' quadrangle), the contact appears generally concordant with a NNW strike and near vertical dip in both the metavolcanic rocks and nearby calc-hornfels layers of the Long Canyon pendant. Dark granitic rocks have intruded along the contact both at the saddle and presumably also in Lynch Canyon about 2 km to the north. Therefore, the actual contact is not preserved. North of the lake the contact is exposed in a road cut along Sierra Way just east of Stine Cove (Lake Isabella North 7-1/2' quadrangle). There, dark thinly layered rocks with volcanic textures on the west and coarse mica schist and quartzite on the east both strike NNW and dip steeply to the east. Elan (1985) observed no structural break at this contact and shows interbedding of metasedimentary and metavolcanic units.

The metasedimentary rocks of the Long Canyon pendant are tightly folded in places and appear to be more structurally complex than the French Gulch rocks on the west. However, I have noted small isoclinal folds locally in the French Gulch rocks. Folds are certainly easier to identify in the Long Canyon rocks than in the dark somewhat featureless rocks of the French Gulch pendant.

The Long Canyon pendant rocks are well into the amphibolite grade, as indicated by coarse prismatic sillimanite and local red garnet in the pelitic layers. By contrast, the French Gulch rocks have been characterized as "greenschist grade" (Busby-Spera, 1983). Actinolitic amphibole, chlorite, epidote and muscovite are common in some layers, but dark brown to olive biotite, dark green hornblende, and accessory garnet crystals are also present in the French Gulch pendant rocks. Overall the French Gulch rocks do appear to be lower grade, but this could be partly due to different response of different rock types to the same metamorphic conditions. Yet an enigma exists here of radiometrically dated mid-Cretaceous volcanic rocks seemingly "interbedded" with sedimentary rocks containing Triassic or Jurassic fossils.

Tungsten production (several hundred units of WO_3) is reported from scheelite disseminated along schistosity and cross fractures in shear zones in limestone, phyllite, argillite, and hornfels at the Unip mine, about 10 km south of Isabella Lake (Troxel and Morton, 1962). The noting of limestone (pretty surely marble) and scheelite, but no mention of tactite is very unusual in this region. This might suggest a lower metamorphic grade for these rocks in the center of the pendant, relative to much of the rest of the region. However, I have observed tactite that was developed from marble along the east side of the French Gulch pendant, suggesting "normal" amphibolite grade metamorphism there.

Cypress pendant

The elongate Cypress pendant is 12 km long and as much as 2 km wide and is named for the Cypress Roadless area (surrounding Bodfish Peak in Lake Isabella South 7-1/2' quadrangle). The pendant trends across the roadless area which hosts an impressive stand of Piute Cypress (Kennedy and others, 1983). A small pendant on the west side of Isabella Lake just south of Wofford Heights west of the Kern Canyon fault may be a disconnected chunk of the Cypress pendant (fig. 3C).

The southern end of the Cypress pendant is marked by an arbitrary and not fully understood contact with gneissic rocks that may be a remnant of the mafic gneiss complex of the San Emigdio and Tehachapi Mountain. Isolated inclusions near the Cypress pendant that I consider to have been once part of the Cypress pendant are highly argillaceous schists with abundant reddish brown biotite and K-feldspar. Much less common are muscovite, quartz, and plagioclase. Andalusite and fibrolite to prismatic sillimanite are also present in these schist samples. These rocks closely resemble the highly argillaceous schist of the western tail of the stubby north end of the Fairview pendant.

In the central part of the Cypress pendant several samples are granular quartzite with angular to subrounded quartz clasts to 3 mm set in a much finer grained (but in part notably clastic) matrix of quartz and lesser plagioclase and varied amounts of clinopyroxene, epidote, hornblende, and garnet that indicate calcareous cement. Some of these rocks closely resemble the calcareous granular quartzite of the Fairview pendant of the Wofford Heights area.

The small area south of Wofford Heights that is considered to be a disconnected piece of the Cypress pendant is characterized by highly argillaceous schist, and is rich in muscovite, with lesser reddish brown biotite and accessory andalusite and sillimanite. Some samples are virtually without quartz and feldspar, but others have significant admixtures of "silty" quartz and plagioclase. In this same area, but much less abundant, is granular, poorly sorted quartzite with quartz clasts as large as several mm. Here again, there are good matches for the rocks of the Fairview pendant. Some schistose layers are composed almost entirely of pale green hornblende and intermediate plagioclase with scattered opaque grains and minor biotite and sphene. These amphibolite layers could be either metavolcanic rocks or metamorphosed calcareous sediments.

Both in the field and in earlier petrographic study of the collected samples and their thin selections, I was uncertain whether the Cypress pendant rocks, particularly the small body near Wofford Heights, were or were not a split off part of the Fairview pendant. A re-examination of all samples of all the metamorphic rocks of this region now suggests to me that the Cypress pendant, containing unsorted granular quartzite and highly argillaceous layers, has been split away from the southern end of the Fairview pendant by the Bodfish Canyon granitic body.

Along the east edge of the Cypress pendant, both along the Saddle Spring Road (Lake Isabella south 7-1/2' quadrangle) and the Clear Creek Trail (along Clear Creek in Lake Isabella South 7-1/2' quadrangle) east from Havilah, metavolcanic rocks are exposed. These rocks exhibit euhedral intermediate plagioclase and quartz phenocrysts (or pyroclasts) to 3 mm set in a finer grained groundmass of quartzofeldspathic material and mica. Some clusters of biotite also mimic probable ferromagnesian phenocrysts. These rocks have only weak foliation (fluxion structure?). One sample has thin wispy biotite concentrations that may have been pumice or glass shards. These rocks may represent ash flow tuffs, but the textures are not as convincing as for many of the ash flow tuff samples from the French Gulch metavolcanic pendant. A dark, foliated layer of dominantly pale green hornblende with lenses and layers of fine-grained plagioclase and abundant metallic opaque grains is present in the middle of the dominantly metasedimentary rocks of the Cypress pendant along the Clear Creek Trail. This amphibolite could be a metamorphosed calcareous layer, but in the context of nearby metavolcanic layers it may be metavolcanic. These metavolcanic rocks suggest that the Cypress pendant has also been split away from the French Gulch pendant by the intrusion of the intervening granitic bodies.

The presence of clinopyroxene, garnet, and sillimanite, as well as the abundance of reddish brown biotite and the virtual absence of chlorite in the Cypress pendant suggests a somewhat higher metamorphic grade than shown by the rocks of the Fairview pendant.

TEHACHAPI METASEDIMENTARY BELT

The Tehachapi metasedimentary belt is named for a number of related pendants south of lat 35°30'N. that are well exposed north of the town of Tehachapi. Originally these rocks were considered part of the Kernville series of Miller (1931), a name that has become almost synonymous with metasedimentary rocks of the southern Sierra Nevada and as such has limited meaning. The Tehachapi metasedimentary belt also encompasses most of the rocks previously called "metasedimentary rocks of the Keene area" (Ross, in press). These rocks consist of thinly layered pure to impure quartzite and mica schist and somewhat more massive, white to gray marble. Calc-hornfels and quartzofeldspathic schist or hornfels are less common. As has already been noted, these rocks are separable from the rocks of the Long Canyon metasedimentary belt only with some difficulty. The Brite Valley pendants are arbitrarily distinguished from the main Tehachapi belt because they are somewhat richer in relatively pure quartzite, but otherwise they contain similar rock types. Also included in the Techachapi belt is the Walker Basin pendant, which appears to be split away from the main Tehachapi belt by intervening granitic rocks, and three small pendants (Clear Creek, Shirley Meadow, and Cow Creek) across the Kern Canyon fault to the west. These are all thinly layered sequences of schist, marble, and quartzite. Somewhat tentatively, a large group of small to large pendants to the northwest are considered part of the Tehachapi belt. Limited studies suggest they have similar lithologies and are on a general strike trend with the previously mentioned small pendants that seem to be related to the main Tehachapi metasedimentary belt. One anomaly appears to be a group of metavolcanic rocks including ash flow tuffs of the King George Ridge pendant, considered for convenience a part of the Tehachapi metasedimentary belt at present.

Tehachapi pendant and related pendants

The Tehachapi pendant, and related pendants, is a belt of essentially north-trending irregularly-shaped pendant extending north from Tehachapi Valley. Several, presumably related, smaller pendants extend east and south of the larger Tehachapi pendant. Marble, pure to impure quartzite, and commonly coarse grained mica schist that contains sillimanite and garnet are the most common rock types in these pendants. Quartzofeldspathic hornfels to schist and calc-hornfels are widespread, though less common.

The marble is fine to very coarse grained and generally white to gray, and contains trains and stringers of graphite flakes and other metamorphic minerals that probably reflect original bedding. Dolomite is present, but calcite predominates. Associated calc-hornfels layers range from trains of calc-silicate grains in relatively pure marble, through thin calc-silicate layers in marble, to calcareous metashale and quartzite. Pale-green clinopyroxene is by far the most common calc-silicate mineral. Some thin layers rich in plagioclase and dark hornblende could be metavolcanic rocks, but the close association of clinopyroxene, epidote, and thin marble layers points to a sedimentary origin. Garnet-clinopyroxene-epidote tactite also occurs along and near some marble contacts with granitic rocks.

Quartzite, ranging from a virtually pure mat of quartz crystals to layers that contain 5 to 25 percent of impurities, is conspicuous and mappable in some of the pendants. In addition, much more is present in layers and lenses too small to map. The purest quartzite contains scattered crystals of clinopyroxene, feldspar, or mica probably formed from original argillaceous and calcareous cement. Many layers seem to contain about 5 to 15 percent of these impurities as scattered crystals and trains and small lenses that mimic original bedding. These quartz-rich rocks grade to quartz hornfels containing 40 to 50 percent impurities. The quartz-rich rocks commonly also contain garnet, tourmaline, and graphite. Some rounded zircon crystals are probably original detrital grains. Locally, there are layers rich in apatite crystals, which may reflect original phosphatic beds.

One of the most distinctive rock types in these pendants is a coarsely crystalline mica schist. This schist is characterized by abundant red to brown biotite, muscovite, and sillimanite; the sillimanite occurs both in fibrous bundles and coarse prismatic crystals. Red garnet is also common. Large, irregular andalusite crystals are present in some sillimanite-bearing rocks. Although most of the rocks are dominated by mica, others contain abundant K-feldspar, lesser plagioclase, and quartz. In some specimens, original clastic quartz grains are preserved where they have been isolated by metamorphic mica from an original argillaceous groundmass. Tourmaline and graphite are present locally. These dark, red- to brown-weathering rocks produce distinctive shiny, coarse-grained, mica-rich outcrops.

Felsic gneisses in the southeast-trending pendant immediately east of the southern Brite Valley pendant are similar to quartzofeldspathic gneisses of the mafic gneiss complex of the San Emigdio and Tehachapi Mountains, yet are intimately associated with typical rocks of the Tehachapi pendant belt. These felsic gneisses as well as similar rocks in the Tejon Canyon pendant, suggest there are elements of the gneissic complex mixed in the Tehachapi belt. Perhaps the quartzofeldspathic gneisses throughout the mafic gneiss complex (which is largely metaigneous) may be metasedimentary framework rocks somewhat similar to the rocks of the Tehachapi belt. One significant difference appears to be the paucity of calcareous beds in the metasedimentary layers of the gneissic complex. However, some marble is associated with mafic gneiss along the Garlock fault east of Cameron and some calc-hornfels layers are present in the main body of the gneissic complex. Therefore, calcareous material is not wholly unknown in the mafic gneissic complex, but merely rare. Perhaps there is a "formational" contact between the main Tehachapi pendant belt and the metasedimentary layers in the mafic gneiss complex.

Brite Valley pendants

The two pendants of Brite Valley are considered part of the Tehachapi metasedimentary belt. However, they seem to have a higher percentage of relatively pure quartzite than the Tehachapi pendants to the east. Dibblee and Louke (1970) have mapped several lenses of quartzite in the Tehachapi pendant immediately north of the town of Tehachapi, and I have noted quartzite beds in the small pendant south of Tehachapi. Nevertheless, my field observations, admittedly cursory, have suggested that pure quartzite beds are much more common in the Brite Valley pendants, particularly just north of Brite Valley (Cummings Mountain 15' quadrangle) and along its east side. Dibblee and Warne (1970) also mapped numerous lenses of quartzite in the southern part of the northernmost Brite Valley pendant.

On the whole, the Brite Valley pendants are not that different from the Tehachapi pendants, with both having abundant marble, impure quartzite, and argillaceous and quartzofeldspathic schist. Probably the Brite Valley pendants could be considered a quartzite-rich "member" of the Tehachapi "formation." If the present position has stratigraphic significance, then the Brite Valley pendants are a quartz rich "megalens" near the base or top of the Tehachapi belt. With the present structural information it is impossible to decide which.

Walker Basin pendant

The Walker Basin pendant and its presumed correlatives, the Clear Creek and Shirley Meadow pendants to the north across the Kern Canyon fault, probably are relatively thin "leaves" split off the Tehachapi pendant by the intervening granitic rocks. There is little to distinguish these three pendants, lithologically, from the Tehachapi pendants. Perhaps the Walker Basin pendant has a higher proportion of argillaceous schist (with much muscovite and sillimanite), but this is an arbitrary observation based on few specimens.

If present position is indicative of original stratigraphic sequence, the Walker Basin pendant, presumably along with its correlative pendants, belongs between the main Tehachapi pendant and the Brite Valley "member."

Clear Creek pendant

The Clear Creek pendant is a stubby mass of metasedimentary rocks about 5 km long and 1 km wide truncated by the Kern Canyon fault. This pendant is probably offset about 10 km from the northern tail of the Walker Basin pendant.

I have examined only the north end of this pendant near Miracle Hot Springs, where I noted coarse white marble, banded calc-hornfels, and reddish weathering impure quartzite.

The pendant was studied by MacKevett (1960) as part of an investigation of uranium deposits near Miracle Hot Springs. The following summary of the metamorphic rocks is abstracted from his description. The most abundant rock in the pendant is muscovite-biotite-quartz schist; oligoclase is found in most of the schist, K-feldspar is sparse to absent. The biotite is reddish brown and garnet was noted in one sample of the schist. Impure quartzite is also abundant, consisting dominantly of a granoblastic mat of quartz in crystals as large as 0.7 mm in diameter. Also present are the same minerals as in the schist, but in lesser amounts, and not as well-aligned. Both dolomite and calcite marble are locally abundant. One thin section of laminated marble that I examined from MacKevett's collection is calc-arenite with calcite and quartz clasts and some garnet and clinopyroxene. Associated with the marble is calc-hornfels, commonly rich in garnet and clinopyroxene; wollastonite is locally significant. Scheelite-bearing tactite is also present and has been exploited by small tungsten mines and prospects.

Based on MacKevett's (1960) description, and the five thin sections I have examined from his collection, these metamorphic rocks are unlike the Fairview and Cypress pendants. Neither of the key lithologies (highly argillaceous rocks and unsorted granular quartzite) of these latter two pendants were noted in the Clear Creek pendant.

Shirley Meadow pendant

The Shirley Meadow pendant is about 8 km long, about 1 km wide. The pendant is notably "sieve-like," with abundant admixed granitic material. The similarity of rock types and the strike and dip of the Cow Creek and Shirley Meadow pendants suggest they are parts of the same sedimentary belt that has been split apart by granitic bodies.

The Shirley Meadow pendant is composed of red- to brown-weathering micaceous to siliceous schist and hornfels, pure quartzite (orthoquartzite with only 5-10 percent impurities), impure quartzite, calc-horfels, marble, and locally scheelite-bearing tactite. These rocks range from thinly layered to blocky, massive beds. In the field I noted that some of the quartzite layers resembled the coarse, granular sandstones of the Fairview pendant, but subsequent petrographic study did not confirm this field impression. The quartzites of the Shirley Meadow pendant are granoblastic, in part sutured, mats of quartz crystals and do not have the finer grained clastic matrix and coarse distinct quartz clasts ("bimodal texture") of the quartzites of the Fairview pendant. The Shirley Meadow quartzites are what I would classify as "normal" Sierran pendant quartzites.

Near the north end of the Shirley Meadow pendant, one layer in a thinly layered micaceous sequence contains abundant, rather coarse, prismatic sillimanite, abundant muscovite, and lesser reddish brown biotite and quartz, as well as possible pinite after cordierite. Perhaps not coincidentally, this sample is at the same latitude as the sillimanite-bearing beds in the south part of the Cow Creek pendant.

<u>Cow Creek pendant</u>

The Cow Creek pendant is about 10 km long, rather narrow, and much intermixed with granitic rocks, particularly near its north end. The pendant is characterized by red to brown weathering thinly layered sugary quartzofeldspathic schist, mica schist and hornfels, calc-hornfels, pure to impure quartzite, and locally conspicuous marble. The marble has been sporadically transformed to coarse-grained garnet-epidote tactite that is partly scheelite-bearing and has been prospected for tungsten within and near this pendant (Troxel and Morton, 1962).

Some impure quartzite and schist layers contain abundant sillimanite, andalusite, and probable pinite after cordierite. Impure quartzite layers that contain considerably more than 50 percent quartz may also contain significant amounts of sillimanite and andalusite.

Near the south end of the pendant are amphibolite layers rich in fine- to medium-grained black hornblende (pale green in thin section). Plagioclase is much less abundant and small rounded sphene crystals are common. This lithology is rather finely layered, the layering being shown by varying proportions of plagioclase and hornblende, and by grain size differences. The amphibolite appears to be interlayered with other metasedimentary rocks, suggesting it was derived from a calcareous sediment. The composition, however, is also compatible with an igneous (volcanic?) parent.

At the north end of the pendant near Tyler Meadow (California Hot Spring 15' quadrangle), dark colored metasedimentary rocks are sparsely exposed. Most are thinly layered, some are strongly schistose and others are only weakly foliated; argillaceous beds dominate. One layer contains abundant discrete orange crystals that are nearly isotropic yet have the textural appearance of mica or chlorite. Most likely this is pinite, indicating abundant cordierite was present in this layer. This same rock also has abundant K-feldspar and reddish brown biotite. Also present is a rock characterized by silty quartz grains to 0.2 mm preserved in a matrix of abundant muscovite and lesser reddish brown biotite. This rock also contains probable pinite. Olive brown tourmaline is a sparse, but conspicuous accessory at the north end of the pendant.

A thin felsic sugary layer in a largely siliceous section of metasedimentary rocks near Deep Creek Cave (California Hot Spring 15' quadrangle) in the north part of the pendant may be a rhyolitic metavolcanic rock. This rock has small plagioclase phenocrysts (or pyroclasts) to 0.8 mm in a fine grained matrix of granoblastic plagioclase, K-feldspar, and quartz, and lesser muscovite and biotite. Small mica-rich lenses may have been pumice or glass shards. Bluish green tourmaline and pink garnet are also present in trace amounts. The felsic layer does not look like an aplite and it is anomalous in this metasedimentary section. Possibly it reflects a rhyolitic ash layer.

Questionable correlatives to the northwest

Red Mountain pendant. The Red Mountain pendant is about 10 km long and about 3 km wide. It trends west-northwest, in contrast to the nearby northwest-trending pendants. Nevertheless, where I have measured attitudes in the eastern part of the Red Mountain pendant, they are mostly northwesterly and essentially parallel to strikes in the nearby pendants. The central part of the Red Mountain pendant has not yet been examined, so the total extent of the pendant is not yet known.

Near Glennville at the north end of the pendant, exposures are sparse, but float from the slopes of metamorphic rocks northwest of State Highway 155 consist of quartzofeldspathic hornfels with a silty texture (coarser quartz clasts to 0.5 mm). These rocks also contain clinopyroxene and pale green to colorless amphibole, but only minor amounts of mica.

The east end of the pendant is characterized by red weathering slopes, including aptly named Red Mountain (Alta Sierra 7-1/2' quadrangle). Dark, thinly layered argillaceous rocks are most abundant, but quartzite is also common. Calc-hornfels is uncommon and no marble was seen. Some of the strongly schistose rocks contain abundant fibrolitic to prismatic sillimanite and reddish brown biotite. Schist layers that are dominated by muscovite, biotite, and opaque material locally contain andalusite remnants, suggesting at least some of the muscovite is secondary after andalusite. Also common are impure quartzite layers with silty quartz grains and locally rounded pebbles to 0.5 cm. These beds also contain variable amounts of plagioclase, reddish brown biotite, muscovite, andalusite, and sillimanite. Less common, but locally conspicuous, are pure quartzite (orthoquartzite) beds that are now granoblastic, in part sutured mats of quartz crystals to 1 mm in maximum diameter. Some quartzite layers that are liberally sprinkled with carbonaceous material may represent metachert. Tourmaline is a widespread accessory mineral in these rocks and locally is coarse and abundant. Pink to red garnet is also present in some schist layers.

Poso Creek pendant. I have only examined the rocks of the Poso Creek pendant west of Posey along Red Grade (California Hot Springs 15' quadrangle), which is fittingly named for dark red weathering rocks exposed along the road. The northeastern part of the pendant is made up of thinly layered argillaceous and siliceous layers, and some nodular bedded quartzite. Local thinly layered dark quartzite resembles ribbon chert. Southwest of a dark-colored diorite sill the pendant rocks are more massive, less well-exposed and look somewhat "melange-like."

Within the thinly layered part of the pendant are some "classic" calc-hornfels layers composed of granoblastic andesine and clinopyroxene. Associated are similar rocks with admixtures of brown biotite and olive brown hornblende. One dark layer is composed dominantly of olive brown hornblende and andesine. This amphibolite may be a metavolcanic rock. However, the presence of clinopyroxene and epidote in this dark layer and the occurrence of brown hornblende in nearby calc-hornfels layers suggests this amphibolite is more likely a metamorphosed calcareous layer. This alternative to the common supposition that plagioclase-hornblende rocks represent an igneous parentage, such as basalt, has been around a long time (Adams, 1909).

Impure quartzite is also present with considerable amounts of plagioclase and reddish brown biotite in the dominantly quartz rocks. The more massive rocks west of the sill are chiefly siliceous calc-hornfels and impure quartzite. Their composition does not appear to be markedly different from the thinly layered rocks east of the sill.

Two small pendants or large inclusions (too small to show on the map) are present 1 and 2 km, respectively, east of the Poso Creek pendant. The easternmost pendant trends northwest, dips steeply to the northeast and is composed of schist, quartzite, and marble. Scheelite-bearing tactite formed from the marble yielded nearly 50,000 units of WO_3 at the Tungstore mine (California Hot Springs 15' quadrangle) (Goodwin, 1958). The westernmost small pendant parallels the easternmost pendant and is composed of schist, quartzite, and three several-meter thick tactite zones. These two small pendants have much in common with the locally tungsten-mineralized Shirley Meadow and Cow Creek pendants. This suggests that at least the eastern half of the Poso Creek pendant and the Shirley Meadow and Cow Creek pendants may be part of the same metamorphic formation.

Deer Creek pendant. The Deer Creek pendant is a large, elongate, but highly irregularly-shaped body of metasedimentary rock that extends north from near Deer Creek for 16 km to the north boundary of the map area and an unknown distance further north. I have only examined the pendant near Deer Creek. The contact to the west with metavolcanic rocks is tentative and arbitrary.

Along Deer Creek, the pendant rocks are thinly layered argillaceous and siliceous metasedimentary rocks, with less abundant, but conspicuous layers of coarsely crystalline white marble. Some quartzite layers are relatively pure but are sprinkled with abundant graphite, and minor plagioclase, mica, and tourmaline. Quartzofeldspathic schist rich in well-aligned reddish brown biotite is abundant. In one layer, probable cordierite and its pinitic alteration product were noted.

Tactite, largely composed of diopside, quartz, calcite, wollastonite, and lesser epidote and garnet, has formed locally from the marble. At the Bull Point (California Hot Spring 15' minute quadrangle) or Tyler Creek Mine scheelite-bearing tactite associated with quartzite and hornfels layers has been developed by a small open pit. Some of the scheelite here occurs as unusual euhedral dipyramids as large as 1 cm across within veinlets of laumontite (Goodwin, 1958).

King George Ridge metavolcanic pendant. The King George Ridge metavolcanic pendant is a small body of mostly felsic volcanic rock no more than 3 km long. The western tail of the Deer Creek pendant is also felsic volcanic rock that is correlative with the King George Ridge pendant. Similar metavolcanic rocks are present as slivers in the granitic rocks both east and west of the King George Ridge metavolcanic pendant. The east and west limits of the metavolcanic rocks are rather closely constrained by bounding metasedimentary rocks, but the contact relations are unknown. To the south no similar metavolcanic rocks are found, but it is possible that they are present in the unstudied north end of the Deer Creek pendant.

The pendant rocks are generally light colored, commonly tan, and are massive to thinly layered. They weather to distinctive bouldery slopes that can be confused with granitic outcrop from a short distance. Locally, these rocks exhibit well developed flow structure with lenticular dark clots of hornblende that may reflect original lapilli or shards. The appearance of the entire section suggests a pyroclastic pile, probably mostly crystal and ash flow tuff.

In thin section the massive units exhibit a dense (to 0.1 mm) granoblastic mat of subequal to variable amounts of quartz, K-feldspar, and plagioclase. Inset are scattered coarser aggregates of plagioclase and subhedral biotite crystals to 1 mm. Some layers contain rounded pyroclasts as large as 1 cm, but this is uncommon. Some layers preserve striking fresh plagioclase crystals and fragments to 5 mm. Hornblende crystals of about the same size are less common. Quartz fragments and locally quartz euhedra with a square outline (beta-quartz) are also preserved in the dense "ashy" matrix of these deposits. Most of this unit is light colored and suggests rhyolite or dacite. The presence, and local abundance, of moderate green hornblende suggests rhyodacite or dacite compositions are also present.

Grapevine Grade pendant. The Grapevine Grade pendant is a thin body about 5 km long that marks the west limit of the pyroclastic section of the King George Ridge pendant. The pendant is composed of red weathering nodular bedded quartzite and schist, with lesser calcareous material. This pendant is similar to most of the metasedimentary pendants to the east.

The pendant was examined in detail only near its south end along Grapevine Grade (Whitw River 7-1/2' quadrangle) where distinctive somewhat graphitic quartzite layers with accessory amounts of clinopyroxene and pale green hornblende occur. Other quartzite layers contain abundant epidote, moderate green hornblende, and plagioclase, suggesting these were originally calcareous sandstone. The schist layers are rather prosaic quartzofeldspathic rocks with abundant biotite.

At the north tip of the pendant mixed metasedimentary and granitic rocks are exposed along the road from Fountain Springs to Pine Flat near the H-B Ranch (White River 7-1/2' quadrangle). Siliceous metasedimentary rocks dominate here. Layered quartz hornfels, which consists of a mat of tiny granoblastic crystals of quartz and plagioclase inset with abundant coarser flakes of reddish brown biotite and pale green amphibole, is present. The texture of this rock is somewhat like the pyroclastic rocks to the east, but there are no obvious clasts. Perhaps this was a tuffaceous sediment. Also present are fine grained, well layered siliceous calc-hornfels beds composed of varying proportions of plagioclase, quartz, pale green clinopyroxene, and lesser pale green amphibole.

Morton Flat pendant. The Morton Flat pendant is a stubby, poorly exposed body of metasedimentary rock covering no more than 2 km^2 west of Morton Flat (Gibbon ~~Flat~~ Peak 7-1/2' quadrangle). A much smaller body south of Morton Flat on the Old Hot Springs road is probably related to the pendant.

The only direct evidence I have at present of the character of the rocks of the main pendant mass is a brief description of the setting of the small Blue Ridge Mine (just west of Morton Flat in Gibbon Peak 7-1/2' quadrangle) (Goodwin, 1958). He noted mica schist with tactite layers striking northwest and dipping southwest about 60° near a contact with granitic rock. Near the west end of the pendant near the gabbroic mass of Galley Mountain, the only possible metasedimentary rock I could find was a sugary amphibolite composed largely of andesine, green hornblende, and brown biotite. I found no evidence in the modest exposures to determine whether this rock was a metaigneous rock or a metamorphosed calcareous sediment.

The small body, poorly exposed along the Old Hot Spring Road, is definitely a metasedimentary section of sugary to dense relatively dark siliceous rocks. Most common is calcareous quartzite with alternating layers of relative coarse (to 2 mm) blocky quartz crystals and much finer-grained quartz-plagioclase layers with varying amounts of clinopyroxene. Also present are dense massive beds composed of granoblastic quartz, plagioclase, clinopyroxene, and lesser K-feldspar.

Woody pendant. The Woody pendant is a thin irregular septum about 1 km long between the Woody and Walt Klein granitic bodies. In a brief field examination, I noted dark ferruginous(?) quartzite, layered calc-hornfels, ribbon quartzite that could be metachert, and tactite. The pendant appears to be sieve-like with intermixed granitic material and some intrusion breccia.

Troxel and Morton (1962) reported schist in the pendant that contains concentrations of magnetite (the main peak of the pendant area is named Iron Mountain). They also noted that tactite in the pendant contains traces of scheelite and copper minerals and that copper-bearing veins are also present in the schist.

Grizzly Gulch remnants. Small, irregular patches of metasedimentary rocks are immersed in the tonalite in the area of Grizzly Gulch. I have not examined these rocks, but Troxel and Morton (1962) noted the presence of schist and coarsely crystalline white marble. Scheelite-bearing tactite formed from the marble has locally been exploited for tungsten.

One sample that I collected from a small inclusion mass along Arrastre Creek about 3 km southeast of White River looks like the tan ashy rocks of the King George Ridge metavolcanic pendant. The relation of this rock to the Grizzly Gulch remnants is not known. The tan sample has a coarse, silty texture with rounded quartz grains to 0.8 mm and some larger grains mosaicked quartz aggregates. Possible plagioclase clasts are also present. The groundmass is quartz rich, but contains pale green hornblende, brown biotite, K-feldspar, and epidote. A small tungsten prospect where scheelite in tactite was noted (Indian prospect, Goodwin, 1958), is probably also in this inclusion, but the location has not been confirmed by me.

Quedow Mountain pendants and related bodies. Four small pendant masses and one thin septum lie on the flanks of and near Quedow Mountain (also shown as Credow Mountain or Cuidado Mountain on some maps). The metamorphic bodies total no more than 2 or 3 km^2 in outcrop area. I have not yet examined these outcrops. They are included in Saleeby and Sharp's (1980) unit of Jura-Trias schist, slate, quartzite, marble, and metavolcanics.

The small pendant on the southeast side of Quedow Mountain is the site of the Credow Mountain tungsten mine. Here scheelite is disseminated in a garnet-rich tactite with minor epidote that developed from a marble layer. Most of the pendant rocks are reported to be quartz-hornblende-diopside schist (Goodwin, 1958).

TEJON CANYON PENDANT

The Tejon Canyon pendant is the westernmost metasedimentary pendant having well-developed, thin layered argillaceous schist (some with sillimanite), quartzite, and marble. This pendant is described as more metamaorphosed than most Tehachapi pendant rocks (Dibblee and Warne, 1970; Sams, 1986) and gneissic and migmatic rocks are present, in part due to the invasion of sills of the tonalite of Bear Valley Springs. Dibblee and Warne (1970) note that these beds may be equivalent to gneissic rocks to the west in the El Paso Creek area.

The Tejon Canyon pendant thus has characteristics in common with both the Tehachapi pendants (thin bedded units, marble, quartzite, and sillimanite) and the quartzo-feldspathjic units of the mafic gneiss complex of the San Emigdio and Tehachapi Mountains (gneissic layers, migmatitie, somewhat higher grade, coarse haloed red garnets) and may be transitional between the two units. The Tejon Canyon pendant as well as some of the felsic gneiss near Comanche Point may be correlative with some of the mixed rocks of the Caliente area. Much granitic rock is mixed with the metamorphic rocks in the Tejon Canyon pendant. Therefore the pendant is tentatively lumped with the mixed rocks and considered related to the mafic gneiss complex.

PAMPA SCHIST AND RELATED BODIES

West of the Tehachapi-like pendants and west of the Breckenridge fault is the Pampa Schist, first described by Dibblee and Chesterman (1953). The schist has not been found east of the White Wolf-Breckenridge-Kern Canyon fault zone. Characteristic of the Pampa Schist are dark colored, notably micaceous layers, some of which contain conspicuous chiastolitic andalusite. Some metavolcanic rocks are present, but marble and quartzite are notably absent. Two pendants that are possibly correlative with the Pampa Schist occur near the western limit of basement rock exposures of the Sierra Nevada about 50 km to the NNW. These two pendants (Fountain Springs and White River) are somewhat more argillaceous than the pendants to the east that are tentatively considered part of the Tehachapi belt. Cursory examination of the eastern part of the White River pendant also revealed metavolcanic rocks. In a 230 km^2 area just west of the Pampa Schist outcrops the subsurface bedrock of the San Joaquin Valley appears to be largely greenschist and low grade amphibolite. The greenschist has textures that strongly indicate a volcanic parentage. These rocks are dominated by chlorite, epidote-clinozoisite, actinolitic amphibole, and lesser sodic plagioclase. No rock samples were available, only small thin sections of these rocks. Some of the volcanic parts of the Pampa Schist are similar, but this rather widespread volcanic terrane may or may not be Pampa Schist-related. Nearby subsurface metasedimentary rocks, dominantly schistose and dark carbonaceous layers, also are tentatively considered to be part of the Pampa Schist.

Pampa Schist

The Pampa Schist is characterized by dark, notably micaceous rocks containing local conspicuous andalusite (chiastolite) crystals and some rocks with metavolcanic affinities, and lacks marble and quartzite. Some quartzofeldspathic layers are indistinguishable from layers in some other metasedimentary belts but overall the Pampa Schist is distinctive and easily separable from other metamorphic units of the southernmost Sierra Nevada.

Probably the most distinctive feature of the Pampa Schist is the dominance of muscovite and biotite in many layers; quartz and plagioclase are present, but they are subordinate. The rocks are dominantly pelitic schists. Andalusite, partly in coarse crystals, is locally abundant in the dark schists. Sillimanite, in part after andalusite(?), is widespread in needlelike bundles and as clusters of acicular to prismatic crystals that are generally small but locally are as coarse as 1 cm by 5 cm. Powdery carbonaceous matter is common and contributes to the dark color of these rocks. In some layers, muscovite occurs in dense clots reminiscent of shimmer aggregates. Some thin sections contain small amounts of orange, nearly isotropic material that has a serpentinelike appearance that may represent pinite alteration of cordierite, but no original cordierite was noted. Pale-green chlorite is present in some layers, but it is not common. Tourmaline and garnet are local accessories in the schist. I conclude that the protolith of much of the Pampa Schist was highly argillaceous.

Amphibolite is a less common but widespread rock type. Some specimens have original phenocrysts mimicked by clots of hornblende and opaque-mineral grains. Although pale-green acicular amphibole is present in some specimens, the association with andesine and (locally) with clinopyroxene suggests that these rocks, though now extensively retrograded, originally reached amphibolite grade. The easternmost exposures of the Pampa Schist include some unusual rocks that I would characterize as retrograde gabbro. Some layers are rich in antigorite(?), tremolite, and muscovite; others are rich in clinopyroxene and chlorite. Associated samples, composed chiefly of olive hornblende and labradorite with accessory metallic opaque-mineral grains and green spinel, show compositional layering and a granoblastic to polygonal texture. In this area, Dibblee and Chesterman (1953) noted a massive chlorite schist that they suggested was "* * * apparently of volcanic origin, probably a basalt." One of the samples from the southwesternmost exposures of the Pampa Schist has a fairly well preserved diabasic texture; some subhedral andesine crystals, as long as 1.5 mm, are set in a somewhat felted groundmass of plagioclase, biotite, and muscovite.

The original sedimentary section was probably dominated by dark shale and silty rocks, with an admixture of volcanic rocks. However, felsic sugary quartzofeldspathic (impure quartzite) rocks are locally abundant, particularly in the northern exposures and in small slivers on the Breckenridge Mountain Road (Mount Adelaide 7-1/2' quadrangle).

Subsurface metaigneous and metasedimentary rocks of the San Joaquin Valley

In three areas (pl. 1) that encompass an area of about 230 km^2 (90 mi^2) the subsurface basement is largely greenschist and amphibolite. The greenschist samples are dark, dense, schistose rocks dominated by chlorite, epidote-clinozoisite, and actinolitic amphibole with plagioclase, generally sodic (in part albite), much less abundant in most thin sections. Minor amounts of quartz, biotite, and muscovite are found in some thin sections. Metallic opaque minerals are common locally. Particularly abundant in some samples are sugary grains and aggregates of sphene; the metallic opaque-mineral and sphene grains probably were derived from ferromagnesian minerals that have been subjected to retrograde metamorphism. Some of the greenschist samples preserve a felty to trachytic texture. From the composition and appearance of these rocks, they are almost certainly metavolcanic.

Somewhat higher grade rocks are also preserved in this suite. Some hornblende-andesine rocks in part preserve a porphyritic texture, but even these rocks generally contain some chlorite and epidote-clinozoisite, as well as actinolitic aggregates that mimic the original hornblende or pyroxene crystals.

Most of these subsurface rocks were originally quite mafic, but one section shows conspicuous square β-quartz phenocrysts, as much as 1.5 mm long, smaller plagioclase phenocrysts (now albite), and clots of fine-grained muscovite set in a hornfelsed groundmass of plagioclase, quartz, and muscovite--probably a quartz porphyry. This sample, however, is north of and isolated from the three large greenschist areas. Some thin sections have a sandy texture suggesting tuff or tuffaceous sedimentary rocks.

In summary, most of the known subsurface metaigneous rocks in the San Joaquin Valley are greenschist that partly preserve a volcanic texture (felty or trachytic). Most probably their protolith was basalt or, possibly, andesite. Some of the amphibolites were probably intrusive rocks, but they are similar in composition to the greenschist and are certainly related in origin.

East of the southernmost mass of greenschist and amphibolite is an elongate belt of metasedimentary rocks that is interrupted by intrusive granitic rocks. These rocks are dominantly schistose, and texturally they resemble the Pampa Schist of Dibblee and Chesterman (1953). The dominant rock type is a dark, strongly schistose rock containing varying amounts of quartz, biotite, muscovite, and chlorite; plagioclase is minor. Opaque carbonaceous dust is common, and garnet and tourmaline occur locally. This carbonaceous schist is similar to some rocks of the Pampa Schist. No andalusite was seen in the subsurface samples, but large areas of the Pampa Schist also lack andalusite. Impure micaceous quartzite, marble containing grains of quartz and plagioclase, muscovite-quartz schist, and calcareous metasiltstone containing epidote are represented by single thin sections. The relation of these rocks to the carbonaceous schist and the outcrops of the Pampa Schist is uncertain; calcareous rocks, for example, are unknown in outcrops of the Pampa Schist.

Both the metaigneous and metasedimentary rocks of the San Joaquin Valley are dominantly dark and strongly schistose, and although these rocks are generally of a lower metamorphic grade than the exposures of the Pampa Schist, there is certainly overlap in grade between the two areas. The Pampa Schist appears to be dominantly metasedimentary, whereas the San Joaquin Valley subcrop is dominantly metaigneous; but some rock types are common to the two areas. The overall appearance and composition suggest that all these rocks are closely related.

Questionable correlatives to the northwest

White River pendant. The White River pendant is a rather large amoeboid-shaped body that underlies about 20 km^2 along the western contact of Sierra Nevada basement with the younger sedimentary cover of the San Joaquin Valley. I have only examined this body at its easternmost nose just north of Coarse Gold Creek (White River 7-1/2' quadrangle) and at the westernmost tongue of basement along the White River near the Gillam Ranch (White River 7-1/2' quadrangle) .

The road leading southwestward from White River that crosses the eastern nose of the pendant, as previously mapped (reconnaissance geologic mapping by G.P. Louke, cited by Smith, 1965), exposes a group of metaigneous rocks including olivine-rich ultramafic rock. Some marble exposed here was the only evidence of metasedimentary rocks.

A small tungsten mine has been described near here by Goodwin (1958). He mentions scheelite and chrysocolla in quartz stringers between granitic rocks and a slate and marble section.

At the west side of the metamorphic body, soft, argillaceous, thin-to-medium-layered dark metamorphic rocks are exposed. Two thin sections from these rocks exhibit a sugary to silty texture with coarser, angular to rounded quartz grains to 0.6 mm in diameter. Also present are rare plagioclase crystals or clasts of about the same size. In addition, these rocks contain larger clasts of polycrystalline quartz and silty fragments. Muscovite and reddish brown biotite are common in variable amounts. Carbonaceous dust is common in one section. Both sections look unsorted and are massive. Although these rocks are definitely clastic, they look quite unlike "typical" siliceous and argillaceous rocks in the unequivocal metasedimentary pendants to the east. Something about the overall texture and appearance of these rocks suggests similarity to the pyroclastic rocks of the King George Ridge pendant.

Saleeby and others (1978) noted that this pendant is dominantly composed of quartz-mica schist. They distinguish it from several pendants to the east that they characterize as largely interlayered quartzite and schist.

Fountain Springs pendant. The Fountain Springs pendant occupies only 2 or 3 km^2 along the western edge of the Sierra Nevada basement. Judging by sparse structural measurements, the Fountain Springs pendant appears to be on-strike with the White River pendant.

Reconnaissance study of the Fountain Springs pendant suggests it consists of mostly dark colored, in part thinly layered rocks, with a silty texture. Some layers have coarse clasts to 2 mm of composite quartz grains, but more commonly individual rounded quartz clasts are no more than 0.8 mm in diameter. These rocks are liberally sprinkled with muscovite and reddish brown biotite. Some layers have considerable epidote, clinopyroxene, and pale green amphibole, suggesting original calcareous cement. Some micaceous layers are liberally sprinkled with tourmaline crystals. These silty rocks are essentially unsorted and one section shows a bimodal grain size distribution--reminiscent of textures in the Fairview pendant.

Thin felsic layers alternate with the darker layers near the north end of the pendant. These felsic layers are lineated, but essentially unfoliated. In thin section they show a dense granoblastic mat of quartz and plagioclase with scattered coarse plagioclase crystals or fragments. The overall appearance of these layers in the field and their texture in thin section suggests a strong resemblance to the pyroclastic rocks of the King George Ridge pendant.

More study is needed of the rocks in the Fountain Springs pendant as well as the White River pendant. At present, however, the rocks of both pendants suggest a strong contrast and a mappable difference from the other pendants at this latitude. Saleeby and others (1978) also grouped the Fountain Springs pendant with the White River pendant. From the presently collected sparse samples there is a dearth of clean quartzite, mica schist, and coarse marble--the hallmarks of most metasedimentary pendants of the region.

RAND SCHIST

Within the Garlock and Pastoria fault zones are three vari-sized slivers (horses) of dark colored schists, metavolcanic rocks, metachert, and lesser serpentinite, that closely resemble the Rand Schist of the Rand Mountains (about 40 km east of the easternmost fault sliver). Conspicuous veins and sills of white bull quartz further the resemblance, as do typical dark plagioclase grains (from included material, probably carbonaceous).

In my investigations of the southernmost Sierra Nevada, I have made only cursory examination of the correlatives of the Rand Schist in the Garlock and Pastoria fault zones. My data come from the west third of the large horse along the Garlock fault and from the small horse near Mojave. In addition, I summarize the data of Wiese (1950), who examined and described rocks from part of the larger horse.

Probably the best and most continuous exposures of the Rand Schist are at the blunted west end of the larger horse in roadcuts along the access road for the Tehachapi crossing of the California Aqueduct (Pastoria Creek 7-1/2' quadrangle). North of Bear Trap Canyon, thin-layered, light to dark schist containing varying proportions of quartz, muscovite, biotite, and minor sodic plagioclase is exposed. A common associate here is thin-layered quartzite (90-95 percent quartz), with trains of garnet, mica, and minor feldspar that probably reflect reconstituted argillaceous impurities from the original rocks. These rocks are partly dark colored from disseminated carbonaceous matter (graphite) and stained red by iron oxides. The overall appearance, composition, and setting of these quartzite layers suggest that they were originally chert. Oxygen-isotope determinations on quartz from two quartzite samples from the western part of the large horse give $\delta^{18}O$ values of +16.97

and +19.53 permil SMOW, well beyond the range of igneous quartz, and confirm that these rocks are, indeed, metachert or clastics derived from chert (Ivan Barnes, written commun., 1979). The presence of some coarse-grained, green actinolite pods and local epidote-rich layers suggests metavolcanic rocks. Quartz sills are also found that range from thin wisps to lenses to thick bull quartz veins. Field relations suggest that these veins have been sweated out of the schist during metamorphism. These white quartz segregations are an index to the Rand and related schists.

Two traverses across the larger horse about 8 km farther east revealed the same rock types as along the aqueduct road. Quartzite (metachert) is abundant, but because it is generally resistant and preferentially exposed, it may appear to be more abundant than it actually is. In addition to the common silvery schist, dark spotted schist occurs in which the spots are small albite crystals around which are molded pale-green actinolitic amphibole sprinkled with sphene and epidote. This rock is almost certainly metavolcanic. Associated with the dark spotted schist is a small knobby outcrop of serpentinite, a few tens of meters across at most, that is crisscrossed with carbonate veinlets. The contact with the surrounding rocks is not exposed. An X-ray diffraction pattern for the serpentinite indicates that it is dominantly antigorite and talc. The nearby float of coarse massive amphibolite, though rare in this horse, is distinctive. A cursory look suggests that the amphibolite is dominated by a mat of blocky hornblende crystals, but closer observation reveals that the blocky crystals are acicular bundles of amphibole, probably actinolite. This amphibolite in no way resembles the dark, hornblende-rich rocks north of the horse composed of the Rand Schist.

Wiese (1950), who examined the central 25 km of the largest horse, observed that the most common rock types are green amphibolite or chlorite schist, with subordinate quartzite and brown mica schist. He noted that albite porphyroblasts are present "in all but the purest quartzite." On the basis of my brief observations and Wiese's (1950) descriptions, I suggest that volcanic rocks and associated chert were the dominant protoliths for the rocks of the larger horse. Sandy and argillaceous rocks also were almost certainly present, but I suspect they were tuffaceous, at least in part. Structural contortions and disruptions preclude any statement about the original thickness of the section.

The smaller horse northwest of Mojave is composed dominantly of dark-gray to green, highly foliated schist that is spotted with poikilitic albite (in part black with included carbonaceous material). The schistose groundmass is dominated by acicular green actinolite and contains lesser biotite and epidote. Associated with this schist is thinly-layered quartzite containing micaceous partings, minor albite, and small garnets. These rocks are almost certainly metasedimentary, and probably metachert, as $\delta^{18}O$ values of +11.87 and +14.84 permil SMOW were determined on quartz from two samples (Ivan Barnes, written commun., 1979). The ever-present white quartz segregations (veins and dikes) are also found here. One specimen of dark albitic schist contains abundant clinopyroxene, which is anomalous in this suite. Another unusual specimen, which may be an albitized intrusive(?) rock, is spotted with scattered black poikilitic albite crystals, as long as 2 mm, and, in addition, contains fresh-looking discretely twinned albite crystals, large areas of quartz, and large discrete K-feldspar masses with planar faces against albite. Iron-stained relict prismatic indeterminate mats are possible pseudomorphs after amphibole. Thus, the Mojave horse appears to be composed entirely of metavolcanic rocks and metachert.

Extending westward from Grapevine Creek (GRapevine 7-1/2' quadrangle) to the area of Antimony Peak (Ross, 1981) is a belt of distinctive dark quartzite and schist (pl. 1) that, early in my field work in the San Emigdio Mountains, I considered to be part of the mafic metamorphic rocks of the San Emigdio-Tehachapi Mountains. Petrographic study, however, revealed the disturbing fact that the quartzite and schist are generally of lower metamorphic grade than the associated gneissic and amphibolitic rocks. This difference in metamorphic grade suggests that the two rock types are separated by a structural break.

The belt of quartzite and schist is characterized by rocks in which coarse, dark, biotite-rich layers alternate with impure quartzite layers, also dark colored. In thin section, the most striking feature of these rocks is the abundance of large poikilitic grains of untwinned sodic plagioclase clouded with graphite or other carbonaceous matter. These plagioclase crystals impart a dark color to the quartzite layers. Another unusual feature of these rocks is the presence of discrete chlorite crystals whose habit and interference color suggest that they are not a penninitic alteration product but are primary and, as such, indicate relatively low metamorphic grade. The belt of quartzite and schist contains conspicuous thick white bull quartz veins.

The physical appearance and metamorphic grade of these rocks is strikingly reminiscent of rocks that I have examined in the Rand Schist in the western part of the Rand Mountains. This similarity and the discordance in metamorphic grade between the rocks of the dark quartzite and schist belt and the enclosing, higher grade gneissic rocks suggest strongly that a sliver of the Rand Schist has been emplaced tectonically in the San Emigdio Mountains. Cursory examination of the sliver of probable Rand Schist in the San Emigdio Mountains suggests that it is dominantly metasedimentary, whereas the two bodies of the Rand Schist along the Garlock fault have strong metavolcanic affinities.

BEAN CANYON FORMATION

South of the Garlock fault and northeast of the San Andreas fault are several bodies of presumably related rocks that were referred to Simpson's (1934) original "Bean Canyon Series." Dibblee (1963, 1967) renamed these rocks the Bean Canyon formation. In Bean Canyon most of the lithologies of this formation are exposed in a small area. Most common is dark siliceous calc-hornfels, micaceous schist (in part andalusite-bearing) impure to pure quartzite, and marble. Metavolcanic rocks ranging from felsic to mafic composition, and at least in part crystal tuffs (or tuffaceous sedimentary rocks), are scattered through most of the bodies of Bean Canyon rocks. These sparse, but widely scattered volcanic types, seem to be more common than in most other metasedimentary sequences in the southern Sierra Nevada. Dunne and others (1975) noted poorly preserved macrofossils in the Bean Canyon Formation, but they were not diagnostic for age determination.
They suggested an early Mesozoic age for this formation based on the presence of rock types similar to the Triassic rocks of the Mineral King pendant (more than 150 km to the north) and an environment of deposition of the Bean Canyon Formation compatible with early Mesozoic paleogeographic data of the region. R.A. Fleck (written commun., 1976) has determined rather equivocal ages of 150 Ma. by the Rb/Sr method on dacitic metavolcanic rocks from Bean Canyon. These ages can be interpreted as the time of dacitic volcanism or the metamorphic homogenization of older volcanic rocks. Thus the dacites are a minimum 150 m.y. old, and possibly much older. Tentatively, the Bean Canyon Formation is considered to be Jurassic.

The two largest bodies of the Bean Canyon Formation on the west may be relatively flat bottomed, judging by their contacts with contiguous granitic rocks and by the topography. Wiese (1950) suggested that these granitic rocks may have been emplaced along a pregranite thrust surface. The contacts are definitely intrusive, however, and contact-metamorphic-mineral deposits are developed locally along them. The easternmost bodies of the Bean Canyon Formation appear to be normal roof pendants, keeled down into the granitic rocks. Although structural details of the metamorphic rocks remain to be worked out, G.A. Davis (written commun., 1977) suggested that the metamorphic rocks in Bean Canyon are isoclinally folded into a synformal(?) structure.

White to gray marble that commonly is coarsely crystalline is probably the most abundant rock type in the Bean Canyon Formation. Possibly the most distinctive rock type is gray to green, dense, in part thinly layered calc-hornfels typified by the porcelaneous appearance of fresh surfaces. Metavolcanic rocks and dark andalusite hornfels occur locally. Individual bodies of the metamorphic rocks from west to east are described below.

Dark, dense hornfels occurs on the north side of the westernmost, largest, relatively flat bottomed metamorphic mass. The hornfels is quartz-rich and contains varying amounts of clinopyroxene, epidote-clinozoisite, and K-feldspar; locally, hornblende and scapolite are present. One specimen has a notable volcanic texture; equant plagioclase crystals, as much as 2 mm long, are set in an acicular mat of olive hornblende and minor plagioclase liberally sprinkled with sphene and some pyrite. The relation of this volcanic rock to the rest of the hornfels is uncertain. The resistant hornfels probably is preferentially exposed at the expense of such rocks as mica schist, which I found to be very rare here, but which were noted in the area by Crowell (1952). The westernmost metamorphic body probably was originally composed of limestone, sandstone, and highly siliceous siltstone. Into these rocks, andesitic(?) flows or intrusive rocks were introduced. The marble here and elsewhere in the Bean Canyon Formation is largely white to gray calcite marble. Graphite is locally abundant, and the marble is in part dolomitized. Bedding is partly preserved, but in much of the coarsely crystalline marble, all traces of original structures have been obliterated. Although the large westernmost metamorphic body is mostly marble, it contains significant layers of green to dark-gray calc-hornfels that are composed of plagioclase, hornblende, clinopyroxene, and epidote in varying proportions and of lesser amounts of K-feldspar, scapolite, and garnet.

The next mass of the Bean Canyon Formation to the east, near the Quinn Ranch, is also relatively flat bottomed; it is dominantly composed of marble, but contains two belts of gray to green, dense calc-hornfels and fine-grained quartzite, and minor amounts of pale-green amphibole, biotite, plagioclase, and clinopyroxene. These rocks probably were originally quartz sandstone with minor amounts of calcareous and argillaceous cement. They grade into schistose rocks rich in muscovite and biotite and locally contain andalusite; garnet is a sparse accessory. These schistose rocks may have originally been siltstone and argillite. No recognizable metavolcanic rocks were found in this pendant, but one layer of plagioclase-hornblende schist contains pale-green hornblende crystals, as much as 3 mm long, that may be remnant crystals or fragments from a tuff or tuffaceous sedimentary rocks.

Between the Quinn Ranch (Neenach 15' quadrangle) and Cottonwood Creek are numerous small pendants composed chiefly of marble. A thin section from a dark layer of thinly laminated rocks in marble in an abandoned quarry just east of Canyon del Gato-Montes may contain relict silty grains. The laminated rocks are composed of alternating quartz-rich and quartz-poor layers. The quartz-poor layers contain varying proportions of brown biotite, K-feldspar, and plagioclase. Minor andalusite is present in some of the biotite-rich layers. Rounded detrital grains of apatite, zircon, garnet(?), and opaque material testify to the clastic origin of these rocks.

From Cottonwood Creek to the east limit of exposures of the Bean Canyon Formation, although marble is still abundant, it no longer dominates the section. Well exposed west of Cottonwood Creek is a belt, nearly a kilometer wide, of dark schist, impure quartzite, calc-hornfels, and minor pure quartzite. Commonly, the dark schist contains abundant andalusite (some with well-formed chiastolite crosses), abundant brown to red-brown biotite, muscovite, and some K-feldspar. Quartz is abundant in some layers, and hints of original silty texture are present. These rocks grade by degrees into impure quartzite with micaceous layers and into rather pure quartzite with scattered mica and amphibole that reflect original argillaceous and calcareous cement. Calc-hornfels rich in clinopyroxene, quartz, and plagioclase is also present. Immediately north of the schist belt are scattered exposures of dark amphibolite that suggest a metavolcanic parentage. These rocks are massive to weakly layered and are rich in fibrous green amphibole and epidote. Largely untwinned plagioclase crystals, as long as 2 mm, are set in this dark groundmass; locally they are in polygonal aggregates, with fibrous amphibole molded around them. The rocks do not resemble the gneissic and amphibolitic mafic rocks north of the Garlock fault but are probably metabasalt or metaandesite related to the Bean Canyon Formation.

Between Cottonwood Creek and Gamble Spring Canyon, Dibblee (1967) delineated several small bodies which he called hornblende diorite. Most of the samples I have studied from those bodies are dark granodiorite to tonalite and probably represent the granodiorite of Gato-Montes contaminated by interaction with metamorphic rocks of the Bean Canyon Formation. Locally unusual gabbroic rocks were found that are probably related to the metavolcanic rocks of the Bean Canyon Formation. One sample from just east of Cottonwood Creek features stubby euhedral crystals of weakly zoned pale-brown to colorless hornblende(?) set in a matrix of clinopyroxene, labradorite, K-feldspar, and minor quartz.

The east-west-trending elongate pendant of the Tylerhorse-Gamble Spring Canyon area has a conspicuous belt of marble along its south side that contains some dark hornfels layers. One dense, dark layer is dominantly quartz but also is rich in K-feldspar. It is liberally sprinkled with opaque carbonaceous(?) matter, as well as tremolite and pale-reddish-brown tourmaline. North of the marble is a section of dark rocks much like those exposed west of Cottonwood Creek--dark micaceous schist, in part containing andulusite, dense dark siliceous calc-hornfels, and lesser marble and light quartzite. Particularly noteworthy in this section are porphyritic volcanic rocks or crystal tuff. These rocks in various shades of gray have phenocrysts (or crystal fragments) of twinned and zoned plagioclase, embayed quartz, and biotite aggregates, as much as 4 mm long, in a dense granoblastic matrix of quartz, plagioclase, biotite, and pale-green hornblende. Also present are layers with a well-preserved felty texture of small tabular plagioclase crystals. These rocks contain small phenocrysts of plagioclase and altered hornblende, as much as 2 mm long, set in a groundmass rich in acicular, pale-green hornblende crystals. The mineral content suggests that these volcanic rocks were originally dacite to basalt.

Bean Canyon was designated the type section of the Bean Canyon Formation (Dibblee, 1963, 1967). Here is well exposed, in a rather limited area, the entire lithologic range of the formation. Dense, dark siliceous calc-hornfels, micaceous schist (in part containing andalusite), impure quartzite, a thick belt of pure quartzite, and marble make up most of the section. A dark belt of altered peridotite(?) that extends across the canyon is highly distinctive. It is made up of fractured, altered olivine laced by colorless to pale-yellowish-green serpentine minerals; abundant acicular, colorless amphibole accompanies the olivine. North of the ultramafic belt is a gray porphyritic metavolcanic layer containing ovoid to equant phenocrysts of plagioclase and quartz set in a granoblastic mat of untwinned plagioclase, quartz, brown biotite, and minor muscovite. Accessory tourmaline is found in this layer and in several other metavolcanic-rock types in the Bean Canyon Formation. This layer somewhat resembles the metavolcanic rocks in Gamble Spring Canyon, but the phenocrysts here are less distinct.

Dunne and others (1975), in a study of the strata in and near Bean Canyon, suggested that the protoliths of the Bean Canyon Formation were about equal amounts of feldspathic and quartz wacke, quartz arenite and siltstone, argillite and shale, and marble; volcanic rocks were subordinate in the original section.

Various scraps, slivers, and pendants of the Bean Canyon Formation are also exposed in the area between the Tehachapi-Willow Springs and Oak Creek Roads. Although marble probably dominates in this area, the bodies mapped as marble generally include other rock types. For example, the marble belt that is cut by Willow Springs-Tehachapi Road (Willow Aprings 7-1/2' quadrangle) has a dark hornfels layer that is a hornfelsed metavolcanic rock in which somewhat embayed plagioclase crystals, as long as 3 mm, are set in a dense matrix of quartz, feldspar, biotite, and minor hornblende. In addition to the plagioclase megacrysts clusters of fine-grained brown biotite, gray-green hornblende, opaque material, and sphene are present that probably mimic original ferromagnesian megacrysts.

On Oak Creek Road, about 1,500 m east of its junction with Willow Springs-Tehachapi Road, gray metavolcanic rocks with well-preserved volcanic textures are exposed. Hand specimens resemble porphyry, but thin-section study suggests that these rocks are pyroclastic. Plagioclase megacrysts as long as 6 mm but generally from 2 to 3 mm long are conspicuous and generally are partly hornfelsed. Smaller, rounded to equant quartz masses are suggestive of clasts, as are some broken-looking plagioclase crystals. These rocks have a dense hornfelsed matrix consisting of quartz, feldspar, brown biotite, and minor green hornblende. The other common rock types composing the Bean Canyon Formation are also seen on Oak Creek Road: micaceous hornfels, impure quartzite, quartzite, and quartz-plagioclase-pyroxene calc-hornfels.

About 800 m east of the Willow Springs-Tehachapi Junction with Oak Creek Road, a layer of gray dense hornfels was found that is studded with euhedral, tabular, grass-green crystals of clinopyroxene, as much as 1 cm long. This highly distinctive rock, with its groundmass of quartz, K-feldspar, minor plagioclase, accessory round sphene grains, and abundant graphite, has not been seen elsewhere in the outcrop area of the Bean Canyon Formation.

SALT CREEK METASEDIMENTARY BELT

The Salt Creek metasedimentary belt consists of inclusions and small pendants of metasedimentary rock in the granodiorite of Lebec. The largest body covers only about 10 km^2. The common rock types are (1) marble, in part dolomitic, (2) pure to impure quartzite, and (3) micaceous schist, commonly containing sillimanite. Calc-hornfels and quartzofeldspathic hornfels are less common, but widespread. These pendant rocks have essentially the same lithologies as in the Tehachapi metasedimentary belt and for that matter in the Long Canyon belt and the belts to the east. It is separately named largely because of its geographic isolation. There are some significant differences between the Salt Creek belt and the Bean Canyon Formation and yet their enclosing granitic rocks are considered correlative.

Quartzite can be delineated locally, but generally quartzite and schist are so interlayered that they are not mappable separately. The protoliths of this section probably were dominantly limestone, quartz sandstone, argillaceous and calcareous sandstone, and shale that was richly argillaceous. These lithologies suggest a continental sedimentary section that was deposited near a stable platform, probably in a miogeoclinal environment.

Marble is the most conspicuous rock type, although not the most abundant. It forms highly visible white outcrops that have been quarried to some extent. Some color layering, possibly reflecting bedding, is present, and some layers are speckled with shiny black graphite flakes. Locally, the marble is ribbon rock, consisting of alternating thin layers of calcite and calc-hornfels made up of quartz, clinopyroxene, epidote, and feldspar. Some of the dominantly marble masses also include calc-hornfels and siliceous layers. Marble interbeds also occur locally within other rock types.

The rock type most characteristic of the metamorphic belt is red- to brown-weathering, relatively pure quartzite. Rarely the dominant rock type in any one pendant or inclusion, it is widespread throughout this belt. The nearly pure quartzite is a granoblastic mat of 90 to 95 percent quartz, with scattered flakes of mica and feldspar; the feldspar probably reflects reconstituted argillaceous cement. These rocks range in composition from nearly pure quartzite to argillaceous and feldspathic quartzite containing more than 25 percent cement. Clinopyroxene, tremolite, and epidote in some of these rocks probably represent original calcareous cement. Tourmaline, garnet, and sillimanite also are found locally. In some specimens, original quartz grains, from 0.4 to 1 mm long are preserved where they are isolated by nests of reconstituted cement. Thus, the pure quartzite is an end member in a sequence that grades with the addition of mica, feldspar, and other minerals into quartz hornfels and highly micaceous schist.

Micaceous schist is the second most abundant rock type in the metamorphic belt. This shiny, well-foliated rock is gray on fresh surfaces and weathers to dark shades of brown or red. Some schist is composed dominantly of reddish-brown biotite and untwinned K-feldspar, with minor muscovite, quartz, and plagioclase. Other schist is dominated by intermediate plagioclase and biotite. In some layers, muscovite is abundant, but rarely is it more abundant than biotite. Sillimanite is notably abundant in these rocks, in part in coarse, skeletal crystals, but more commonly in bundles of acicular crystals. Red garnet is also present in some layers. Shimmer aggregates of muscovite are rather widespread. Cordierite, which has been identified in two of these rocks, probably was originally more widespread and has been largely converted to muscovite.

The metamorphic belt contains rock types intermediate between quartzite and micaceous schist. Most of these rocks are strongly foliated and probably are best classified as quartzofeldspathic schist to hornfels. Some of the schist is dominantly a granoblastic mat of varying proportions of quartz, intermediate plagioclase, and K-feldspar, with a directed fabric shown in thin section only by aligned reddish-brown biotite and lesser muscovite. Small amounts of pink garnet and green hornblende are also present.

Two unusual rock types with very limited outcrop bear special note. Near the center of the largest pendant, dark layers in a dominantly quartzite sequence are composed of a decussate mat of olive-brown hornblende, minor epidote, and some sphene. These dark layers are partly replaced by light-colored thin layers and narrow tongues consisting of plagioclase (about An_{50}), pale-green clinopyroxene, and abundant tiny round grains of highly pleochroic sphene. Some calcite is present locally in the lighter layers. The general appearance, composition, and setting of this rock suggest that it was derived from a calcareous sedimentary rock.

A dark chloritic schist was noted in a poorly exposed sequence of quartzite and quartzofeldspathic schist about 700 m S. 60° E. from San Emigdio Mountain along the road that skirts a tremendous cliff (landslide scarp?). The rock is composed almost entirely of pale-green chlorite and colorless to pale-green amphibole, with abundant, scattered opaque matallic grains and calcite. Although it is tempting to suggest that this rock is a volcanic greenschist, the absence of feldspar, the presence of abundant calcite, and the geologic setting suggest otherwise. I could speculate that this layer is a retrograde hornblendite dike or sill, but it seems more reasonable to suggest that it was a sedimentary layer. By any account, this is an unusual rock type for this area, although some chlorite is present in other schistose layers in the metamorphic belt. The occurrence of these two rock types points out the perils of assuming that hornblende-rich metamorphic rocks have an igneous origin.

ADDITIONAL DATA

The metamorphic rocks of the southern Sierra Nevada consist principally of several belts of relatively thin-bedded siliceous, argillaceous, and calcareous rocks. A major exception is the largely mafic metamorphic rock assemblage in the San Emgidio and Tehachapi Mountains (Ross, 1983; Sams. 1986). These rocks are not discussed here, but they contain felsic paragneisses, minor impure quartzites and calc-hornfels, and, locally, marble, that may be related to the largely metasedimentary belts elsewhere in the southern Sierra Nevada.

Age data on these largely metasedimentary belts is sparse. The only fossil locality known is in the Long Canyon pendant, where Late Triassic or Early Jurassic bivalves have been identified. The Long Canyon pendant is lithologically similar to the Big Meadow, Tehachapi, and Salt Creek metasedimentary belts, and also to the Bean Canyon Formation, which is tentatively considered of Jurassic age based on Rb/Sr data on associated metavolcanic rocks (R.A. Fleck, written commun., 1976). Thus, the large bulk of metamorphic rocks from the southern Sierra Nevada are lithologically somewhat similar and at least very locally bear evidence of a Jurassic or Triassic age. Saleeby and others (1978) have expanded the more localized usage of the Triassic and Jurassic Kings Sequence in the central Sierra Nevada (Bateman and Clark, 1974) to include most of these metamorphic rocks of the southern Sierra Nevada north of the Garlock fault.

The Rockhouse Basin belt has some features that distinguish it from the other belts. The Paso-Baryta barite deposit, in the Rockhouse Basin pendant, appears to be a bedded deposit in a zone 10 to 15 feet wide that extends over a strike length of one mile, and is conformable to the beds in the enclosing metasedimentary rocks (Goodwin, 1958; Taylor, 1985). Bedded barite deposits in California and Nevada are almost invariably in rocks of Paleozoic age (Brobst, 1958). This suggests that the Rockhouse Basin may be Paleozoic, and thus older than the other metasedimentary rocks of the southern Sierra. In addition, dark shaly rocks and pillow basalts that are somewhat reminiscent of the Paleozoic rocks in the nearby El Paso Mountains have been noted in the Rockhouse Basin pendant (G.C. Dunne, oral commun., 1986). Significantly, a granitic pluton dated at about 235 Ma. (Middle Triassic) based on Rb/Sr studies (R.W. Kistler, written commun., 1986) appears to intrude the Owens Peak Pendant, a probable correlative of the Rockhouse Basin pendant. A granitic mass with a similar Rb/Sr pattern, but with too few data to date (R.W. Kistler, written commun., 1986), intrudes the Rockhouse Basin pendant. Although the present evidence thus suggests the Rockhouse Basin belt is Paleozoic, sections in the Owens Peak and Hi Peak pendants are not that distinct lithologically from the dated Mesozoic Long Canyon pendant. In fact, without the Mesoazoic fossil locality, the Long Canyon pendant, with its thick pure quartzite, marble, and argillaceous schist, would be a good candidate for a section of lower Paleozoic rocks similar to these in the Cordilleran miogeocline.

The Fairview pendant is a distinct anomaly in the sedimentary section. This pendant is composed dominantly of a dark-colored, generally massive pile of largely unsorted quartzite with coarse granular texture and lesser dark shaly interbeds and metavolcanic layers. The contrast with the thin bedded belts of varied lithologies on both sides is striking. The Fairview pendant appears to be a mega-lens that dies out to the south.

The Fairview pendant is also distinct from the other metasedimentary pendants of the southern Sierra Nevada in structural style. At the north end of the pendant (near Fairview) the elongation of numerous marble lenses and a subtle closure based on steep attitudes in quartzitic layers suggests a relatively open megafold in the pendant (fig. 4), although further south the generally northerly strikes and steep attitudes do not suggest such a folded pattern.

About 1 km south of Limestone Cliffs campground (Kernville 15' quadrangle), Saleeby and Busby-Spera (1986) noted graded beds with scoured bases and current ripples that indicated top directions to the south. Attitudes I have measured near there generally are northeast-striking and dip steeply northeast to vertical. Thus on the basis of sparse data the beds may be overturned and the fold on figure 4 may be synformal rather than antiformal as it appears on the map. The more open style of folding, at least locally, in the Fairview pendant contasts with the steeply-dipping homoclinal-appearing (or isoclinal, based on hints from small tight folds) beds in most of the other pendants. This suggests that the Fairview pendant is structurally less complex than the other pendants, although it is also possible that the more massive quartzite layers of the Fairview pendant simply reacted differently to the same structural conditions than the other more thinly layered pendants. The implication that the less intensely deformed Fairview pendant may be younger than the surrounding pendants may be therefore suspect, but regardless there is a marked anomaly (lithologically) between the granular Fiarview quartzites and the thinner layered pendants.

One more, possibly significant difference at the north end of the Fairview pendant (fig. 4) is the argillaceous-rich western tail of the northern bulge. Argillaceous beds are present throughout the dominantly quartzitic pendant, but nowhere else has a dominance of argillaceous beds been noted in the pendant. This suggests either the western tail is a local argillaceous lens or possibly a representative of an argillaceous-rich "formation" west of the quartzite beds and only preserved here, being elsewhere engulfed by younger granitic rocks.

The French Gulch metavolcanic pendant, which is probably related to the Fairview belt, but is not as yet fully understood, is a north-trending belt of dark metavolcanic rocks, of intermediate to felsic composition, that occur between the Long Canyon belt to the east and correlatives of the Fairview pendant to the west. The contact relations of the French Gulch pendant are only known north of Isabella Lake where Elan (1985) mapped interbedded units of the French Gulch and Long Canyon beds. The relation of the French Gulch pendant to adjacent metamorphic rocks is particularly important because isotopic ages have been determined from the French Gulch pendant. An ash flow tuff near the south end of the pendant (Piute Lookout ash flow tuff unit of Busby-Spera, 1983) has been dated at 98 $\pm$ 3 Ma. by the U-Pb method on zircon (daleeby and Busby-Spera, 1986) and at 98 Ma. by the Rb/Sr method (R.W. Kistler, written commum., 1983). Another ash flow tuff in the central part of the pendant has been dated at 102 $\pm$ 5 Ma. and a rhyolite sill in Erskine Canyon that intrudes quartzitic beds (that may be part of the Fairview belt) has been dated at 105 $\pm$ 2 Ma. (Saleeby and Busby-Spera, 1986).

The dated rhyolite sill has a peperitic margin with the quartzitic beds suggesting contemporaneity of volcanism and sedimentation (Saleeby and Busby-Spera, 1986). I have been tempted to speculate that the Fairview pendant, with its anomalous granular turbidity-like beds was not only different, but possibly younger, than the surrounding metasedimentary rocks. Here in Erskine Canyon are beds, possibly offset from the Fairview pendant by the Kern Canyon fault, that may indeed be younger than the bulk of the Jurassic or Triassic Kings Sequence of the southern Sierra Nevada.

Possible vents for some of the rocks of the French Gulch pendant are present in distinctive porphyritic rocks along Gold and Corral Creeks that are interpreted as hypabyssal intrusives by Saleeby and Busby-Spera (1986). A few kilometers south of these localities a U-Pb zircon age of 101 $\pm$ 4 Ma. has been determined on a hypabyssal rock that is probably correlative. The close correspondence of this age and that of ash flow tuffs in the French Gulch pendant suggests that these 100 Ma. hypabyssal rocks may have been feeders for at least some of the ash flows. These hypabyssal rock are presumably the rocks I identified as andesite porphyry (fig. 3).

Other enigmas are the contact relation between the south end of the French Gulch pendant and the north end of the Tehachapi pendant, and the relation between these rocks and the gneiss body at Brown Meadow (Piute Peak 7-1/2' quadrangle) which may be related to the mafic gneiss complex of the San Emgidio and Tehachapi Mountains (fig. 5). The gneissic rocks of the Brown Meadow area seem to interfinger with both the Tehachapi and Cypress pendants in a way as yet poorly understood. Further detailed study in this area of poorly exposed, vegetation covered outcrops is certainly called for.

The contact between the southern end of the metavolcanic French Gulch pendant was shown to be grossly concordant in an earlier reconnaissance by G.P. Louke (written commun., 1975). I have measured north to NNW striking, steeply east dipping layers in the volcanic pendant near the contact, but have only noted cataclastic foliation parallel to the metavolcanic pendant trending NNW and dipping steeply to the west of vertical in the gneiss layers of the Brown Meadow unit (fig. 5). This suggests the possibility of a structural contact between the metavolcanic and metasedimentary rocks. These two different interpretations show, on the basis of scant data, the doubt about the relations at this contact.

Field notes taken in the area mapped as Brown Meadow repeatedly made reference to "strongly deformed hybrid rocks, augen gneiss, fine-grained gneiss, dirty diorite, and irregularly textured gabbro." These were more or less lumped together and shown interdigitated with the metasedimentary rocks. The mixture of dark plutonic rocks and sheared dark and light gneisses (possibly orthogneisses) are reminiscent of the mafic gneiss complex that is also associated with the metasedimentary rocks of the Tehachapi belt further south at Tweedy Creek and Mountain Park. Presumably these contorted plutonic rocks were intruded into the Tehachapi belt and much deformed prior to the major batholithic intrusions. The large lenses of marble within the gneiss of Brown Meadow are very likely remnants of the Tehachapi pendant rocks. The association of this gneissic occurrence intimately mixed with thinly layered metasedimentary rocks is also somewhat similar to the relations in the Tejon Canyon pendant. The Tehachapi metasedimentary belt thus appears to contain (be intruded by?) several elements of the mafic gneiss complex (the Browns Meadow, Tweedy Creek, Mountain Park, and Tejon Canyon) as alluded to previously.

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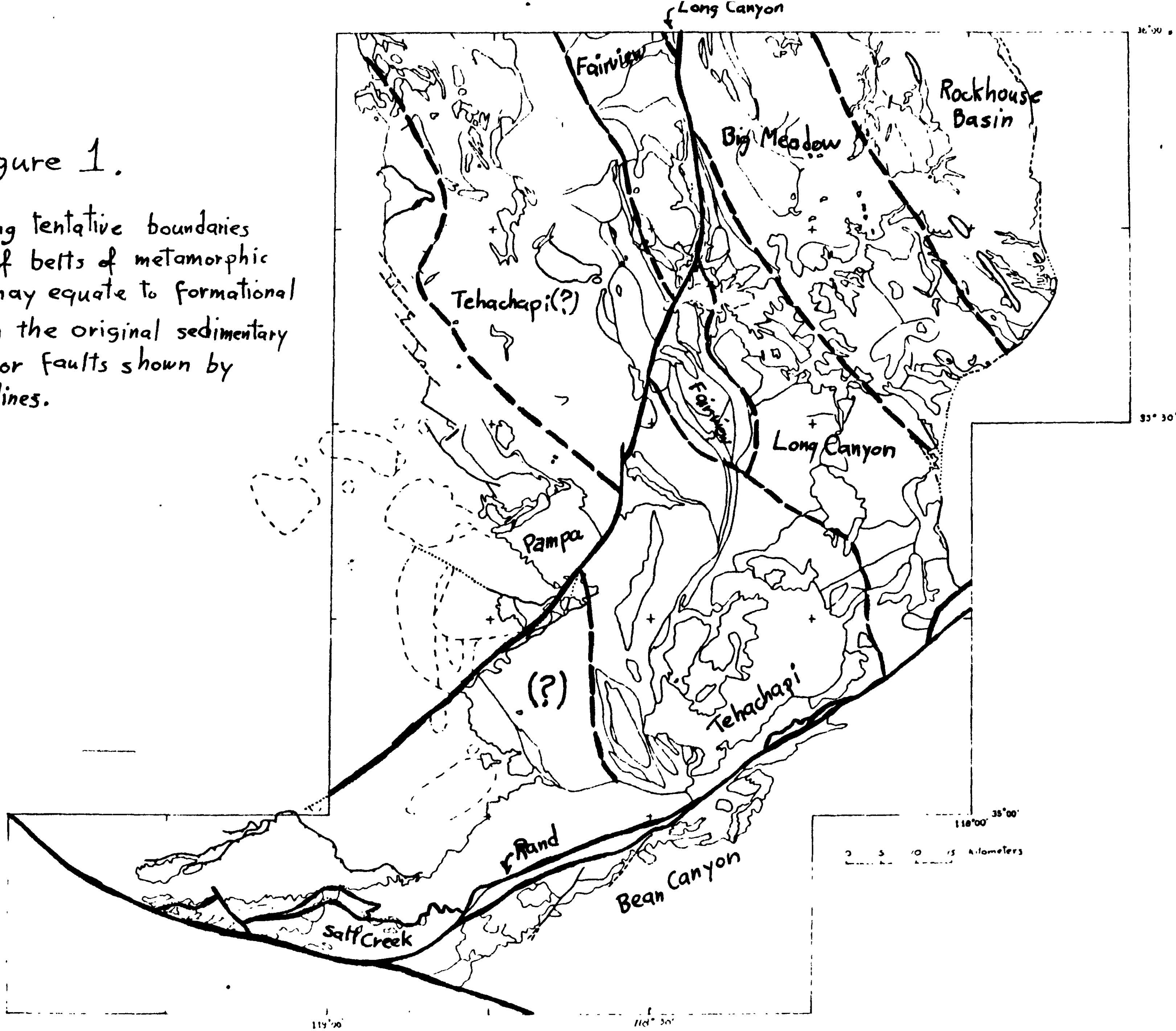


Figure 1.

Map showing tentative boundaries (dashed lines) of belts of metamorphic rocks that may equate to formational boundaries in the original sedimentary section. Major faults shown by heavy solid lines.

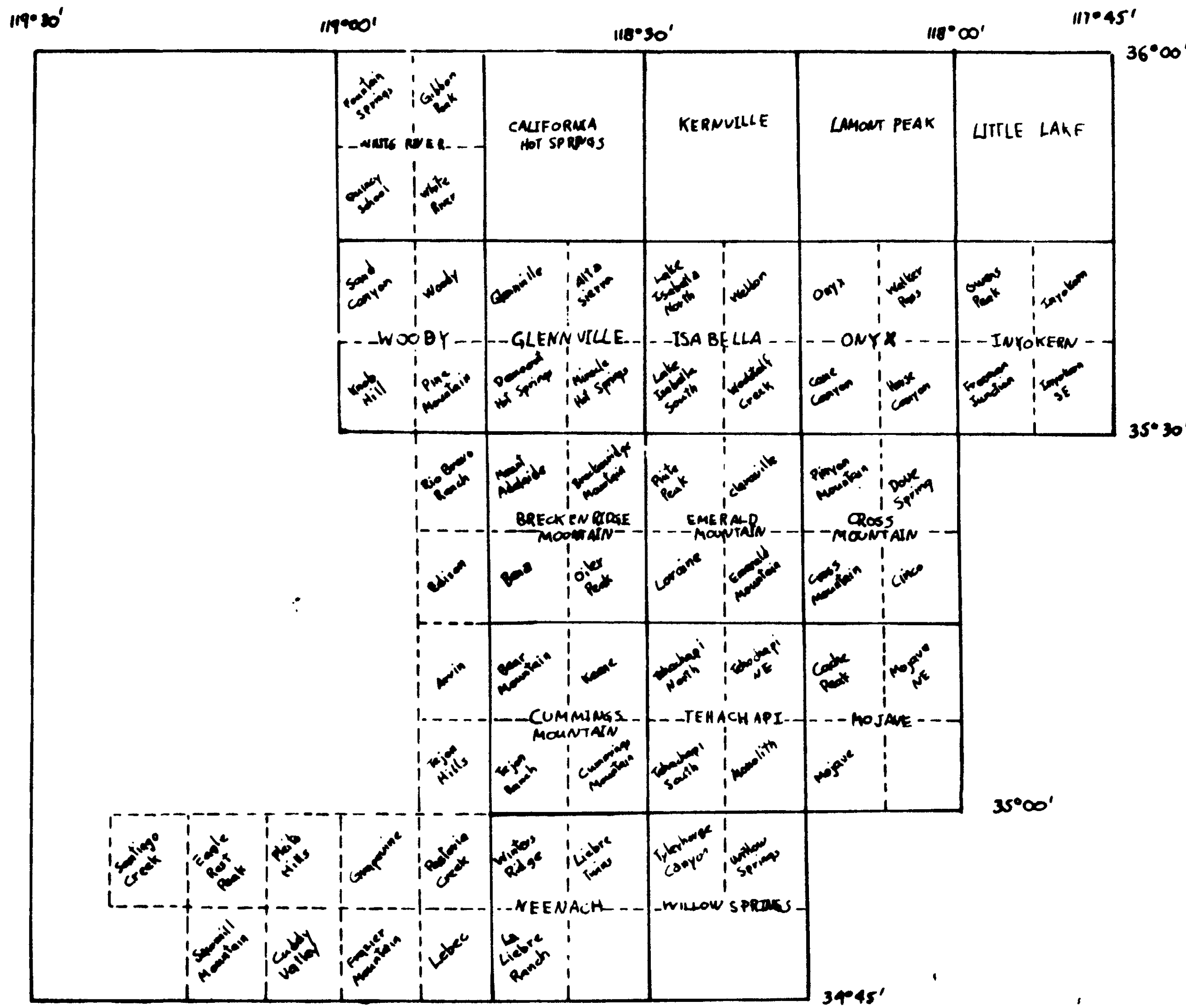


Figure 2. Index to 7 1/2 and 15 minute topographic quadrangles in the southern Sierra Nevada that contain basement rock outcrops. Geographic localities noted in the text, but not shown on the base map, are keyed to these quadrangles.

EXPLANATION

- ● Granular unsorted quartzite
- ○ Volcanic(?) quartzite
- x Volcanic texture, in part ash flow tuff
- △ Argillaceous schist and hornfels
- ■ Low-grade amphibolite
- □ Andesite porphyry
- ⦶ Calc-hornfels

0 2 4 6 8 Kilometers

(all three maps)

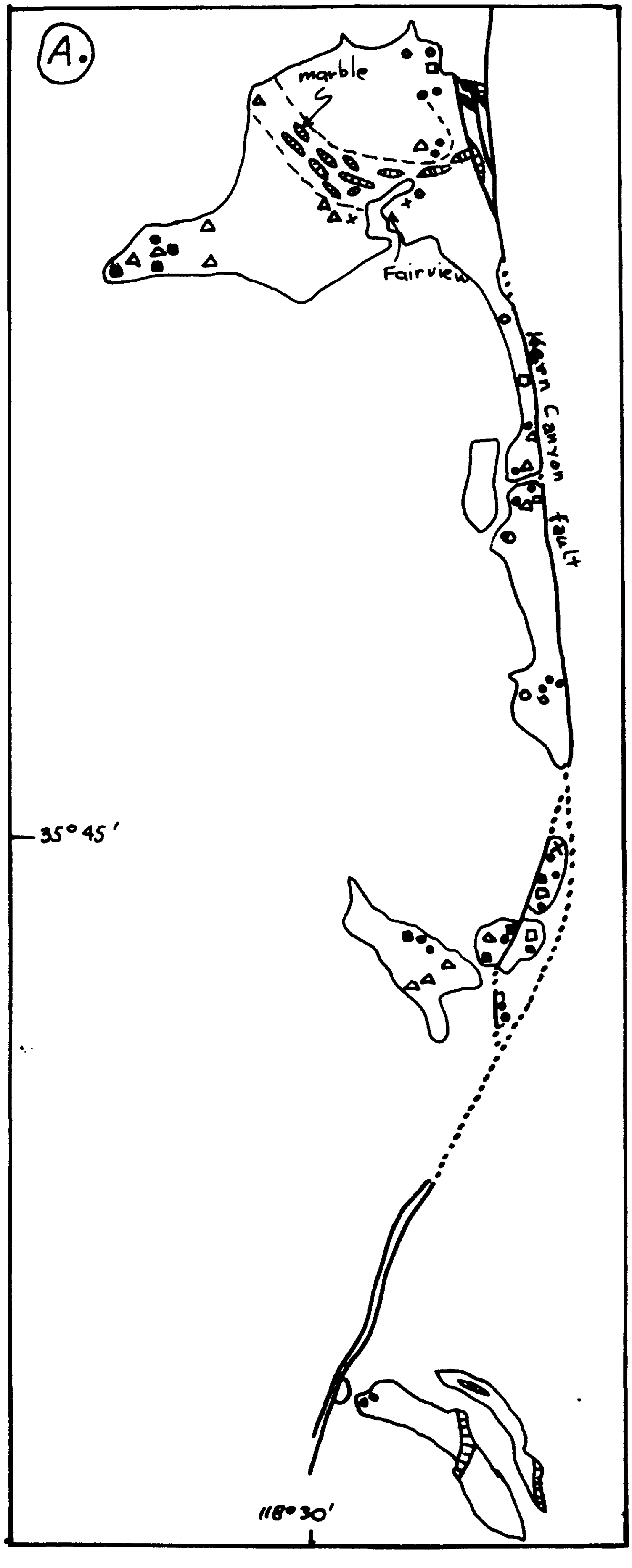


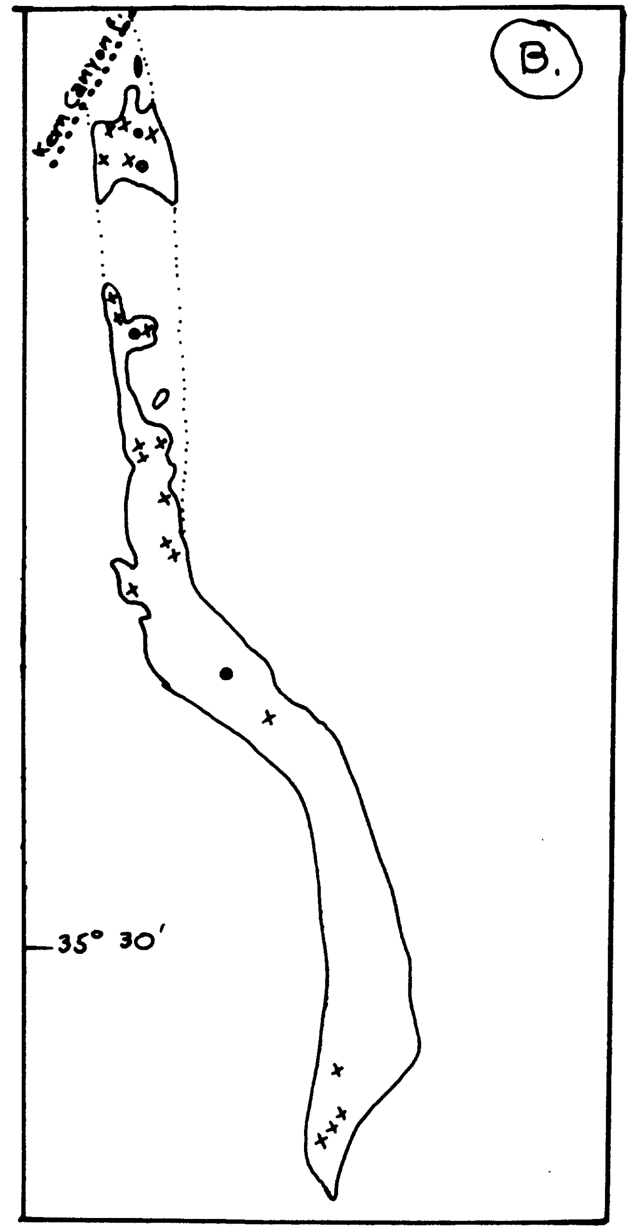
Figure 3. Location of selected samples from pendants of the Fairview belt. Rock types determined by thin section petrographic examination.

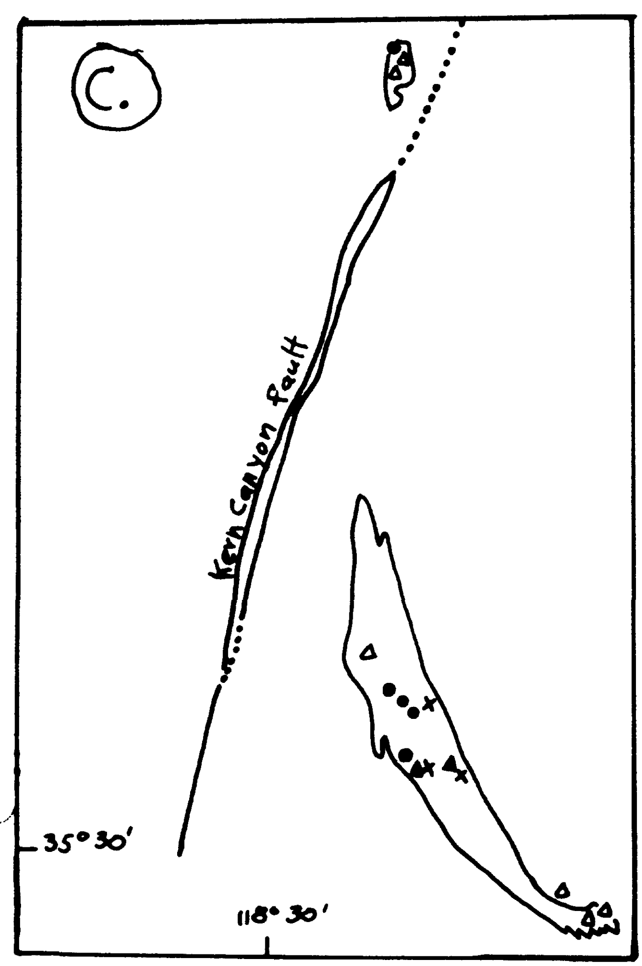
A. Fairview pendant and related bodies

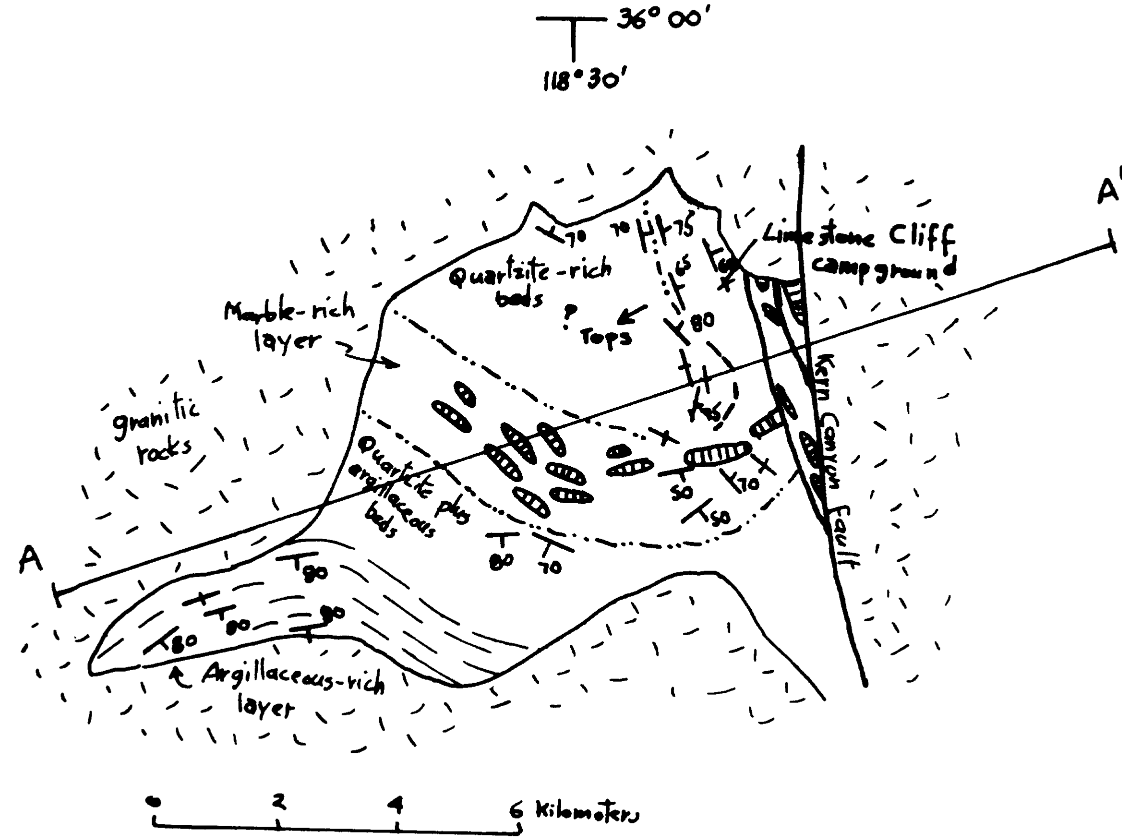
B. French Gulch pendant

C. Cypress pendant and related body.

Figure 3 (cont.)







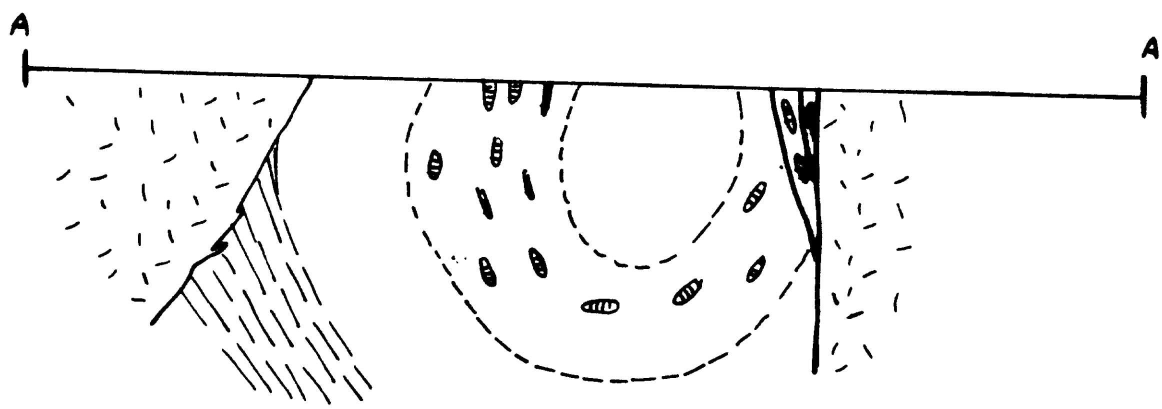


Figure 4. Geologic map and diagrammatic cross-section of north end of Fairview pendant.

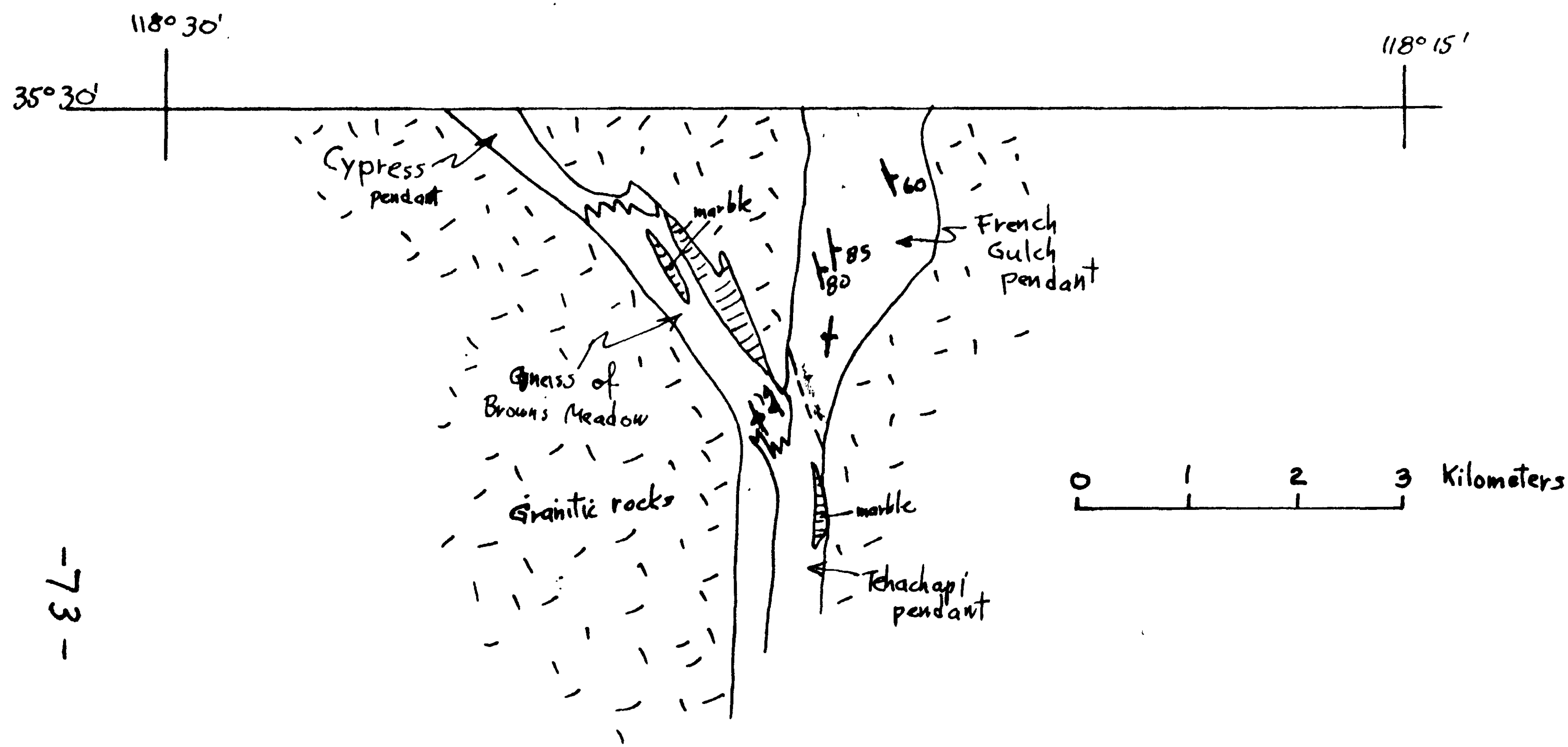


Figure 5. Area of enigmatic contact relations near the south end of the French Gulch pendant.

Table 1. SUMMARY OF LITHOLOGIC AND PETROGRAPHIC CHARACTER OF EACH METAMORPHIC BELT IN THE SOUTHERN SIERRA NEVADA

Rockhouse Basin

Dominantly thin layered, red- to brown-weathering siliceous, argillaceous, and calcareous beds; minor intermediate to felsic metavolcanic rocks. Pure quartzite notably absent. Bedded barite present. Some marble altered to scheelite-bearing tactite.

Big Meadow

Only cursorily examined. Features conspicuous white calc-hornfels beds with green to purple spots that weather out giving distinctive "fish eye beds." Also impure quartzite, biotite quartzofeldspathic schist (containing sillimanite), and minor marble.

Long Canyon

Distinctive "trinity" of lithologies: (1) relatively pure white, red weathering, quartzite, (2) white to gray marble in thick beds, and (3) dark-colored micaceous schist containing andulasite and sillimanite. Also common is gray to green thinly-layered calc-hornfels.

Fairview

Dark, granular to pebbly, virtually unsorted, quartzite in massive to poorly-bedded sequence. Siliceous to micaceous schist also present. Marble abundant only locally. Distinctive, related (?) pendant (French Gulch) contains intermediate to felsic, mostly dark colored metavolcanic rocks, including much ash-flow tuff with strong fluxion structure.

Tehachapi

Thinly layered pure to impure quartzite, mica schist (containing garnet and sillimanite), and somewhat more massive white to gray marble. Calc-hornfels and quartzofeldspathic schist is less common. Pyroclastic beds (mostly crystal and ash flow tuffs) in questionable correlative pendant of this belt.

Pampa Schist

Dark colored, notably micaceous layers, some of which contain conspicuous chiastolite. Clusters of acicular to prismatic sillimanite and much carbonaceous matter also present. Much less common is quartzofeldspathic schist. Some amphibolitic rocks with relict volcanic textures.

Rand Schist

Exotic slivers (horses) in the Garlock and Pastoria fault zones. Thinly layered light- to dark-colored mica schist, and graphitic quartzite (metachert), metavolcanic rocks with conspicuous dark albite augen, and minor serpentinite.

Bean Canyon Formation

Most common are dark siliceous calc-hornfels, micaceous schist (with andalusite), impure to pure quartzite and marble. Felsic to mafic metavolcanic rocks (at least in part crystal tuff) are scattered through most bodies of the formation.

Salt Creek

Most common rock types are (1) marble, in part dolomitic, (2) pure to impure quartzite, and (3) micaceous schist, commonly containing sillimanite. Calc-hornfels and quartzofeldspathic hornfels are less common, but widespread.