FIELDTRIP GUIDE TO THE METAMORPHIC FRAMEWORK ROCKS OF THE LAKE ISABELLA AREA, SOUTHERN SIERRA NEVADA, CALIFORNIA

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INTRODUCTION

Metamorphic framework rocks of the southern Sierra Nevada occur primarily as N to NW striking, steeply dipping septa, within or separating granitoid plutons. The Lake Isabella area offers an excellent opportunity to study some of the interesting structural and stratigraphic problems posed by the southern Sierra framework rocks. Figure 1 is a generalized geologic map of the Lake Isabella region which focuses mainly on the metamorphic framework rocks. The map is derived primarily from our detailed mapping which was based on several earlier field studies. The general distribution of the major igneous and metamorphic units of the region was originally mapped by Miller and Webb (1940) with contributions by Jenkins (1961) and Alvarez (1962). Miller and Webb (1940) termed the distinctive quartz-rich metasedimentary rocks and marble of the region the Kernville series. Detailed mapping immediately adjacent to Lake Isabella by L.E. Weiss (unpublished data) revealed some of the complex deformation patterns in rocks of the Kernville Series, and also led to the discovery of the only fossil locality of the region. In later regional studies Saleeby and others (1978) noted that the Kernville Series and newly discovered silicic metavolcanic rocks of the area were similar to the Kings sequence of the central Sierra as defined by Bateman and Clark (1974). Metamorphic framework rocks referred to as the Kings sequence by these workers consist of quartz-rich metasedimentary strata, marble, local pelite and scattered intervals of silicic metavolcanic rocks forming numerous steeply dipping septa in the central part of the range. Recognizing that regional workers are more familiar with Kings sequence rocks of the central Sierra, Saleeby and others (1978) suggested that Kernville Series rocks be termed Kings sequence, and that such rocks also extend southward from the Lake Isabella area to the southern terminus of the range. Thus the Kings sequence extends for ~300 km along the axis of the Sierra Nevada, and constitutes one of the major framework elements of the range.

The purpose of this fieldtrip is to present an overview of the structure and "stratigraphy" of the Kings sequence in the Lake Isabella area, and to focus attention on four topics of regional interest:

1. All fossil ages reported thus far from the Kings sequence are early Mesozoic in age, mainly Late Triassic to Early Jurassic (Christensen, 1963; Jones and Moore, 1973; Saleeby and others, 1978; Busby-Spera, 1983). Bateman and Clark (1974) and Saleeby and others (1978) suggested that such ages may represent the general age span of all Kings sequence rocks. Based on regional considerations, however, one would expect to find Paleozoic shelfal strata along the axial Sierra Nevada region. Thus far Paleozoic ages are only known from the western metamorphic belt and from roof pendants of the east-central Sierra (Bateman and Clark, 1974; Saleeby, 1979; Sharp and others, 1982). During the fieldtrip we will discuss whether or not any elements of the Kings sequence from the Lake Isabella region may be Paleozoic in age. The early Mesozoic fossil locality is from a very representative part of the "section," and thus significant Paleozoic elements seem unlikely.

2. Silicic to intermediate metavolcanic rocks of the axial and eastern Sierra are generally interpreted as the products of an early Mesozoic Andean arc. Deformation of these rocks is commonly attributed to Late Jurassic orogenesis that distinctly pre-dated the emplacement of the Sierra Nevada batholith. Our field and geochronological studies in the Lake Isabella region show that the metavolcanic rocks of this region were erupted unconformably above largely nonvolcanic Kings sequence strata during the mid-Cretaceous and then deformed in mid- to Late Cretaceous time.

3. The development of pervasive metamorphic tectonite fabrics and isoclinal folds in Sierran metamorphic framework rocks are generally interpreted as regional orogenic deformations that distinctly pre-dated the emplacement of the Sierra Nevada batholith. In this context batholith-related metamorphism has been regarded as a static overprint imparted on the earlier regional fabrics. Our work in the Lake Isabella region shows, however, that metamorphic tectonites developed during batholith emplacement, when steeply-plunging stretching and steeply-dipping flattening fabrics tightened pre-existing folds into isoclinal geometry. One explanation for such deformation patterns is the downward return flow of framework septa dynamically linked to silicic magma ascent (Saleeby and others, 1986).

4. Deformational and metamorphic fabrics related to mid-Cretaceous batholith emplacement and earlier orogenic deformation were transposed into greenschist facies phyllonites and mylonites in Late Cretaceous time along a north-south trending belt inferred to represent the proto-Kern Canyon fault. North of Kernville the phyllonite belt

Saleeby, J., and Busby-Spera, C. J., 1986, Fieldtrip guide to metamorphic framework rocks of the Lake Isabella area, southern Sierra Nevada, California, in Dunne, G. C. (ed.), Mesozoic and Cenozoic Structural Evolution of Selected Areas, East-Central California: Guidebook and Volume, Geol. Soc. America Cordilleran Section Meeting, p. 81-94.

occurs along part of the northern Kern Canyon fault. South of Kernville, the belt continues due south but the modern fault diverges to the west. The Kern Canyon fault is thus divided into northern and southern branches with only the northern branch coinciding with the proto-fault. Mylonitic granitoids dated as Late Cretaceous (~80 Ma) were deformed as they cooled and solidified along the northern branch of the fault thus dating movement on the proto-Kern Canyon fault. The relations between the southern branch of the Kern Canyon fault, the proto-fault, and the southern continuation of the proto-fault (phyllonite belt) are under investigation.

OVERVIEW OF STRATIGRAPHY

Kings Sequence

The main element in the metamorphic framework rocks of the Lake Isabella region is the Kings sequence. This sequence has been broken into two grossly correlative assemblages in Figure 1. The western medium-grade assemblage occurs to the west of the proto-Kern Canyon fault. It is typically high greenschist to amphibolite facies with sillimanite yet to be observed in pelitic members. Andalusite is widespread, and protolith textures and structures are commonly preserved. The second assemblage occurs east of the proto-Kern Canyon fault and is typically in high amphibolite facies with widespread sillimanite and local migmatization. Protolith textures and structures are rarely preserved. Ironically, the one fossil location within the Kings sequence of this region is from the high-grade assemblage. Undifferentiated Kings sequence rocks are shown to the west of the proto-Kern Canyon fault south of Erskine Canyon (Fig. 1). Exposures of these rocks are poor and textural reconstitution by thermal metamorphism is greater than in western assemblage rocks to the north.

The western assemblage is broken into three map units on Figure 1. The stratigraphically lower and upper units each consist of centimeter to meter scale beds of quartz-rich sandstone, grit and pebble conglomerate with psammitic, pelitic and occasional calc-silicate interbeds. The sandstone detritus is overwhelmingly quartzose with monocrystalline grains dominating. Most quartz grains are milky when observed in hand lens with dark cherty-appearing and bluish grains common but not abundant. Plagioclase and lesser K-feldspar are also common detrital components, but definitely subordinate. The local occurrence of plagioclase phyric tuff beds suggest a volcanic origin of the feldspar grains. The source of the coarse quartz detritus could be a silicic plutonic or volcanic terrane, or perhaps a metamorphic terrane with abundant coarse vein quartz or coarsely recrystallized metaquartzite. Ductile deformation and marginal recrystallization make the original nature of the quartz grains difficult to assess.

Well-bedded intervals with features suggestive of turbidite deposition (graded beds, flame structure, amalgamated beds) alternate with intervals containing shallow water features (cross beds, carbonates, thick massive beds). The lower map unit is distinguished from the upper unit by numerous massive and highly recrystallized and veined quartzite beds often as thick as 10 m. A highly contorted and recrystallized marble unit separates the upper and lower units. The marble contains numerous calc-silicate rich horizons and a large amphibolite lens. The amphibolite appears to have been derived from mafic volcanic and hypabyssal rocks. The western assemblage appears to represent a homoclinal sequence which dips steeply to moderately to the south between the Fairview and Kernville areas (Fig. 1). The lower unit occurs only north of Fairview. The upper unit may be imbricated along bedding-parallel thrusts, yielding a structural thickness in excess of 10 km.

The eastern assemblage contains similar quartz-rich rocks but with strong metamorphic tectonite fabrics. The remnants of the thicker quartzite beds are dispersed as dismembered lenses within laminated quartz-mica schist. Marble and amphibolite units are quite similar to those of the western assemblage, but early generally EW structures and deformation fabrics well-preserved in the Fairview-Kernville "section" are completely transposed into NW structures and fabrics. A notable difference in protolith assemblage is a greater volume of pelite in the eastern assemblage. Pelite occurs as a mappable unit which crosses the South Fork of the Kern River, and as a major pelite-psammite unit in the area of fieldtrip Stop 9. In contrast pelite intervals in the western assemblage are not thick enough to show on Figure 1. Gross similarities in marble, amphibolite and quartz-rich units and local preservation of the distinct detrital assemblage of the quartz-rich sandstones, grits and conglomerates form a basis for correlation between the two Kings sequence assemblages. Vestigial blocks of the quartz-rich detrital rocks along with lenses of marble and pelite occur within the phyllonite belt of the proto-Kern Canyon fault, which transposed and retrograded both eastern and western assemblages. Thus high-grade rocks were juxtaposed against medium-grade rocks of the same protolith along the fault.

Erskine Canyon Sequence

Kings sequence rocks of the Erskine Canyon area are unconformably overlain and intruded by mid-Cretaceous sedimentary and volcaniclastic rocks and hypabyssal instrusions called the Erskine Canyon sequence. In Erskine Canyon, a thick sequence of quartzite clast breccias and grits with a silty to calcareous matrix and calc-silicate interbeds unconformably overlies previously deformed marbles and quartzose metasediments of the Kings sequence. The quartzite-clast breccias are in turn overlain by rhyolitic to andesitic volcaniclastics locally admixed with quartzose detritus of Kings sequence provenance. The volcaniclastic rocks include rhyolitic ash-flow tuffs that may extend southward to the Piute Lookout area. The quartzite breccias and volcaniclastic rocks are intruded by penecontemporaneous rhyolitic sills and dikes, which form peperites in the quartzite breccias (see Stop 11). Another felsic hypabyssal intrusion, 4 km by 1 km in size, intrudes western assemblage Kings sequence north of Kernville. Volcaniclastic rocks and hypabyssal intrusions in the phyllonite belt are also included in the Erskine Canyon sequence. Zircon ages on hypabyssal intrusions and ash flow tuffs of the Erskine Canyon sequence indicate a major pulse of volcanism between 105 and 100 Ma.

The mid-Cretaceous Erskine Canyon sequence represents fault-talus breccias and felsic volcanics ponded along a fault scarp intruded by hypabyssal rocks. The Erskine Canyon sequence was then deformed along the phyllonite belt (proto-Kern Canyon fault) in mid- to Late Cretaceous time. The proto-Kern Canyon fault could thus be interpreted as a mid- to Late Cretaceous volcano-tectonic fault zone. The proto-Kern Canyon fault has nearly juxtaposed plutonic rocks intruded into eastern assemblage Kings sequence against coeval extrusive rocks of the Erskine Canyon sequence. The structural relief across the phyllonite belt is therefore 8-10 km, the inferred depth of pluton emplacement into the eastern assemblage (geobarometry from Elan, 1985). The amount of strike slip displacement along the proto-Kern Canyon fault is not yet known in this region.

Cretaceous Plutons

Metamorphic framework rocks of the Lake Isabella region are surrounded by Cretaceous batholithic rocks which range in composition from olivine gabbro to granite. In general batholithic rocks lying west of the Kern Canyon fault are tonalitic in composition and those to the east granodioritic. On a regional scale this relation follows the proto-Kern Canyon fault zone southward from the area of Figure 1 rather than the south branch of the modern fault. Zircon ages from the map area and from the region to the south (Sams and Saleeby, 1986) indicate that the large plutons of the region were emplaced primarily between 100 and 90 Ma, with smaller granitic stocks emplaced as late as ~80 Ma.

In most localities pluton-metamorphic framework contacts are sharp, and grossly concordant. A notable exception is the margin of the pelite-psammite unit south of Stop 10 where a broad zone of migmatite undergoes a mixed and continuous gradation into the adjacent pluton. The plutons commonly show planar deformation fabrics that parallel concordant contacts with framework rocks. Such relations are best developed adjacent to the higher grade eastern assemblage septa.

OVERVIEW OF STRUCTURE

Early stuctures within the Kings Sequence (D1)

Kings sequence rocks south of the Kernville area are characterized by strong NW trending deformation fabrics that developed during high grade metamorphism and batholith emplacement, or by later shear along the proto-Kern Canyon fault. Such structures appear to have transposed an earlier generally EW set of structures and fabrics that are best preserved between Kernville and Fairview. A regional expression of this earlier D1 trend is the moderate to low southerly dips in well-preserved bedding along the highway between Kernville and Fairview. Low-angle intersections between such bedding and a near penetrative spaced to continuous cleavage also reflect the D1 trend. In the Fairview area D1 open to tight folds are observed in the generally EW trending marble belt that crosses the river. Protomylonitic zones within the quartz-rich strata transpose bedding, resulting in a distinct ribbon structure within beds rich in coarse quartz detritus. Such protomylonitic zones have also been observed locally south of the Fairview area and suggest that the generally EW trending section may be imbricated by bedding parallel thrust faults.

Structures and fabrics of D1 are transposed into NNW trending isoclinal folds and steeply plunging linear (± planar) shape fabrics east of Fairview (Fig. 1). The NNW trend is manifest along the west margin of the transposition zone by domainal spaced cleavages which coalesce and intensify eastward into the transposition zone over a distance of less than 1 km. The growth of andalusite and biotite in pelites, and of hornblende and plagioclase in amphibolites as part of the transposition fabric suggests a D2 origin for the zone as defined below. Superposed homoaxial phyllonitic zones and cataclastic deformation immediately adjacent to the north branch of the Kern Canyon fault represent proto-Kern Canyon shearing (D3), and subsequent Kern Canyon faulting.

Between Kernville and the Corral Creek area a strong NNW-trending phyllonitic cleavage (D3) is superimposed across D1 structures. South of Kernville along the north shore of Lake Isabella vestigial blocks of quartz-rich arenites within siliceous phyllonite (D3) locally preserve D1 fabrics (Fig. 2A), and occasional bedding. In the Erskine Canyon area D1 fabrics are well preserved in quartzite clasts of the basal breccia of the Erskine Canyon sequence (Fig. 2B). D1 folds are also marked in marbles of that area by cross-cutting of rhyolitic dikes of the Erskine Canyon sequence. D1 structures were transposed by D2 deformation in the eastern assemblage of the Kings sequence. Pre-D2 folding is suggested however, by complex map patterns exhibited in some of the marble units (Fig. 1).

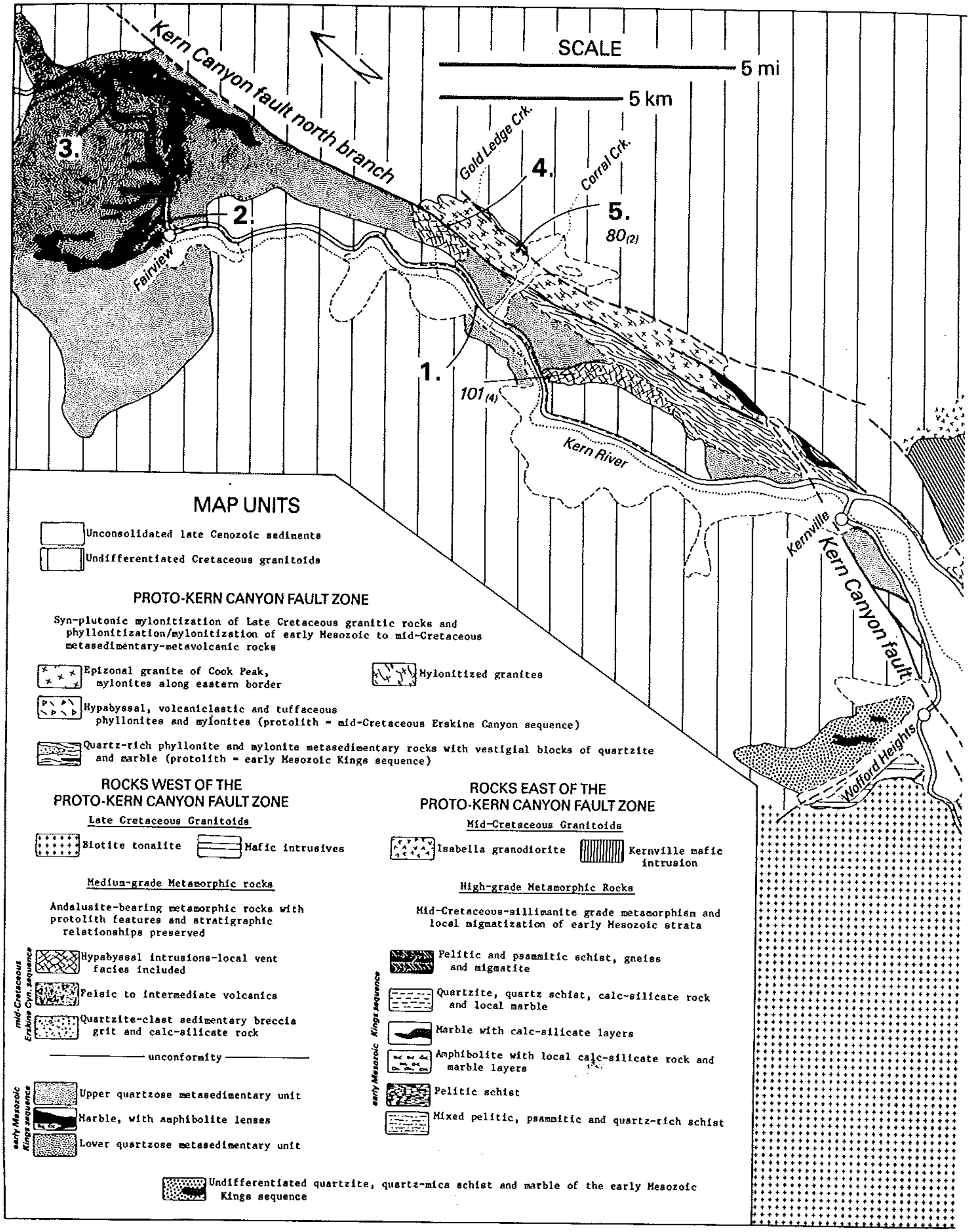
The only age constraints on D1 are that it pre-dates the 105 to 100 Ma sedimentation and igneous activity of the Erskine Canyon sequence, and that it pre-dates the ~100 Ma high grade metamorphism and deformation of D2. There is no evidence for penetrative Jurassic age NW trending structures in the Lake Isabella region.

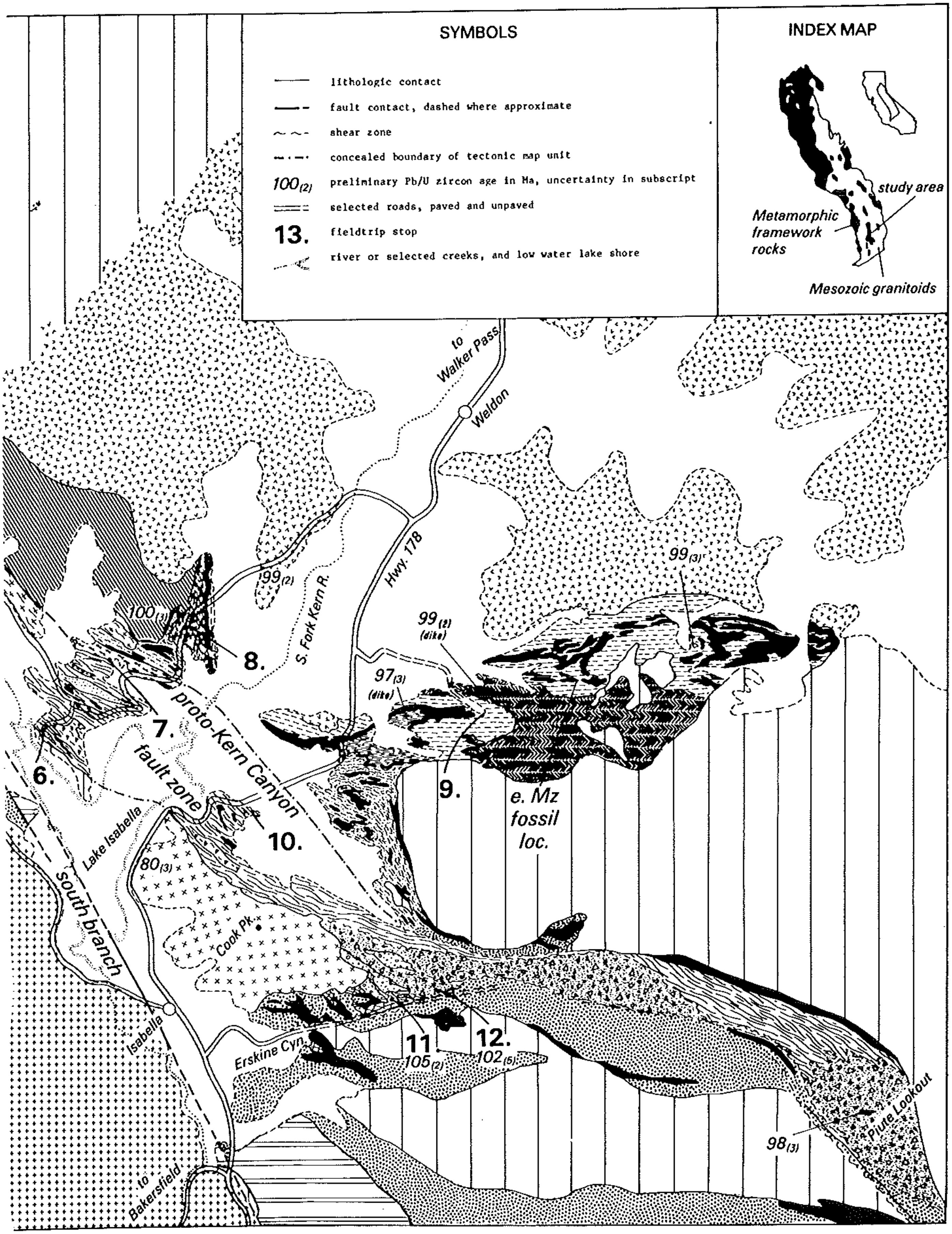
High Grade Metamorphism and Deformation (D2)

Strong schistose and gneissic fabrics transpose all pre-existing fabric elements in Kings sequence rocks east of the proto-Kern Canyon fault. Reclined isoclinal and sheath folds are developed in marble and calc-silicate units. Steeply dipping flattening fabrics are well-developed along attenuated limbs of large folds, and steeply-SE plunging stretching fabrics pervade hinge areas. Flattening fabrics commonly have an associated steeply-plunging linear component as well.

An arcuate belt of marble which crosses the South Fork of the Kern River (Fig. 1) appears to have been strongly attenuated along a west directed "blister" which grew off of the margin of the 99 Ma

Figure 1 (next page): Generalized geologic map of Lake Isabella region based on detailed mapping by J. Saleeby and C. Busby-Spera, and modified after Miller and Webb (1940), Jenkins (1961), Alvarez (1962), Smith (1964) and L.E. Weiss (pers. commun., 1977).


Kern Canyon fault north branch
SCALE
5 mi
5 km
Gold Ledge Crk.
Corral Crk.
3.
2.
4.
5.
80(2)
1.
101(4)
Fairview
Kern River
Kernville
Kern Canyon fault
Wofford Heights
MAP UNITS
Unconsolidated late Cenozoic sediments
Undifferentiated Cretaceous granitoids
PROTO-KERN CANYON FAULT ZONE
Syn-plutonic mylonitization of Late Cretaceous granitic rocks and phyllonitization/mylonitization of early Mesozoic to mid-Cretaceous metasedimentary-metavolcanic rocks
Epizonal granite of Cook Peak, mylonites along eastern border
Mylonitized granites
Hypabyssal, volcaniclastic and tuffaceous phyllonites and mylonites (protolith = mid-Cretaceous Erskine Canyon sequence)
Quartz-rich phyllonite and mylonite metasedimentary rocks with vestigial blocks of quartzite and marble (protolith = early Mesozoic Kings sequence)
ROCKS WEST OF THE PROTO-KERN CANYON FAULT ZONE
Late Cretaceous Granitoids
Biotite tonalite
Mafic intrusives
Medium-grade Metamorphic rocks
Andalusite-bearing metamorphic rocks with protolith features and stratigraphic relationships preserved
mid-Cretaceous Erskine Cyn. sequence
Hypabyssal intrusions-local vent facies included
Felsic to intermediate volcanics
Quartzite-clast sedimentary breccia grit and calc-silicate rock
unconformity
early Mesozoic Kings sequence
Upper quartzose metasedimentary unit
Marble, with amphibolite lenses
Lower quartzose metasedimentary unit
ROCKS EAST OF THE PROTO-KERN CANYON FAULT ZONE
Mid-Cretaceous Granitoids
Isabella granodiorite
Kernville mafic intrusion
High-grade Metamorphic Rocks
Mid-Cretaceous-sillimanite grade metamorphism and local migmatization of early Mesozoic strata
early Mesozoic Kings sequence
Pelitic and psammitic schist, gneiss and migmatite
Quartzite, quartz schist, calc-silicate rock and local marble
Marble with calc-silicate layers
Amphibolite with local calc-silicate rock and marble layers
Pelitic schist
Mixed pelitic, psammitic and quartz-rich schist
Undifferentiated quartzite, quartz-mica schist and marble of the early Mesozoic Kings sequence


SYMBOLS
lithologic contact
fault contact, dashed where approximate
shear zone
concealed boundary of tectonic map unit
100(2) preliminary Pb/U zircon age in Ma, uncertainty in subscript
selected roads, paved and unpaved
13. fieldtrip stop
river or selected creeks, and low water lake shore
INDEX MAP
study area
Metamorphic framework rocks
Mesozoic granitoids
to Walker Pass
Weldon
Hwy. 178
S. Fork Kern R.
99(2)
100(3)
8.
99(2) (dike)
97(3) (dike)
99(3)
proto-Kern Canyon fault zone
7.
6.
9.
e. Mz fossil loc.
10.
Lake Isabella
80(3)
south branch
Cook Pk.
Isabella
11
12.
105(2)
102(5)
Erskine Cyn.
Piute Lookout
98(3)
to Bakersfield

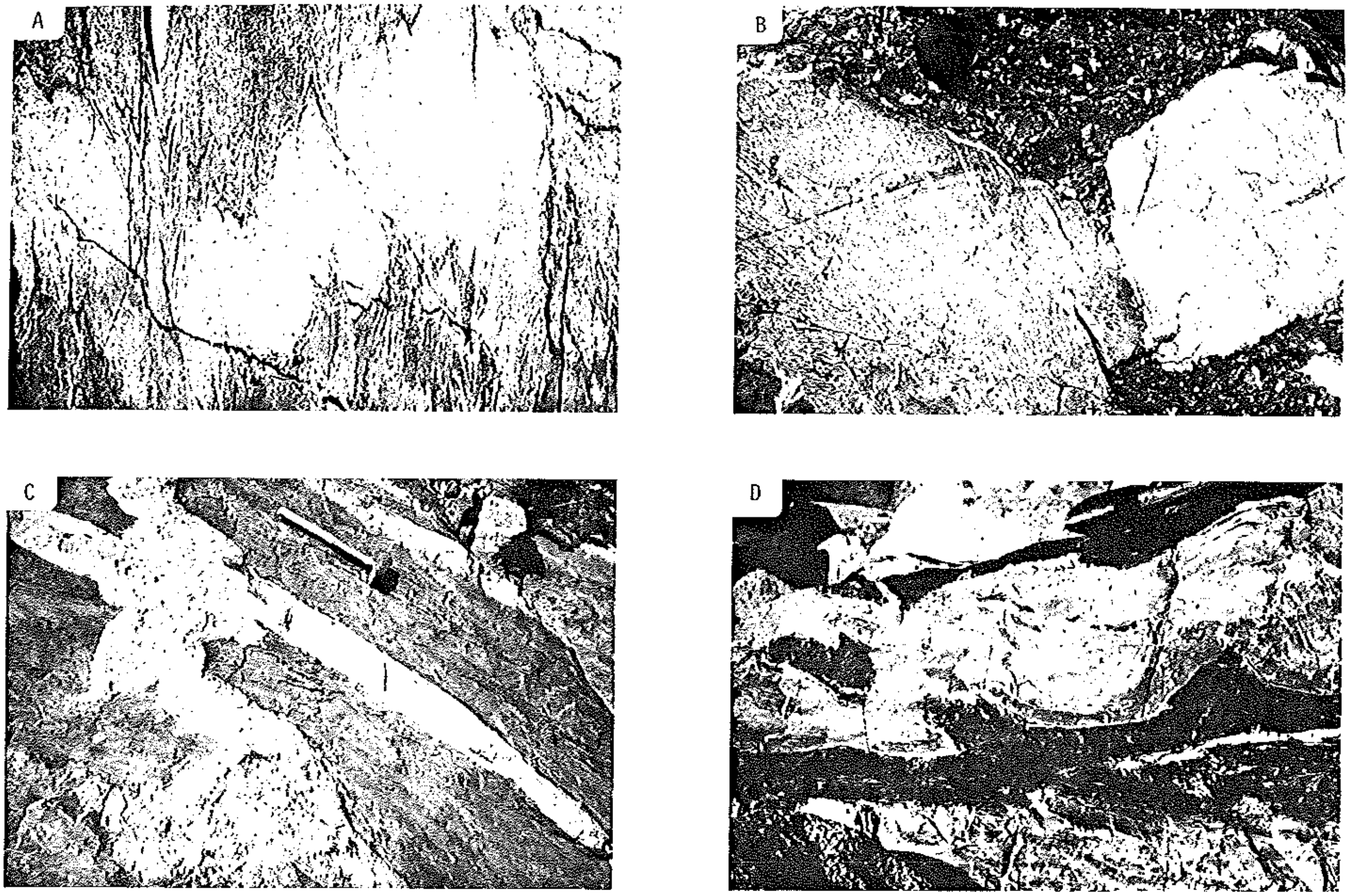


Figure 2. Assortment of field shots. A: Quartz-rich arenite beds with bedding and parallel S1 foliation folded along S3 phyllonitic foliation - north shore near Stop 6. B: Clasts of foliated and veined Kings sequence quartzite within Erskine Canyon sedimentary breccia; note lens cap for scale. C: Deformed dike and sill of ~100 Ma age within eastern assemblage Kings sequence. Dike shows folding along S2 axial surface and sill shows boudinage along S2. D: Flame structures within Kings sequence turbidites of Stop 1.

Isabella granodioritic batholith. Strong flattening fabrics also developed along the southern wall of the ~100 Ma Kernville mafic pluton. Granitoid dikes, sills and cupolas within the metamorphic rocks also show various degrees of deformation with textural and structural relations indicating synplutonic deformation. Concordant tabular bodies are typically boudinaged, and discordant bodies are commonly folded (Fig. 2C). Some cupolas are deformed into steeply-plunging rods. Three small intrusives showing the structural relations noted above yielded zircon ages of between 97 and 99 Ma. Quasi-flexural flow folds developed in migmatites which accompanied the 100 Ma deformation-metamorphic peak. Geobarometric data on metamorphic mineral assemblages which equilibrated during this peak indicate a pressure of 3 kb (Elan, 1985).

The structural and metamorphic style exhibited in the NNW-trending transposition zone east of Fairview is similar to the D2 style, except for the development of andalusite rather than sillimanite and other high temperature phases (garnet, cordierite, orthopyroxene). The Fairview transposition zone may represent a higher crustal-level remnant of D2 deformation preserved across the Kern Canyon fault. Relations preserved in Erskine Canyon indicate substantial structural relief across the proto-Kern Canyon fault and its continuation along the north branch of the modern fault. As discussed above, D3 structures and fabrics of the proto-Kern Canyon fault zone overprint the high grade D2 structures of the eastern assemblage.

The Kern Canyon Fault (D3)

The Kern Canyon fault is a major north-trending right-lateral fault that has been mapped for a distance of 140 km. The northern end of the fault appears to die out in Late Cretaceous batholithic rocks of the east-central Sierra (Moore and duBray, 1978). The southern end may continue along the Breckenridge-White Wolf fault system. Although the White Wolf fault is active (1952 Arvin-Tehachapi earthquake, magnitude 7.7), and the Kern Canyon fault roughly coincides with a broad zone of microseismicity (Allen and Whitcomb, 1980), overlapping basalts of 3.5 Ma age indicate the Kern Canyon fault is not active (Webb, 1946). Moore and duBray (1978) have mapped offsets in Mesozoic (mainly Cretaceous) plutonic rocks of the upper Kern Canyon that suggest a southward increase in right-lateral slip, with up to 13 km of displacement just north of the Figure 1 map area. Reliable slip indicators in or south of the map area have not been recognized.

The Kern Canyon fault has been broken into two branches in the study. The north branch separates Cretaceous granitic rocks from the Kernville-Fairview framework septum. The south branch truncates small remnants of septa, but runs mainly through batholithic rocks. These batholithic rocks, like those studied to the north of the map area by Moore and duBray (1978), show a narrow zone of brittle deformation along the trace of the fault. We present evidence here for Late Cretaceous ductile deformation of granitoids along the north branch of the Kern Canyon fault and its southern extension along the phyllonite belt of the proto-Kern Canyon fault zone. From the north shore of Lake Isabella northward to Gold Ledge Creek (and possibly beyond) we have mapped thin, discontinuous mylonitic granite bodies. These show recrystallization of microcline, suggesting deformation at a relatively high temperature, probably as the granites cooled and solidified. One of the granitic mylonites, named here the Gold Ledge granite (Fig. 1), has yielded a zircon age of 80 Ma.

Kings sequence rocks exposed along the Kern Canyon fault between Kernville and Corral Creek (Fig. 1) contain superimposed phyllonitic cleavage and shear surfaces. The phyllonitic belt is roughly coextensive with the mylonitic granitoids, with both diverging eastward from the modern Kern Canyon fault south of Kernville. The belt of phyllonitic rocks south of Kernville is believed to be the southern branch of the proto-Kern Canyon fault. This belt of rocks in the area of the lake consists primarily of siliceous phyllonites derived from quartz-rich clastic rocks. Lenses of mylonitic quartz sandstone and porphyritic metavolcanic or meta-hypabyssal rock are encased within the siliceous phyllonites along with lenses of phyllonitic metavolcanic - meta-hypabyssal rock and marble. The phyllonitic cleavage is superimposed over high-grade metamorphic fabrics of D2 and, as mentioned above, the cleavage is also observed to overprint D1 structures north of Kernville. The phyllonitic belt runs southward through the Erskine Canyon area where it becomes the main deformation fabric in the Erskine Canyon sequence. This deformation belt continues to the southern end of the Figure 1 map area where it is the main fabric in the Puite Lookout ashflow unit. Additional mylonitic granitoids and deformed Kings sequence rocks continue southward from the Puite Lookout area.

The phyllonite belt and zones of mylonitic granitoids are believed to represent the proto-Kern Canyon fault zone. This zone coincides with the north branch of the fault, but diverges from the south branch. The relative importance of the proto-fault zone versus the modern branches of the system in terms of net slip are unknown. It is clear that the proto-fault zone resulted in a tremendous amount of structural relief between the mid-Cretaceous volcanic and hypabyssal rocks to the west (Erskine Canyon sequence) and coeval plutonic rocks and related high-grade metamorphic derivatives of the Kings sequence to the east.

ROADLOG

The twelve stops planned for the field trip are labeled on Figure 1. Additional helpful maps include the Bakersfield Sheet (1:250,000) of the Geologic Map of California (Smith, 1964), and the Kern County roadmap published by the Automobile Club of Southern California. The road log begins at the eastern edge of the town of Kernville at the "T" intersection of Sierra Way and Kernville Road. Driving north on Sierra Way from the intersection, numerous roadcut exposures of moderate- to low-dipping Kings sequence are passed. These beds represent the upper map unit of the western Kings sequence assemblage. The first stop is at 7.9 mi prior to a relatively sharp right-hand bend in the road. Narrow parking areas are available off the shoulder of the road on both sides.

Stop 1

This stop is intended to provide a sampling of turbidites from the upper quartz-rich map unit of the Kings sequence western assemblage. An upward-thinning and upward-fining sequence of turbidite beds (7 m thick) is well-exposed along the shore of the Kern River here. The thick beds can be classified as Mutti and Ricci-Lucchi turbidite facies A and B, and the thin beds show Bouma divisions a and b. Siliceous argillites cap each bed; these are deformed into flame structures and rip-up clasts by overlying beds (Fig. 2D). This upward-thinning sequence may represent the fill of a deep marine channel. Metasedimentary rocks stratigraphically below these turbidites, between the highway and the Kern Canyon fault, are calcareous quartzites and marbles, with locally preserved medium-scale cross-lamination. These probably represent a shallow marine facies.

The coarse- to medium-grained sandstones at this locality are dominantly composed of monocrystalline and polycrystalline quartz, but subordinate plagioclase and potassium feldspar are present. The fine-grained sandstones are recrystallized to felsite with opaque minerals, sericite and biotite. Dark greenish beds contain concentrations of calc-silicate minerals suggesting an original calcareous cement. In thin section, the monocrystalline quartz grains commonly show marginal recrystallization, with some grains nearly completely recrystallized. Fine-grained quartz also replaces feldspars along cleavage and margins of grains, and there is sericitization of the potassium feldspar. Much of the quartz is strained, and some is ribboned. The recrystallization of the quartz makes it difficult to determine whether or not any grains were originally polycrystalline and of a sedimentary or felsic volcanic source. The presence of plagioclase and potassium feldspar, as well as relict monocrystalline quartz, suggests that the provenance of these sandstones is at least in part igneous.

A moderately well-developed cleavage lies subparallel to bedding at this locality (N40W, 25 SW). In thin section this structure is seen to be primarily a solution cleavage. The cleavage is crenulated by a vertical, N20W cleavage (barely visible here) that becomes progressively stronger toward the Kern Canyon Fault to the east.

Return to vehicles and continue north. At 15 mi (from original intersection) Fairview Forest Service Campground is reached. Pull off in overflow parking area on northwest side of road.

Stop 2

This stop is intended to serve as an overview and discussion of the Fairview area Kings sequence and to prepare observers for the drive through the steep canyon walls leading to Stop 3. Looking northwestward across the Kern River excellent exposures of generally EW trending marble and quartzite can be observed. The orientation of these beds is controlled by D1 structures. Looking northeastward some complex contact patterns can be seen in thick marble beds. Many of the complex patterns are too small-scale to show on Figure 1. The patterns result from the interference of D1 and D2(?) structures. As noted above the D1 structures of this region are transposed by NNW trending structures believed to be D2, but the transposition structures could possibly be related to D3. The actual transposition zone is out of view from Stop 2.

Continuing northward another 2.7 mi (total = 17.7 mi) a sharp right hand bend in the road and river is encountered and then a left hand bend. Stop 3 is planned for the area between the two bends; however, parking may be difficult off the right side of the road. It is suggested that you drive another 0.6 mi to Limestone Forest Service Camp and turn around. Driving southward abundant parking is available just prior to the first bend or at the second bend.

Stop 3

This stop is intended to provide a sampling of the lower quartz-rich unit of the western assemblage. Excellent exposures are present along the shore of the river and in the adjacent road cut. Looking across the river one can assess the bedded nature of this unit with the distinct NW-trending ridges forming the sharp bends in the river due to resistant thick recrystallized quartzite beds. The thick beds are virtually 100 percent quartz. Darker and thinner quartz-rich and more argillaceous beds constitute much of the section here. The compositions of the sands are overwhelmingly quartzose with a dominance of monocrystalline grains. Most grains are strained and many have recrystallized margins. Dark and maroon impurities in the sandstone beds and in finer-grained interbeds are dominated by biotite + muscovite ± minor calc silicate minerals. Detrital plagioclase occurs as a minor component. A 1 m thick plagioclase phyric felsic tuff bed in this section lies on the west side of the river. Excellent preservation of detrital textures can be observed along stream-polished exposures on the southeast side of the river.

Sedimentary facing indicators are present in the polished stream exposures on the northwest side of the river. These include graded and amalgamated beds with scoured bases and current ripples, all indicating a southward facing direction. Many of the thinner beds (<1 m) of this unit exhibit features suggestive of turbidite deposition much like strata of Stop 1. The thick, massive quartzite interbeds are somewhat of an enigma becuase they appear to be purer in quartz detritus. Perhaps they represent grain flow deposits shed into the turbidite sequence from a slightly different source area.

Cleavage surfaces are developed mainly in argillaceous interbeds. The orientation of most of these surfaces is that typical of D2. However, a clear overprint pattern has not been observed in the area of Stop 3, and the cleavages may be rotated D1 structures.

Return to vehicle and continue driving south for 5.5 mi. Turn left on dirt road ("Bryn Canyon"). The turn is about 100 yards north of Gold Ledge Forest Service Campground, if it is missed on the first pass. The unpaved road runs parallel to the highway; after a short distance it curves east. Continue 0.5 mi to where two roads (5A and 5B) branch off to the left and take the second one (5B). Continue to the end of the road (0.3 mi) and park. A small trail continues east from the right side of the flume about two hundred yards to the north-south creek along the Kern Canyon fault. Walk south along the creek.

Stop 4

This stop focuses on the Kern Canyon fault and evidence of a Late Cretaceous component of movement. Here, a hypabyssal intrusion (mapped as metamorphic rocks on the Bakersfield sheet) lies west of the Kern Canyon fault, and the Gold Ledge mylonitic granite lies to the east. The hypabyssal intrusion has a patchy porphyritic texture with plagioclase phenocrysts set in a dark green microcrystalline groundmass. Mafic dikes are common. Within several meters of the fault, the hypabyssal intrusion is cut by many interconnected fracture planes. A crush-breccia zone ~10 m wide marks the trace of the fault and includes three rock types: the hypabyssal intrusion, the Gold Ledge granite, and small pods of metasedimentary rock.

Along the east margin of the crush zone, we will examine ultramylonitic textures in the Gold Ledge granite. There has been severe grain size reduction, recrystallization of potassium feldspar as well as quartz, and mafic minerals are destroyed. As one traverses eastward away from the fault, the grain size gradually becomes coarser, the recrystallization and realignment of potassium feldspar decreases, and biotite is progressively better preserved. At other localities, to the south (Fig. 3A), folded, strongly foliated and partially recrystallized felsic dikes lie within 20 m of the fault. Ductile deformation of the Gold Ledge mylonitic granite provides evidence for movement of the proto-Kern Canyon fault as the pluton cooled and solidified. Zircon ages on the granite indicate intrusion and fault movement of ~80 Ma.

Note: The granite float with the K-spar megacrysts is from the pluton that cross-cuts, locally engulfs and, to the north, obliterates the mylonitized Gold Ledge granite (Fig. 1). This granite is cut by the narrow crush-breccia zone but is not mylonitized. Geochronological work is in progress on the cross-cutting granite.

Return to Sierra Way and turn south (left) and continue back towards Kernville. At 2.5 mi from the return point onto the paved road, leave the highway by turning left onto an unpaved road to the

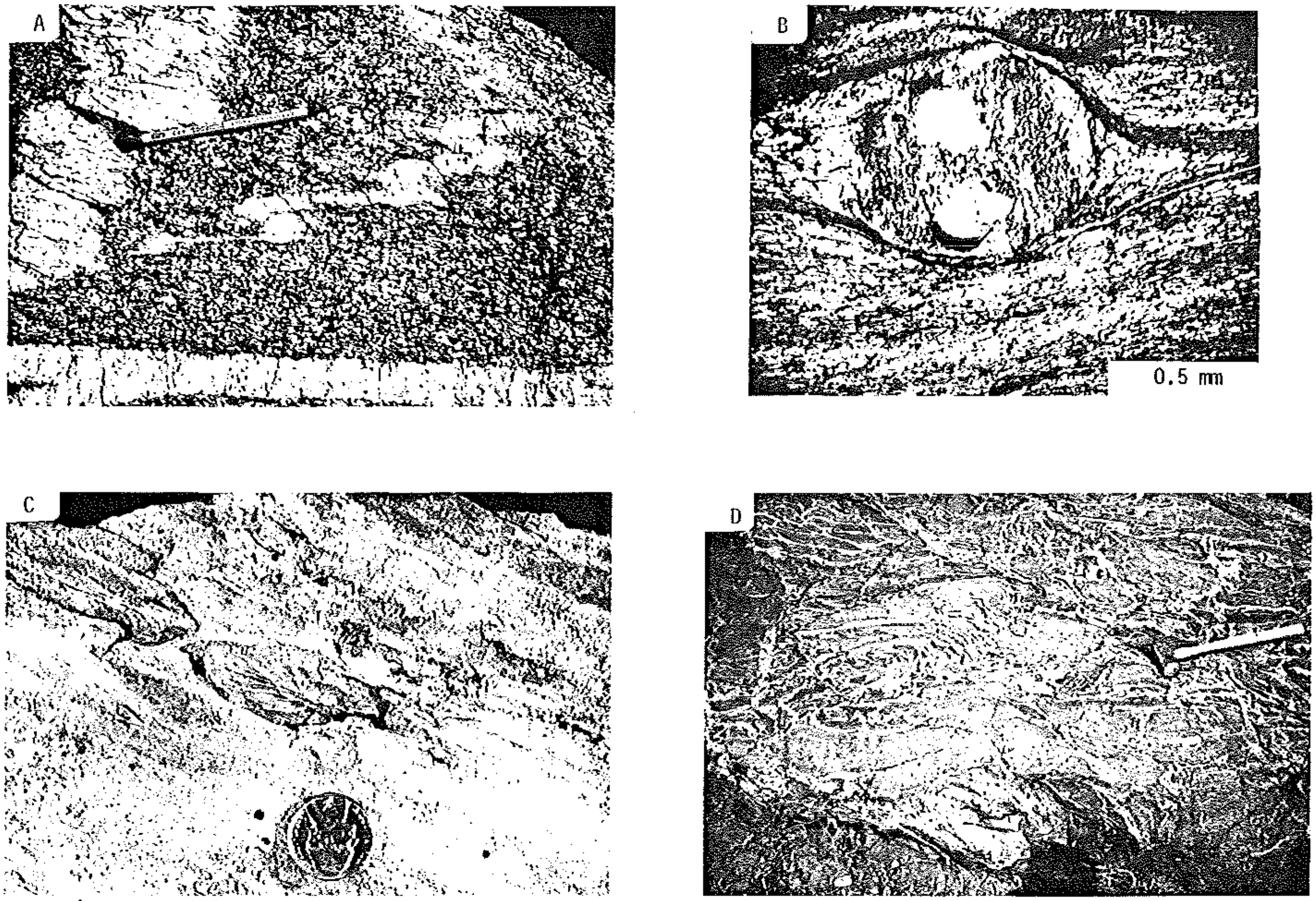


Figure 3. Assortment of field shots and photomicrograph. A: Folded and mylonitized felsic dikes within Gold Ledge mylonitic granite. B: Photomicrograph of relict and andalusite porphyroblasts set as partially retrograded porphyroclast within pelitic phyllonite, crossed nicols. C: Distorted bivalves from Kings sequence preserved on cleavage surface. D: Deformed migmatite from pelitic-psammitic unit of eastern assemblage of Kings sequence.

east that runs parallel to the highway for 0.4 mi. Continue east 0.8 mi more (past road cut in metasedimentary rocks) and take the left fork across Corral Creek (0.2 mi) to the right fork that continues up the north side of the creek. Go 0.3 mi and park; walk down to the creek and cross the small bridge.

Stop 5

This is a very accessible place to view the Gold Ledge granite at a distance of 0.5 km from the Kern Canyon fault. Although a foliation is defined by alignment of quartz, feldspars and biotite, there is no grain size reduction of feldspars, or alteration of mafic minerals, except along thin (cm-scale), spaced zones of mylonitic shear. Felsic dikes are generally sub-parallel to the foliation and none are folded. Schlieren are well-preserved and are also oriented parallel to foliation. The 80 Ma U-Pb zircon age sample was collected here. This relatively undeformed granite can be walked, with continuous exposure, through progressively greater degrees of mylonitization toward the Kern Canyon Fault at this and numerous other localities.

In this area, a long thin belt of metasedimentary rock lies in fault contact with the eastern boundary of the Gold Ledge granite; these in turn are intruded on the east by the granite that truncates the Gold Ledge granite north of Gold Ledge Creek (Fig. 1) The calc-silicates that make up this small pendant are thoroughly mylonitized.

Return to Sierra Way, turn left (south) and go back into the town of Kernville. At the "T" intersection of Sierra Way and Kernville Road begin logging the mileage as you continue south on Sierra Way. At 4.7 mi turn right on paved road that leads down to the lake. At about 0.6 mi park on either side of the road.

Stop 6

This stop focuses on vestigial blocks of quartz-rich sandstone and volcanic or hypabyssal rock within the phyllonite unit. The phyllonite matrix is only locally exposed in this area, but roadcuts between Stops 6 and 7 and outcrops at Stop 10 offer excellent exposures for examination. Time permitting, we will hike to the top of hill 3066, the high rounded hill to the south of the road.

Upon walking up the north slope, numerous outcrops of deformed quartz-rich rocks are encountered. Varieties include: 1) knobby outcrops with well-preserved detrital textures, some with distinct blue quartz grains; 2) felsic mylonite with flat-lying lineations; 3) bedded sandstone with steeply-plunging tight folds; and 4) blocks of bedded sandstone with EW bedding and cleavage (D1) attitudes crossed by NNW D3 cleavage surfaces. At the top of the hill, a well-exposed quartz sandstone block shows remnants of a D1 fabric cut by spaced D3 cleavage surfaces. Traversing down to the northeast towards the gully, fragments of mylonitic porphyritic felsite are encountered. Strong deformation in this area makes it impossible to resolve a volcanic versus hypabyssal origin for the felsites.

Return to vehicles and drive back to intersection with Sierra Way. Turn right (south) and continue driving through the phyllonite belt. The sharp point at about 1.4 mi is the terminus of a large vestigial slab of Kings sequence quartzites, similar to rocks at and in the vicinity of Stop 1. The slab forms the major resistant NNW-trending ridge north of the road. At 1.7 mi turn left (north) onto the unpaved road that heads up an alluviated drainage area. Go through gate and leave it as it was found. Drive 1.1 mi to sharp switchback and park.

Stop 7

At this stop we will traverse from the margin of a large amphibolite unit of the high-grade eastern assemblage westward into the phyllonite zone. The amphibolite constitutes the single largest mafic metamorphic body within the area of Figure 1. It is typically a dense, dark, moderately banded plagioclase + green hornblende ± diopside ± quartz ± calcite rock with local thin layers of marble and calc-silicate rock. Coarse crystalloblastic textures developed during the main foliation forming event (D2), along with steeply-plunging, tight, commonly intra-folial folds. Continuity of fabrics and structures with those of Stop 8, and similar spatial relations between amphibolite lenses of the south shore and features of Stop 9, indicate a D2 origin for the amphibolite fabric and related structures. The east margin of the large amphibolite unit is in contact with marble and with pelitic to quartz-rich schist. The overall massive character of the amphibolite, in conjunction with little evidence of reaction with neighboring metasedimentary rocks, suggests an igneous versus metasomatized sedimentary origin for the amphibolite. Local layers of marble and calc-silicate rock suggest a bedded protolith sequence with a volcanic origin for the mafic rocks. Local lenses of similar amphibolite but with relict hypabyssal textures occur in metasedimentary units to the east. They may represent shallow-level intrusives related to the metabasalt protolith of the larger amphibolite unit. The amphibolite unit in the Fairview area (western assemblage) contains both hypabyssal and volcanic protolith features as well.

Traversing westward from the interior of the amphibolite unit, a homoaxial ductile deformation fabric reduces the coarse crystalloblastic fabric to a protomylonitic to phyllonitic fabric with retrograde growth of biotite and chlorite. This superposed fabric is present primarily along the southwest margin of the amphibolite and is related to D3 fabric development in the adjacent phyllonite belt. The amphibolite is bounded on the southwest by pelitic to psammitic phyllonitic rocks. A conspicuous white metaquartzite lens runs along much of the contact. Quartz grains within the lens show extreme ductile deformation and marginal recrystallization. Traversing up the unpaved road from the quartzite a couple of marble lenses within the phyllonite can be seen. Throughout the phyllonite unit such marble lenses have fabrics showing ductile deformation and grain size reduction of previously coarsely recrystallized calcite (D3 overprinting D2). Farther up the road, relict andalusite porphyroblasts in phyllonitic pelitic rocks occur as retrograded porphyroclasts (Fig. 3B). This is again related to a D3 overprint on D2 metamorphic fabrics.

Return to vehicles and drive back out to the paved road. Turn left (east) and continue for 1.8 mi and then park at broad turnout on right.

Stop 8

This stop presents some of the high grade metamorphic and plutonic features associated with the D2 event. From the parking area walk up the small hill just to the right of the road. Within about 100 yards you will encounter coarsely recrystallized banded pelitic granofels with deep red garnet porphyroblasts. The mineralogy of this rock is garnet + biotite + sillimanite + cordierite + plagioclase + K-feldspar + quartz. Granofelsic or migmatitic fabrics occur in the pelites within about 50 m of the contact with the mid-Cretaceous tonalite-gabbro Kernville pluton. Contact metamorphic textures are typically strongly schistose, however. Cordierite and K-feldspar are lost and andalusite coexists with sillimanite 1 km to the west just along the east side of the amphibolite unit.

Looking northward across the road one can easily spot the Kernville pluton (named by Miller and Webb, 1940). The core phase of the pluton consists of hornblende leucogabbro and pyroxene-hornblende gabbro. The outer phase grades between hypersthene quartz diorite and granodiorite with tonalite predominating. Zircon ages of 100 ± 3 Ma have been obtained on tonalitic and quartz dioritic phases. Across the road one can also see a tightly folded marble which occurs as an infold of the metasediments in the edge of the pluton. The contact between the pelite and a mixed pelitic, psammitic and quartz schist unit to the west also shows the geometry of the infold. Looking due west towards the point that terminates the south-trending hilly ridge against the lake, isoclinally folded marble layers are visible as light grey streaks. Relationships between metamorphic textures and fold structures of the marble show that much of the strain is linked to the metamorphic peak.

Next, carefully drop down into the roadcut watching closely for cars and trucks. Just above the roadcut you will have crossed a poorly exposed contact between the pelite and the Kernville pluton. Within the roadcuts, excellent exposures of xenolith-rich tonalite can be observed. The xenoliths were derived from pelitic and psammitic schist of the wallrocks. Contamination of the mafic to tonalitic magma with such wallrock fragments has resulted in a significant component of mid-Proterozoic zircon within the pluton. The Kernville pluton appears to represent the early phases of a major plutonic pulse which resulted in the emplacement of the granodiorite of Isabella, a probable batholith-scale pluton located to the east. A major westward projecting "blister" on the edge of the Isabella body has severely deformed the framework rocks as can be seen by the attenuated arcuate marble belt which projects across the lake (Fig. 1). This granodiorite "blister" has yielded a 99 ± 2 Ma zircon age.

Structural and textural relations demonstrate a deformational-metamorphic peak during the emplacement of the Kernville and Isabella plutons (100 Ma). Elan (1985) has conducted geobarometric studies on pelitic assemblages from the area of Stop 3 which suggest equilibration at $P_T = 3 \pm 0.5$ kb. Such a pressure corresponds to a depth of 9 ± 2 km. As discussed earlier and at Stops 11 and 12, 105 to 100 Ma volcanic and hypabyssal rocks were built above Kings sequence rocks just a few kilometers to the west across the phyllonite belt (proto-Kern Canyon fault) during this 9 ± 2 km deep metamorphic-deformational event.

Return to vehicles and continue driving east on Sierra Way. After about 5 mi Sierra Way ends at California Highway 178. Turn right (west) on Highway 178. At about 2 mi turn left on Navaho, a paved road with a fire station on its right hand side. Continue for 0.3 mi and then turn right on the Collins unpaved road. At about 1.7 mi be sure you are driving carefully when you pass the Collins residence. Continue up and veer to the right up the east side of the canyon. At about 3 mi up from the Collins turnoff the road ends. Park off of dry grass and hike westward down into the gully.

Stop 9

This stop focuses on the "stratigraphic" setting of the early Mesozoic fossils within the Kings sequence of the Lake Isabella area, and on some of the high grade metamorphic features of the eastern assemblage. As you walk across the gully, you will see exposures of steeply-lineated and folded, thinly-banded quartzite and quartz mica schist. This location is in the hinge area of a large steep SE plunging D2 antiform that can be seen in the map patterns of the marble-quartzite and quartz schist-pelite and psammite units on Figure 1. As you walk southwestward out of the gully and up the gentle slope you can observe the termination of the large marble fold nose.

Within the quartzite-schist unit local stretched quartzite pebble conglomerates and grits can be observed. Of special interest in this area are siliceous calc-silicate layers which weather out as relatively bold outcrops. The siliceous calc-silicates consist of quartz with various combinations of calc-silicate minerals including plagioclase, Ca-amphibole, epidote and diopside. These distinctive rocks were derived from calcareous quartz sandstones. About 2 mi to the southeast similar rocks in the same map unit yielded early Mesozoic bivalves. Due to time constraints we will not be able to hike to the fossil location. However, map and petrographic features suggest that stop 9 is within the same stratigraphic sequence as the fossil-bearing rocks. Small reddish-brown to deep green wisps in the siliceous calc-silicate rocks of stop 9 are identical to the transposed mineralogical remnants of fossils observed at the fossil location. Look closely at cleavage surfaces; fossils may yet be found at this location.

The original fossil collection was made by L.E. Weiss. J.W. Durham (pers. commun., 1977) identified the bivalves as Late Triassic to Early Jurassic in age. Later study by D.L. Jones (pers. commun., 1977) indicated an Early Jurassic age. Where preserved, the fossils occur in the hinge area of a tight D2 fold. They are typically distorted along the axial plane foliation surface (Fig. 3C). At the fossil location thin marble beds are interlayered and folded with the fossiliferous siliceous calc-silicate beds. The point stressed here is that the early Mesozoic fossils are from quartz-rich strata of one of the main map units of the Kings sequence.

Traversing southward up the slope, float derived from the pelite-psammite unit that forms the envelope of the large antiform is encountered. We will continue traversing up the slope and across the non-exposed contact with the pelite unit. The pelite-psammite unit consists primarily of biotite + sillimanite (± andalusite) ± cordierite + K-feldspar + plagioclase + quartz schist and gneiss. Partial melt features are present along D2 foliation surfaces (Fig. 3D) and in tension gashes that are transposed into the D2 fabric to various degrees. Partial melt products are typically biotite granite in composition. As discussed above, structural relations of the migmatitic rocks indicate partial melting during D2. Geochronological work is in progress on the migmatites and on the adjacent batholithic rocks to the south. Zircon ages on three deformed dikes from the septum of Stop 9 indicate peak deformation at 100 Ma, as at the north shore near Stop 8.

Hiking eastward across the slope we will drop into the steep gully where the gradational contact between the pelite-psammite unit and the quartzite-schist unit can be observed. The contact consists of a mixed gradation of dark micaceous and quartz-rich beds over a 50 m interval. Local marble lenses also occur within the gradation zone.

If time permits we will hike eastward up into the pelite-psammite unit again to the hilly ridge top. The ridge top offers an excellent view of complexly folded marble and adjacent quartz-rich units to the east and the large marble fold nose to the west. Looking northward, the long attenuated limb of the marble fold can be seen running northward across the lake to the north shore near Stop 8. Hike back down to vehicle and drive back out to Highway 178. Drive about 3 mi west to the Kissack Cove recreation area. Park as close to the highway as is possible.

Stop 10

Stop 10 may be optional due to the fact that permission to take a large group into the fenced area is still pending. Carefully walk southward across the highway and through the barb-wire fence to the south of the highway. Climb up to the east end of the low hilly ridge with the jagged outcrops.

This stop offers some of the freshest

exposures of the matrix material for the phyllonite belt yet discovered. Here the steeply-dipping D3 planar fabric of the phyllonite produces tombstone-like exposures. The phyllonite consists of fragmented and ductilely-deformed quartz grains showing marginal recrystallization of porphyroclasts and widespread recrystallization of fine matrix material. The dark color of the rock results from fine granulation of biotite and, locally, aluminosilicates that developed during the D2 metamorphic peak. White mica and, locally, chlorite are observed as retrograde phases growing along the D3 fabric. Steeply-plunging dextral sense kink folds are superimposed over the D3 phyllonitic fabric. Such kink folds are also mapped in marble layers which occur within the phyllonite. Most of the phyllonite appears to have been derived from the quartz-rich and pelitic rocks of the Kings sequence. However, lenses of porphyritic felsic to intermediate meta-igneous rock occur in the Stop 10 area as in the north shore (Stop 6).

Looking westward from Stop 10 the east margin of the ~80 Ma Cook Peak granitic pluton can be observed. This pluton represents an epizonal intrusion that was emplaced along the proto-Kern Canyon fault zone during its movement history. The pluton's eastern contact with the phyllonite belt is in some places a thin mylonite zone, and elsewhere a brittle shear zone. Brittle shear zones also overprint the D3 fabric in numerous locations throughout the phyllonite belt.

Return to vehicles and continue driving westward on Highway 178. After about 4 mi you will enter the town of Isabella. Drive southward on Lake Isabella Blvd., the main street through town. From the center of town, the Kernville Rd.-Lake Isabella Blvd. intersection, drive 0.8 mi south and then turn left (southeast) on Erskine Creek Rd. Drive 4.5 mi and then park in clearing on south side of road past ruins of an old building.

Stop 11

This stop focuses on quartzite clast sedimentary breccia and grit, calc-silicate rocks, and penecontemporaneous hypabyssal intrusives of the Erskine Canyon sequence. Walk northward across Erskine Creek and enter the mouth of the sharp canyon cut into the steep south-facing slope. As you cross the creek you may notice a large rhyolitic float block with remnants of peperite. This stop will consist of a traverse up the steep canyon as far as possible and then out of the canyon westward across a steep talus slope. Along the steep slopes the remnants of an unconformity between the basal breccias of the Erskine Canyon sequence and the underlying Kings sequence can be observed. In most places the unconformity is obliterated by hypabyssal intrusions of the Erskine Canyon sequence.

The quartzite-clast breccias of the Erskine Canyon Sequence have angular to subrounded clasts of quartzite (with folded cleavage) and vein quartz, up to 70 cm in size, supported in a meta-argillite (quartz, biotite and garnet) or meta-calcareous mudstone matrix. Stratification is generally lacking or very crudely developed; however, the occasional graded bed or sets of graded beds with scoured bases provide evidence that: 1) the section is upright (N40-50W, 45NE) and 2) deposition was subaqueous (lacustrine or marine). The coarseness and angularity of the debris, as well as the restricted clast types, suggests accumulation at the base of a fault scarp. Penecontemporaneous rhyolite volcanism provides evidence that this basin was a volcano-tectonic depression.

The quartzite-clast debris deposits, and interstratified argillites and calcareous mudstones, form the host sediment for well-developed peperites on the margins of rhyolite sills and dikes in Erskine Canyon. Peperite is defined as the product of interaction between magma and wet sediment. Wet, unlithified sediment and pressures of less than 200 bars (that is, a maximum of 1 km of sediment or 2 km of water column) are required to form peperites (Kokelaar, 1982). Thus, recognition of peperite is important for demonstrating contemporaneity of volcanism and sedimentation. Zircon ages on the peperitic rhyolite sills in Erskine Canyon are 105 ± 2 Ma, and the host quartzite-clast breccias must be of similar age. Furthermore, zircon ages of 102 ± 5 Ma have been determined on ash-flow tuff that lies stratigraphically above the quartzite clast breccia (Stop 12).

Textures of peperites can be used to infer the degree of lithification of the host sediment at the time of intrusion. Brooks and others (1982) proposed the following progression with increasing wetness of environment: (1) injection of rigid sedimentary clasts into the magma, (2) injection of fluidal sediment into shrinkage fractures and between jig-saw pieces formed by thermal contraction of the magma ("quiet fragmentation"), (3) dispersal of magma into sediment by steam explosions, (4) globulation (formation of very irregular, complex forms by deformation of plastic masses of magma) followed by granulation (through shrinkage cracking) and (5) formation of small pillow-like masses with infragmented margins. Numbers (3) through (5) dominate the peperites in Erskine Canyon, with (2) locally present. Number (3) results in unsorted volcanic fragments supported in the host sediment; sharply pointed fragile corners and smoothly curved (conchoidally fractured) surfaces are formed by shrinkage cracking during rapid cooling (Fig. 4A). The fluidal behavior of magma required for (4) and (5) (Fig. 4B) is possible in rhyolite magmas if steam enters the magma to reduce its viscosity.

Our traverse up the steep canyon will begin in the rhyolite hypabyssal intrusion in Erskine Canyon which locally contains irregular masses of andesite apparently mixed during intrusion by magma mixing. Traversing up the steep canyon and across the talus slope, peperites and sedimentary host rocks are encountered along with the white massive rhyolitic intrusives. Traversing westward and down off the talus slope the intruded unconformity is crossed where marble and quartz-rich schist of the Kings sequence are exposed.

Return to vehicle and continue driving southeast on Erskine Creek Rd. After an additional 1.2 mi park in clearing near switchback which starts up south facing slope east of steep canyon (Spring Gulch). Walk up jeep trail that follows south end of Spring Gulch.

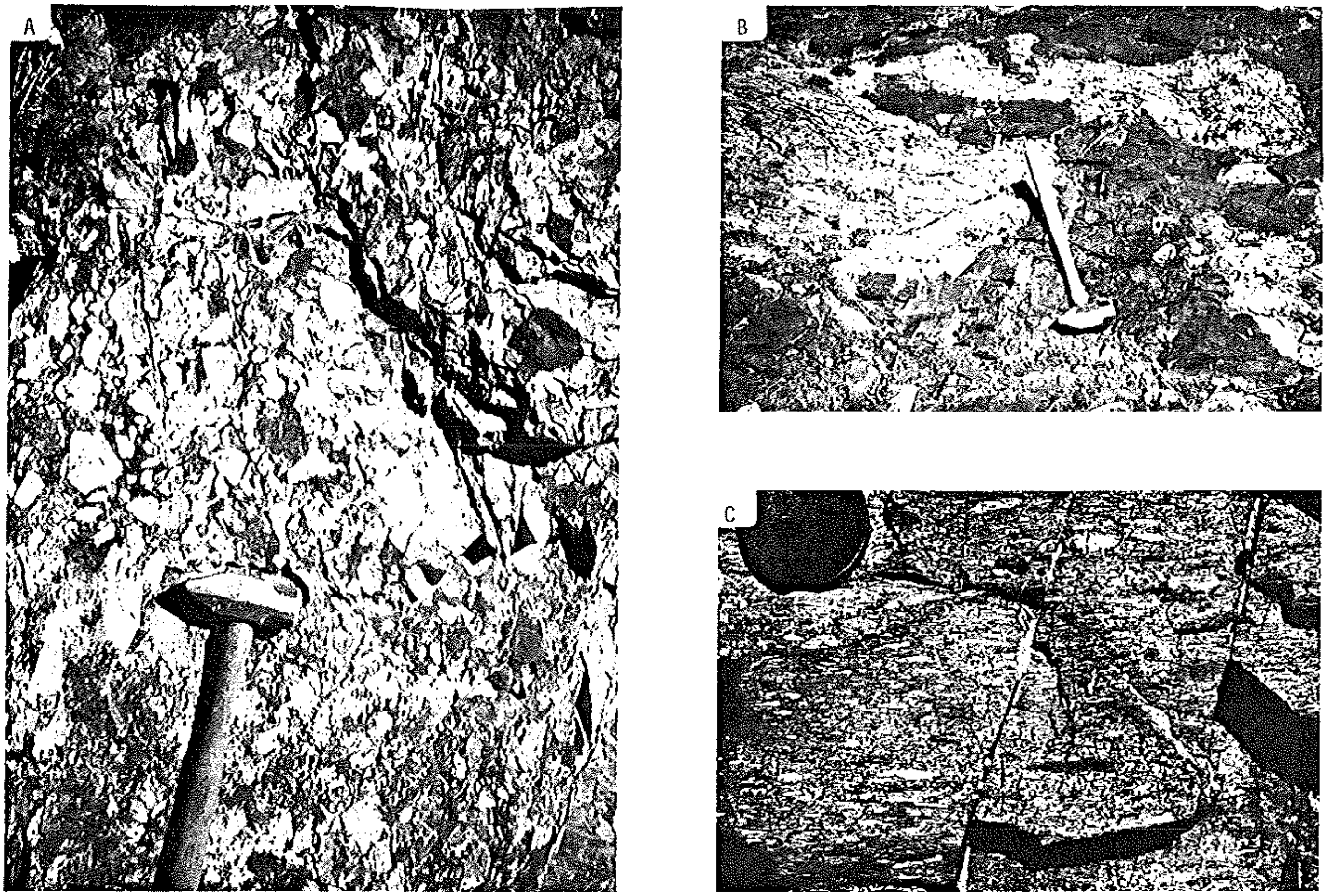


Figure 4. Field shots from the Erskine Canyon sequence. A: Peperite showing angular and conchoidally fractured rhyolite clasts within silty and calc-silicate matrix. B: Peperite showing injection of rhyolitic magma globs into soft sediment. C: Ash flow tuff of Stop 12 showing D3 flattening of pumice lapilli.

Stop 12

This stop offers a glimpse of the felsic volcanic section which appears to overlie the quartzite clast breccia. A mixed felsic to intermediate volcanic and sedimentary section lies above the breccia, and is in turn overlain by rhyolitic ash flow tuff. The base of the ash-flow tuff is encountered about 100 yards up the jeep trail. The ash flow shows the effects of D3 fabric development which northward and eastward disrupt the volcanic section and tectonically mix it with siliceous phyllonites of the Kings sequence basement. In the ashflow tuff deformed relict pumice lapilli and quartz and feldspar phenocrysts can be observed. A zircon date of 102 ± 5 Ma was obtained at this locality. The ashflows may continue for up to 15 km southward where in the Piute Lookout area a 98 ± 3 Ma zircon age was determined.

Return to vehicles and drive back out of Erskine Creek Road. A freeway onramp onto Highway 178 can be entered about 0.5 mi west along the Kernville Road from Lake Isabella Blvd. Southwest on the highway leads to the San Joaquin Valley, northeast leads to the southern Owens Valley.

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