BEDROCK GEOLOGIC MAP OF THE EL PASO MOUNTAINS IN THE GARLOCK AND EL PASO PEAKS 7-1/2' QUADRANGLES, KERN COUNTY, CALIFORNIA

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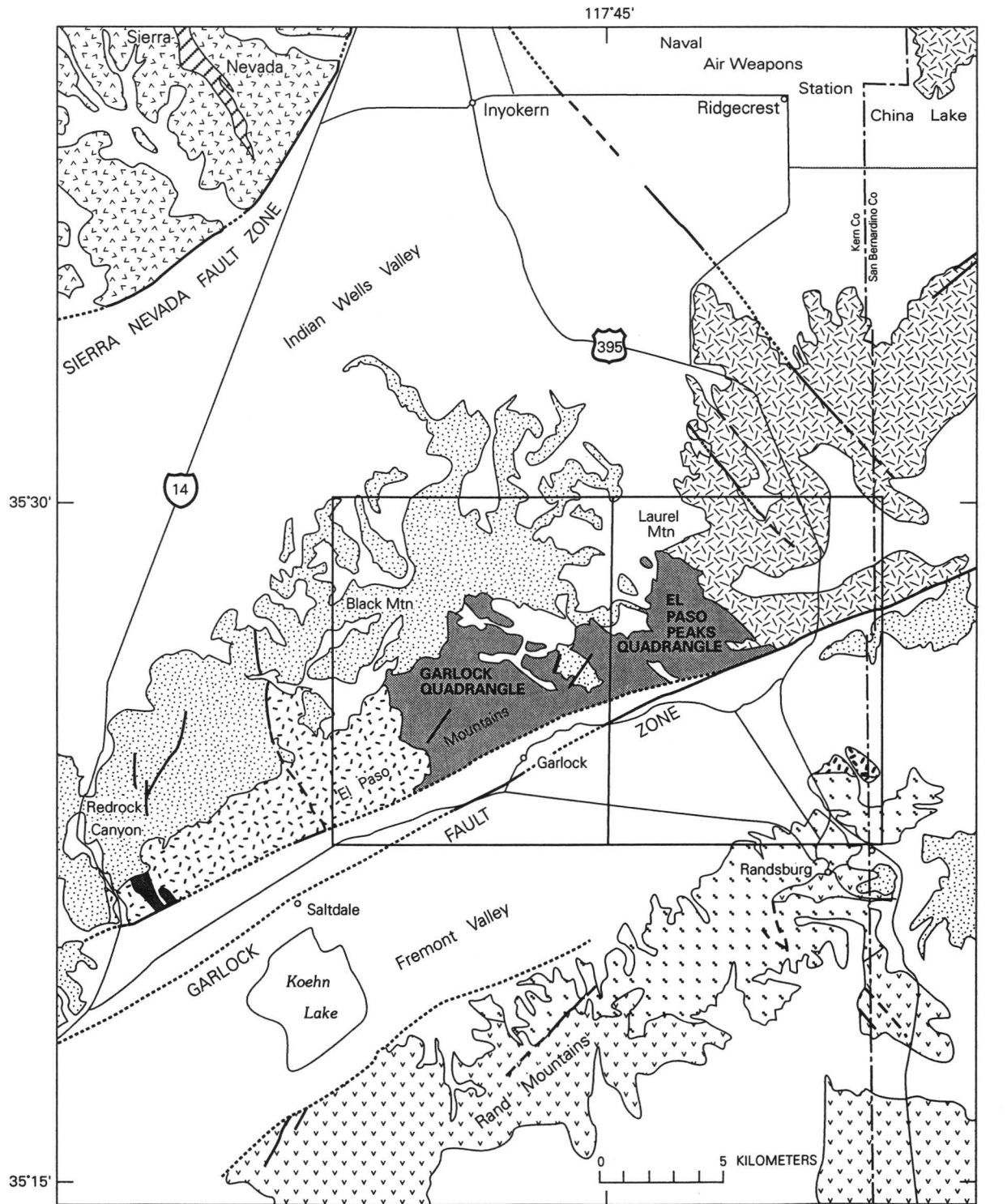
GEOLOGIC SETTING

The El Paso Mountains are a range of mountain peaks trending east-northeast along the north side of the Garlock Fault, approximately 25 km southwest of the city of Ridgecrest in eastern Kern County, California. The south flank of the range is structurally controlled by the left-lateral Garlock Fault and descends abruptly into Fremont Valley, an alluvial basin with a closed drainage system that terminates in Koehn Lake playa (see fig. 1). Numerous surficial features that indicate youthful activity along the left-lateral Garlock Fault are present along the south edge of the mountain range (Clark, 1973). The north flank of the range slopes more gently and is bordered by a tableland terrain underlain by gently dipping Tertiary sedimentary and volcanic strata (Dibblee, 1952; Cox and Diggles, 1986). Numerous narrow canyons dissect these tablelands. Most of these canyons drain northward and westward into Indian Wells Valley, but several prominent drainages cut southward through deeply incised canyons that cross the axis of the El Paso Mountains, exposing the pre-Tertiary metamorphic and plutonic rocks that form the core of the range. The west end of the El Paso Mountains is separated from the south end of the Sierra Nevada by low hills west of Red Rock Canyon; eastward the El Paso Mountains merge into a hilly terrain underlain by Mesozoic granitic rocks.

Most of the west half of the El Paso Mountains (west of Mesquite Canyon) is underlain by an intrusive suite of Late Permian and Early Triassic age (table 1; appendix 1; Cox and Morton, 1980; Carr and others, 1984) ranging in composition from gabbro to granite (Dibblee, 1952; Christiansen, 1961). [Note: Geologic ages in this report are based on the time scale of Palmer, 1983; ages cited from the literature have been converted as necessary to conform to decay constants recommended by Steiger and Jäger, 1977.] Immediately west of Mesquite Canyon, the Late Permian gneiss of Weiss Mountain and numerous smaller bodies of foliated felsic and mafic Late Permian intrusive rocks intrude the diverse assemblage of Paleozoic metasedimentary and metavolcanic marine strata that underlies most of the east half of the El Paso Mountains. The Permian intrusive rocks are gneissic, having a penetrative foliation that is coplanar with the foliation in the metamorphic rocks to the east. The Triassic plutons that intrude the gneiss of Weiss Mountain on the west are undeformed; their intrusion postdates the ductile deformation that affected the older rocks (Christiansen, 1961). A Late Jurassic (table 2; Armstrong and Suppe, 1973; Carr and others, 1984) quartz diorite to quartz monzodiorite pluton, also unaffected by any ductile deformation, intrudes the metasedimentary and metavolcanic rocks in the easternmost El Paso Mountains.

The stratigraphy and structure of the Paleozoic metasedimentary and metavolcanic marine strata in the eastern part of the El Paso Mountains are the focus of this study. Hess (1909) and Hulin (1925) briefly described these rocks, and Hess (1909, p. 30) reported two poorly preserved fossils from the eastern part of the metamorphic rock assemblage as probably no younger than Carboniferous in age. Dibblee (1952, 1967) mapped the central part of the El Paso Mountains at a scale of 1:62,500 and formally divided the metasedimentary and metavolcanic rocks into the now-abandoned Mesquite Schist and the now-abandoned Garlock Formation (see Carr and others, 1984). Dibblee (1952) subdivided the Garlock Series (later renamed the Garlock Formation by Dibblee, 1967) into twenty-two members and reported Permian fusulinids near the middle part (his Member 12) of the formation. Christiansen (1961) mapped the El Paso Mountains from Red Rock Canyon eastward to the longitude of the village of Garlock at a scale of 1:24,000; his mapping of the area now covered by the Garlock 7.5-minute quadrangle forms a partial basis for this compilation. Poole and others (1977, 1980) and Poole and Christiansen (1980) reported the results of additional fossil discoveries from the western (structurally lower) part of the Garlock Formation, demonstrating the presence of Ordovician and Devonian rocks in the formation. Poole (1974) also tentatively correlated rocks near the middle part of the Garlock Formation with Mississippian rocks of the Antler foreland basin of Nevada. Building on this previous work, the remainder of the present compilation is based on 1:24,000-scale geologic mapping and stratigraphic studies done between 1979 and 1982. The preliminary findings of this study were presented by Carr and others (1980, 1984) and include the results of additional fossil discoveries throughout much of the Garlock Formation.

The metasedimentary and metavolcanic marine strata of the El Paso Mountains represent nearly every system of the Paleozoic Era. There is no direct fossil evidence for the Silurian, but Silurian to Early Devonian fossils have been recovered from generally correlative rock sequences exposed in Pilot Knob Valley, about 50 km east of the El Paso Mountains, and some Silurian rocks could be present in the El Paso Mountains as well (Carr and others, 1992).

EXPLANATION

Surficial deposits (Quaternary)
Sedimentary and volcanic deposits (Tertiary)
El Paso Mountains
Granitoid pluton (Jurassic)
Granitoid pluton (Triassic and Permian)
Bond Buyer sequence
Garlock assemblage

Sierra Nevada
Sierra Nevada batholith
Metasedimentary rocks
Rand Mountains
Granitoid pluton
Rand Schist
Johannesburg Gneiss of Hulin (1925)

——— Contact
—— Fault—Dashed where inferred or approximately
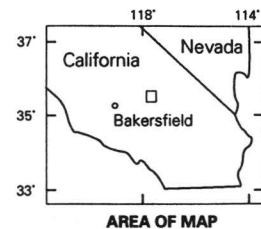located; dotted where concealed

Figure 1. Generalized geologic map of El Paso Mountains and surrounding area. Modified from Jennings and others (1962) and Carr and others (1984).

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Two distinct sequences of Upper Cambrian and Ordovician rocks are present in the El Paso Mountains section. Upper Cambrian and Ordovician strata in the Garlock 7.5-minute quadrangle (metasedimentary rocks of Colorado Camp) are mostly meta-argillite and argillitic metachert belonging to an outer continental-margin facies. Upper Cambrian and Ordovician rocks in the El Paso Peaks 7.5-minute quadrangle (metasedimentary rocks of El Paso Peaks) are lithologically more diverse, including meta-argillite, marble (detrital metalimestone), graptolitic slate, and orthoquartzite. These rocks represent facies transitional between the outer and inner continental margin.

The Devonian rocks in the Garlock and parts of the El Paso Peaks quadrangles (metasedimentary rocks of Gerbracht Camp) also represent outer continental-margin facies. The metasedimentary rocks of Gerbracht Camp comprise a sequence of metachert, metatuff, sandy marble (detrital metalimestone), and meta-argillite with fine-grained quartzite (distal turbidites). Greenstone that we tentatively assign to the Devonian and infer to lie stratigraphically below the metasedimentary rocks of Gerbracht Camp is present, as well, in both the Garlock and El Paso Peaks quadrangles. Calcsilicate hornfels and subordinate marble mapped as the upper member of the metasedimentary rocks of El Paso Peaks could also be, in part, Silurian(?) and Devonian(?) judging from their apparent stratigraphic position. These rocks, like the lower members of the metasedimentary rocks of El Paso Peaks, probably represent a facies transitional between the outer and inner continental margin.

Lower Mississippian rocks assigned to the Robbers Mountain Formation (Carr and others, 1992) rest unconformably on the metasedimentary rocks of Gerbracht Camp in the Garlock quadrangle. The lower member of the Robbers Mountain Formation consists of metaconglomerate containing clasts derived from the underlying Devonian section, whereas the upper member consists of meta-argillite, signifying return to a low-energy depositional regime. Nevertheless, the Robbers Mountain Formation marks the end of passive continental-margin sedimentation and the beginning of a new episode in the geologic history of the region. The Robbers Mountain Formation was interpreted by Carr and others (1992) as a syntectonic deposit, corresponding in age with the Antler orogeny. During the Late Devonian to Early Mississippian Antler orogeny, as it is understood from the geology in Nevada, oceanic strata deposited along the western outer continental margin of early and middle Paleozoic North America were emplaced eastward over coeval inner continental-margin strata (Burchfiel and Davis, 1972, 1975), disrupting sedimentation patterns and shedding an apron of siliciclastic debris eastward into a late Paleozoic foreland basin (Poole, 1974).

A Late Mississippian age is inferred for intercalated meta-argillite, quartzite, and sparse metaconglomerate that form a turbidite sequence exposed near the Apache Mine in the Garlock quadrangle (metasedimentary rocks of Apache Mine). Strata conformably overlying the metasedimentary rocks of Apache Mine have yielded Pennsylvanian conodonts. Poole (1974) provisionally correlated the rocks comprising the Apache Mine unit with Mississippian rocks in the Great Basin interpreted as foreland basin deposits shed from the Antler orogenic highland. He interpreted the basal (western) contact of these rocks (metasedimentary rocks of Apache Mine) as a faulted unconformity (see Poole, 1974, Carr and others, 1980).

The Pennsylvanian strata (metasedimentary rocks of Benson Well) that conformably overlie the meta-sedimentary rocks of Apache Mine also are a turbidite sequence (slate and quartzite member). In the El Paso Peaks quadrangle, however, metalimestone representing a shallower water environment forms the basal member (metalimestone member) of the metasedimentary rocks of Benson Well, and the Pennsylvanian section rests unconformably on rocks of inferred Devonian age. The metalimestone member of the Benson Well unit grades upward into a sequence of very fine grained turbidites (slate and quartzite member), suggesting basin subsidence.

West of Mormon Flat, Permian strata (metasedimentary rocks of Holland Camp, in part) rest unconformably on Upper Cambrian or Lower Ordovician rocks. There, the lowermost part (member A) of the Permian section is a lithologically heterogeneous unit of slate containing beds of arkosic quartzite, metaconglomerate, metadolostone, and metalimestone. The quartzite, metaconglomerate, and beds of metamorphosed carbonate rocks are mostly debris-flow and turbidite deposits. Early Permian fusulinids are present in the lower part of the section. Member B is slate containing turbidite beds of coarse-grained calcarenitic metalimestone. East of Goler Gulch, most of the Permian section consists of rocks assigned to member B (in part). There, member B apparently has a greater age range, possibly as old as Pennsylvanian. Deposition in this section could have been continuous from the metasedimentary rocks of Benson Well to the metasedimentary rocks of Holland Camp, but the contacts of both units with an intervening unit of poorly dated chert and marble are faulted, obscuring the original stratigraphic relations. In the section exposed south of Mormon Flat, the turbidite sequence comprising member B is gradationally overlain by member C, which contains beds of tuffaceous metasandstone and metaconglomerate. The influx of volcanogenic material in this section heralds the initiation of a magmatic arc along the western continental margin of Paleozoic North America. The Lower Permian metasedimentary succession is overlain conformably by Upper Permian andesitic metavolcanic flows (andesite of Goler Gulch).

Most of the Paleozoic strata of the El Paso Mountains dip moderately eastward, giving the appearance of a thick homoclinal section. However, the entire Paleozoic section is deformed into tight to isoclinal, westward-vergent folds with subhorizontal axes. Few of the largest map-scale folds close within the range. Faults that are nearly parallel to layering truncate many of the fold limbs and juxtapose contrasting rock sequences, many of which are inverted. Penetrative foliation and (or) spaced cleavage are present in many of the rocks. Penetrative foliation is particularly strong

near the west end of the Paleozoic section, where it is in ductile-fault contact with the gneiss of Weiss Mountain. A zone of blastomylonite marks this fault zone. Foliations in the Paleozoic rocks, the mylonite zone, and the gneiss are coplanar.

Low-grade regional dynamothermal metamorphism altered most of the metasedimentary and metavolcanic rocks of the El Paso Mountains. In most areas, relic sedimentary structures and textures are preserved. In a zone 1 to 2 km wide adjacent to the gneiss of Weiss Mountain, however, there is a progressive westward increase in grade of the metamorphic rocks. Mineral assemblages indicate a progression through the albite-epidote-hornfels to the hornblende-hornfels facies of contact metamorphism and from quartz-albite-musco-vite-chlorite subfacies to almandine-amphibolite facies in a dynamothermal metamorphic progression. Formation of penetrative foliation in all of the metamorphic rocks accompanied metamorphism. These metamorphic relations, together with the structural relations between the metamorphic rocks and the gneiss of Weiss Mountain, led Christiansen (1961) to conclude that intrusion of the pluton (comprising the gneiss of Weiss Mountain) was simultaneous with both ductile deformation and regional metamorphism of the Paleozoic metasedimentary and metavolcanic rocks. The thermal aureole of the pluton apparently caused an overprint of higher temperature contact and dynamothermal metamorphic mineral assemblages on an otherwise-typical, penetratively deformed, low-grade metamorphic terrane. Local retrograde metamorphism in the contact aureole of the gneissic pluton may have resulted from later static contact metamorphism accompanying emplacement of the postkinematic Triassic plutons that intrude the gneiss (Christiansen, 1961).

An aureole of static contact metamorphism surrounds the Jurassic pluton that intrudes the metamorphic rocks in the easternmost part of the El Paso Mountains. Throughout most of the aureole, the rocks are altered to pelitic and calcsilicate hornfels in the albite-epidote facies. The metamorphism reaches hornblende-hornfels facies near El Paso Peaks, however, where marbles are altered to garnet-bearing tactite. Hornfelsic textures have obliterated primary structures in this aureole.

The Tertiary strata that unconformably overlie the crystalline and metamorphic rocks of the El Paso Mountains along the north side of the range are tilted gently to the northwest, indicating that the entire range block has been tilted in that direction since the deposition of the Tertiary strata (Dibblee, 1952; Christiansen, 1961; Cox and Diggles, 1986). At the southwest end of the El Paso Mountains, Tertiary rocks are warped around an anticlinal arch that parallels the axis of the range (Christiansen, 1961). Locally, throughout the eastern part of the El Paso Mountains, metasedimentary and metavolcanic strata are deformed by a second weak system of upright open folds with axes trending parallel to the range axis. These folds are postmetamorphic and deform the older ductile fabrics. Such folding diminishes northward away from the mountain front and the Garlock Fault (Christiansen, 1961).

SUMMARY OF GEOLOGIC HISTORY

Lower and middle Paleozoic strata exposed in the El Paso Mountains were deposited along the outer continental margin of Paleozoic North America. Cambrian and Ordovician outer continental-margin rocks (metasedimentary rocks of Colorado Camp) probably represent environments on the continental slope, continental rise, and (or) adjacent ocean-basin floor. Most of these very fine grained siliciclastic rocks originated as distal turbidites and hemipelagic accumulations of mudstone and argillaceous chert. The sparse thin interbeds of carbonate rocks present in one interval of this section could represent the distal tails of calcarenitic turbidites shed from the continental shelf. The transitional-facies Cambrian and Ordovician strata, exposed in the eastern part of the El Paso Mountains (metasedimentary rocks of El Paso Peaks), probably formed in continental-slope or outer continental-shelf environments. Most of these rocks are sequences of medium-grained turbidites and debris-flow materials shed into a distal basin that was accumulating hemipelagic mudstone and some argillaceous chert. Many of the turbidite and debris-flow beds consist of detrital carbonate rocks, reflecting the lithology of the predominant deposits in the source terrane, probably on the early Paleozoic continental shelf.

Passive continental-margin sedimentation continued to the end of the Devonian (metasedimentary rocks of Gerbracht Camp). Lithologic variation in the stratigraphic section depended principally on the provenance and proximity of turbidites and debris-flow materials shed into the outer continental-margin basins. Sedimentation was disrupted only by eruptions of submarine mafic volcanic flows. The chemistry of greenstones lithologically similar to those in the El Paso Mountains section was studied in the Roberts Mountains allochthon of western Nevada by Madrid (1987). Greenstones in the Roberts Mountains allochthon were found, regardless of their age, to be alkalic, suggesting an intraplate origin consistent with a rifted outer continental-margin setting (Madrid, 1987; Turner and others, 1989; Poole and others, 1992).

A major restructuring of the western continental margin of Paleozoic North America began during the Late Devonian to Early Mississippian Antler orogeny, resulting in emplacement of the Roberts Mountains allochthon exposed in western Nevada (see Burchfiel and Davis, 1972, 1975; Poole, 1974). The full extent of the Roberts Mountains allochthon, especially westward into the metamorphic pendants of the Sierra Nevada and southward into the southwestern Great Basin and Mojave Desert regions, remains to be conclusively established. It cannot be satisfactorily demonstrated whether the Antler orogenic belt actually extended southward to the latitude of the El Paso Mountains (Poole and Sandberg, 1977, 1991; Carr and others, 1984; Poole and others, 1992), whether the El Paso Mountains section represents a fragment of the Roberts Mountains allochthon offset southward during later Paleozoic or early Mesozoic strike-slip faulting (Davis and others, 1978; Poole and Christiansen, 1980; Burchfiel and Davis, 1981), or whether some other alternative

(or combination of circumstances) correctly explains the composition and current position of the El Paso Mountains section. It is possible that during the latest Devonian or earliest Mississippian, the outer continental-margin rocks of the El Paso Mountains were displaced eastward over the inner continental margin, analogous to the Roberts Mountains allochthon in Nevada. However, there is no definitive structural evidence of an Antler orogeny at the latitude of the El Paso Mountains, and pre-Mississippian as well as Mississippian and younger Paleozoic strata in the El Paso Mountains all exhibit deformational fabrics similar to each other. The structural framework and depositional patterns along the part of the continental margin represented by the El Paso Mountains section were profoundly changed about the time of the Antler orogeny, and the restructured geologic framework persisted for most of the late Paleozoic.

Upper Paleozoic rocks in the El Paso Mountains are typified by numerous stratigraphic and facies variations, including local unconformities with widely disparate age ranges. Lower and middle Paleozoic sections were uplifted (or sea level lowered) and eroded, and the debris was incorporated into upper Paleozoic deposits. The complex stratigraphy suggests complex bathymetry in a terrane of structurally controlled submarine basins and highs along the late Paleozoic continental margin (Carr and others, 1984). Whereas overall subsidence during the late Paleozoic is suggested by most of the stratigraphic sequences, individual sections indicate that the timing of the onset of sedimentation and burial of exposed lower and middle Paleozoic strata varied greatly among the basins. Similar patterns of late Paleozoic basin formation have been described for the south-central Great Basin (Stone and Stevens, 1988), but in that area, the lower and middle Paleozoic rocks on which the late Paleozoic basins were superimposed mostly represent inner continental-margin facies. Whether or not the model proposed by Stone and Stevens (1988) of continental truncation by a sinistral transform fault system active during most of the late Paleozoic is correct, the similarities in late Paleozoic basin development between the south-central and southwestern Great Basin suggest ties in the tectonic evolution of the two areas during the late Paleozoic.

A second major restructuring of the western continental margin of Paleozoic North America began in the late Early Permian with the local eruption of andesitic volcanoes along the continental margin. The evidence of these eruptions in the El Paso Mountains section is the influx of volcanogenic sandstone and conglomerate into the Permian marine section during the latest Leonardian, followed abruptly by deposition of a thick sequence of andesite flows exposed in Goler Gulch. Synchronous deformation, metamorphism, and plutonism followed rapidly in the evolving magmatic arc. The Paleozoic sedimentary and volcanic rocks were metamorphosed and deformed in westward-vergent, fold-thrust structures. The entire structural package of metasedimentary and metavolcanic rocks was ductilly thrust relatively westward over a penetratively deformed pluton that has yielded U-Pb zircon (Carr and others,

1984; table 1) and conventional K-Ar hornblende ages (Cox and Morton, 1980; appendix 1) indicating latest Permian crystallization and cooling. Undeformed posttectonic plutons, which have yielded conventional K-Ar ages indicating early Middle Triassic crystallization and cooling, intrude the deformed complex on the west; an undeformed Late Jurassic pluton intrudes the deformed rocks on the east. These granitoid plutons are typical products of the regional, subduction-related magmatism that occurred in the North American Cordillera during the Mesozoic.

There are no rocks to record the geologic history between the emplacement of the Late Jurassic intrusions and the deposition of the Goler Formation (Paleocene—and possibly latest Cretaceous; McKenna, 1960; Cox and Diggles, 1986; Reid and Cox, 1989). Except for a brief marine incursion during the latest Paleocene, which is recorded by mudstone in the upper part of the Goler Formation, the Cenozoic history is characterized by nonmarine sedimentation and volcanism accompanying basin-range extensional tectonism (Cox and Diggles, 1986; Reid and Cox, 1989). Gentle folding parallel to the range axis apparently accompanied the tilting and warping of the mountain block during the Cenozoic (Christiansen, 1961). Deformation along the left-lateral Garlock Fault and probably tilting and gentle warping of the entire mountain block continue in the contemporary tectonic setting.

ACKNOWLEDGMENT

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Table 1. *Uranium-lead isotopic ages of zircon from foliated intrusive rocks, central El Paso Mountains, California*

[Analyses and age calculations by Lynn Fischer, U.S. Geoloical Survey, Denver Colorado. Samples collected by M.D. Carr and F.G. Poole]

Mesh size	Concentration (parts per million)		Isotopic composition of lead (atom percent)				Age (Ma)		
	U	Pb	^{204}Pb	^{206}Pb	^{207}Pb	^{208}Pb	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$
Gneiss of Weiss Mountain[1]									
+150	281.1	11.48	0.0497	85.07	8.085	9.796	252	252	249
+200	290.6	19.11	0.1107	79.04	7.240	13.609	369	465	973
-200	546.7	28.74	0.0503	81.29	5.930	12.727	309	366	742
Concordia intercepts at 242±9 Ma and 1659±76 Ma									

Decay constants: $^{238}U=1.55125 \times 10^{-10} yr^{-1}$; $^{235}U=9.8485 \times 10^{-10} yr^{-1}$; $^{238}U=137.88$. Isotopic composition of common lead assumed to be $^{204}Pb:^{206}Pb:^{207}Pb:^{208}Pb=1:18.7:15.6:38.2$.

[1]Sample number: C82EP-82; location: lat 35°25'32"N., long 117°50'56"W.; Garlock 7.5' quadrangle, California.

[2]Sample number: C82EP-88A; location: lat 35°25'06"N., long 117°50'29"W.; Garlock 7.5'quadrangle, California.

Table 2. *Conventional potassium-argon ages for the Laurel Mountain pluton, eastern El Paso Mountains, California*

[Analyses by U.S. Geological Survey, Menlo Park, California. Analysts: M. Pernokas and R.F. Marvin. Potassium measured by flame photometry following lithium metaborate fusion (Suhr and Ingamells, 1966). Argon measurements using standard techniques of isotope dilution (Dalrymple and Lanphere, 1969). Decay and abundance constants as recommended by Steiger and Jäger (1977). Sample location: lat 35°26'54"N., long 117°40'52"W.; El Paso Peaks, California, 7.5' quadrangle]

Sample	Material	Percent K_2O	$mol^{40}Ar^*/g$	Percent $^{40}Ar^*$	Age (Ma)[1]
C80EP-95	hornblende	0.34	7.740e-11	59.2	151.6±1.9
do.	biotite	8.67	1.895e-9	81.2	145.8±1.0

$^{40}Ar^*$ = radiogenic ^{40}Ar.

[1]Uncertainties given at one standard deviation.

Table 3. *Comparison of the stratigraphic nommenclature of Dibblee (1952, 1967) with the stratigraphic nommenclature proposed in this report*

[Correlations are approximate]

Dibblee (1952, 1967)		This report
	Garlock Formation	
Member 22		Upper member of metasedimentary rocks of El Paso Peaks (part)
Member 21		Middle member of metasedimentary rocks of El Paso Peaks
Member 20	(upper part)	Calcsilicate hornfels
Member 20	(lower part)	Middle member of metasedimentary rocks of El Paso Peaks
Member 19		Upper member of metasedimentary rocks of El Paso Peaks
Member 18	(upper part)	Upper (part), middle, and lower members of metasedimentary rocks of El Paso Peaks
Member 18	(lower part)	Metasedimentary rocks of Gerbracht Camp (part), greenstone, metasedimentary rocks of Benson Well, and metasedimentary rocks of El Paso Peaks (part)
Member 17		Slate and quartzite member of metasedimentary rocks of Benson Well
Member 16	(upper part)	Chert and marble
Member 16	(lower part)	Member B (part) of metasedimentary rocks of Holland Camp
Member 15		Member B (part) of metasedimentary rocks of Holland Camp
Member 14		Member C (part) and member D of metasedimentary rocks of Holland Camp
Member 13		Andesite of Goler Gulch
Member 12		Member C, member B (part), and member A of metasedimentary rocks of Holland Camp
Member 11		Metasedimentary rocks of Apache Mine (part)
Member 10		Metasedimentary rocks of Apache Mine (part)
Member 9	(upper part)	Metasedimentary rocks of Colorado Camp
Member 9	(lower part)	Metasedimentary rocks of Gerbracht Camp (part)
Member 8		Greenstone
Member 7		Metachert member of metasedimentary rocks of Gerbracht Camp
Member 6	(upper part)	Metatuff, sandy marble, and meta-argillite members of metasedimentary rocks of Gerbracht Camp
Member 6	(middle part)	Robbers Mountain Formation
Member 6	(lower part)	Meta-argillite member of metasedimentary rocks of Gerbracht Camp
Member 5		Sandy marble member of metasedimentary rocks of Gerbracht Camp
Member 4		Meta-argillite member of metasedimentary rocks of Gerbracht Camp
Member 3		Robbers Mountain Formation
Member 2		Greenstone
Member 1		Graphitic phyllite
	Mesquite Schist	
(upper and lower part)		Schist and marble
(middle part)		Schist and quartzite

Appendix 1a. *Conventional K/Ar and $^{40}Ar/^{39}Ar$ ages for several plutons in the central El Paso Mountains, California* by Brett F. Cox and Jan L. Morton

Conventional potassium-argon ages

[Analyses by U.S. Geological Survey, Menlo Park, California. Analyst: J.L. Morton. Potassium measured by flame photometry following lithium metaborate fusion (Suhr and Ingamells, 1966); argon measurements using standard techniques of isotope dilution (Dalrymple and Lanphere, 1969). Decay and abundance constants as recommended by Steiger and Jäger (1977)]

Sample	Material	K_2O Percent	$mol\,^{40}Ar^*/g$	$^{40}Ar^*$ percent	Age (Ma)[1]	Location[2] Latitude	Longtitude
			Gneiss of Weiss Mountain				
M5-9	hornblende	0.929	3.524^{-10}	89	246±7	35°25.65'	117°50.92'
M1-9	hornblende	1.009	3.464^{-10}	88	224±7	35°25.21'	117°51.07'
			Burro Schmidts pluton				
M2-9	biotite	8.965	21.211^{-10}	93	157±5	35°24.62'	117°51.99'
do.	hornblende	0.902	3.296^{-10}	77	238±7	do.	do.
			Last Chance Canyon pluton				
M4-9	biotite	9.035	19.715^{-10}	91	146±4	35°26.00'	117°53.92'
do.	hornblende	0.605	2.127^{-10}	74	229±7	do.	do.
E59-3	biotite	8.21	28.998^{-10}	92	230±7	35°23.65'	117°55.26'
do.	hornblende	0.446	1.640^{-10}	75	239±7	do.	do.

$^{40}Ar^*$ = radiogenic ^{40}Ar.

[1] Analytical uncertainties (approximately ±3 percent) are combined precision of argon and potassium analyses at one standard deviation.

[2] Samples M5-9, M1-9 and M2-9 located on Garlock, California 7.5' quadrangle; samples M4-9 and E59-3 located on Saltdale NW, California 7.5' quadrangle.

Appendix 1b. *Conventional K/Ar and $^{40}Ar/^{39}Ar$ ages for several plutons in the central El Paso Mountains, California* by Brett F. Cox and Jan L. Morton—Continued

$^{40}Ar/^{39}Ar$ incremental heating analytical data and apparent ages for sample M5-9 (gneiss of Weiss Mountain)

[$^{40}Ar/^{39}Ar$ incremental heating experiment follows procedures described in Dalrymple and Lanphere (1971) and Lanphere and Dalrymple (1971)]

Temperature[1] (°C)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	^{39}Ar (% of total)	$^{40}Ar^*$(%)	^{36}Ar(%)	Apparent age (Ma)
750	189.5	3.676	0.5651	4.8	12.0	0.2	191±20
890	40.48	5.877	0.0375	54.4	73.7	4.3	246±4
925	40.45	5.299	0.0350	23.9	75.4	4.1	251±3
960	39.02	5.633	0.0289	6.2	79.3	5.3	254±5
1000	40.19	5.928	0.0337	5.8	76.4	4.8	235±5
1040	36.48	5.677	0.0189	4.1	85.9	8.2	258±4
1075	96.08	5.593	0.2454	0.7	25.0	0.6	201±35
fuse	20.64	1.940	6.992	0.08	–	0.0	–

Apparent total fusion age=246 Ma Plateau age=252±4 Ma

[1] Sample was heated for thirty minutes at each temperture step.