DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT
88-503

Base from U.S. Geological Survey, 1983

Geology mapped in 1983-87

SCALE 1:24 000

1 ½ 0 1 MILE

1 5 0 1 KILOMETER

CONTOUR INTERVAL 10 METERS
SUPPLEMENTARY CONTOUR INTERVAL 5 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

APPROXIMATE MEAN DECLINATION, 1988

QUADRANGLE LOCATION

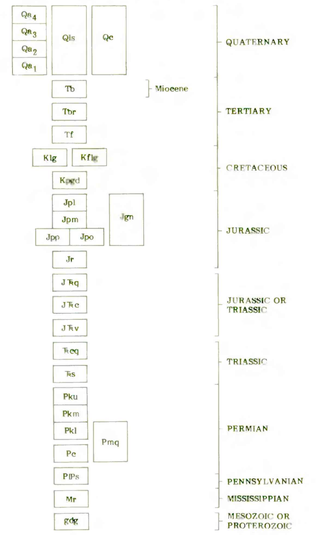
PRELIMINARY GEOLOGIC MAP OF THE PALEN PASS QUADRANGLE, RIVERSIDE COUNTY, CALIFORNIA

By

Paul Stone and Michael M. Kelly

1988

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Alluvium (Quaternary)—Poorly sorted, locally derived gravel, sand, and silt deposited on modern and ancient alluvial fans. Divided into:

Qa_4 **Unit 4**—Deposits of active washes and alluvium forming active and recently active fan surfaces. Correlated with the "Q4 alluvium" unit as used by Bull (1974) in the Vidal area 35 km to the northeast; estimated age 0 to 2,000 yrs B.P.

Qa_3 **Unit 3**—Alluvium forming relatively young inactive fan surfaces that are lightly to darkly varnished, undissected to slightly dissected, and preserve bar-and-swale topography. Correlated with the "Q3 alluvium" unit as used by Bull (1974) in the Vidal area; estimated age 2,000 to 11,000 yrs B.P.

Qa_2 **Unit 2**—Alluvium forming relatively old inactive fan surfaces that are generally darkly varnished and form smooth, slightly to moderately dissected pavements. Correlated with the "Q2 alluvium" unit as used by Bull (1974) in the Vidal area; estimated age 11,000 to 200,000 yrs B.P.

Qa_1 **Unit 1**—Alluvium forming deeply dissected longitudinal hills and ridges. Correlated with the "Q1 alluvium" unit as used by Bull (1974) in the Vidal area; estimated age 500,000 yrs B.P. to greater than 1.5 m.y.B.P. Queried outcrops may instead be the Tertiary monolithologie breccia unit (Tbr)

Qls **Landslide deposits (Quaternary)**—Lobate masses of gravel inferred to have been deposited by landsliding

Qc **Colluvium and talus (Quaternary)**

Tb **Olivine basalt flows and dikes (Miocene)**—Dated by K-Ar whole-rock analysis as approximately 6.2 to 6.4 Ma (Table 1)

Tbr **Monolithologic breccia (Tertiary)**—Masses of unsorted, unstratified, silty and sandy sedimentary breccia interpreted as landslide deposits. Forms complexly dissected hills. Derived primarily from the Jurassic porphyritic granodiorite unit (Jpp) and rhyodacitic metavolcanic rocks unit (Jr). Mass southwest of Palen Pass is overlain by Miocene basalt flows and is cut by Miocene basalt dikes (Tb). Previously mapped as bedrock intrusive outcrops by Pelka (1973) and Leveque (1982)

Tf **Fanglomerate (Tertiary)**—Poorly sorted sandstone and conglomerate composed primarily of plutonic and metaplutonic rock detritus. Occupies a narrow structural basin bounded by faults at south base of Granite Mountains. Probably older than the monolithologic breccia unit (Tbr) which is inferred to postdate these and other faults in the Palen Pass area

Klg **Leucogranite (Cretaceous)**—Leucocratic muscovite-biotite granite to granodiorite. Color index 1 to 5. Intrudes the granodiorite gneiss and amphibolite unit (gdg). Considered part of the Cadiz Valley batholith of Late Cretaceous age (John, 1981; Howard and others, 1982; Miller and Howard, 1983)

Kflg **Foliated leucogranite (Cretaceous)**—Similar in composition to the Cretaceous leucogranite unit (Klg) and probably continuous with that unit at depth, but generally finer grained and weakly to strongly foliated. Mylonitic foliation and lineation common, especially in northeast part of outcrop area. Intrudes the foliated porphyritic granodiorite unit (Kpgd) and the granodiorite gneiss and amphibolite unit (gdg) intrusive contacts with these units are broad zones of mixed rock that are oriented approximately parallel to foliation. Encloses scattered unmapped bodies of country rock similar to units Kpgd and gdg. Considered part of the Cadiz Valley batholith

Kpgd **Foliated porphyritic granodiorite (Cretaceous)**—Moderately to strongly foliated porphyritic sphene-biotite granodiorite containing euhedral phenocrysts of light-gray potassium feldspar 2 to 10 cm long. Color index 10 to 15. Potassium feldspar phenocrysts characterized by concentric zones of mafic mineral inclusions. Pervasively intruded by unmapped sills, dikes, and pods of strongly foliated to unfoliated leucogranite inferred to be equivalent to units Klg and Kflg. Foliation in both the porphyritic granodiorite and the leucogranite is generally mylonitic; foliation surfaces commonly have a distinct mylonitic lineation. Contact with the layered orthogneiss and orthoschist unit (Jgn) is obscured by unmapped leucogranite bodies. Considered part of the Cadiz Valley batholith

Plutonic and metaplutonic rocks of Palen Pass (Jurassic)—Intrusions into Mississippian to Permian metasedimentary rocks. Considered part of the informally designated Middle and Late Jurassic (160-165 Ma) Kitt Peak-Trigo Peaks granitic superunit of Tosdal and others (in press). Three K-Ar biotite ages of about 62 to 68 Ma and one K-Ar hornblende age of about 116 Ma (Martin and others, 1982) are interpreted as cooling ages; the biotite ages are interpreted to approximate the age of cooling after Late Cretaceous regional metamorphism (Hoiseh and others, 1988). Divided into:

Jpl **Leucogranite**—Weakly foliated to unfoliated leucocratic granite characterized by pale-lavender potassium feldspar. Color index 1 to 5. Intrudes the porphyritic granodiorite unit (Jpp)

Jpm **Muscovite-bearing granodiorite**—Foliated biotite granodiorite containing abundant secondary muscovite, primarily along fractures and foliation surfaces. Color index 5 to 15. Intrudes the orthogneiss and orthoschist unit (Jpo)

Jpp **Porphyritic granodiorite**—Weakly to strongly foliated sphene-biotite granodiorite that generally contains abundant euhedral to subhedral phenocrysts of white to pink potassium feldspar 1 to 3 cm long. Color index 15 to 20. Typically has a greenish color imparted by metamorphic epidote. Biotite occurs in recrystallized clots that produce a spotted texture. Fine-grained mafic inclusions common. Gradational with the orthogneiss and orthoschist unit (Jpo). Correlated with lithologically similar rocks in the Big Maria Mountains, 40 km to the east, that have U-Pb zircon ages of 160 to 165 Ma (L.T. Silver, in Hamilton, 1982, 1987)

Jpo **Orthogneiss and orthoschist**—Strongly foliated, dark-green to black, fine-grained biotite and hornblende orthogneiss and orthoschist of probable granodioritic to dioritic composition. Contains abundant metamorphic epidote. Color index 30 to 50

Jgn **Layered orthogneiss and orthoschist (Jurassic)**—Interlayered granite to granodiorite gneiss and fine-grained dark-colored orthogneiss and orthoschist, pervasively intruded by unmapped sills, dikes, and pods of foliated to unfoliated leucogranite inferred to correlate with units Klg and Kflg. Individual gneiss layers are lithologically similar to rocks mapped separately as units Jpp and Jpo in the Palen Pass area, but are more strongly foliated than those rocks

Jr **Rhyodacitic metavolcanic rocks (Jurassic)**—Weakly to strongly foliated, weakly metamorphosed extrusive and hypabyssal intrusive rocks of rhyodacitic composition (Pelka, 1973). Consists partly of bedded tuff, lapilli tuff, and tuff breccia, and partly of dark-greenish-gray, massive, aphanitic to weakly porphyritic rhyodacite that is interpreted to intrude the extrusive rocks. Minor conglomerate containing clasts of quartzite and volcanic rock present locally near base. Main body of unit overlies the Triassic or Jurassic quartzite unit (JTrq); two small bodies of massive rhyodacite intrude that quartzite unit at lower stratigraphic levels. Unit age based primarily on stratigraphic position above unit JTrq and on lithostratigraphic correlation with metavolcanic rocks that are intruded by plutons considered part of the Middle and Late Jurassic Kitt Peak-Trigo Peaks superunit in the Big Maria Mountains (Hamilton, 1982, 1987) and in the Dome Rock Mountains, Arizona, 70 km to the east (Tosdal and others, in press). A sample collected approximately 2 km south of the quadrangle boundary gave a K-Ar plagioclase age of about 180 Ma (D. Krummenacher, in Pelka, 1973; age recalculated using decay constants of Steiger and Jager, 1977). A mean K-Ar biotite age of 68.7±1.7 Ma from a sample near the base of unit (Table 1) is interpreted to approximate the age of cooling after Late Cretaceous regional metamorphism (Hoiseh and others, 1988). Structural thickness, including continuation south of quadrangle, approximately 4 km; partial thickness of unit in quadrangle is approximately 500 m

JTrq **Quartzite (Jurassic or Triassic)**[1]—Predominantly tan to light-pink, fine-grained crossbedded quartzite; medium- to dark-gray, fine-grained arkosic sandstone forms lowermost 30 m of unit. Generally unfoliated; beds well preserved. Contact with the underlying conglomerate unit (JTrc) gradational. Correlated with a lithologically similar quartzite unit in the Big Maria Mountains that has been interpreted as the metamorphosed equivalent of the Triassic(?) and Jurassic Aztec Sandstone (Hamilton, 1982, 1987), and with the quartzitic upper part of the Triassic or Jurassic Vampire Formation of Reynolds and others (1987) in the Buckskin Mountains, Arizona, 90 km to the northeast. Structural thickness approximately 300 to 400 m

JTrc **Conglomerate (Jurassic or Triassic)**[1]—Conglomerate and metaconglomerate containing clasts of quartzite, volcanic rocks, carbonate rocks, and granite. Interbedded with minor arkosic and calcareous sandstone. Commonly green owing to abundance of metamorphic epidote. Locally unfoliated with beds well preserved, but beds commonly are transposed into a penetrative foliation. Most carbonate clasts are flattened in the plane of foliation; some are metamorphosed to wollastonite rock. Correlated with the conglomeratic basal part of the Vampire Formation of Reynolds and others (1987) in the Buckskin Mountains. Structural thickness ranges from approximately 150 to 300 m

JTrv **Volcanic sandstone (Jurassic or Triassic)**—Dark-gray to dark-greenish-gray, fine-grained volcanic sandstone, tuff or tuffaceous sandstone, and minor mudstone. Sandstone is composed primarily of volcanic rock fragments and euhedral plagioclase. Weakly to strongly foliated; beds preserved locally. Present only at north end of Palen Mountains where structural thickness is approximately 350 m; absent at west end of Palen Pass where the calcareous quartzite unit (TRcq) is overlain by the conglomerate unit (JTrc)

TRcq **Calcareous quartzite (Triassic)**[1]—Tan, brown, and green, fine-grained, locally crossbedded calcareous quartzite containing abundant metamorphic epidote. Includes minor conglomerate composed of rounded quartzite pebbles. Generally unfoliated, but beds are commonly obscured by brecciation on outcrop surfaces. Correlated with the upper member of the Buckskin Formation of Reynolds and others (1987) in the Buckskin Mountains; the Buckskin Formation is considered correlative with the Lower and Middle(?) Triassic Moenkopi Formation. Structural thickness approximately 300 to 350 m

TRs **Schist and calcareous quartzite (Triassic)**[1]—Light-green chloritic schist and tan to brown calcareous quartzite that form alternating units 50 to 75 m thick. Calcareous quartzite partly metamorphosed to calc-silicate rock in which epidote is locally abundant. Strongly foliated; beds not preserved. Concordantly overlies upper member of the metamorphosed Kaibab Limestone on an overturned contact 1 km south of Palen Pass; this contact was previously considered to be a thrust fault (Leveque, 1982). Correlated with the three lowermost members of the Buckskin Formation of Reynolds and others (1987) in the Buckskin Mountains. Structural thickness approximately 350 m

Metamorphosed Kaibab Limestone (Permian)[2]—Calcitic marble, dolomitic marble, anhydrite or gypsum, metachert, and minor calcareous quartzite and calc-hornfels. Strongly foliated; beds transposed. Small-scale interfolial folds locally abundant. Divided into:

Pku **Upper member**—Slope-forming light-gray anhydrite or gypsum, brown to green fine-grained calcareous quartzite and calc-hornfels, and white to dark-gray calcitic marble, some containing thin layers of brown metachert. Upper contact placed above a resistant bed of dark-gray marble. Structural thickness approximately 250 m

Pkm **Middle member**—Cliff-forming white calcitic marble containing thin layers of brown metachert. Stratigraphic base absent because of faulting. Exposed structural thickness approximately 100 m

Pkl **Lower member**—Massive white, light-gray, and buff calcitic and dolomitic marble; minor light-gray gypsum or anhydrite. Stratigraphic top of unit absent because of faulting. Maximum exposed structural thickness approximately 700 m

Pmq **Marble and quartzite (Permian)**—Highly foliated white marble and light-gray, fine-grained quartzite that form a thin band bounded on both sides by layered orthogneiss and orthoschist (Jgn) at southeast end of the Granite Mountains. Probably equivalent to lower member of the metamorphosed Kaibab Limestone and the metamorphosed Coconino Sandstone

Pc **Metamorphosed Coconino Sandstone (Permian)**[2]—Strongly foliated, light-gray, fine-grained quartzite. Lower part includes light-green schist that may correlate with the Permian Hermit Shale. Structural thickness approximately 100 m

PPs **Metamorphosed Supai Formation (Permian and Pennsylvanian)**[2]—Cliff-forming, dark-brown-weathering quartzite, calcareous quartzite, and calc-silicate rock. Strongly foliated; beds transposed. Stratigraphic base and top locally absent because of faulting or intrusion by Jurassic metaplutonic rocks. Maximum exposed structural thickness approximately 400 m

Mr **Metamorphosed Redwall Limestone (Mississippian)**[2]—Massive white marble. Stratigraphic base absent because of faulting or intrusion by Jurassic metaplutonic rocks. Maximum exposed structural thickness approximately 50 m

gdg **Granodiorite gneiss and amphibolite (Mesozoic or Proterozoic)**—Hornblende-biotite granodiorite gneiss and amphibolite. Color index 10-20 for gneiss, 50 or higher for amphibolite. Gneiss locally contains large elongate mafic inclusions oriented parallel to foliation. Pervasively intruded by unmapped sills, dikes, and pods of foliated to unfoliated leucogranite inferred to correlate with units Klg and Kflg

[1]Previously considered part of the Palen Formation by Pelka (1973, 1974) and Leveque (1982)

[2]Assignment of unit names and ages based on lithostratigraphic correlation with Paleozoic formations of the Colorado Plateau and southern Great Basin (Stone and others, 1983)

Contact—Dashed where inferred or approximately located

Fault—Showing dip where known. Dashed where approximately located, dotted where concealed, queried where inferred. In cross section, arrows indicate direction of relative movement

Inferred anticline

Inferred syncline

Minor fold axis—Showing plunge

Strike and dip of beds

Inclined

Vertical

Horizontal

Overturned

Strike and dip of foliation—Includes transposed beds in some metasedimentary rocks and mylonitic foliation in some metaplutonic rocks

Inclined

Vertical

Strike and dip of inclined foliation and plunge of lineation in mylonitic rocks

Strike and dip of inclined foliation and horizontal lineation in mylonitic rocks

Strike and dip of joints

Potassium-argon sample locality

REFERENCES CITED

Bull, W.B., 1974, Geomorphic tectonic analysis of the Vidal region, in Information concerning site characteristics, Vidal Nuclear Generating Station: Southern California Edison Company, v. 3, Appendix 2.5S, 66 p.

Demaree, R.G., 1981, Geology of Palen Pass, Riverside County, California: San Diego, Calif., San Diego State University, M.S. thesis, 133 p.

Hamilton, Warren, 1982, Structural evolution of the Big Maria Mountains, northeastern Riverside County, southeastern California, in Frost, E.G., and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, California, Cordilleran Publishers, p. 1-27.

_____ 1987, Mesozoic geology and tectonics of the Big Maria Mountains region, southeastern California, in Dickinson, W.R., and Klute, M.A., eds., Mesozoic rocks of southern Arizona and adjacent areas: Arizona Geological Society Digest, v. 18, p. 33-48.

Hoiseh, T.D., Miller, C.F., Heizler, M.T., Harrison, T.M., and Stoddard, E.F., 1988, Late Cretaceous metamorphism in southeastern California, in Ernst, W.G., ed., Metamorphism and crustal evolution of the western United States: Englewood Cliffs, New Jersey, Prentice-Hall, p. 338-371.

Howard, K.A., Miller, D.M., and John, B.E., 1982, Regional character of mylonitic gneiss in the Cadiz Valley area, southeastern California, in Frost, E.G., and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, California, Cordilleran Publishers, p. 441-447.

John, B.E., 1981, Reconnaissance study of Mesozoic plutonic rocks in the Mojave Desert region, in Howard, K.A., Carr, M.D., and Miller, D.M., eds., Tectonic framework of the Mojave and Sonoran Deserts, California and Arizona: U.S. Geological Survey Open-file Report 81-503, p. 48-50.

Leveque, R.A., 1982, Stratigraphy and structure of the Palen Formation, Palen Mountains, southeastern California, in Frost, E.G., and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, California, Cordilleran Publishers, p. 267-273.

Martin, D.L., Krummenacher, Daniel, and Frost, E.G., 1982, K-Ar geochronologic record of Mesozoic and Tertiary tectonics of the Big Maria-Little Maria-Riverside Mountains terrane, in Frost, E.G., and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, California, Cordilleran Publishers, p. 519-549.

Miller, D.M., and Howard, K.A., 1985, Bedrock geologic map of the Iron Mountains quadrangle, San Bernardino and Riverside Counties, California: U.S. Geological Survey Map MF-1736, scale 1:62,500.

Pelka, G.J., 1973, Geology of the McCoy and Palen Mountains, southeastern California: Santa Barbara, Calif., University of California, Ph.D. thesis, 162 p.

_____ 1974, Geology of the McCoy and Palen Mountains, southeastern California: Dissertation Abstracts International, v. 35, no 1, p. 327-B.

Reynolds, S.J., Spencer, J.E., and DeWitt, Ed, 1987, Stratigraphy and U-Th-Pb geochronology of Triassic and Jurassic rocks in west-central Arizona, in Dickinson, W.R., and Klute, M.A., eds., Mesozoic rocks of southern Arizona and adjacent areas: Arizona Geological Society Digest, v. 18, p. 65-80.

Steiger, R.H., and Jager, Emilie, 1977, Subcommission on geochronology: convention and use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Stone, Paul, Howard, K.A., and Hamilton, Warren, 1983, Correlation of metamorphosed Paleozoic strata of the southeastern Mojave Desert region, California and Arizona: Geological Society of America Bulletin, v. 94, p. 1135-1147.

Tosdal, R.M., Haxel, G.B., and Wright, J.E., in press, Jurassic geology of the Sonoran Desert region, southern Arizona, southeast California, and northernmost Sonora: construction of a continental-margin magmatic arc: Arizona Geological Society Digest, v. 17.

Table 1. Potassium-argon geochronologic data

Map locality number	Field sample number	Location (lat., long.)	Map unit	Rock description	Material dated	Percent K_2O (ave.)	$^{40}Ar_{rad}$ (10^{-10} moles/gm)	Percent $^{40}Ar_{rad}$	Apparent age (Ma)
1	84-PL-30	33°53'06" 115°02'48"	Jr	rhyodacite	biotite	9.45	9.62 9.43	76.8 51.5	69.4±1.7 68.0±1.7
2	85-PL-9	33°53'39" 115°04'44"	Tb	basalt flow	whole rock	2.16	0.19	61.4	6.2±0.2
3	85-PL-10	33°53'55" 115°05'06"	Tb	basalt dike	whole rock	1.87	0.17	54.5	6.4±0.2
4	85-PL-11	33°53'31" 115°05'08"	Tb	basalt flow	whole rock	2.27	0.21	49.8	6.4±0.2

Geochronology by J.K. Nakata: K_2O analyses by S. Neil

Constants used are: $\lambda_\epsilon + \lambda_{\epsilon'} = 0.581 \times 10^{-10}yr^{-1}$; $\lambda_\beta = 4.92 \times 10^{-10}yr^{-1}$; $^{40}K/K = 1.167 \times 10^{-4}$ (Steiger and Jager, 1977)

Error represents 2.5 percent of apparent age