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GEOLOGIC MAP OF THE CENTRAL AND NORTHERN FUNERAL MOUNTAINS AND ADJACENT AREAS, DEATH VALLEY REGION, SOUTHERN CALIFORNIA

by

B. W. Troxel and L. A. Wright

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Scale 1:48,000

Base from U.S. Geological Survey 15 Minute Quadrangle Series
Chloride Cliff, California-Nevada (1959)
Big Dune, Nevada-California (1952)
Stovepipe Wells, California (1952)

Geologic mapping by B.W. Troxel and L.A. Wright 1961-1987; mapping of evaporite deposits in Death Valley modified after Hunt and Mabey (1966). Although geologic section lines are indicated on the map, no geologic sections are intended to accompany this publication.

INTRODUCTION

This map, which includes the central and northwestern parts of the Funeral Mountains and the adjacent part of northern Death Valley, contains exposures of major features in the structural and stratigraphic framework of the Death Valley region. Within the map area, the Funeral Mountains consist of a parautochthonous backbone bounded on the northeast by the gently northeast-dipping Boundary Canyon fault and on the southwest by the gently- to moderately-dipping Keane Wonder fault. The map area also lies athwart the Furnace Creek fault zone, the single most prominent structural feature in the region.

The backbone of the central and northwestern Funeral Mountains is underlain mostly by Proterozoic rocks and displays an Early Cretaceous metamorphic overprint which decreases southwestward from a maximum of amphibolite grade in the most northwesterly part of the mountains (Labotka, 1980; De Witt and others, 1988) to lowermost greenschist grade in the Echo Canyon area of the southeast Funeral Mountains (Tom Hoisch, oral communication).

The oldest of the Proterozoic rocks are exposed in a doubly-plunging anticline in the most northwesterly part of the mountains. A quartzofeldspathic basement complex radiometrically dated at about 1.7 Ga is exposed in two inliers in the deeply eroded core of the anticline, and is overlain by the three formations of the Pahrump Group. The Pahrump, in turn, is overlain unconformably by the Johnnie Formation, the basal unit of the miogeoclinal succession in the southwestern Great Basin. Most of the central part of the Funeral Mountains is underlain by the Johnnie and, more extensively, by the overlying Stirling Quartzite. The two formations are involved in broad, northeast-trending folds, each extending across the full width of the backbone. The most prominent of these is an anticline, steepened on the southeast and truncated on the southwest by the Keane Wonder fault. Exposed in the southeast corner of the map area is a segment of a zone of Mesozoic thrust faults which places the Cambrian Wood Canyon Formation over formations of younger Cambrian to Devonian age. The central part of the Funeral Mountains has also been broken, but not greatly extended by numerous north-northeast striking normal faults.

Where the Boundary Canyon fault is continuously exposed for a distance of about 18 km along the northeastern edge of the Funeral Mountains, it cuts downsection in the underlying rock units through the lower part of the Stirling Quartzite and the upper part of the Johnnie Formation. The upper plate consists of units no older than member C of the Stirling. Thus, along the most northwesterly exposures of the Boundary Canyon fault, a stratigraphic thickness of about 4 km is missing and relatively unmetamorphosed units of the upper part of the Stirling Quartzite overlie staurolite-bearing pelitic schist of the lower part of the Johnnie Formation.

In the map area the upper plate also contains the Wood Canyon Formation and, locally, the Zabriskie Quartzite, as well as a succession of Tertiary sedimentary rocks. The latter sequence includes the Oligocene Titus Canyon Formation at its base and the Miocene (11.3 to 11.1 Ma) Timber Mountain Tuff near its top. The entire upper plate has been deformed to a much greater degree than the rock units beneath the Boundary Canyon fault. Both the pre-Tertiary and Tertiary formations have been folded, along northwest- to northeast-trending axes. The folds in the pre-Tertiary formations range from large-scale to small-scale and are characteristically tight and overturned to the southwest. Those that involve only Tertiary rocks are more open and upright. A general parallelism between the bedding in the Titus Canyon Formation and the bedding in the underlying Wood Canyon Formation indicates that the major deformational features of the upper plate, including the folds in the pre-Tertiary rock units, are Tertiary in age. The folds, in turn, have been cut by numerous normal faults, all of them confined to the upper plate and commonly showing listric terminations against the Boundary Canyon fault.

In its northwesterly exposures, the Keane Wonder fault zone separates Tertiary sedimentary rock units on the southwest from brecciated Proterozoic rocks. To the southeast, it extends into the bedrock where the mountain front bends abruptly westward. Traced southeastward, beyond the southern boundary of the map, the fault zone terminates by splaying southward into arcuate normal faults.

For most of its exposed length, the Keane Wonder fault is the principal and southwesternmost break in a zone of complex brecciation and faulting and folding in the pre-Tertiary rock units. Several of the normal faults in the interior of the range extend into this zone southward to southeastward in a manner consistent with right lateral movement on the Keane Wonder fault.

About 5 km of right lateral displacement on the southeastern segment of the Keane Wonder fault is indicated by matching offset fold axes across the fault. Specifically, the major northeast-trending anticline-and-syncline pair exposed in the Stirling and Johnnie exposed on the northeast side of the fault appears to be matched uniquely by an anticline and syncline of comparable size and orientation about 5 km to the northwest and on the southwest side of the fault. On the northeast side of the fault zone, the core of the anticline exposes strata in the upper part of the Johnnie that are about 1.5 km stratigraphically beneath the oldest strata in the core on the opposite side. The tilting, thus indicated, was apparently coeval with the strike-slip displacement and probably was accompanied by a shallowing of the dip of the Keane Wonder fault zone. The northeastern side of the most northwesterly segment of one Keane Wonder fault zone contains additional evidence for right lateral movement in that various units of the Pahrump Group, Johnnie Formation, and Stirling Quartzite are bent westward to northwestward and severely attenuated, apparently the effects of right-lateral drag.

The northwestward convergence of the Boundary Canyon and Keane Wonder faults, their opposing dips, and their common Neogene ages would suggest that they are

remnants of a single antiformal fault surface. That they evolved separately, however, is indicated principally by the fact that the structural features of the upper plate of the Boundary Canyon fault are very different from those of the rock units that border the Keane Wonder fault on the southwest. Indeed, the pre-Tertiary rock units in the upper plate of the latter display features characteristic of the lower plate of the Boundary Canyon fault, including the offset folds. Also, the geometry of the two faults and of their associated structural features is markedly different, the Keane Wonder features being much the more complex. Moreover, the northeastward tilting of the Funeral Mountain block, if coeval with strike slip movement on the Keane Wonder fault, would require the spatial separation of the two faults. The tilting also points against the antiform concept.

ACKNOWLEDGEMENTS

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DESCRIPTION OF MAP UNITS

SALINE DEPOSITS

(mapping modified from Hunt and Mabey, 1966)

Qs — Sand (Holocene)--Sandy playa or lake deposits impregnated with younger carbonate salts. Commonly a caliche-like layer of sulfate salts below the surface. Equivalent to unit Qcs of Hunt and Mabey (1966)

Qmg — Massive gypsum (Holocene)--Massive gypsum capped by anhydrite and/or bassinite. Thin veins of rock salt. At surface, light-brown silty gypsum layer containing various salts and clastic minerals, probably eolian. Equivalent to unit Qsg of Hunt and Mabey (1966)

Qms — Sulfate salts (Holocene)--Mostly sulfate salts, with some rock salt. Equivalent to unit Qsm of Hunt and Mabey (1966)

Qmc — Carbonate salts (Holocene)--Sodium carbonate and other carbonate salts. Equivalent to unit Qcm of Hunt and Mabey (1966)

Qsc — Slabby rock salt (Holocene)--Surface layer of brown silt containing sulfate salts. Underlain by irregular slabby rock salt. Silt at base. Equivalent to unit Qch of Hunt and Mabey (1966)

Qr — Reworked rock salt (Holocene)--Silty rock salt reworked from other chloride-zone deposits. Equivalent to unit Qhe of Hunt and Mabey (1966)

Qrss — Smooth silty rock salt (Holocene)--Surface layer is brown silt containing sulfate and borate salts. Underlain by rock salt with smooth surface. Silt at base. Equivalent to unit Qhs of Hunt and Mabey (1966)

Qrsr — Rough silty rock salt (Holocene)--Surface layer is brown silt containing sulfate and borate salts. Underlain by rock salt with rough surface. Equivalent to unit Qhr of Hunt and Mabey (1966)

OTHER SURFICIAL DEPOSITS

Qd — Dune sand (Holocene)--Unconsolidated wind-blown sand forming active dune fields

Qfp — Flood plain deposits (Holocene)--Mostly unconsolidated silt and sand, locally includes gravel near gradational contacts with alluvial fan units

Qt — Talus (Holocene and Pleistocene)--Unconsolidated, locally derived, angular rock fragments forming talus cones and slope wash

Qtr — Travertine (Holocene and Pleistocene)--Spring-generated travertine deposits, mostly along the southwest rangefront of the Funeral Mountains

Ql — Landslide deposits (Holocene and Pleistocene)--Semi-coherent masses of rocks that have been dislodged from underlying bedrock unit and moved downslope. (Slide masses are colored on map to depict parent bedrock unit)

Alluvial fan gravel and associated stream gravel deposits (Holocene and Pleistocene)--Divided into:

Qg4 — Unit 4 (Holocene)--Fan and stream deposits. Relatively undissected and devoid of desert varnish. Southwest of Funeral Mountains is mostly channel fill on older Quaternary units

Qg3 — Unit 3 (Holocene and Pleistocene)--Fan and stream deposits, undeformed and moderately dissected. Moderately dark coating of desert varnish common

Qg2 — Unit 2 (Pleistocene)--Fan and stream deposits, undeformed and deeply dissected. Dark coating of desert varnish characteristic

Qg1 — Unit 1 (Pleistocene)--Fan and stream deposits. More deeply eroded than unit Qg2. Commonly caps one or more erosion surfaces tens of feet above present stream channels. Displays dark coat of desert varnish. Also includes isolated deposits high in Funeral Mountains

Qlm — Deposits of Lake Manly (Pleistocene)--Mostly unconsolidated shoreline gravel deposits, locally includes some ponded silt deposits

BEDROCK

Funeral Formation (Pleistocene? and Pliocene)--Unit here may include strata older than those at its type locality in Furnace Creek Wash. Divided into:

QTfc — Conglomerate facies--Mostly fanglomerate derived from Funeral Mountains (predominantly contains clasts derived from the Wood Canyon Formation and Stirling Quartzite with sparse clasts derived from the Johnnie Formation); in the western part of Salt Creek Hills clasts of the Hunter Mountain Quartz Monzonite are common (nearest outcrops of the Hunter Mountain Quartz Monzonite are 25 km to the west in southern Cottonwood Mountains). Distinguished by stippled pattern on map

QTfs — Siltstone-sandstone facies--Mostly unconsolidated silty lake sediments

QTb — Basalt (Quaternary or Pliocene)--Basalt flows associated with outcrops of the Funeral Formation southwest of Devils Cornfield

Td — Mafic dikes (Tertiary)--Fine to medium crystalline mafic dikes cutting pre-Cenozoic bedrock in the northern Funeral Mountains

Furnace Creek Formation (Pliocene? and Miocene)--Divided into:

Tfc — Conglomerate facies--Mostly fanglomerate, derived mainly from reworking of older Tertiary conglomerate units similar to those still exposed on the flanks of the Funeral Mountains. Distinguished by stippled pattern on map

Tfs — Siltstone-sandstone facies--Mostly poorly consolidated silty lake sediments

Ts — Sedimentary rocks (Pliocene and (or) Miocene)--Siltstone, sandstone, and conglomerate, lying concordantly on the Timber Mountain Tuff in northeastern corner of Chloride Cliff quadrangle. (Also included in this unit are conglomerate deposits cropping out in the southeastern part of the Funeral Mountains, which contain intercalated layers of monolithologic breccia derived mainly from the Wood Canyon and Bonanza King Formations.) These conglomerate deposits may or may not correlate with the sedimentary rocks in the northeast corner of the Chloride Cliffs quadrangle

Tb — Basalt (Pliocene or Miocene)--Basalt flows intercalated with unit Ts and sills and dikes intruding older Tertiary volcanic and sedimentary deposits in the northeast corner of the Chloride Cliff quadrangle

Timber Mountain Tuff and associated sedimentary rocks (Miocene)--Divided into:

Ttma — Ammonia Tanks Member--Ash-flow tuff and air-fall(?) tuff

Ttmt — Tuffaceous beds--Interlayered tuff, siltstone, sandstone, and conglomerate

Ttmr — Rainier Mesa Member--Ash-flow tuff and air-fall(?) tuff

Sedimentary rocks (Miocene)--Strata older than the Timber Mountain Tuff. Divided into:

Tsa — Arkosic sandstone, conglomerate, and subordinate siltstone--Volcanic clasts abundant. Locally contains several layers of tuff (t)

Tst — Tuffaceous sandstone and volcanic breccia

Tsm — Sandstone, siltstone, conglomerate, and tuff (Miocene)--Unit includes subordinate limestone in upper part

Ttc — Titus Canyon Formation (Oligocene)--Mostly pebble-to-boulder conglomerate with well-rounded and commonly polished clasts, subordinate sandstone, siltstone, tuff and algal limestone. Lenses of monolithologic breccia composed of clasts of Cambrian formations common in basal part

DSh — Hidden Valley Dolomite (Devonian and Silurian)--Dolomite, thick-bedded; chert common in lower part

Oes — Ely Springs Dolomite (Ordovician)--Dolomite, mostly thick-bedded, commonly chert-bearing

Oe — Eureka Quartzite (Ordovician)--Orthoquartzite, poorly bedded

Op — Pogonip Group (Ordovician)--Mostly dolomite, subordinate layers of sandstone, siltstone, and limestone

Cn — Nopah Formation (Cambrian)--Dolomite and limestone, mostly thick bedded

Cbk — Bonanza King Formation (Cambrian)--Dolomite and limestone, mostly thick-bedded; very subordinate silty layers in lower part

Cc — Carrara Formation (Cambrian)--Limestone interlayered siltstone intervals containing subordinate sandstone beds

Cz — Zabriskie Quartzite (Cambrian)--Orthoquartzite, fine- to coarse-grained, generally thin-bedded

Wood Canyon Formation (Cambrian)--Divided into:

Cwu — Upper member--Interlayered fine- to medium-grained feldspathic sandstone, and siltstone and dolomite. Contains lowest-occurring trilobite fossils in the Funeral Mountain section. Dolomite lens (dol) forms uppermost part in exposures north and east of Chloride Cliff

Cwm — Middle member--Conglomeratic arkose in lower part; grades upward into coarse- to fine-grained feldspathic sandstone and subordinate siltstone

Cwl — Lower member--Interlayered fine- to medium-grained feldspathic sandstone, siltstone, and dolomite

Stirling Quartzite (Late Proterozoic)--Divided into:

Zse — Member E--Medium- to coarse-grained sandstone; mostly altered to orthoquartzite

Zsd — Member D--Mostly fine- to medium-grained feldspathic sandstone; siltstone layers common in lower part and are progressively less abundant upward

Zsc — Member C--Dolomite and limestone; massive to thin-bedded and very fine grained, upper part silty in northern part of map area

Zsb — Member B--Fine-grained arkosic sandstone, micaceous siltstone, and beds of carbonate rocks; typically laminated. Siltstone within this member metamorphosed to garnet-bearing schist in northern Funeral Mountains

Zsa — Member A--Mostly fine- to coarse-grained sandstone, ranging from orthoquartzite to arkose; contains abundant beds of quartz-pebble conglomerate and platy siltstone. Also contains a dolomite and limestone marker bed (dl) in upper part. Intervals of siltstone with abundant thin interlayers of carbonate rocks occur above and below

carbonate marker unit. Relative proportion of carbonate rocks in these intervals increases northward. Siltstone within this member metamorphosed to garnet-bearing schist in northern Funeral Mountains

Johnnie Formation (Late Proterozoic)--Mostly pelitic metasedimentary rocks, greenschist grade in southeast part of map area to staurolite-biotite amphibolite grade in northwest part. Divided into:

Zju — Upper member--Alternating layers of schist and quartzite (and/or pebbly quartzite). Carbonate rock unit in upper part probably correlative with Rainstorm Member (of the Johnnie Formation) mapped elsewhere

Zjm — Middle member--Pelitic schist; upper part mostly green-weathering schist. Lower part commonly contains silty, orange-weathering, calcareous layers

Zjl — Lower member--Mostly pelitic schist; Contains amphibolite layers in upper part; contains layers of calcite-marble and pebbly quartzite in lower part

Kingston Peak Formation (Middle? Proterozoic[1/])--Divided into:

Yku — Upper member--Conglomerate; clasts mostly quartzite and limestone supported in matrix of pelitic staurolite- and biotite-bearing schist. Limestone clasts commonly are severely stretched

Ykl — Lower member--Pelitic staurolite- and biotite-bearing schist and subordinate calcite marble; typically laminated

Yb — Beck Spring Dolomite (Middle? Proterozoic[1/])--Calcite marble facies; well laminated

Crystal Spring Formation (Middle? Proterozoic[1/])--Divided into:

Ycu — Upper member--Mostly staurolite- and biotite-bearing pelitic schist and micaceous quartzite; subordinate layers of calcite marble and amphibolite

Ycm — Middle member--Mostly calcite marble, subordinate layers of staurolite- and biotite-bearing pelitic schist

Ycl — Lower member--Mostly staurolite- and biotite-bearing pellitic schist; also abundant tabular bodies of amphibolite and several carbonate marker beds (a,b,c)

Xmi — Metamorphic and igneous rocks (Early Proterozoic)--Unit composed of sillmanite-grade metasedimentary rocks, commonly migmatized. Contains abundant pegmatite dikes and other small acidic plutons. Two-mica granitic rocks from this unit yield U-Pb age for zircon of about 1.7 Ga (Zartman, written communication, 1985)

[1/]Albee and others (1981) consider these formations to be Proterozoic in age. In this report, we assign a provisional age of Middle(?) Proterozoic to these units on the basis of their intermediate position in the Proterozoic sequence, separated by profound unconformities from the overlying Late Proterozoic Johnnie Formation and the underlying Early Proterozoic metamorphic and igneous rocks unit.

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