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Geological landscapes of the Death Valley region☆

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1. Introduction

Death Valley's location and climate make it one of the most dramatic geological landscapes on Earth. The region lies near the western edge of cratonic North America, and so it contains a record of plate boundary effects that date back to the Proterozoic. These effects include rifting and the development of the passive margin during the Late Proterozoic, crustal shortening and Sierra Nevada magmatism largely during the Mesozoic, and crustal extension and magmatism during the Late Cenozoic. Because crustal extension continues today, the region also showcases spectacular landforms that relate to active mountain-building.

When combined with this geology, Death Valley's harsh climate makes it unique. As the hottest and driest area in North America, both its geological record and landforms are unusually visible to geologists and non-geologists alike. It is for this reason that the national park overflows with geology field trips during the spring months, and many visitors gain a deeper understanding of Earth processes.

The authors of this volume represent several hundred years of collective experience working on the geology of the Death Valley region. Lauren Wright and Bennie Troxel alone have logged more than one hundred years. It is easy to see why so many geologists keep coming back: traveling through this landscape is like walking through a beautifully illustrated geology textbook, only better. The following photographs attempt to portray some pages of that textbook, but like all photographs, they fall well short of an actual visit.

Each photograph is keyed to a number on the accompanying geologic map (Miller and Wright, 2004) (Fig. 1). An arrow adjacent to a number indicates the direction of view. Those photographs that portray crustal extension or modern landforms appear in the first section. Those that illustrate the older geologic history appear in the second section.

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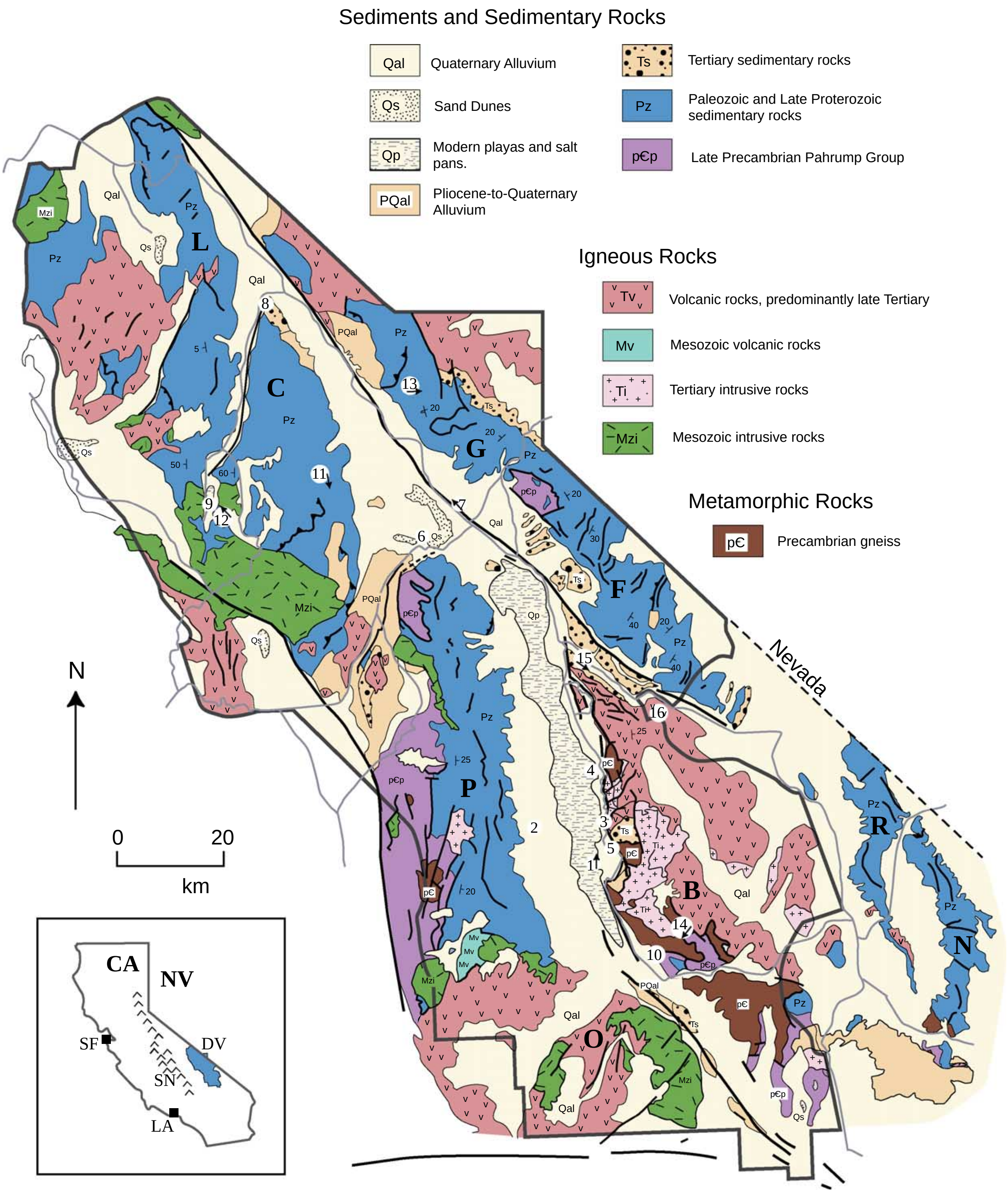

Fig. 1. Geologic map of Death Valley area, compiled by Miller and Wright (2004). Numbers and arrows depict corresponding photo location and direction of view. Abbreviations for mountain ranges are as follows: B: Black Mountains; C: Cottonwood Mountains; F: Funeral Mountains; G: Grapevine Mountains; L: Last Chance Range; N: Nopah Range; O: Owlshead Mountains; P: Panamint Mountains; R: Resting Spring Range. Abbreviations on location map of California are as follows: CA: California; DV: Death Valley National Park; LA: Los Angeles; NV: Nevada; SF: San Francisco; SN: Sierra Nevada Mountains.

2. Modern landforms and crustal extension

Photo 1. View northward along west side of Black Mountains. The Black Mountains consist predominantly of late Tertiary plutonic, volcanic, and sedimentary rock and a basement of Late Proterozoic metamorphic rock. They rise above the floor of Death Valley along the Black Mountains fault zone. The alluvial fans that spill out of each canyon tend to be relatively small because the valley floor tilts gently eastward. The Grapevine Mountains, in the far background, are approximately 80 km away.

Photo 2.

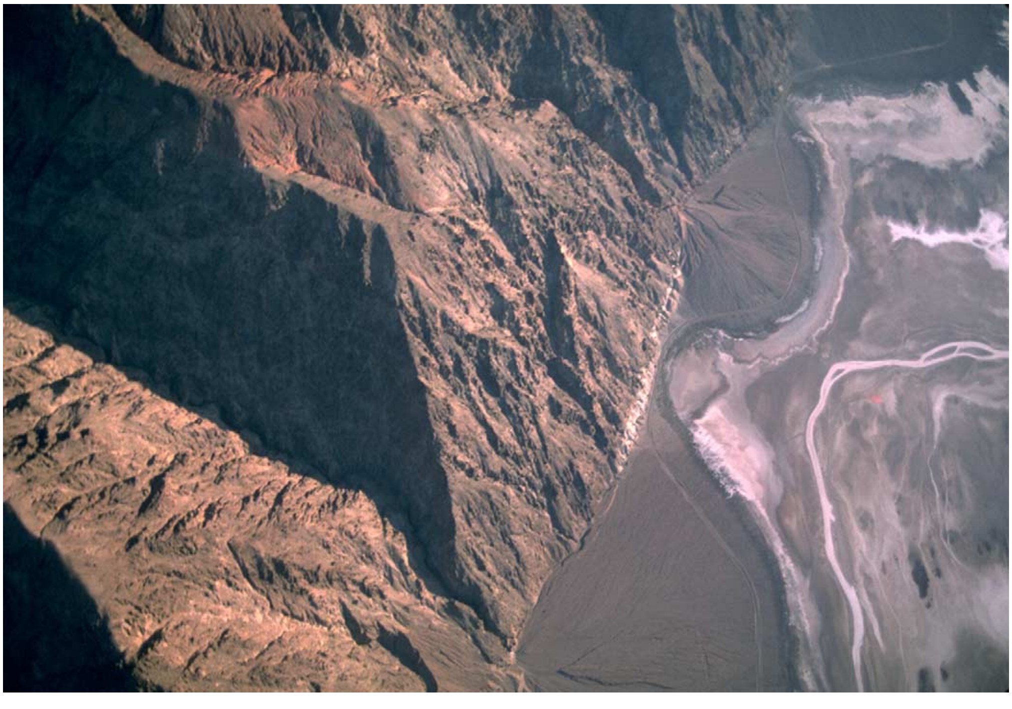

Photo 3.

Photo 2. Bajada at Hanaupah Canyon (see preceding page). In contrast to the small, well-shaped fans on the east side of Death Valley, those on the west side coalesce into a gigantic bajada at the mountain front. Jayko (2005—this volume) characterizes rates of erosion for the Panamint Mountains. A fault scarp cuts diagonally across the bajada in the bottom half of the photo. Vegetation marks locations of springs at the lowest reaches of the bajada.
Photo 3. Black Mountains fault zone (see preceding page). The Black Mountains fault zone displays all the characteristics of active faults, including an extremely abrupt and linear range front, faceted spurs, and wineglass canyons.
Photo 4. Salt pan at Badwater, view southward. Much of the valley floor of Death Valley is covered by salt that is broken into large polygons. This view to the south also shows the abrupt western edge of the Black Mountains. Messina et al. (2005—this volume) characterize polygon morphology in northern Panamint and Eureka valleys.

Photo 5. Copper Canyon turtleback. There are three turtlebacks in the Black Mountains, named because their broadly convex-upwards geometries resemble turtle shells (Curry, 1938). Each turtleback exposes a core of metamorphosed sedimentary and basement rock separated from an upper plate of sedimentary or volcanic rock by a fault zone. This photograph shows green-colored metamorphic rock faulted against red- and tan-colored sedimentary rock just south of Copper Canyon. Miller and Pavlis (2005—this volume) describe the structural evolution of the three turtlebacks and their implications for crustal extension in the region. Cemen et al. (2005—this volume) describe similar features in Turkey.

Photo 6. Mesquite Flat Sand Dunes (see next page). The Death Valley region hosts numerous sand dune fields, each of which exists in a setting that is partially protected from the wind. These dunes on Mesquite Flat lie at the northern foot of Tucki Mountain, off to the side from the main part of Death Valley. They contain both crescentic and star dunes.

Photo 7. Kit Fox Hills and Northern Death Valley fault zone (see next page). The Kit Fox Hills consist of folded and faulted Late Tertiary and Quaternary sediments. The hills end abruptly at the northern Death Valley fault zone, shown here cutting diagonally across the photo. This view to the northwest also shows much of northern Death Valley, with the Cottonwood Mountains on the left and the Grapevine Mountains on right.

Photo 6.

Photo 7.

Photo 8.

Photo 9.

Photo 8. Little Hebe Craters (see preceding page). This cluster of small phreatic explosion craters exists on the shoulder of the much larger Ubehebe Crater in northern Death Valley. A total of 13 explosions produced the entire field (Crowe and Fisher, 1973).

Photo 9. Sliding rock at Racetrack Playa (see preceding page). At an elevation of 4000 ft and a long stretch of valley to funnel the wind, Racetrack Playa hosts rocks that occasionally slide across the playa surface. No one has actually seen them move, so the actual cause has been long debated. The rock in this photo is approximately 30 cm across.

3 . Geologic history

Photo 10. Diabase sill and basement unconformity, view southward. The Crystal Spring Formation, which is the lower part of the Pahrump Group, rests depositionally on basement rocks. It is intruded by green-colored diabase sills that yielded an age of 1.08 Ga (Heaman and Grotzinger, 1992). Metamorphic reactions between the diabase and dolomite of the Crystal Spring Formation produced large deposits of talc, which have been mined throughout the Death Valley region. To the south, this photograph shows the western edge of the southern Black Mountains, and in the distant background, the Avawatz Mountains.

Photo 11. Cliffs of Paleozoic rock, Cottonwood Mountains. With the exception of the Black Mountains, every range in the Death Valley region is underlain by Late Proterozoic through Paleozoic marine sedimentary rocks. These rocks attain thicknesses of 10 km and were deposited on a long-lived passive margin, similar in many ways to the present-day eastern seaboard of North America.

Photo 12. Hunter Mountain Batholith and Paleozoic rock at Racetrack Playa (see next page). The Hunter Mountain Batholith, part of which is shown here as the dark-colored rock, is a Middle Jurassic pluton that reflects activity during early stages of the Sierran magmatic arc. Here it intrudes folded and thrust faulted Paleozoic rock (tan) to establish a pre-Middle Jurassic age for those structures. Stevens and Stone (2005—this volume) review these compressional structures. Saline Valley lies in the background; the Sierra Nevada lies in the far background, about 70 km away.

Photo 13. Folded rock in Grapevine Mountains (see next page). The Grapevine Mountains, mapped in detail by Reynolds (1969) and Niemi (2002), contain thick sequences of Paleozoic rock that was deformed into large-scale folds and faults during crustal shortening. Overlying these rocks are less deformed Tertiary sedimentary and volcanic rock.

Photo 12.

Photo 13.

Photo 14. Smith Mountain, Black Mountains. Smith Mountain, on the right side of this photograph, is underlain by the Smith Mountain pluton, one of several mid-Miocene plutons that intrude the Black Mountains. It consists largely of granite and locally contains distinctive rapakivi textures, described in detail by Calzia and Rämö (2005—this volume). Wingate Wash, a site of transtensional deformation described by Luckow et al. (2005—this volume) lies in the background.

Photo 15. Furnace Creek Formation at Zabriskie Point (see next page). The Furnace Creek Formation consists primarily of alluvial fan and playa deposits, shown here in the foreground and middle ground respectively. It was deposited from about 6–4 Ma, in the Furnace Creek Basin, an extensional basin that formed along the Furnace Creek fault zone prior to opening of modern Death Valley.

Photo 16. Angular unconformity at Ryan Mesa (see next page). This photograph shows undeformed 4 Ma basalt overlying Artist Drive Formation (left) faulted against tilted Furnace Creek Formation (right). This unconformity marks the end of active extension in the Furnace Creek Basin and the approximate onset of crustal extension in modern Death Valley. Knott et al. (2005—this volume) reconstruct the stratigraphy during this transition period.

Photo 15.

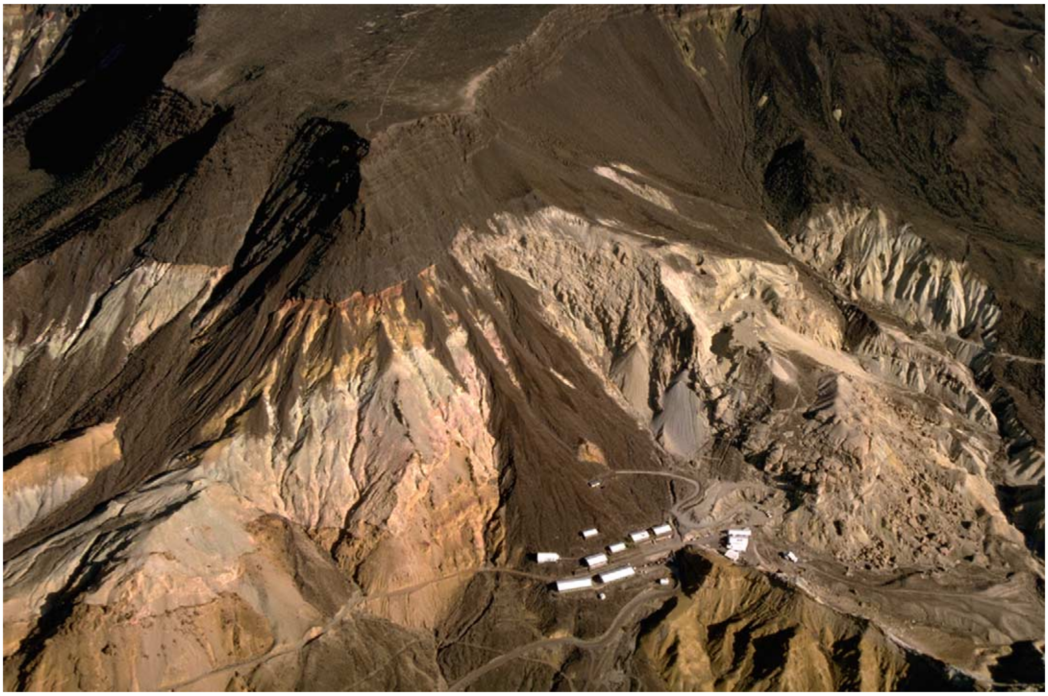

Photo 16.

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