PRICE
10
CENTS

The
NATURAL LANDSCAPE
of
JOSHUA TREE NATIONAL MONUMENT
a Geologic Résumé

Understand the landscape and you will know
800 million years of Earth's history.

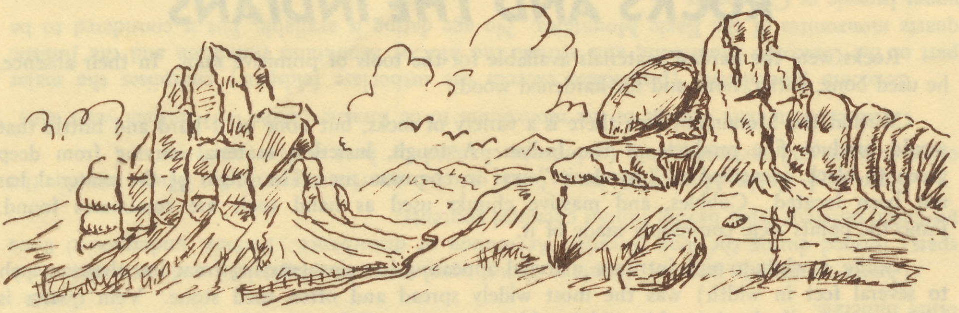
Published 1974 *by the*

JOSHUA TREE NATURAL HISTORY ASSOCIATION
74485 PALM VISTA DRIVE
TWENTYNINE PALMS, CALIFORNIA 92277

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

NATIONAL PARK SERVICE
Department of the Interior

DRINK A GALLON OF WATER A DAY DURING HOT WEATHER



THE NATURAL LANDSCAPE

MINING INTEREST

Rocks of the area range from ancient to modern. The first commercial interest in them was during the last part of the 1800s, especially by prospectors who were not successful in the mid-century rush to the coastal gold fields of California.

Gold was widely scattered in the general region. However, the quantity was so small that most miners spent more money mining and milling ore than was paid for it by the U.S. Mint. Selling stock in mining ventures probably yielded more profits than the mining.

The combined gold and silver production for the region weighed 16,000 ounces, 77% of which was gold. The total production was worth about $434,200 based on 1950 values of $35 an ounce for gold, and 80 cents for silver.

As of 1950, only one mine was still "active." Most gold was associated with vein quartz which was a relative newcomer in the geologic story of the area.

Many chapters and pages of Earth's history are missing. However some can be assumed or inferred from nearby and regional events which have left clues that are now found in well drillings, seismographic studies, exposed rock formations, and paleographic maps of western United States.

"Space" is a one-word description of the Monument. Here is one of the rare areas where one can see so far and so much without the invasion of man-made structures. "Catastrophe" describes the strewn, tumbled piles of rocks. "Confusion" is a geologic resumé.

Shapes of rocks are largely determined by two things, the regional cracks (joints) that have formed in the bedrock, and the effects of weathering after the chunks of rock have been freed from each other.

CRACKS IN THE ROCKS

The western side of Malapai Hill (near the middle of the Monument) has an exposure of lava, a rock that flowed as a hot molten mass close to the surface of the Earth and without great pressure from overlying materials. As it cooled, it shrank in volume. Patterns of cracks were similar to a honeycomb; they formed 5 to 8 sided figures which continued to pull apart as the cooling progressed deeper into the rock. When erosion undercuts the blocks, they fall apart and are prismatic in shape.

Reduction in volume through shrinking is also seen in the layers of mud in the playa (temporary) lakes of Pleasant and Queen Valleys as they dehydrate and become dry.

If large masses of bedrock are observed, it would be noted that when rocks of varying ages are in contact, and are cut by joints that don't deviate either horizontally or vertically, it is reasonable to assume that the factor(s) causing jointing must be younger than the youngest rocks. A further clue to this cause(s) of jointing is that it creates rectangular patterns and fragments. Such box-like fragments can be produced by releasing pressure. (Billings, 1946, p. 125)

The quartz monzonite granites that are frac-tured with rectangular joints infer another clue to the geologic story. Granites are only formed deep within the earth (several thousand feet

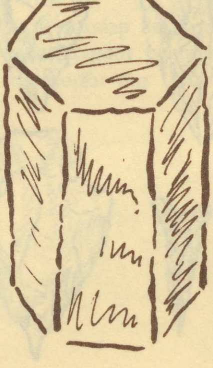


FIG. 1. HEXAGONAL PRISMATIC BLOCKS OF BASALT

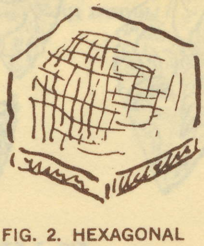


FIG. 2. HEXAGONAL MUD CRACKS

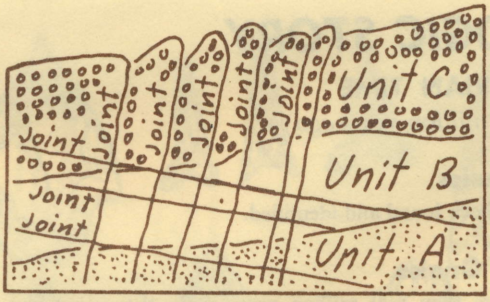


FIG. 3. RECTANGULAR JOINTING THROUGH ADJACENT STRATA OF DIFFERENT PERIODS

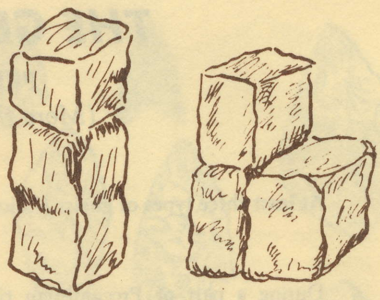


FIG. 4. BOX-LIKE FRAGMENTS CAUSED BY PARALLEL JOINTS

to several miles). Therefore it would be safe to assume that a very thick layer of materials (marine and otherwise, seen elsewhere in southern California) was eroded from the granites that are now on the surface. The loose erosional materials (sand, rocks, etc.) that fill the deep intermountain valleys also imply such an extensive removal of strata, otherwise where did it come from?

When adjacent blocks are separated by natural wedging of frost and humidity (and sometimes plants), they form box-like pieces of six sides.

Natural weather attacks the exposed angular edges to gradually form rounded boulders that could easily be confused with those formed by glacial activity.

Intermountain valleys have been filled with waste from the deteriorating rocks. Lacking slopes steep enough to provide movement of rock masses by gravity, or solifluction (sliding down hill) even in the presence of heavy rains or melting snows, the piles weather in place. Intermountain valleys remain essentially free of boulder fields. Flash floods do move some large boulders, but usually in very restricted valleys or canyons with steep gradients.

Other forces affect large masses of bedrock not so susceptible to jointing and block removal. The head of Rattlesnake Canyon in Indian Cove has well developed pot holes ground into bedrock. Rocks, churned by flash floods continue to move within the holes. The grinding action gradually enlarges their capacities to hundreds of gallons, often resulting in very steep or even undercut sides. These "pot" holes can form death traps for animals seeking water.

Pot holes sometimes provide water for the unfortunate person who becomes stranded in the desert. They are not a dependable source and are often polluted by stagnation and dead animals.

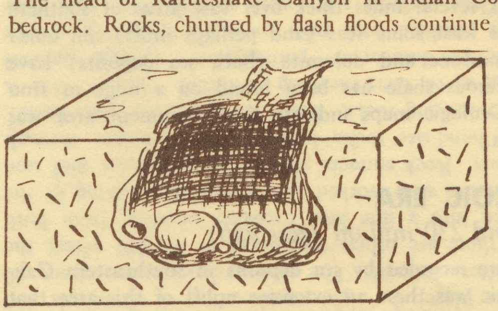


FIG. 6. POTHOLES GROUND INTO BEDROCK

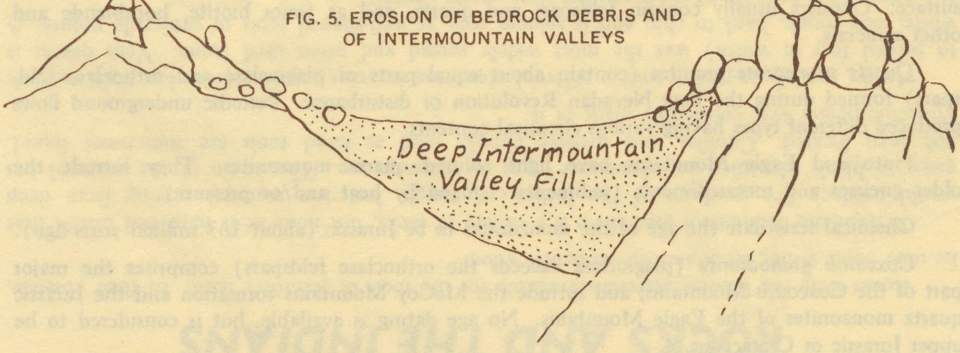


FIG. 5. EROSION OF BEDROCK DEBRIS AND OF INTERMOUNTAIN VALLEYS

ROCKS AND THE INDIANS

Rocks were the hardest materials available for the tools of primitive man. In their absence, he used bone, antler, horn and fire-hardened wood.

Within the Monument area there is a variety of rocks, but none of it hard and brittle that would produce fine products of the Indian. A tough, lusterless material varying from deep green to black, identified as "rhyodacite" was in common use. The origin of the material has not been located. Cobbles, and massive chunks used as hand tools are sometimes found. Projectile points were commonly made of it.

Aplite, a white-to-pink intrusive material appearing in veins (varying from less than an inch to several feet in width) was the most widely spread and often used stone. Vein quartz is white, very tough, hard to chip and is seldom seen as well-shaped tools or projectile points. A few points have been found made of glass-clear quartz crystals.

The red-to-brown, fine grained hard mineral called "jasper" is occasionally found in small veins. Its color rather than its quality was probably the reason for its use as tools. Obsidian, the most favored of materials, is black, hard, brittle, and easily shaped. Only pieces have been found. Even though volcanic activity did take place, the right combination of chemicals and activity failed to produce this highly sought-after material. The closest deposits are about 50 miles north of the Twentynine Palms Oasis; there are others southward in Mexico where the flaking and working of obsidian was developed into a fine art. Probably obsidian from both sources was traded for and used widely. Fragments were worked and reworked, resulting in the utilization of even tiny pieces as projectile points. Rock surfaces stained by manganese and iron oxides produced black surfaces. Using smaller hand-size rocks, Indians pecked designs through the stain to expose the lighter colors of the underlying rocks. Many designs have been found, but there is much doubt and misunderstanding as to their meaning or intent. As yet there is no method of dating the age of the rock pictures known as "petroglyphs." Designs painted onto the rocks are called "pictographs." The jumbled rock piles provided temporary shelter for wandering family-size bands of Indians. Their periodic stays were so temporary that they failed to even improve crude shelters with piled rock walls. The only evidence of their existence is the rock art, scattered fragments of pottery, stone tools, and darkened areas of decomposed campfire charcoal. Not one skeleton of these prehistoric people has been found.

FIG. 7. STONE PROJECTILE POINTS AND STONE TOOLS CHIPPED BY INDIANS

THE GEOLOGIC STORY

PRECAMBRIAN TIME

(*More than* 600 *million years ago*)

Gneiss

At least three types of gneiss ("nice") have been found and identified.

Pinto Gneiss

During a part of Precambrian times (more than 600 million years ago), the region was covered by sedimentary deposits resulting from well-weathered igneous (solidified molten rock) debris. All but the most durable minerals were destroyed by erosion; the resulting deposits were largely quartz sands mixed among boulders, cobbles and pebbles.

In Precambian times these deposits were buried to a depth of several miles, sufficient for the overlying weight to create heat and/or pressure of sufficient magnitude to cause the weathered materials to compress, flow and change their physical nature to black gneiss which was basically unchanged chemically. The excess quantity of quartz (as much as 70%) implies the original material was well weathered before transformation. Most igneous rocks have less than 40% silica or quartz. Formation of the gneiss is estimated to have occurred as much as 800 million years ago. Excess deposits of quartz became light colored zones which sometimes took the patterns of gracefully flowing lines that preserved the contortion and stresses of the changing rocks.

There are no known local clues as to the geologic events between the formation of the gneiss and the Paleozoic Era. Major faults of the region probably had their origin prior to the Cambrian and have maintained their zones of activity through geologic time.

PALEOZOIC ERA

(*Between* 230 *million and* 600 *million years ago*)

Seas deposited layers of marine sediments several miles thick over vast areas of southern California; the total thickness is unknown. At least some seas (and perhaps most) did cover the Monument. Thin layers of Paleozoic limestone and dolomite (both sea deposits) have been found near the south boundary. Fossilferous shale has been found on a ridge in Iron Mountain near the northeastern boundary. Geologic maps indicate the Monument area was covered by at least eight different Paleozoic seas.

MESOZOIC ERA

(*Between* 63 *million and* 230 *million years ago*)

Triassic and Jurassic Periods of this era are recorded by sea deposits in southeastern California. Not until the upper part of the Jurassic was there an extensive uplift of this area that raised the marine deposits to drive the inland seas back to the ocean basins. This marked the Nevadan Revolution of western U.S., a time when great masses of molten underground rock pushed upward. Some ejected from the Earth as volcanics (lava and ash). Some, under the Monument area, failed to break through and formed masses of granite several miles below the surface. Granites usually contain feldspars and quartz, and at times biotite, hornblende and other minerals.

Quartz monzonite granites (contain about equal parts of plagioclase and orthoclase feldspars) formed during the long Nevadan Revolution or disturbance. Periodic underground flows produced different types having various chemical contents.

Pinto and Eagle Mountains have light colored quartz monzonites. They intrude the older gneisses and metasediments (sediments changed by heat and/or pressure).

Chemical tests date the age of the monzonites to be Jurassic (about 163 million years ago).

Coxcomb granodiorite (plagioclase exceeds the orthoclase feldspars) comprises the major part of the Coxcomb Mountains, and intrude the McCoy Mountains formation and the Jurassic quartz monzonites of the Eagle Mountains. No age dating is available, but is considered to be upper Jurassic or Cretaceous.

CRETACEOUS PERIOD

(Between 63 million and 135 million years ago)

Quartz monzonite of the Hexie and Eagle Mountains has intruded a gneissic mass, and has a lead-alpha age of 131 million years. It and the White Tank quartz monzonite are very similar.

White Tank quartz monzonite intrudes all surrounding major rock bodies. It has a potassium-argon date of about 83 million years, whereas a lead-alpha test indicated 161 million years. Type locality is at White Tank.

CENOZOIC ERA

(Present 63 million years of time)

Since the White Tank quartz monzonite is dated to be Cretaceous, the dikes cutting them are considered to be of Tertiary age (early part of Cenozoic Era). Several types have been recognized, and perhaps still more will be found during future studies.

Propylitic andestite dikes (all feldspar phenocrysts are plagioclase, extrusive equivalent of diorite) are widespread; usually trend northwest to north; do not occur in the Little San Bernardino or Coxcomb Mountains; sharply truncate older igneous and metamorphic deposits. Pleistocene olivine basalts and sediments overlie them but are not cut by the dikes. Their thickness varies from a few inches to 20 feet.

Rhyolite dikes (extrusive equivalent of granite) occur in the Eagle Mountains, but are rare in Pinto and Hexie Mountains; vary from a few to 100 feet in width; are a light tan color when weathered, but darker gray on freshly broken surfaces. They are probably post Jurassic as they cut quartz monzonite of that period.

Quartz latite porphyry dikes (extrusive equivalent of granodiorite with more than 5% quartz), a series of which cut across rhyolite dikes in the Eagle Mountains, also appear in the Pinto Mountains; trend northeast; are usually a few feet thick, and younger than the rhyolite dikes in the Eagle Mountains.

Granite aplites and granite pergmatites (aplites contain little to no ferromagnesian minerals; pegmatites have obvious crystals of feldspar) are found in the broad zone where the Fargo quartz monzonite intrudes the Blue granodiorite; are similar to dikes common in the Blue granodiorite; trend northwest; are common around Keys (Salton) View. The Fargo is probably Precambrian.

Pleistocene (?) deposits include olivine basalt flows interlaced with thin deposits of sand-

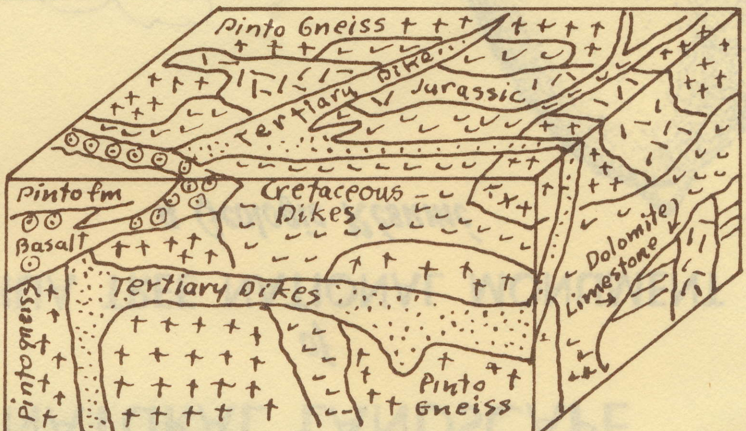


FIG. 8. DIAGRAMATIC BLOCK DRAWING SHOWING RELATIONSHIP OF MAJOR STRATA AND DIKES

stone, siltstone, conglomerate, clay and gypsum. Some vertebrate fossils have been found in the Pinto Basin area. Other fossils found east of Twentynine Palms were also identified as Pleistocene species. Several areas in the Monument have sedimentary rocks capped by or intermixed with olivine basalt flows. Those near Pinto Basin were probably exterior flows, whereas Malapai Hill has characteristics indicating it is the result of an old underground volcanic flow that has been exposed by erosion.

POST GLACIAL TIME

The flanks of San Gorgonio Mountain (west of the Monument) have glacial moraines, indicating that a much colder climate once existed. However, no glacial boulders, earth deposits or rock features suggesting glacial activity have been recognized among the more recent deposits in the Monument.

Studies of faults, especially long extensive ones, do not reveal any clues as to any major topographic changes since the last glacial period. However, there have been changes in the weather.

Immediately following the glacial period, sufficient water drained from the western highlands to support a lake in the Pinto Basin. Lake and river deposits indicate the lake overflowed and cut through a natural dam toward the southeast. Only a wide meandering river remained for a long period of time. Although some animal fossils have been found in fresh water deposits, only the shore deposits of the river contain the tools and campfire charcoals of the primitive Pinto Man culture. No fossils of fresh water animals have been found in any of the lake or river deposits. However some probably thrived in the fresh waters.

Today the climate is very hot and arid. Region-wide the annual precipitation varies from about 2 inches in the Lower Desert (containing the Pinto Basin) to about 6.5 inches in the higher altitudes. Temperatures range from the low 20s in mid-winter to well above 140° F. *in the summer sun.*

FAULTS

The Monument area has hundreds (if not thousands) of sub-major and minor faults both within and extending beyond the boundaries. Minor ones are normally the causes for the deeply cut, steep valleys and steep cliffs of rock. Faulting of impervious layers of valley fill resulted in the formation of the Twentynine Palms Oasis. It had active flowing sources of water until 1948. Several earthquakes a year occur, some strong enough to feel, so it is obvious that some of these faults are still active.

Blue Cut Fault is an east-west fault through the Little San Bernardino Mountains on the south side of the Monument. The west end merges with the Dillon Fault. Eastward, the fault probably terminates in the vicinity of the Sheep Hole Fault zone near the east boundary of the Monument. South of the Blue Cut and Dillon Faults lies the major San Andreas Fault. Other more localized ones join the Blue Cut, especially in Pleasant Valley and the Pinto Basin areas. The Blue Cut Fault is probably of Precambrian origin.

Pinto Mountain Fault goes westward to eventually join the San Andreas Fault zone. Eastward it lies along the north slopes of the Monument and is paralleled by a second extensive but minor fault in the vicinity of Twentynine Palms. The Twentynine Palms Oasis is on the Pinto Mountain Fault.

Miscellaneous related faults. Although not within the Monument area, several parallel faults do extend northwestward from the vicinity of the Pinto Mountain Fault. Some are unnamed, others include: Mesquite, Copper Mountain, Johnson Valley, Lenwood, Old Woman Springs, and the Pipes Canyon.

The Monument sits on the southern edge of the Mojave Block which is the desert portion of the Transverse Range Province. The Block is bounded on the north by the Garlock Fault, and on the south by the San Andreas fault.

GEOLOGIC INFORMATION

Joshua Tree National Monument

Era	Period	Epoch	Geologic events and rocks	
CENOZOIC ERA Recent 63,000,000 yrs.	Quaternary	Recent	Prehistoric man	
		Pleistocene	Horse and camel fossils Olivine basalt flows mixed with clay, gypsum, conglomerate, etc.	Pinto form.
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	Abundant dikes injected: Propylitic andesite with gold-bearing quartz veins Rhyolite Qtz. latite porphyry Granite pegmatites Granite aplites	
MESOZOIC ERA 63,000,000-230,000,000 yrs.		Cretaceous Jurassic Triassic	NEVADA REVOLUTION Retreat of inland seas. Extensive igneous intrusions. White Tank quartz monzonite Milk-white quartz	
PALEOZOIC ERA 230,000,000-600,000,000 yrs.		Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian	Periodic invasion of inland seas between periods of severe weathering and crustal movements. Metamorphism of some marine deposits. Most marine sediments removed or destroyed.	
PRECAMBRIAN 600,000,000 yrs.	Precambrian or Cambrian	Quartzite Limestone Dolomite Jade Shale	Palms quartz monzonite Gold Park gabbro, diorite Fargo formation Pinto Gneiss (original strata not found)	

MAJOR ROCK TYPES
(Based on % of volume)

PINTO GNEISS. Quartz 40-50; feldspars, potash 5-25; plagioclase 20-30; biotite 4-15; muscovite 1-10; etc.

GOLD PARK GABBRO and DIORITE. Plagioclase 43-47; hornblende 7-47; biotite 0-28; olivine 0.2-3.8; chlorite 0-3.6; augite 0-0.9; accessory.

PALMS QUARTZ MONZONITE. Quartz 30; feldspars, potash 30; plagioclase (oligoclase) 40; biotite 5; etc.

WHITE TANK QUARTZ MONZONITE. Quartz 30; feldspars, potash 30; plagioclase 35; biotite 4; hornblende rare; muscovite rare; accessory.

GRANODIORITE. Quartz 27.5; feldspars, potash 11.3; plagioclase 48; biotite 9.4; hornblende 2.7; accessory

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