IS MUSHROOM ROCK A VENTIFACT?

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Photo 1. Mushroom Rock, Death Valley, California. This unusual feature is a resistant bedrock knob that was once part of an ancient basalt flow. *Photo by Dick Hilton, Sierra College, Rocklin, California.*

Ventifact: a geologic term derived from a combination of the Latin *ventus* (wind) and *factum* (something made, a product), and is thus applied to those features shaped from wind-erosion.

When trying to understand a landform's origin it is important to keep an open mind and be observant to all possible clues. To practice this, a good exercise is to examine the well-known feature, Mushroom Rock in Death Valley, California (Photo 1). This curious, mushroom-shaped, knob of basalt is commonly cited as formed by sand-laden wind—or a ventifact. We however disagree. Our observations contradict the wind-erosion view, and also lead us to an alternate hypothesis—salt weathering.

Our observations that contradict wind-erosion are as follows:

1) According to the wind-erosion view, the thin neck of Mushroom Rock was worn down by sandblasting. If this were the case, preferential wear reflecting predominant wind direction should be evident, but instead erosion is the same on all sides, even on the wind-protected side facing the slope. 2) Very little wind-deposited sand surrounds the site. 3) The smooth-looking portion at the base of the knob is not smooth, but quite rough to the touch. This is contrary to typical sandblasted surfaces that are slick.

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GARNET

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Grossularite. A variety of garnet. Dodecahedron crystal, 2.7 centimeters wide. From the Coyote Front Range, Bishop, Inyo County, California. California State Mining and Mineral Museum. *Photo by Jeff Scovil ©. DMG B8040.*

The birthstone of those born in January—garnet—symbolizes grace, truth, and fidelity, and is recognizable by its deep red color as one of the most common semi-precious stones.

Garnet is the most diverse of the gem minerals with varied chemistry resulting in a variety of colors. And although since ancient times, garnet has been associated with the color red, it actually occurs in all colors except blue. Garnet varieties *pyrope* and *almandine* or *almandite* occur in shades of red and violet. *Grossularite* can occur in pale green or in colors of orange-yellow to orange brown (Photo). Varieties *tsavorite* and *uvarovite* occur in deep green colors. *Andradite* can occur in transparent green and yellow green to black.

Garnets have the general chemistry of the iron(Fe)-rich garnet *almandine* ($3FeO\ Al2O_3\ 3SiO_2$). The variety of color comes from its chemical make-up that follows the garnet's "solid solution" series. In a "solid solution" series, ions (elements) of a similar size can substitute with each other in its crystal lattice. For example, ions that can substitute for Fe in garnets include calcium (Ca), magnesium (Mg), manganese (Mn), and chromium (Cr). Sometimes a combination of ions will substitute for both Fe and aluminum (Al) such as in the beautiful green *uvarovite* where Ca substitutes for Fe and Cr for Al. The substitution of the ions in the crystal lattices also imparts specific physical properties to the crystals. This makes some garnets not only beautiful as gems, but because of their hardness, useful in other applications as well.

A high melting point (1250°C), high resistance to chemical degradation, and a high resistance to physical abrasion make garnets good gemstones and very desirable as abrasives. Garnets are used in sandpaper, abrasive wheels, polishing grains, powders, and grits. Garnets are also used in sandblasting, water-jet cutting equipment and as tumbling (polishing) media. Garnets occur as equidimensional grains so they can be separated and marketed by size, and when broken, as equidimensional grains with very sharp edges. Hardness ranges from 6.5 to 7.5 (quartz is 7 on the Mohs hardness scale) so some garnets will scratch glass! Garnets are also used in non-skid surfaces because of their hardness and resistant to wear. The Fe-rich variety, *almandine*, is most in demand as an abrasive. Garnet's crystal form, the 10-sided dodecahedron, hardness, and high density also make it suitable as a filtering agent for fluids.

Garnets are composed of some of the most common elements in the earth's crust: Al, Si, O, Fe, Ca and Mg. They are abundant in the metamorphic rocks, schist and gneiss, and a common accessory (secondary) mineral in some igneous rocks such as pegmatites. The Mg-Al variety *pyrope* occurs in mafic (dark-colored) igneous rocks such as peridotites and kimberlites. As crystals, garnets most commonly form 10-sided grains ranging from millimeters to several centimeters. A high specific gravity and resistance to wear means that garnets are often found somewhat intact in stream deposits and are sometimes mined by dredges or drag lines during placer operations.

The United States is one of the largest producers of garnet, supplying 25 to 30% of the world's production—preliminary 1999 world production is about 214,000 tons. Most of the US production comes from the Adirondack region of New York; other producing states are Idaho, Maine, Montana, New Hampshire, North Carolina and Oregon. Other worldwide major producers are Australia, India, and China. Minor production of garnet comes from Russia, Turkey, Norway, Canada, the Czech Republic, Pakistan and Ukraine.

So the next time you ponder getting a garnet ring for Great Aunt Tillie's January birthday, remember that garnet is not just a pretty little gem!

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Compared to the recently taken Photo 1, an earlier (1930s) photo of Mushroom Rock (Photo 2) shows significant parts of the structure have since collapsed. This older photo also better shows the distinguishing features that help us puzzle-out Mushroom Rock's origin. Because the lower half of Mushroom Rock has obviously experienced more erosion than the upper half, wind-erosion was initially assumed. The reason for this is that the movement of sand (saltating) in blowing wind is most intense near ground surfaces and hence most effective at wearing down rock within this zone. Alternatively, we reason that the neck of Mushroom Rock is at the former location of a zone of intense, near-surface salt-weathering. Prior to erosion, Mushroom Rock was intact and partially buried—the prominent notches probably indicate the zone of most intense salt-weathering just below the ancient ground surface.

In order for salt-weathering to occur in this zone, it must have been close enough to the surface to be wetted by occasional rain. Salt-weathering is a common process in Death Valley, especially in those shallow subsurface zones close to salt playas (Goudie and Day, 1980; Sharp and Glazner, 1997). It also occurs in the upper layers of arid, saline soils that are periodically moistened by rain and dew.

As dissolved salt permeates the rock's pores and cracks, it starts a weathering process that attacks the rock mechanically and chemically. Mechanical weathering occurs when growing salt crystals wedge apart the rock's minerals as they precipitate out from solution. This wedging action also occurs because salt crystals expand and contract to greater volumes than the surrounding rock minerals. Salt-rich waters also chemically attack the rock by helping dissolve the rock's silicate minerals.

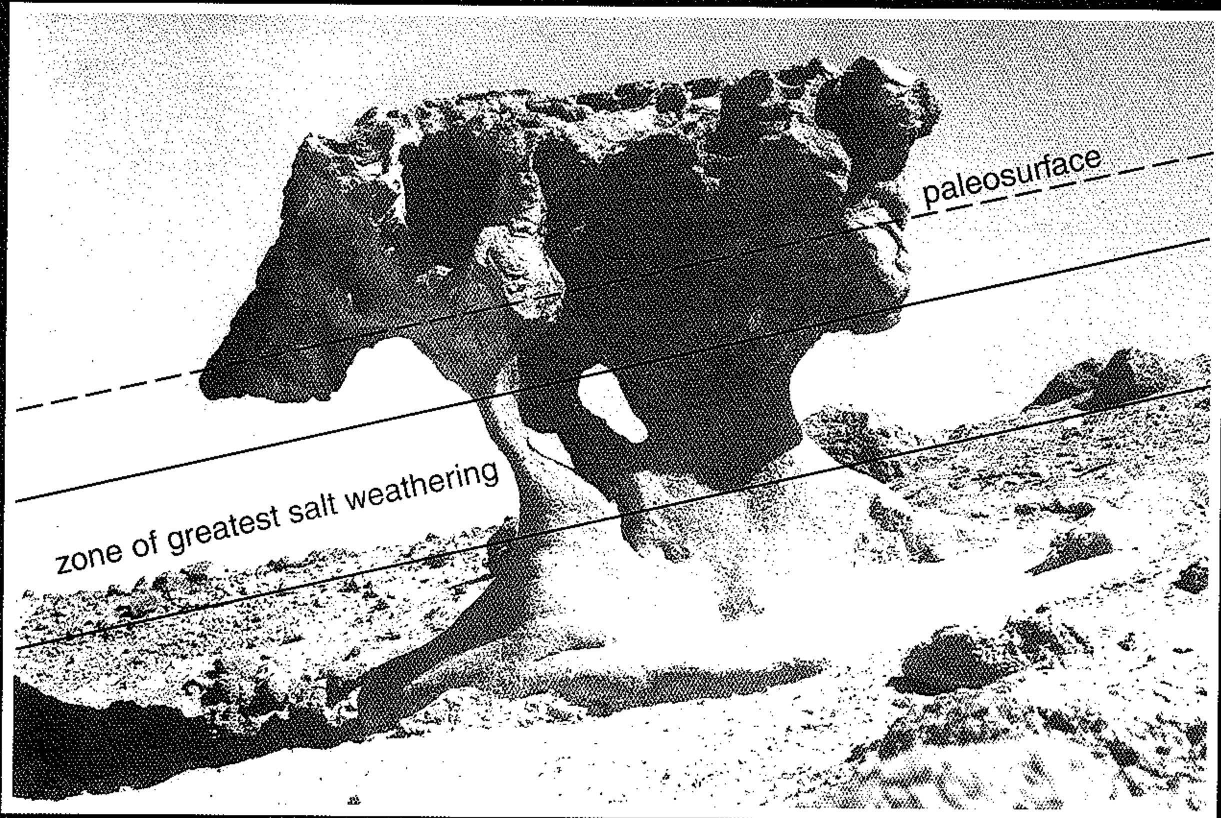

Photo 2. Mushroom Rock in the 1930s. The zone of most intense salt-weathering is shown. *Photo courtesy of National Park Service, Death Valley National Park.*

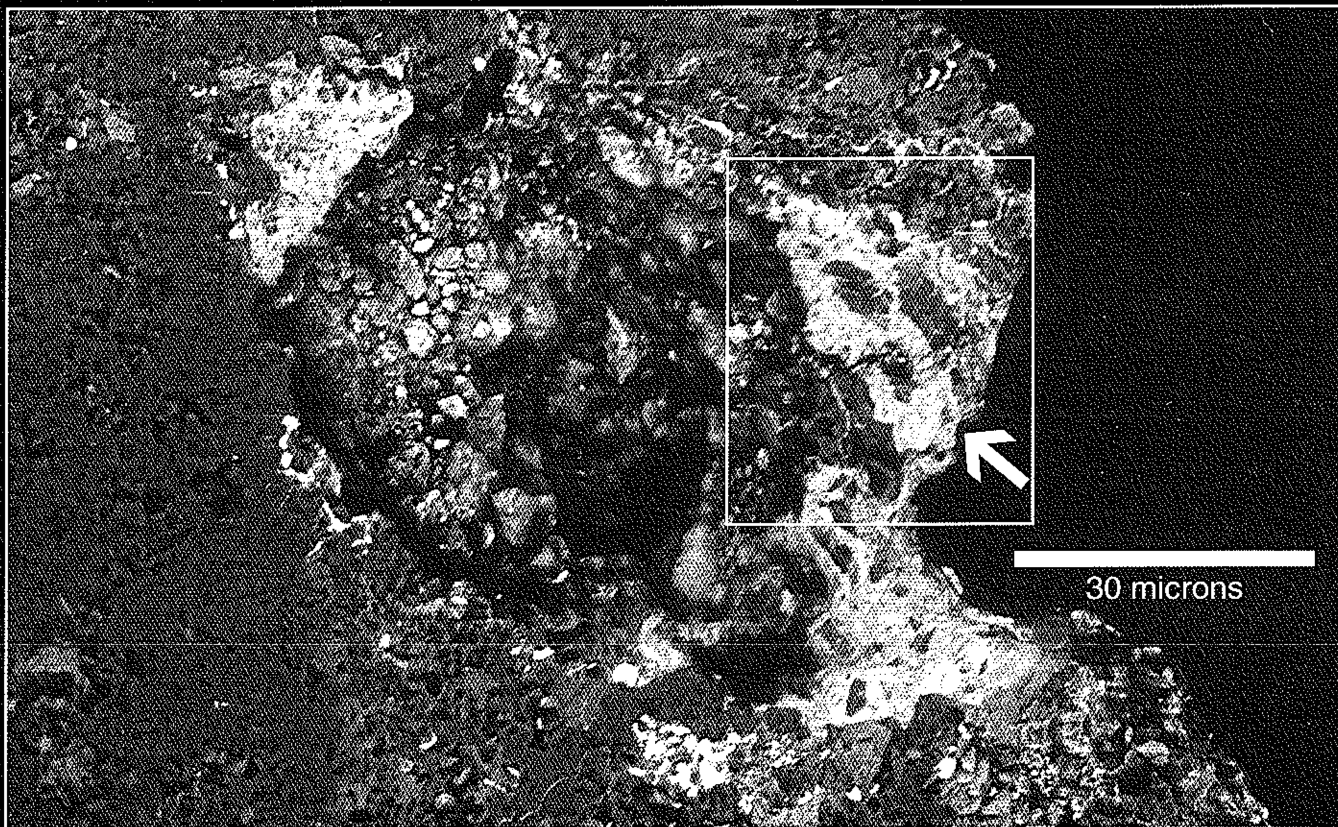

Photo 3. Back-scattered electron photomicrograph. Within the outline, light salt crystals (arrow) of barite (barium-sulfate [$BaSO_4$]) invade and break apart the darker host basalt rock. The scale bar (30 microns) is about the width of three human hairs. *Photo by Ron Dorn.*

When Mushroom Rock was later exposed by erosion, the salt-infested, thus weaker part flaked off, and the unusual profile of Mushroom Rock resulted. This would also explain why we observed salt crystals inside naturally flaked fragments from Mushroom Rock (Photo 3).

The salt-weathering hypothesis for the origin of Mushroom Rock has several major advantages compared to the ventifact hypothesis. First, it explains why the lower half of Mushroom Rock is most weathered and eroded—and why a smaller "notch" has also formed at the base of the rock at the new ground surface. Second, it explains why the indented part of the rock is still rough, rather than smooth. Third, it is consistent with the pattern of honeycombed weathering on the top of Mushroom Rock, since honeycombed weathering is not found on ventifacts but rather is associated with salt weathering. Fourth, it explains why the neck is eroded on all sides. Finally, it is consistent with plentiful evidence of intense salt weathering occurring in the immediate vicinity and the lack of wind-blown sediments. We conclude that Mushroom Rock is not a ventifact but rather an excellent example of a salt-weathered bedrock knob.

REFERENCES

Goudie, A.S. and Day, M.J., 1980, Disintegration of fan sediments in Death Valley, California: Physical Geography, v. 1, p. 126-137.

Sharp, R.P. and Glazner, A.F., 1997, Geology underfoot in Death Valley and Owens Valley: Mountain Press Publishing Company, Missoula, MT, p. 319.