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Arizona Geological Survey

416 W. Congress St. #100 Tucson, Az

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LIMESTONE DISCOVERY IN THE MCDOWELL SONORAN PRESERVE

Brian Gootee, Dan Gruber,
Larry Levy, Joni Millavec and Bill Ruppert

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Limestone Discovery in the McDowell Sonoran Preserve

Brian Gootee (Research Geologist, Arizona Geological Survey: Supervising Project Geologist); Dan Gruber, Larry Levy, Joni Millavec, and Bill Ruppert (Stewards, McDowell Sonoran Conservancy: Project Leaders)

Summary

Our interdisciplinary team of a geologist and volunteers, working with the City of Scottsdale and the McDowell Sonoran Conservancy (MSC), has confirmed that an unusual rock outcropping in the McDowell Mountains within the McDowell Sonoran Preserve in Scottsdale is travertine, a form of limestone. Limestone has not been identified previously in the McDowell Mountains or in the metro Phoenix area. This research is part of a coordinated effort on the part of MSC and the City of Scottsdale's Preservation Division to use the talents and energy of MSC volunteers to better understand the geologic setting of the McDowell Sonoran Preserve.

Travertine is a whitish sedimentary rock consisting of calcium carbonate. Travertine forms when calcium carbonate is deposited by mineral springs. There also is evidence of possible plant fossils and algal residue associated with the travertine. Our preliminary analysis indicates that the travertine was deposited 2 to 20 million years ago, during the formation of the McDowell Mountains.

Additional Information

The limestone outcropping is inconspicuous from the air and ground. At first glance it resembles a thick bed of exposed caliche, a similar rock common throughout the area but formed by different processes. The unique nature of this outcrop was first noticed by the chief author on a field visit to review sites previously identified by MSC volunteers. The outcrop is unlike any other in the park containing inter-bedded (layered) and distinctive varieties of chert. (See Figure 1.)

Figure 1. An opaline variety of chert layered within limestone.
(All photos by Brian F. Gootee)

Chert is a crystalline sedimentary rock rich in silicon dioxide (silica). It often is associated with limestone. Some of the chert on the outcropping showed orange weathering, the result of manganese and iron oxide buildup that is absent from the limestone. (See Figure 2.) The limestone deposit overlies or rests on a larger area of metamorphic rhyolite rock. Blocks of the meta-rhyolite are incorporated into the base of the limestone deposit, which is fractured and heavily weathered. The meta-rhyolite, a rock rich in silica, likely is the source of the mineral constituting the chert. The source of the limestone itself is unknown.

Figure 2. Varnished chert encased in limestone.

Droplets of dilute hydrochloric acid caused the rock to bubble or effervesce, an unambiguous indication of the presence of calcium carbonate. We also noticed an unusual feature in the chert—tubes. (See Figure 3.) The tubes are visible running to the upper-right and lower-left of the pencil point and also curving across the lower-left portion of the picture. These structures are part of the chert and made of the same material. The black color appears to be desert varnish, which is a coating of clay, manganese oxide, and iron oxide created in part by bacterial action. Varnish generally does not form on highly water-soluble rocks like limestone but is common on harder material like the chert here.

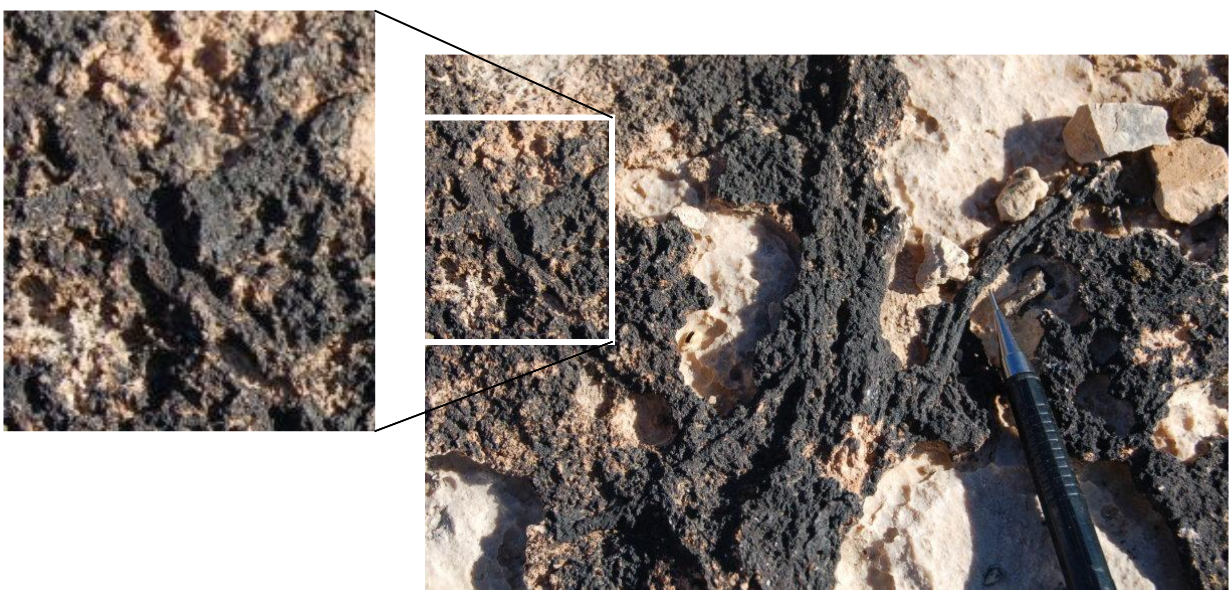

Figure 3. Tube-like chert features on limestone. Inset: Detail of possible branching tube structure.

In some places the tubes are eroded through their diameter and appear to show a faint wall. There is also one place (see upper left inset in Figure 3) where a tube appears to branch. The combination of the location, dimensions, and the double-walled tubes and branching structure may indicate that these features are plant fossils, although more detailed analysis would be needed to confirm this. If these tubes are plant fossils, they would support the interpretation of the outcrop as spring-deposited travertine.

Because of the unique nature of the find, the chief author requested and received permission from the City of Scottsdale Preservation Division staff to remove a small sample of the rock. MSC funded the preparation of a thin-section from the sample to facilitate microscopic examination. The micrographs (photographs taken through a microscope) shown below are typical of the material and illustrate numerous features which help to interpret the geological history of the sample.

Figure 4 shows a thin slice (0.03 mm thick) of the sample mounted on a glass plate and stained dark red to help determine the composition of the rock. Calcite, a calcium carbonate mineral and common constituent of limestone, absorbs the red stain whereas chert does not and remains clear. (The original travertine material is labeled A in Figures 4 and 5.)

In the microscopic view the small white circles (B) are chalcedony, a variety of chert. (Much of the chert crust on the travertine is composed of huge numbers of these tiny spheroidal shapes cemented together.) The pink areas (D) are voids that were dissolved out of the original material by water. Notice that there are narrow bands (C) around the edges of the voids. These bands appear to be calcite, silica, and possibly algae (the opaque dark brown material). These bands are uniform in thickness and surround almost every void on the thin-section slide. Furthermore, the voids often are filled with pink-stained calcite (with a slightly different crystalline structure than that forming the bands), indicating that during this period the limestone was in a water-saturated environment.

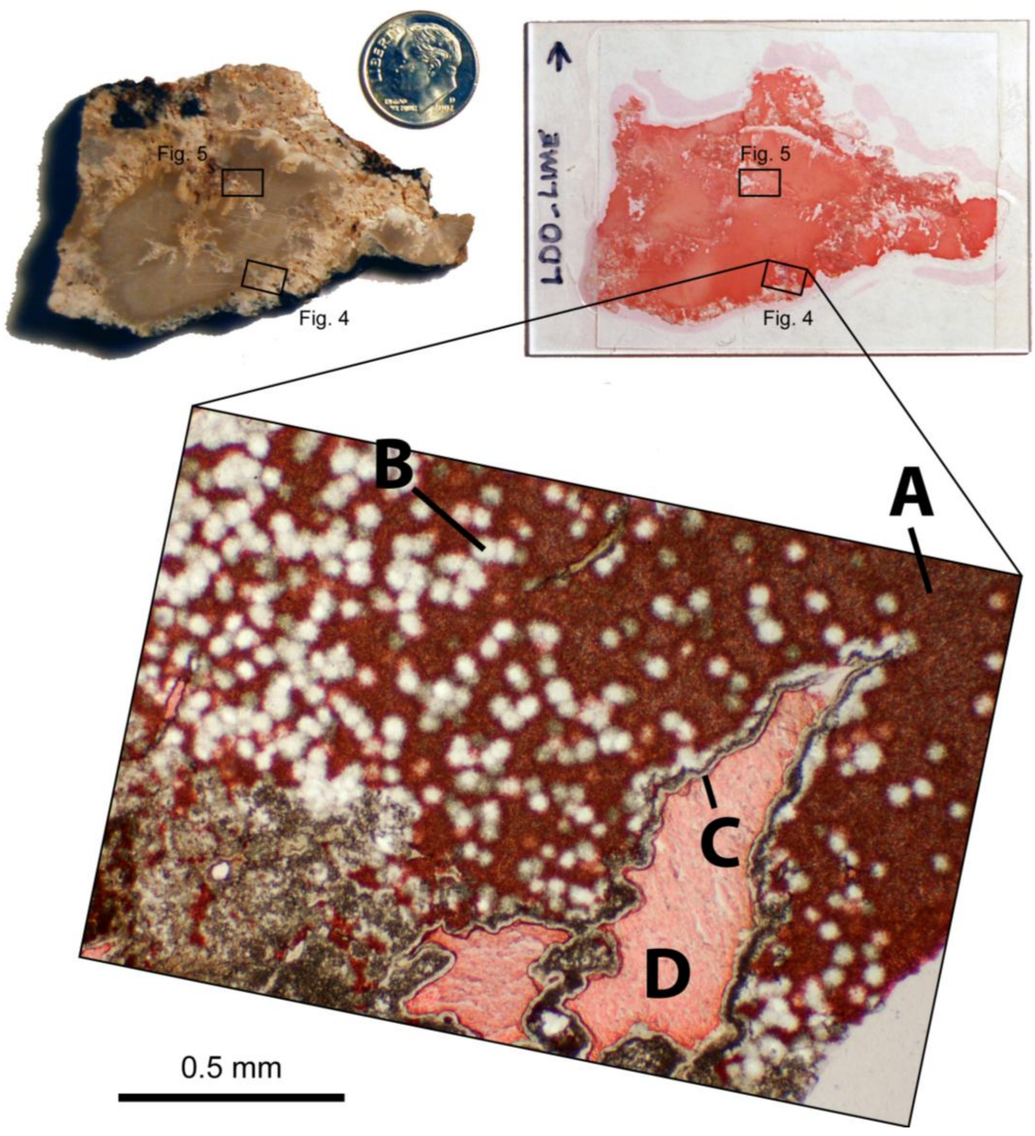

Figure 4. Clockwise from upper left: original sample, mounted thin section, and photo-micrograph. The black arrow on the thin section is right-side up on the outcrop. Black boxes on sample and thin section show the extent of the photo-micrographs in Figures 4 and 5. Geologic events include A. original travertine limestone deposition, B. formation of orbicular (concentrically-layered spheroidal) chert and possibly dissolution of limestone, followed by C. coatings of calcite, silica, and possibly algae in cavities, and D. void-filling by coarse calcite in a water-saturated environment.

Figure 5 shows a similar sequence. The labels correspond to those in Figure 4. The right portion of the photo and most of the immediate area around the central void shows the original travertine material. The void was created by dissolution of the original material in a saturated environment. The void seems to be lined with a thin layer of calcite but then partially filled with silica-rich chert (white). Finally, happening last, the center of the void is filled with pink-stained calcite. (The pink area at the upper left of the photo is a much larger, calcite-filled void.)

Note that the voids seen in Figures 4 and 5 appear closed because this is a two-dimensional slice of material. In reality, the travertine is full of inter-connected pores and microscopic fractures. In a saturated environment, water with dissolved silica and calcium carbonate probably could have penetrated almost anywhere in the rock.

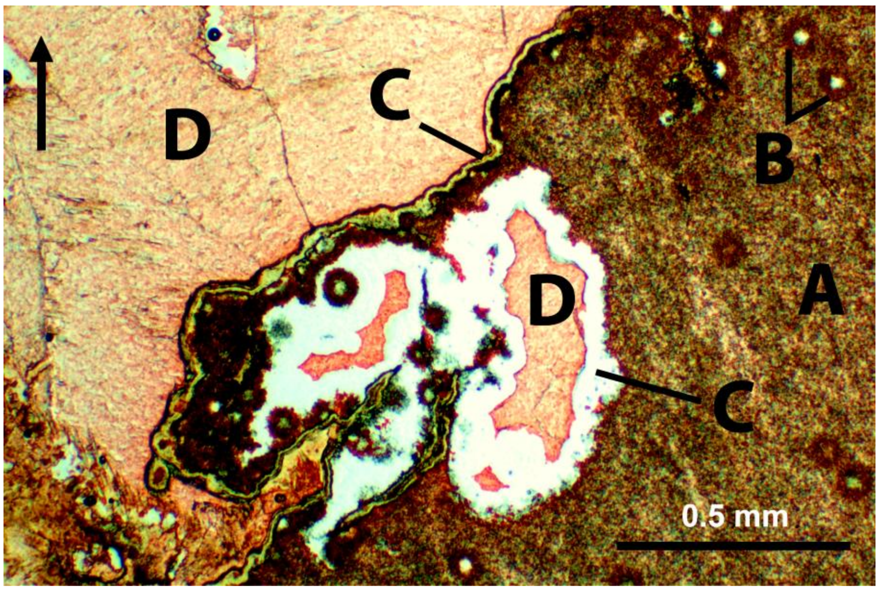

Figure 5

After examining these and other micrographs, we developed the following tentative description of the sequence of geologic events that occurred here:

1. The original material probably is travertine deposited by the evaporation of water from a surface mineral spring in an area surrounded by vascular plants (the tube structures seen in Figure 3). Algae (possible remnants of which appear in several micrographs) might have grown in surface cavities in the travertine. This probably happened between 2 and 20 million years ago, during the formation of the McDowell Mountains. (See A in Figures 4 and 5.)

2. Sometime later the travertine was affected by water of a different pH (acidity or alkalinity) and/or temperature than the original conditions. During this period, partial dissolution of the original travertine formed voids and also led to the precipitation of silica into balls. (See B in Figures 4 and 5.)

3. Subsequently, another change in pH and temperature led to a separate event of precipitation of silica, calcite, and possibly the growth of algae lining the edges of the voids. (C in Figures 4 and 5.)

4. A final change in water pH and temperature conditions allowed coarser-grained calcite to fill up many remaining voids. (D in Figures 4 and 5.)

5. After the formation of chert and calcite-filled voids, the environment apparently dried out. As a result, dissolution and precipitation of material stopped.

6. Eventually any overburden covering the outcrop and possibly some amount of the original limestone outcrop itself eroded away, exposing the limestone for eventual discovery.

Additional research and analysis will be required to confirm and possibly expand these tentative conclusions about the geological history of the limestone outcropping as well as to address other significant questions raised by this discovery:

- Where did the calcium-rich water that produced the outcrop between 2 and 20 million years ago come from? There is no known source of calcium-rich rock in the vicinity that dates to that period.

- Can the deposition date of the original travertine material and the period when the tentative sequence of geological events occurred, be determined more precisely?

- What is the nature of the tube-like structures in the chert and of the dark brown material resembling algae on several micrographs?

Please note that the limestone outcrop is not accessible on any trail in the McDowell Sonoran Preserve. Off-trail travel in the Preserve and the removal of any material from the Preserve is strictly prohibited except with the express permission of the City of Scottsdale Preservation Division. The geological research project and all associated work described in this article have been done under a permit issued by the Preservation Division and with its approval and supervision. This and all other geological project work has been done by or under the scientific supervision of Brian F. Gootee of the Arizona Geological Survey.

Acknowledgements

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Front Cover: Volunteers Jennifer Polakis and Frank Romaglia examining a portion of the limestone outcrop. (Photo courtesy of Brian F. Gootee)