How Water affects inscriptions at El Morro National Monument, New Mexico

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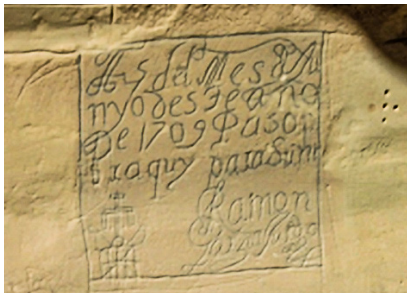
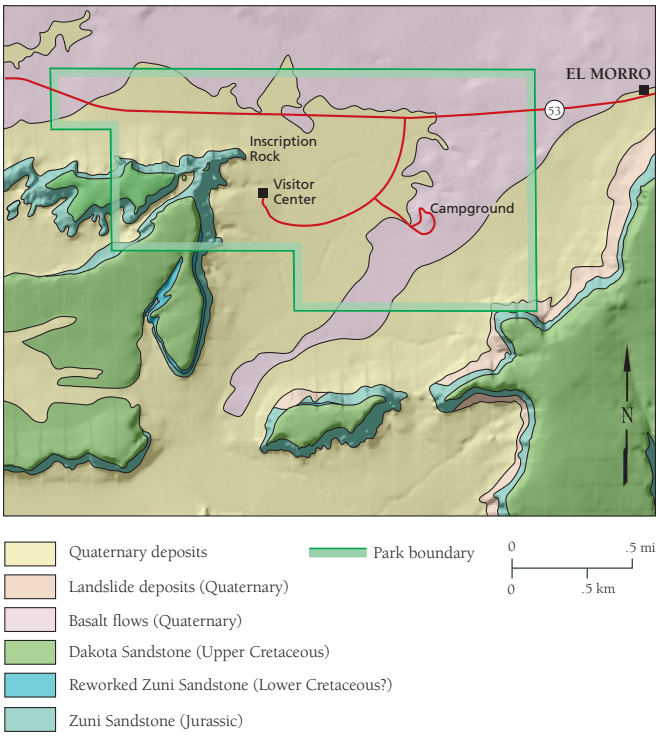
El Morro National Monument is located in Cibola County in western New Mexico and features the 200 to 145 million year old, Zuni Sandstone cliffs of El Morro, which served as a prominent landmark and water source (a perennial pool lies at the base of the cliff) for Puebloan people, Spanish explorers and American settlers for hundreds of years. Inscription Rock, a 70-meter-high sandstone monolith, documents a long history of human activity featuring the Atsinna Pueblo ruins, petroglyphs, and thousands of signatures carved into the cliff walls by Spanish explorers and American emigrants. One of the primary goals of El Morro National Monument, established in 1906, is the preservation of these historic inscriptions that are deteriorating due to both natural and anthropogenic processes. Much research has been conducted to understand the natural erosional processes that contribute to the deterioration of the inscriptions in order to identify possible methods to mitigate their eventual loss. Geochemical reactions between water and minerals and the freezing and thawing of water are the primary drivers of these weathering processes. Therefore, it is important to understand how water comes in contact with the sandstone in areas where there are inscriptions.



Top: Inscription Rock at El Morro National Monument.

Bottom: Example of an inscription on Inscription Rock dated 1709. *Photos by Shari Kelley.*

Researchers at the New Mexico Bureau of Geology and Mineral Resources have recently conducted a study that aimed to understand the different travel pathways that bring water in contact with the inscriptions. Of the many scientific techniques used for this study, the measurement of soil moisture at different areas throughout the Monument provided insight to the process by which rain and snow-melt at the top of the cliff moves downward through the subsurface. Instruments that recorded hourly measurements of the amount of water present in the top 12 inches of soil were installed at different distances from Inscription Rock. For areas located out in the open, away from the cliff, rain storms resulted in small increases in soil moisture in the top 4 inches, which quickly decreased within a few days due to evaporation and transpiration (water used by plants) if no other storms occurred. This pattern in post-storm soil moisture loss was also detected in some areas next to the cliff, indicating that precipitation was the only source of soil moisture in these areas. However, in some areas near the cliff, it appeared that extra water entered the soil during these storms, resulting in much higher increases in soil moisture in the top 12 inches below the surface. In addition, the soil moisture in these areas did not decrease as quickly as was observed at points away from the cliff. These data indicate that when it rains or snow melts on top of the cliff, some water flows through northeast-trending joints downward to the bottom of the cliff. These joints are fractures that began to form between 35 and 80 million years ago during the Laramide orogeny, a period of heightened tectonic activity that formed the mountains in western North America. Researchers have found that water traveling along these joints may be the contributing to the deterioration of some of the inscriptions.



Generalized geologic map for El Morro and vicinity. From *The Geology of Northern New Mexico's Parks, Monuments, and Public Lands* book, p.42.

Aerial view of Inscription Rock shows prominent linear joints that provide pathways for water to move through the cliff. Pinion and Juniper trees for scale. *Photo courtesy of Google Earth.*