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Salt weathering and geoheritage - Sulfate efflorescences in historical underground quarries of tuff

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One of the most popular and intensively extracted building stones in Japan is a Miocene dacite-rhyolite ignimbrite known as Oya-ishi, quarried nearby the city of Utsunomiya (Tochigi). Traces of its historical usage in the last 1,500 years survive in vernacular architecture, construction, rock-cut and relief sculpture, but large-scale exploitation commenced only in the Edo period (i.e., from the 17th century), an epoch of economic growth and flourishing arts and culture. Among the over 200 underground quarries in the region, few are still active, the others abandoned or converted into geoheritage and tourist attractions (e.g., History Museum, Heiwa Kannon monument, Keikan Park). Salt weathering is one of the decay aspects of Oya stone jeopardizing the preservation of those sites of historical and geological interest and, indirectly, visitor safety. The efflorescences on the tuff quarry walls turn out to be composed of sulfates, namely gypsum, mirabilite, and thenardite, their crystallization being controlled by the relevant microenvironmental conditions. In the extremely humid underground spaces, the phases having a very high deliquescence relative humidity are stable: gypsum is essentially ubiquitous, even in the deepest quarry levels, the most environmentally isolated; mirabilite needs a slightly dryer environment, so is observable in the middle levels or semi-underground quarries; thenardite requires further dryer conditions, and is mainly detected in the open air. The mechanisms of formation of these efflorescences are still under investigation: the classic minero-petrographic and geochemical characterization of the rock and its weathering phases is being supported by a microclimatic monitoring in different sites and seasons, and the chemical analysis of rainwater and groundwater. The research direction is aimed at the identification of the environmental and lithological constraints on the salt weathering of Oya tuff, that is: the spatial and temporal variability of relative humidity, and its influence on the cycles of salt crystallization/dissolution and the resulting mechanical stresses; the chemical driving forces, related to the rock mineralogy (zeolites, feldspar alteration, etc.) and water quality.