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Inclusions in precious Australian opals offer a unique access to Martian-like weathering processes

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Spectral signatures of the surface of Mars indicate a variety of hydrated minerals, including Al- and Fe/Mg-rich phyllosilicates, iron oxides, sulfates, and opaline silica. Their formation has been attributed to a long-lived low-temperature aqueous weathering history (e.g. Bishop et al., 2008; Ehlmann et al., 2013) followed by a period of intense acidic oxidative weathering (e.g. Carter et al., 2013). Very acidic weathering, driven by volcanic-derived sulfuric acid, is possible on a regional scale on Mars because of the lack of carbonate. On Earth, however, low-pH weathering on a regional scale is unusual because of the abundance of carbonate. Finding regional-scale Martian analogues on Earth is therefore a challenge.

The Great Artesian Basin (GAB) in central Australia formed during the Early Cretaceous from the deposition of pyrite-rich volcaniclastic sediments in a cold, muddy, anoxic and shallow continental sea. Following mid-Cretaceous sea regression, a deep (∼100 m) weathering profile recorded a protracted episode (∼from 97 to 60 Ma) of oxidative weathering during continuous uplift and denudation, which stopped 60 myr ago. Since then, the weathering profile, which consists of Al- and Fe-rich phyllosilicates, iron oxides, and sulfates, has been constantly reworked. Interestingly, this profile hosts the bulk of the world's precious opal deposits. Since no opal deposit can be found in post-60 Ma rock formations, it is most likely that opal is part of the weathering profile developed during the drying out of central Australia.

We analysed the mineral inclusions from six opal samples from the GAB to better document the early oxidative weathering. Using VNIR and Raman spectroscopy we were able to identify a variety of minerals including ferrihydrite, barite, gypsum and alunite replaced by goethite. This mineralogical assemblage is indicative of acidic oxidative conditions that points to Martian-like acidic weathering. We propose that acidity was derived from the oxidation of biogenic pyrite, and that the quasi absence of carbonates allowed very acidic conditions to take hold at a regional scale. If this model is valid, central Australia may be one of the best terrestrial analogues for the understanding of some of Mars' weathering processes.

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