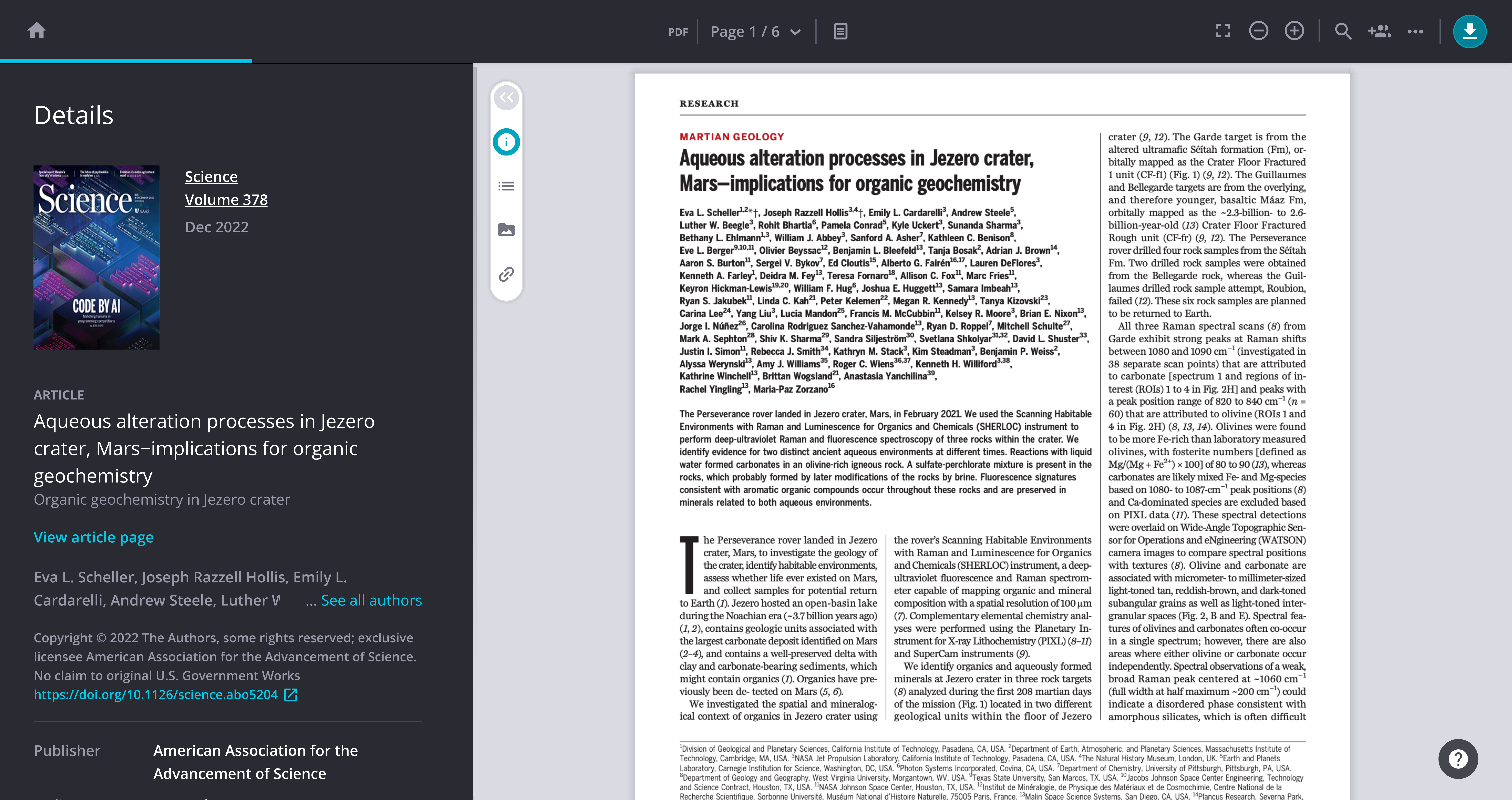

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MARTIAN GEOLOGY

Aqueous alteration processes in Jezero crater, Mars—implications for organic geochemistry

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The Perseverance rover landed in Jezero crater, Mars, in February 2021. We used the Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) instrument to perform deep-ultraviolet Raman and fluorescence spectroscopy of three rocks within the crater. We identify evidence for two distinct ancient aqueous environments at different times. Reactions with liquid water formed carbonates in an olivine-rich igneous rock. A sulfate-perchlorate mixture is present in the rocks, which probably formed by later modifications of the rocks by brine. Fluorescence signatures consistent with aromatic organic compounds occur throughout these rocks and are preserved in minerals related to both aqueous environments.

The Perseverance rover landed in Jezero crater, Mars, to investigate the geology of the crater, identify habitable environments, assess whether life ever existed on Mars, and collect samples for potential return to Earth (1). Jezero hosted an open-basin lake during the Noachian era (~3.7 billion years ago) (1, 2), contains geologic units associated with the largest carbonate deposit identified on Mars (2–4), and contains a well-preserved delta with clay and carbonate-bearing sediments, which might contain organics (1). Organics have previously been detected on Mars (5, 6).

We investigated the spatial and mineralogical context of organics in Jezero crater using the rover's Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) instrument, a deep-ultraviolet fluorescence and Raman spectrometer capable of mapping organic and mineral composition with a spatial resolution of 100 µm (7). Complementary elemental chemistry analyses were performed using the Planetary Instrument for X-ray Lithochemistry (PIXL) (8–11) and SuperCam instruments (9).

We identify organics and aqueously formed minerals at Jezero crater in three rock targets (8) analyzed during the first 208 martian days of the mission (Fig. 1) located in two different geological units within the floor of Jezero crater (9, 12). The Garde target is from the altered ultramafic Séítah formation (Fm), orbitally mapped as the Crater Floor Fractured 1 unit (CF-f1) (Fig. 1) (9, 12). The Guillaumes and Bellegarde targets are from the overlying, and therefore younger, basaltic Máaz Fm, orbitally mapped as the ~2.3-billion- to 2.6-billion-year-old (13) Crater Floor Fractured Rough unit (CF-fr) (9, 12). The Perseverance rover drilled four rock samples from the Séítah Fm. Two drilled rock samples were obtained from the Bellegarde rock, whereas the Guillaumes drilled rock sample attempt, Roubion, failed (12). These six rock samples are planned to be returned to Earth.

All three Raman spectral scans (8) from Garde exhibit strong peaks at Raman shifts between 1080 and 1090 cm^{-1} (investigated in 38 separate scan points) that are attributed to carbonate [spectrum 1 and regions of interest (ROIs) 1 to 4 in Fig. 2H] and peaks with a peak position range of 820 to 840 cm^{-1} (n = 60) that are attributed to olivine (ROIs 1 and 4 in Fig. 2H) (8, 13, 14). Olivines were found to be more Fe-rich than laboratory measured olivines, with fosterite numbers [defined as $Mg/(Mg + Fe^{2+}) \times 100$] of 80 to 90 (13), whereas carbonates are likely mixed Fe- and Mg-species based on 1080- to 1087-cm^{-1} peak positions (8) and Ca-dominated species are excluded based on PIXL data (11). These spectral detections were overlaid on Wide-Angle Topographic Sensor for Operations and eNgineering (WATSON) camera images to compare spectral positions with textures (8). Olivine and carbonate are associated with micrometer- to millimeter-sized light-toned tan, reddish-brown, and dark-toned subangular grains as well as light-toned intergranular spaces (Fig. 2, B and E). Spectral features of olivines and carbonates often co-occur in a single spectrum; however, there are also areas where either olivine or carbonate occur independently. Spectral observations of a weak, broad Raman peak centered at ~1060 cm^{-1} (full width at half maximum ~200 cm^{-1}) could indicate a disordered phase consistent with amorphous silicates, which is often difficult

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