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Salty Mars, from Perseverance to Viking: Geochemical Themes, Variation, and Habitability

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The Perseverance rover has discovered significant levels of salts in rock, from 10x to 100x their whole-rock abundances in martian meteorites, which imply a range of aqueous episodes in Jezero crater. Numerous high-concentration occurrences, compared to terrestrial abundances in igneous rocks, include sulfates, Cl-salts, phosphates, and carbonates. With its x-ray fluorescence quantitative microanalysis capability (120 μm contiguous spots), the PIXL instrument is discovering some spots in rocks that approach 100% salt. Although the Cl/S relative abundances (atom/atom) are ~0.26 in martian soils, the interiors of five rocks analyzed to date in Jezero crater have Cl/S >1 (up to 3.2 for Guillaumes abrasion of flat-rock Máaz).

Sulfur is generally found as $MgSO_4$ or $CaSO_4$, but in variable proportions in different rocks, including a major patch of nearly pure $MgSO_4$ and associated $CaSO_4$ in scan-1 of the Quartier abrasion (Issole rock, in the Séítah landform). A highly Mn-enriched sulfate of Ca in Guillaumes is consistent with the mineral despujolsite (hydrated $Ca_3Mn(SO_4)_2$). Enriched Mn associated with sulfate-rich coatings were discovered previously in “Island rocks” at Endeavour crater. Mn-S-phosphate associations have been discovered in Gale crater.

Cl-enrichment is generally more uniformly dispersed on the microscale in Séítah rocks, and 80% of the spots in the Dourbes-2 abrasion (Brac rock) have Cl/S ratio greater than 10x soil. Some areas in Guillaumes have highly correlated Na-Cl, with indications of oxidation up to perchlorate.

Local, patchy concentrations of carbonates of Mg and Fe are found within Brac: in PIXL scan-1 surrounding a concentrated patch of $CaSO_4$ and in scan-2 in small patches distinct from a patch of $MgSO_4$*n H_2O, where n ~ 4. Phosphate is unusually high in Bellegarde, as non-Cl apatite, whereas in other rocks is consistent with merrillite; both may be of magmatic origin but are readily mobilized.

As a tracer of aqueous activity, salts provide evidence that Jezero Crater hosted habitable brines, likely as refugia scavenging the last traces of H_2O. Salt ions could have supported an origin of life itself (with key elements P-S-Mg-Fe). Salts and their inclusions are also promising reservoirs for preservation of biosignatures.