Enigmatic linear patterns of hydrogen concentration on Mars

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Chemically or physically bound hydrogen within a meter of the Martian surface has been mapped using neutron spectroscopy [1]. The Neutron Spectrometer, part of the Gamma-Ray Spectrometer on board Mars Odyssey, is able to detect thermal, epithermal and fast neutron fluxes. Each of these have specific energy ranges with epithermal neutron energy ranging from 0.4 – 500 keV. This band is the most sensitive for hydrogen mapping purposes. Regions with high hydrogen concentrations have a low epithermal energy flux.

These concentrations are believed to indicate locations of subsurface water ice. As such the flux maps pinpoint locations where small quantities of liquid water may intermittently form today or where liquid water may have pooled in the past. The possibility of life existing on Mars – either in the distant past or at present – depends on the availability of liquid water.

Epithermal neutron flux maps of the equatorial region east of Schiaparelli Crater in Mars' eastern hemisphere indicate hydrogen ion concentrations in the shallow subsurface with a hydrogen water equivalent of just over 10 percent [1]. Published maps [2] reveal anomalous linear concentrations of hydrogen with a northeast to southwest trend. The width and trend of these linear anomalies match those of the graben between Scylla Scopulus and Charybdis Scopulus, west of Hellas Basin.

These linear ion concentrations suggest structural control of the hydrogen. Structural control of fluids can be attributed to fault activity or structural topography. Terrestrial faults are known to exert a strong control on groundwater flow immediately after earthquake events. Subsurface faults may also act as a barrier to fluid flow, creating a confined channel or aquifer within the width of the graben. Alternatively, the graben may have acted as a topographic control on surface water accumulation in the past. Any seepage of this water into the subsurface may have resulted in a hydrogen ion fingerprint in graben valleys, resulting in the linear patterns observed.

References

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Columbia Plateau Basalt as an analog to the basalt of the Martian Northern Plains

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The basalt of the northern plains on Mars is more andesitic and weathered than the basalt of the southern highlands. It appears to be well represented by the Bounce Rock at the Meridiani Site, which is dominated by pyroxene (clinopyroxene ~55%, orthpyroxene ~5%) and plagioclase (~20%), and is poor in olivine (~5%). Oxides are acounting for ~10%. The chemical composition of Bounce Rock is more evolved than the basalts in the Gusev crater. It has a high P_2O_5 content of 0.95wt%, a Fe/Mg ratio of 36, a low Mg number (molar MgO/ MgO+FeO) of 0.42 and a high Ca/Al ratio of 1.7, a lower FeO (15.6%), and a higher CaO (12.5%) content. The basalt in the northern plains is in general rich in sulfur and variably enriched in bromine relative to chlorine, indicating a past interaction with water.

The Columbia Plateau Basalt (CPB) is a typical continental flood basalt, composed of four basalt formations made up of more than 300 individual basalt flows. The wrinkle ridges and low viscosity of these basalt flows are typical features of CPB. On a normative cpx-ol-pl-qz projection, the Grande Ronde Formation (~ 87% of CPB), is very close to the 1 atmosphere pseudo-cotextic, indicating that the erupted melts underwent fractionation and mixing processes at a very shallow level. CPBs are dominated by relatively low Mg tholeiite and basaltic andesite, with SiO_2 at 52-58%, FeO 10.0-13.5%, CaO 8.6-10.4%, a Mg number of 0.55, and a higher P_2O_5 content of 0.68%.

Both, CPB and Mars basalt were formed at low pressure conditions with low-vicosity basaltic lava spreading over wide areas. Basaltic rocks in the northern part of Mars and the CPB were subject to sporadic interactions with water bodies, weathering, and glacial processes. The northern Martian basalts and CPB are similar geochemically and mineralogically being both evolved basalts with some signatures of andesite. Also, the higher P content of Bounce rock and the wrinkle ridges of Martian basalt are similar to that of CPB. Life based entirely on chemoautotrophic energy sources has been reported from a deep basalt aquifer of the CPB. Since Martian surface conditions are extremely hostile for life as we know it, the primary energy source for putative life on Mars is likely chemical energy rather than light energy. Thus, CPB and the chemotrophic organisms in the CPB serve as a suitable analog to Mars.