Petrologic and Metasomatic Controls on H and Cl Abundances and Isotopes in Lunar Rocks

JEREMY W. BOYCE[12], ALLAN H. TREIMAN[3], J OHN M. EILER[2], CHI MA[2], YUNBIN GUAN[2], JAMES P. GREENWOOD[4], JULIANE GROSS[5] AND EDWARD M. STOLPER[2]

[1]Dept. of Earth & Space Sciences, UCLA (jwboyce@alum.mit.edu)
[2]Division of Geological and Planetary Sciences, Caltech
[3]Lunar and Planetary Institute, Houston TX
[4]Dept. of Earth & Environmental Sci, Wesleyan University
[5]Dept. of E & P S, American Museum of Natural History

Abundances and isotopic compositions of H and Cl have been measured in apatites from twelve lunar samples, permitting systematic comparison of relationships between these properties and other petrologic and geochemical characteristics. High $d^{37}Cl$ values are found in relatively H-rich apatites, apparently falsifying the hypothesis that elevated $\delta^{37}Cl$ arises only from single-stage degassing of anhydrous magmas. Nevertheless, high $\delta^{37}Cl$ is preferentially associated with relatively low H apatites and so seems to be a property of relatively degassed reservoir(s). The most H-rich apatites tend to have 'low' $\delta^{37}Cl$, < +25‰. Higher $d^{37}Cl$ values (> +25‰) are seen only in highlands rocks and breccias, and the highest value is in a rock that may be from an impact melt/breccia sheet. Among the eight mare basalts analyzed by us and others, δD of apatite shows no correlation with H abundance or $\delta^{37}Cl$. δD is, however negatively correlated with pyroxene homogeneity [(minimum Mg#)/(maximum Mg#)]; basalts that experienced protracted thermal histories (igneous, impact, or metamorphic) have low δD. Finally, it is common to observe both significant heterogeneity in abundance and isotopic composition of H and Cl within apatites from a single sample, or even individual crystals, indicating a lack of equilibrium.

These results can be interpreted in terms of planet-scale evolution; for example, the high $d^{37}Cl$ of highlands rocks could be inherited from a partially degassed (H-poor) magma ocean. However,it is also possible that elevated $d^{37}Cl$ in some samples arose through devolatilization during impact metamorphism and/or metasomatism of the crust. Variations in dD could represent mixing of a high δD (>+500‰) component in pristine igneous rocks (either because this is a signature of their mantle sources or because of magmatic degassing) with a low-δD component like solar wind implanted into regolith. If so, much of the volatile element geochemistry of lunar rocks may reflect crustal and near-surface processes.

Hot spring environments as accessible portals into the metabolic underpinnings of the deep hot biosphere

ERIC S. BOYD[1], ERIC A. ALSOP[2], EVERETT L. SHOCK[3] AND JASON A. RAYMOND[4]

[1]Department of Chemistry and Biochemistry, Montana State University, Bozeman, MT, USA, eboyd@montana.edu
[2]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA, ealsop@asu.edu
[3]Department of Chemistry and Biochemistry, Arizona State University, Tempe, AZ, USA, eshock@asu.edu
[4]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA, jraymond@asu.edu

The Earth's crust contains an extensive and diverse deep biosphere that is sustained by chemical energy under dark and oligotrophic conditions. Much remains unknown and in need of discovery in these ecosystems due to their deep and hard-to-reach nature. Herein, it is proposed that much information directly relevant to the deep, hot, biosphere of continental subsurface systems is directly accessible in the form of sediments and near-subsurface investigation in the globally relevant hot springs of Yellowstone National Park (YNP), Wyoming, USA. We investigated the composition of ~30 community metagenomes in YNP using a suite of bioinformatic and ecological modeling tools. The results suggest that the metabolic composition of microbial mat communities can be accurately predicted based on the physical and chemical attributes of the environment. Of particular significance is the strict temperature-dependent demarcation noted between the metabolic composition of chemotrophic communities and phototrophic communities as well as the pH-dependent demarcation in the metabolic composition of chemotrophic communities. . Additional results from modeling and *in situ* activity-based studies will be presented that reveal the environmental constraints that shape the distribution of metabolic processes in these accessible portals to the deep hot biosphere.

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