

Primordial Delivery of Potassium to Mercury and Enstatite Chondrites

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In orbit around Mercury, gamma and x-ray spectrometers on the MESSENGER spacecraft return data indicating terrestrial K/Th [1] and high S/Si ratios [2] in the Mercurian mantle. Sulfur behaves as a refractory element in a vapor of solar composition that is enriched in a dust of anhydrous chondritic interplanetary dust particle (C-IDP) composition [3]. This scenario allows for accretion of Mercury from primordial disk solids in equilibrium with vapor at high temperatures, and suggests a similar origin for the highly reduced enstatite chondrites. Potassium, however, should be strongly depleted in such a scenario. But current equilibrium condensation calculations [3] do not include the refractory phase djerfisherite, $\sim K_6(Fe,Ni,Cu)_{25}S_{26}Cl$, an important carrier of K in EH enstatite chondrites [4].

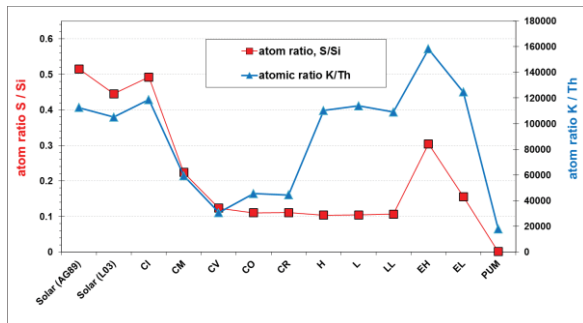


Figure 1: K/Th and S/Si ratios in solar compositions [5,6], carbonaceous chondrites (CI, CM, CV, CO [7] CR [8]), ordinary chondrites (H, L, LL [7]), enstatite chondrites (EH, EL [7]), and primitive upper mantle (PUM [9]).

It was shown by [3] that CaS, FeS and MgS are stable solids above 1100 K in vapor enriched above $\sim 700\times$ (atoms) in C-IDP dust. Little is known of the thermodynamic properties of djerfisherite. To first order, the free energy of djerfisherite may not differ substantially from that of FeS. If so, the abundance of K in both enstatite chondrites and Mercury may be consistent with their accretion from solids formed in equilibrium with highly reduced, C-IDP dust-enriched vapor at high temperature.

[1] Peplowski et al. (2011) *Science* 333, 1850-1852. [2] Nittler et al. (2011) *Science* 333, 1847, 1850. [3] Ebel & Alexander (2011) *Planet. Space Sci.* 59, 1888-1894. [4] El Goresy et al. (1988) *Proc. NIPR Symp. ANtarct. Meteorites* 1, 65-101. [5] Anders & Grevesse (1980) *Geochim. Cosmochim. Acta* 53, 197-214. [6] Lodders (2003) *Ap. J.* 591, 1220-1247. [7] Wasson & Kellemeyn (1988) *Phil. Trans. R. Soc. A* 325, 535-544. [8] Lodders & Fegley (1998) *Planetary Scientist's Companion*. [9] McDonough & Sun (1995) *Chem. Geol.* 120, 223-253.

Metal fractionation in the water column of a former U open pit mine

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Objectives, background and methods

Lake Tranebärssjön, a former open pit mine in Ranstad in Sweden has an interesting geochemistry; slightly alkaline, groundwater fed, stratified with high sulphate and metal concentrations and with an anoxic hypolimnion. The aim of this study was to investigate the partitioning of metals in the water column by (i) different size fractions: 0.45 μm filters, and ultrafiltration (10 kDa, 3 kDa and 1 kDa) and (ii) compare the analytical results with chemical equilibrium modeling calculations using Visual MINTEQ including Stockholm Humic Model (SHM). The hypothesis was that a more thorough examination of the distribution of metals in the water column would reveal that the size fractions of metals differs strongly between water layers with deviating geochemical conditions. The findings of the study could be relevant for restoration and remediation of mining sites.

Results and conclusions

The chemical analyses showed a stratified lake with an anoxic hypolimnion and high total concentrations of metals including Fe, Ca, Mn and U as well as sulfate and carbonate anions. The extremely high Fe concentration increased with depth and was dominated by particulate and colloidal fractions (>1 kDa) in the epilimnion, whereas in the hypolimnion the dissolved fraction (<1 kDa) held the major part. This was confirmed by analysis of Fe(II) which showed that in the epilimnion Fe(II) constituted less than 1% of the total Fe in contrast to the hypolimnion where Fe(II) made up 95% of the total Fe. For Mn, U, Ca, Co, As and Mo, the dominating fraction in both the epilimnion and the hypolimnion was the dissolved fraction. This is supported by the equilibrium model that suggests soluble inorganic complexes as the dominant species, with the exception of As where the model suggests that the major part is adsorbed to ferrihydrite and U in the hypolimnion for which the model suggests oversaturation with respect to uraninite. For U this partly agrees with the fractionation results as the particulate and colloidal fractions (>1 kDa) where about 30% in the hypolimnion.

Our study shows that the results of the size fractionations agreed well with the models using chemical equilibrium calculations for the water in Lake Tranebärssjön. However there are limitations in the models in the speciation of, e.g. U and of As in waters with high concentrations of Ca and carbonate, which need further investigation. High metal concentrations are still an environmental problem in Lake Tranebärssjön. The fractionation study indicates that a major part of many metals exist in the dissolved form in the anoxic hypolimnion and/or the epilimnion, and can thus be transported to downstream waters during lake turnover.