EPSC Abstracts,
Vol. 2, EPSC2007-A-00404, 2007
European Planetary Science Congress 2007

A search for metals in the atmosphere of Mercury

T. Bida (1), R. Killen (2), and T. Morgan (3)

(1) Lowell Observatory, Flagstaff, AZ, USA, (2) Department of Astronomy, University of Maryland, College Park, MD, USA, (3) NASA Headquarters, Washington, DC, USA

We have observed the atmosphere of Mercury with the HIRES spectrograph at the Keck Observatory within 5 of the years 1997-2005. An important product of these observations has been the discovery of Ca in the atmosphere (Bida, Killen, and Morgan, 2000), and the subsequent study of its local physical properties and source processes (Killen, Bida, and Morgan, 2005). The observed calcium exosphere is very tenuous and localized (tangent column density of 1.3 x 10^8/cm^2, concentrated near the poles), hot (12000-20000 K), and displays a persistent average excess velocity of about 2.2 km/s. In comparison, the average sodium zenith column abundance is 2 x 10^{11}/cm^2. Based on a preferred model for the Mercury mantle composition (Goettel, 1988), and assuming stoichiometric atmospheric production from a regolith of equal composition, the calcium to sodium atmospheric abundance ratio should be at least 4.6/1. However, the measured calcium tangent column density, only observed thus far with Keck/HIRES, is repeatedly less than 10% of sodium. The high temperature and localized distribution of Ca suggests that it is liberated from the crust to the atmosphere with energetic processes: impact vaporization producing CaO and clusters, followed by photo-dissociation, and/or ionic sputtering of Ca as atoms, ions, or in molecules (Killen, Bida, and Morgan, 2005). The low Ca atmospheric density implies that the species is quickly lost by bonding to the surface, direct escape, or rapid loss of its ion.

Here, we report on low measured upper limits of the metals Mg and Al in Mercury's atmosphere, as derived from the Keck/HIRES data sets. A wide range of compositional models, from refractory to volatile-rich, predict significant mantle abundances for these metals (Goettel, 1988). We find an upper limit for the Mg tangent column of 3.9 x 10^7/cm^2, and that for Al of 7.6 x 10^7/cm^2. In contrast to sodium, magnesium should be 10-times more abundant than calcium based on stoichiometry with

the preferred mantle compositional model, yet we find it severely depleted relative to calcium by a factor of 30. For aluminum, our measured upper limit tangent column indicates crustal depletion by 1.75 from the preferred model abundance. The lack of detection of Al and Mg to date implies that either the crustal composition is markedly different than current models suggest, or the processes for liberation of the possible source compounds Al_2O_3 and MgO, and/or single atoms are extremely inefficient relative to those for Ca and Na. We also present the spatial dependence of the Mg and Al abundance upper limits, and discuss possible source processes for these metals. In addition, we report on new measurements of the abundance of these elements in Mercury's atmosphere made in late May 2007 with Keck-1/HIRES.