# Geochemical behavior of elements under reducing conditions relevant to Mercury

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The MESSENGER spacecraft provided our first quantitative constraints on the structure and composition of Mercury. Mercury is a volatile-rich planet with low abundances of Fe and elevated abundances of S at its surface. The coupling of low Fe and elevated S is a clear indication of highly reducing conditions, and the most recent estimates of Mercury's $fO_2$ are between 3.2 to 4.3 log units below the iron-wüstite (IW) buffer. These values are at least 2 orders of magnitude more reducing than the Moon, and are many orders of magnitude more reducing than the Earth or Mars. Much of our geochemical understanding of elements in natural systems comes from empirical observations of rocks on Earth and from other planetary bodies, however Mercury's oxygen fugacity lies outside the range of these observations, so any broad geochemical interpretations that are rooted in these empirical observations may not apply to Mercury.

We have evaluated our previously unpublished experimental data on highly reducing systems as well as experimental data from the literature to assess the behavior of major and minor elements under highly reducing systems. Our results indicate that Si and Fe becomes less lithophile with decreasing $fO_2$, although Si remains mostly lithophile and Fe exhibits both siderophile and chalcophile behavior down to about 7 log units below the IW buffer. Titanium and Mn are no longer lithophile and transition to chalcophile elements by 7 log units below IW, although Ti also exhibits siderophile behavior. Chromium exhibits both siderophile and chalcophile behavior and is not lithophile under highly reducing conditions. Sulfur remains chalcophile, but it also exhibits lithophile behavior as its solubility in silicate melts increases substantially at lower $fO_2$, although it crystallizes sulfide minerals if the melt is allowed to crystallize without quenching to a glass. Fe, Si, Mn, Cr, S, and Ti exhibit similar behavior in highly reduced meteorites and highly reducing experiments. Chlorine, K, and Na exhibit lithophile behavior in reduced experiments, but they exhibit some chalcophile behavior within reduced meteorites, namely through the presence of djerfisherite. Experiments are ongoing to further assess the behavior of other major, minor, and trace elements in highly reducing systems.