

Compositional variability of ultramafic lavas on Mercury: Implications for surface mineralogy and mantle sources

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Measurements of major element ratios obtained by the MESSENGER spacecraft using x-ray fluorescence spectra are used to calculate absolute element abundances of lavas at the surface of Mercury. We discuss calculation methods and assumptions that take into account the distribution of major elements between silicate, metal, and sulfide components and the potential occurrence of sulfide minerals under reduced conditions. Available compositional data for the northern volcanic plains and for intercrater plains and heavily cratered terrain display significant variations although they share common silica- and magnesium-rich characteristics (basaltic komatiites to komatiites). The inferred mineralogy at Mercury's surface should be dominated by orthopyroxene, plagioclase, minor olivine if any, clinopyroxene (augite), and tridymite. Two compositional groups are distinguished based on mineral components, particularly by the presence or absence of clinopyroxene. Melting experiments at one atmosphere demonstrate that these compositional groups cannot be simply related to each other by any fractional crystallization process, suggesting differentiated source compositions and implying multi-stage differentiation and remelting processes for Mercury. Magma ocean crystallization followed by adiabatic decompression of mantle layers during cumulate overturn and/or convection would have produced adequate conditions to explain surface compositions. Thus, the surface of Mercury is not an unmodified quenched crust of primordial bulk planetary composition. Ultramafic lavas from Mercury have high liquidus temperatures (1450-1350 °C) and very low viscosities, in accordance with the eruption style characterized by flooding of pre-existing impact craters by lava and absence of central volcanoes.

New tricks with old tracers: Sr stable isotope variations in an evolved volcanic system investigated using an ⁸⁴Sr-⁸⁷Sr double spike

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Strontium is a refractory lithophile element with four stable isotopes, ⁸⁴Sr, ⁸⁶Sr, ⁸⁷Sr and ⁸⁸Sr. However, ⁸⁷Sr is also produced by the long-lived radioactive decay of ⁸⁷Rb, and this parent-daughter isotope system has long been a key pillar of geochronology and geochemical tracing. Conventional Sr isotopic measurements made using TIMS or MC-ICP-MS are corrected for instrumental mass fractionation assuming a value for the ⁸⁸Sr/⁸⁶Sr ratio of 8.375209. This internal normalisation permits the measurement of ⁸⁷Sr/⁸⁶Sr ratios to a very high precision. However, normalisation to a fixed ⁸⁸Sr/⁸⁶Sr ratio using a mass-dependent fractionation law assumes that the stable isotope ratio is uniform in natural samples and erases the possible signature of any mass-dependent natural variation in the ⁸⁸Sr/⁸⁶Sr and ⁸⁴Sr/⁸⁶Sr ratios. In this study, we present high-precision Sr stable and radiogenic isotope data (determined using a double spike and TIMS) along with trace element data for a suite of samples from a single evolved volcanic system (Huckleberry Ridge Tuff, Yellowstone). Strontium stable isotope values vary by up to ~0.5 ‰ and correlate well with Ba and Eu/Eu* variations in whole rocks and glass separates. Our data suggest that crystallisation of sanidine (± plagioclase) and/or mixing of melts that have experienced such fractionation is the main driver for the stable isotope variations. Sr-isotopic studies on volcanic rocks require re-evaluation.