EXPECTED GEOCHEMICAL AND MINERALOGICAL PROPERTIES OF METEORITES FROM MERCURY: INFERENCES FROM MESSENGER DATA

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Introduction: Meteorites from the Moon, Mars, and many types of asteroid bodies have been identified among our global inventory of meteorites, however samples of Mercury and Venus have not been identified. The absence of mercurian and venusian meteorites could be attributed to an inability to recognize them in our collections due to a paucity of geochemical information for Venus and Mercury. In the case of mercurian meteorites, this possibility is further supported by dynamical calculations that suggest mercurian meteorites should be present on Earth at a factor of 2-3 less than meteorites from Mars [1]. In the present study, we focus on the putative mineralogy of mercurian meteorites using data obtained from the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft, which has provided us with our first quantitative constraints on the geochemistry of planet Mercury. We have used the MESSENGER data to compile a list of mineralogical and geochemical characteristics that a meteorite from Mercury is likely to exhibit.

Geochemistry and Mineralogy: Mercury's surface has low abundances of Fe (<2 wt.%), elevated abundances of S (up to ~4 wt.%), and elevated abundances of Na (up to 5 wt.% in the northern latitudes) [2-6]. The surface of Mercury is boninitic in composition with correspondingly elevated SiO_2 and MgO abundances [7]. These properties have been used to bracket the oxygen fugacity of mercurian rocks to be between 3 and 7 log units below the iron-wüstite (IW) buffer [8, 9]. Mercury's surface composition yields a primary normative mineralogy of albitic plagioclase (primary phase), Mg-rich orthopyroxene, and forsteritic olivine. Consequently, these three minerals are likely to make up the major mineralogy of a mercurian meteorite. There are additional accessory mineral phases that are likely to occupy a mercurian meteorite. Graphite has been reported as the most likely darkening agent and the principle component in a primary flotation crust on Mercury [10, 11], so graphite could occur as an accessory phase in mercurian regolith breccias or (less likely) as xenocrysts in volcanic rocks. Furthermore, experimental studies of mercurian melts under highly reducing conditions indicate that sulfides consisting of Fe, Mn, Ti, Cr, Mg, and Ca are also likely to occur in mercurian rocks [7]. Cl-bearing sulfides or chloride salts may also occur as an accessory phase [12].

Conclusions: Meteorites with many or all of these characteristics should be further vetted for a potential mercurian origin. Of the existing meteorite classes, mercurian meteorites will most resemble aubrites or enstatite achondrites with much higher abundances of albitic plagioclase than typically occurs in aubrites. If such a meteorite is identified, radiometric dating could provide further insights into a mercurian origin. The ages of most surface volcanics on Mercury are estimated to be between 4.1 and 3.7 Ga [13-14], which is considerably younger than most aubrites, which typically have 4.56 Ga ages [15].

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