PETROLOGIC MODELING OF CHONDRITIC PARENT MELTS: IMPLICATIONS FOR MESSENGER

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Introduction: Earth- and spacecraft-based reflectance spectra of Mercury exhibit no 1-µm absorption feature associated with FeO in silicates [1-5], limiting FeO in silicates to less than 2-3 wt. % [1,4]. However, the low surface albedo and MESSENGER neutron spectrometer measurements of the Intermediate Terrain are consistent with the presence of significant abundance of ilmenite (up 22 wt. % [3], 7-19 wt. % [6]). Ilmenite-rich surface may have formed from Ti-rich and relatively FeO-poor magmas near the iron-wüstite buffer in which early-crystallizing ilmenite limits the amount of FeO available for later-crystallizing pyroxene [3]. We tested this hypothesis with MELTS modeling of proposed Mercury compositions.

Starting compositions: A variety of chondritic mantle compositions have been proposed for Mercury [e.g., 7-8 and references therein], including the bencubbinite (CB) chondrite composition of [7] and chondritic and non-chondritic CB compositions of [8]. To gain insights into high-Ti magmas likely derived from remelting of magma ocean cumulates, we modeled Apollo sample suite high-Ti rocks including average compositions of high-Ti lunar basalts returned from Apollo 11 and 17 missions, and high-Ti picritic glasses returned by Apollo 15 and 17 missions [9]. A range of FeO/MgO ratios was achieved in the lunar compositions by replacing molar FeO with MgO to mimic expected mercurian magmas.

Methods: Equilibrium and fractional crystallization MELTS models were run at the iron-wüstite buffer. The resulting mineralogy and mineral compositions were compared to the expected limitations for Mercury (e.g., low FeO silicates, abundance of opaque phases) and the reasonableness of the starting composition was assessed.

Results: In general, bencubbinite- and lunar basalt-based starting compositions do not reproduce the estimated Mercury surface composition. The crystallization models produce mafic silicates (opx ± cpx ± olivine) that contain too much FeO. In addition, the models do not crystallize any ilmenite; instead, the models crystallize other opaques (spinel ± rutile) in very low abundances (≤ 2 wt. %). However, the low-FeO compositions based on high-Ti picritic glass produce models with more promising results. These models crystallize mafic silicates at or below 2-3 wt. % FeO. In addition, the models result in a high abundance of opaques (11-17 wt. % opaques), dominated by rhombic oxides (ilmenite, geikielite) with minor spinel and rutile.

Conclusions: The high-Ti picritic glass results are the most promising match for estimated Mercury surface compositions. If the surface of Mercury contains low FeO silicates and high abundances of oxides, the origin may be more akin to that of lunar high-Ti picritic glasses than melting of a chondritic source.

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