Final Report

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Phase Equilibrium Investigations of Planetary Materials

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This grant provided funds to carry out experimental studies designed to illuminate the conditions of melting and chemical differentiation that has occurred in planetary interiors. Studies focused on the conditions of mare basalt generation in the moon's interior and on processes that led to core formation in the Shergottite Parent Body (Mars). Studies also examined physical processes that could lead to the segregation of metal-rich sulfide melts in an olivine-rich solid matrix. The major results of each paper are discussed below and copies of the papers are attached as Appendix I.

A paper with Tom Wagner was published in *Geochimica Cosmochimica Acta*. Experiments reported in this paper measured the dissolution rate of ilmenite in a broad spectrum of mare basalt and lunar ultramafic glass compositions. The dissolution rates were used to assess the efficiency of assimilation mechanisms that produce high-Ti ultramafic glasses by assimilating pyroxene + ilmenite magma ocean cumulates. Phase equilibrium experiments were also performed on an Apollo 14 Black Glass to 2.2 GPa, and used to model the thermal energy budget of assimilation.

A paper with Glenn Gaetani was also published in *Geochimica Cosmochimica Acta* . The partitioning behavior of V, Cr, Mn, Co, Ni, Cu and W among coexisting sulfide melt, silicate melt, and olivine was investigated. Experiments were performed at 1 atm pressure, 1350°C, with the fugacities of oxygen and sulfur controlled by mixing CO_2, CO, and SO_2 gases. One result of this study was the calibration of the functional relation between sulfide melt/silicate melt partitioning and f_{O2} and f_{S2}. The experiments also used the abundance of transition series elements to provide constraints on the mass and composition of the core of the Shergottite Parent body (Mars).

An abstract with Glenn Gaetani published in Lunar and Planetary Science XXVII explores the potential controls of variations of f_{O2}/f_{S2} on the wetting angle between olivine and Fe-Ni-S-O melts. Experiments performed on aggregates of mantle olivine and iron sulfide melt over a range of oxygen and sulfur fugacity conditions demonstrate that the amount of oxygen dissolved in the melt has a strong influence on olivine/melt wetting angles. Iron sulfide melts containing dissolved oxygen at parts-per-million concentrations form dihedral angles close to 90° in polycrystalline olivine aggregates. These melts will be trapped in isolated pockets at four-grain junctions in mantle peridotite. Iron sulfide melts containing a few weight percent dissolved oxygen form dihedral angles of 60° or lower. These oxygen-rich melts will form an interconnected network in the upper mantle even at very low melt fractions. This may allow efficient segregation of an iron sulfide melt from the Earth's mantle into the outer core via porous flow.

Appendix I

Publications resulting from Grant NAGW-3586

Gaetani GA and Grove TL (1996) The effect of variable f_{O2}/f_{S2} conditions on wetting angles olivine/sulfide melt aggregates: Mobility of sulfide melt in the Earth's upper mantle. In *Lunar and Planetary Science XXVII*, p. 389-390. The Lunar and Planetary Institute, Houston.

Gaetani GA and Grove TL (1997) Partitioning of moderately siderophile elements among olivine, silicate melt and sulfide melt: Constraints on core formation in Earth and Mars. *Geochim Cosmochim Acta 61,* p. 1829-1846.

Wagner TP and Grove TL (1997) Experimental constraints on the origin of lunar high-Ti ultramafic glasses. *Geochim Cosmochim Acta 61,* p. 1315-1327.