Chapter I

Introduction

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An equation of state (EOS) (i.e., density as a function of pressure and temperature) for silicate melts at high pressure is of primary importance for understanding processes occurring within terrestrial interiors. There has previously existed only limited knowledge of melt density and compressibility determined at low pressures (< 40 GPa) on a restricted range of compositions. The goal of my graduate work documented by this thesis was to constrain the EOS for a number of important end-member liquids using shock wave studies and to incorporate them into an empirical, predictive model of melt density as a function of temperature, pressure and composition.

Chapter II describes the multi-technique collaboration of the University of Michigan, the University of New Mexico, and Caltech to constrain the EOS of molten Fe_2SiO_4 (fayalite). Shock wave experiments further extended the fayalite Hugoniot of *Chen et al*. [2002], which aided in resolving previously discrepant results for that study and the sink/float data set of *Agee* [1992]. The majority of the shock wave methods used for pre-heated experiments are described in this chapter. Subsequent chapters cover only changes made during each new set of experiments. The equations and derivation of the model used for creating isentropes of liquid mixtures is presented in detail in this chapter and is employed throughout the rest of the thesis.

The determination of the molten Mg_2SiO_4 (forsterite) EOS is presented in Chapter III, along with revised EOS parameters for $CaMgSi_2O_6$ (diopside), $CaAl_2Si_2O_8$ (anorthite) [*Asimow and Ahrens*, 2010], and $MgSiO_3$ (enstatite) melts [*Mosenfelder et al.*, 2009] . This new set of end member EOS, including fayalite, is used to determine the isentropic temperature profile of a fully molten magma ocean of two hypothetical bulk mantle compositions, chondrite [*Andrault et al.*, 2011] and peridotite[*Fiquet et al.*, 2010], by way of the isentrope mixture model presented in Chapter II. The temperature and pressure of first crystallization was determined from the intersection of the isentrope and the experimental liquidus. This chapter also describes a melting model which employs linear mixing of liquid volumes to determine whether a partial melt and its equilibrium residue could produce an aggregate density that is comparable to that estimated by *Rost et al.*[2006] for a ultralow velocity zone and still maintain a low melt-residue density contrast (~1%) employed by the seismic modeling of *Williams and Garnero* [1996].

The EOS for $CaFeSi_2O_6$ (hedenbergite), a 50-50 mixture of $CaAl_2Si_2O_8$-$CaFeSi_2O_6$ (anorthite-hedenbergite), and an equimolar mixture of $CaAl_2Si_2O_8$-$CaFeSi_2O_6$-$CaMgSi_2O_6$ (anorthite-hedenbergite-diopside) are determined and described in Chapter IV. A series of tests on the validity of using linear mixing of volumes to predict the densities of multicomponent liquids at high temperature and pressure are presented. Results for these tests indicate that Fe-bearing silicate liquid densities can only be approximated as ideal under certain compositional restrictions.

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