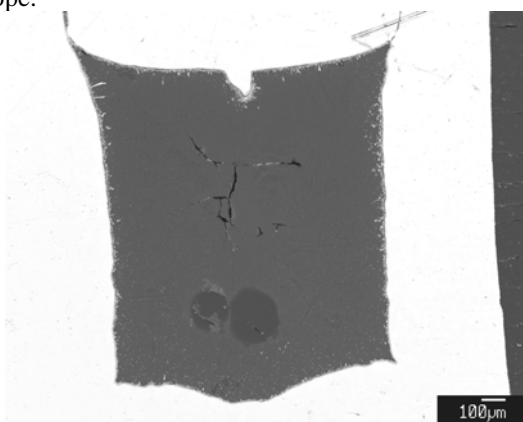**PARTIAL MOLAR VOLUME OF CO_2 IN PERIDOTITE PARTIAL MELT AT HIGH PRESSURE.** M. S. Duncan[1] and C. B. Agee[2], Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico (MSC03 2050 University of New Mexico, Albuquerque, NM 87131-1126, United States [1]msduncan@unm.edu, [2]agee@unm.edu).

Introduction: Knowing the density of mantle melts is vital to understanding the processes that occurred during planet formation and the petrogenesis of the rocks seen on the surface of planets today. One way to determine the densities of a variety of compositions of mantle melts is by using the partial molar volumes of the liquid oxides. Partial molar volumes for various major element oxides have been experimentally determined [1], but the values for volatiles, such as carbon dioxide, have not been extensively studied. Knowing the effect of volatiles on the density of the partial mantle melts are key to discerning the mechanics of density crossovers in the mantles of the terrestrial planets.

Methods: Using the sink/float method [2] on an undepleted upper mantle peridotite partial melt composition [3], approximately 5 wt% CO_2 was added to a powdered oxide mix as $CaCO_3$. The mix is placed in a molybdenum capsule with two density marker spheres. Starting with the low density forsterite 100 spheres and using increasingly denser minerals the pressure/density, or compressibility, curve of the carbonated and non-carbonated melts can be bracketed for increasing pressures.

A Walker multi-anvil device is used for these high pressure (>3GPa) experiments. After held at pressure and temperature for 30 seconds, the experiments are quenched. To determine a sink (fig.1), float (fig. 2), or neutral buoyancy result, the experiments are mounted in epoxy and ground into to expose the inside of the capsule and then observed under an optical microscope.

Once the placement of the spheres has been determined, the quench material is analyzed under an electron microprobe to confirm the retention of CO_2. Because of the inherent difficulties when analyzing for the lighter elements carbon and oxygen, the experiments are also analyzed using Fourier Transform Infrared Spectroscopy (FTIR) which detects the carbonate anion.

Using the third-order Birch-Murnaghan equation of state, the density of the mineral spheres is determined as a function of pressure, given constant temperature. This creates a pressure/density curve for each mineral. From the sink/float information, a similar curve can be constructed for the experimental partial melt. The crossover of the mineral curve and the experimentally determined curves, allow the neutral buoyancy density of the partial melt to be determined (fig. 3).

From this density information and the compositional information determined analytically, the partial molar volumes of the liquid oxide components of the carbonated and non-carbonated melts are determined, in particular the partial molar volume of CO_2 ($\overline{V}_{CO_2}$) in the silicate melt.

Results: Preliminary results show a neutral buoyancy for the carbonated peridotite partial melt at 4.6 GPa and 1800°C, while the non-carbonated has an inferred neutral buoyancy at 4.0 GPa and 1850°C (fig.3) using the Fo-100 spheres. Using Fo-90 spheres, a sink at 5.6 GPa and 1850°C has been found for the carbonated composition.

Figure 1. DG-5-9 A carbonated melt sink. The Fo-100 spheres are visible at the bottom of the capsule.
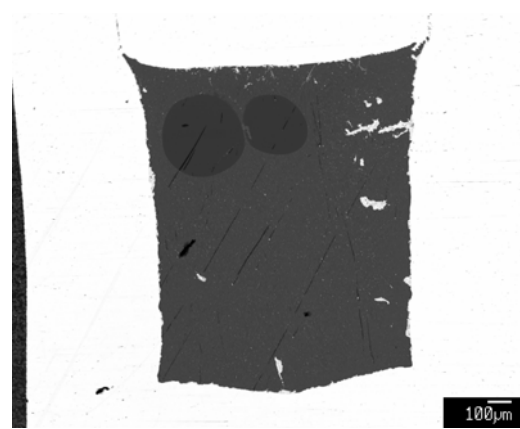
Figure 2. DG-N-7 A non-carbonated melt float. The Fo-100 spheres are visible at the top of the capsule.

The initial microprobe results and the FTIR results calculate the amount of CO_2 in the melt to be approximately 5.2 wt%, within error of the added amount. These results allow the calculation of $\overline{V}_{CO_2}$ at 4.6 GPa and 1800°C to be 17.7 cm^3/mol.

With a thermal expansion correction, this $\overline{V}_{CO_2}$ is plotted with previously calculated and experimental data at 1 bar [4, 5] and 19.5 GPa [6] which constrains the shape of the compression curve (fig. 4).

Implications: This study has implications for density crossovers in the mantles of terrestrial planets. Because the addition of CO_2 to a melt will lower the density of the melt, the density crossover will move to a higher pressure. At this new pressure, the density crossover may no longer exist due the phase transformation of the crystal phase making it denser than the melt.

Our experimental results will help place constraints on the role of volatiles in mantle low velocity zones and can be used to calculate the depth of neutral buoyancy for carbonated partial melts such as kimberlite. By knowing where these partial melts are neutrally buoyant, the minimum amount of CO_2 present during melting can be determined that still allows for their eruption. These results can also be used to describe any other planetary differentiation scenario where CO_2 is present.

Conclusions: This study now places constraints on the $\overline{V}_{CO_2}$, such as pressure and temperature, as well as any compositional effects. By knowing the $\overline{V}_{CO_2}$ at a given pressure and temperature, the density of carbonated magmas, as well as their compressibilities, can be calculated for natural systems.

The analytical results from the electron microprobe and FTIR closely agree on the amount of CO_2 present in the quench material indicating no CO_2 was lost during the experiment. From this information, we have calculated the $\overline{V}_{CO_2}$ in silicate melt to be 17.7 cm^3/mol at 4.6 GPa and 1800°C. This value constrains the shape of the compression curve at low pressure indicating a significant decrease in $\overline{V}_{CO_2}$ from 0 to 5 GPa.

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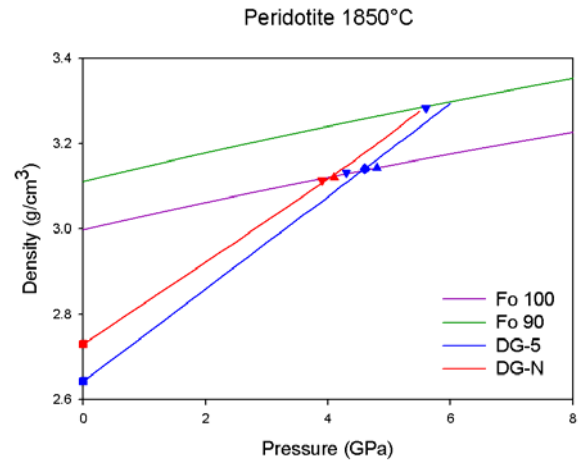
Figure 3. Compressibility curves for non-carbonated melt (red) and carbonated melt (blue) and experimental sinks (down arrow), floats (up arrow), and neutral buoyancy (diamond). Density marker curves are purple for forsterite 100 and green for forsterite 90.
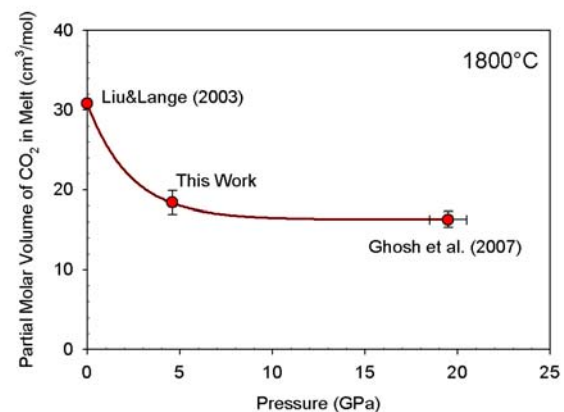
Figure 4. Partial molar volume of CO_2 in silicate melt plotted as a function of pressure. The partial molar volume decreases significantly from 0 to 5 GPa then remains fairly constant.