USING HIGH PRESSURE and HIGH TEMPERATURE TO CREATE HYDROCARBONS: AN APPLICATION OF THE HYDROTHERMAL DIAMOND ANVIL CELL

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A diamond anvil cell (DAC) is an instrument used for creating high pressures. One application of a DAC is the replication of the pressures found at depth in Earth's crust and mantle, and we are specifically interested in the potential for hydrocarbons, such as methane, to form at mantle pressures. Briefly, DACs use two diamonds to compress a sample which is held in a chamber drilled into a metal gasket. We indirectly determined sample pressures by adding a ruby crystal to the chamber and using a 532 nm-wavelength laser in order to make the ruby fluoresce; the pressure-induced fluorescence shift in ruby is well-documented, and the measured fluorescence spectrum was used to calculate sample pressure. Temperatures in the DAC were controlled by flowing current through resistive wires wrapped around each anvil, and temperatures were measured with thermoucouples in direct contact with the anvils. Consistent with previous workers, we found that temperature had a detrimental effect on our ability to measure ruby fluorescence within the DAC. As an alternate method of obtaining the pressure while at higher temperatures, we attempted to use a samarium-doped yttrium aluminum garnet (Sm:YAG) as a phosphor, but the fluorescence was extremely weak, even at high laser power. Instead, a larger ruby crystal was placed into a Au-lining inside the chamber that allowed the crystal to not react with the sample and still be easily found by the laser. We tested this technique of simultaneously measuring both pressure and temperature on a sample of Fe-Calcite-H_2O. We intially compressed the sample to 2 GPa prior to heating. We slowly increased the temperature to 600 °C and found that the pressure increased to 5 GPa. After temperature quenching the sample we measured Raman spectra of the reaction products (while still at high pressure) at Argonne National Lab. The Raman data suggest the formation of methane; heavier hydrocarbons do not seem to be produced. Notably, it appears that a some of the methane reacted with H_2O to form a clathrate stucture.