EXPERIMENTAL CONSTRAINTS ON UREILITE PETROGENESIS. S.J. Singletary[1] and T. L. Grove[1] ([1]Massachusetts Institute of Technology, Dept. of Earth, Atm. And Planet. Science, Cambridge, MA 02139)(jumper@mit.edu, tlgrove@mit.edu)

Introduction: We have conducted melting experiments on liquids predicted to be in equilibrium with ureilites to explore the petrogenesis of ureilites by a partial melting/smelting process. Correlations of modal mineralogy, mineral chemistry and texture are consistent with smelting as a major process involved in ureilite petrogenesis [1]. Although ureilites resemble igneous rocks their mode of origin remains controversial. The competing hypotheses include origin as products of fractional crystallization, residues of partial melting, or a nebular origin. Previous experiments provided support for the hypothesis that ureilites are the residues of a partial melting/smelting event that began just as augite was exhausted from the residue [2]. Ureilites are comprised of ~90% anhedral olivine and pyroxene and <10% dark interstitial material consisting of a mixture of silicates, carbon, metal, carbides and sulfides [3]. The mg# (100*molar Mg/[Mg+Fe]) of olivine in ureilites varies from 75 to 95. In addition to systematic variations in mg#, the ureilites can be divided into sub-groups based on pyroxene occurrence. The majority of ureilites consist of the assemblage olivine + pigeonite + carbonaceous matrix; the remaining ureilites contain olivine ± pigeonite ± augite ± opx [4].

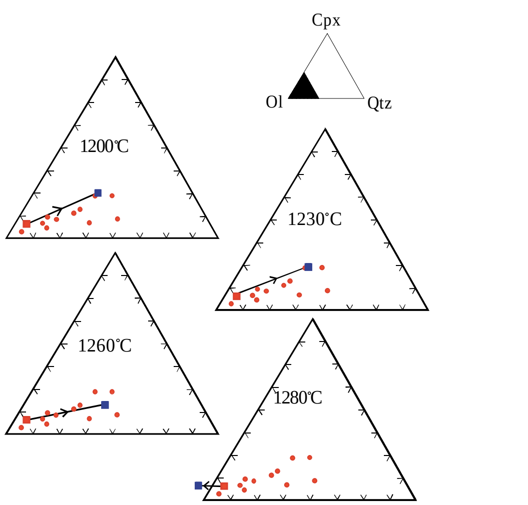

Figure 1. Modeled trends of a hypothetical residue produced by progressive smelting. Red squares represent the starting bulk composition of 7% liquid in equilibrium with low mg# ureilites, 91% Fo75 olivine and 2% clinopyroxene with an mg# of 76. The blue squares represent the end composition after a model progressive smelting event. Red circles are ureilite bulk compositions as determined from the data of [1]. Reaction coefficents for each model trend were determined from experimental data obtained at the same temperature of the model run.

Methods and Results: Experiments have been performed over temperature (1150-1280ºC), pressure (5 to 12.5 MPa) and low oxygen fugacity (graphite-CO gas) conditions appropriate for a hypothetical ureilite parent body ~200 km in size. Experimental and petrologic modeling results indicate that a partial melting/smelting model of ureilite petrogenesis can explain many of the unique characteristics displayed by this meteorite group.

Compositional information preserved in the pigeonite-olivine ureilites was used to estimate the composition of melts in equilibrium with the ureilites. The results of twenty experiments saturated with olivine, pyroxene, metal and liquid with ureilite appropriate compositions are used to calibrate the phase coefficients and pressure-temperature dependence of the smelting reaction. The calibrated coefficients are used to model the behavior of a hypothetical residue that is experiencing fractional smelting.

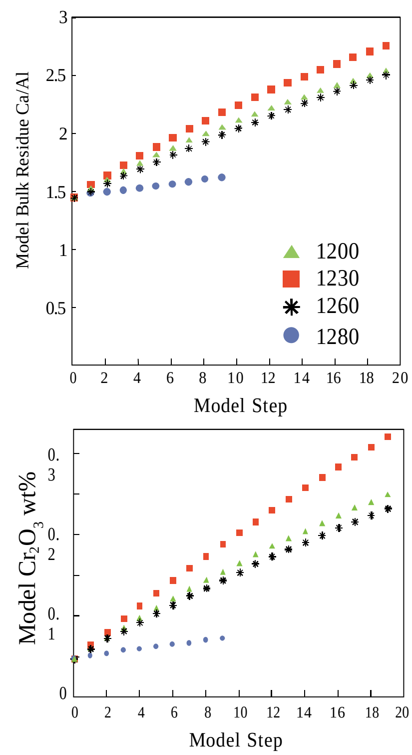

Figure 2. Model residue compositional trends. A) The Ca/Al ratio of the modeled residue is increased at a higher rate at low temperatures. B) The same trends are observed in the Cr_2O_3 wt% of the residue as well.

The residue is initially olivine-rich and smelting progressively depletes the olivine content and enriches the pyroxene and metal contents of the residues. The modeled residue composition at 1260ºC best reproduces the trend of ureilite bulk compositions (Figure 1). The model results also indicate that as a ureilite residue undergoes progressive heating, Ca/Al values and Cr_2O_3 contents are enriched at lower temperatures (below ~1240ºC) and tend to decrease at higher temperatures (Figure 2).

Fractional smelting, as we model it, may provide a mechanism to account for the high Ca/Al and Cr_2O_3 wt% values observed in ureilites. We propose that ureilites were generated from a residue that was initially olivine-rich and cpx bearing. These residues experienced varying degrees of fractional smelting to produce the compositional variability observed within the pigeonite bearing ureilites. Variations in mineral composition, modal proportions and isotopic signatures are best described by heterogeneous accretion of the ureilite parent body followed by minimal and variable degrees of igneous processing.

References: [1] Singletary, S.J. and Grove, T.L. (2003) *Meteoritics v. 38:* 95-108. [2] Singletary, S.J. and Grove, T.L. (2002) LPSC **33** #1382. [3] Middlefehldt, D.W. et al. (1999) In *Planetary Materials, Rev. Mineral. v. 36*: 4-73 – 4-95. [4] Goodrich, C.A. (1992) *Meteoritics v. 27*: 327-352.