EXPERIMENTAL INVESTIGATIONS OF UREILITE PETROGENESIS: RELATIONSHIPS BETWEEN MG# AND SMELTING EXTENT. 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 phase relations of the smelting reaction and understand the relations between ureilites. 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. Here we present new experimental data on the low mg# end of the ureilite suite. 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].

Methods and Results: Previous experiments were conducted in the pressure range of 50 to 125 bars, temperatures of 1200 to 1260°C and below the IW buffer [2]. The experiments were successful in reproducing a ureilite-type mineral assemblage of olivine-pigeonite-metal, however the mg#s of the experimentally produced phases were restricted to the middle mg# range of that displayed by the ureilites. The experiments were conducted using the composition of a liquid calculated to be in equilibrium with an average ureilite (grey circle in Figure 1)

In order to explore smelting phase relation space more fully, we have recalculated the liquid composition for subsets of the ureilite population based on mg#. Here we report experimental results using a liquid composition calculated to be in equilibrium with the low mg# ureilites. Experiments were also conducted with the liquid composition plus 20 wt% Fo_{75} (yellow square in Figure 1) and with 5 wt% clinopyroxene (yellow triangle in Figure 1). The calculated liquid composition (yellow circle in Figure 1) plots to the right of the Cpx-Opx join and below that of the average calculated liquid of [2] (grey circle in Figure 1).

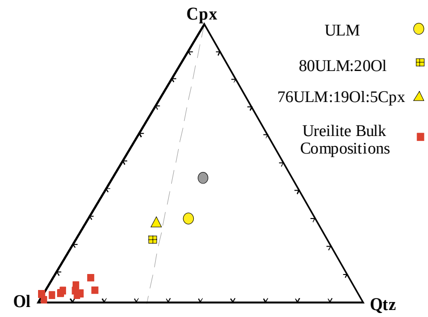

Figure 1. Experimental bulk compositions plotted in the Ol-Cpx-Qtz ternary phase diagram projected from Plag.

Application to Ureilites: Partial smelting of ureilite bulk compositions would produce a melt at the olivine + pigeonite + augite reaction point. As the extent of smelting increases, the liquid composition moves up the olivine-pigeonite boundary. The compositions of the liquids (both calculated and experimental) indicate that augite was initially present in the residue but exhausted early and that the low mg# pigeonite-bearing ureilites have experienced greater extents of partial smelting. Monomict pigeonite-olivine ureilite bulk compositions fall to the left of the Cpx-Opx join in the Olivine-Clinopyroxene-Quartz ternary diagram and would be in equilibrium with a liquid on the olivine – pigeonite reaction boundary. This result stands in contrast to our previous finding that the average ureilite residue composition was near saturation with olivine + pigeonite + augite. Previous experiments [5] led to the suggestion that the low mg# ureilites originated at greater depth in the ureilite parent body than the high mg# samples. Our current experiments and petrologic modeling support a similar range of depths for ureilite smelting, but also indicate that the shallower, high mg# ureilites represent smelting at a high temperature (~1290 ^{o}C), while the lower mg# ureilites represent smelting at ~ 1200 ^{o}C. This reverse correlation in temperature vs. depth also extends to smelting extent. The low mg#, lower temperature and presumably deeper ureilites also appear to represent higher extents of partial smelting than an average ureilite. This apparent contradiction in smelting amount and major element composition may be

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related to the role played by Fe metal in the smelting process and is currently under investigation.

References: [1] Singletary, S.J. et al. (2001) LPSC **32** #2000. [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.[5] Walker D. and Grove T.L.(1993) *Meteoritics v. 28*, 629-636.