EVOLUTION OF THE UREILITE PARENT BODY. P.Hudon[1] , C. Romanek[2], Lindy Paddock[2] and D.W. Mittlefehldt[1], [1]Astromaterials Research and Exploration Science Office, NASA Johnson Space Center, Mail Code SR, 2101 NASA Road 1, Houston, Texas, USA, pierre.hudon1@jsc.nasa.gov, [2]Department of Geology and Savannah River Ecology Laboratory, University of Georgia, Aiken, S.C., 29802, USA.

Introduction: Ureilites are ultramafic achondrites composed primarily of olivine and pyroxene with intergranular fine-grained metal, sulfides, and silicates [1,2]. Ureilites contain significant amounts of carbon (up to about 6.5 wt%) as graphite, lonsdaleite, and/or diamond. It has been shown that carbon-silicate redox (i.e. "smelting") reactions are responsible for the negative FeO-MnO (or positive Fe/Mn-Fe/Mg with constant Mn/Mg) trend seen in the mineral and bulk compositions of ureilites [4-6] and for the positive correlation between modal percent pigeonite and mg# [7]. Carbon redox reactions are strongly exothermic and pressure dependent [3]; so ureilites with the largest mg# are the most reduced, experienced the highest temperatures, and formed at the lowest pressures, i.e. near the surface of the ureilite parent body. Ureilites with the largest mg# have the smallest the $\delta^{18}O$ and the largest $\Delta^{17}O$. To explain this, Singletary and Grove [7] proposed that heterogeneous accretion took place on the ureilite parent body, which lead to a radial distribution of the oxygen isotopes. To further investigate possible relationships, we performed carbon isotope and electron probe measurements on a suite of 27 ureilites in order to see the type of correlation that exists between mg#, oxygen isotopes, and carbon.

Methods: Carbon content and isotopic compositions were determined using a Delta^{plus}XL isotope ratio mass spectrometer (IRMS) functioning in continuous flow mode. Samples were combusted, the gases were passed through a Cu reduction furnace before water removal and separation of CO_2 by gas chromatography, and the purified CO_2 was analyzed for %C and $^{13}C/^{12}C$ ratio determinations. The estimated sample precisions are better than ±0.2 wt% and ±0.2‰; 1σ std. Electron probe microanalysis of the olivine cores was performed on the Cameca SX-100 probe at the Johnson Space Center using WDS.

Results and discussion: Results are shown in Figs. 1, 2, and 3. Mg#s, carbon contents, and $\delta^{13}C$ data were taken from this study and the literature [8-19], and averaged. Polymic ureilites were not considered. A well-defined negative correlation is observed between the mg# of olivine cores and $\Delta^{17}O$ [7] (Fig. 1). A less well-defined negative correlation, may exist between mg# and $\delta^{13}C$ (Fig. 2), but there is substantial scatter in the data. At first glance, this trend is unexpected: if ureilites with the largest mg# experienced the greatest amount of reduction, they should have the largest $\delta^{13}C$. A plot of carbon content versus $\delta^{13}C$ (Fig. 3) seems to show a general trend: the smaller the carbon content, the heavier is the carbon. This general trend is exactly what one would expect if smelting has affected the ureilite parent body: the more C is consumed during smelting, the heavier the residue become. However, mg#s do not support this interpretation. Ureilites with the largest mg# (light blue) should have the smallest carbon content and the highest $\delta^{13}C$, while ureilites with the smallest mg# (dark blue) should have the opposite. To explain this apparent contradiction, one could propose that heterogeneous accretion took place on the ureilite parent body, which led to a radial distribution of the oxygen and carbon isotopes [7]. There is, however, another possible explanation for the data distributions observed in Figs. 1-3.

Ureilites have experienced two reducing events. The first one is recorded in the cores of the olivine crystals while the second is seen in the strongly reduced rims. During the heating of the ureilite parent body, the olivine cores first equilibrated with the carbon and their mg# were fixed according to their depth (see the expected trend in Fig 2) : the deepest olivine experienced little reduction, had low mg#, relatively

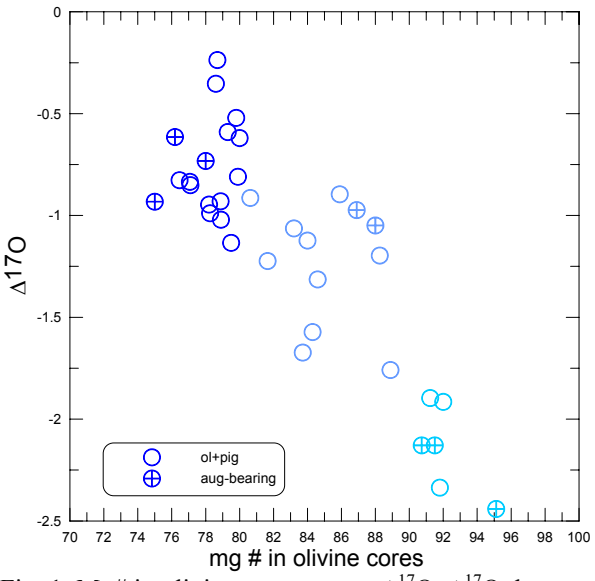

Fig. 1. Mg# in olivine cores versus $\Delta^{17}O$. $\Delta^{17}O$ data are from Clayton and Mayeda [20-21]. Samples on this Fig. and Figs 2 and 3 are color coded with mg#≥ 90 in dark blue, those with 90>mg#>80 in blue, and those ≤80 are in light blue.

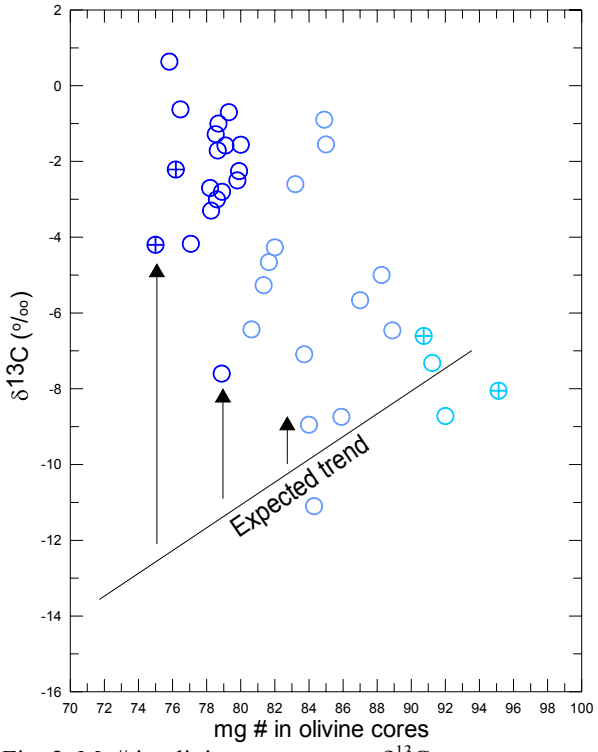

Fig. 2. Mg# in olivine cores versus $\delta^{13}C$.

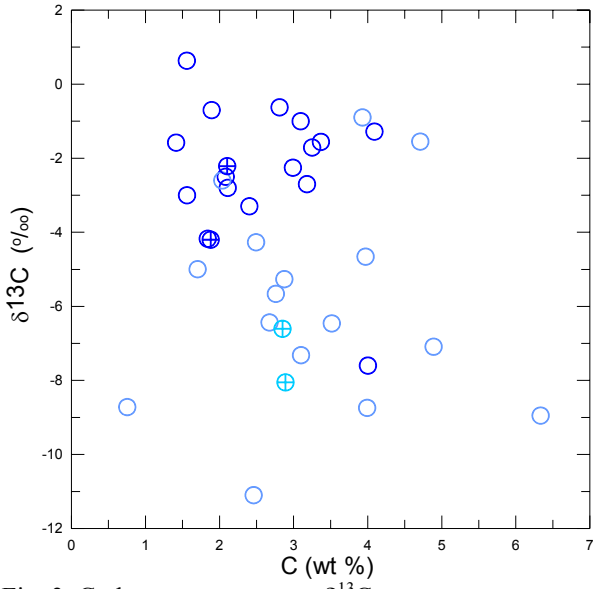

Fig. 3. Carbon content versus $\delta^{13}C$.

light carbon ($\delta^{13}C \leq$ -10 ‰) and high carbon content (about 7-8 wt%); the shallowest olivines experienced the greatest reduction, resulting in high mg#, relatively light carbon ($\delta^{13}C \leq$ -8 to -10‰) and low carbon content (about 4 wt%). The second reducing event was marked by a sudden drop in pressure (possibly due to an impact that disrupted the parent body). During this event, olivines that formed in depth were now strongly reduced along their rims (the cores preserved their initial mg#), their carbon became heavier ($\delta^{13}C >$ -8‰) and their carbon content decreased (below about 4 wt%). On the other hand, olivines that formed initially near the surface of the parent body did not experience much changes in terms of mg#, $\delta^{13}C$, and carbon content.

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