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Heterogeneous distribution of noble gases in carbonaceous materials of Shisr 007 Ureilite

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We have characterized carbonaceous materials in Shisr 007 ureilite by multidiscipline techniques for mineralogy and noble gas signatures to gain better understandings of the differentiation process of ureilite parent body and the formation mechanism of carbonaceous materials.

Optical microscope observation revealed that Shi.r 007 is an olivine-pigeonite type monomict ureilite. The olivine shows undulatory extinction and planar deformation fractures,corresponding to shock stage S3 (Shock pressure <20GPa). EPMA analysis showed that core composition of olivine (Fo=79) and pyroxene (En=73) in Shisr 007 are close to the average composition of silicates in ureilites and therefore Shisr 007 formed via differentiation process similar to other ureilites.

Diamond, graphite, and compressed graphite, which is an intermediate phase formed during graphite-diamond phase transition, are identified in carbonaceous materials by SR-XRD. Shisr 007 contains a large carbonaceous material (BCM ; 1000 x 1500 microns on a polished section). It has rectangular, blade-like shape,

implying that it was a large single crystal of graphite, as is observed in ALH 78019. Using an edged tool, BCM was separated into small pieces typically 200-300 micron in diameter. A amoeboid-shape carbonaceous materials (ACM; typically 100-400 micron in size) commonly occur and were separated from the polished section with HF/HCl. Individual 17 pieces of the BCM were first measured with Si-std by synchrotron X-ray diffraction (SR-XRD) to determine their diamond abundances. The data show that diamond abundance is roughly proportional to the weight. After the SR-XRD analyses, noble gas compositions of 10 ACMs and 16 BCMs were analyzed by stepwise heating method (600, 1300, 1900, and 2100C) using Pot-pie furnace designed for small sample analysis. In addition, 2 samples of BCMs are measured in 6 steps adding 1000 and 1600C fraction. The ACMs have relatively constant 36Ar contents (30-200 x 10-6ccSTP/g) and 36Ar/132Xe elemental ratios (100-200), while BCMs show a wider range of 36Ar contents (3-400 x 10-6ccSTP/g) and a higher 36Ar/132Xe ratios (150-450). A major part (70-95%) of primordial 36Ar, 84Kr, and 132Xe was released at 1600-2100C fraction. To identify where the carrier of noble gases are, we performed the heating experiment of CVD diamond synthesized by the hot filament method. CVD diamonds were started to decompose at 1600C, confirmed by their Raman spectra and microscopic observation, which is consistent that the main gas carrier phase of Shisr 007 is diamond. However, diamond abundances and gas concentrations did not correlated, indicating that diamonds have variable gas contents: Some diamonds contain large amounts of noble gases, but the other diamonds are almost free of gases. The heterogeneous noble gas compositions of the BCMs and ACMs imply that they have formed from multiple stages of thermal and shock metamorphism.

Keywords: Ureilite, Noble gases