AL JAWF 001, A NEW H-CHONDRITE BRECCIA. L. M. Combs[1], E. A. Gass[1], H. Y. McSween[1], D. W. Jahn[2], and L. A. Taylor[1]; [1]Planetary Geosciences Institute, Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, Knoxville, TN 37996-1410, USA; [Email: lcombs2@utk.edu]; [2]DWJ Resources LLC, 6 Victoria Lane, Signal Mountain, TN 37377 USA.

Introduction: The 3.16 kg Al Jawf 001 meteorite was found in the desert of the Al Jawf region of northwest Saudi Arabia and is named after the region of its discovery. It is an H 4/5 ordinary chondrite breccia, and has been officially approved (1/7/2014).

Silicate, FeNi metal, sulfide, and phosphate minerals dominate the meteorite. It is a genomict breccia with the clasts and matrix from the same compositional group but different petrologic types [1]. Using two polished thin-sections, we have studied seven clasts in this breccia, denoted A-G, with the matrix as M. The clasts range in size up to 4 cm. The outlines of chondrules blur into the groundmass as recrystallization increases [2]. Texturally, the clasts of petrologic type 4 can be distinguished from the type 5 clasts. For example, the type 4 clast B contains an abundance of chondrules with sharply defined edges. This texture is in contrast to the type 5 clast D in which the edges of the chondrules are beginning to merge with the surrounding groundmass. Also, the clasts of petrologic type 4 have a fine-grained texture compared to those of type 5. The grains of the type 5 clasts have recrystallized and thus have larger grain sizes. There are also varying amounts of shock melt in the clasts, with clast C being nearly completely composed of shock melt. Clast C contains relict grains of olivine surrounded by an overgrowth of low-Ca pyroxene. In contrast to the rest of the sample, there is little FeNi metal or troilite in this clast. Through the center of clast C, there is glassy mesostasis containing skeletal crystallites of feldspar. Where the low-Ca pyroxene overgrowth is in contact with the glassy mesostasis, there are rims of high-Ca pyroxene.

In order to classify Al Jawf 001, we analyzed the compositions of olivine and low-Ca pyroxene in each of the major clasts and in the matrix. Also, we analyzed low-Ca pyroxene vs. adjacent high-Ca pyroxene to obtain peak metamorphic temperatures, and taenite within kamacite to estimate the cooling rate.

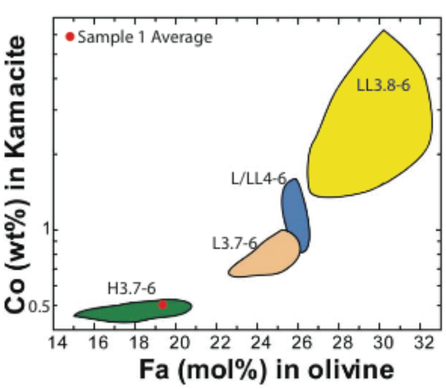

Figure 1: cobalt content in weight percent of kamacite vs the mol percent of fayalite in olivine of sample 1.

Methods: The weight % of Co in kamacite throughout the sample was plotted versus the mol% fayalite in olivine (Fig. 1), thereby identifying this meteorite as an H chondrite. Olivine and pyroxene grains were identified using back-scattered electron (BSE) images and energy dispersive spectroscopy (EDS). We then analyzed at least 5 grains of olivine and 5 of pyroxene in each of the clasts. In total, 47 olivine and 42 pyroxene grains were analyzed. Points in the cores and rims of the grains were analyzed in order to assess their compositional ranges. Using the averaged data obtained from these analyses, we plotted the mole percent fayalite vs. the mole percent ferrosilite, to identify each of the major clasts as an H, L, or LL chondrite (Fig. 2).

Elemental X-ray maps of the thin-sections were produced for Al, Ca, Cr, Fe, Mg, Ni, P, S, Si, and Ti. Using these maps and the software ENVI, we were able to determine the modal mineral abundances of Al Jawf 001.

To determine the cooling rates of the chondrite and its clasts, we used the method designed by Wood [4], with the revised cooling-rate curves that account for 10% weight Ni as calculated by Willis and Goldstein [5]. The shortest distance from the center to the border between exsolved taenite and host kamacite was measured. Analyses of the Ni contents of the taenite grains were taken from the center point of the exsolved grains and plotted on the metallographic cooling-rate curve as shown in Figure 3.

With BSE images, high-Ca pyroxene is nearly indistinguishable from olivine. However, using the Ca and Mg X-ray maps along with EDS, we were able to identify orthopyroxenes and adjacent high-Ca pyroxenes. Once located, we analyzed points on either side of the grain boundary between the two pyroxenes. These data are plotted on the modified pyroxene quadrilateral, seen in Figure 4, to obtain the peak metamorphic temperatures. The modified pyroxene quad was taken from Lindsley's two-pyroxene geothermometry method [3].

Results: Modal abundances (area %, assumed to equate to vol. %) are as follows: olivine = 30.3 %, pyroxene = 42.7 %, feldspathic glass = 16.5 %, FeNi metal = 8.1 %, troilite = 2.0 %, phospates = 0.2 %, and chromite = 0.3 %. The average composition for all of the clasts (19.4 % fayalite, 17.9 % ferrosilite) was determined to lie within the H group range, except for the matrix and impact-melt clast C. The average Co and fayalite compositions (0.50 weight% Co, 19.4 mol% fayalite) fall into the H range as well, seen in Figure 1. Using the pyroxene analyses, we calculated the percent mean deviation (PMD) of ferrosilite in low-Ca pyroxenes for each clast [6]. If the PMD of ferrosilite in low-Ca pyroxenes is between 5-20, the chondrite is of petrologic type 4. If it is below 5, then the chondrite is of petrologic type 5. Clasts B, E, and the matrix had PMD's of 12.1, 5.7, and 7.4, respectively, corresponding to petrologic type 4 chondrites. The rest of the major clasts, A, D, F, and G had PMD's of 3.8, 2.0, 1.9, and 3.1, respectively, corresponding to petrologic type 5 chondrites.

The metallographic cooling rate for most analyzed grains was found to lie within 0.1 and 1.0 degrees per million years (Fig. 3). The metamorphic temperatures were calculated to be approximately 850 °C for clasts A and F, 800 °C for clast G, 750 °C for the matrix, and 800 °C for Sample 2. These temperatures are close to those determined for H6 chondrites. However, H4 and 5 chondrites can reach similar peak temperatures, but cool at a quicker rate [6]. In addition, there were a small number of taenite grains, not plotted in Figure 3, that have lower Ni contents (~18-20 wt%) in comparison to other measurements used in finding the metallographic cooling rate for the sample. These taenite grains were located in metal veins. These veins formed during shock melting and cooled rapidly.

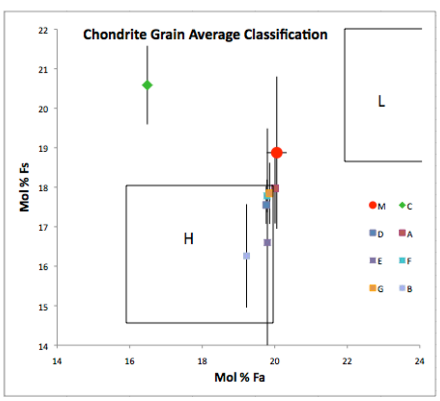

Figure 2: Averages of the Fa and Fs compositions of grains A – G and M. Boxes denote the ranges for the H, L, and LL groups of ordinary chondrites. The error bars show the standard deviations for each clast.

Discussion: The mol% compositions of ferrosilite and fayalite for all but the matrix and clast C plot within the H group. However, the matrix does not plot within either the L or LL groups. Once vertical and horizontal error bars are added, accounting for the standard deviations of % fayalite (Fa) in olivine and % ferrosilite (Fs) in pyroxene, the composition plots within the H chondrite range. Its petrologic type matches those of other clasts with the matrix as petrologic type 4. The composition of clast C falls outside of the range for H group chondrites, because C is an impact-melt clast. In addition, accompanying the processes of shock melting, the compositions of the relict olivine have also been altered to a more forsteritic composition. The overgrowths of pyroxene have higher ferrosilite content than the rest of the sample.

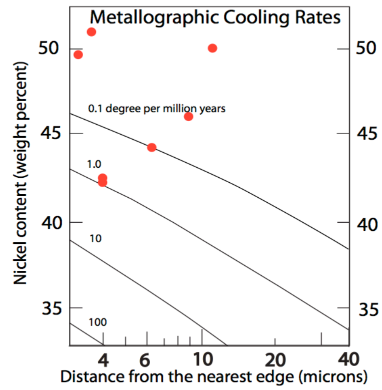

Figure 3: Metallographic cooling rate – points represent the nickel content of the kamasite and taenite grains found within both samples. Temperature is in Kelvin

Conclusion: The new meteorite, "Al Jawf 001", is hereby classified as an H 4/5 ordinary chondrite.

References: [1] Biscoff, S. A. et al. (2006) *Meteorites and Early Solar System 11*, 679-710. [2] Hutchison, R. (2004) *Meteorites,* 128-141. [3] Lindsley, D. H. (1983) *Amer. Mineral.* 68(5-6), 477-493. [4] Wood, J. A. (1967) *Icarus* 6, 1–49. [5] Willis, J. and Goldstein, J. I. (1981) *LPS XII*, 1135–1143. [6] Huss, G. R. et al. (2006) *Meteorites and Early Solar System 11*, 567-586.

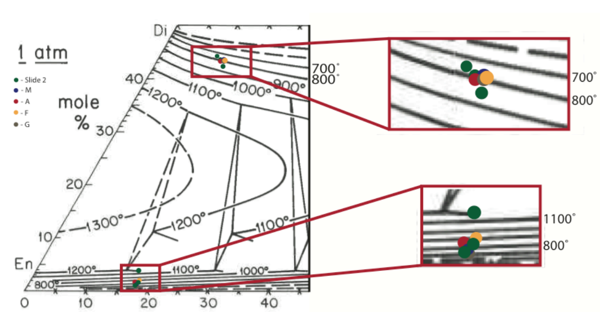

Figure 4: Lyndsley's two-pyroxene geothermomter. Many of the peak metamorphic temperatures lie between 750 and 850°C.