PETROGRAPHY AND GEOCHEMISTRY OF UREILITES JIDDAT AL HARASIS 1100, JIDDAT AL HARASIS 1101, AND JIDDAT AL HARASIS 1102. P. J. A. Hill[1]; N. R. Banerjee[1]; S. Nasir[2]; G. R. Osinski[1,3] [1]Department of Earth Science and Centre for Planetary Science and Exploration (CPSX), University of Western Ontario, London, ON, Canada. [2]Earth Sciences Research Center, Sultan Qaboos University, Muscat, Oman. [3]Department of Physics and Astronomy, University of Western Ontario, London, ON, Canada.

Introduction: Jiddat al Harasis 1100, Jiddat al Harasis 1101, and Jiddat al Harasis 1102 are ureilites recently classified from the Jiddat al Harasis region of Oman (19°42.31'N, 56°35.64'E; 18°45.30'N, 54°31.15'E; 19°25.34'N, 55°53.44'E respectively). The mass of each meteorite is 365 g, 460 g and 95 g, respectively. The fusion crust on these meteorites is a millimeter thick and dark brown in colour. The surfaces are mainly rough and there is no clear evidence of contraction cracks. One face of JaH 1102 does have a relatively smooth surface with small remaglypts present. Each cut face of the meteorites shows rounded, interlocking, grey laths that are mostly less than 2 mm wide.

Petrography: Each meteorite is a comprised of elongated grains of olivine and pyroxenes that are ~1–2 mm wide as seen Fig. 1A. The olivine grains show mosaicized texture with some grains meeting at 120˚ angles. Each meteorite is predominately comprised of olivine (~60 vol%) and low-Ca pyroxene (~30 vol%). The occurrence of pyroxene is commonly associated with the presence of large fractures and graphite. In many cases, large rims of oxides surround pyroxene grains (Fig. 1B). Throughout the pyroxene grains there are many small pores measuring <50 µm in diameter. Though long, distinct exsolution lamellae are not present, small blebs, of a more Ca-rich pyroxene, were observed within the laths. In many cases the pyroxene grains are surrounded by olivine laths as seen in Fig. 1A and 1B. In one instance in JaH 1101, a single grain of pyroxene (100 µm wide) is surrounded by olivine and completely rimmed by iron oxide that is ~50 µm thick in some places. Though the grain boundaries between olivine and pyroxene grains are defined by iron oxides, in certain instance the grains do intermix as seen in Fig. 1C. Kamacite and taenite are present as inclusions within the grains where fractures have not exposed the metal and allowed for oxidization. Fe-Ni metal commonly occurs as small blebs that are <50 µm wide, as seen in Fig. 1D. In addition to metal, minor amounts of troilite were identified within the samples (<1 vol%).

The olivine grains within all three samples contains reductions rim ~50 µm thick. There are also significant amounts of graphite remaining within the meteorites. Based on the classification put forward by Wittke et al. [1], this sample fits into the R2 grade. Overall there is no evidence of the silicate phases weathering in these samples, and other than the occurrence of several sulphate veins, the main weathering product is oxidization of most of the Fe-Ni metal, suggesting the samples have been moderately altered by weathering. In regards to shock metamorphism, the olivine within these ureilites shows undulose extinction and a mosaic texture. The pyroxene grains within these sample are occasionally fractured but still have distinct extinction. Overall the olivine and pyroxene grains within the samples suggest that the meteorites have been moderately to strongly shocked [2].

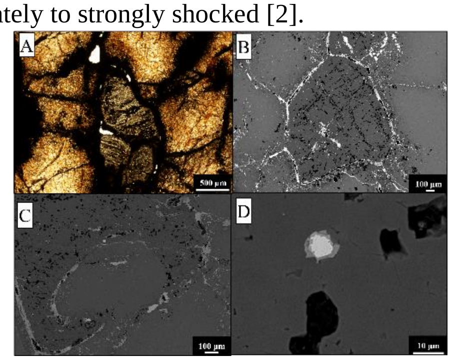

Fig. 1: (A) A plane polarized image of JaH 1100 showing multiple olivine laths surrounding three pyroxene laths. (B) A pyroxene surrounded by olivine and rimed by iron oxide in JaH 1101. (C) Intermixing of pyroxene and olivine in JaH 1102. (D) A bleb of Fe–Ni metal that has been partially oxidized.

Isotope Geochemistry: The oxygen isotope composition of JaH 1100 and JaH 1102 (Fig. 2) is best represented by $\delta^{17}O$ = +3.9‰ and $\delta^{18}O$ = +8.1‰ (n=1); $\delta^{17}O$ = +3.8‰ and $\delta^{18}O$ = +8.2‰ (n=2), respectively. The calibration method used for triple oxygen isotope data gives an accuracy and precision better than ± 0.1‰ for both $\delta^{18}O$ and $\delta^{17}O$ [3]. JaH 1101 was run twice; however, the analysis resulted in consistently high $\delta^{17}O$ and $\delta^{18}O$ values and further investigation is underway.

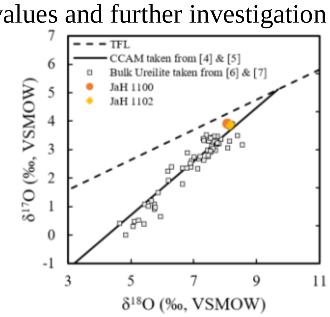

Fig. 2: $\delta^{17}O$ vs. $\delta^{18}O$ for JaH 1100 and JaH1102 plotted alongside the terrestrial fractionation line (TFL), carbonaceous chondrite anhydrous mineral line (CCAM) [4,5], and literature data for monomict ureilites [6,7] for context.

Mineral Chemistry: The olivine within JaH 1100, JaH 1101, and JaH 1102 is compositionally similar with an avg. ± 2σ composition of $Fo_{76\pm5.4}Fa_{23\pm4.9}$ across all three meteorites. Fig. 3A shows the distribution of the Fo content of all olivine analyses across the three meteorites. The Ca-content of the olivine grains is minimal in all three meteorites; however, there is some variation (avg. ± 2σ = 0.44 ± 1.45 wt%). Grains that show higher CaO concentration also have higher wt% of Cr_2O_3, similar to what was observed by Goodrich et al. [8]. The pyroxene composition in all three meteorites was also consistent across the three samples with an avg. ± 2σ composition of $En_{77\pm6.1}Fs_{16\pm4.2}Wo_{7\pm4.2}$. Fig. 3B shows the range of pyroxene composition across all three meteorites.

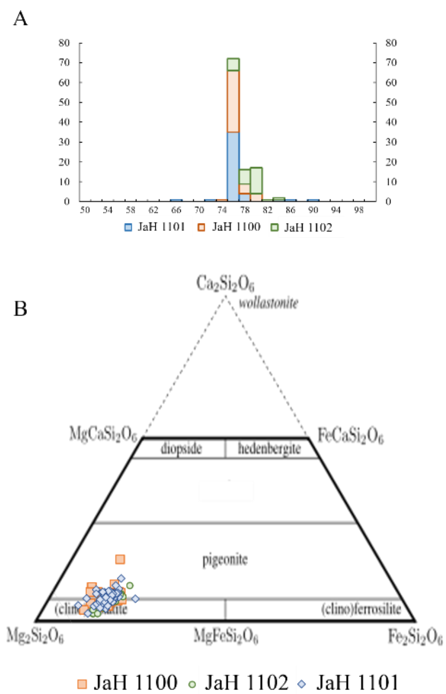

Fig. 3: (A) Fo content of all olivine analyzes from JaH 1100, JaH 1101, and JaH 1102. (B) The composition of pyroxene within JaH 1100, JaH 1101, and JaH 1102 and the corresponding mineral phases.

Bulk Chemistry: Major oxide geochemistry was determined using X-ray fluorescence (XRF) spectrometry at the Central Analytical and Applied Research Unit (CAARU) at the Sultan Qaboos University. SiO_2, FeO, MnO, and MgO (wt%) can be found in Table 1.

Table 1: SiO_2 (wt%), FeO (wt%), and MgO (wt%) of JaH 1100, JaH 1101, and JaH 1102.

Meteorite	SiO_2 (wt%)	FeO (wt%)	MnO (wt%)	MgO (wt%)
JaH 1100	35.05	21.93	0.39	32.26
JaH 1101	35.19	22.47	0.37	31.65
JaH 1102	35.12	22.18	0.38	31.96

Overall the whole rock major oxide concentrations are dominated by MgO and FeO (wt%). All meteorites are similar in composition and are within 1 wt% for each oxide phase. CaO in all three meteorites was the only other oxide to exceed 1 wt% other than SiO_2, MgO and FeO (JaH 1100: 1.60 wt%; JaH 1101: 1.59 wt%; 1.68 wt%).

Discussion: In addition to the ureilite texture observed in thin section, Fe/Mn and Fe/Mg ratios are consistent with those observed in other ureilites. As seen in Fig. 4, the olivine and pyroxene in JaH 1100, JaH 1101, and JaH 1102 plot along power law put forward by Goodrich et al. [9]. The fact that these meteorites plot along this line indicates that these samples formed as residues from the partial melting of chondritic material [9]. These meteorites plot slightly to the right of the line (Fig. 4B) due to the crystallization of augite [9], which within these meteorites, is present as blebby exsolution in pyroxene laths.

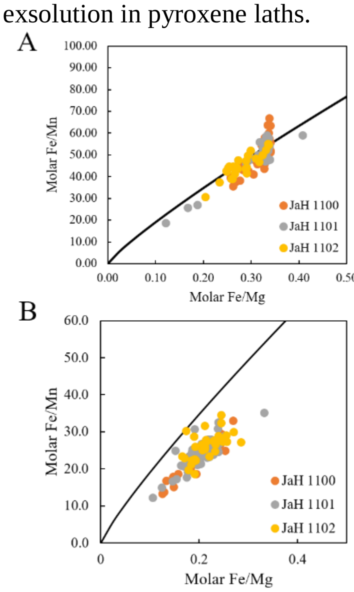

Fig. 4: (A) Molar Fe/Mn vs. Molar Fe/Mg for olivine grains in JaH 1100, JaH 1101, and JaH 1102. (B) Molar Fe/Mn vs. Molar Fe/Mg for pyroxene grains in JaH 1100, JaH 1101, and JaH 1102.

References: [1] Wittke J. H., Bunch T. E., Goodrich C. A., (2007) *70th Annual Meteoritical Soc. Meet. Abstract #5246*. [2] Reimold W. U. and Stöffler D. (1978) *9th LPSC, 2,* 2805-2824. [3] Ali A., Jabeen I., Gregory D., Verish R., Banerjee N. R. (2016) *Meteoritics & Planet. Sci., 51,* 981–995. [4] Clayton R.N., Onuma N., Grossman L. and Mayeda T. K. (1977) *Earth Planet. Ssci. Lett. 34,* 209–224. [5] Clayton R.N. (1993) Ann Rev Earth Planet Sci 21, 115–149 [6] Clayton R.N. and Mayeda T. K (1988) *Geochem. Cosmochim. Acta, 52,* 1313–1318 [7] Clayton R. N. and Mayeda T. K. (1996) *Geochem. Cosmochim. Acta, 60,* 1999–2017 [8] Goodrich C. A., Sutton S. R., Wirick S. and Jercinovic M. J. (2013) *Geochem. Cosmochim. Acta, 122,* 280–305. [9] Goodrich C. A., Scott E. R. D. and Fioretti A. M. (2004) *Geochem. Cosmochim. Acta, 64,* 283–327.