HAMMADAH AL HAMRA 193: AN AMPHIBOLE-BEARING WINONAITE. C. Floss, B. Jolliff, J. Reid, G. Benedix; Dept. of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130, USA; (email: floss@wuphys.wustl.edu).

Introduction: Winonaites are reduced meteorites with oxygen isotopic compositions distinct from those of other primitive achondrites, except for silicate inclusions from IAB irons [1,2]. They have equigranular textures and chondritic mineralogies, but can contain mm- to cm-sized regions with different textures and/or mineralogies. These include plagioclase-diopside-rich regions, coarse-grained olivine-rich areas and/or large poikilitic calcic pyroxenes [2]. Here we report on a texturally and mineralogically unusual winonaite, Hammadah al Hamra (HaH) 193.

Results: HaH 193 was found in 1996 in the Libyan desert as a single stone of 259 g. Its identification as a winonaite [3] was confirmed by oxygen isotopic analysis ($\delta^{18}O = +4.79$, $\delta^{17}O = +1.90$; R. Clayton, pers. commun.). We obtained a thin section of HaH 193 for a trace element study of winonaites [4] and discuss here its mineralogy and petrology.

Our section of HaH 193 is dominated by very large (up to 5 mm) optically continuous orthopyroxenes that poikilitically enclose smaller grains of olivine, plagioclase and occasionally clinopyroxene. Two distinct lithologies occur interstitial to the poikilitic orthopyroxenes. One consists of clumps of equigranular 200-300 μm olivine grains, similar to areas described in Winona and other winonaites [2]. The other lithology contains abundant amphibole and clinopyroxene, as well as olivine and lesser amounts of plagioclase and orthopyroxene. The amphiboles are large (up to 2 mm) and poikilitically enclose smaller grains of primarily olivine, but also plagioclase, clinopyroxene and orthopyroxene.

Major element mineral compositions are similar to those seen in other winonaites (orthopyroxene: $Fs_{4.9–5.1}Wo_{1.7–2.0}$; clinopyroxene: $Fs_{1.3–2.2}Wo_{43.2–44.2}$; olivine: $Fa_{4.3–4.6}$; plagioclase: $An_{20.9–21.4}$). The amphibole in HaH 193 is nearly stoichiometric fluoro-edenite, $K_{0.1}Na_{1.1}Ca_{1.7}Mg_{4.8},Fe_{0.1},Ti_{0.1}Si_{7.0}Al_{1.0}O_{22}(F)_{1.8}$. Raman spectroscopy confirms the amphibole structure and shows no OH peak. Edenite is rare and endmember fluoro-edenite has only recently been identified terrestrially [5]. This is the first reported meteoritic occurrence.

Discussion: Textures suggest that fluoro-edenite is replacing clinopyroxene in HaH 193, probably in a reaction between clinopyroxene and plagioclase. This is supported by trace element evidence. Clinopyroxene and edenite have similar bow-shaped REE patterns with negative Eu anomalies. However, relative to clinopyroxene, the edenite has lower trivalent REE abundances (~2x), and higher abundances of Eu (~3x), Ba (~15x), Na (~10x) and K (~100x), all elements that are typically enriched in plagioclase. The source of the F is probably apatite. Apatite is rare in HaH 193, but several grains associated with edenite have F contents ranging from 3.9 to 4.2 wt.%, in contrast to the chlorapatite commonly found in other winonaites.

Although HaH 193 is fairly weathered and our section contains several alteration-filled veins, the edenite appears to be of pre-terrestrial origin. Evidence for this includes textural relationships and its OH-free composition, as well as the fact that HaH 193 minerals show little evidence of the terrestrial alteration commonly observed in other hot desert meteorites [*e.g.*, 6].

References: [1] Clayton and Mayeda (1996) GCA 60, 1999. [2] Benedix et al. (1998) GCA 62, 2535. [3] Grossman (1998) MAPS 33, A221. [4] Floss et al. (2003) this vol. [5] Gianfagna and Oberti (2001) Am. Mineral. 86, 1489. [6] Crozaz et al. (2002) GCA 66, A158.