

PETROGRAPHY, MINERALOGY AND MATRIX COMPOSITION OF YAMATO-82162, A NEW CI2 CHONDRITE: M.E. Zolensky¹, R.A. Barrett² and M. Prinz³, ¹NASA, Johnson Space Center, Houston, TX 77058, ²Lockheed Engineering and Sciences Co., 2400 NASA Rd. 1, Houston, TX 77058, ³American Museum of Natural History, New York, NY 10024.

YAMATO-82162 is a newly recognized CI chondrite, as determined by oxygen isotopes [1], now the subject of a consortium effort organized by Prof. Y. Ikeda. We have analysed the major minerals in two thin sections using quantitative SEM-EDX techniques [2] and TEM-EDX procedures on ultramicrotomed samples. Results are compared to those of two similar studies [3, 4].

PETROGRAPHY Y-82162 resembles CI1 chondrites in that it is a breccia exhibiting (1) absence of chondrules, (2) abundance of partially filled fractures (veining) and (3) abundance of sulfides, carbonates, and magnetite with traditional CI1 morphologies throughout the fine-grained and opaque matrix. It contrasts with CI1s in its apparent absence of sulfates, which are major phases in the CI1s. It also contains rare metal and no dolomite. The phases observable petrographically are described below.

PHYLLOSILICATES These are the most pervasive and important phases within Y-82162. As previously reported [3], there are two principal phyllosilicates present, serpentine and saponite (conceivably a vermiculite). Serpentine is very fine-grained ($\ll 1 \mu\text{m}$), and was observed to have the average composition: $\text{Mg}_{1.9}\text{Fe}_{1.1}(\text{Si}_{1.83}\text{Al}_{.17})\text{O}_5(\text{OH})_4$ (OH not directly determined). Saponite has a wider variation in grain size, with aggregates (clusters) measuring several hundred microns being present. However, the saponite analysis was complicated by the ubiquitous presence of sub-micron sized grains of an Fe-Ni oxyhydroxide. Analysis of 7 large clusters of the saponite (10-200 μm) yielded an average composition of:

$(\text{Mg}_{2.45}\text{Fe}_{.59}\text{Cr}_{.02})(\text{Si}_{3.45}\text{Al}_{.55})(\text{Na}_{.42}\text{Ca}_{.03}\text{K}_{.02})\text{O}_{10}(\text{OH},\text{Cl})_{2.90}$ which is a textbook trioctahedral ferrous saponite composition. The low amount of hydroxide (should be 4) is explained by dehydration during analysis.

SULFIDE Grains are ubiquitous, although their distribution varies from clast to clast. They appear to be more abundant than in most CI1 chondrites. Morphologies range from anhedral to euhedral, and sizes range continuously from sub-micron to 300 μm . The largest crystals are tabular and platy. Most of the sulfides are pyrrhotite, with compositions of $\text{Fe}_{.93}\text{S}$ to $\text{Fe}_{.94}\text{Ni}_{.01}\text{S}$, although small crystals of troilite and cubanite are present. The large tabular and platy pyrrhotite crystals contain no appreciable nickel. Pentlandite, reported by Tomeoka et al. [3], was not found in our study.

AWARUITE Grains are found within one rounded pyrrhotite grain. The largest grain (~8 μm) has the composition $\text{Ni}_{.66}\text{Fe}_{.34}$, at the nickel-poor end of awaruite. Awaruite is rare in chondrites and, although present in Allende [5], has not been previously recognised within CI1 chondrites.

MAGNETITE This is a major constituent, occurring as framboidal aggregates, spherulites, plaquettes and aggregates of euhedral to subhedral crystals, as previously reported [3]. Crystals have variable grain size, with the largest sizes being attained by the subhedral crystals (up to 12 μm) and spherulites (up to 25 μm). Different magnetite morphologies are commonly found intimately mixed within the same aggregates. The magnetite is generally quite pure, although some subhedral crystals have the composition $\text{Fe}_{2.8}\text{Mn}_{.1}\text{Mg}_{.1}\text{O}_4$.

WHITLOCKITE This phase is present as small (<8 μm) crystals within some magnetite and carbonate aggregates, and as vein-fillings, as reported [4].

BRUCITE Found as both individual grains (generally <10 μm) and finer-grained vein fillings, this brucite has particularly high Fe and Mg, compared to CI1

chondrites. It varies from $Mg_{.73}Fe_{.19}Na_{.05}Mn_{.02}Ca_{.01}(OH)_2$ to $Mg_{.54}Fe_{.20}Na_{.03}Mn_{.23}Ca_{.01}(OH)_2$.

CARBONATES These are the most common vein-filling phases in Y-82162, and vary in composition from $CaCO_3$ to $Ca_{.94}Mg_{.06}CO_3$ to $Ca_{.56}Fe_{.44}CO_3$. Drusy crusts of magnesite-breunnerite are also present in veins. No magnesian siderite, as reported in [3], was found.

MATRIX This is composed principally of saponite and serpentine, with other phases including olivine (Fo74 ave.), magnetite, carbonates, whitlockite, pyrrhotite, Fe-Ni oxyhydroxides, and ilmenite. Ilmenite is rare in chondrites, and has not been previously found in a CI1 chondrite. It was found in a CI-like clast in a polymict ureilite [6]. Matrix compositions have been shown to vary between the different groups of carbonaceous chondrites. The average of 40 matrix bulk analyses is displayed in a S/Si vs. Fe/Si plot in [7] and is similar to CI1 chondrites.

DISCUSSION AND CONCLUSIONS The presence of abundant olivine within the matrix of Y-82162 seems inconsistent with its classification as a type 1 chondrite and suggests the classification of CI2 as more appropriate for this meteorite. As noted earlier [3], this meteorite could represent precursor material to CI chondrites at an arrested stage of alteration or, alternatively, be derived from CI material through heating. Since our saponite analyses included Fe-Ni oxyhydroxide grains, the composition we derived must have considerably more iron than is presently in the saponite proper. The apparent coincidence that the saponite and iron-hydroxide phases combined yield a perfect ferrous saponite composition can be explained in a manner which sheds light on the alteration history of the Y-82162 parent body. We hypothesize that when first formed the saponite on (in) the Y-82162 parent body was a ferrous saponite with the above composition. Such a phase would form under very reducing, highly alkaline (note the high sodium content) conditions [8]. Later, the environment became more oxidizing. Under these conditions ferrous saponite is extremely unstable, and quickly breaks down to ferric saponite (with a composition intermediate between tri- and dioctahedral) and the excess iron is shed to form iron-oxyhydroxides [8, 9]. These resultant phases are what we now observe in Y-82162. Saponite with an almost identical composition to that in Y-82162 is also a major phase within Orgueil, along with finely intergrown iron-oxyhydroxides [10]. We therefore propose that the saponite in Orgueil underwent a similar genesis. An important remaining question is where the oxidation event took place, on the parent body, or on earth. In CI1 chondrites abundant sulfates are present as a result of late-stage oxidizing conditions on their parent body [11]. No such abundant sulfates are observed within Y-82162, where most of the sulfur is tied up in pyrrhotite. If Y-82162 never experienced the late-stage oxidizing solutions which affected CI1 chondrites, this suggests that Y-82162 does represent CI1 precursor material. The iron-oxyhydroxides in Y-82162 could then be of terrestrial origin.

REFERENCES [1] Mayeda et al. (1987) Mem. Natl. Inst. Polar Res., Spec. Issue 46, 144-150; [2] Zolensky et al. (1987) Lunar Planet. Sci. XIX, 1327-1328; [3] Tomeoka et al. (1988) 13th Symp. Antarctic Meteorites, 126-127; [4] Watanabe et al. (1988) 13th Symp. Antarctic Meteorites, 128-129; [5] McSween (1977) Geochim. Cosmochim. Acta 41, 1777-1790; [6] Prinz et al. (1987) Meteoritics 22, 482-483; [7] Zolensky et al. (1989) this volume; [8] Badaut et al. (1985) Clay Mins. 20, 389-404; [9] Kodama et al. (1988), Clays Clay Mins. 36, 102-110; [10] Tomeoka and Buseck (1988) Geochim. Cosmochim. Acta 52, 1627-1640; [11] Zolensky et al. (1989) Icarus, in press.