MINERALOGICAL INVESTIGATION OF D'ORBIGNY: A NEW ANGRITE SHOWING CLOSE AFFINITIES TO ASUKA 881371, SAHARA 99555 AND LEWIS CLIFF 87051.

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Introduction: Angrites are a small but important group of achondrites showing unique mineralogy and ancient crystallization ages [e.g., 1]. However, our understanding of their origin is still incomplete, in part because of the small number of angrite samples. Recently, D'Orbigny, a new angrite from Argentina, was discovered [2] and it may offer new and useful data to better understand angrite petrogenesis and igneous activity in the early solar system. In this abstract, we present preliminary petrology and mineralogy of D'Orbigny, and compare it with other angrites.

Petrography: Several rock chips (0.8 g ~ 40 g) were studied by naked eye and binocular microscopy. Most chips have a medium-grained texture with abundant vesicles. However, some chips contained a fine-grained lithology, separated from the medium-grained lithology by a sharp contact (Fig. 1a). Weathering is moderate, and some cavities contain brownish (Fe rust?) and white (calcite?) weathering products. Three chips contained large olivine grains. Two of these are anhedral 3-4 mm grains with translucent green color similar to San Carlos olivine. The other is ~6 mm long and pale green (Fig. 1b). The abundance of these large olivine grains is clearly less than 1 vol. %. A polished thin section from each chip in Fig. 1 was analyzed, although the section from the chip in Fig. 1a did not include the fine-grained region. Both sections show subophitic textures dominated by Ca-rich olivine, fassaitic clinopyroxene, and anorthitic plagioclase, although there are minor textural differences between the two sections. Some anorthite grains show skeletal growth in one section, but this is rare in the other. However, modal abundances of minerals appear nearly identical between the two sections. The mode is 39.4 % anorthite, 27.7 % fassaite, 19.4 % Mg-rich olivine, 11.9 % Ca, Fe-rich olivine, 0.6 % spinel (mostly ulvöspinel), 0.5 % troilite, and 0.5 % Ca silico-phosphate. Grain sizes of plagioclase and phenocrystic olivine are about 0.5-1 mm, and they are usually euhedral to subhedral. Fassaite has a slightly larger grain size in one section than the other (up to 3 mm long), and subhedral grains are common. The large olivine grain in the chip from Fig. 1b shows a granoblastic texture composed of small polygonal olivine crystals (~10 µm). Such textures are known in heavily shocked meteorites like ureilites and formation by a shock event at high temperature is considered [3].

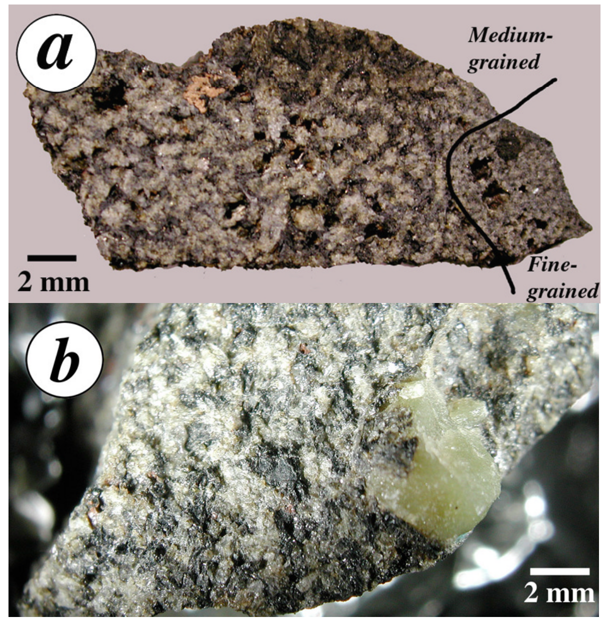

Fig. 1. Small rock chips of the D'Orbigny angrite. a: Note fine-grained lithology at the right end of chip. b: Note pale green olivine megacryst.

Mineral Chemistry: Mineral compositions are consistent between the two sections and are in general agreement with those reported by [4]. Fassaite and olivine show extensive chemical zoning, though plagioclase is homogeneous at An_{100}. ***Fassaite*** has atomic Fe/(Fe+Mg) (*fe#*) ranging from 0.37 in the most magnesian cores to ~1 at the rims (Fig. 2). Al_2O_3 is usually homogeneous in the core regions (8 wt%), but drops to 6 wt% at the outer rims (*fe#*>0.95). Some fassaite grains have Al-poor areas in the cores (4 wt% Al_2O_3). TiO_2 increases from cores (1.4 wt%) to rims (5 wt%), but like Al, drops to 2.5 wt% at the outer rims (*fe#*>0.95). The Al-poor cores are also low in TiO_2 (0.7 wt%). Cr_2O_3 decreases from cores (0.8-1 wt%) to nearly Cr-free rims at *fe#*>0.6. ***Phenocrystic olivine*** is Ca-rich, and contains 0.8 wt% CaO in the most magnesian cores (Fa_{37}, Fig. 3). Also, Al_2O_3 is clearly detectable in the cores at 0.1 wt%, although it is below detection limits in the rims. The CaO content steadily increases to ~8 wt% until *fe#* reaches ~0.9, at which point olivine becomes an intergrowth of subcalcic kirschsteinite and Ca-rich fayalite. ***Granoblastic olivine*** is much more magnesian than phenocrystic olivine (Fo_{90} *vs.* Fo_{63}). Each small olivine crystal in this large olivine aggregate is homogeneous except for a ~50 µm Fe-rich rim. These rims were clearly formed by diffusive interaction with the surrounding Fe-rich melt. Because diffusion is faster along grain boundaries than within crystals, interaction is restricted to rims of the individual grains comprising the aggregate. Granoblastic olivine is poor in CaO (0.4 wt%) and rich in Cr_2O_3 (0.3 wt%) and Al_2O_3 (0.15 wt%) compared with phenocrystic olivines. Opaque phases include troilite, ulvöspinel, ilmenite, and rare hercynite spinel. Ulvöspinel is normally homogeneous and has 27 wt% TiO_2, 2.5 wt% Al_2O_3, and 68 wt% FeO. Ca silicophosphate is euhedral or lath-shaped and homogeneous. It is more fully described by [5].

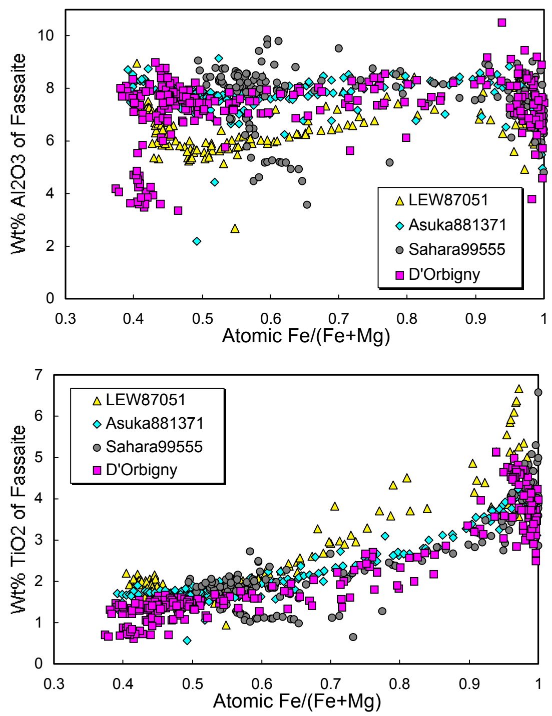

Fig. 2. Atomic Fe/(Fe+Mg) vs. minor element contents of fassaite from D'Orbigny and other angrites.

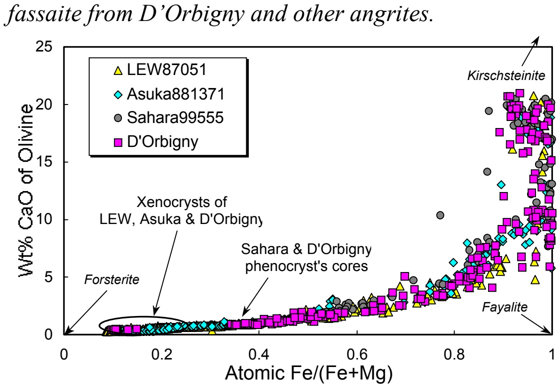

Fig. 3. Atomic Fe/(Fe+Mg) vs. Wt% CaO contents of olivine from D'Orbigny and other angrites.

Comparison with Other Angrites: Among the five previously described angrites, D'Orbigny is most similar to Sahara 99555 (Sah99), Asuka 881371 (Asu88), and LEW 87051 (LEW87). It differs from LEW 86010, in that the latter shows a granular texture with evidence of slower cooling [7] than D'Orbigny. It also differs from Angra dos Reis, a fassaitic clinopyroxenite that is different from all other angrites. The subophitic texture and presence of exotic Mg-rich olivine grains in D'Orbigny are most similar to Asu88 [6].

Although the olivine megacryst in Fig. 1b turned out to be a polycrystalline aggregate, yet-to-be-studied translucent green olivines in other chips may be single crystals. Both polycrystalline and large single olivine grains are known in Asu88 [8]. However, the abundance of these exotic olivine grains is much smaller in D'Orbigny than Asu88 (<1 *vs.* ~10 vol.%). Such olivine megacrysts are also known in LEW87 [6] although they are absent in Sah99 [9]. They are interpreted as xenocrysts because their extremely magnesian, Ca-poor, and Cr-rich composition is clearly in disequilibrium with the groundmass.

Phenocrystic olivine cores in D'Orbigny are more Fe-rich than Asu88 and LEW87, and best match Sah99. In contrast, fassaites in D'Orbigny are comparable to Asu88 and LEW87 in both major and minor element variations, while Sah99 fassaite has more Fe-rich core compositions. Accessory minerals in D'Orbigny, Sah99, Asu88, and LEW87 have nearly identical compositions [6&9].

The mineralogy of D'Orbigny suggests its formation by rapid crystallization of angritic magma, as proposed for Sah99, Asu88, and LEW87 [6&9]. The D'Orbigny cooling rate was probably most similar to Asu88, whereas more fine-grained textures of Sah99 and LEW87 suggest slightly faster cooling. Because exotic magnesian olivines are commonly observed in all these angrites (except for Sah99), they might have crystallized from the same magma with locally different abundances of entrained olivine xenocrysts. The presence of granoblastic olivines in D'Orbigny and Asu88 implies a shock event prior to the crystallization of these angrites because the groundmass portions are unshocked. Furthermore, the presence of large single olivine grains with identical compositions to granoblastic olivines suggests a complex history for the precursor materials.

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