GLASSES IN THE D’ORBIGNY ANGRITE

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The new angrite D’Orbigny, found in the Buenos Aires province of Argentina, is the largest member of the six angrites known up to now and gives us a wonderful opportunity to study in detail the origin of these achondrites. The stone had a mass of 16.55 kg and had a peculiar shape (Fig 1 a-b). As a typical oriented-flight stone it had a front shield (~ 35 cm long) which gently sloped from the stagnation centre and which was covered by regmaglypts and a dark brown fusion crust. The back side had a much smaller diameter (~ 20 cm) and consisted of a concave, round, pan-like indentation with a marked large (2 cm) and several smaller, round open vugs. It was also covered by fusion crust, much less than the front side, and had also less developed regmaglypts [Kurat G. et al., (2001 a-b)].

D’Orbigny is peculiar in several respects, one of them being the abundant presence of glasses, a phase which has not been previously reported from any other angrite.

D’Orbigny principally consists of three major lithologies [1-2]: a dense, medium-grained, sub-ophitic basaltic rock (Fig 2a), a porous, coarse-grained sub-ophitic basaltic rock with abundant open druses (Fig 2b) containing augite and anorthite single crystals, and round, hollow spheres (Fig 2 c). The hollow spheres are unevenly distributed throughout D’Orbigny, present in all parts, but most common in the porous inner portion .

Glasses in the D’Orbigny angrite occur in the following modes:

- glass filling in part open druse space with free surfaces forming menisci (Fig 3a)
- glass filling a few of the abundant hollow spheres (Fig 3b),
- glass filling interstitial space between major silicates (olivine, augite, anorthite)(Fig 3c),
- glass inclusions in olivine (Fig 3d).

The sizes of these glasses vary from tens of µm (glass inclusions) to several mm (in druses and spheres). The most common glass fills former open spaces, is black (brown in transmitted light) with brilliant lustre and conchoidal fractures (Fig 4a). It can be dense, containing only a few bubbles, or foamy (Fig 4b-c), with all possible transitions, also over short distances.

Some glasses (e.g., glass sphere) show dark-light schlieren in transmitted light, which resemble flow lines. However, the associated bubbles are always perfectly round (Fig 5a-b). Glasses occasionally contain rounded mineral and – rare – rock fragments, some contain small dendrites of olivine and/or magnetite. Small (1-50 µm) sulphide blebs (Ni-bearing FeS) associated with small bubbles are common.

The chemical composition of the most common, pore space and hollow sphere-filling glasses resembles that of angrite bulk rocks, in particular that of LEW 86 and Sahara.

Table: Major elements (wt%) contents of representative glasses in the D’Orbigny angrite and C and N content in glasses of glass inclusions

	GI			Glass patches			GWB	IG		GS
	*	*	*							
SiO_2	38.2	39.4	40.0	40.2	41.1	40.4	37.2	38.5	38.4	37.4
TiO_2	1.75	1.38	1.65	0.83	0.81	1.04	0.50	0.38	2.54	0.70
Al_2O_3	17.8	18.7	12.2	13.1	13.2	12.5	11.9	8.3	8.1	10.9
Cr_2O_3	0.04	0.15	0.10	0.07	0.16	0.05	0.00	0.00	0.09	0.00
FeO	10.5	10.2	20.7	23.3	23.2	24.5	25.9	24.7	25.8	27.1
MnO	0.78	0.17	0.27	0.36	0.25	0.28	0.34	0.62	0.32	0.10
MgO	1.09	0.99	5.70	7.5	7.7	7.5	6.6	2.03	4.20	6.0
CaO	28.8	27.3	18.3	13.8	14.5	14.5	16.5	25.2	20.4	16.7
Total	98.8	98.3	98.9	99.2	100.9	100.7	98.9	99.7	99.8	98.9
C ppm	40	64								
N ppm	180	150								

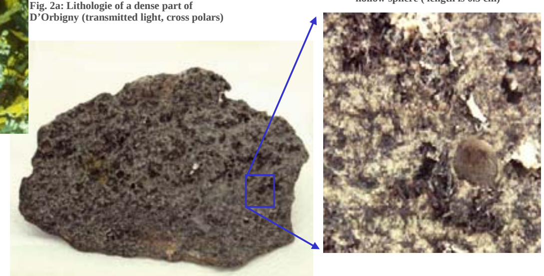
GI = Glass Inclusions; GWB= glass with bubbles; IG= Interstitial Glass; GS = Glass Sphere; * Mean of two analyses.

Fig. 1a : front shield (35 cm)

Fig. 1b: back side

Fig. 2a: Lithologie of a dense part of D’Orbigny (transmitted light, cross polars)

Fig. 2b: Detail of a druse and a hollow sphere (length is 0.5 cm)



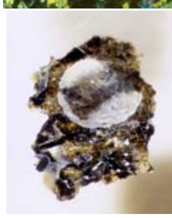


Fig. 2c: Detail of a hollow sphere (length is 0.4 cm)

Fig. 3b: glass filling a hollow sphere (length is 6 mm)

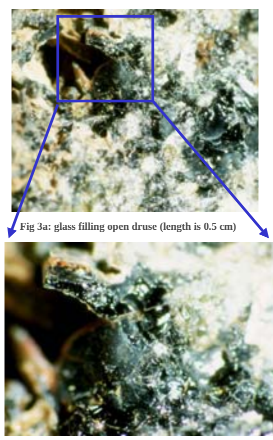


Fig 3a: glass filling open druse (length is 0.5 cm)

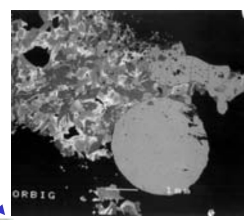


Fig. 3b: BSE image of glass filling a hollow sphere.

Fig. 3d: Glass inclusion in olivine.

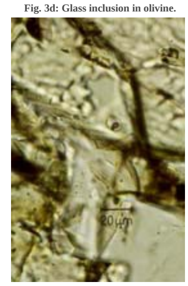


Fig 3e: Glass in druse surrounding an olivine (length is 0.3 cm)

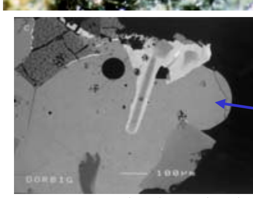


Fig3a: BSE image of glass filling open druse. Note the free surface forming menisci.

Fig. 4b: Foamy glass (length is 0.5 cm)

Fig. 4c:, Optical image of Fig 4b in reflected light

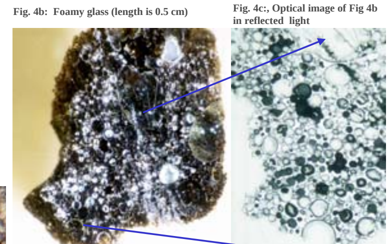


Fig.4a: Coarse-grain specimen showing glass, a hollow sphere and a druse. (length is 1 cm).

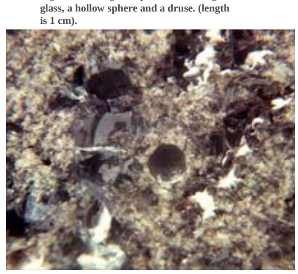
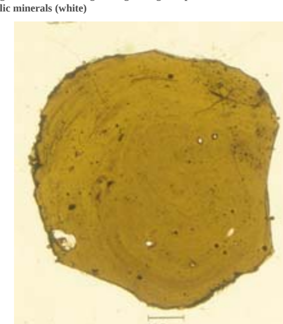


Fig. 5b: transmitted light image of a glass sphere showing schlieren, bubbles, and residual material from the shell (arrow)

Fig 5b: Transmitted light image of a glass sphere. Note schlieren and relic minerals (white)



Glasses have superchondritic Ca/Al ratios, similar to the angrites (Fig 6), and their contents of FeO and TiO_2 are within the range of the angrites bulk rock composition.

However, and with the exception of LEW 86010, glasses have lower contents of MgO as compared to ADOR, LEW87051 and Asuka 881371.

The D’Orbigny angrite is very rich in glass unlike other members of this group: Angra dos Reis, LEW 86010, LEW 87051, Asuka 881371 and Sahara 99555 [Prinz M. et al. (1977); Mittlefehldt D.W. and Lindstrom M. M. (1990); Prinz M. et al. (1990); Mikouchi T. et al.(1996); Bischoff A.et al. (2000)], which are devoid of glass. (in reference figures shortened to ADOR, LEW 86, LEW 87 Asuka and Sahara).

The angrites are rocks with unusual petrological and geochemical characteristics. Notwithstanding their controversial genesis, they are considered to be igneous rocks of basaltic composition. Several petrology studies were carried out to determine if angrites could represent a melt composition. Treiman (1989) attempted to determine the composition of the melt from which ADOR could have crystallised and came up with a melt not saturated in olivine. According to melting experiments, McKay et al. (1988) concluded that LEW 86010 crystallised from a melt of a composition close to that of the bulk rock. Also, minimum partial melts obtained from CM and CV chondrites were angritic in composition and resemble LEW 86010 [Jurewicz A. J. G. et al. (1993)].

The D’Orbigny glasses can very well be considered melts from which angrites could be crystallised as from them olivine, augite, plagioclase and larnite can by precipitated (CIPW-norm has An:Di:Ol ~1:1:1). However, the petrologic characteristics are against this assumption.

Glasses are hosted either as glass inclusions in olivine or they are filling former empty space. Thus, the latter clearly were added to the rock after its formation. The mechanism of glass formation as well as its source remains in the dark. Shock has to be excluded as no shock features are present but very delicate structures like the hollow spheres are.

References: Bischoff A.et al. (2000) MAPS 35, Suppl., A27; Jurewicz A. J. G. et al. (1993) Geochim. Cosmochim. Acta, 57, 2123; Kurat G. et al., (2001) Lunar Planet. Sci.32, 1753; [2] Kurat G. et al., (2001) Lunar Planet. Sci. 32, 1737; McKay G. et al. (1988) Lunar Planet. Sci. 19, 760; Mikouchi T. et al.(1996) Proc. NIPR Symp Antarct. Meteorites 9, 174; Mittlefehldt D.W. and Lindstrom M. M. (1990) Geochim. Cosmochim. Acta 54, 3209; Prinz M. et al. (1977) Earth Planet. Sci. Lett. 35, 271; Prinz M. et al. (1990) Lunar Planet. Sci. 21, 980; Treiman A. H. (1989) Proc. Lunar Planet. Sci. Conf.19, 443.