GLASSES IN THE D'ORBIGNY ANGRITE. M. E.Varela[1], G. Kurat[2], F. Brandstaetter[2], M. Bonnin-Mosbah[3] and N. Metrich[3] [1]CONICET- UNS, Dpto de Geologia, San Juan 670, 8000, B. Blanca, Argentina, evarela@criba.edu.ar, [2]Naturhistorisches Museum, Postfach 417, A1014, Vienna, Austria, gero.kurat@univie.ac.at ; franz.brandstaetter@nhm-wien.ac.at, [3]Laboratory Pierre Süe, CEA-CNRS, F-91191 Gif sur Yvette, France, Bonnin-Mosbah@drecam.cea.fr, Metrich@drecam.cea.fr.

Introduction: 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 (see [1]). D'Orbigny is peculiar in several respects [2], one of them being the abundant presence of glasses, a phase which has not been previously reported from any other angrite. This is a preliminary report on the features of these glasses and an attempt to shed light on their possible origin(s).

Analytical Techniques: Major chemical compositions of glasses were obtained using an ARL-SEMQ microprobe operated under 15 kV and 10 nA., (Na was analyzed first and counting time for all elements was 10 s) and a scanning electron microscope JEOL 6400, (NHM, Vienna). A Nonius KappaCCD diffractometer (Institute of Mineralogy, University of Vienna) was used to verify the amorphous nature of our samples. C and N measurements in glass inclusions were carried out at the nuclear microprobe facilities of Pierre Süe laboratory (Saclay, France) by using the $^{12}C\ (d,p)^{13}C$ and $^{14}N\ (d,p)^{15}N$, nuclear reactions, respectively.

Samples: The investigated samples are: a PTS D'Orbigny B and different types of glasses separated from rock specimens and rock debris: D'Orbigny B2, [CC1, HH1, AA2, C] and MF2 (all from NHM, Vienna).

Results: D'Orbigny principally consists of three major lithologies [1,2]: a dense, medium-grained, subophitic basaltic rock, a porous, coarse-grained subophitic basaltic rock with abundant open druses containing augite and anorthite single crystals, and round, hollow spheres with a shell consisting of a granular intergrowth of olivine and anorthite with few augites. Glasses in the D'Orbigny angrite occur in the following modes: *glass filling in part open druse space with free surfaces forming menisci, *glass filling a few of the abundant hollow spheres, *glass filling interstitial space between major silicates (olivine, augite, anorthite), *glass inclusions in olivine. 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. It can be dense, containing only a few bubbles, or foamy, with all possible transitions, also over short distances. Some glasses show dark-light schlieren in transmitted light, which resemble flow lines. However, the associated bubbles are always perfectly round (Fig 1).

Glasses occasionally contain rounded mineral and – rare – rock fragments (Fig.2), some contain small dendrites of olivine and/or magnetite. Small (1-50 µm) sulphide blebs (Ni-bearing FeS) associated with small bubbles are common. An X-ray test of a representative sample of druse-filling glass revealed glass fringes only.

Primary glass inclusions hosted by olivine have sizes up to 20 µm and consist of glass and a shrinkage bubble with one of them containing a sulphide globule (Ni-free).

The chemical composition of glasses (Table) varies somewhat: SiO_2 (35 to 42 wt%); TiO_2 (0.4 to 4.4 wt%); Al_2O_3 (4.9 to 19.3 wt%); MgO (1 to 7.8 wt%); FeO (10.2 to 25.9 wt%).

Discussion: The D'Orbigny angrite is unusually rich in glass as compared with other members of this group: Angra dos Reis, LEW 86010, LEW 87051, Asuka 881371 and Sahara 99555 [3-7] (henceforth shortened to ADOR, LEW 86, LEW 87 Asuka and Sahara). 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. They are, however, compositionally at the lower end of the range for the MgO contents (except for LEW 86) and the CaO/Al_2O_3 ratio (except for LEW 87) and at the higher end of the range for the FeO content (except for Asuka and Sahara). Glasses have superchondritic Ca/Al ratios, similar to the angrites (Fig 3), 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 86, glasses have lower contents of MgO as compared to ADOR, LEW87 and Asuka.

The angrites are rocks as old as the solar system [8] 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 [9] 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, [10] concluded that

LEW 86 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 86 [11].

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. We might speculate that the extremely foamy glasses could possibly indicate the presence of carbonates in the source.

Table: Major element (wt%) contents of representative glasses in the D'Orbigny angrite and C and N contents of inclusion glass

	GI (Ol)			Glass patches			GWB		IG	GS
	*	*	*							
SiO_2	39.4	38.2	40.0	40.2	41.1	40.4	37.2	38.5	38.4	37.4
TiO_2	1.38	1.75	1.65	0.83	0.81	1.04	0.50	0.38	2.54	0.70
Al_2O_3	18.7	17.8	12.2	13.1	13.2	12.5	11.9	8.3	8.1	10.9
Cr_2O_3	0.15	0.04	0.10	0.07	0.16	0.05	0.00	0.00	0.09	0.00
FeO	10.2	10.4	20.7	23.3	23.2	24.5	25.9	24.7	25.8	27.1
MnO	0.17	0.78	0.27	0.36	0.25	0.28	0.34	0.62	0.32	0.10
MgO	0.99	1.09	5.7	7.5	7.7	7.5	6.6	2.03	4.20	6.0
CaO	27.3	28.7	18.3	13.8	14.5	14.5	16.5	25.2	20.4	16.7
Total	98.3	98.8	98.9	99.2	100.9	100.7	98.9	99.7	99.9	98.9
C ppm	64	40								
N ppm	150	180								

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

Figure 1: Transmitted light image of a glass sphere showing schlieren, bubbles, and residual material from the shell (top).

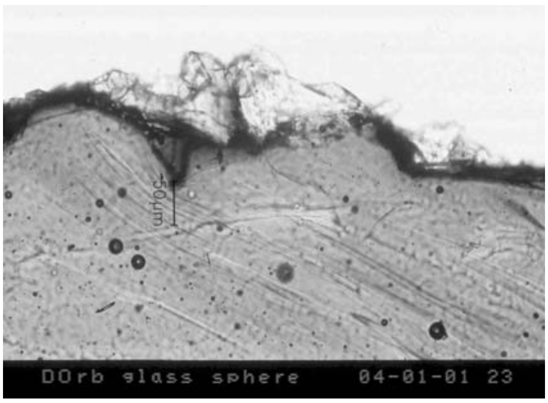


Figure 2: Transmitted light image of a glass sphere.Note schlieren and relic minerals(white).

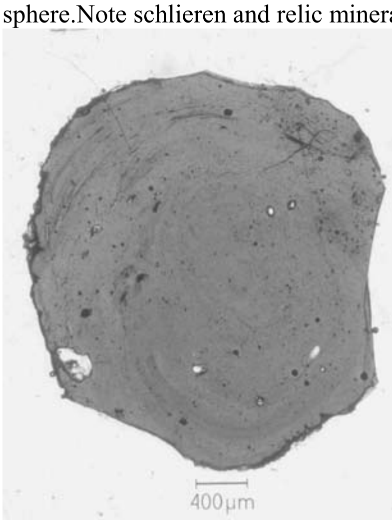
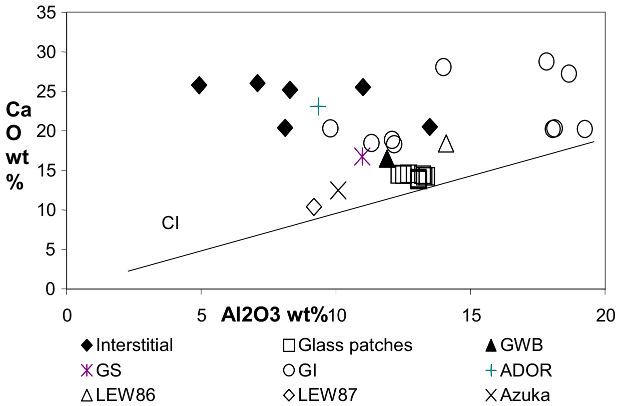


Figure 3:



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