GEOCHEMISTRY OF IMPACT GLASS FROM THE AOUELLOUL CRATER, MAURITANIA.

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INTRODUCTION. The Aouelloul meteorite impact crater is situated at 20° 15'N and 12° 41'W in the Adrar region of the western Sahara Desert in Mauritania, northwest Africa. The crater has a diameter of about 350 m. It was discovered from the air by A. Pourquié in 1938 and was first visited on the ground by Th. Monod in 1950, who made the first scientific investigation of this structure and suggested that it is a meteorite impact crater **[1]**. Upon his first visit to the crater, Th. Monod discovered abundant glass fragments which were studied by Campbell Smith and Hey **[1,2]**, who concluded that they are Si-rich glass, similar to Darwin glass or Wabar glass. However, they suggested **[2]** that the impactor was a glassy body which melted the local sandstone; they described the chemistry of the glasses as a mix of tektite and sandstone material. The crater is situated in Ordovician Zli sandstone which was reported to have a major element chemistry similar to the Aouelloul glass **[3]**, which, however, has higher iron and nickel abundances. Chao et al. **[3]** ascribed the Fe and Ni excess in the glass to the presence of a meteoritic component. Chao et al. **[4]** also found Ni-Fe spherules with Ni ranging from 1.7-9.0 wt.% which they interpreted as evidence in favor of an origin from a meteoritic impactor. However, no shock features were found in the local rocks. (This has now changed with the study of our new sandstone samples in which shocked quartz was found; Sharpton and Koeberl, in preparation.) Apart from some preliminary data reported by **[3]**, not much geochemical work has been done. Cressy et al. **[5]** reported K, Rb, Sr, Th, and U in a few samples and concluded that the glasses have been derived from the local Zli sandstone, and Koeberl et al. **[6]** analyzed REE in one impact glass sample. Here we present the first report of a thorough geochemical study of Aouelloul impact glasses and target rocks.

SAMPLES AND METHODS. In October 1989, one of us (C.K.) participated in an expedition to the Aouelloul crater and studied the distribution of glasses in and around the crater, and collected numerous glass and target rock samples. Most glass samples were found outside the southern part of the crater rim, but some were found inside and all around the outside of the rim. We report here major and trace element (INAA) data for seven Aouelloul glass samples. At the time of writing, analyses of 30 more glasses and 5 sandstone samples, and AAS trace element analyses, are in progress. Major element data were obtained by averaging multiple electron microprobe point analyses, and trace elements were obtained by INAA.

RESULTS AND DISCUSSION. Average and range of the major element compositions of the seven Aouelloul glass samples are given in Table 1, compared to local Zli sandstone (the data in Table 1 has been averaged and recalculated to a water-free basis from data given by Chao **[3]**; own data in progress). The range of compositions of the glasses is very narrow, and, as shown in Fig. 1, mostly in agreement with the composition of the Zli sandstone. Only two elements show significant deviations: Fe, and, to a lesser extent, Ca (Fig. 1). On a micrometer scale, the glasses show some inhomogeneities. Lechatelierites are common, and a few "patches" of Si-rich glass (10-100 μm diameter) (SiO_2 variation 84-88 wt.%, with the other major elements "diluted" accordingly) were found in sample AOU-9006. Another sample, AOU-9004, showed an inclusion of a Fe/Al-rich component (wt.%: SiO_2 67.0, TiO_2 0.86, Al_2O_3 16.5, FeO 10.0, MnO 0.17, MgO 2.25, CaO 0.77, Na_2O 0.31, K_2O 2.13), which may be derived from a heavy mineral fraction (garnet, spinel?) in the parent sandstone. Another very interesting inclusion, in sample AOU-9005, was a zircon/baddeleyite assemblage (wt.%: ZrO 43.5-55.6, SiO_2 38-46.7), similar to the ones described by El Goresy **[7]**. These inclusions are further proof for an origin from a sedimentary precursor. Table 2 gives average and range of the trace element compositions in the 7 glasses, which mostly show relatively little variation. The Na, K, Fe, and Mn values obtained by INAA are in excellent agreement with the EPMA values. Some volatile elements (e.g., Zn, Ga, As, Br, Sb) show more variation than lithophile refractory elements. The enrichment in Fe, Co, and Ni has been noted before **[3]**, and was attributed to a possible cosmic component, maybe a pallasite or an iron meteorite of groups IIIB or IIID **[8]**, although this interpretation is not unequivocal. Siderophile element analyses are in progress; at this time, two samples with 0.1 ppb Ir have been found. The REE abundances and patterns (Fig. 2) show a narrow range and are consistent with derivation from a sedimentary precursor. The same 7 samples have also been analyzed for noble gases **[9]**, and it was found that they are consistent with an origin from the terrestrial atmosphere. At this point we can conclude that the Aouelloul glass was formed from impact melting of the local sandstone, although the geochemical details have to await completion of the analyses.

Acknowledgements: C.K. wants to thank Th. Monod for the invitation to join the 1989 expedition to the Adrar plateau and the possibility to visit the Aouelloul crater, and also the other colleagues on the trip, P. Pellas, C. Perron, and P. Fontes, for making the expedition an experience. We are grateful to F. Brandstätter (Naturhistorisches Museum, Vienna) for the major element electron microprobe analyses of the glasses.

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References: [1] *Th. Monod and A. Pourquié (1951) Bull. IFAN* **13**, *293-304.* [2] *W. Campbell Smith and M.H. Hey (1952) Bull. IFAN* **14**, *762-776.* [3] *E.C.T. Chao, C.W. Merrill, F. Cuttitta, and C. Annell (1966) EOS* **47**, *144.* [4] *E.C.T. Chao, E.J. Dwornik, and C.W. Merrill (1966) Science* **154**, *759-765.* [5] *P.J. Cressy, C.C. Schnetzler, and B.M. French (1972) JGR* **77**, *3043-3051.* [6] *C. Koeberl, F. Kluger, and W. Kiesl (1985) Chem. Erde* **44**, *107-121.* [7] *A. El Goresy (1968) in: B.M. French and N.M. Short, Shock Metamorphism of Natural Materials, Mono Book Co., p. 531-553.* [8] *J.W. Morgan, H. Higuchi, R. Ganapathy, and E. Anders (1975) Proc. Lunar Sci. Conf. 6th, p. 1609-1623.* [9] *K. Matsubara, J.-I. Matsuda, and C. Koeberl (1990) GCA, subm.*

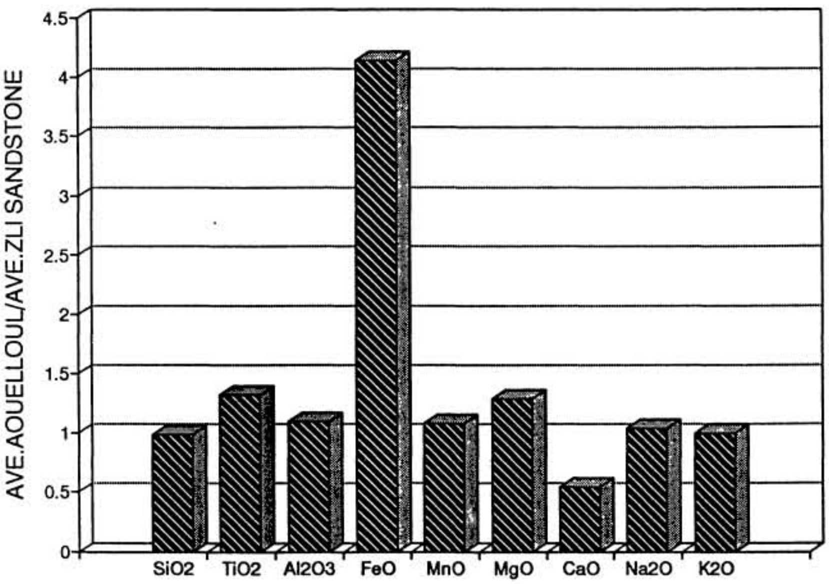

Fig. 1. **Ratio of major elements in average Aouelloul glass to local Zli sandstone [3]; the enrichment of Fe in the glass (and a depletion of Ca) is evident.**

Fig. 2. **Chondrite-normalized rare earth element patterns of average Aouelloul impact glass and the range from 7 samples. The pattern is characteristic of a sedimentary precursor material.**

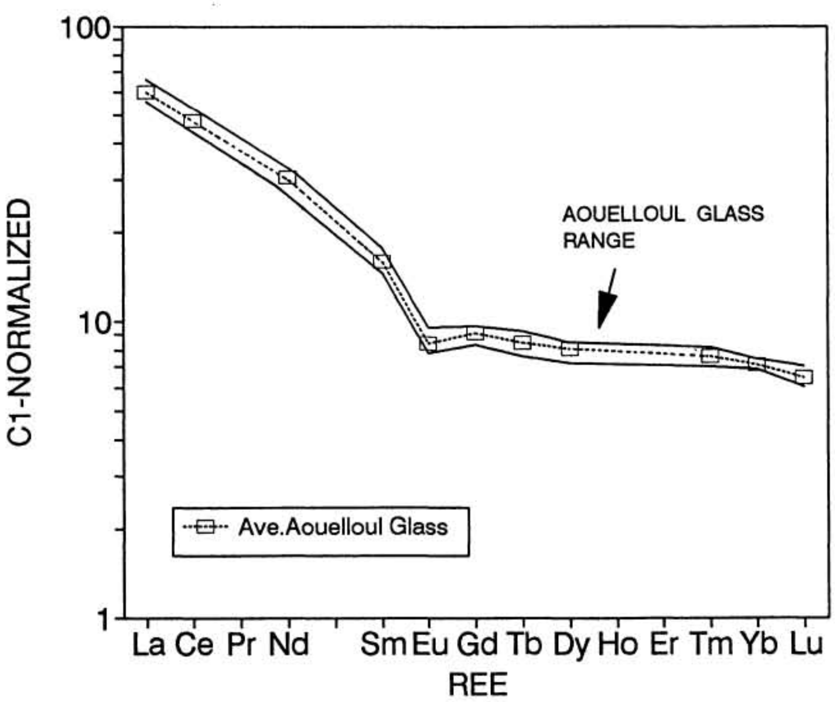

Table 1. **Major element composition (average and range) of 7 Aouelloul impact glass samples (this work), compared to average Zli sandstone (water-free composition recalculated from Chao et al. [3]). Data in wt.%.**

	Ave. Aouelloul	Range Aouelloul	Zli sandstone
SiO_2	86.04±0.68	84.9-86.9	87.9
TiO_2	0.47±0.03	0.43-0.53	0.35
Al_2O_3	6.87±0.41	6.36-7.57	6.30
FeO	2.36±0.17	2.20-2.74	0.57
MnO	0.03±0.01	0.02-0.05	0.03
MgO	1.15±0.11	0.98-1.32	0.89
CaO	0.34±0.03	0.31-0.40	0.63
Na_2O	0.23±0.03	0.17-0.27	0.22
K_2O	2.32±0.17	2.06-2.56	2.34
Tot.	99.83	-	99.27

Table 2. **Average and range of trace elements in 7 Aouelloul glasses. Data in ppm, except as noted.**

	Aouelloul Glasses Ave.	Range
Na (wt.%)	0.19±0.04	0.13-0.27
K (wt.%)	1.85±0.15	1.61-2.11
Sc	4.42±0.20	4.06-4.70
Cr	75.0±3.9	69.3-80.7
Mn	240.±14	218-260
Fe (wt.%)	1.87±0.13	1.65-2.08
Co	19.3±0.63	17.9-19.9
Ni	327.±32	303-402
Zn	18.9±4.1	12.9-24.4
Ga	12.6±5.0	7.8-22.3
As	0.12±0.09	0.06-0.35
Se	0.55±0.11	0.38-0.72
Br	0.23±0.11	0.17-0.50
Rb	55.0±4.2	50.2-63.1
Sr	52.0±11.6	40-72
Zr	483.±30	440-530
Ag	0.2	-
Sb	0.14±0.06	0.086-0.28
Cs	1.38±0.12	1.24-1.57
Ba	251.±19	220-280
La	21.9±1.31	20.5-24.2
Ce	45.8±2.9	42.1-50.7
Nd	21.7±1.4	19.9-24.1
Sm	3.65±0.22	3.35-4.06
Eu	0.73±0.05	0.68-0.83
Gd	2.79±0.15	2.55-2.95
Tb	0.49±0.04	0.44-0.54
Dy	3.06±0.18	2.75-3.24
Tm	0.27±0.02	0.25-0.29
Yb	1.78±0.05	1.71-1.85
Lu	0.25±0.01	0.23-0.27
Hf	16.1±0.62	15.4-17.4
Ta	0.64±0.04	0.58-0.70
W	0.24±0.06	0.13-0.30
Ir (ppb)	0.1	-
Au (ppb)	1.6±0.5	0.7-2
Th	7.52±0.35	7.19-8.14
U	1.19±0.21	0.92-1.54
K/U	15900.±2600	13000-19500
Zr/Hf	30.1±2.7	27.0-34.4
Eu/Eu*	0.70±0.03	0.65-0.74
Th/U	6.52±1.17	4.88-8.64