BP AND OASIS IMPACT STRUCTURES, LIBYA: PRELIMINARY PETROGRAPHIC AND GEOCHEMICAL STUDIES, AND RELATION TO LIBYAN DESERT GLASS Begosew Abate[1], Christian Koeberl[1], James R. Underwood, Jr.[2], Wolf Uwe Reimold[3], Paul Buchanan[1,3], Edward P. Fisk[4], and R.F. Giegengack[5]. *[1]Institute of Geochemistry, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria (christian.koeberl@univie.ac.at); [2]Department of Geology, Kansas State University, Manhattan, KS 66506-3201, U.S.A.; [3]Department of Geology, University of the Witwatersrand, Johannesburg 2050, South Africa (065wur@cosmos.wits.ac.za); [4]1026 N 600 E Street, Logan, UT 84341, U.S.A.; [5]Department of Geology, University of Pennsylvania, Philadelphia, PA 19104, U.S.A.*

Introduction: The B.P. impact structure is located in Libya at 25° 19' N and 24° 20' E. It was first described by Martin [1] and is named after the B.P. Exploration Company. The structure consists of two eroded and discontinuous rings of hills surrounding a central block, the S half of which is deeply eroded. The inner ring is about 2 km in diameter with an average relief of 30 m, while the outer ring has a diameter of about 2.8 km and a maximum relief of about 20 m. Recent space-shuttle-radar studies show that the structure probably is 3.2 km in diameter, the outermost disturbed beds being covered by a thin veneer of sand [2,3]. The rocks at the center of the structure show intense jointing. Rocks exposed are the Cretaceous (?) Nubia Group and include quartz sandstone, siltstone, and conglomerate. Medium- to coarse-grained quartz sandstone yielded shocked quartz grains with multiple sets of planar deformation features (PDFs) [4]. The geology of the structure has been studied (e.g., [5]), but no geochemical study of its rocks has yet been done. The Oasis impact structure, also in Libya, is centered at 24° 35' N and 24° 24' E. This eroded structure, named after the Oasis Oil company, has a diameter originally determined to be about 11.5 km, but the most prominent part is a central ring of hills, about 5.1 km in diameter and 100 m high. The diameter of Oasis, determined from radar images, now is estimated to be approximately 18 km [2,3]; as at BP a thin cover of sand obscures the outermost disturbed beds. The structure exposes the same rocks as the B.P. structure (ca. 85 km NNW of Oasis). As at BP, multiple sets of planar elements were detected in quartz grains [4]. A few samples of microbreccia were found at the crater, containing fragments of brownish, partly devitrified glass with sandstone fragments and shocked quartz grains [4]. As with the B.P. structure, its age is only constrained as younger than the target rocks, which are sandstones of the Nubia Group.

Petrology and Geochemistry: We have studied the petrographical characteristics and geochemical composition of 29 samples from the BP and Oasis sites [4,5]. Such a study is particularly desirable because of a possible association of the structures with the occurrence of Libyan Desert Glass (see below). Petrographic studies on thin sections of the samples showed that they represent mostly submature, moderately to poorly sorted, medium- to fine-grained quartzite sandstone, or quartzitic breccia. Most of the studied samples do not show evidence of shock, but in a few sections some quartz grains with up to 3 sets of shock-characteristic planar deformation features were found. Major element compositions of the samples were determined by XRF and trace element compositions by neutron activation analysis. The results available so far indicate a limited range in composition of all analyzed samples (Table 1).

Comparison with Libyan Desert Glass: Libyan Desert Glass (LDG) is an enigmatic natural glass found in an area of about 6500 km² between sand dunes of the southwestern corner of the Great Sand Sea in western Egypt, near the Libyan border. The glass occurs as centimeter to decimeter-sized irregular and strongly wind eroded pieces. Its fission-track age has been determined at around 29 Ma [6]. LDG is very silica-rich at about 96.5-99 wt.% SiO_2, and shows a limited variation in major and trace element abundances (e.g., [7-9]). Although the origin of LDG is still debated by some workers, an origin by impact seems most likely. Evidence for an impact origin includes the presence of schlieren and partly digested mineral phases, lechatelierite (a high-temperature mineral melt of quartz), baddeleyite, a high temperature breakdown product of zircon, and the possible existence of a meteoritic component [8]. Thus, while the impact origin of the LDG is fairly well established, no source crater is known so far. The geographic proximity of the BP and Oasis structures has previously led to speculation that one of them might be the LDG source. Our geochemical studies provide the first data for such a comparison. Table 1 gives the average LDG composition [9] in comparison with some of the BP and Oasis sample compositions. The similarity between these compositions is obvious. For example, all have low alkali element contents, and quite similar interelement ratios. The chondrite-normalized rare earth element (REE) diagrams also show this similarity. However, the present data do not allow a firm conclusion regarding a connection between either the BP or the Oasis structures and LDG. So far the data only allow the conclusion that LDG most likely formed from rocks that had compositions very similar to those found at both of these impact structures. Further chemical and isotopic work is in progress and should help to provide additional constraints.

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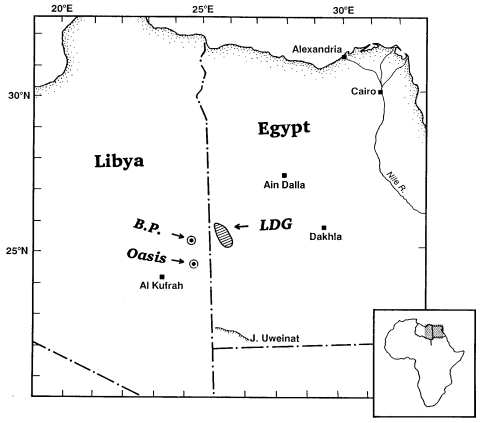
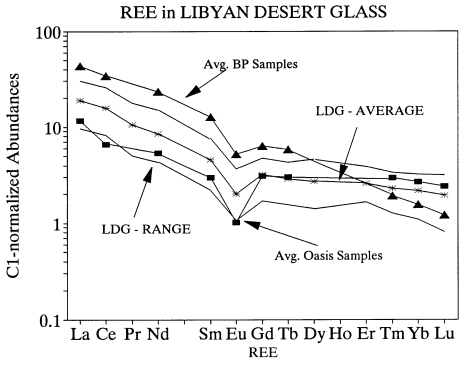
Table 1. Minor and Trace Element Composition of Average Libyan Desert Glass and Selected Rocks from the BP and Oasis Impact Structures, Libya.

	Avg. LDG	BP-22-1A Quartzite	BP-6-1 Qtz.Sandst.	BP-11-1 Qtz.Sandst.	OA-43-1 Quartz.Brecc.	OA-39-1 Qtz.Sandst.	Avg. BP	Avg. OA
Na	37	58	156	25	33	44	42	39
K	74	2.5	127	24	179	100	13	140
Sc	0.79	0.92	5.01	0.56	0.39	1.76	0.74	1.08
Cr	5.74	11.7	110	19.7	23.3	66.6	15.7	45.0
Fe	929	260	5650	1670	947	3700	965	2324
Co	0.26	0.18	1.09	0.2	0.62	2.13	0.19	1.38
Ni	7.9	6	<12	<10	<5	3	3.0	1.5
Zn	8	<3	<3	3.5	4.4	11	4.0	7.7
As	0.17	0.16	0.34	0.33	0.48	2.12	0.25	1.3
Se	0.02	0.04	0.12	0.01	<0.02	<0.05	0.03	n.a.
Br	0.06	0.49	0.44	1.05	0.06	0.55	0.77	0.31
Rb	0.46	<1.5	<2	0.7	0.5	0.4	0.35	0.45
Sr	24	54	11	17	10	6	36	8
Zr	196	112	542	41	59	70	77	65
Ag	0.025	<0.04	<0.06	<0.01	<0.02	0.01	n.a.	0.01
Sb	0.089	0.05	0.12	0.04	0.03	0.14	0.05	0.085
Cs	0.092	0.016	<0.02	0.014	0.027	<0.01	0.015	0.014
Ba	37	22	60	18	18	48	20	33
La	6.91	26.1	19.6	5.62	2.91	5.65	15.9	4.28
Ce	15.1	54.9	35.9	9.9	4.54	8.1	32.4	6.32
Nd	6.01	28.8	18	4.6	2.9	4.7	16.7	3.8
Sm	1.06	4.98	3.32	0.83	0.46	0.91	2.91	0.69
Eu	0.17	0.74	0.61	0.17	0.089	0.088	0.46	0.09
Gd	0.97	2.9	4.8	1	0.5	1.4	1.95	0.95
Tb	0.17	0.53	0.79	0.15	0.08	0.27	0.34	0.18
Tm	0.08	0.086	0.46	0.05	0.04	0.17	0.07	0.11
Yb	0.53	0.51	3.11	0.26	0.23	1.09	0.39	0.66
Lu	0.07	0.055	0.39	0.037	0.033	0.15	0.05	0.09
Hf	4.30	1.99	10.3	0.09	1.79	2.27	1.04	2.03
Ta	0.28	0.13	1.72	0.07	0.06	0.36	0.10	0.21
W	0.16	0.06	0.85	0.08	0.15	0.08	0.07	0.12
Ir (ppb)	0.04	<1	<1	<1	<1	<1	<1	<1
Au (ppb)	0.66	0.2	0.4	0.2	0.4	0.4	0.2	0.4
Hg	0.01	0.009	0.02	<0.02	<0.02	0.003	0.01	0.003
Th	2.59	2.14	12.4	0.88	0.66	1.23	1.51	0.95
U	0.96	0.33	1.94	0.27	0.23	0.52	0.30	0.38
K/U	77.5	7.58	65.5	88.9	778.3	192.3	44.2	372.0
Th/U	2.72	6.48	6.39	3.26	2.87	2.37	5.03	2.52
La/Th	2.66	12.20	1.58	6.39	4.41	4.59	10.50	4.53
Zr/Hf	45.6	56.3	52.6	455.6	33.0	30.8	73.6	31.8
Hf/Ta	15.41	15.31	5.99	1.29	29.83	6.31	10.40	9.67
LaN/YbN	8.73	34.58	4.26	14.61	8.55	3.50	27.84	4.38
Eu/Eu*	0.52	0.60	0.47	0.57	0.57	0.24	0.58	0.34

All data in ppm, except as noted. Avg. LDG (Libyan Desert Glass) data from [9]; avg. BP = average of samples BP-22-1A and BP-11-1 from the BP structure; avg. OA = average of samples OA-39-1 and OA-43-1 from the Oasis structure.





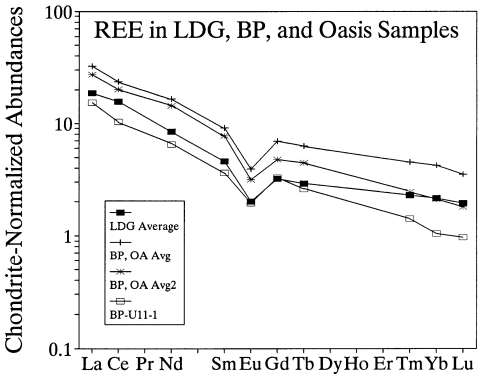


Fig.1. Location map, showing parts of Egypt and Libya. The position of) is shown in relation to the BP and Oasis impact structures in neighboring Libya. In general, no LDG is found in Libya. The name derives from the classical name for the NE part of the Sahara, known since the time of Herodotus as the Libyan Desert.

Fig. 2. Chondrite-normalized rare earth element patterns. a) Libyan Desert Glass (LDG; average and range) shown together with the averages for the BP and Oasis samples as indicated in Table. b) Average LDG composition shown in comparison with BP sample 11-1 and two different average compositions obtained from Table 1 (BP, OA Avg is calculated from all five samples; Avg2 excludes sample BP-6-1).