THE METEORITIC CONTENT OF LYBIAN DESERT GLASSES. R. Rocchia, E. Robin, L. Froget, J. Gayraud, Centre des faibles radioactivités, Laboratoire mixte C.E.A.-C.N.R.S., Avenue de la Terrasse, 91198 Gif-sur-Yvette, France. H. Méon, Centre de Paléontologie Stratigraphique et Paléoécologie, UA 11CNRS, 29 Bd. du 11 Novembre 1918,69622 Villeurbanne Cedex, France. E. Diemer, 149 rue du Murger Papillon, 77350 Le Mée-sur-Seine, France.

Scientific summary. The existence of natural glass in the Lybian Desert, known since the nineteenth century, has for long been considered as a mystery. The finding of anomalously high concentrations of siderophilic elements by Murali et al.[1] in some brown-coloured streaks suggests that the Lybian Desert Glass (LDG) contains locally a small fraction, on the order of 0.1%, of meteoritic material. We report here new results about such coloured parts which confirm the quite frequent occurrence of a chondritic component which, in some cases, represents up to 1% in mass of the samples. This supports an impact origin for LDGs.

Geological setting. Natural silica glasses are found in abundance in the western part of the Great Sand Sea in Egypt. Pieces of glass, ranging in mass from a few grams to a few kilograms cover an area of more than 150x50 km2 of the so-called Lybian Desert. They are essentially found in the inter-dune channels which are oriented along the NNO-SSE direction [2,3] and, presently, represent a total mass of about 10^4 tons.

Compositional analyses. Samples of Lybian Desert Glasses (LDGs) were collected by Th. Monod and one of us (E. D.). Major element concentrations were determined with the X-ray spectrometer on the SEM. Trace elements were measured by INAA. Iridium was counted with a γ–γ spectrometer. An X-ray diffractometer was used for mineralogical studies.
In most samples, the X-ray diffraction diagram does not show any crystallized component. Some samples, however, contain cristobalite which appears in the plain glass as white spherical inclusions. A first analysis of bulk samples gave a rather high Ir concentration (0.3 ng/g) in an apparently homogeneous translucent specimen. Similar values have already been reported in brown-stained LDGs by Murali et al.[1]. A second set of samples selected for their deep brown streaks gave still higher Ir concentrations. Such inhomogeneous samples were fragmented into small pieces. Fragments with different pigmentations were compared for their compositions with samples of perfectly transparent greenish glass. Iridium is hardly detectable in most perfectly transparent specimens. In most brown-stained fragments Ir is measured with concentrations well above the detection limit of the γ–γ spectrometer (0.01 ng/g). The maximum concentrations (5 ng/g) are found in the deepest stained fraction. Ir is strongly correlated with other meteoritic elements (Fe, Ni, Co, Cr..). Ni, Co and Cr exhibit the most important variations (factor 10-20). Sc also shows some variations with Ir but its concentration does not vary by more than a factor 2 to 3. On the contrary, REEs do not show any correlation with Ir concentrations. We have to note that the correlation Ir/meteoritic elements is good when large or homogenized samples (a few ten milligrams of ground glass) are considered. In individual small fragments (a few mg.), the dispersion of observed concentrations with respect to the regression line is important, indicating that the carrier of meteoritic elements is not homogeneous in composition. However, the good overall correlation of Cr, Ni, Co, Fe and Ir strongly suggests different degrees of mixing of a silica-rich glass (98%) with a meteoritic material characterized by Fe/Ir, Ni/Ir, Cr/Ir and Co/Ir ratios close (within a factor 2) to those observed in chondritic meteorites. This interpretation is consistent with the rather stable values of REE abundances. These elements, strongly depleted in meteorites with respect to crustal materials, are likely attached to the dominent terrestrial silica phase of LDGs.The maximum degree of mixing, in the sample most enriched in Ir ($\approx$5 ng/g), corresponds to about 1% of chondritic material. A pure chondritic component, melted or unmelted, has not been isolated so far in the limited number of analyzed samples. We have to note also the presence in many samples of numerous amorphous pure silica inclusions (possibly lechatelierite) similar to those found in tektites (fig. n°1).

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Discussion. These observations strongly supports an impact origin for LDGs. Two hypotheses for the source of the meteoritic content can be envisaged. The first one supposes that siderophilic enrichments are due to cosmic spherules which might have been present in the target material (sand according to the high Si content of the glass). This explanation could account for small quantities of meteoritic material only, as the sizes of cosmic spherules are on the order of 50-100 microns. The observed siderophilic enrichement ([Ir]=5ng/g) in glass fragments of about 10 mm^3 correspond to more than 100-300 micrograms of meteoritic matter. This is far beyond what we expect from a single cosmic spherule whose weight rarely exceeds a few micrograms. The only acceptable explanation is that the siderophile overabundances result from the inclusion and melting of big fragments from the projectile. The rapidity of th heat flash experienced by the samples could account for their inhomogeneous dispersion in the glass.

Search for a biological component. In order to test the idea that LDGs could be formed by precipitation of amorphous silica from a continental water rich in siliceous organisms [4] we have searched for pollens possibly trapped during the precipitation process. A few massive samples were first cleaned on the flame. Then, for a better cleaning, 10-15 % of the mass was dissolved in HF. The rest (≈100g) was digested in HF for analysis. We have not obtained any evidence that pollen grains existed within LDGs. The rare grains found in the residues seem to result from a bad cleaning of the external part of the samples or possibly from a laboratory contamination (?). Presently, we have not found any evidence for the presence of a biological component. This is quite consistent with the high temperature experienced by all impact derived glasses.

Conclusions. The presence in LDGs of meteoritic elements in nearly chondritic proportions points to an impact origin. The chondritic fraction likely derives from the impactor. The high melting temperature of silica makes that, at least in the samples we have investigated, this fraction was completely melted and dissolved in the target material. The presence of amorphous pure silica inclusions (lechatelierite?), similar to those found in tektites, is also consistent with a high temperature formation mode .The geographical origin of the target material has not been identified so far.

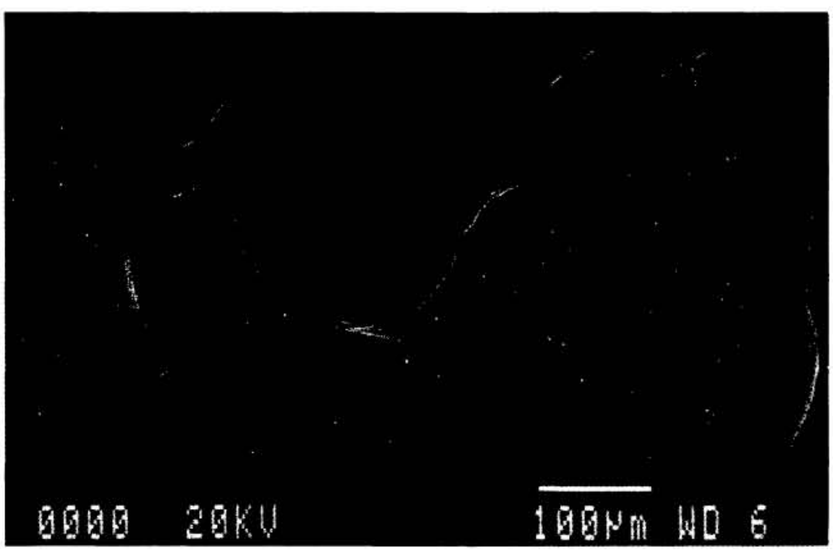

Fig. n°1. Amorphous inclusion of pure silica (dark grey part) in LDG.

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