Silica-glass from the Libyan Desert.[1]

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Discovery and occurrence (P. A. Clayton).

AN occurrence of silica-glass in lumps up to 10 lb. in weight, smaller fragments being scattered over an area at least 80 by 25 kilometres, has been discovered in the course of the work of the Egyptian Desert Surveys. A Survey expedition under Mr. P. A. Clayton was sent out in December 1932 to work in the unexplored area of the Sand Sea and Gilf Kebir, west of Major R. A. Bagnold's 1930 route, and found the glass on December 29, 1932. It occurs lying on the surface of the Nubian sandstone in the sand-free corridors between the high north-south dune ranges of the south-west of the Sand Sea (fig. 1). The largest lumps were found in approximately latitude 25° 25′ N., longitude 25° 30′ E. The district is not easily accessible, as direct travel from Abu Mungar or Dakhla by car is impracticable. Water is only available at Ain Dalla, reached by a winding route some 500 km. long through the Sand Sea, or at Kufara Oasis some 300 km. away in Italian Cyrenaica.

A hurried preliminary reconnaissance has so far not revealed anything in the geology of the district which throws light on the occurrence of the silica-glass, and no crater has been found in the district. Some 30 per cent. of the area is hidden by dune ranges nearly 100 m. high, but the dunes are so regular that it is probable that the surface on which they lie is featureless. The dunes run in parallel north-south ranges 2 to 5 km. apart, steep on the eastern face, with a long soft sand slope on the west, and the underlying Nubian sandstone plain, generally free of sand, has an almost imperceptible slope averaging 1 in 1000 from south to north.

[1] Portions of this paper were published in the Geographical Journal, October, 1933, vol. 82, pp. 375–377.

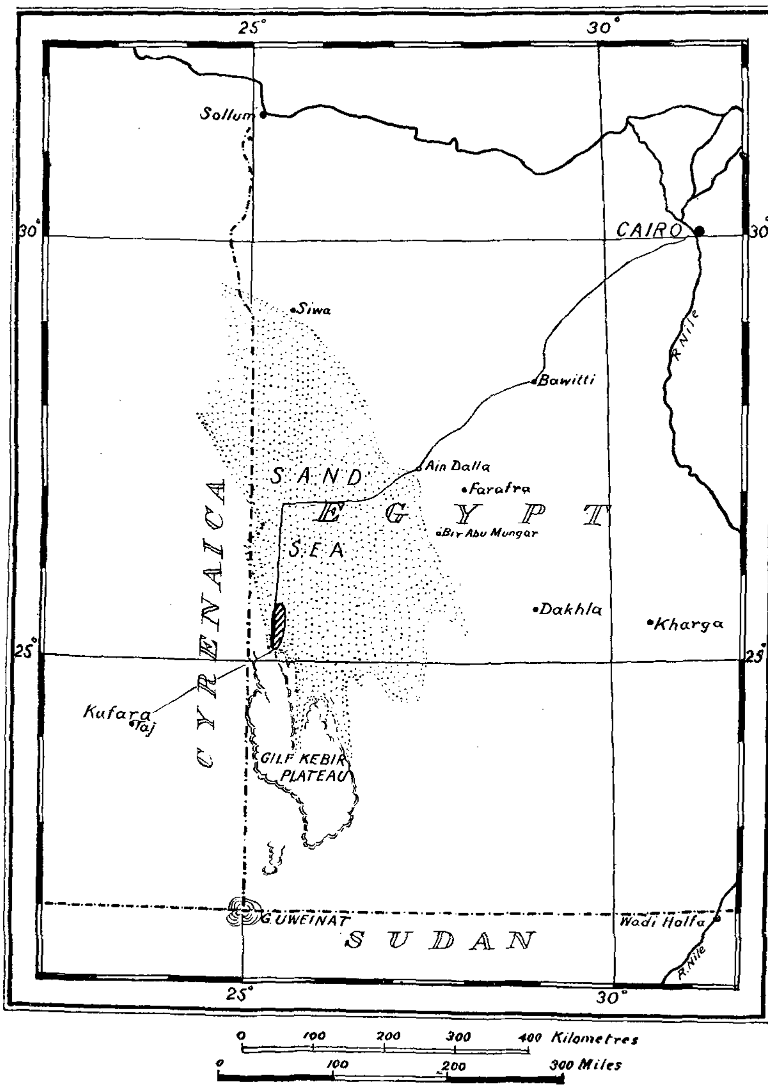
The surface of this plain in the southern part of the silica-glass area is hard quartzite, overlain in places with reddish sandstone, and also in parts by a reddish alluvial deposit probably derived from weathering of the sandstone. Some of this reddish material can be seen adhering to the specimens of glass which were lying on it. Such specimens were not found more than half embedded, and though holes were dug where the glass lay thickest, none was found below the surface.

Farther north the surface is a coarse quartz gravel, the pebbles of which are very rounded, while the glass shows no signs of having been rolled, though its surface is wind-eroded. As one goes north the gravel becomes finer, till at the northernmost point where glass was definitely found the surface is a thin crust of fine gravel over a white angular quartz sand. Small pieces of clear quartz are common in the gravel, and not easy to distinguish when searching from fragments of glass 3–5 mm. long.

No well-worked tools of silica-glass were found, though a few flakes were certainly made by man. Only two small fragments, in company with a definite artifact of quartzite, were found actually on the sand ridges, and these must have been carried up there and dropped. Near the largest lumps a number of spots were found where groups of fairly large (10 cm.) fragments occur within a square metre, as though a large lump had been broken up. Attempts to fit the pieces together were unsuccessful, possibly due to the way in which the glass flies to pieces on fracture.

The extent of the area over which it is distributed is only vaguely known. None was seen south of the old Kufara to Abu Mungar camel route, and the first pieces were seen about 4 km. north of this, For about 26 km. farther north up the central corridor in which it occurs pieces are visible every few yards, even from a moving car, while farther north one has to stop and search, sometimes for minutes before a single fragment is found. 84 km. north of the old camel road it was only after considerable search that a few tiny fragments were found. The distribution in the adjacent corridors on either side was similar, though the lumps were smaller and less plentiful than in the central corridor, while pieces were also picked up in the next corridors east and west.

About a hundredweight of the silica-glass was collected and brought to Cairo, though more could have been collected if transport were available.



= Distribution of Silica-glass in the Libyan Desert

FIG. 1. Sketch-map showing the locality of the silica-glass.

Subsequently sorting over the collection of small pieces, it was surprising to find how many of them (at least 10 %) showed old fractures which might have been produced by an intentional blow (fig. 2). Mr. George Murray and the Rev. P. Bovier-Lapierre were prepared to accept most of these as having been chipped off; but Dr. John Ball and Mr. Brunton, regarding the curved bump as a conchoidal fracture and not a bulb of percussion, will admit only

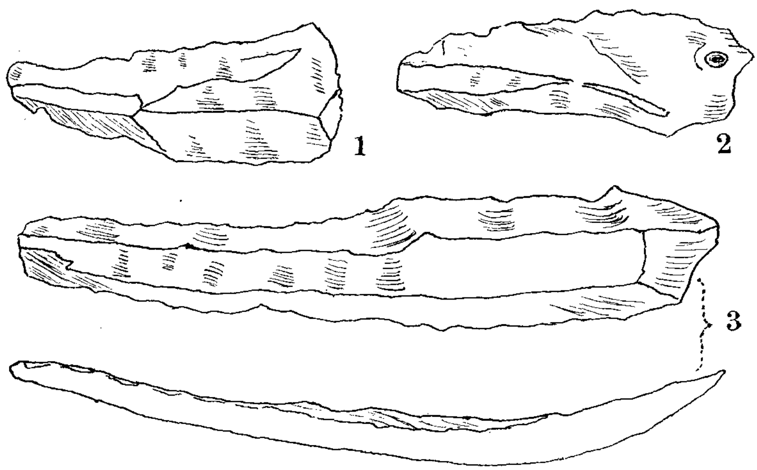


Fig. 2. Worked flakes of silica-glass. No. 2 is perforated by a hole in which a sand grain is wedged.

about 1 %. Three of these authorities agree in calling the flakes 'late neolithic or pre-dynastic'. A possible explanation of the groups of fragments found on the surface of the desert, as mentioned above, is that they were broken by human hands.

Characters and origin (L. J. Spencer).

Seven pieces of this remarkable material have been generously presented by the Survey of Egypt for the Mineral Collection of the British Museum (Natural History), and are now displayed in the Recent Addition Case in the Mineral Gallery at South Kensington, together with other material to which they appear to be most closely related, namely tektites from Bohemia, Moravia, French Indo-China, Australia, and Colombia. The masses are irregular in shape and are wind-worn on all sides (figs. 3 and 4). They range in weight from 90·4 to 2279 grams (3¼ oz. to 5 lb.). The colour is pale greenish-yellow and the material is in part quite clear and transparent. Some parts are cloudy owing to the presence of minute bubbles, and when these are still more abundant the material has a milky white appearance. One piece shows smoke-grey streaks in the greenish-yellow glass, and indications of a flow structure are also shown in other pieces.

The clear material when cut and polished (in a step-cut form) makes quite an effective gemstone. One cut for the Museum weighs 10·57 grams (52·86 carats).[1] The specific gravity of this was determined by hydrostatic weighing to be 2·21. On the refractometer it gave the following values for the refractive index. Less reliable values were obtained by the prism method through a 60°-prism cut from the glass, owing to the scattering of the rays of light by the minute bubbles. The dispersion n_{Tl-Li} is very low.

Light.	Silica-glass, Libyan Desert. Refractometer.	Silica-glass, Libyan Desert. Prism.	Pure Silica-glass.[2]
Red (Li)	1·4595	1·459	1·45605
Yellow (Na)... ...	1·4624	1·462	1·45845
Green (Tl)	1·4645	1·465	1·46053
n_{Tl-Li}	0·0050	0·006	0·00448

The hardness is 6 on Mohs's scale; the material readily scratches window-glass and is itself readily scratched by quartz.

In thin sections under the microscope the glass is colourless and optically isotropic. The minute bubbles do not exceed 0·1 mm. across, and the larger ones are usually collected into groups. They are round or elongated, but the direction of elongation is variable, and no indications of flow structure are seen in the sections. A very fine brownish dust pervades the whole glass, and there are a few small brown patches of irregular outline, and very few minute (0·02 mm.) black spots.

Small white spherulites, apparently due to devitrification, are occasionally present. In one specimen these are more abundant and are arranged in approximately parallel lines, like strings of small (¾ mm.) beads. They have a minutely hummocky surface, and in

[1] L. J. Spencer, Gemmologist, London, 1933, vol. 3, p. 111. [Min. Abstr., 5-398.]

[2] Values (for Li and Tl by interpolation) given by R. B. Sosman, International Critical Tables, 1929, vol. 6, p. 341.

thin section are seen to consist of a radial aggregate of comparatively coarse acicular crystals of quartz. This specimen is also peculiar in showing a clean-cut cylindrical bore completely traversing the mass of glass; it is 3½ cm. long and 6 mm. in diameter, and approximately

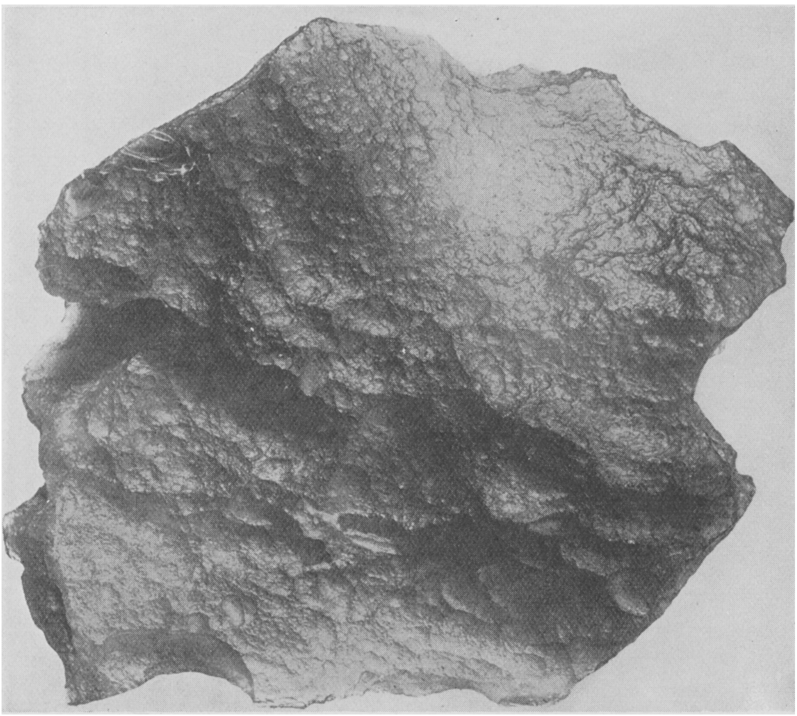


FIG. 3. Silica-glass from the Libyan Desert. Wind-worn mass of 5 lb. Half actual size.

parallel to the lines of spherulites (fig. 4). Two other such bore-holes with rounded ends penetrate for only a short distance in the same general direction. Occasionally small pits are seen on the surface of the specimens, in which a grain of sand is sometimes wedged (compare fig. 2).

The largest spherulite, 1½ mm. in diameter, occurring alone and partly projecting from a small fragment of clear glass, afforded an opportunity of detaching a fragment for examination. This has specific gravity 2·35, and is very weakly birefringent with refractive index less than 1·49, suggesting cristobalite.

A chemical analysis of the glass made by Mr. M. H. Hey in the Museum laboratory gave:

SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	Na_2O.	H_2O.	Total.
97·58	0·21	1·54	0·11	0·23	0·38	0·34	0·10	100·49

Traces of NiO, MnO, and MgO are also present. K_2O is absent. Of the water 0·05 % was lost at 110° C., and the remainder on ignition. For the main analysis 1·0339 gram was used, and for FeO and

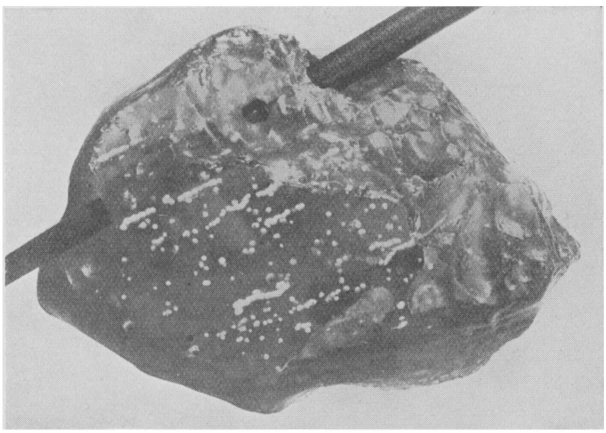


FIG. 4. Silica-glass from the Libyan Desert. Actual size. Spherulites are shown more distinctly through the flat polished surface. The rod marks a cylindrical bore which is penetrated sideways at one point. Another shorter bore with rounded end is seen towards the bottom.

alkalis separate portions of about 1 gram and ½ gram respectively. A special test was made for nickel on 2·97 grams, and the amount of NiO is probably less than 0·001 %, certainly less than 0·005. The specific gravity of the solid lump was found to be D_4^{20} 2·206 ± 0·002, and of the fine powder D_4^{20} 2·208 ± 0·002, corrected to vacuum, indicating that the bubbles present are not more than 0·6 % of the material by volume.

This silica-glass in its characters and mode of occurrence is most closely allied to tektites. But it is found in much larger masses and in larger quantity than any tektites previously known, and also it is different in colour. Tektites are usually black and in the mass opaque, but those from Bohemia and Moravia are a clear green, and small ones from Colombia are pale smoky-grey to almost colourless.

The origin of tektites is still an unsolved problem.[1] The generally accepted view at the present time is that they are of cosmic origin, but none has been actually observed to fall from the sky. The presence of silica-glass in large quantity around the meteorite craters recently discovered at Wabar in Arabia and Henbury in Central Australia, suggests that tektites may have been formed by the fusion of desert sand in the heat developed by the fall of gigantic meteorites. No evidence of this, however, has been detected in the Libyan Desert; and, moreover, the wide distribution (80×25 km.) of the material is rather against this view. Mr. Clayton remarks that from the surface geology of the district there are no indications that the material might have been transported by water, as is undoubtedly the case in the distribution of tektites.

The origin of this silica-glass on the Libyan Desert thus remains an unsolved problem. More observations are needed.

A group of craters in the Libyan Desert at about 22° 20′ N., 25° 30′ E., between Gebel ‘Uweinat and Gilf Kebir, was photographed from the air by Sir Robert Clayton[2] in 1932 and was visited later in the same year by Major R. A. Bagnold's expedition.[3] They are described by Dr. K. S. Sandford[4] as explosion craters with walls of ‘steeply tilted, hardened, and locally fused Nubian sandstone’. Within the craters are ‘plugs of white trachytic rock and adjacent to them the fusion of the sandstone walls was very marked’. Mention is also made of an ‘irony sinter’. Such a description is suggestive of meteorite craters rather than volcanic craters. Some of the silica-glass from Meteor Crater in Arizona would answer to the field description of a ‘white trachytic rock’, and the ‘irony sinter’ may perhaps be meteoritic iron-shale. ‘A dark basalt-like rock of much the same specific gravity as the trachyte’ is rather suggestive of the silica-glass from the meteorite craters at Henbury and Wabar. Although this locality is 200 miles to the south of the area where the lumps of clear silica-glass are found, it seems possible that there may be some connexion between the two occurrences.

[1] Nature, London, 1933, vol. 131, pp. 117, 876; vol. 132, pp. 571, 678. [Min. Abstr., 5–303, 304, 407.]

[2] Geogr. Journ., 1933, vol. 81, p. 257, and plate facing p. 252.

[3] Geogr. Journ., 1933, vol. 82, pp. 106, 215.

[4] K. S. Sandford, Volcanic craters in the Libyan Desert. Nature, London, 1933, vol. 131, pp. 46–47.