Origin of Tektites

By Dr. L. J. SPENCER, F.R.S.

SMALL, curiously shaped pieces of green, brown, or, more usually, black glass have long been known from certain regions, and have been called moldavites from the Moldau River in Bohemia and from Moravia; australites or obsidianites from Australia; billitonites from the tin-bearing gravels in the island of Billiton, Dutch East Indies; and Darwin glass from Tasmania. They have also recently been found in some abundance in French Indo-China and in the Philippine Islands. In chemical composition they are peculiar in containing a very high percentage of silica (SiO_2, 70–89 per cent).

Many theories have been advanced to account for the origin of these bodies, which are known collectively as tektites. Those from Bohemia and Moravia were formerly thought to be relics from a prehistoric glass factory. They have been thought to be 'bombs' or bubbles shot out from volcanoes (even from volcanoes on the moon). The fusion of atmospheric dust or desert sand by lightning has been suggested. Another theory is that they are colloidal bodies formed by the action of humic acids on the underlying rock in certain climates. The view most generally accepted at the present time is that they are meteoric, although they are entirely different in all their characters from any meteorite that has been actually observed to fall.

In a recent elaborate and beautifully illustrated monograph[1] Prof. A. Lacroix gives a detailed review of the whole question. He elaborates a suggestion first made by H. Michel in 1925 that tektites have been formed in the earth's atmosphere from meteoric material consisting of the element silicon and the lighter metals (aluminium, calcium, potassium and sodium). Such material heated by friction with the air would rapidly oxidise with the production of a temperature sufficient to fuse the products of oxidation; and subsequent rapid cooling would yield a glass.

Although much has been written on the subject of tektites, the elementary fact that the material of which they are composed is really an impure silica-glass has been entirely overlooked. Pure silica-glass has a specific gravity of 2·20 and refractive index 1·46—both low values. The values for tektites are 2·27–2·51 for the specific gravity and 1·48–1·52 for the refractive index.

Now the 'cinders' of the legendary city of Wabar, 'destroyed by fire from heaven', which was discovered early this year by Mr. H. St. J. Philby in the Rub' al Khali, Arabia,[2] consist of such a silica-glass. The vesicular white glass contains SiO_2, 92·88 per cent, with specific gravity 2·10 and refractive index 1·468; whilst the black glass, almost free from bubbles, contains SiO_2, 87·45 per cent, with specific gravity 2·24 and refractive index 1·50. The black glass contains also Fe_2O_3, 0·28; FeO, 5·77; NiO, 0·35 per cent. At this spot pieces of meteoric iron were found, the largest rusted remnant weighing 25 lb.; and also a series of craters that must have been formed by the impact of a shower of large meteorites. When a large mass of iron travelling with planetary velocity is suddenly stopped, the kinetic energy ($\frac{1}{2}mv^2$) is transformed into heat at a localised spot with the development of a very high temperature. The 'bombs' of silica-glass collected by Mr. Philby at Wabar suggest there must have been a pool of molten silica in the desert sand and that this material was shot out from the craters through an atmosphere of silica, iron, and nickel vapours.

At the group of meteorite craters discovered in 1931 near Henbury in Central Australia[3] silica-glass has also been found, but in smaller quantity and only around the largest crater. Here the country-rock is a ferruginous sandstone and the glass that resulted from the fusion of this rock is black and less pure. It contains SiO_2, 68·88 per cent and has specific gravity 2·31 and refractive index 1·545. It also contains Fe_2O_3, 8·46; FeO, 7·92; NiO, 0·28 per cent. Nickel is not shown in analyses of tektites, probably because it was not suspected and not looked for.

The pieces ('bombs') of silica-glass from both Wabar and Henbury present many similarities to tektites; especially to the Darwin glass from Tasmania, with which some can be matched exactly in both form and appearance. Beads and tear-shaped drops are common and there are some disc-shaped pieces, but none with the perfect button-like shape of true australites. I have been much struck with this similarity, but now that I have seen pictures of the tektites from Indo-China given by Prof. Lacroix in his monograph, I have no hesitation in concluding that tektites are not meteoric, though they are connected with the fall of large meteoric masses, but that they have resulted from the fusion of terrestrial rocks, especially in sandy deserts, by the heat so developed.

Silica-glass and tektites could, of course, be formed only in very exceptional circumstances. The fall of very large meteorites on the earth's surface is fortunately not of frequent occurrence. With the possible exception of the still debatable Siberian fall on June 30, 1908, none has in fact taken place during historic times. Further, the terrestrial rock at the place of fall must be of the right kind, such as sandstone or quartzite, or perhaps best of all a clean desert sand. The composition of tektites indicates that a certain amount of felspar, mica, or clayey material was present in the rock (arkose or siltstone); and no doubt these extra constituents (Al_2O_3, 12; CaO, 3; K_2O, 2; Na_2O, 1 per cent) gave to the molten material just the right viscosity for it to

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assume particular shapes when spinning through the air after being shot out by the gaseous explosion from the meteorite crater. The craters, supposed to be meteoric, on the Island of Oesel in Estonia are in dolomite, while the rocks in the region of the Siberian fall are basaltic. In neither of these places could silica-glass and tektites be formed.

Silica-glass is very resistant to chemical action and it will withstand weathering processes longer than many other materials. Also, with its very low coefficient of thermal expansion, it will not be affected by changes in temperature—a very potent agent of rock disintegration in desert regions. For this reason tektites are preserved in recent deposits, such as the glacial deposits of Tasmania, the alluvial deposits of Bohemia, Indo-China, and the Philippine Islands, and in the tin-gravels of Billiton, where by slow chemical corrosion they have acquired a peculiar sculptured surface. The australites found on the surface of the Australian deserts do not show this surface sculpturing and are more perfect in form. They are therefore of more recent origin. An aerial survey of the districts where australites are found would probably reveal the presence of meteorite craters with associated large masses of meteoric iron. In the other districts, all traces of the craters would probably have been obliterated by denudation, and the meteoric iron rusted away.

[1] "Les Tectites de l'Indochine." By Prof. A. Lacroix. *Arch. Mus. Nat. Hist., Paris*, **8**, 139, 1932.
[2] NATURE, **129**, 932, June 25, 1932.
[3] NATURE, **129**, 781, May 28, 1932.

Recent Research on the Vitamins

ADVANCES in our knowledge of the chemistry of the vitamins have recently been so rapid that a review of the position at any moment may require correction or amplification almost as soon as it is published. A useful summary of our knowledge of the nature and function of vitamins was provided in April and May of 1932 by Prof. J. C. Drummond in his Cantor lectures.[1] Some of the points made by the author may be briefly referred to here, and opportunity taken at the same time to review work which has been published since the delivery of the lectures.

Prof. Drummond summarises some of our knowledge in tabular form: the charts showing the minimum effective doses of the different vitamins in test animals, the functions and properties of the six B vitamins, and the distribution of the vitamins in foods are specially useful. He considers first the water-soluble vitamins C and B. The work of O. and A. Rygh and P. Laland[2] on the antiscorbutic potency of narcotine derivatives has not been confirmed by S. Smith and S. S. Zilva[3]. Daily doses of 1·37, 2·75 and 5·5 mgm. of dimethyl and methyl*nor*narcotine had no protective effect in guinea pigs kept on a scorbutic diet. It is possible that the doses were incorrectly chosen as Rygh *et al.* state that only optimal doses prevent the onset of scurvy in guinea pigs on a scorbutic diet. On the other hand, the fact that all Rygh's animals given narcotine derivatives died like the controls indicates that these supplements are not acting in the same way as a daily dose of lemon juice.

Negative results have been described also by other observers, including L. J. Harris and I. Mills, who found that irradiated narcotine and methyl*nor*narcotine were not antiscorbutic in doses ranging from 10 mgm. to 0·001 mgm. daily.[4] Zilva[5] and his colleagues have recently published full details of their work. No narcotine could be isolated from unripe orange juice by ethereal extraction, nor was a concentrate of vitamin C obtained from lemon juice by such means. Methyl*nor*narcotine in daily doses ranging from 10 γ to 2·7 mgm. had no antiscorbutic effect at all in guinea pigs maintained on a scorbutic diet, the experimental animals dying in 30–35 days with all the signs of severe scurvy.

Reference has already been made in these columns to the claim that vitamin C is a hexuronic acid[6]. The experiments on which the claim is based have now been published in detail.[7] Svirbely and Szent-Györgyi found that 1 mgm. of their product daily completely protected guinea pigs on a scorbutic diet from scurvy for 90 days: the animals also showed normal growth during this period. The minimum protective dose of lemon juice is usually regarded as 1·5 c.c. and this quantity contains approximately 0·5 mgm. of the acid. Since the substance contains a molecule of water less than is required for a hexuronic acid, Szent-Györgyi and W. N. Haworth have now suggested the name "ascorbic acid" for it (NATURE, **131**, 24; 1933). Waugh and King have also isolated a crystalline solid from lemon juice which was protective in a daily dose of 0·5 mgm. The possible objection that the material isolated from lemon juice was merely contaminated with a more potent antiscorbutic substance is not valid in the case of the work of the former authors, since the acid used was prepared from ox suprarenal glands. If the antiscorbutic factor is ascorbic acid, it is necessary to explain Zilva's observation that it is possible to oxidise the reducing factor in lemon juice without destroying the antiscorbutic potency, although the vitamin is now very labile: Svirbely and Szent-Györgyi suggest that in these conditions the acid may be present in a reversibly oxidised state. The antiscorbutic potency of this acid has been confirmed by Harris and Mills (*loc. cit.*), who also found raw suprarenal cortex potent, the activity running parallel to the acid content.

Turning to vitamin B, Prof. Drummond reviews the work of Jansen and Donath, Odake, and Windaus and his co-workers on the chemistry of vitamin B_1.[8] All observers now agree that the crystalline vitamin contains sulphur in its molecule, as well as carbon, hydrogen, oxygen and nitrogen.

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