Australites: a unique shower of glass meteorites.[1]

By CHARLES FENNER, D.Sc.
University of Adelaide.

[Read March 10, 1938.]

IT is just over a hundred years since Charles Darwin, during his great voyage, visited Sydney, New South Wales. While there, he was given, by the explorer Major Sir Thomas Mitchell, a small and curiously shaped glassy object. In his 'Geological Observations' (1844) Darwin figured this object and speculated as to its origin, which he suggested was volcanic. This is the first recorded reference to what are now known as australites, many tens of thousands of which have been collected from widespread localities over the whole of southern Australia.

About fifty years before the first appearance of Darwin's australite, references occurred in literature to numberless fragments of greenish glass found in Bohemia and Moravia; these fragments came to be called moldavites. Later, in 1900, Professor F. E. Suess, of Vienna, linked up the moldavites and the Australian objects and gave them the general name of tektites ('melted'). Since then several other groups of tektites have been discovered and these may be briefly listed as follows:

(*a*) Moldavites, in Bohemia and Moravia.
(*b*) Australites ('blackfellows' buttons'), in southern Australia.
(*c*) Darwin Glass (queenstownites), in north-western Tasmania.
(*d*) Billitonites, in Billiton and other East Indian islands.
(*e*) Rizalites, in the Philippine Islands.
(*f*) Javanese tektites (? billitonites) in Java.
(*g*) Indochinites, in Cambodia, Annam, and Siam.
(*h*) Colombian tektites, western South America.
(*i*) Ivory Coast tektites, from the Ivory Coast, Africa.

[1] Read at the British Association meeting at Nottingham in September 1937; abstract in Rep. Brit. Assoc. Adv. Sci., 1937, p. 356. A paper on similar lines was also read at the fifth annual meeting of the Society for Research on Meteorites at Denver, Colorado, in June 1937, and printed in Popular Astronomy, Northfield, Minnesota, 1937, vol. 45, pp. 504–507. [M.A. 7–78.] Compare C. Fenner, Australites, Parts I and II. Trans. Roy. Soc. South Australia, 1934, vol. 58, pp. 62–79, 6 pls.; 1935, vol. 59, pp. 125–140 [M.A. 6–18, 208]; and L. J. Spencer, The tektite problem. Min. Mag., 1937, vol. 24, pp. 503–506.

In some cases tektite groups mentioned separately in this list may prove to belong to the one group. There are, however, seven or eight quite distinct groups separable according to (*a*) distribution, (*b*) chemical composition and physical properties, and (*c*) forms. Dr. L. J. Spencer, who is the leading British authority on these objects, has also investigated and recorded a remarkable occurrence of silica-glass in the Libyan Desert. There are other localities where the possibility of tektite occurrence has been suggested or is being investigated.

All the tektites agree in that they are objects composed of natural glass, scattered over the earth's surface in more or less limited areas, and having compositions, forms, and physical characters peculiar to each group. In almost all cases the areas of distribution are remote from any possible contemporary volcanic activity. Suess, Lacroix, and many others accept them as of cosmic origin, and classify them as 'glass meteorites'. Among Australian geologists, where the australites have naturally quickened interest and discussion, there is a general acceptance of the meteoritic theory of their origin. Australites, as well as each other separate tektite group, are accepted as a 'shower of glass meteorites'.

In the very extensive literature that has now accumulated concerning tektites, the following theories of their origin have been put forward and supported. That they were:

1. Relics from a prehistoric glass factory.
2. Cast in a mould (australites).
3. Volcanic bombs from terrestrial volcanoes.
4. Blebs cast forth from the mountains of the moon.
5. Relics of bubbles blown from terrestrial volcanic craters.
6. Formed by lightning by the fusion of sand in the air.
7. Colloidal bodies formed by the action of humic acids in soils.
8. Flung out when the moon was torn from the Pacific area.
9. Blebs swept from the tails of meteors.
10. Formed by the fusion of siliceous rocks by the impact of meteorites.
11. Molten blebs resulting from the combustion of a large light-metal meteorite.
12. Of all the theories that have been advanced perhaps the most positively worded was that of Hillebrand, that they were 'artificial products formed by man savage, or civilized, either by accident or by design'.

Most of these theories are incompatible with the facts of distribution, composition, and form types.

The australites stand out particularly by reason of the remarkable series of regular forms they present. Their distribution also appears to be more extensive than that of any other series, and it has been estimated that the total numbers involved over the whole area of the 'strewnfield' is between one and ten millions.

Distribution.—Australites are somewhat irregularly spread over the whole of southern Australia, south of a line joining Kyogle in New South Wales and Derby in Western Australia.

Composition.—SiO_2 70%+, Al_2O_3 13%+, FeO and Fe_2O_3 6%+, MgO 2%+, CaO 3%+, K_2O and Na_2O 4%+, traces of Mn, Ti, Ni, Co. Specific gravity 2·3–2·5.

Forms.—The greater number conform to a regular series that have been termed according to their shapes: buttons, lenses, ovals, boats, canoes, dumb-bells, and tear-drops. They have also a characteristic internal flow structure, and either a flange or rim (equatorial) separating two distinct types of surfaces. Important information concerning these objects is also to be gained from the surface-markings and the characteristic types of fracture.

Sizes.—The smallest known australite weighs 0·15 gram, and the largest 218 grams. The majority weigh about one gram, and that is the average weight of the Shaw collection. The largest known tektite is an indochinite of over 4 kilograms. The probable total weight of the whole of the australites that fell is between one and and ten tons.

Of the formidable list of theories given above, the greater number are ruled out by the facts of distribution, composition, and form. Their Pleistocene to Recent age rules out certain of the theories. Only two theories remain with any scientific support: (*a*) meteoritic impact fusing terrestrial material, and (*b*) the theory of cosmic origin.

In the case of the australites the evidence is totally against the theory of meteoritic impact. Australites are found lying on or near the surface, over practically the whole of the area of southern Australia, about 2,000,000 square miles. This area includes rocks of all types and compositions, but there is no corresponding variation in the composition or relative abundance of australites, nor in the types of forms. Vast numbers occur upon the Nullarbor plains, which are wholly limestone. The theory of human distribution is untenable. In the whole area here concerned there is only one place where meteoritic impact has occurred, and this occurrence has in no way affected the distribution of australites. The theory of meteoritic impact cannot, therefore, explain the occurrence and distribution of australites. It is suggested, therefore, that the only

theory which is in harmony with all the known facts is that of cosmic origin.

Even with the acceptance of the cosmic theory of origin, many problems remain. It has been urged that the heat generated by atmospheric friction would be insufficient to melt the blebs. But the australites carry, in their external and internal structures, clear evidence of two periods of melting. Each complete specimen likewise shows two distinct types of surfaces: an earlier or primary surface, partly destroyed and representing the rear part of the australite; and a later surface, secondarily developed, being the 'front' portion of the object, plus the flange (where present). The two stages may not have been separated in origin by any measurable period of time, the one merging into the other during the brief term of their development.

It seems possible, following Suess, Lacroix, and others, that the australites originated within the atmosphere as a shower of siliceous blebs shed from a burning meteoritic body, at that moment assuming their primary forms of sphere, dumb-bell, &c. Then, while still molten, they sped spinning towards the earth, cooling on their rearward side, the heat of friction volatilizing some portion of the object and the pressure of the air on the re-heated forward portion giving the 'front' end its fresh (secondary) shape, forming also the characteristic flange or rim.