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SMALLEST KNOWN COMPLETE AUSTRALITE

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Abstract

The smallest known complete Australian tektite, recently discovered 10 km NNE. of Princetown, Western Victoria, is a minute oval, bowl-shaped australite weighing only 0·026 gm, with a specific gravity of 2·410. It is practically a complete form shaped and sculptured by aerodynamic processes at hypersonic speeds, and subsequently subjected to relatively minor losses by terrestrial natural solution etching. Virtually no effects of terrestrial mechanical abrasion are detectable.

Introduction

A recently discovered australite having the least weight of the 45,000 or so australites so far brought to scientific notice is an elongated, bowl-like specimen from the Fergusons Hill area some 10 km NNE. of Princetown on the S. coast of W. Victoria. It was discovered by W. J. Cappadona on 10 February 1971 resting with its anterior surface uppermost on light greyish to white, leached sandy clay on the W. side of a new access road in the closer settlement region opened up in the past few years between Princetown and Simpson.

The location is 143°10′30″ E. and 38°36′45″ S. in the region whence seven australites were described by Baker (1968a) during the early phases of road formation. Some 400 or so australites have been discovered in this area since the virgin bush country was cleared for closer settlement. Unfortunately very few of these have been submitted for scientific investigation. Among those examined is another small, shallow, oval dish-like form weighing 0·097 gm and constituting the third lightest complete australite known. It was also found by W. J. Cappadona, in September 1970. Both of these small bowl-shaped to dish-like australites are lodged in the private collection of W. J. Cappadona of Dandenong, Victoria.

Dimensions, Weight, and Specific Gravity

Although the dimensions of the australite from Fergusons Hill are shown in Table 1 in round figures, it is worth noting, by virtue of its minute size and weight, that the actual measurements are length = 4·9 mm, width = 2·9 mm, depth = 2·1 mm. The thickness of the glass averages 0·6 mm. The form is comparable in size with an ordinary match head (4·5 mm × 3·0 mm × 2·5 mm).

The specimen weighs 0·026 gm, and the specific gravity averaged from five determinations using distilled water (20°C) is 2·410, which is not much different from that of the mode for australites in the Port Campbell region (Baker 1968a, p. 25). It should be pointed out that the weight and specific gravity values are affected by small amounts of adventitious matter embedded in schlieren accentuated by natural solution etching inside the shallow bowl (Pl. 13 fig. E.). The adventitious matter consists of leached clay with minute quartz grains, and is partially cemented. In the interests of keeping the specimen intact, it was not subjected to ultrasonic cleaning.

A quarter of a century ago, the lightest known australite was 0·0645 gm (Baker 1946), so the complete form now recorded is only one third its weight. The heaviest australite (265 gm) so far recorded (Baker 1962) is 10,000 times its weight. The heaviest recorded tektite from all strewnfields weighs 3,200 gm (Laos, Indo-China) which is some 121,000 times heavier.

For purposes of comparing and contrasting some of the physical properties of the known lightest bowl-shaped and dish-like aus-

TABLE 1

BOWL-SHAPED AND DISH-LIKE AUSTRALITES IN ORDER OF INCREASING WEIGHT

	Weight (gm)	Specific Gravity	Diameter (mm)	Length (mm)	Width (mm)	Depth (mm)	Thickness (mm)	Reference
1	0·026	2·410	—	5	3	2	0·5	This paper
2	0·065	2·406	—	9	6	1	0·5	Baker 1963a
3	0·097	2·410	—	8·5	7	1	0·25–0·5	This paper
4	0·100	2·422	—	12·5	2–3	2	0·25–0·5	Baker 1964
5	0·123	2·431	7·5	—	—	1·5	1	Baker 1963a, 1963b
6	0·135	2·410	—	7·5	5	3	0·5	Baker 1940, 1946, 1963a
7	0·149	2·442	—	9	4	3	0·5–0·75	Baker 1940
8	0·154	2·406	—	8	7·5	2	1	Baker 1963a
9	0·177	2·408	—	12	5	2	0·5	Baker 1963a
10	0·230	2·421	—	9	7	2·5	0·75	Baker 1963a, 1963b
11	0·245	2·414	—	10·5	6·5	4	1	Baker 1963a, 1963b
12	0·276	2·400	—	9	8	2·5	0·75–1	Baker 1963a
13	0·305	2·440	10	—	—	3	1	Baker 1963a
14	0·371	2·441	—	14·5	13	1–3	1	Baker 1963a, 1963b

Key: 1 = oval shallow bowl, 10 km NNE. of Princetown.
2 = oval shallow bowl, Port Campbell.
3 = oval shallow bowl (dish-like), 6·5 km NNE. of Princetown.
4 = elongated bowl, Nurrabiel.
5 = round shallow bowl, Port Campbell.
6 = elongated deep bowl, Port Campbell.
7 = elongated deep bowl, Kalgoorlie.
8 = oval shallow bowl.
9 = elongated bowl.
10 = elongated deep bowl.
11 = elongated deep bowl.
12 = oval shallow bowl.
13 = round shallow bowl.
14 = oval shallow bowl.
All localities are in Victoria except 7 which is in W. Australia. 8-14 are from Port Campbell.

tralites, 14 are listed in Table 1. Among these, elongated specimens exceed round specimens in the ratio 7 to 1.

Range in weight of the australites in Table 1 is 0·026 gm to 0·371 gm, their average weight is 0·175 gm, and their specific gravity values range from 2·400 to 2·441 with an average of 2·419.

Three other similar forms have been figured by Dunn (1916, Pl. 23, figs. 6, 8, 9) but no details of weight or measurements were given, except that the smallest example (fig. 9) weighed 0·2044 gm; measurement of the photograph gives its diameter as 8 mm. In weight, this round shallow bowl fits into Table 1 between specimens 9 and 10, but its inclusion is not warranted in view of paucity of data.

Four small dish-like forms have been figured by Fenner (1940, figs. 18, 21-22, 27), but no details were given. A few specimens included in other private collections were not available for study.

Within the weight range of the australites in Table 1 there occurs a small number of flat disc- and plate-shaped australites from 0·112 gm to 0·308 gm (Baker 1963a p. 38, Skeats 1915 p. 362), and two or three slightly heavier specimens weigh up to 0·636 gm.

Description of Features

In reflected light, the colour of the glass is black in the thickest portion of the specimen, but in transmitted light is yellowish-green to brownish-green, typical of Australian tektite glass generally. The lustre is characteristically vitreous, and as far as its diaphaneity is concerned, the glass is translucent throughout because of its thinness.

The specimen is oval in plan although not perfectly so (Pl. 13, figs. A, C). The broad arc of curvature of the anterior surface is evident from its side elevation (Pl. 13, figs. B, F), while the rather steeper arc of curvature of the end-on aspect is shown in Pl. 13, fig. D. The posterior surface is concave, while the anterior surface is convex, and was faced down the flight path earthwards during high velocity transit through the earth's atmosphere. Fig. E shows the posterior surface with its somewhat shallow curvature; Fig. G is a plan view of the convex surface.

The radius of curvature of the anterior surface (R_F) along the long axis is 2·6 mm, while that along the short axis is 1·2 mm. As the posterior surface is hidden within the bowl-shape, its arc of curvature (R_B) cannot be precisely determined. However, there is a back curvature of some regularity for the end-on aspect of the specimen, as revealed in Pl. 13, fig. D; this represents the curved character of the lip of the bowl arising from the backward bending of plastic glass during the end phases of atmospheric transit. This curvature is negative in sense relative to the aerodynamic orientation of the form, and is 2·75 mm radius.

The surficial sculpture pattern is a consequence of burial in moist soil for a considerable period of time, with resultant differential etching from slight chemical variations within the streaky, rather inhomogeneous tektite glass.

Effects of Natural Etchants

The principal effect of natural solution etching of the glass has been the accentuation of its schlieren. This is a tertiary phase, commencing only after earth landing, and it has the effect of slightly modifying the secondary aerodynamic form shaped from the primary form during atmospheric transit.

The somewhat complex flow-line pattern evident in Pl. 13, figs. B-C, and shown in more detail in figs. E-G, is a consequence of minute differential etching of adjacent streaks of glass of slightly varying chemical composition by soil etchants. The strength and quantity of the etching solutions would vary significantly from time to time throughout the period of burial, and after exhumation, the upwardly exposed anterior surface would be less etched than the still partially buried posterior surface. It is therefore not surprising to find that the schlieren trends on the posterior surface (Pl. 13, fig. E) are more overdeepened than those on the anterior surface (Pl. 13, fig. G).

Of less significance in the sculpture pattern are the etch pits, which are rare and small. They range up to 0·25 mm across, and are discernible in the side elevation shown in Pl. 13, fig. F; they are also very shallow. More outstanding are two prominent etch craters on the posterior surface which are somewhat deeper and up to *c.* 1 mm across. There is one at each end of Pl. 13, fig. E. Both reveal schlieren trending across their walls, while the one at the bottom, right-hand side of Pl. 13, fig. E reveals a smaller etch pit on the crater floor.

The rather irregular posterior surface is evidently a result of two effects (1) a 'hummocky' build-up of plastic glass on bending back into the bowl-shape, combined with (2) accentuation of the irregularity of the surface by differential etching, some overdeepening occurring in the small depressions separating the minute 'hummocks'.

It is difficult to assess the loss of glass by etching, but it has not been of any great significance. From detailed examination under × 10 magnifications, it is evident that virtually nothing has been removed by subaerial mechanical abrasion. This leads to the important conclusion that the specimen has not been transported into the area by any known terrestrial agency, and that it was found substantially where it fell. The general geomorphology supports this conclusion, the locality being at the summit of an interfluve.

Origin of Bowl-Shaped Australite

It is concluded this australite was aerodynamically shaped and sculptured in the manner set out in detail by Baker (1958, pp. 380-382) for other bowl-shaped and dish-like australites of small size. The most interesting point is that the secondary shape was evidently derived from the smallest spheroid of primary glass in the australite swarm that survived aerodynamic ablation. The small primary ellipsoid of tektite glass was ablation-reduced to a thin, flattened oval disc-like form near the end stage of transit through the earth's atmosphere. During this phase of earthward flight, depth of penetration of aerothermal heating would be sufficient to render the thin form plastic throughout, and under such circumstances, with frontal shock waves perpendicular and frontal pressures increased by up to 50 per cent, increased drag on the surface pointed down the flight path would cause the softened material to bend backward into a bowl-shaped form. As the specimen was evidently solid and cold on reaching the earth, the backward bending is deemed to have occurred at the very end of hypersonic flight or during the transonic period, because once it had passed into subsonic flight, all aerodynamic heating, ablation and sculpturing would have ceased (cf. Baker 1959, pp. 159-173).

One effect of the australite becoming non-elastically flexed is that the flow schlieren in the thin glass became differentially contorted, as indicated after accentuation of the schlieren by etching (Pl. 13, fig. G).

Contrast with Microbeads from Oceanic Sediments

The smallness of this australite has significance for the origin of microbeads of glass recovered from oceanic sediments (Glass 1967, 1969). The lightest australite is 10,000 times lighter than the heaviest (Baker 1962), but the largest of the microbeads obtained off the coasts of Australia and the Ivory Coast (Africa) is only 34 times lighter than the lightest known australite. Of particular significance is the marked contrast between the form of this australite and that of the glass microbeads. The australite has a form produced by the secondary effects of aerodynamic processes acting upon a small primary spheroid of tektite glass traversing earth's atmosphere with a single pass entry (Baker 1958). On the other hand, the forms of the microbeads (spheres, spheroids, ellipsoids, etc.) are all fundamentally those of primary forms. None of these microbeads reveals any evidence of the secondary effects of hypersonic flight through the earth's atmosphere.

On this basis alone, we have a pointer to the minute bowl-shaped australite being within the lowest possible size range for tektites generally. Primary forms smaller than that from which this australite was produced should be completely ablated during hypersonic flight through the earth's atmosphere, and hence leave no micro-residual secondary forms. It should be borne in mind that every australite in each of the known shape groups, no matter what its weight, is a secondary form. Throughout the whole weight range from 265 gm down to 0·026 gm not one australite possesses a complete primary shape any more, for the reason that all the original primary shapes have been severely modified by aerodynamic ablation and sculpture, some more so than others. On the other hand, not a single glass microbead from the oceanic sediments reveals any evidence of secondary shape development from the primary forms, and no sign of aerodynamic sculpture arising from hypersonic passage through the earth's atmosphere. The size of these glass microbeads, ranging up to about 800 microns in diameter, is evidently such that they would not survive the effects of such severe conditions as suffered by australites whilst travelling earthwards.

The conclusion is that there are no such objects as microtektites with primary shapes, the nearest object to a microtektite being the minute australite described herein. The microbeads called microtektites (Glass 1967, 1969) are more likely minute beads of wood silica glass, many of which have now been observed by incinerating certain Australian timbers rich in opal phytoliths. These are comparable in size, shape, colour, and other characteristics described for microbeads generated from the burning of haystacks (Baker 1968b), and generally comparable with the glass microbeads recovered from oceanic sediments.

Description of Plate 13

Smallest known complete australite

Fig. A—Oval outline in plan aspect; posterior surface view.

Fig. B—Slightly undulating edge of lip of bowl-shaped form on posterior surface (uppermost) and more open nature of curvature of anterior surface (lowermost in photo) compared with that in Fig. D.

Fig. C—Oval outline in plan aspect; anterior surface view.

Fig. D—Compressed, steep arc of curvature of anterior surface (lowermost) in end-on aspect, and more open nature of arc of curvature of the lip edge on the posterior surface (uppermost) of the bowl-shaped form.

Fig. E—Interior of the bowl-shaped form (i.e. posterior surface view) showing schlieren (flowlines) accentuated by natural solution etching, and two relatively deep etch craters at left- and right-hand ends of photo. White streak represents leached clay with minute quartz grains embedded in overdeepened portions of etched-out schlieren.

Fig. F—Side elevation (reverse to that shown in fig. B) showing irregularity of lip of bowl due to differential natural solution etching. The etch crater at the top left-hand edge of the photo is the same as that at the bottom right-hand corner of fig. E.

Fig. G—Twisted, complex schlieren trends revealed by natural etching of the anterior surface.

(Photos A—D by Mr S. Jame, Monash University; Photos E—G by Mr W. A. Jackson, R.M.I.T.)

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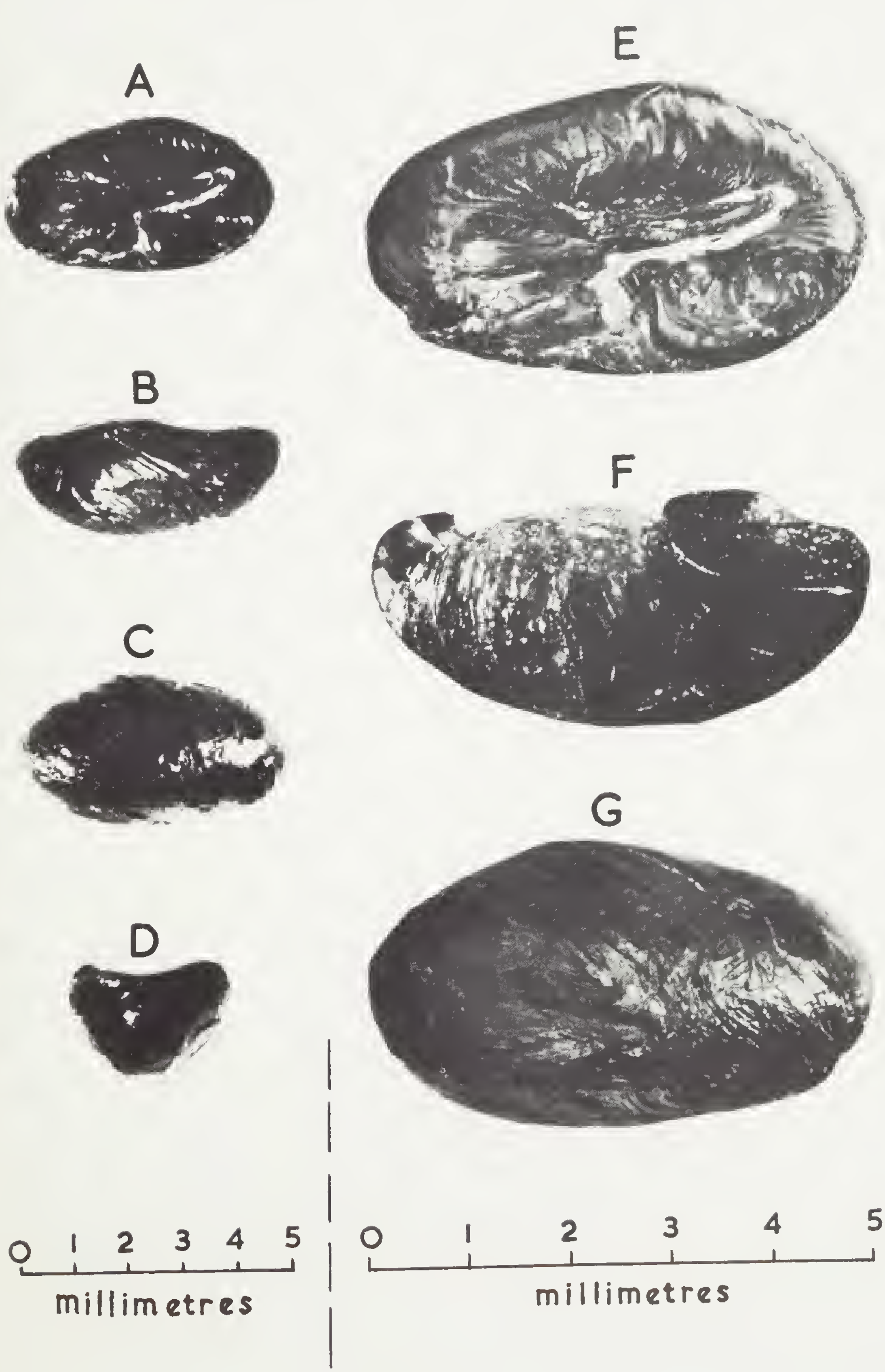
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