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FIVE LARGE AUSTRALITES FROM VICTORIA, AUSTRALIA, AND THEIR RELATIONSHIPS TO OTHER LARGE FORMS

By George Baker

Abstract

Fifteen of the 17 known australites with weights over 100 g have been recorded from the SW. portion of the vast Australian tektite strewnfield of 2,000,000 square miles. Only two are on record from the south-central portion (i.e. in S. Australia), and none from the E. or SE. portion. Recently, four large australites from Victoria have been noted in the National Museum of Victoria, and a fifth is privately owned, so that the distribution of the larger forms is by no means as confined as originally thought. These additional five specimens constitute the 10th, 11th, 13th, 14th and 17th largest among the 22 largest forms so far brought to scientific notice.

The largest Victorian specimen is a boat-shaped form from Port Campbell, followed by an oval core from Gymbowen, near Goroke, a round core from Lower Norton, near Horsham, then a dumbbell from Laing, and finally a round core from Lake Wallace, near Edenhope. Large australites characteristically show natural solution etch grooves (gutters) and etch pits, and usually reveal a flaked equatorial zone arising from subaerial exfoliation of the aerothermal stress shell generated during hypervelocity passage through the earth's atmosphere.

Introduction

The recent recording of eight large specimens, each weighing over 100 g, from the SW. part of W. Australia (Baker 1961, 1962, 1963, 1966, 1967; McCall 1965), taken in conjunction with the nine large forms recorded earlier by Fenner (1955) from W. Australia (7) and S. Australia (2), makes it worthy of note that four equally large australites from Port Campbell, Gymbowen, Lower Norton, and Lake Wallace in W. Victoria, each weighing over 100 g, are lodged in the collection of the National Museum of Victoria, and a fifth, privately owned large form has been recently examined from Laing in W. Victoria. None of these specimens has been previously recorded. Their addition to those already recorded from W. Australia (15) and S. Australia (2) increases to 22 the total of large australites known among the 45,000 to 50,000 specimens so far found.

The sites of discovery of specimens weighing over 100 g are shown in Fig. 1 relative to the N. limits of the australite strewnfield. About 32 per cent occur towards the SE. portion of the strewnfield, i.e. in SW. Victoria and SE. S. Australia. The remainder occur in the SW. portion of the strewnfield, in SW. W. Australia some 900 miles distant, these two principal regions of occurrence being separated by the Great Australian Bight. The most westerly discovered large specimen, a thick-waisted dumbbell-shaped form from Cuballing, W.A. is a little over 1,350 miles distant from the most easterly discovered, a boat-shaped form from Port Campbell, Victoria. No large specimens have yet been reported from the northern portion of the australite strewnfield, i.e. from areas N. of latitude 30°S. Furthermore, no large specimens are known S. of latitude 39°S., although smaller specimens have been collected from as far S. as latitude 43°30′S. (i.e. in S. Tasmania). None has been recovered from the ocean floors or continental shelf regions S., W., or E. of the strewnfield.

From area to area within these two principal regions where large specimens have been found, and also from major region to major region, there are marked differences in the degree of preservation, some showing the effects of natural solution etching more than others, and some being more affected by abrasional weathering. This is to be expected over so vast a strewnfield over which the present climate varies significantly (40° of latitude and 26° of longitude). The area has been subjected to marked climatic changes in the immediate geological past. Furthermore, some specimens have been exposed to subaerial agents longer than others according to the times of release from the enclosing soils. The large, boat-shaped form from Port Campbell, Victoria (Pl. 5), which is the tenth heaviest of all known Australian tektites and the largest Victorian specimen, possesses the best preservation.

FIG. 1—Sketch map of Australia showing (broken heavy line) the N. limit of the australite strewnfield and sites of discovery in SW. Western Australia, SE. South Australia, and SW. Victoria of the 22 known australites weighing over 100 g.

KEY: B—Babakin, W.A. C—Corrigin, W.A. CU—Cuballing, W.A. E—Edenhope, V. EG—Eastern Goldfields, W.A. G—Gymbowen, V. GR—Graball, W.A. H—Horsham, V. K—Karoonda, S.A. KA—Karoni, W.A. L—Between Lowalda and Karoonda, S.A. LB—Lake Buchan (? Buchanan of earlier literature), W.A. N—Newdegate, W.A. NA—Narembeen, W.A. NO—Norseman, W.A. O—Ongerup, W.A. P—Port Campbell, V. SG—Salmon Gums, W.A. T—Laing, V. W—Warralakin, W.A. WG—Western Goldfields, W.A. Y—Lake Yealering, W.A.

Descriptions of Victorian Forms

1. *Boat-shaped form.* The large boat-shaped form (Pls. 5, 6) from Port Campbell, Victoria (Fig. 1) was found in the Sherbrook River area some three miles E. of Port Campbell township. It was presented to the National Museum of Victoria (M11402) on 2nd November 1910 by Mr A. Wishart, a local farmer. The date of presentation is approximately a quarter of a century before the author discovered the first specimen of a collection now totalling a little over 2,000 australites from the Moonlight Head—Princetown—Port Campbell—Peterborough coastal region in W. Victoria, and in which the heaviest specimen weighs approximately 56 g. Statements of having seen other large forms (round, mainly) are made from time to time by the local inhabitants, but the specimens have not been produced.

The weight of the specimen is 141·575 g, its length 86·2 mm, width 41·3 mm at the widest part (Pl. 5A), and depth 30·5 mm. It is the heaviest and largest australite for the Victorian part of the australite strewnfield. The specific gravity of this large boat-shaped form is 2·414, which is 0·017 above the average SG. value (2·397) for 573 australites (Baker 1956, p. 90) from the Port Campbell district. The width of the flaked equatorial zone (Pls. 5B, 6B) is 6 mm. This zone was produced by later spallation of the aerothermal stress shell generated on the forwardly directed surface of the australite during hypervelocity entry through the earth's atmosphere, much of the exfoliation evidently occurring as a consequence of subaerial effects brought into operation after landing on the earth's surface, although some spallation may have occurred during the final phases of atmospheric flight earthwards. In proportion to its size, this specimen has evidently lost the least amount of peripheral glass by spallation compared with other australites weighing over 100 g, and its flaked equatorial zone is proportionately the narrowest. In these respects it is closely matched by a smaller boat-shaped australite from Corop, Victoria, which weighs 88·5 gms, measures 64 mm by 35 mm by 25 mm, and is lodged in the University of Melbourne geological collection. The narrow flaked equatorial zone reveals etch grooves which cross the equatorial portion of the anterior surface and terminate abruptly at the rim separating the posterior and anterior surfaces.

Five well-defined, relatively smooth flow-swirled areas on the posterior surface of the Port Campbell large boat-shaped form (Pls. 5A, 8B) measure 49 mm by 27 mm, 21·5 mm by 15 mm, 16·5 mm by 7·5 mm, 14 mm by 9 mm, and 5 mm by 3 mm respectively. With three additional but indistinctly defined flow-swirled areas, the overall group of flow swirls occupies a little over half of the posterior surface, the remainder of which is lightly etch-pitted in places, densely pitted elsewhere, with sub-circular to oval and occasionally elliptical etch pits (Pls. 5A, 8B). The oval etch pits pass, along the trend of the flow schlieren that have become exposed by natural solution etching, into elongated, narrow gutters approximately the same depth as most of the pits (Pl. 8B).

A depressed area with relatively regular symmetry and 2 to 3 mm deep on the posterior side of the otherwise sharply defined rim (Pls. 5B, 8A) on one side of the specimen, measures 8 mm long and 5 mm wide, and is evidently a depression left by a flattened bubble after some exfoliation, rather than being an early-developed spall-mark subsequently modified by natural solution etching in moist soil. The sharply marked rim of the specimen (Pls. 5B, 6B) separates the flow-swirled and etch-pitted posterior surface from the spalled and subsequently etch-grooved anterior surface, and it delimits the zone of exfoliation of the aerothermal stress shell for which spallation was more pronounced, leaving a more noticeable flaked zone, around the equatorial regions of the boat-shaped form.

Natural solution-etch gutters (Pl. 8A) are confined to the surface exposed after loss by spallation, and their trends have been largely determined by the very nature of the exfoliation process itself, relative to the curvature of the anterior surface. These gutters average 0·5 mm in width, range from 1 mm to nearly 15 mm in length, and are up to 0·5 mm deep. They are typically U-shaped in cross section, while longitudinally they mostly follow the general curvature of the anterior surface. Rather lighter etching of the glass forming the surface between the gutters has revealed the complex, fold-like character of the sub-surface schlieren, and the general overall trend of the schlieren is thereby shown to extend fundamentally in the direction of the longer axis. Schlieren are also well-exposed on the walls and floors of the gutters (Pl. 8A). Those on the floors represent a lower level in the snb-surface flow-line pattern than those higher up on the walls of the gutters and on the surface between the gutters. All the exposed schlieren are nevertheless part of the complex system of internal flow lines.

The radii of curvature for the posterior (R_B) and the anterior (R_F) surfaces have been determined across the width of the specimen, from enlarged silhouettes, as being $R_B = 23·2$ mm, and $R_F = 23·2$ mm. From graphical reconstruction, it is deduced that the forwardly directed surface during atmospheric entry, lost a maximum depth of 14·6 mm of glass by the combined effects of (a) ablational processes, (b) exfoliation of the aerothermal stress shell, and (c) some subsequent etching by subaerial processes of the surface exposed by the spallation process, provided that the original ellipsoidal form from which the ablated form was developed was biaxial and had a circular cross section normal to the long axis of the ellipsoid.

The specimen provides no evidence to indicate that a circumferential flange was developed at any stage of its aerodynamic history. This applies to all of the large forms weighing over 100 g without doubt, and in fact to all australites examined that weigh over 15 or 20 g. No flange fragments are ever found that would be large enough to fit the larger australites, and no large forms have been observed to possess flanges, remnants of flanges, nor the flange bands that result when circumferential flanges become detached by fracture. Evidently there is an optimum weight and size for australites above which circumferential flanges cannot be generated.

2. *Oval core.* A large oval core (Pl. 7A-D) from Gymbowen, near Goroke, Victoria (Fig. 1), was presented to the National Museum of Victoria (M11401) by G. T. Hause on 26th May 1911. The weight of the specimen after cleaning in an ultrasonic vibrator is 135·09 g, its length = 55·0 mm, width = 51·4 mm, and depth = 36·3 mm. The width of its well-marked flaked equatorial zone (Pl. 7B-C) ranges from 12 mm to 15 mm. The SG. was determined as 2·417. The artificial removal of a chip from towards one end of the posterior surface, evidently before lodgement in the National Museum collection, has left a conchoidal fracture surface (Pl. 7A, right-hand end) which measures 14·4 mm by 11·3 mm and shows well developed sub-concentric ripple fracture marks and a highly vitreous lustre, bnt no flow schlieren since they only appear after natural solution etching. Six flat-bottomed depressions on the anterior surface of the specimen (Pl. 7D) are evidently percussion produced or else represent small spall structures; they are approximately circular in outline with a diameter of 3 mm and a depth of about 0·5 mm.

The rim between the posterior surface and the flaked equatorial edge of the anterior surface is quite sharply defined (Pl. 7, B-C) and a remnant of non-spalled surface glass is left in the otherwise almost completely flaked equatorial zone (right-hand end of Pl. 7C). The flaked equatorial zone reveals a few gutters produced by natural etching (about four or five are showing in Pl. 7B-C), and these gutters trend up and down across the flaked zone. A few short solution-etch gutters on the anterior surface (left-hand side of Pl. 7D) are like those on the anterior surface of the larger boat-shaped form from Port Campbell (Pl. 6A) and resemble the stitching on a softball.

A depression on the posterior surface measures 7 mm by 6 mm (top of Pl. 7C, 7A, bottom right) and is either an original deformity or the site of a pre-existing gas bubble. The posterior surface is otherwise generally smooth (Pl. 7A), with a dull lustre, occasional scratch marks of subaerial origin, and a few etch pits up to 1 mm across. Most of these pits seem to be etched spall marks of small size and of the 'chatter-mark' type.

Radii of curvature (R_B and R_F) determined across the width and along the slightly greater length were $R_B = 36{\cdot}8$ mm and $R_F = 32{\cdot}1$ mm across the width, and $R_B = 42{\cdot}9$ mm, $R_F = 34{\cdot}3$ mm along the length. Even though there is a difference of only 3·6 mm between the width and length of the specimen, an accurate reconstruction of the primary ellipsoid from which the secondary ablated form was developed could not be guaranteed, as it can with more truly spherical primary forms, hence the calculation of the amount of glass lost from the forwardly directed surface could be grossly erroneous. On the basis that the arc of curvature across the width of the specimen is more nearly part of a circle than that provided by the arc of curvature along the greater diameter (i.e. = length) of the oval-shaped core, and with the R_F measurement for this direction being 32·1 mm, then the calculated loss of glass from the front surface along the line of the front to rear poles (i.e. the depth of ablation in the stagnation region) would be 31·4 mm. This figure would include loss of glass by subsequent exfoliation and a little further loss by natural etching, and it is almost equal to the present depth of the core (no. 11, Table 1) and appears to be excessive. On this basis, it may be that the primary form was a triaxial ellipsoid, in which event a cross section through the primary form taken normal to its length would not have been circular as it would have been if the primary form was that of a biaxial ellipsoid.

3. *Round cores*. The two large round cores, one from Lower Norton via Horsham, and one from Lake Wallace near Edenhope, show no structural nor sculptural features of significance over and above those described herein for other large forms. Their dimensions, weights, and specific gravity values are listed in Table 1. The round core from Lower Norton was found on the banks of a dam and presented to the National Museum of Victoria (E2730) on 29th August 1961 by Mrs M. Hannan. The round core from Lake Wallace was discovered about 1936 and is N.M.V. E1986.

4. *Dumbbell-shaped form*. The large dumbbell-shaped australite from Laing in W. Victoria (Pl. 9-10) was brought to notice per favour of the Assistant Director, Mr E. D. Gill. The specimen was found by Master Andrew Halford in 1966, in a low cutting some 2 ft 6 in. high, on the S. side of the Allansford-S. Ecklin road on the N. side of Buckley's Creek, Laing. The site of discovery is 1·1 miles W. of the Terang-Curdie Vale road. The specimen was partially exposed on reddish-brown soil 6-9 in. below ground level and thus within the plant root zone. It

weighs 115·752 g after cleaning, using 1:1 HCl to release iron-rich clay partially cemented in some surface pits and gutters. Its SG. was determined on a Walker's Steelyard as 2·467. This is unusually high for Victorian australites generally, but consistent results were obtained on repeating the determinations.

The form is that of a slightly distorted, thick-waisted dumbbell having one gibbosity (36 mm wide and 29·7 mm thick) a little larger than the other gibbosity (35 mm wide and 26·3 mm thick), and a distinctly marked dimple measuring 15 mm by 14 mm situated in the waist region of the posterior surface (Pl. 9A-B). Radius of curvature measurements across the widths of the gibbosities are $R_B =$ 21·2 and 21·5 mm for the smaller and larger gibbosities respectively, with $R_F =$ 18·8 mm and 26·7 mm, where $B =$ the posterior surface, and $F =$ the anterior. If cross sections through the gibbosities of the primary form were circular prior to modification, the depths of ablation in the stagnation regions (i.e. front polar regions) of the larger and smaller gibbosities were respectively 11·8 mm and 18·1 mm, without allowing for glass lost subsequently by subaerial spallation and weathering.

A flaked equatorial zone has been developed on one edge only of the specimen (Pl. 10B), and it varies in width from 10 mm where developed on the smaller gibbosity to 18 mm where produced on the larger gibbosity. A depression on the flaked equatorial zone of the waist region (Pl. 10B) measures 17 mm by 12 mm in area, and is up to 3 mm deep. It is of a somewhat similar nature to the depression on the side of the large boat-shaped form from Port Campbell (Pl. 5B), and evidently represents a somewhat compressed, elongated bubble exposed by exfoliation of the aerothermal stress shell. Its presence would weaken the glass in this zone and probably contributed to more ready spallation of the equatorial zone on the side of the tektite carrying the bubble (cf. Pls. 9B, 10B for comparison of the two edges, one non-spalled, the other spalled). Etch pits are approximately equally developed (Pls. 9-10) on all surfaces except the flaked equatorial zone which was evidently a much later exposed surface. The etch pits range in diameter from 0·25 mm to 2·0 mm. Etch gutters occur on all surfaces except that of the flaked equatorial zone, again indicating that the spallation was a relatively late event. The gutters range up to 15 mm in length, 0·75 mm in width, and 0·5 mm in depth. They are typically U-shaped in cross section. Their trends are largely across the width (i.e. approximately normal to the long axis) of the specimen on the anterior and posterior surfaces (Pls. 9A, 10A), but they take on complex patterns on the two ends (Pls. 9C, 10C) and on one side (Pl. 9B). Some of the gutters reveal outward radiating arrangements from two or three of the etch pits (Pl. 9A, top centre and right, 9B bottom left).

Internal schlieren exposed on some surfaces by etching are best seen under higher magnifications on the walls and the floors of etch pits and etch gutters, being largely normal or oblique to the trends of the gutters, but sometimes parallel to or trending more acutely to the gutter trends. Smaller etch pits are occasionally present on the floors of the gutters and even on the floors of some of the larger of the etch pits; sometimes the larger pits interrupt the trends of some of the gutters (Pl. 10A), sometimes they terminate a gutter. Where the larger diameter etch pits lie athwart the trends of the etch gutters, they are invariably more deeply etched into the glass than the gutters, sometimes being up to nearly twice as deep. Intersecting gutters with different trends are also somewhat different in depth at the points of intersection (Pl. 9B left-hand end, 9C central portions). In plan, some gutters are more or less straight (Pls. 9A, 10A, C), but some are curvilinear (Pl. 9B central portion, 9C), but in the third dimension, all are slightly curved in that they follow the curved outer surfaces. The glass between the etch pits and etch gutters reveals under higher magnifications a distinct, very finely pitted 'orange-peel' effect through which flow schlieren can be only vaguely traced compared with those shown on the more lustrous walls and floors of the pits and gutters.

Aspects of Production of Surface Sculpture

The etching of different parts of the tektite to form natural solution pits, gutters, and 'feathery' schlieren lines is a function of several factors, including (a) slight variations in the chemical composition of the tektite glass from place to place, (b) variability in the strength and nature of the etchants from time to time and from place to place on the tektite surface, (c) differences in the time the etchants lie in contact with different parts of the specimen, (d) the variable nature of the curvature of the external surface and (e) whether one particular surface always remained directed upwards to be in contact with soil while buried, and exposed to atmospheric agents after soil deflation, while the other surface was always downwardly directed to and hence always in contact with the soil, or whether the tektite has been turned over, as for example by release from the soil, transportation down a slope, and reburial at a lower topographic level, or even by tipping more or less in situ during disturbance of the enveloping soil.

Further to the above factors concerned with the natural solution etching, it is known from thin section examinations under the petrological microscope that differences in the refractive index of different schlieren point to differences in chemical composition, some schlieren being richer in silica than others, and some richer in iron, hence they are liable to differential dissolution. The effects of differential dissolution can be demonstrated experimentally by immersing fractured tektites in 4 per cent hydrofluoric acid. In a matter of hours, pits, gutters, and flow schlieren can be brought out on the freshly fractured glass surfaces. These are surfaces that were smooth apart from concentric and ripple fracture patterns, and they showed a highly vitreous lustre prior to immersion in the acid. Where tektites are found, such potent acids are not available in the requisite amounts and strengths for such a rapid reaction, but soil etchants are nevertheless present and the time factor is highly favourable, for tektites have been lying in a soil environment for at least a few thousand years in the Australian strewnfield. The strength and nature of soil etchants enveloping a tektite will vary according to variations in the supply of downward percolating rain water and the circulation of subterranean solutions. Also there are variations in the nature and supply of etchants from plants. In some places the tektites lie within the root zone, while in others they are found in semi-arid to arid terrains which were much more humid in the immediate geological past. Hence all the tektite specimens are liable to have been exposed to biochemical attack by the soil biota.

As to differences in the time that etchants lie in contact with particular parts of a tektite surface, great variations can have occurred during the thousands of years that australites have lain on the earth's surface. At present, the overall effect is controlled in the first place by alternate wetting and drying of soils, more especially in the temperate regions of the strewnfield. During the drying out process, solutions are likely to lodge longer in small depressions on the tektite surface, provided the specimen lies in a favourable position. Furthermore, plant roots and fungal filaments in actual contact with the tektite could be potent factors in supplying as well as directing the attack by etchants on the glass. Once pits and gutters become established, some widening and overdeepening continues. In course of time, soil constituents become cemented to their walls and floors, sometimes relatively loosely, sometimes quite firmly, mostly by secondary iron hydroxide. Even after excavation by soil deflation, most of the cemented materials remain, as in the specimen from Laing. Tektite glass not covered by cemented soil is subjected to dulling (e.g. Plate 9A) by atmospheric agents, and the lustre of such surfaces contrasts sharply with the highly vitreous lustre revealed on cleaning out the cemented soil. Evidently soil constituents remained in contact with the walls and floors of the pits and gutters all the time that differential solution was progressing, until the cementation was sufficient to protect the surface.

Notes on the 22 Large Australites

Thirteen of the large australites were listed in an earlier publication giving their weights, SG. values (where available) and dimensions (Baker 1966, Table 1). This list is re-cast (Table 1) to accommodate the nine additional large australites now reported. The discovery sites of these large specimens are shown in Fig. 1.

For dumbbells in Table 1 (nos. 5, 8, and 14) the numbers in brackets are measurements of the waist regions. For no. 1, Table 1, the number in brackets is the present length resulting from artificial fracturing. The weight of the fractured form is 238 g, while the original weight has been calculated as approximately 265 g (allowing for a relatively large piece artificially spalled off with a crowbar when the specimen was unearthed in a post hole). Some of the forms classified as round cores are slightly oval in plan aspect, but since their two diameters are only 1 or 2 mm different, this is evidently a consequence of terrestrial weathering. The size measurements in the fifth colum of Table 1 are given in the order: length, width, depth (= thickness) for the elongated specimens, and in the order: diameter, depth (= thickness) for forms that are round in plan.

Grouping of Large Forms according to Shape Types

Large round cores. The two Victorian specimens from Lower Norton and Lake Wallace weighing 115 92 g and 111 25 g respectively are the fourth and sixth heaviest recorded round cores. Heavier round cores have been described from Newdegate, W.A. (243 08 g, McCall 1965), Lake Yealering, W.A. (218 g, Fenner 1955, Pl. 7, 1-2), Graball, W.A. (168 28 g, Baker 1963, Pl. 1, figs. A, B), and from between Karoonda and Lowalda, S.A. (113 g, Fenner 1955, Pl. 7, 7-8).

Three other round cores weighing over 100 g have been found at Norseman, W.A. (111 g, Fenner 1955, Pl. 8, 14), at Salmon Gums, W.A. (102 37 g, Baker 1967), and on the Eastern Goldfields, W.A. (108 30 g, Baker 1967). Two large forms weighing 147 g and 116 g from Corrigin, W.A. and Lake Buchanan, W.A., are recorded (Fenner 1955) but neither the shape types nor illustrations were given for these specimens, and they have not been examined by the author.

Large oval cores. The Victorian oval core from Gymbowen, near Goroke, weighing 135 09 g (Pl. 7) is the third heaviest oval core recorded from Australia. The two heavier specimens of oval cores are from Warralakin, W.A. (265 g, Baker 1962, Pl. 5A-D), and from an unspecified locality in the W.A. Goldfields (154 3 g, Fenner 1955, Pl. 7, 5-6).

Two other oval cores weighing over 100 g have been found at Karoni, W.A. (101 g, Fenner 1955, Pl. 8, 15-16), and at Babakin, W.A. (112 9 g, Fenner 1955).

Large boat-shaped australites. The large form from the Sherbrook River area

TABLE 1

Dimensions and weights of australites exceeding 100 g

No.	Shape type	Locality	Weight (g)	Measurements (mm)	S.G.	Reference
1	Oval core	Warralakin, W.A.	Originally 265	70(65) × 62·5 × 42	2·409	Baker 1962
2	Round core	Newdegate, W.A.	243·08	58 × 52	(not given)	McCall 1965
3	Round core	Lake Yealering, W.A.	218	64 × 64·5 × 39·4	(not given)	Fenner 1955
4	Boat (abraded)	Karoonda, S.A.	208·9	82 × 46·8 × 37·9	(not given)	Fenner 1955
5	Dumbbell	Cuballing, W.A.	175·996	100 × 42(35·8) × 33·7(25)	2·435	Baker 1966
6	Round core	Graball, W.A.	168·28	57 × 34·5	2·434	Baker 1963
7	Oval core (chipped)	Western Australian Goldfields	154·3	51·5 × 48·5 × 43	(not given)	Fenner 1955
8	Dumbbell	Ongerup, W.A.	151·286	98·4 × 35·6(33·2) × 29·6(26·8)	2·460	Baker 1967
9	(not given)	Corrigin, W.A.	147	(not given)	(not given)	Fenner 1955
10	Boat	Port Campbell, V.	141·575	86·2 × 41·3 × 30·5	2·414	(this paper)
11	Oval core	Gymbowen, near Goroke, V.	135·09	55 × 51·4 × 36·3	2·417	(this paper)
12	(not given)	Lake Buchanan, W.A.	116	(not given)	(not given)	Fenner 1955
13	Round core	Lower Norton, via Horsham, V.	115·92	52 × 33	2·463	(this paper)
14	Dumbbell	Laing, V.	115·752	74·9 × 36(33·4) × 29·7(24·8)	2·467	(this paper)
15	Round core	Between Lowalda and Karoonda, S.A.	113	52 × 51·5 × 36·5	(not given)	Fenner 1955
16	Broad oval	Babakin, W.A.	112·9	52 × 46 × 37·5	(not given)	Fenner 1955
17	Round core	Lake Wallace, near Edenhope, V.	111·25	49·6 × 36·5	2·447	(this paper)
18	Round core	Norseman, W.A.	111	51·1 × 50·5 × 33·1	(not given)	Fenner 1955
19	Round core	Eastern Goldfields, W.A.	108·30	52·4 × 33	2·440	Baker 1967
20	Boat	Narembeen, W.A.	107·46	64 × 37 × 30·5	2·431	Baker 1961
21	Round core	Salmon Gums, W.A.	102·37	46·4 × 38	2·450	Baker 1967
22	Oval core	Karoni, W.A.	101	49·1 × 45·5 × 35·5	(not given)	Fenner 1955

E. of Port Campbell, Victoria, is the second largest boat-shaped australite (Pl. 5-6) known. It is a very well preserved specimen and although a little longer than the biggest boat-shaped form from Karoonda, S.A. (Table 1, 4), it is narrower and thinner. Its weight of 141·575 g is approximately 67 g less than the biggest boat-shaped form which is an abraded specimen measuring 82 mm by 46·8 mm by 37·9 mm and weighing 208·9 g (Fenner 1955, Pl. 7, 3-4).

The only other known boat-shaped form weighing over 100 g is a specimen from Narembeen, W.A. which measures 64 mm by 37 mm by 30·5 mm and weighs 107·457 g (Baker 1961, Pl. 5A-E).

Large dumbbell-shaped forms. Three large dumbbell-shaped australites each weighing over 100 g and typically possessing thick waist regions have been found at Cuballing W.A. (176 g, Baker 1966, Fig. 1, A-F), at Ongerup, W.A. (151 g, Baker 1967), and at Laing, V. (115·75 g, Table 1). These three specimens constitute the fifth, eighth, and fourteenth largest of the 22 large australites. For convenience, a grouping of these 22 large forms in four shape types is given in Table 2, along with the symbol used on the distribution map (Fig. 1), and the locality of occurrence. This reveals that six large round cores have been found in SW. Western Australia, one in S. Australia, and one in Victoria, while four large oval cores come from W. Australia and one from Victoria. One large boat-shaped form has been found in each of the three states W. Australia, S. Australia, and Victoria, and two large dumbbell-shaped forms come from W. Australia, with one from Victoria.

TABLE 2

Grouping of shape types of australites weighing over 100 g

Shape types	Symbol on Fig. 1	Locality
I. Large round cores (in order of decreasing size—N to SG)	N	Newdegate, W.A.
	Y	Lake Yealering, W.A.
	GR	Graball, W.A.
	H	Lower Norton, Horsham, V.
	L	Between Lowalda and Karoonda, S.A.
	E	Lake Wallace, Edenhope, V.
	NO	Norseman, W.A.
	EG	Eastern Goldfields, W.A.
	SG	Salmon Gums, W.A.
II. Large oval cores (in order of decreasing size—W to KA)	W	Warralakin, W.A.
	WG	Western Goldfields, W.A.
	G	Gymbowen, V.
	B	Babakin, W.A.
	KA	Karoni, W.A.
III. Large boat-shaped forms (in order of decreasing size—K to NA)	K	Karoonda, S.A.
	P	Port Campbell, V.
	NA	Narembeen, W.A.
IV. Large dumbbell-shaped forms (in order of decreasing size —CU to T)	CU	Cuballing, W.A.
	O	Ongerup, W.A.
	T	Laing, V.

Among these shape groupings (Table 2) of the large australites (1) no particular shape group is confined to any particular region. (2) no australite over 100 g has been brought to notice for the following shape groups: buttons, lenses, canoes, teardrops, discs, aberrants. (3) none of the large forms possess circumferential flanges. and (4) where surface features are not destroyed flaked equatorial zones are present.

There seems to be no significance in the fact that the known 22 largest australites occur between latitude 30°S. and 39°S., and between longitude 116°E. and 143°E. Smaller specimens are known in greater numbers (45,000 to 50,000) throughout the two million square miles of the australite strewnfield.

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Description of Plates

Plate 5

Large boat-shaped australite from Port Campbell, V. (x 1.64.)

A. Posterior surface showing smooth, flow-swirled areas with high degree of lustre, surrounded by variously etch-pitted glass.
B. Side view (representing bottom edge of Pl. 5A) showing circular spalled area or burst bubble at the rim separating the posterior surface (uppermost) from the anterior surface.
C. End-on view (representing right-hand end of Pl. 5A) showing residual 'bung-like' character resulting from spallation. Posterior surface uppermost.

Plate 6

Large boat-shaped australite from Port Campbell, V. (x 1.64.)

A. Anterior surface, showing solution-etch gutters, occasional flow lines, and few etch pits.
B. Side view (representing top edge of Pl. 5B) showing solution-etch gutters in the flaked equatorial zone terminating abruptly at the well-defined rim. Posterior surface uppermost.
C. End-on view (representing left-hand end of Pl. 5A, i.e. right-hand end of Pl. 6B) showing etch pits and flow swirl on posterior surface, solution-etch gutters on surface exposed by exfoliation. Posterior surface uppermost.

Plate 7

Large oval core from Gymbowen, V. (x 1.4.)

A. Posterior surface, showing oval outline, conchoidal fracture and vitreous lustre of artificially chipped area at right-hand side, 'dimple' in surface at bottom right (Pl. 7C), and generally smooth character of surface, with few etch pits (? etched 'chatter-marks').
B. End-on view for the shorter diameter of oval specimen, showing well-developed flaked equatorial zone and some natural solution-etch gutters on surface exposed after spallation. Posterior surface uppermost.

C. Side view for the longer diameter of oval specimen, showing well-developed flaked equatorial zone except at right-hand end where some of the aerothermal stress shell remains as a partial 'indicator' of the secondary, aerodynamically shaped anterior surface developed prior to terrestrial exfoliation. Pronounced 'dimple' shown in right central region of posterior surface (uppermost).

D. Anterior surface showing six percussion spall marks (circular to ovate areas) and occasional short, natural solution-etch gutters developed on surface exposed by exfoliation and shedding of aerothermal stress shell.

PLATE 8

Enlarged photographs of portions of large boat-shaped australite from Port Campbell, V.

A. Depression interrupting the sharp rim that separates pitted and flow-swirled posterior surface (uppermost) from flaked and subsequently grooved equatorial zone and anterior surface (lowermost) (x 5.2).

B. 'Contorted' contact zone of two flow-swirled areas on the posterior surface, showing flow schlieren in the smoother flow-swirled areas and etch pits of elongated to short gutter-like character between the two flow swirls (x 5.5).

PLATE 9

Large dumbbell-shaped australite from Laing, V. (x 1.65.)

A. Posterior surface showing marked waist constriction on one side only of specimen and 'dimple' in centre (cf. 'dimple' on posterior surface of oval core shown in Pl. 7A); narrow etch gutters trend partly across width of specimen, while etch pits are sporadically distributed.

B. Side view (representing lower edge of Pl. 9A) showing constricted waist region, edge-on view of 'dimple' in Pl. 9A, and etch gutters trending in several directions (Posterior surface uppermost).

C. End-on view (representing left-hand end of Pl. 9A-B) showing straight and curvilinear etch gutters sometimes intersecting, and a few scattered etch pits.

PLATE 10

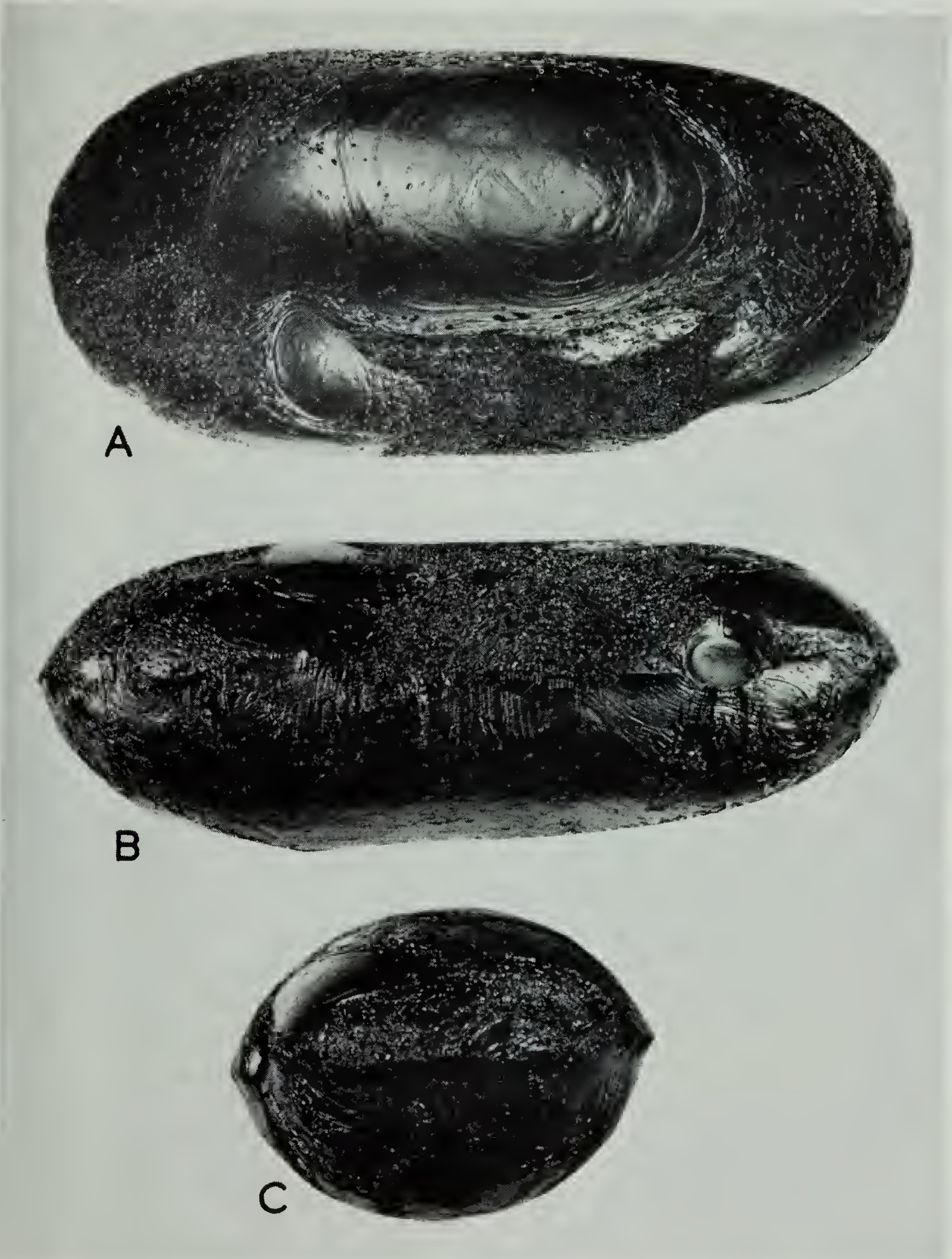
Large dumbbell-shaped australite from Laing, V. (x 1.65.)

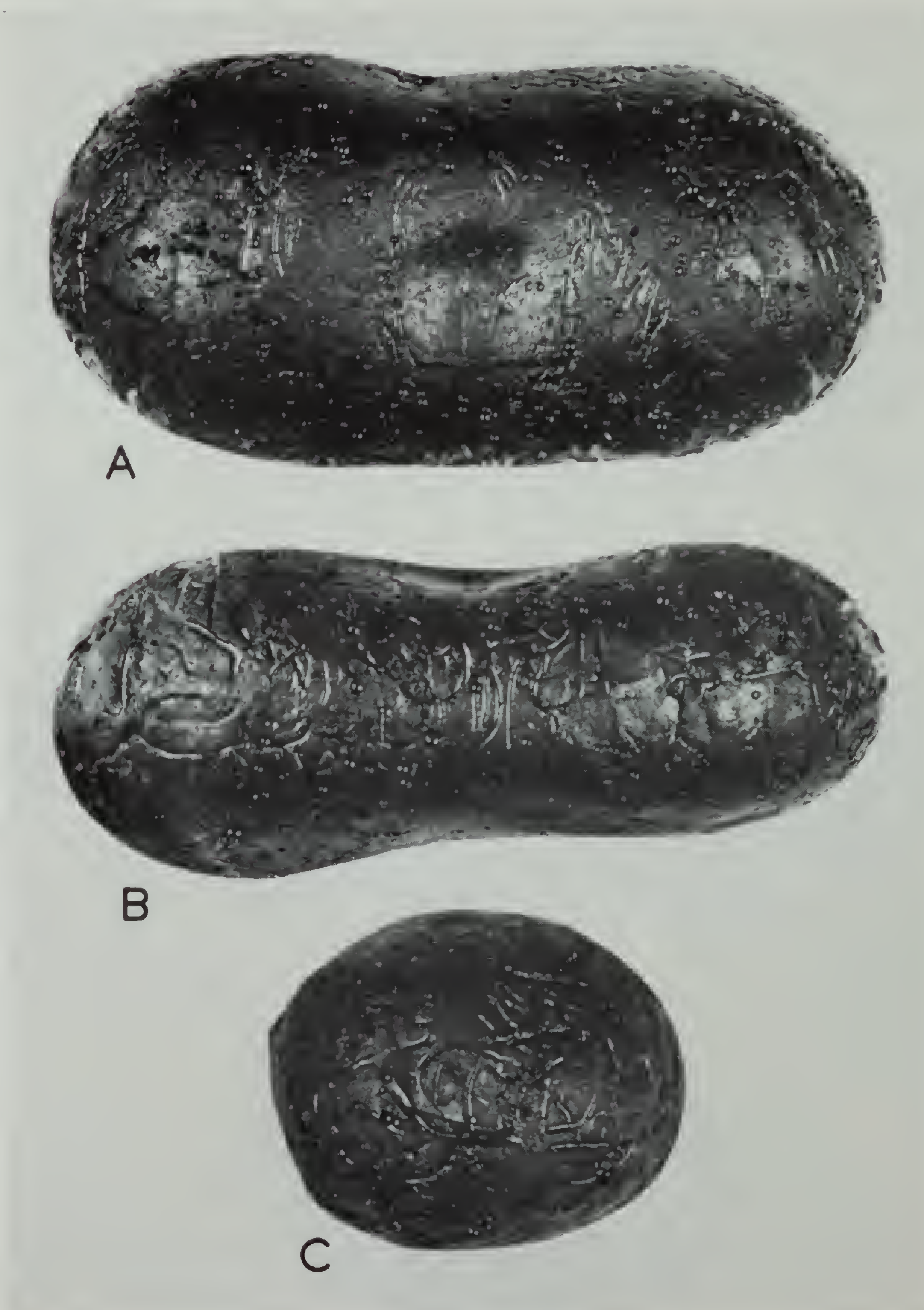
A. Anterior surface showing etch gutters extending partly across width of specimen, and etch pits sporadically distributed.

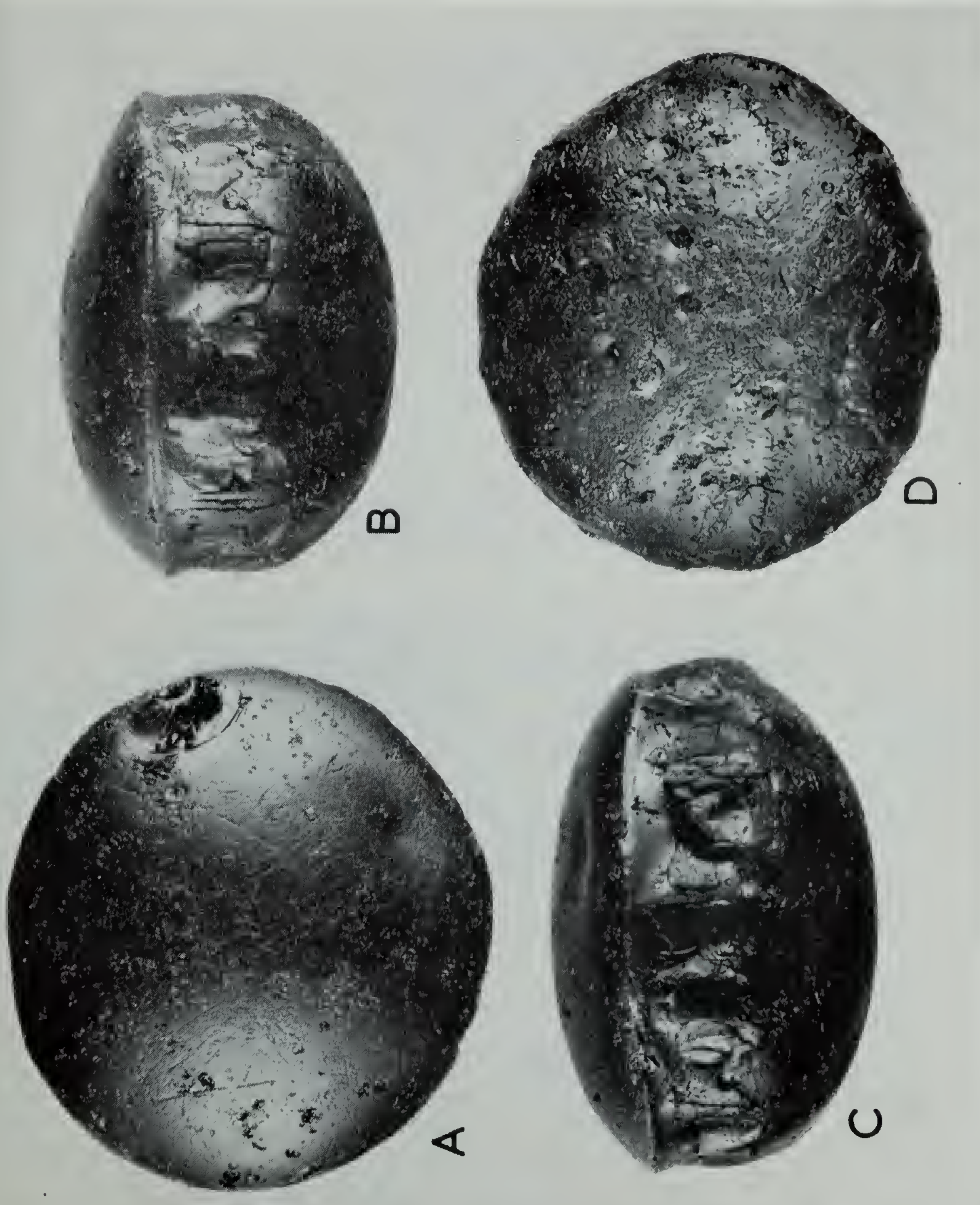
B. Side view (representing bottom edge of Pl. 10A) showing relatively smooth-surfaced flaked equatorial zone with depression resulting from exposure on spallation of a compressed, elongated bubble. Fine flow lines representing internal flow schlieren brought out by natural solution-etching of surface exposed by spallation, can be detected on bubble walls and parts of smooth flaked equatorial zone.

C. End-on view (representing left-hand end of Pl. 10B, right-hand end of Pl. 10A) showing slightly deeper etch gutters trending mainly from left to right, and a few scattered etch pits.

All Photographs by G. J. Squance.



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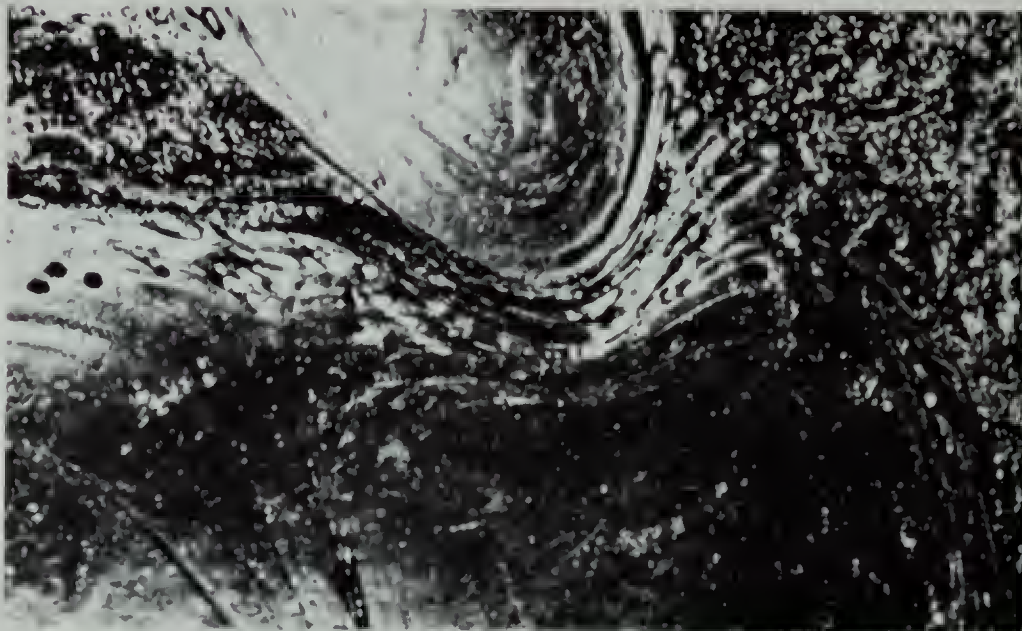

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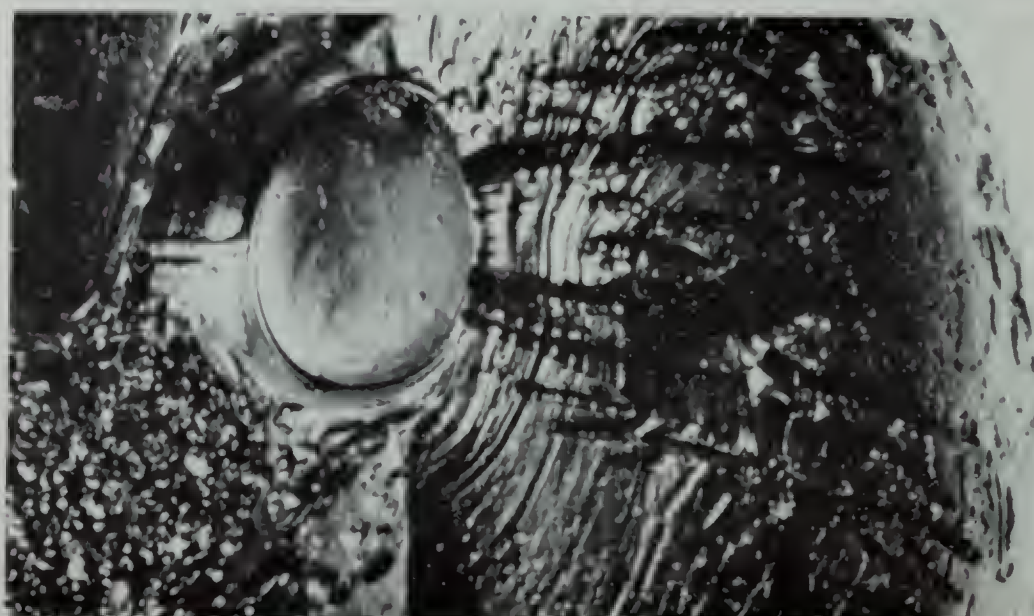

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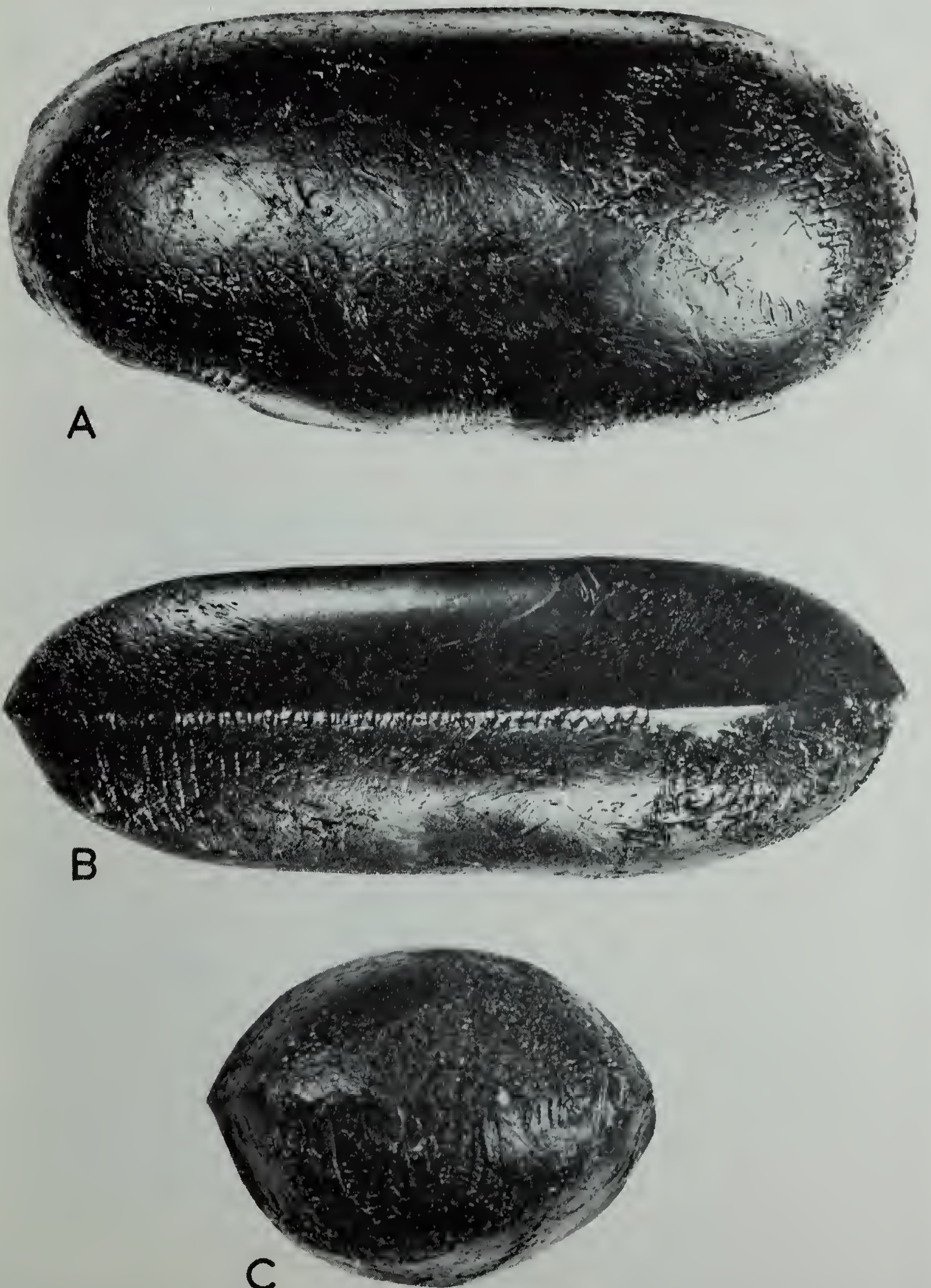
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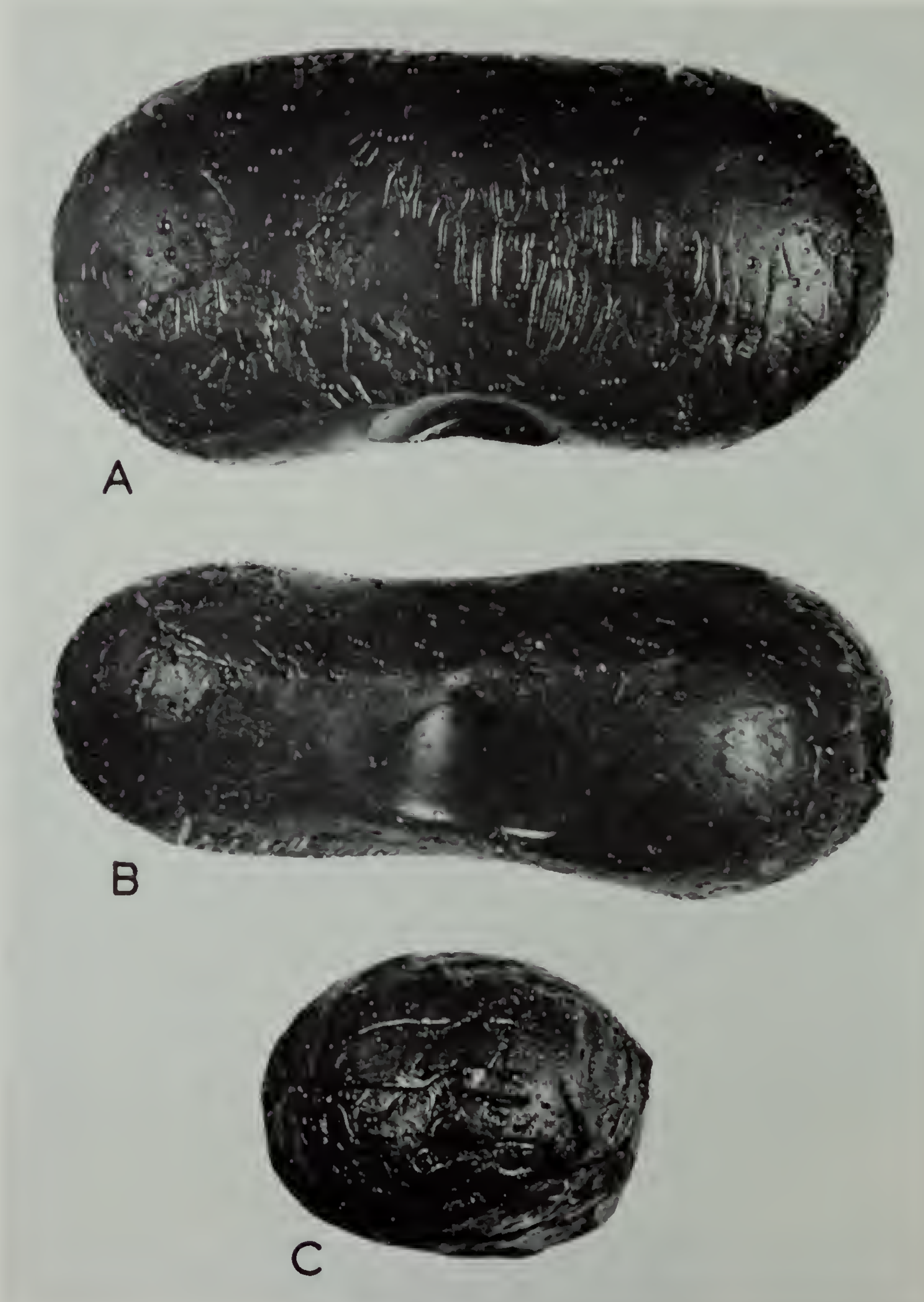
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