# 14.—A second large dumbbell-shaped australite, Ongerup, Western Australia, with notes on two other large australites

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### Abstract

Following the discovery in 1960 of the largest known dumbbell-shaped australite at Cuballing, W.A., a second specimen of comparable size and shape has recently been found at Ongerup, W.A., approximately 110 miles distant and to the southeast of Cuballing. The Ongerup specimen, measuring 98.4 mm long, and weighing approximately 151 grams, is the second longest, and the eighth heaviest, australite recorded.

Straight, sinuous, and sometimes connected grooves (gutters) of U-shaped cross section and produced in a terrestrial soil environment by differential natural solution etching, dominate the sculpture of the exfoliated anterior surface and of the flaked equatorial zone, both of which are generally free from pits. Shorter, shallower etch grooves appear on parts of the non-spalled posterior surface which is otherwise generally smooth but has a dull lustre, a few small pits, and, like parts of the anterior surface, shows traces of the internal body schlieren that have been made evident by light terrestrial solution etching. Because of the effects of overall weathering and loss from the anterior surface by exfoliation of an aerothermal stress shell that was produced by aerodynamic heating during hypervelocity, one-way (earthwards) transit through the atmosphere, the specimen does not reveal any remnants of the type of sculpture attributable to aerodynamic processes.


### Introduction

A large dumbbell-shaped australite from Ongerup is 1.6 mm shorter and about 25 grams lighter than the largest known dumbbell-shaped australite recently described from 110 miles to the northwest at Cuballing in Western Australia (see Fig.1); it has been made available for study through the courtesy of J. H. Lord, Director of the Geological Survey of Western Australia.

The specimen, which weighs about 151 grams and reveals well-developed natural solution etch grooves (gutters) but few pits, comes from a region of 72,500 square miles extent within which 71 per cent. of australites weighing over 100 grams have been found. This region occupies one twenty-eighth of the total area of the australite strewnfield. The australite was collected by Mr. K. A. O'Neill on his property some ten miles northwest of Ongerup in the southwest portion of Western Australia; it was recently presented to the Geological Survey of Western Australia by Mr. O'Neill. Ongerup is 210 miles southeast of Perth (see Fig.1) on approximately 34° S and 118° 30′ E. The specimen was obtained from a soil environment when Mr. O'Neill, who was clearing his property of poison, revisited a spot where he had grubbed out the ground to ascertain whether the poison had been eradicated. He considered that he should have seen the australite when he initially grubbed out the poison, but the chances are that the specimen was made visible after the grubbing process through washing away of masking soil by rain or winnowing by wind. Presumably the specimen came from up to 9 inches depth in the soil.

### Size, weight, and specific gravity

Measuring 98.4 mm in length, the specimen from Ongerup is slightly shorter than the similar thick-waisted specimen, 100 mm long, from Cuballing, W.A. Its width ranges from 35.6 mm across the gibbosities to 33.2 mm across the waist region, while the depth (= thickness) measurements are 29.6 mm for the gibbosities and 26.8 mm for the waist region. These differences in dimensions are small but sufficient to enable classification of the specimen as a thick-waisted dumbbell-shaped australite (Fig.2).

The larger gibbosity is only 0.5 mm wider and 2.4 mm deeper than the smaller gibbosity, whereas in the Cuballing specimen, the dimensions of the two gibbosities are significantly different.

Its weight of 151.286 grams makes this specimen from Ongerup the second largest known dumbbell-shaped australite and the eighth heaviest australite so far recorded in the literature on australites. Including this specimen and (1) a specimen recently described from Newdegate, W.A. by McCall (1965), (2) two round australite cores from the Eastern Goldfield region and from Salmon Gums, W.A., (see Fig.1) recently brought to notice by W. H. Cleverly (on 31/10/66), and (3) four specimens from Victoria, now in the collection of the National Museum of Victoria, the total number of australites known to weigh over 100 grams each is increased to twenty-one (13 listed, Baker 1966 p.60). The total weight of these twenty-one large australites is 3,108 grams, which on a rough estimate would be about one hundredth of the total weight of all australites in known collections.

Prior to weighing in air and deionized water ($T_{H_2O} = 23°C$) for determining its specific gravity, the Ongerup specimen was treated in 1 : 1 HCl in an ultrasonic vibrator to remove soil constituents and natural cementing substances that occurred within and attached to the walls and floors of some of the gutters. Its specific gravity value of 2.460, determined with a Walker's Steelyard, is significantly higher

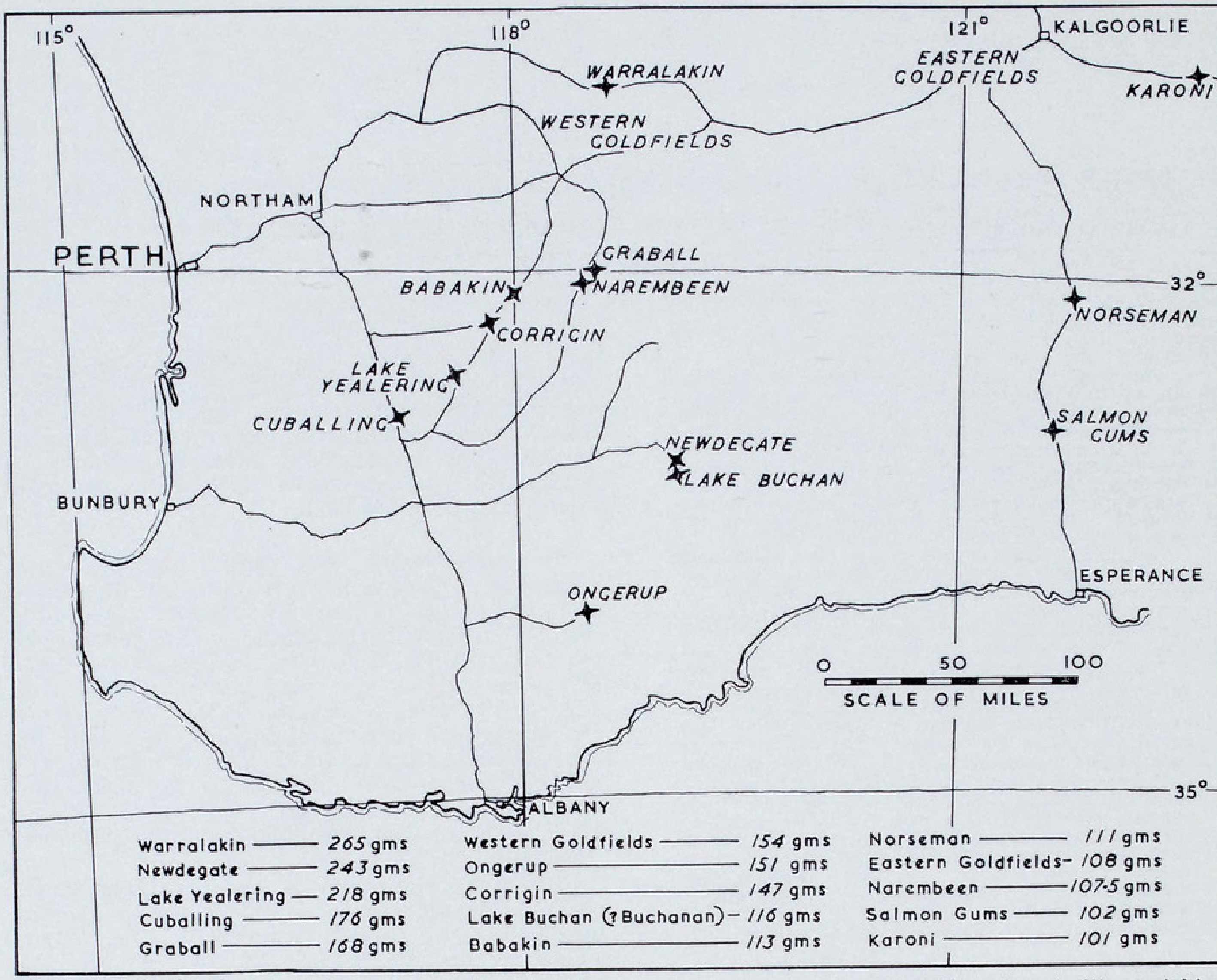


Fig. 1.—Sketch map of the southwest portion of Western Australia showing discovery sites of australites weighing over 100 grams. The sites for a specimen from the Western Goldfields area and one from the Eastern Goldfields region are not precisely known. Lines between localities represent roads.

than that for the Cuballing dumbbell-shaped australite (sp. gr. = 2.435). The difference is interpreted as a pointer to the Ongerup specimen being rather less acidic (some 2 to 2.5 per cent. less $SiO_2$) than the Cuballing specimen, provided that the difference in specific gravity is not a result of differences in gas bubble content, a check on which would mean destruction of the specimens for specific gravity determinations of the australite glass in the powdered state.

The average specific gravity value of the nine* only that have been determined among the twenty-one large australites recorded as having weights of over 100 grams each, is 2.431. Whereas the Western Australian large australites have an average specific gravity value of 2.437, the Victorian large specimens average 2.416, thus pointing to significant differences in composition for large specimens in the western and eastern portions of the australite strewnfield. Since silica content decreases with increase in specific gravity of tektite glass generally, it can be deduced from the specific gravity-silica graph (see Baker 1959 p.56) that the large Victorian australites have a silica content of approximately 74 to 75 per cent., whereas the large Western Australian specimens contain approximately 72 per cent. $SiO_2$.

* Warralakin, Cuballing, Graball, Ongerup, Eastern Goldfields, Narembeen, and Salmon Gums in Western Australia; Port Campbell and Gymbowen in Victoria.

**Arcs and radii of curvature of the surfaces**

Silhouette traces of the curved posterior and anterior surfaces at magnifications of just over x4 were prepared across the width of the slightly larger of the two gibbosities of the Ongerup dumbbell-shaped australite. The traces of the curvature of the two surfaces fitted reasonably well with the curvatures of circles constructed about them. The relationships of the arcs of curvature are shown by Fig.2D, where the posterior surface is uppermost. The radii of curvature ($R_B$ and $R_F$) were determined graphically as $R_F$ = 22.5 mm, and Rf = 16 mm, where Band F refer to the posterior and anterior surfaces respectively. The radius of curvature ($R_F$) of the back surface of the Ongerup specimen is comparable with that ($R_B$ = 23.0 mm) for the Cuballing specimen (Baker 1966), thus indicating that the primary forms from which

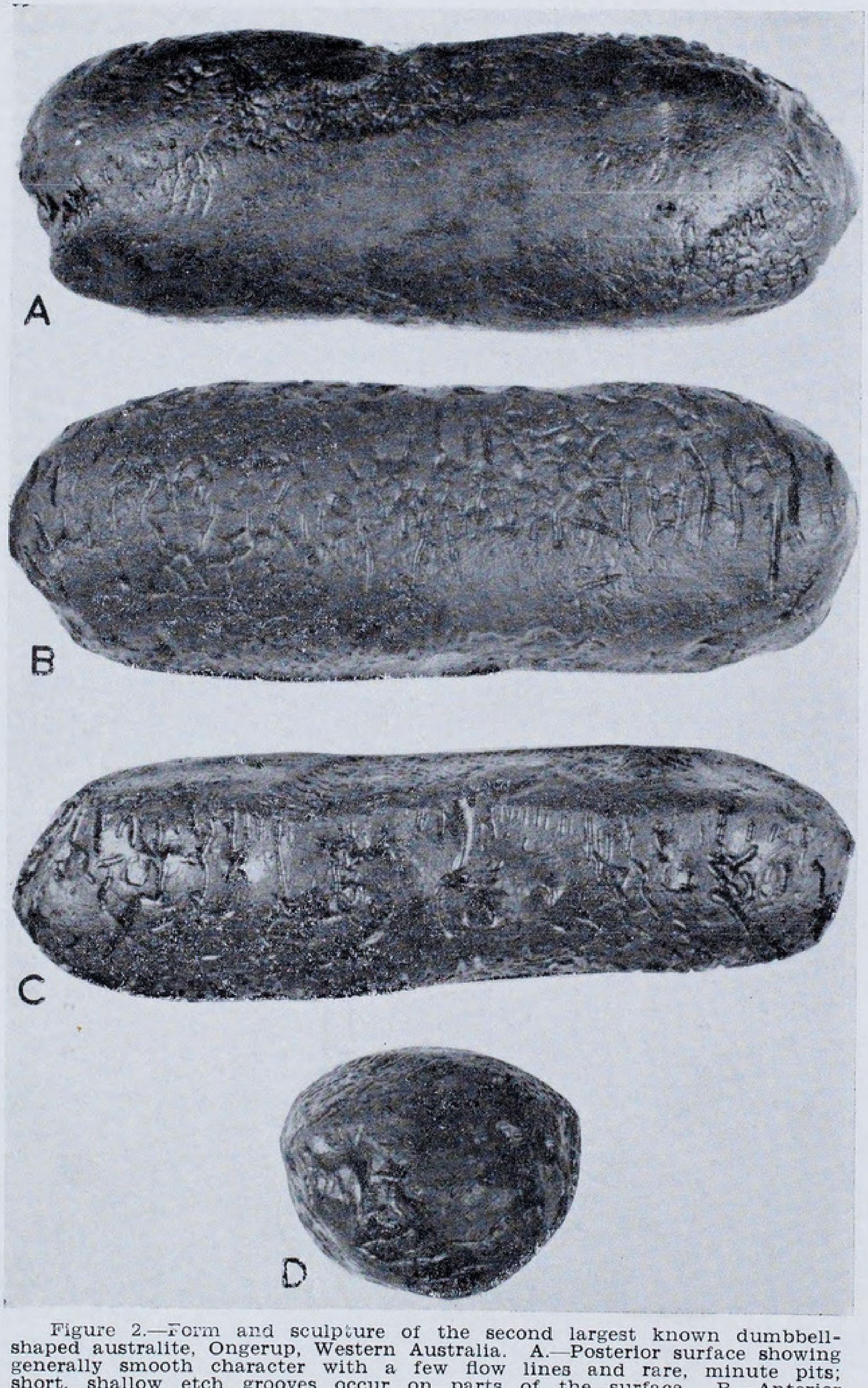


Figure 2.—Form and sculpture of the second largest known dumbbell-shaped australite, Ongerup, Western Australia. A.—Posterior surface showing generally smooth character with a few flow lines and rare, minute pits; short, shallow etch grooves occur on parts of the surface. B.—Anterior surface showing deeper and longer etch gutters transecting fine flow lines that trend generally parallel with the long axis of the specimen. C.—Side aspect (posterior surface uppermost) showing rim separating posterior and anterior surfaces, and etch gutters in the flaked equatorial zone comparable with those on the anterior surface. D.—End-on aspect of the slightly larger gibbosity (posterior surface uppermost) showing exfoliated anterior surface with occasional etch grooves. (A to C natural scale; D$\times$1.05) (Photographs by G. J. Squance)

these two specimens were derived were evidently closely comparable in size. The radius of curvature ($R_F$) of the front surface, however, is significantly lower than that ($R_F$ = 20.0 mm) for the Cuballing specimen, indicating that more glass was evidently lost from the forwardly directed surface of the Ongerup specimen as a consequence of (a) aerodynamic ablation during high speed atmospheric entry, followed by (b) differential exfoliation of the anterior surface causing shedding of the aerothermal stress shell after landing.

### Sculpture of the surfaces

The dominant sculpture pattern is a consequence of natural solution etching in terrestrial soil, and the two surfaces, posterior and anterior respectively, show marked differences in the nature and extent of etching. (Figs.2A&B.)

In contrast with the pitted posterior surface of the Cuballing dumbbell-shaped australite (Baker 1966 Figs.1A&C), the posterior surface of the Ongerup specimen is much smoother, with a few schlieren made evident by small amounts of natural etching and occasional patches up to 1 mm below the general level of the tektite glass where short, shallow etch grooves have been developed (Fig.2A). The trends of the flow lines (schlieren) are fundamentally parallel with the long axis of the specimen.

The anterior surface shows a marked development of etch grooves (Figs.2B&C). In cross section, these are mostly U-shaped, less commonly rounded V-shaped, and are much more pronounced than on the Cuballing specimen (Baker 1966 Fig.1B).

The flaked equatorial zone (Fig.2C) is not particularly sharply marked because of modification by weathering after exfoliation, but it is nevertheless plainly distinguishable in places where the surface exposed by spalling has not been too extensively etch-grooved. The width of the flaked equatorial zone is up to 14 mm; numerous etch grooves cross this zone, sometimes extending across its width and continuing around on to the curving anterior surface (Figs.4&5); in the opposite direction, they generally terminate abruptly where the rim separates the posterior surface from the flaked equatorial zone (Figs.2C, 3A-C).

Another feature on the flaked equatorial zone, to which it is restricted, is represented by the flat, circular spalled areas from 3 mm to 4 mm in diameter (Figs.3A-C.) These are evidently determined by the manner of spallation of the aerothermal stress shell. After etching, some of these appear horse-shoe shaped (Fig.3A), some become pitted (Fig.3C), others become concave (Fig,2C, left-hand end).

The gutters formed by etching are straight to branching, sometimes meandrine and vermicular in plan aspect (Figs.3,4&5). They vary up to

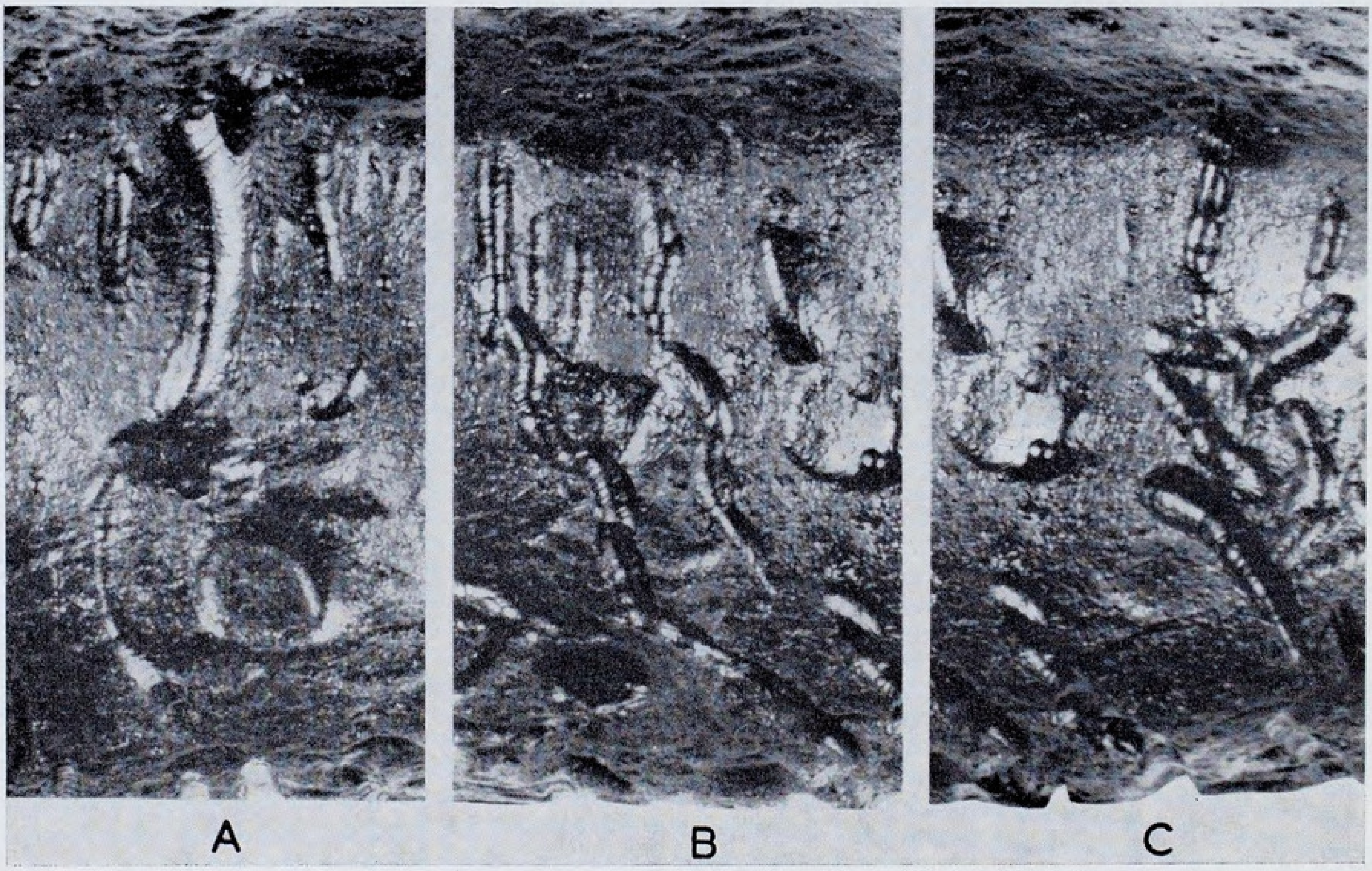


Fig. 3.—Etch gutters on the flaked equatorial zone, terminating at the edge (rim) of the posterior surface (uppermost in photographs), and occasional circular flat-bottomed spalled areas carrying an occasional etch pit. Dumbbell-shaped australite from Ongerup, Western Australia. A to C = x3.9.) (Photographs by G. J. Squance.)

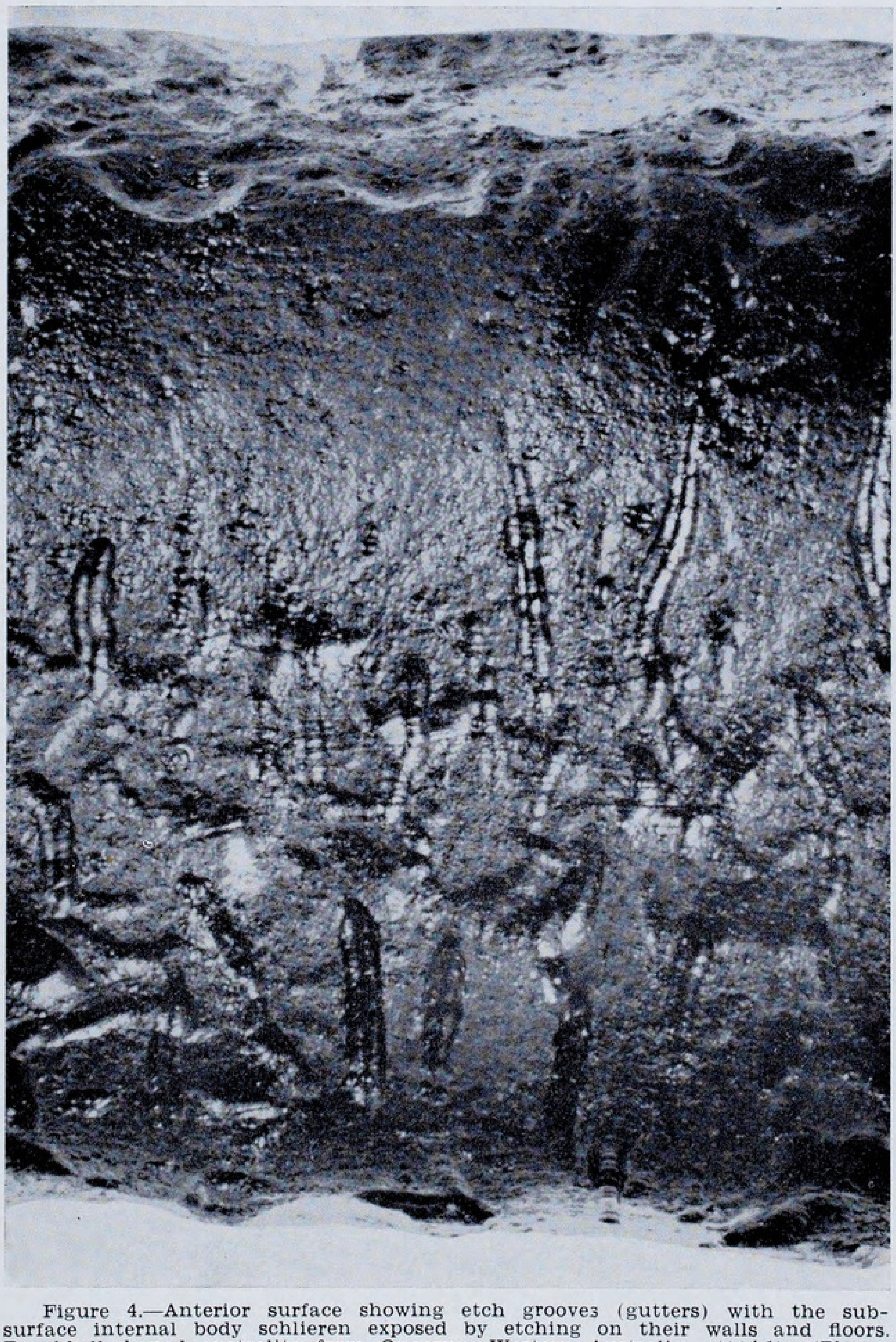

Figure 4.—Anterior surface showing etch grooves (gutters) with the subsurface internal body schlieren exposed by etching on their walls and floors. Dumbbell-shaped australite from Ongerup, Western Australia. (×4.1) (Photograph by G. J. Squance)

Figure 5.—Anterior surface (continuation of right-hand side of Fig.4) showing sub-surface internal body schlieren (exposed on walls and floors of gutters) extending generally parallel with the long axis of the specimen. Dumbbell-shaped australite from Ongerup, Western Australia. ($\times 4.1$) (Photograph by G. J. Squance)

1.5 mm in width, up to 4 mm in depth, and up to 21 mm in length, but are never flat-bottomed because of their development on the curved surfaces of the australite glass. Sometimes the gutters are at slightly different levels relative to each other, indicating greater overdeepening by solution along some directions compared with others, and where such gutters intersect, those at the slightly higher level appear as miniature hanging valleys relative to those at the lower level (Fig.5—connected gutters in centre of photograph).

Characteristic features displayed on the walls and floors of a number of the etch gutters are cross striae (Figs.2C,3A-C,4&5) which represent the internal schlieren brought out by natural solution etching downward into the subsurface regions of the flow-lined tektite glass. Sometimes the striae are more or less normal to the major trends of the gutters, but some are oblique to and less commonly parallel with these trends. This is a function of local variability in the trends of the internal schlieren relative to the major trends of the gutters, some of which trend across almost the entire width of the specimen and others trend obliquely to or almost parallel with its length (Figs.2B&5).

The dull lustre of parts of the australite glass on surface areas between the gutters is an outcome of micro-etch pitting (Figs. 4&5), possibly combined with the effects of a small degree of abrasional weathering. The more prominent types of etch pits encountered on some australites are generally insignificant in size and number on the Ongerup specimen. The few present are principally sub-circular to occasionally elliptical in outline, and up to just under 2mm across and about 0.5 mm deep; a few of these are visible towards the left central portion of the posterior surface (Fig.2A).

The prominent gutters on the Ongerup dumbbell-shaped australite are evidently not due directly to sculpturing by aerodynamic air flow, whether turbulent or otherwise. They occur on a surface which was part of the subsurface region of the interior of the specimen and hence was never exposed to aerodynamic forces. This surface has only been subsequently exposed by exfoliation and shedding of an original overlying aerothermal stress shell a few millimetres thick. Such grooves have not been obtained on the front surfaces of australites or other tektite glass models in experiments conducted to study ablational effects with aerodynamic flow instabilities at hypersonic velocities, but comparable grooves have been produced artificially by the chemical etching in 4% commercial HF of freshly fractured surfaces of tektite glass. Tektite glass typically breaks with a conchoidal to sub-conchoidal fracture and often reveals subsidiary ripple fracture marks crossing the conchoidal fracture surfaces. On etching the freshly fractured surfaces, pits develop in places in a few hours and grooves are produced along the trends of some of the ripple fracture marks. At a later stage in the etching process, the pits enlarge and their rims meet, while the shallow grooves pass into deeper and wider gutters. Inasmuch as the specimen came from a soil environment, it is deduced that natural soil etchants were probably responsible for the development of the gutters during the period of several thousand years that the australite has lain in the moist soil environment. Available etchants in moist soils are the soil acids and alkalies, and the pattern of the etching sculpture may well be accredited to plant roots; parts of the pattern of distribution of the etch gutters certainly resemble that of groups of hyphal filaments of certain fungi (basidiomycetes) that grow in moist soils. The time factor is an unknown quantity relative to the operation and effects of soil etchants, likewise their potency, relative to tektite glass which is rather more durable than most other natural or artificial glasses, It is known from observations in the tektite strewnfields, however, that relatively deeply etched specimens generally come from areas where lateritization has been severe. Inasmuch as there has been extensive removal of silica from such lateritic horizons, it is not surprising that any associated tektite glasses undergo strong etching in such a milieu.

## References


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## Appendix

Two large, round australites, each weighing over 100 grams, were submitted by W. H. Cleverly for examination in connection with the recent discovery and recording of the larger types of australites from the south-west portion of Western Australia. These are registered as Nos. 9421 and 10,199 respectively in the collection of the School of Mines of Western Australia, Kalgoorlie.

No. 9421, a round core from 7 miles S.E. of Salmon Gums, W.A. (see Fig.1) is 44.6 mm to 46.4 mm in diameter (difference due to weathering) and 38.0 mm thick. It reveals a flaked equatorial zone averaging 18.5 mm in width, produced by exfoliation of the strained aerothermal stress shell that was secondarily formed on the forward surface during atmospheric flight earthward. Its weight is 102.37 grams, and the specific gravity as determined on a Walker's Steelyard is 2.45.

The principal sculptural features are a few meandrine gutters produced by etching in moist soils, occasional circular etch pits 1 mm across, and more numerous micro-etch pits that impart a fine "orange-peel" effect to parts of the sculpture pattern, A few sub-surface internal flow lines have been revealed by the effects of natural solution etching.

No. 10,199, a round core presumed to be from the Eastern Goldfields region, W.A. (see Fig.1), is 49.8 mm to 52.4 mm in diameter and 33 mm thick. The difference in the diameter measurements appears to be largely a consequence of spallation and weathering. Its weight is 108.30 grams and the specific gravity as determined on a Walker's Steelyard is 2.44. Because of weathering, it is difficult to discriminate between the anterior and posterior surfaces, and there is no longer a clearly marked flaked equatorial zone. However, a very faint trace of a rim around parts of the periphery of the specimen helps to decide between the anterior and posterior surfaces respectively; the edge of the specimen is elsewhere rounded off by weathering. Only a few flow lines are faintly shown in places—these may have been more clearly defined at an earlier phase of natural solution etching, but are now nearly obliterated by the later effects of abrasional weathering. Few etch pits are present, probably for the same reason, but several etch gutters remain, although they were most probably deeper before the onset of abrasion; one of these gutters is reverse S-shaped. The posterior surface has been artificially chipped on one side, revealing the highly vitreous lustre and conchoidal fracture of the tektite glass, with secondary ripple fracture marks detectible on the fresh, glassy fracture surface. The anterior surface reveals a flatter facetted area on one side, this probably being an effect of irregular spallation. The etch gutters on this surface are up to 2 mm wide, approximately 0.75 mm deep, and in places meandrine in plan aspect. Etch pits associated with them on the same surface are few in number, circular to elliptical in outline, and best revealed on the facetted portion of the anterior surface.