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AUSTRALITES FROM KANAGULK, TELANGATUK EAST AND TOOLONDO, WESTERN VICTORIA.

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Abstract.

The weights, specific gravity values, dimensions, radii of curvature of posterior and anterior surfaces, and intercepts of the radical line upon the polar axis, have been determined for 48 round and elongated australites with typical button-, lens-, core-, oval-, boat-, dumbbell- and teardrop-shapes from Kanagulk (Lat. 37° 8′ S. and Long. 141° 50′ E.), and nearby localities at Telangatuk East and Mt. Talbot, Toolondo, vicinity of Harrow in Western Victoria. Refractive indices and specific refractivities have been determined for 24 of these australites, so selected as to represent the several shape groups and to cover variations in specific gravity within and between the shape groups. The frequency distribution of the specific gravity values, the relationships between weight of particular shapes and their respective specific gravity values, and the relationships between (i) depth and diameter of round forms, and (ii) radii of curvature of posterior and anterior surfaces shown by means of scatter diagrams, reveal no abnormalities among these australites. The results accord with the recently advanced theory that, allowing for tertiary processes of erosion (etching and abrasion) while resting upon the earth's surface, the shapes of australites as found, are secondary shapes, developed from a few typical, small primary shapes (spheres, spheroids, ellipsoids, dumbbells and apioids) by ablation and fusion stripping during ultrasupersonic airflow over their forwardly directed surfaces, whilst travelling earthwards, without rotation, at high speeds through the atmosphere.

Introduction.

Three collections of australites totalling 34 specimens from Kanagulk, one collection of five australites from Mt. Talbot, Toolondo, and a collection of nine australites from Telangatuk East, have been studied from the aspects of their shape, size, radii of curvature of back (R_B) and front (R_F) surfaces, specific gravity and refractive index values, and their specific refractivities. All of these localities are near Harrow in the Western District of Victoria.

The three collections from Kanagulk and the one from Mt. Talbot, Toolondo, were submitted for examination by four separate owners, per courtesy of the National Museum of Victoria, Melbourne.

Location and Mode of Occurrence.

Kanagulk lies on Lat. 37° 8′ S. and Long. 141° 50′ E., some 35 miles south-south-west of Horsham, and 13 miles almost due east of Harrow, Western District of Victoria. Telangatuk East is approximately 8 miles north-east of Kanagulk, and Mt. Talbot is 6 miles north-east of Telangatuk East.

The specimens constituting the collection from Kanagulk, are herein numbered 1 to 34 for convenience of reference (see Tables 2 and 8; those from Telangatuk East are numbered 35 to 43, and those from Mt. Talbot, Toolondo, 44 to 48.

Among the Kanagulk specimens, numbers 1 to 12 were collected on cultivated land by Mr. R. T. P. Elliott over the past twenty years. Numbers 13 to 15 came from uncultivated areas, and were collected by Mr. A. C. Bennett during the past four or five years. Numbers 16 to 34 were collected by Mr. W. R. Jasper, all within a radius of 1 mile of his homestead on the property of "Foster", Kanagulk, Parish of Telangatuk; only four of these were found during the past ten years. The Jasper collection originally contained 40 specimens, but many of these were given away, including one large round core measuring 2½ to 3 inches across. Prior to 1910, these australites were known locally as "black diamonds" because they scratched ordinary glass. Information supplied by Mr. W. R. Jasper relating to the field occurrence of the Kanagulk australites, reveals that some were found on the surface of the ground amid surrounding superficial materials consisting largely of magnetic and non-magnetic ferruginous accretionary growths ("buckshot gravel"), resting upon yellow clay. Most, however, were discovered where the surface soil has been cultivated to a depth of 3 inches to 5 inches. Specimens 13 to 15, and most of those numbered 16 to 34, came from an area of 5 or 6 acres in allotment 84, adjoining allotment 83A, and the remainder were found in allotments 64 and 87, Parish of Telangatuk.

Numerous enquiries in reference to australites, made throughout the district by Mr. Jasper, have not revealed the existence of other collections, apart from one or two specimens. A resident some 10 miles north-west of "Foster" reported finding a button-shaped australite complete with circumferential flange, in clay 15 feet below the surface in a well; this specimen could have fallen down from the surface during construction of the well, or from its sides subsequently. The largest specimen noted in the Kanagulk district, is stated to be a round australite core some 2½ inches in diameter, found 5 miles north-west of "Foster", but the specimen was not submitted for examination.

The largest complete form among the 48 specimens examined, is an oval-shaped australite core (No. 16, Table 2), weighing 39·13 grams, measuring 36 mm. long, 30 mm. wide, and 27 mm. thick, and having a specific gravity value of 2·426. In contrast, the smallest complete specimen in the collection is an oval-shaped australite (No. 7, Table 2), weighing 0·792 grams, measuring 11 mm. long, 9 mm. wide, and 5·5 mm. thick, and with a specific gravity value of 2·408.

The specimens from Telangatuk East (Nos. 35 to 43, Table 2), are registered as numbers 3,418 to 3,426 in the Rock and Mineral Collection of the Melbourne University Geology Department. They are all complete or nearly complete forms, the maximum and minimum weights of which, fall well within the range of weights of the Kanagulk specimens; the same applies to the five australites from Mt. Talbot, Toolondo (Nos. 44 to 48, Table 2), which were submitted for examination by Mr. L. Officer.

On many of the Kanagulk australites, adventitious ferruginous clay had become firmly cemented into some of the bubble pits and into the more deeply etched grooves on several specimens, also into the gap region between circumferential flange and body portion of most of the flanged australites. This is a secondary product of terrestrial origin, and in no way to be connected with australite origin. Prior to weight and specific gravity determinations, it was necessary to remove this clay by boiling in concentrated hydrochloric acid and scrubbing. This treatment had no perceptible effect upon the australite glass itself, as checked by weighing a clean specimen before and after immersion for two hours in boiling HCl, after which time, no change in weight could be detected.

Nature of the Australites.

Eighty-five per cent. of the 34 Kanagulk australites are complete or nearly complete forms, while the remainder are relatively large fragments all of which provide sufficient evidence of the original shape type from which they were broken. The nature of these fragments points to natural fracture rather than working by aboriginal man. Sixty-six per cent. of the complete or nearly complete forms have round shapes (i.e., are circular in plan aspect, although lenticular in side aspect). The remainder are elongated (oval-, boat-, dumbbell-, and teardrop-shaped in plan, mainly lenticular in side aspect). If the five fragments are introduced into the comparisons of the proportions of round to elongated australites in the Kanagulk collections, the percentage of round forms is reduced to 62. The various shape types represented from the three localities, are listed in Table 2.

All of the Telangatuk East and the Mt. Talbot, Toolondo australites are complete or nearly complete forms, although the Mt. Talbot specimens are generally much more weathered (etched and somewhat abraded).

Fourteen of the total of 48 australites reveal flow ridges still in a good state of preservation on their anterior surfaces. Most of these are round forms of australites (ten button-shaped and two lens-shaped forms). Of the two elongated forms showing flow ridges, one is a small oval-shaped australite, and the other teardrop-shaped with one concentric ridge on the bulbous end, and four ridges extending across the anterior surface in arcuate fashion from side to side of the constricted end.

The proportions of the three different types of flow ridges represented, are listed in Table 1.

TABLE 1.—PROPORTIONS OF FLOW RIDGE TYPES.

Nature of flow ridges	Percentage
Concentric	57
Clockwise spiral	14
Counterclockwise spiral	29
	100

Specimens without flow ridges are (*a*) the larger australite cores, and (*b*) some of the button- and lens-shaped forms which have been strongly etched and partially abraded, so that the original flow ridge structures have been more or less removed.

For comparison with the percentages of the types listed in Table 1, flow ridges displayed by 100 australites from the Nirranda Strewnfield, 105 miles distant to the south-east (Baker, 1956), occur in the following proportions—46 per cent. concentric, 27 per cent. clockwise spiral, and 27 per cent. counterclockwise spiral.

The shapes and sculpture patterns of the majority of the australites from Kanagulk, Telangatuk East, and Mt. Talbot, are generally comparable with those of many other well-preserved australites described from other parts of Western Victoria (see Baker, 1937, 1940a, 1940b, 1944, 1946, 1950, 1955a, 1955b, and 1956). Two in particular, however, are worthy of more detailed description in being somewhat unusual (Specimens Nos. 2 and 19,

Table 2). One of these (No. 2) is the largest round australite core which the author has so far observed to possess remnants of a flange. The specimen was produced from a sphere of australite glass having an original diameter of approximately 4·5 cms. as obtained graphically from determination of the radius of curvature of the posterior surface, which is a remnant of the primary surface. Such a sphere would have weighed about 175 grams, assuming its specific gravity to have been the same (2·412) as that of the ultimately produced secondary form—a round core resulting from ablation of the original sphere while traversing the earth's atmosphere at ultrasupersonic velocity. Approximately five-sixths by weight of the original sphere was ablated away in this manner, leaving a secondary form weighing 31·599 grams and measuring 32 mm. in diameter, and 22 mm. in thickness. The second specimen (No. 19) is a dumbbell fragment which has lost one of its bulbous ends as a result of relatively recent fracture, and reveals some extraordinary features. An unusually long, relatively smooth, attenuated waist region is preserved and reveals well-developed longitudinal flow lines. This is attached to the remaining bulbous end in such a way as to recall the appearance of attachment of the stalk to the head of a mushroom. The bulbous end shows a complex pattern of " crinkled " flow ridges, and is almost circular in cross-sectional aspect, having only lost approximately one-fourteenth part of its original diameter (20 mm.) by ablation.

Measurements of the Australites.

The weights, specific gravity values, dimensions, radii of curvature (R_B = back surface, R_F = front surface*), and intercepts made by the diameter (= radical line) upon the depth line (= polar axis), are shown in Table 2 for the individual specimens. ON represents the distance to the back pole, and OM the distance to the front pole from the central point in the plane containing the diameter line.

The specific gravity values were obtained by weighing in air and in distilled water (T°C. = 15·5), on an air-damped chemical balance.

For purposes of comparison with forms that have lost their flanges, the diameter, width and length measurements of specimens with attached flange or flange remnants, were made across the body portion of each form, so that all such measurements are ex-flange. Width and depth measurements of Specimen No. 42,

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* The front or anterior surface was directed earthwards during downward atmospheric flight.

TABLE 2.

No.	Shape Type	Weight (gms.)	Specific Gravity	Diameter (mm.)	Depth (mm.)	Flange Width (mm.)	Width (mm.)	Length (mm.)	R_B (mm.)	R_F (mm.)	ON (mm.)	OM (mm.)
	KANAGULK.											
	R. T. P. Elliott Collection.											
1	Button (with flange band) ..	3·860	2·405	19	9	..	..	..	12·5	11·5	4	5
2	Round Core (with flange remnant)	31·599	2·412	32	22	..	..	..	21·5	20	10	12
3	Hollow Round-Form Fragment	8·668	2·400	25·5	31	..	..	..	21·5	16·5	4	27
4	Boat Core	5·445	2·415	..	12	..	16	23	26	21	5	7
5	Button (with flange remnant) ..	2·285	2·398	14	8	3	..	..	8	9	4·5	3·5
6	Oval (flat)	1·467	2·417	..	4	..	14	16	20·5	11·5	2	2
7	Oval (small)	0·792	2·408	..	5·5	..	9	11	7	7	2·5	3
8	Button (with flange remnants)	2·140	2·404	13	8	3	..	..	7·5	8	4·5	3·5
9	Boat Fragment (with attached flange)	3·234	2·380	..	10·5	2·5	17	..	8·5	10·5	7	3·5
10	Oval Core	1·981	2·415	..	10	..	12	14	9·5	7	3·5	6·5
11	Core Fragment	1·996	2·416	..	10·5	..	15	..	14·5	10	3·5	7
12	Boat Core	17·974	2·383	..	16	..	19	51	11·5	9·5	5	11
	A. C. Bennett Collection.											
13	Round Core	18·218	2·396	26	19	..	..	..	14·5	18·5	7	12
14	Button (with flange remnants)	3·680	2·413	16	10·5	3	..	..	10	9·5	5·5	5
15	Button Fragment (with flange band)	3·775	2·383	..	17·5	..	..	..	15	11	5·5	12
	W. R. Jasper Collection.											
16	Oval Core (large)	39·133	2·426	..	27	..	30	36	23·5	23·5	13·5	13·5
17	Boat Core	22·305	2·441	..	16	..	19	44	10	10	8	8
18	Boat Core	12·659	2·414	..	13	..	14	45	9·5	8·5	5	8
19	Dumbbell Fragment	14·097	2·386	20	18·5	..	..	..	10	10	10	10
20	Boat Core	8·904	2·406	..	14	..	17	28·5	15·5	10	3·5	10·5
21	Round Core	25·580	2·390	31	22	..	..	..	19·5	18	10	12
22	" Aerial Bomb "	16·700	2·391	21	..	..	..	30	10·5	10·5	10·5	10·5
23	Round Core	19·463	2·394	27	20	..	..	..	17·5	16	9	11
24	Round Core	15·713	2·403	28	16	..	..	..	20	15·5	6	10

TABLE 2—*continued.*

No.	Shape Type	Weight (gms.)	Specific Gravity	Diameter (mm.)	Depth (mm.)	Flange Width (mm.)	Width (mm.)	Length (mm.)	R_B (mm.)	R_F (mm.)	ON (mm.)	OM (mm.)
	KANAGULK—*continued.*											
	W. R. Jasper Collection—continued.											
25	Button (with flange remnants)	5·971	2·406	19	13	5	..	..	11·5	12	7	6
26	Button (with flange remnant)	3·562	2·404	18	8	3	..	..	10·5	12·5	4·5	3·5
27	Button (with flange remnant)	4·406	2·390	18	9·5	3	..	..	10·5	11	5	4·5
28	Button (with flange band) ..	3·400	2·408	18	10	..	..	..	10	10·5	5·5	4·5
29	Button	3·982	2·403	18	10·5	..	..	..	11	10·5	5·5	5
30	Button (with minute flange remnant)	2·225	2·394	15	8	..	..	..	8·5	10	4·5	3·5
31	Lens	1·691	2·399	15	7		..	..	9·5	10	3·5	3·5
32	Lens	1·678	2·404	14·5	6·5	..	..	..	9·5	10	3·5	3
33	Lens	1·427	2·410	13·5	6·5	..	..	..	9·5	9·5	3·5	3
34	Lens	1·538	2·416	13	7	..	..	..	7·5	8	4	3
	TELANGATUK EAST.											
	Melbourne University Collection.											
35	Oval Core	12·686	2·429	..	19	..	21	27	17	11	10·5	8·5
36	Oval Core	13·204	2·437	..	15·5	..	22·5	27	16·5	15	9·5	6
37	Round Core	9·732	2·422	21	15	..	..	..	20	18·5	7	8
38	Round Core	8·776	2·397	20	17·5	..	..	..	14	14	9	8·5
39	Button (with flange remnants)	4·681	2·378	19	11	..	..	..	12	12	6	5
40	Lens	3·872	2·400	17	10	..	..	..	11	11	5	5
41	Button (with flange band) ..	1·732	2·401	14	7	..	..	..	10	12·5	4	3
42	Dumbbell	2·764	2·408	..	6	..	9·5	29·5	6	5·5	2·5	3·5
43	Teardrop	2·785	2·401	..	8·5	..	13·5	22	7	11·5	5·5	3
	MT. TALBOT, TOOLONDO.											
	L. Officer Collection.											
44	Lens	3·712	2·410	17	11·5	..	..	..	9	10·5	6·5	5
45	Lens	2·894	2·424	17·5	8	..	..	..	12	12	4	4
46	Lens	3·022	2·414	17	9	..	..	..	11	10·5	4	5
47	Button (with flange band) ..	3·231	2·409	17	9	..	..	..	10	10·5	4·5	4·5
48	Button (with flange remnants)	1·980	2·392	13	8·5	..	..	..	7·5	9	5	3·5

a dumbbell-shaped form, were determined across the bulbous ends, the waist region of this specimen measuring 8·5 mm. wide and 5 mm. thick. Width and depth measurements of Specimen No. 43 were determined across the widest and thickest portions of the bulbous end.

Radii of curvature values (R_B and R_F), and the intercept values (ON and OM) on the depth line (polar axis), were determined graphically from silhouette tracings magnified 5·5 times. All direct measurements, graphical measurements and calculations of measurements, have been taken to the nearest 0·5 mm. Radius of curvature values for the elongated australites are listed for determinations made across the widths of the specimens, but not along the lengths since the results indicate circular cross sections only for positions normal to the long axes of elongated australites.

The flange bands referred to on Specimens Nos. 1, 15, 28 and 41 (Table 2), mark the former positions of attachment of the circumferential flanges to equatorial edges of the posterior surfaces of the body portions. Their presence provides proof

Table 3.

Locality	Number of Specimens	Percentage	Total Weight (gms.)	Range in Weight (gms.)	Average Weight (gms.)	Range in Specific Gravity	Average Specific Gravity
Kanagulk	34	70	314·577	0·792 to 39·133	9·252	2·380 to 2·441	2·404
Telangatuk East . .	9	19	60·232	1·732 to 13·204	6·692	2·378 to 2·437	2·408
Mt. Talbot, Toolondo	5	11	14·839	1·980 to 3·712	2·968	2·392 to 2·424	2·410
Totals . .	48	100	389·648	0·792 to 39·133	8·717	2·378 to 2·441	2·405

that the original complete round forms were button-shaped. The vitreous, very little etched character of the surfaces of these flange bands, points to relatively recent fracturing away and loss of the flange structure.

The total weights, range and average weights, and the range and average specific gravity values of the australites from Kanagulk, Telangatuk East and Mt. Talbot, Toolondo, are shown in Table 3.

There is a notable absence from these collections (cf. Table 2) of canoe-shaped australites, aberrant shapes, small forms (such as round discs and oval plates), complete flanges and flange fragments, compared with australites from Port Campbell on the south coast of Western Victoria (Baker, 1937, 1940, 1946, 1955b). The smaller forms of australites have thus evidently been overlooked in the field, or else, being relatively fragile, they may have disintegrated to smaller fragments which would go unnoticed unless specifically searched for.

The averages and ranges in values of these various measurements for the different shape groups represented among the Kanagulk, Telangatuk East and Mt. Talbot, Toolondo australites, are listed in Tables 4, 5 and 6.

TABLE 4.—NUMBERS, WEIGHTS, AND SPECIFIC GRAVITY VALUES.

Shape Types	Number in Each Group	Percentage	Range in Weight (gms.)	Average Weight (gms.)	Range in Specific Gravity	Average Specific Gravity
Round Forms (64·5 *per cent.*)						
Buttons	14	29	1·732 to 5·971	3·369	2·378 to 2·413	2·400
Lenses	8	16·5	1·427 to 3·872	2·041	2·399 to 2·416	2·406
Round Cores	7	15	8·776 to 31·599	18·869	2·390 to 2·422	2·402
Button Fragment ..	1	2	..	3·775	..	2·383
Hollow Round-Form Fragment	1	2	..	8·668	..	2·400
Elongated Forms (35·5 *per cent.*)						
Ovals	2	4·5	0·792 to 1·467	1·130	2·408 to 2·417	2·413
Oval Cores	4	8·5	1·981 to 39·133	16·751	2·415 to 2·437	2·427
Boat Fragment	1	2	..	3·234	..	2·380
Boat Cores	5	10·5	5·445 to 22·305	13·457	2·383 to 2·441	2·412
Dumbbell	1	2	..	2·764	..	2·408
Dumbbell Fragment ..	1	2	..	14·097	..	2·386
" Aerial Bomb "	1	2	..	16·700	..	2·391
Teardrop	1	2	..	2·785	..	2·401
Core Fragment	1	2	..	1·996	..	2·416
Totals	48	100·0	0·792 to 39·133	8·717	2·378 to 2·441	2·405

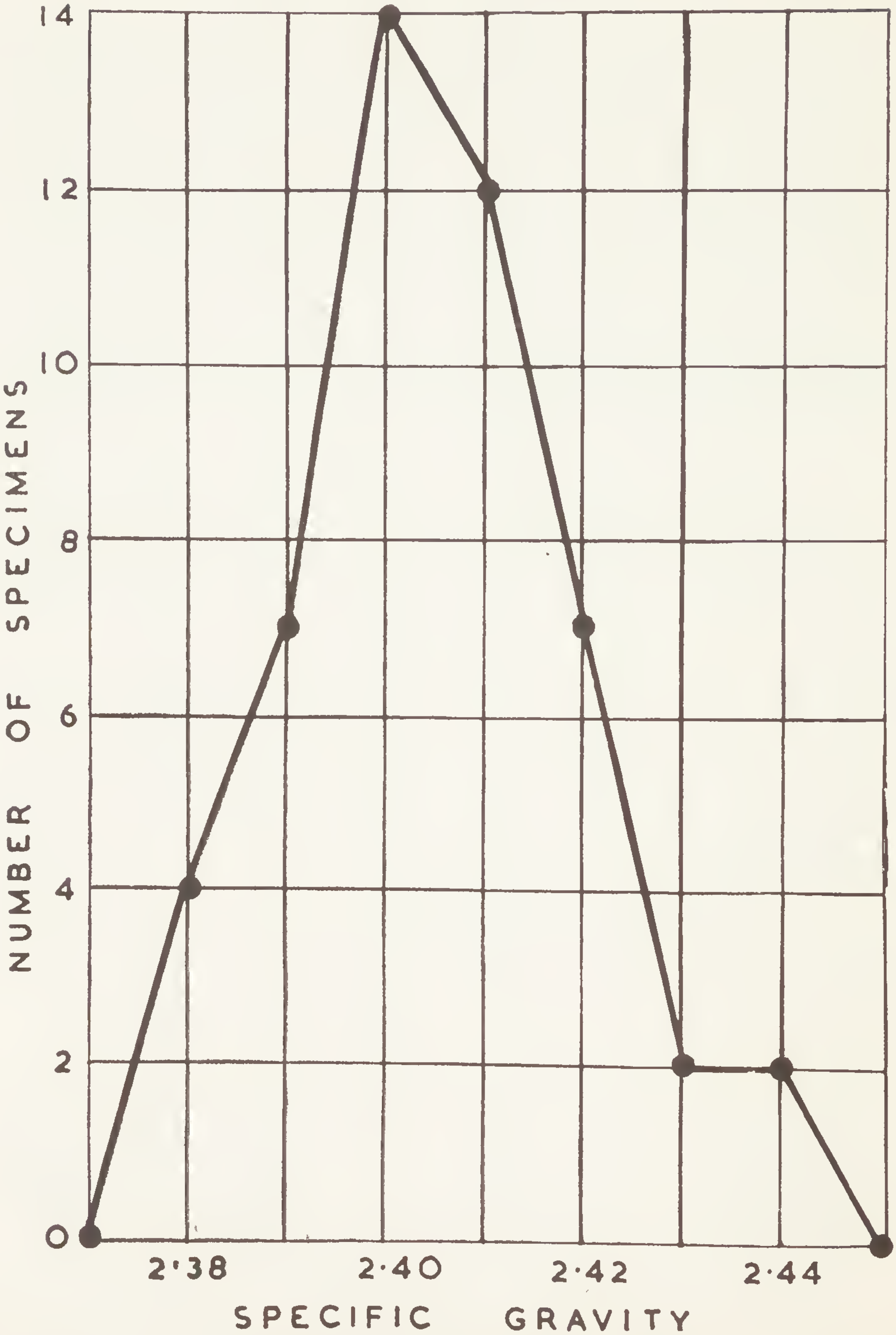

Fig. 1.—Frequency distribution of 48 specific gravity values of australites from Kanagulk (34), Telangatuk East (9), and Mt. Talbot, Toolondo (5).

Relationships between Specific Gravity and Weight.

The frequency distribution of the specific gravity values (taken to the second decimal place), is shown in Figure 1.

The over-all mode of the frequency distribution for the three localities, is 2·40 (Fig. 1), as compared with a calculated average specific gravity of 2·405.

The specific gravity values have been plotted in Figure 2 against the weight values for the 39 complete australites from the three localities.

The scatter diagram (Fig. 2) serves to illustrate that there are both heavier and lighter weight forms in the same and in different shape groups, which have much the same specific

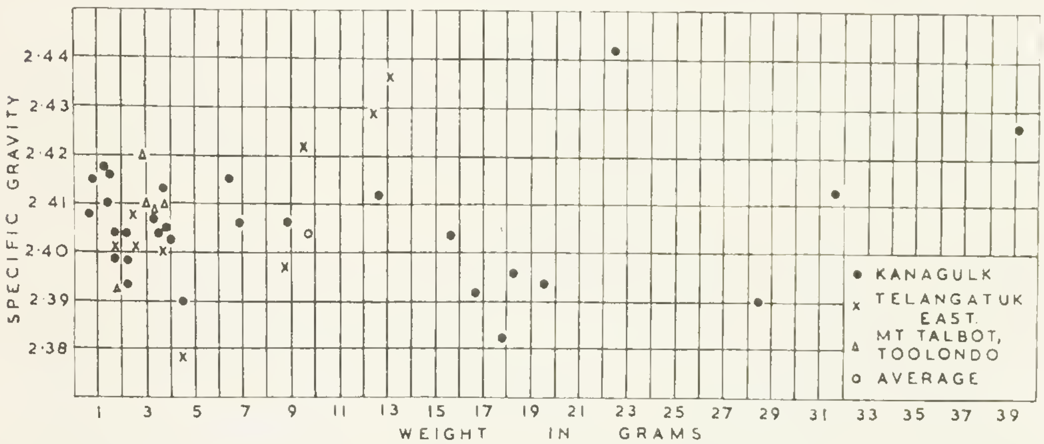

Fig. 2.—Scatter diagram illustrating specific gravity-weight relationships for complete australites from Kanagulk (29), Telangatuk East (9), and Mt. Talbot, Toolondo (5).

gravity, e.g. forms with a specific gravity of 2·41, range in weight from approximately 0·8 to nearly 32 grams. Conversely, a number of individuals in the same or in different shape groups, have approximately the same weight, but reveal a range in specific gravity, e.g. types weighing about 4 grams, vary in specific gravity from 2·378 to 2·415. The average weight of the complete forms plotted in Figure 2, is 8·323 grams, and the average specific gravity is 2·405.

Relationships between Dimensions.

The relationships between depth and diameter values of 30 round forms of australites represented among the specimens from Kanagulk, Telangatuk East and Mt. Talbot, Toolondo, are shown by the scatter diagram, Figure 3.

The scatter diagram (Fig. 3) reveals that diameter is greater than depth for each specimen (hollow round form excepted—cf. Table 2, No. 3). The ratios between diameter and

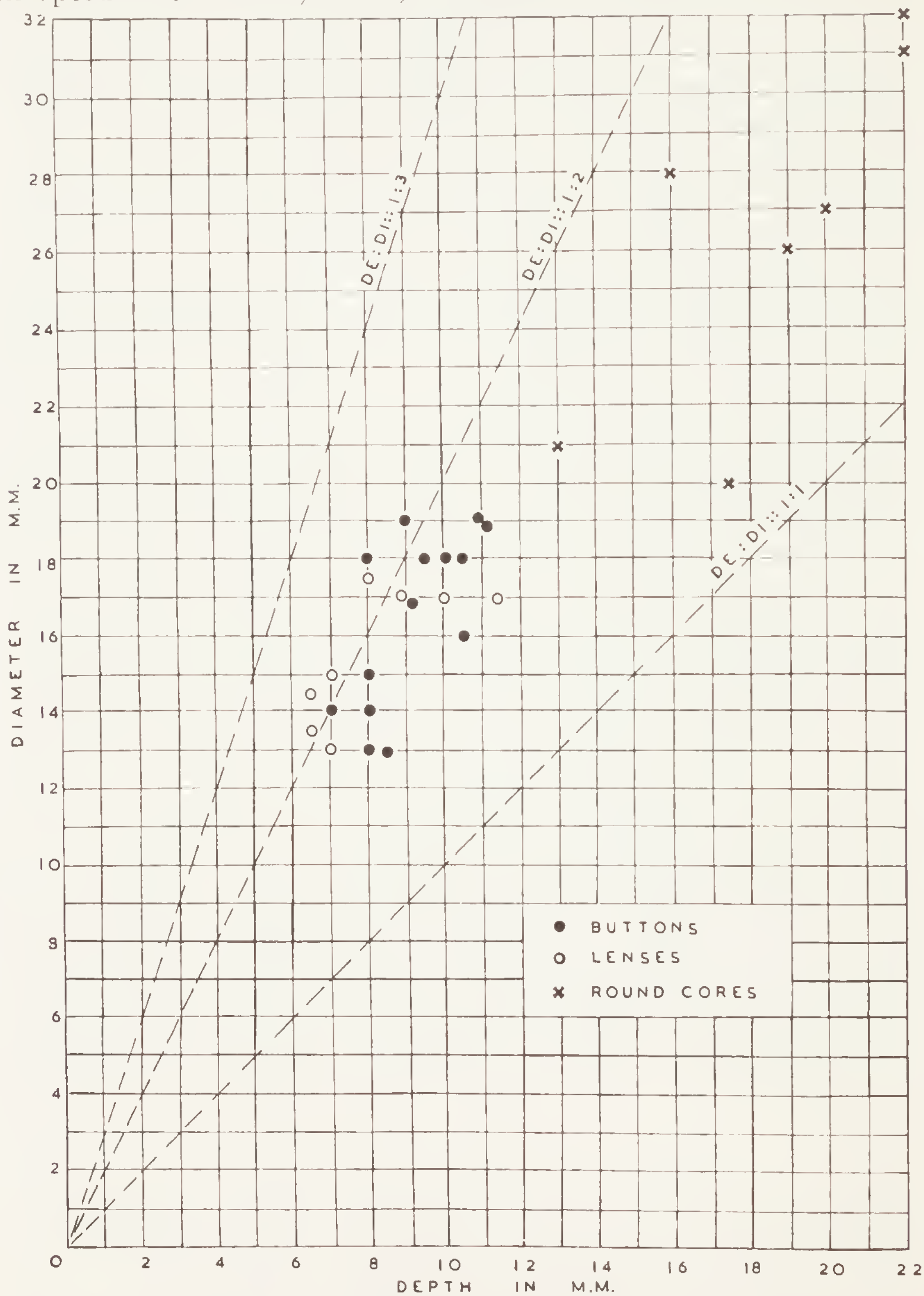

Fig. 3.—Scatter diagram showing relationship of depth and diameter values for round forms of australites from Kanagulk, Telangatuk East and Mt. Talbot, Toolondo.

depth are typically Di : De :: 1·5 : 1 to Di : De :: 2 : 1. There is a general increase in depth with increase in diameter, but some forms with the same depth, have different diameter values, e.g. 13 to 18 mm. diameter for a depth of 8 mm. Conversely there are other forms with the same diameter which have different depth values, e.g. 8 to 10·5 depth for a diameter of 18 mm. Such relationships are comparable with those of the round forms of australites from Port Campbell, south-western Victoria (Baker, 1955b, Fig. 11, p. 181), and like them, it is apparent that during atmospheric flight, differential ablation of original forms of the same or of different size, has yielded secondary modified shapes sometimes with the same depth, sometimes with the same diameter.

Relationships between Radii and Arcs of Curvature.

Relationships between the radii of curvature of the posterior (RB) and anterior (RF) surfaces, reveal a typical scatter of values (Fig. 4), generally comparable with those shown for the Port Campbell australites (Baker, 1955b) and for the Nirranda Strewnfield australites (Baker, 1956).

It was determined from the silhouette tracings that each radius of curvature for each australite, is in itself constant for all radial sections taken through the plane containing the polar axis of any individual round forms; this does not apply, however, to the elongated forms of australites, where the only radius of curvature considered herein, is that for sections normal to the long axis.

The distribution of RB and RF values in the scatter diagram (Fig. 4) reveals that RB values are confined to the range 6 mm. to 26 mm., and RF values to the range 5·5 mm. to 23·5 mm. The general trend evident from the scatter diagram (Fig. 4), is one of increasing RF with increased RB, thus indicating that processes of ablation generally followed a steady, regular pattern on forms of different original size. Round forms with the same RB but different RF values, e.g. RF range of 9·5 mm. to 12·5 mm. for a value of 10 mm. for RB, indicate differential ablation of spheres of the same original size (since RB is constant and represents the radius of curvature of the posterior surface, which is a remnant of the primary sphere surface). Round forms with the same RF but different RB values (e.g. RB range of 10·5 mm. to 15 mm. for a value of 11 mm. for RF), indicate differential ablation of spheres of different original size (since the radius of curvature of the primary spheres ranged from 10·5 to 15 mm.).

All values plotted in the scatter diagram (Fig. 4) fall within the range $R_B : R_F :: 2 : 1$ to $R_B : R_F :: 1 : 2$, further indicating that processes of frontal ablation* maintain relatively normal

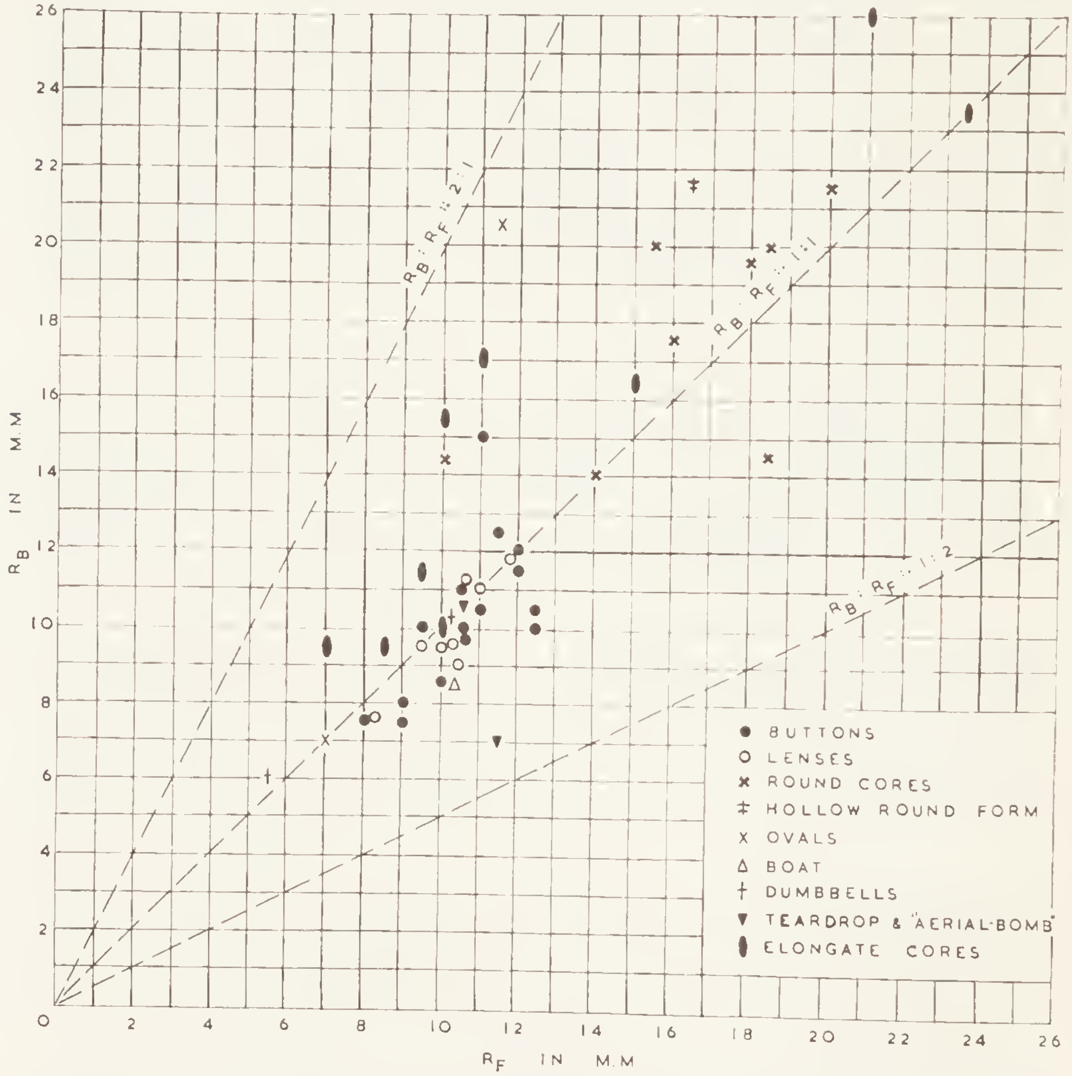

Fig. 4.—Scatter diagram showing relationships of R_B and R_F values of australites from Kanagulk, Telangatuk East and Mt. Talbot, Toolondo. (R_B and R_F = radii of curvature of posterior and anterior surfaces of the australites.)

arcs of curvature upon the diminishing anterior surfaces of australites; only forms that become ablated to 1 to 2 mm. in thickness ultimately become more or less flat and thus have infinite arcs and radii of curvature.

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* The phenomenon of frontal ablation (and associated phenomena) arises from and is controlled largely by the effects of ultrasupersonic airflow at the high speeds of flight of australites downwards through the atmosphere (see Baker, 1956).

For the round forms, which constitute 64·5 per cent. of the australites examined, 37·5 per cent. have greater values for R_B than for R_F, and 50 per cent. of the forms in this group consist of the larger round cores; steeper curvatures are thus developed on the front surfaces by ablation. In 15·5 per cent., R_B and R_F are equal in amount, and in this group, 60 per cent. of the forms are lenses; since similar curvatures are maintained by ablation, the ultimate secondary forms are perfectly lenticular. In 47 per cent., R_B is less than R_F, and 66·5 per cent. of the forms in this group are flanged buttons; flatter curvatures are thus developed on the front surfaces by ablation. It is thus seen that on the larger round forms (round cores), ablation produces steeper arcs of curvature on front surfaces. As the forms become reduced in size on further ablation, the arcs of curvature tend to become flatter on the front surfaces (button-shaped australites); with further decrease in thickness, ablation processes produce slightly steeper arcs of curvature of front surfaces, which in the larger proportion of the lenses, become the same as that of posterior surfaces. The final stage is one where the smaller of the lens-shaped forms pass by continued ablation to the thin disc-shaped australites.

Relationships between Intercepts.

The relationships of the intercepts ON and OM (see Baker, 1956) cut off on the depth line (polar axis) by the diameter line (radical line), show trends which are comparable with and governed by the relationships between the radii of curvature of the posterior and anterior surfaces of the australites. Examples in which the value of OM is greater than that of ON, are made up of 64 per cent. core-shaped forms, 18 per cent. button-shaped, and the remainder lens-shaped. In these forms, the back pole (N) is thus nearer to the centre of the plane containing the radical line, hence the greater bulk of australite glass is located on the front pole side of the radical line; this is more especially pronounced in the australite cores. Examples with OM and ON equal in value, are comprised of 60 per cent. lens-shaped forms, 20 per cent. button-shaped, and 20 per cent. cores, in which the back (N) and front (M) poles are equally spaced from the radical line and since $R_B = R_F$, such forms tend to be lenticular in side aspect; this applies more particularly to the lens-shaped forms which are largely perfectly lenticular. Examples in which OM is less than ON, consist of 81 per cent. button-shaped forms and 19 per cent. lens-shaped. In them, the front pole (M) is nearest to the centre of the plane containing the radical

TABLE 5.—DIMENSIONS.

Shape Types	Range in Depth (mm.)	Average Depth (mm.)	Range in Diameter (mm.)	Average Diameter (mm.)	Range in Width (mm.)	Average Width (mm.)	Range in Length (mm.)	Average Length (mm.)
Buttons	7 to 13	9·5	13 to 19	16·5	..	..	..	..
Lenses	6 to 10	7·5	13 to 17	14·5	..	..	..	..
Round Cores ..	15 to 22	19·0	20 to 32	26·0	..	..	..	..
Button Fragment ..	..	..	..	..	..	..	..	..
Hollow Round-Form Fragment ..	..	31·0	..	25·5	..	..	..	..
Ovals	4 to 5·5	4·5	..	..	9 to 14	11·5	11 to 16	13·5
Oval Cores	10 to 27	18·0	..	..	12 to 30	21·5	14 to 36	26·0
Boat Fragment ..	..	11·0	..	..	..	17·0	..	..
Boat Cores	12 to 16	14·0	..	..	14 to 19	17·0	23 to 51	38·0
Dumbbell	..	6·0	..	..	..	9·5	..	29·5
Dumbbell Fragment ..	..	20·0	..	..	..	20·0	..	..
"Aerial Bomb" ..	..	..	..	..	..	21·0	..	30·0
Teardrop	..	8·5	..	..	..	13·5	..	22·0
Core Fragment ..	..	10·5	..	..	..	15·0	..	..
Totals ..	4 to 27	12·0	13 to 32	18·5	9 to 30	16·5	11 to 51	29·0

TABLE 6.—RADII OF CURVATURE AND INTERCEPT VALUES.

Shape Types	Range of R_B (mm.)	Average R_B (mm.)	Range of R_F (mm.)	Average R_F (mm.)	Range of ON (mm.)	Average ON (mm.)	Range of OM (mm.)	Average OM (mm.)
Buttons	7·5 to 12·5	10·0	8 to 12·5	11·0	3·5 to 7	5·5	3 to 6	4·5
Lenses	7·5 to 11	9·5	8 to 11	9·5	3·5 to 5	4·0	3 to 5	3·5
Round Cores ..	14 to 21·5	18·0	14 to 20	17·0	6 to 10	8·5	8 to 12	10·5
Button Fragment ..	..	15·0	..	11·0	..	5·5	..	12·0
Hollow Round-Form Fragment ..	..	21·5	..	16·5	..	4·0	..	27·0
Ovals	7 to 20·5	14·0	7 to 11·5	9·0	2 to 2·5	2·0	2 to 3	2·5
Oval Cores	9·5 to 23·5	16·5	7 to 23·5	14·0	3·5 to 13·5	9·5	6 to 13·5	8·5
Boat Fragment ..	..	8·5	..	10·5	..	7·0	..	3·5
Boat Cores	9·5 to 26	14·5	8·5 to 21	12·0	3·5 to 8	5·5	7 to 11	9·0
Dumbbell	..	6·0	..	5·5	..	2·5	..	3·5
Dumbbell Fragment ..	..	10·0	..	10·0	..	10·0	..	10·0
"Aerial Bomb" ..	..	10·5	..	10·5	..	10·5	..	10·5
Teardrop	..	7·0	..	11·5	..	5·5	..	3·0
Core Fragment ..	..	14·5	..	10·0	..	3·5	..	7·0
Totals ..	7 to 26	12·5	7 to 23·5	11·5	2 to 13·5	6·0	2 to 13·5	7·0

line, so that the greater bulk of australite glass is thus situated on the back pole side of the radical line, and this is more pronounced among the button-shaped forms.

Taken in conjunction with RB — RF relationships, the intercept relationships are of such a nature as to indicate that among the round forms of australites, there has been greatest volume reduction by frontal ablation of the primary spheres of australite glass which ultimately yielded lens- and button-shaped forms. Such spheres were originally somewhat smaller than the primary spheres from which the australite cores were produced by ablation.

The primary spheres from which the round forms of the Kanagulk, Telangatuk East and Mt. Talbot australites were produced, ranged in diameter from 1·5 to 4·3 cms.; those from which lenses were formed, ranged from 1·5 to 2·2 cms., those from which the button-shaped forms resulted ranged from 1·5 to 2·5 cms., and those which yielded cores, ranged from 2·8 to 4·3 cms.

Comparable modifications of primary forms of revolution such as the spheroid, dumbbell and apioid, resulted in the variations in RB — RF and ON — OM relationships noted for the various elongated forms of australites from the same localities (cf. Table 2).

Comparisons with Other Localities.

The ranges and average values for the weight and specific gravity of the australites from the Kanagulk — Telangatuk East — Mt. Talbot district, are compared in Table 7 with those determined from other localities in the Western District of

TABLE 7.

Concentration Centre	Number of Complete Specimens	Range in Weight of Complete Specimens (gms.)	Average Weight of Complete Specimens (gms.)	Range in Specific Gravity	Average Specific Gravity
Port Campbell ..	212	0·065 to 56·482	2·734	2·33 to 2·47	2·404
Kanagulk	29	0·792 to 39·133	9·752	2·380 to 2·441	2·404
Telangatuk East ..	9	1·732 to 13·204	6·692	2·378 to 2·437	2·408
Nirranda – Stanhope's Bay	155	0·247 to 55·100	2·560	2·37 to 2·47	2·409
Mt. Talbot, Toolondo	5	1·980 to 3·712	2·968	2·392 to 2·424	2·410
Mt. William ..	2	..	..	2·393 to 2·443	2·418
Harrow	33	1·230 to 33·780	8·970	2·386 to 2·468	2·420
General range ..	..	0·065 to 56·482	..	2·330 to 2·470	..
General average ..	..	..	3·514	..	2·407

Victoria (cf. Baker, 1955a, 1955b, 1956; Baker and Forster, 1943). Only complete or nearly complete specimens are considered in these comparisons, and only a proportion of the complete australites so far found in the Port Campbell and Nirranda Strewnfields, have been taken into consideration.

There are statistically significant numbers of specimens for comparative purposes from nearly all of the localities shown in Table 7. The general trend is for specimens with higher specific gravity values to occur in the north-west (Harrow) of the distribution region provided by the localities listed, while specimens with the lower specific gravity values occur in the south-east, in the Port Campbell district, some 125 miles south-east of Harrow. For localities relatively close together, however, such a trend is not apparent (e.g. Kanagulk, Telangatuk East and Mt. Talbot) over the short distances involved; moreover, the average specific gravity value (2·405) for these three closely-spaced occurrences, is nearer to that for Port Campbell than for Harrow, even though situated spatially much closer to Harrow. These are relatively minor discrepancies, however, when fitted into the general provincial trend known to occur across 2,000 miles of the Australian Strewnfield as a whole.

Refractive Index and Specific Refractivity.

The refractive index values determined by the Immersion Method, using monochromatic (Na) light for 16 australites from Kanagulk, 3 from Telangatuk East and 5 from Mt. Talbot, Toolondo, are listed in Table 8, together with their respective specific gravity values and the calculated specific refractivity ($k = (n - 1)/d$). These specimens were so chosen as to represent the several shape groups in the collections, and the variations of specific gravity within and between those shape groups. The table is arranged primarily according to shape of australites, and secondarily according to increase in refractive index values among the individuals of each shape group.

There are statistically insufficient numbers of determinations in each separate shape group to warrant the calculation of their average refractive index and specific refractivity values. Table 8 reveals that the specific refractivity is more or less constant for a range in both specific gravity and in refractive index values, which properties show sympathetic variations within each separate shape group, and from shape group to shape group.

The average refractive index and specific gravity values of the smaller number of complete elongated forms determined, are slightly in excess of the averages for the larger number of round forms, but the average specific refractivity values are much the same.

Since refractive index and specific gravity values of australites are unlikely to have become radically altered, either during flight through the atmosphere of the primary forms undergoing shape modification, or subsequently thereto while the

TABLE 8.

Australite Shape Group	Listed Number of Specimen	n_{Na}	Specific Gravity	K
Round Forms.				
Button (body portion)	15	1·497	2·383	0·2086
Button (body portion)	39	1·498	2·378	0·2094
Button (body portion)	48	1·501	2·392	0·2094
Button (body portion)	47	1·503	2·409	0·2088
Flange from button	25	1·502	2·404	0·2088
Flange from button	26	1·502	2·406	0·2086
Flange from button	27	1·500	2·395	0·2088
Body of same button	27	1·499	2·388	0·2090
Lens	32	1·502	2·404	0·2088
Lens	44	1·503	2·410	0·2087
Lens	46	1·504	2·414	0·2088
Lens	45	1·506	2·424	0·2087
Round Core	23	1·500	2·394	0·2088
Round Core	2	1·504	2·412	0·2088
Hollow Round-Form Fragment	3	1·502	2·400	0·2092
Elongated Forms.				
Oval	7	1·503	2·408	0·2089
Oval Core	16	1·506	2·426	0·2086
Boat Core	12	1·498	2·383	0·2090
Boat Core	4	1·504	2·415	0·2087
Boat Core	17	1·510	2·441	0·2090
Dumbbell Fragment	19	1·498	2·386	0·2087
Dumbbell	42	1·502	2·408	0·2085
" Aerial Bomb "	22	1·501	2·391	0·2095
Teardrop	43	1·502	2·401	0·2091
Summary.				
Averages of all specimens listed in this table		1·502	2·403	0·2089
Ranges of all specimens listed in this table		1·497 to 1·510	2·378 to 2·441	0·2085 to 0·2095
Averages for round forms		1·501	2·401	0·2089
Averages for elongated forms		1·503	2·407	0·2090

(The listed numbers of the specimens are the same as those in Table 2.)

ultimate secondarily shaped forms were lying upon the earth's surface, it is evident that the differences and similarities existing among these properties as between members of the same shape group and between the separate shape groups, must primarily be a function of the mode of origin at their extraterrestrial birthplace.

Comparisons with Other Localities.

The ranges and average values of the refractive index, specific gravity and specific refractivity of a proportion of the complete australites from the Kanagulk — Telangatuk East — Mt. Talbot district, are compared in Table 9 with those so far determined from different concentration centres in south-western Victoria. Those listed for Mt. William are from Tilley (1922).

TABLE 9.

Concentration Centre	Number of Determinations	Range in n_{Na}	Average n_{Na}	Range in Specific Gravity	Average Specific Gravity	Range in K	Average K
Loch Ard Gorge, east of Port Campbell ..	1	1·513 to 1·515	..	..	2·427	..	0·2080
Telangatuk East ..	3	1·498 to 1·502	1·501	2·378 to 2·408	2·396	0·2085 to 0·2094	0·2090
Kanagulk	16	1·497 to 1·510	1·502	2·383 to 2·441	2·402	0·2086 to 0·2095	0·2089
Mt. Talbot, Toolondo	5	1·501 to 1·506	1·503	2·392 to 2·424	2·410	0·2087 to 0·2094	0·2089
Harrow	2	1·512 to 1·517	1·514	2·431 to 2·446	2·438	0·2103 to 0·2114	0·2108
Mt. William ..	2	1·504 to 1·520	1·512	2·393 to 2·443	2·418	0·2106 to 0·2128	0·2117
General range ..	..	1·497 to 1·520	..	2·378 to 2·446	..	0·2080 to 0·2128	..
General average ..	..	..	1·504	..	2·406	..	0·2094

n_{Na} = refractive index for sodium light; K specific refractivity.

(The specific gravity values listed in Table 9, refer to only those australites for which the refractive index has been determined.)

In Table 9, the specific gravity value of the Port Campbell example is well above the average (2·404) for 212 complete specimens from this field, and since refractive index and specific gravity both increase and both decrease proportionately to yield a constant specific refractivity, it is thus expected that the refractive index value shown in Table 9 for this specimen, is also much above the average. The general trend in refractive index variations across the area of comparison, more or less parallels that shown by the specific gravity variations (cf, Table 7).

Specific gravity and refractive index variations reflect variations in the silica content of natural glasses, both properties showing an increase with decreasing silica (Spencer, 1939, p. 430). Inasmuch as specific gravity and refractive index variations mean variations in silica among the individuals of the separate shape groups (Table 8), and also among the shape groups themselves (Table 8), it becomes evident that physical shape and chemical composition of australites are virtually independent of one another. This is even further stressed by more general comparisons of such properties from east to west across the vast australite strewnfield, although the range of variations is not marked between more closely spaced centres of australite concentration (cf. Table 9).

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