Tasmania

DEPARTMENT OF MINES

GEOLOGICAL SURVEY RECORD

No. 3

Darwin Glass

A NEW VARIETY OF THE TEKTITES

BY

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ILLUSTRATIONS.

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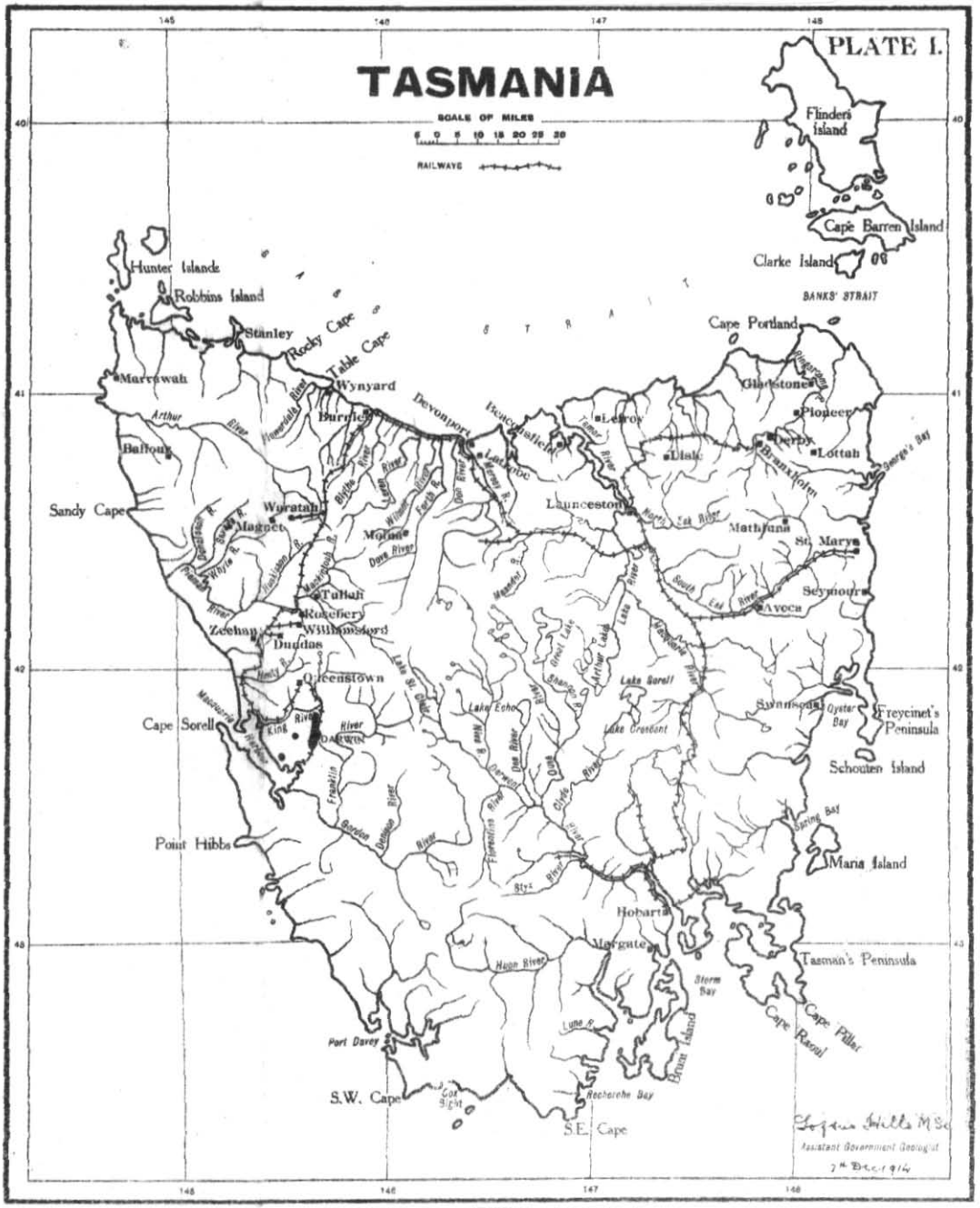

LOCALITY MAP

Photo Algraphed by John Vail Government Printer Hobart Tasmania

The Darwin Glass.

I.—INTRODUCTION.

THIS substance, with which this record deals, occurs on the West Coast of Tasmania in what has been termed the Jukes-Darwin Mining Field. Its occurrence and character were studied in conjunction with the investigation of that field, but it has been deemed advisable to publish the details concerning it as one of the series of Geological Survey Records which deal exclusively with matters of purely scientific interest.

This volume therefore should be read in conjunction with Bulletin No. 16 of the Geological Survey, which gives full details of the general geology of the area in which this substance occurs.

The Jukes-Darwin Mining Field is situated north of Kelly Basin, on Macquarie Harbour, and is bounded on the east by the North Lyell Railway. At the 10-mile peg on that railway, measured from Kelly Basin, there occurs a hill known as the Ten-mile Hill. It was on this hill that the Darwin glass was first discovered. To the west and north of this locality rise the mountain masses known as Mts. Darwin and Jukes, which reach an elevation of 3800 feet above sea-level. The exact location will be seen by referring to Plate I.

II.—HISTORY OF DISCOVERY.

This occurrence is of great scientific interest, being altogether unique. As this is the first official description of this most interesting occurrence, the writer considers that this is the proper place to give a complete statement of the history of its presentation to the scientific world.

This substance has been known to those few men who have been resident on this field for some years. Its strange character was early appreciated by these men, and speculations as to its nature and origin resulted in the application to it of the term *petrified kelp*. It is certainly strange that for the number of years which this substance has been known on the field, it is only quite recently that its occurrence has been brought under the notice of the Geological Survey. Perhaps this is explained by the great scarcity of men of scientific attainments who have visited the field.

However, the date of the first discovery is uncertain, but Vincent Bruscoe, an old identity of this field, claims to have been the first to find it, the location of the discovery being the Ten-Mile Hill, up which he used to pack his food supplies.

In the year 1910 M. Donoghue, who acted on several occasions as field assistant to Mr. L. K. Ward, then Assistant Government Geologist, presented to the latter a few pieces of slag-like glass, which he stated came from the eastern side of Jukes and Darwin. As, however, there previously existed a smelting works at Crotty, on the eastern side of Jukes, and these fragments on a casual examination would be judged as smelter slag, that conclusion was arrived at, and no further notice was taken of the matter. The fragments were, however, the real Darwin glass. To M. Donoghue, therefore, belongs the credit of attempting to bring the occurrence under official notice.

At the close of the year 1912 a fragment of light-greenish vesicular glass was received by the Geological Survey from Mr. Hartwell Conder, M.A., State Mining Engineer. In his letter to the Survey, Mr. Conder stated that the fragment had been dug up from a depth of 6 feet at a point about 3 miles west of Mt. Sorell, by trustworthy and reliable men. This certainly was puzzling, but the writer was then inclined to regard it as glass which had been melted in a camp fire, probably lighted by a party from

the convict settlement on Macquarie Harbour, although the distance from the surface was rather disconcerting.

Early in the next year (1913) Mr. Conder employed Vincent Bruscoe and his mate, Harry Thompson, as State prospectors, and Bruscoe took the opportunity of presenting to Mr. Conder a few fragments of his " petrified kelp." Mr. Conder at once recognised its resemblance to the occurrence west of Sorell, and communicated this to the Survey. At this time the writer had commenced the geological survey of this region, and on receiving word from headquarters that the " glass " had turned up on Mt. Darwin, took the first opportunity to investigate its actual occurrence. As a result, the possibility of an artificial origin was at once negatived, and the details of its mode of occurrence were thoroughly investigated. These details are presented for the first time.

III.—DISTRIBUTION AND MODE OF OCCURRENCE.

The location of the first discovery, as stated above, was the Ten-Mile Hill, and this is the point where the writer first investigated the occurrence. At the eastern foot of this hill is the North Lyell Railway, and the hill rises from this point to a total height of 500 feet above the railway, with a slope of 1 in $2\frac{1}{2}$. The glass occurs from the level of the railway-line up to a point 400 feet above it, and there ceases. This point is 1240 feet above sea-level. The glass occurs in fragments of all sizes, lying loose on the surface or in the detrital material of the surface, but is wholly confined to the upper 9 inches of that deposit. The underlying rock is quartzite and sandstone of the West Coast Range Conglomerate series of indeterminate Pre-Silurian age, and the detrital material consists of angular fragments of these rocks together with the glass.

The cessation of the occurrence of glass before the summit of the hill is reached is very marked, and the writer in no part of the field found the glass at a greater elevation than 1240 feet above sea-level.

On the western side of the Ten-Mile Hill is a depression, west of which is a continuous rise to the South Darwin Plateau. In this depression the country rock changes to felsites and schists of the porphyroid series of Pre-Silurian age, but much older than the conglomerate series, which continue up the rise to the plateau, which is composed of porphyroid granite. *Neither in this depression, nor up the rise, nor on the plateau itself, is this glass observable.* It may be accepted as a positive fact that no glass does exist on the plateau, as alluvial deposits thereon have been sluiced for gold by Bruscoe, and no glass observed.

Going north from the Ten-Mile, the glass was found constantly and persistently to Crotty, and was again observed in limited amount on the track to the Jukes Proprietary, but there again ceasing at a point above sea-level corresponding with the point of cessation at the Ten-Mile Hill.

In addition it was observed east of the railway-line, lying directly on the Silurian limestone, and in soil composed wholly of the residual weathering products of the limestone. As the railway was chosen as the eastern boundary of the area studied as the Jukes-Darwin Mining Field,

the distribution of the glass to the eastwards of the railway-line was not definitely determined.

In no case, however, was the glass observed high up on the mountain ranges.

Summing up, therefore, we see that the distribution on the eastern side of the mountain range is included in a narrow strip about 9 miles long by about 20 chains wide, and not exceeding a height of 1240 feet above sea-level. Its most plentiful occurrence is on the Ten-Mile Hill, where large quantities can be collected.

On the western side of the mountain range it has been reported, as stated previously, from a point 3 miles west of Mt. Sorell, and quite recently Bruscoe reported that he had observed its occurrence at Flannagan's Flat, west of Mt. Darwin, at about 500 feet above sea-level.

These are the only recorded occurrences in Tasmania. The geographical positions of the known occurrences are shown in Plate I.

IV.—CHARACTER AND MODE OF ORIGIN.

The writer collected a considerable amount of this glass, fully realising that there would be some demand for specimens from scientists in different parts of the world. Immediately on his return from the field, therefore, several specimens were submitted to Professor F. E. Suess, of Vienna, the well-known authority on cosmic glasses. Since then a reply has been received from Professor Suess, and as his remarks are of great interest and importance they are quoted below, this being a somewhat free translation of his letter.

Description by Professor F. E. Suess.

" Of the nine fragments submitted to me, eight consist of greenish-brown glass; one, however, is of quite a different character. It is an irregular massive fragment of a whitish-green, smooth and enamel-like smelted product, with adhering particles of sand, earth, and plant fibres. It is opaque, and in the interior is porous, thus resembling scoriæ. The lustre is much less than that of thoroughly melted glass. I have seen nothing among Moldavites that is in the least comparable to this fragment. Certainly their occurrence in localities where Moldavites have been found would be regarded as due to artificial agencies, and would not be looked upon in a broader way. If such fragments have been found in the totally unsettled region of Western Tasmania, they are to me quite puzzling. I would be grateful to you if you would inform me whether more fragments of the same character were found in the same deposit.

" The eight glass fragments I cannot definitely class as Moldavites, yet they bear the closest resemblance thereto of any extra-European glass I have yet seen.

" They are distinguished from the Moldavites first by their colour. These are mostly beautiful bright-green (seldom brownish-green), and in transmitted light—if they are not too thick—very clearly transparent. The glasses from Tasmania are more turbid, yellowish-green, and less transparent. The transparency would obviously be decreased in part by the adhering impurities (probably traces of devitrification), and to some extent by the number of enclosed vesicles.

" The fragments show no Moldavite structure, none of the sharply-defined grooves or the fine truly thread-like furrows which coincide with the air-ejection lines, and which are highly characteristic of the Moldavites in their most typical developments. Under the lens there is to be seen on many pieces the occurrence of a brilliant granulation consisting of fine, irregular pits, as in many Moldavites; they have probably originated through devitrification and chemical corrosion.

" The glass of Moldavites is much clearer and more dense, not so full of vesicles, and not so slaggy as that of the Tasmanian pieces.

" The latter are also fragmentary in character, like most of the Bohemian Moldavites, and thus differing from all other extra-Eurpoean Tektites. On a cross-section of one piece I see a sinuous fluidal structure brought into relief by weathering; also this can be seen in many Moldavites.

" These Tasmanian fragments are very similar to only one group of Moldavites which I have called *stretched or distorted forms*, and have likened to twisted volcanic ejectamenta. Here are also found roll-shaped and plug-shaped stretched forms and elongated vesicles; the furrowing along the stretched vesicles which I have designated air passages (S. Herk. d. Moldavite, p. 304, Figs. 28 and 29) is found in one piece in an exactly similar manner; but they are only isolated in Moldavites, whereas they are quite crowded in the Tasmanian pieces. In the Moldavites there are found occasionally single larger vesicles, but never have I seen Moldavites so thickly studded with vesicles as in one of the pieces before me.

" The outlines of the Tasmanian glasses are smoother and more rounded. In two pieces I see small drops adhering to a larger flat surface as if they had been welded or smelted on to it. I do not remember ever having seen anything resembling this in Moldavites.

" By virtue of all these characteristics the Tasmanian glasses would have a greater resemblance to stretched volcanic ejectamenta than have the twisted forms among the Moldavites. Nevertheless, I am inclined, on account of the nature of the glass and on account of the situation of the place of discovery, to place them amongst the Tektites. A decisive conclusion must depend on the chemical analysis."

In amplification of the above very complete description of this Darwin glass, the writer may add that the white or whitish-grey enamel-like pieces are quite common amongst the other fragments in the same deposit.

The size of the fragments generally varies from rounded or drop-like masses the size of a pin's head, to irregular-shaped fragments up to 6 cm. long by 2.3 cm. wide, and weighing 21 grams. All these varying sizes are indiscriminately mixed in the one deposit.

The colour varies from the white or whitish-grey of the enamel-like pieces to a deep-black, which, however, appears on the edges by transmitted light to be greenish-brown. Some fragments are a fine pale yellowish-green in colour, and these are quite transparent.

The number of vesicles present in different fragments varies greatly, all gradations existing, from a thoroughly scoriaceous and pumiceous fragment to almost solid glass with a few elongated vesicles. These vesicles have a maximum length of 2 cms.

The fragments vary from complete transparency to completely opaque, with, however, a slight transparency at the edges. This opacity is seemingly due to the crowded vesicles.

The vesicles are generally elongated, but rounded approximately circular cavities also occur. The elongated vesicles are generally parallel.

A marked and almost uniform characteristic is undoubtedly the distorted, twisted structure. This resembles the appearance of a strip of plastic material which has been pulled and twisted, and then occasionally doubled back on itself; in addition, also, there occur forms which show such a twisted strip irregularly stuck on to a fragment showing no distortion.

The occurrence of pronounced pimples on the surface, as pointed out by Professor Suess, is quite characteristic. These are practically spherical masses of glass from 1 to 2 mm. in diameter, adhering to the relatively flat surface by a point only.

Another characteristic feature in some specimens is the corkscrew-like twist which has been given the fragment as a whole. The result is a fragment possessing a half corkscrew twist, which is faithfully followed by the elongated vesicles.

Plates II. and III. show photographs of some typical fragments. Plate IV. features a fragment showing the remarkable pimply excrescences.

Examined in thin section under the microscope, the glass shows absolutely no structure, there being no indication whatever of incipient crystallisation. The vesicles are generally empty, but occasionally are partly filled with an indeterminate brownish substance.

The specific gravity varies in different fragments from 2·180 to 1·874, varying with the number of vesicles present. The hardness is 7 in Mohr's scale.

The chemical composition is certainly remarkable, as the following analysis by Professor Ernest Ludwig, of Vienna, will show:—

Professor Ernst Ludwig's Analyses.

	(1) Olivine Green.	(2) Dirty White.
SiO_2	88·764	89·813
TiO_2	1·240	0·857
Al_2O_3	6·127	6·207
Fe_2O_3	—	0·258
FeO	1·238	0·895
CaO	0·174	—
MgO	0·575	0·727
K_2O	1·363	1·054
Na_2O	0·129	0·010
MnO	Trace	Trace
	99·610	99·821

Other constituents were not present.

The most striking feature of these analyses is the silica percentage, which is higher than has been previously recorded in any glass, either artificial or natural.

Turning now to the question of mode of origin of this glass, we will first compare its composition with that of the other natural glasses. The following table will enable such a comparison to be made:—

	Moldavites.							Billitonites.		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
SiO_2	82·28	77·75	77·69	81·20	82·68	78·61	77·96	74·30	71·14	70·92
Al_2O_3	10·08	12·90	12·78	9·65	9·56	12·01	12·20	13·83	11·99	12·20
Fe_2O_3	—	—	2·05	2·25	1·13	0·16	0·14	—	—	1·07
FeO	2·03	2·60	1·45			3·09	3·36	3·60	5·29	5·42
MnO	—	—	—	0·11	0·18	0·11	0·10	—	0·32	0·14
CaO	2·24	3·05	1·26	2 65	2·06	1·62	1·94	5·22	2·84	3·78
MgO	0·98	0·22	1·15	1·80	1·52	1·39	1·48	1·50	2·38	2·61
K_2O	2·20	2·58	2·78	2·34	2·28	3·06	2·70	—	2·76	2·49
Na_2O	0·28	0·26	0·78		0·63	0·44	0·61	—	2·45	2·46
TiO_2	—	—	—	—		—	—	—	trace	—
Ignition loss	0·06	0·10	—	—	—	—	—	0·13	—	—
Total	100·15	99·46	99·74	100·0	100·04	100·49	100·49	98·58	99·17	101·09

	Australites.									Darwin Glass.	
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
SiO_2	73·70	64·68	71·38	73·40	71·22	68·91	79·51	69·80	73·59	88·764	89·813
Al_2O_3	4·99	16·80		12·65	13·52	15·42	10·56	15·02	12·35	6·127	6·207
Fe_2O_3	—	1·01	19·36	4·74	0·77	0·40	0·60	0·40	0·38	—	0·258
FeO	6·08	6·57			5·30	4·86	3·11	4·65	3·79	1·238	0·895
MnO	—	0·20	--	—	0·28	0·08	0·06	0·18	0·15	trace	trace
CaO	4·20	3·88	2·86	4·30	3·52	3·88	1·48	3·20	3·76	0·174	—
MgO	0·10	2·50	1·89	0·74	2·38	2·49	1·35	2·47	1·80	0·575	0·727
K_2O	4·83	4·01	—	--	2·28	2·50	1·25	2·56	1·93	1·363	1·054
Na_2O	5·20	trace	—	—	1·48	1·20	0 91	1·29	1·03	0·129	0·010
TiO_2	—	—	—	—	—	0·08	0·63	0·80	0·70	1·240	0·857
Ignition loss	0·55	—	—	—	—	0·13	0·19	—	0·80	--	—
Total	99·65	99·65	95·49	95·83	100·75	99·96	99·65	100·37	100·29	99·610	99·821

1. Moldavite from Radomilitz, near Budweis, light-green.
2. Moldavite from Radomilitz, near Budweis, dark-green. } C. v. John Jahrb. d. kk. geol. R.-A. 1899. S. 473.
3. Moldavite from Radomilitz, near Budweis, light-brown.
4. Moldavite from Wittingau, near Budweis. J. Hanamann.
5. Moldavite from Budweis, light-green. } C. v. John Verhandl. d. kk. geol. R.-A. 1899. S. 179.
6. Moldavite from Trebitsch.
7. Moldavite from Trebitsch.
8. Billitonite, Dr. Cretier in Batavia. De Groot Jaarboek van bet Mijnwezen 1879, II. S. 229.
9. Lura Mijn Nr. 13 Dendang. Dr. Brunck in Freiberg. Verbeck Jaarb v. h. Mijnwezen 1897, S. 240.
10. Tebrug, Dendang. C. v. John Wien, geol. R.—A. 1900.
11. Wimmera (Victoria), Australia. Analysis, J. Cosmo Newbury, Melbourne Exhibition Catalogue, 1866.
12. Uralla, New South Wales, 1897.
13. Mt. Elephant (Victoria), 1898. M. Stone, Assayer to the Mines Department.
14. Central Australia. Analysed 1898 by R. H. Walcott.
15. Between Everard Range and Fraser Range Analysed in 1900 by C. v. John, Vienna.
16. From Uralla, New South Wales. Analysed by J. C. H. Mingaye.
17. From Curdie's Inlet, Victoria. Analysed by G. Ampt, B.Sc.
18. From Upper Weld, Tasmania. Analysed by W. F. Hillebrand, 1905.
19. From Pieman River, Tasmania. Analysed by W. F. Hillebrand, 1905.
20. From Ten-Mile Hill, Mt. Darwin, West Coast, Tasmania. Analysed by Professor Ernst Ludwig, Vienna, in 1913.
21. From Ten-Mile Hill, Mt. Darwin, West Coast, Tasmania. Analysed by Professor Ernst Ludwig, Vienna, in 1913.

An examination of this table will serve to show that there is sufficient agreement in all these analyses to suggest a general relationship between the Darwin Glass and Moldavites, Billitonites, and Australites.

Discussing now the mode of origin of this Darwin glass, as indicated from its mode of occurrence and composition,

we find that there are several sources which are suggested by a casual examination. These are—(1) Artificial products; (2) volcanic products; (3) fulgurites; and (4) cosmic or meteoric origin.

(1) *Artificial Products.*—The existence of a copper smelting works at Crotty, which is in the northern portion of the area over which this glass is spread, was responsible for the failure to recognise its unique character when first brought under the notice of the Geological Survey. When the mode of occurrence and composition are taken into consideration, the possibility of such an artificial origin is at once negatived. In the first place the glass is found consistently between the site of the smelting works and its most plentiful occurrence—the Ten-Mile Hill—a distance of 9 miles, which could hardly be explained as due to human agencies. In addition, also, such an origin cannot account for the occurrence west of the mountains. Not only so, but its occurrence a foot and more below the surface cannot be explained as due to human agencies in a locality known to have been penetrated by man for at most 17 years, and then only by a few men, who only traversed it *en route* to other spots; it has never been a scene of habitation. Finally, to exclude this mode of origin is the composition, which is totally distinct from that of smelter slag.

(2) *Volcanic Products.*—There are no acid volcanic rocks in Tasmania of recent date. The most recent volcanic rock is basalt of Tertiary age. If the glasses are volcanic products they must have travelled through the atmosphere for great distances. It is not feasible to suppose, either, that they are derived from the old Pre-Silurian extrusions of the porphyroid series, for the great age of the latter would necessarily have developed devitrification, which is totally absent. In fact, the chemical composition again precludes a volcanic origin, for no volcanic glass with 89 per cent. silica has yet been recorded. Thus it is possible to definitely state in the case of this Darwin glass that a volcanic origin, from whatever source suggested, is impossible, a statement which has not been altogether justifiable from a chemical point of view in regard to the Australites.

(3) *Fulgurites.*—This origin has been suggested, but again it will not account for the facts. The plentiful distribution is hardly explicable on this supposition. The recorded occurrences of fulgurites are comparatively few, and although resembling in some respects this Darwin glass,

yet hardly agree in essential characteristics. A fulgurite being caused by the fusion of a rock by an atmospheric electric discharge must necessarily correspond in approximate composition with that rock. How, then, is it possible to account in this way for the occurrence of the glass lying directly on limestone in soil wholly composed of peat and the residual weathering products of that limestone, such as occurs at Darwin east of the railway-line? These fragments so found are similar in every way to those found resting on quartzite, and still preserve the "pimply" excrescences, which would be worn away if carried by water. The only explanation in the case we are now considering is that the fragments were dropped on to the surface during the formation of the present soil. The "fulgurite" origin cannot, therefore, be substantiated.

(4) *Cosmic or Meteoric Origin.*—A derivation from this source is the only remaining explanation of this substance. This conclusion agrees with that arrived at by the majority of investigators in regard to Moldavites, Australites, and Billitonites. As previously remarked, there is a strong similarity in the composition of these and the Darwin glass, the latter, however, being distinguished from the remainder by its especially high silica percentage. From the point of view of physical characteristics and external form, the conclusion arrived at is that the glass is very similar to Moldavites, but differs from them as a whole in the large number of vesicles and the pronounced "distorted structure," although it is difficult to decide, on examining certain fragments, whether they are Moldavites or the Darwin glass. As stated by Professor Suess, the Darwin glass is the nearest approach to Moldavite of any cosmic glass found outside Europe. The regular form of the Australites and the rounded shape of the Billitonites are not charactristic of this variety.

The writer therefore has no hesitation in stating that the Darwin glass belongs to the family of the Tektites, and that it constitutes a new variety thereof. Its relatives, therefore, are the Moldavites, Billitonites, and Australites. Its mode of occurrence as herein described proves in his opinion beyond doubt that these Tektites are of extra-terrestrial origin.

LOFTUS HILLS, M.Sc.,
Assistant Government Geologist

Launceston, 7th December, 1914

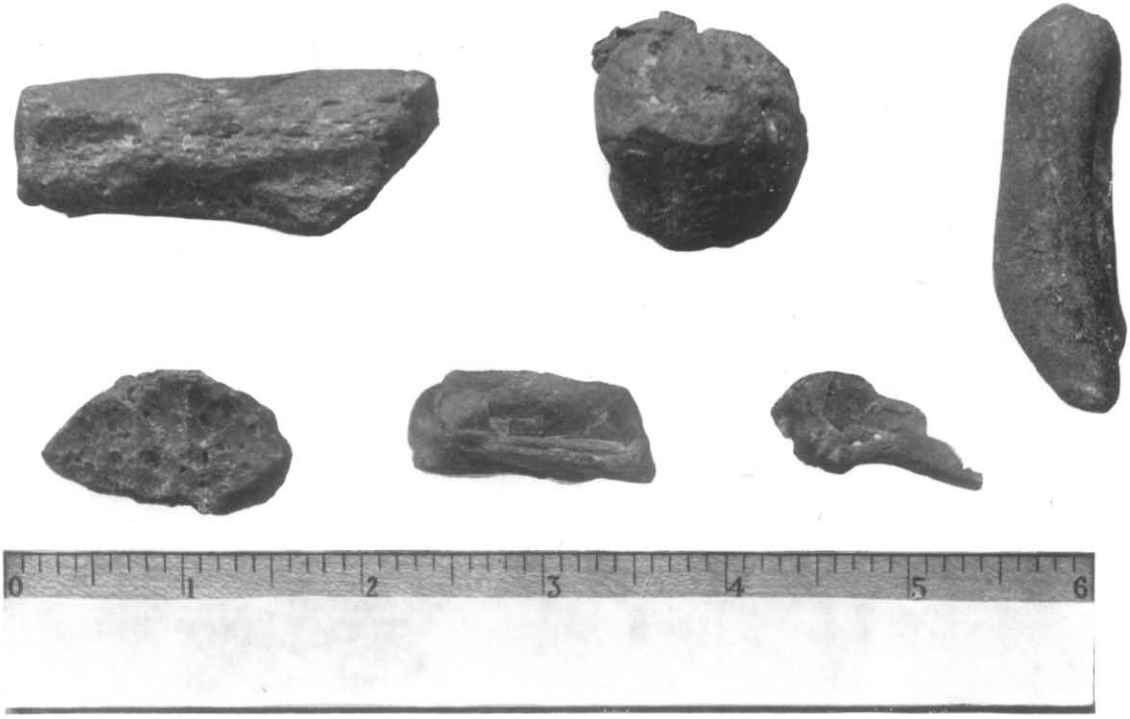

PLATE II.—Typical Fragments of Darwin Glass.

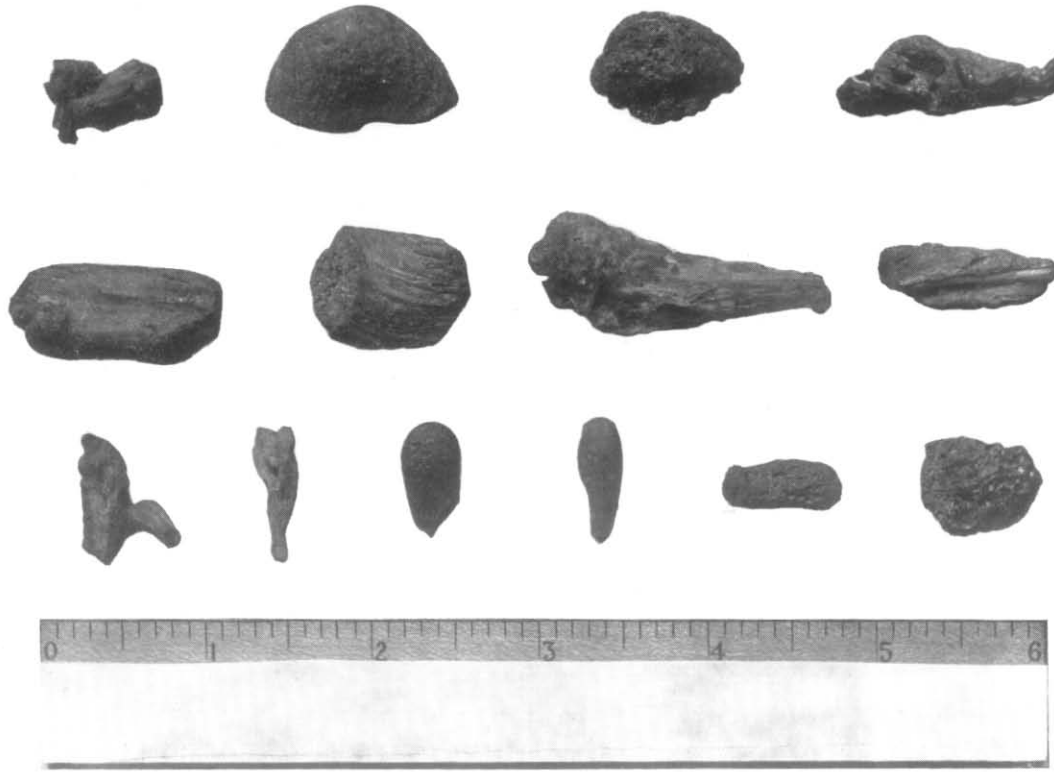

PLATE III. - Typical Fragments of Darwin Glass.

PLATE IV.—Fragment of Darwin Glass showing "pimply excrescences."