ON TEKTITES AND PSEUDO-TEKTITES FROM DUTCH EAST INDIES AND PHILIPPINES

BY

CATH. M. KOOMANS.

With 14 chemical analyses.

CONTENTS.

I. INVESTIGATED MATERIAL

Dr. KUIPER and Dr. NIEUWENKAMP collected remarkable, etched pieces of dark glass, strongly resembling tektites, in Patagonia. Dr. PH. H. KUENEN director of the geological institute of the Rijksuniversiteit at Groningen kindly put them at our disposal for investigation. They are now in the Rijksmuseum van Geologie en Mineralogie of Leiden. The chemical analysis and the optical examination showed that these objects are not tektites, but pebbles of volcanic glass.

From Palembang pebbles of obsidian are known, which might be taken for tektites by a layman in these matters, but not by an expert. These pebbles were collected by Prof. Dr. B. G. ESCHER in 1917 in South-Palembang, Boorterrein Soengei Taham near Moeara Enim, on account of their interesting sculpture. They were analysed together with the well-known obsidian from Goenoeng Kiamis near Garoet (collected by ESCHER in 1929) and were found to bear much resemblance in chemical respect.

From Siam we recieved some tektites through the kind intermediary of Dr. PHRA UDOM in 1934. An analysis of these tektites amplifies the knowledge of these tektites, of which till now only one analysis has been published by A. LACROIX (bibl. 3).

From the Philippines Dr. P. V. VAN STEIN CALLENFELS sent us tektites. In 1934 Rev. M. Selga sent some tektites and pseudo-tektites from the Philippines. In 1936 we recieved a collection of tektites, pseudo-tektites (including pseudo-amerikanites) and obsidian from Dr. H. OTLEY BEYER of Manilla.

In 1935 Dr. G. H. R. VON KOENIGSWALD was so kind as to send us some tektites from Java, from the occurrence discovered by him, Kaliosso, Soerakarta.

Once again we cordially thank all for their gifts, by which the collection of the Rijksmuseum van Geologie en Mineralogie at Leiden was enlarged to such an important extent.

II. THE SCULPTURE OF TEKTITES AND PSEUDO-TEKTITES.

A. Tektites.

Besides the dark colour and shape of the pseudo-tektites it is especially their sculpture by which they resemble real tektites. Most investigators of tektites are convinced that they owe their sculpture to etching in the soil. If it is assumed that tektites really are meteorites then their sculpture is not the result of superficial melting during their fall through the atmosphere. The sculpture may therefore not be compared with that of ironmeteorites and stonemeteorites on which symptoms of superficial melting, flowing away and blowing away of material are to be observed.

The intensity of etching of the tektites shows much variation. The *Australites* are not etched at all, slightly etched are the tektites from Indo-China and Siam and the *Moldavites*. As far as the material which reached us allows a judgment, the tektites from the Philippines are also only slightly etched. As in the first place groundwater is necessary for etching, it is not astonishing that the australites, which are found for the greatest part in a territory with a desert climate, are not etched. Where groundwater does occur in the layers in which the tektites lie, as in Bohemia, Indo-China, Siam, the Philippines and Java, the etching is clearly present. Pieces occur with surfaces showing slighter etching beside other parts with an etching normal for these objects prove that these tektites were broken a considerable time after their appearance in the layers in which they lie. Also Billitonites are known, which were carried along by brooks after they were etched and entirely or partly lost their etching-sculpture. Instead they present a grained surface as a result of transport together with gravel through running water.

The billitonites are by far the most strongly etched and it seems to me that the presence of tin-ore, topaz and tourmaline in Billiton is significant. All these minerals point to pneumatolitic influence, through which fluor is present in the ground and strongly diluted hydrofluoric acid would make the stronger etching of the billitonites clear.

Very remarkable etched billitonites, in which etching has evidently taken place along cracks, which ran more or less parallel to the original surface, have been figured by LACROIX (bibl. 3, pl. IV).

In fig. 1 some remarkable examples of this kind are combined

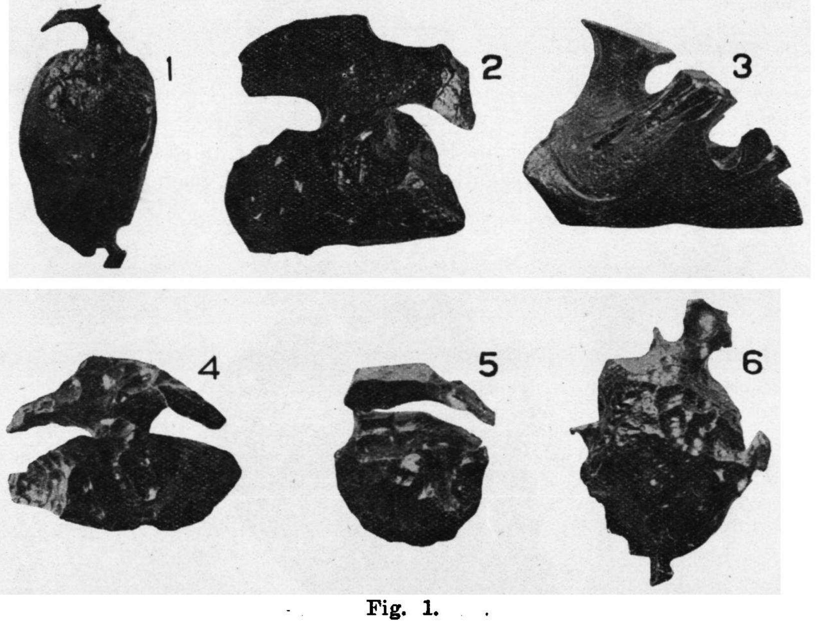

Fig. 1.

Billitonites 1—6. × 1.5.

with interesting specimens with little tables. In particular fig. 2 should be noted which shows a billitonite with 8 tables, of which the upper surfaces are parallel to the body of the billitonite and through which a former surface can easily be reconstructed (fig. 3).

B. Pseudo-tektites.

As has already been said it is in the first place the resemblance in sculpture between the tektites and the pseudo-tektites which caused the name pseudo-tektites to be given to the latter. Not much need be said about them.

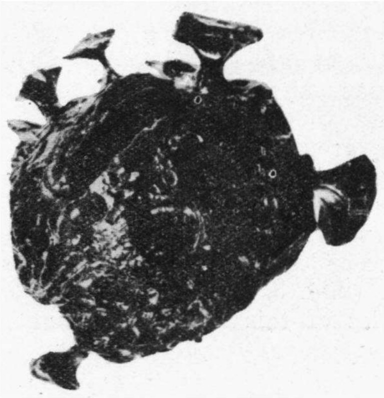

Fig. 2.

Billitonite with tables. $\times$ 2.

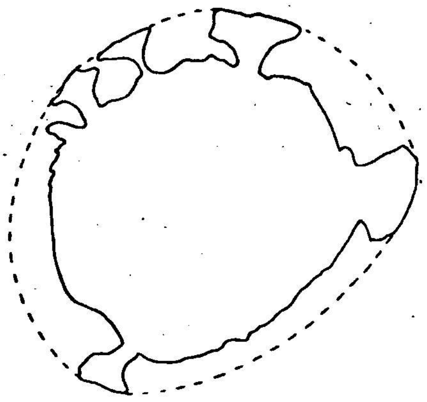

Fig. 3.

Former surface of Billitonite.

The pseudo-tektites from Patagonia are the most strongly etched (see fig. 4 and 5). The pseudo-amerikanites and pseudo-tektites from

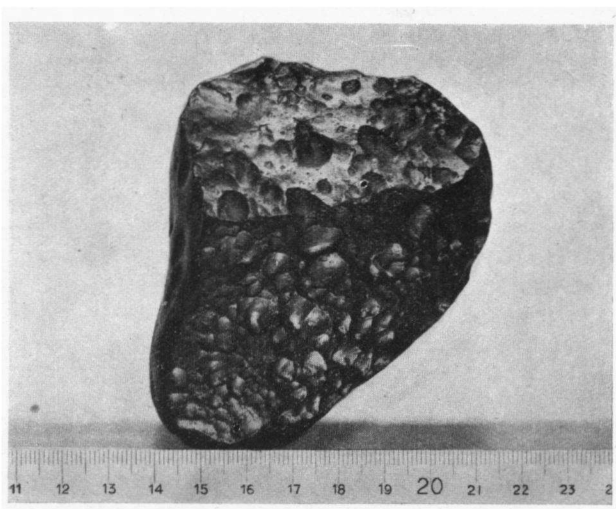

Fig. 4.

Pseudo-tektite from Patagonia.

the Philippines are much less strongly etched, the degree of etching, however, is the same as that of the real tektites from the Philippines (fig. 6).

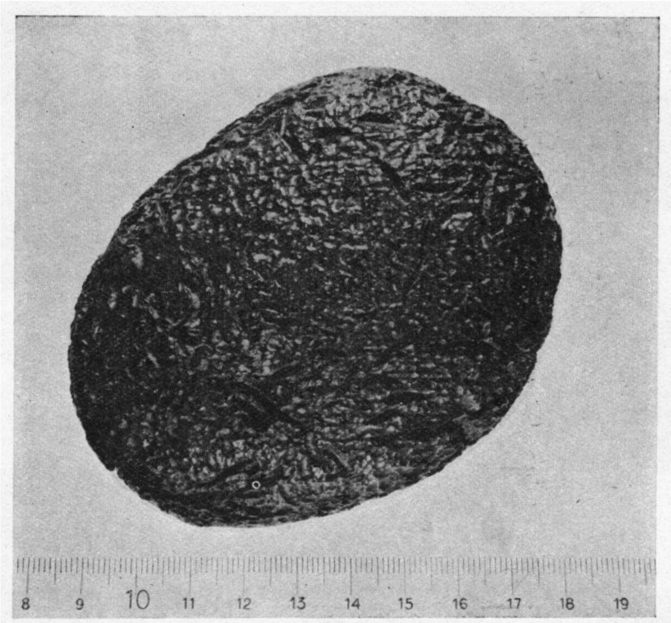

Fig. 5.

Pseudo-tektite from Patagonia.

III. FORM AND PHYSICAL PROPERTIES OF THE INVESTIGATED MATERIAL.

The tektites from Siam, Java and the Philippines do not show much difference. As far as they are not chips, they are spheres or rotation-ellipsoids of 4 to 2 cm at most. In transmitted light they all have a bronze-green colour. If small pieces are heated at 1000° in the electric oven, the colour changes to dark brown after half an hour, while the surface obtains a mother of pearl lustre. There is no development of gas, but the corners are rounded by the beginning of melting.

By means of the SCHROEDER VAN DER KOLK method the refractive index was determined. For the Siam-tektite was found 1.50 and for the Java- and Luzon-tektite 1.51. The specific gravities vary from 2.409 to 2.442 (see table 1). The slides show no trace of cristallization, the tektites consist entirely of isotropic glass.

The pseudo-amerikanites (bibl. 7) have irregular, but always rounded shapes, the dimensions are small, 1½ to 2 cm. In transmitted light the colour is grey, when heated at 900° the pieces are blown up already after five minutes to a porous sphere by the escape of gas.

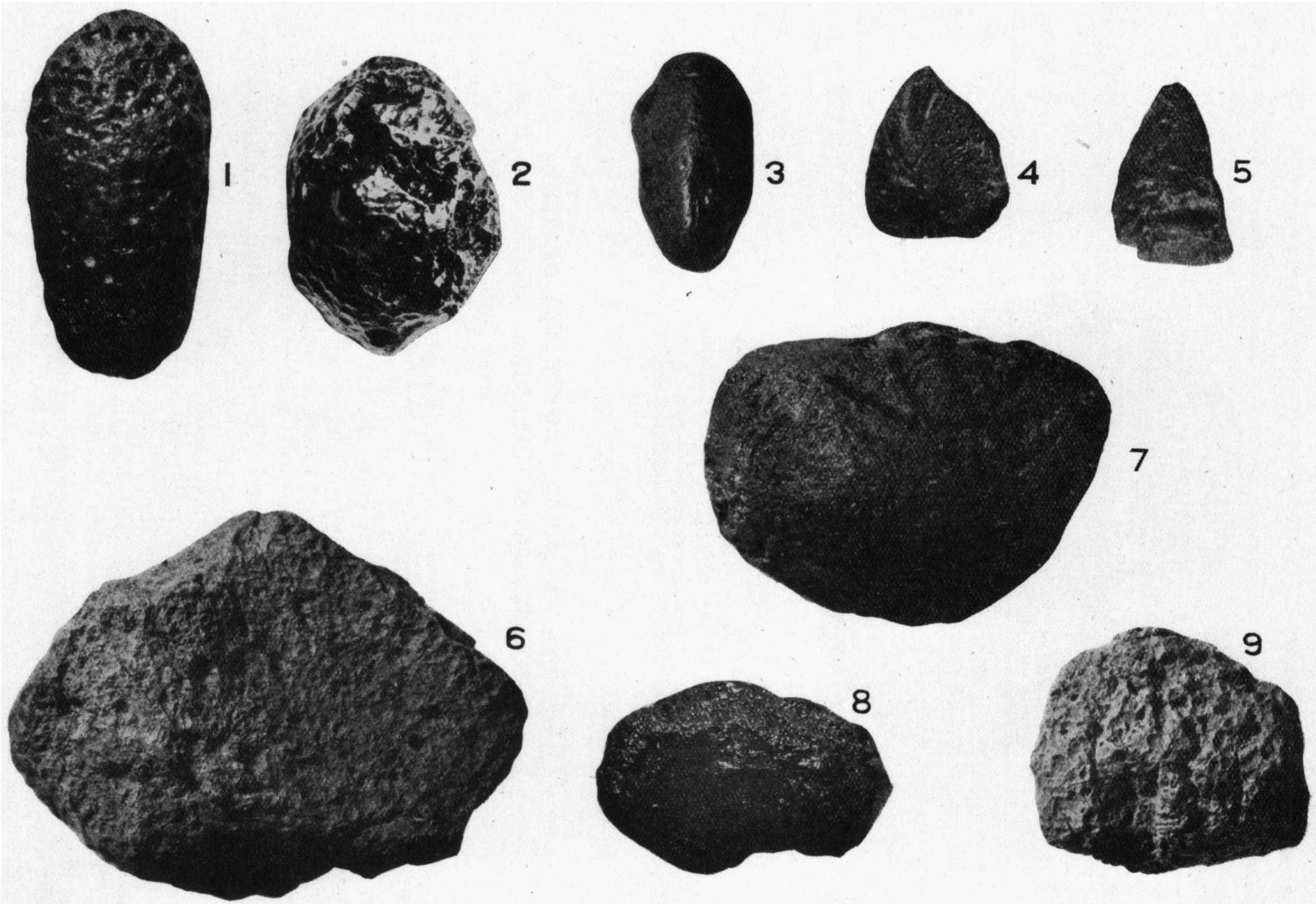

Fig. 6.

1 and 2 Tektites; 3, 4 and 5 pseudo-amerikanites; 6, 7, 8 and 9 pseudo-tektites from the Philippines. $\times$ 1.5.

The refractive index is 1.48, the specific gravity 2.32—2.34. The slide looks exactly the same as that of the tektites showing no trace of cristallization.

The obsidian from the Philippines has entirely the same properties as the pseudo-amerikanites, the only difference is the presence of microlites in the slide.

Two kinds can be distinguished in the pseudo-tektites from the Philippines, namely

a. with a specific gravity of about 2.59, and a refractive index 1.53.

b. with a specific gravity 2.77 to 2.91 and a refractive index varying from 1.57 to 1.61.

Outwardly the first kind mostly resembles the real tektites, rounded shapes with a black, etched surface, which is somewhat less lustrous than that of the tektites. In transmitted light they are very dark grey to almost opaque. After ten minutes heating at 1100° the pieces extended by the escape of gas and obtained a brown metallic lustre. After half an hour the sphere begins to reduce in size and to melt. The slide shows that these pseudo-tektites are also entirely vitreous without any cristallization.

The second kind has much larger dimensions, the largest is 14×7 cm. The surface is brown and weathered. When heated gas is produced just as in the case of *a* and the colour obtains a greyish-brown lustre. When heated for a long time however no melting could be obtained at 1100°. Under the microscope double refraction is visible with crossed nicols, but distinct crystals are not to be seen.

The pseudo-tektites from Patagonia are very large too, 14×9 cm. Only very thin fragments are translucent and then the colour is dark grey. The specific gravity is 2.55 and the refractive index 1.51 to 1.52. In contrast with all the other pseudo-tektites no gas is produced after half an hour heating at 1100°. However, the piece melted to a little sphere. The slide shows fenocrists lying in a groundmass of glass. The fenocrists are **1.** plagioclase, sometimes with symptoms of corrosion and often slightly zonal. **2.** monoclinic pyroxenes, often twinned. The pleochroism is colourless to light-green. The extinction angle is 28—45°, sothat probably it is diopside. The pyroxen fenocrists are nearly always surrounded by a reaction-rim. **3.** magnetite grains.

The pebbles of obsidian from Palembang are entirely similar to the obsidian from the Philippines. At 900° gas escapes. The specific gravity is about 2.35 and the refractive index 1.48. Plagioclase fenocrists in a groundmass of glass are to be seen under the microscope.

TABLE 1.

	1 (L 103)	2 (L 64)	a	3 (L 101)	4 (L 102)	5 (L 99)	b
s.g.	2.442	2.409	2.429	2.431	2.436	2.439	2447-2.451
SiO_2	70.62	72.40	73.74	71.32	71.20	70.66	71.64
TiO_2	0.62	0.74	0 84	1.04	0.92	0.63	0.98
P_2O_5	0.12	0.14	—.—	0.13	0.10	0.18	—.—
Al_2O_3	12 34	12 68	12.71	12.16	13.52	12.08	12.53
Fe_2O_3	2.25	0.23	—.—	2.03	0.59	1.78	—.—
FeO	3 17	3.59	4.78	3.03	3.89	4.52	5.32
MnO	0.10	0.06	0.10	0.11	0.08	0.16	0.10
MgO	3.61	2.34	1.39	2.94	2.23	3.65	2.79
CaO	2.99	2.75	2.52	2.95	3.40	2.97	3.42
Na_2O	1.68	1.68	1.92	1.66	1.59	1.62	1.21
K_2O	1.57	3.16	2.20	1.90	1.84	1.69	2.28
$+H_2O$	0.75	0.43	0.26	0.51	0.63	0.15	0.19
$-H_2O$	—.—	—.—	—.—	—.—	—.—	—.—	—.—
	99.82	100.20	100.46	99.78	99.99	100.09	100.46
si	309	340	376	328	331	299	321
al	32	35	38	33	37	30.5	33
fm	42.5	31	31.5	39.5	33	45	38.5
c	14	14	14	14.5	17	13.5	16.5
alk	11.5	20	16.5	13	13	11	12
ti	2.10	2.50	3.36	3.59	3.07	2.03	3.22
p	0.26	0.28	—.—	0.28	0.28	0.25	—.—
h	11.02	6.76	4.28	7.73	9.78	2.03	2.96
k	0.39	0.48	0.43	0.42	0.43	0.41	0.55
mg	0.55	0.52	0.34	0.51	0.47	0.51	0.48
c/fm	0.33	0.44	0.44	0.37	0.52	0.30	0.42

TABLE 2.

	6 (L 63)	7 (L 97)	8 (L 96)	9 (L 98)	10 (L 100)	11 (L 66)	12 (L 65)
s.g.	2.551	2.323	2.338	2.330	2.594	2.767	2.912
SiO_2	64.75	73.56	73.05	72.76	58.17	50.68	50.12
TiO_2	0.99	—.—	—.—	—.—	1.47	0.88	0.92
P_2O_5	0.29	0.10	0.11	0.16	0.26	0.17	0.16
Al_2O_3	17.22	14.11	14.42	14.42	18.90	14.28	14.02
Fe_2O_3	2.16	1.65	0.97	2.28	1.21	2.14	5.85
FeO	2.83	1.18	1.44	1.19	5.12	10.24	7.20
MnO	0.08	0.08	0.08	0.12	0.24	0.14	0.14
MgO	1.63	0.55	0.36	0.59	3.37	5.29	6.27
CaO	2.98	1.33	1.45	1.45	5.06	11.11	10.39
Na_2O	3.76	3.33	4.40	3.38	3.44	3.05	3.26
K_2O	2.85	3.49	2.83	3.15	2.15	1.07	0.79
$+H_2O$	0.31	0.86	0.80	0.49	0.37	0.96	0.96
$-H_2O$	0.04	—.—	—.—	—.—	—.—	0.15	0.13
	99.89	100.24	99.91	99.99	99.76	100.16	100.21
si	256	403	391	381	184	121	117
al	40	45.5	45.5	44.5	35	20	19.5
fm	26	16.5	13.5	19.5	33	43	46
c	12.5	8	8.5	8	17	28	26
alk	21.5	30	32.5	28	15	9	8.5
ti	3.80	—.—	—.—	—.—	3.41	1.30	1.30
p	0.48	0.33	0.32	0.31	0.38	0.14	0.14
h	4.52	15.80	14.20	8.50	3.98	8.90	8.50
k	0.33	0.41	0.30	0.38	0.29	0.18	0.13
mg	0.37	0.27	0.21	0.24	0.48	0.43	0.47
c/fm	0.49	0.47	0.62	0.42	0.52	0.66	0.56

IV. THE CHEMICAL COMPOSITION OF THE MATERIAL.

The exceptional composition of the tektites has more and more drawn the attention in the tektite-problem. Consequently this composition, which does not correspond to that of the terrestrial eruptive rocks, is a very important argument for the cosmis origin of the tektites.

Therefore it is of great importance to ascertain the chemical composition of the pseudo-tektites, the more so as their specific gravity differs from that of the tektites. It is therefore to be expected, that the composition too will be different.

In the first place the following tektites were analysed (Table 1):

1. Tektite from Java .... anal. C. M. KOOMANS.
2. „ „ Siam, Dhupan Hill. .... „ „
a. „ „ Siam, Roi Eit. .... „ M. RAOULT.
3. „ „ Busuanga, Philippines .... „ C. M. KOOMANS.
4. „ „ Bulakda, „ .... „ „
5. Rizalite, Philippines .... „ „
b. Tektite from Rosario, Philippines .... „ M. RAOULT.

For comparison the analyses of a tektite from Siam and of a tektite from Rosario, published by LACROIX (bibl. 2, 3), have been added to the table.

Table 2 includes the analyses of the pseudo-tektites:

6. Pseudo-tektite, Comodore Rivadavia, Patagonia .... anal. C. M. KOOMANS.
7. Pseudo-amerikanite, Santa Mesa, Philippines „ „
8. „ „ „ „ „ „ „
9. Obsidian, Gelerang Kawayan, „ „ „
10. Pseudo-tektite, Claveria Type, „ „ „
11. „ „ N. W. Luzon, „ „ „
12. „ „ „ „ „ „

When first the analyses of the tektites are considered, the characteristic properties of the chemical composition appears to be the following:

a. slight variation of the SiO_2 percentage.
b. very high FeO percentage.
c. high CaO percentage.
d. low alkali-percentage.

Or expressed in Niggli-values: high fm, c, and mg, and low al and alk.

These properties are clearly shown on comparison with magmatic rocks, which have about the same si-values. For instance with the following Magma-types of Niggli (Gesteins- und Mineralprovinzen).

si	al	fm	c	alk	k	mg	Magma-type
420	44	12	6	38	0.50	0.25	Engadinitic.
350	43	16	13	30	0.45	0.30	Yosemititic.
350	42	12	11	35	0.23	0.27	Trondhjemitic.
310	42	16	16	26	0.22	0.47	Plagioclase-granitic.

The c- and mg-values of the last type agree with those of the tektites, but the al- and alk-values are still higher here and the fm-values lower than that of the tektites.

Table 2 shows that the relation between the pseudo-tektites and the magmatic rocks is of a different nature. In the first place the great variation of the SiO_2 percentage is worthy of note. In this respect the pseudo-tektites 6, 10, 11 and 12 differ entirely in chemical composition from the tektites.

As far as the SiO_2 is concerned the pseudo-amerikanites agree with the tektites. In other respects, however, the composition shows striking differences, which are of the same nature as the differences between the tektites and the magmatypes, viz: in the pseudo-amerikanites again higher al- and alk-values and lower fm, c and mg than in the tektites.

The analyses 7 and 8 can best be compared with the Yosemititie magmatype, as also the analysis 9 of the obsidian from the Philippines.

It is therefore a plausible assumption that the so-called pseudo-amerikanites are nothing else than pieces of obsidian, which have obtained the sculpture of the tektites through etching. The pseudo-amerikanites entirely agree also in chemical character with the amerikanites (bibl. 5) which are probable too pieces of obsidian.

The pseudo-tektites with their much lower SiO_2 percentage also agree with magmatic rocks, for instance:

si	al	fm	c	alk	k	mg	Magmatype
270	35	26	15	24	0.42	0.33	Normalgranitic.
220	31	31	19	19	0.25	0.48	Quarzdioritic.
135	24.5	42.5	23	10	0.28	0.50	Gabbrodioritic.
108	21	52	21	6	0.20	0.55	Normalgabbroid.

The pseudo-tektites from Patagonia are to be compared with the normalgranitic magmatype.

No. 10 of the Philippinian pseudo-tektites agrees with the quarzdioritic magmatype, while 11 and 12 lie between the gabbrodioritic and the normalgabbroid magmatype.

Now it is of importance to examine whether these analyses are comparable to analyses of magmatic rocks from the Philippines. The analyses of these rocks are given in Table 3 and 4 (bibl. 11).

1.	Granite.	Bagan	anal.	Govt. Lab.
2.	Dacite.	Corregidor Island	„	E. W. Morley.
3.	Granite.	Ilocas Norte	„	L. A. Salinger.
4.	Andesite.	Benguet Road	„	E. W. Morley.
5.	„	Antamok River, Benguet	„	P. J. Fox.
6.	„	Olongapo	„	E. W. Morley.
7.	„	Antamok River	„	P. J. Fox.
8.	„	„	„	„
9.	Basalt.	Mayon Volcano	„	E. W. Morley.
10.	„	Taal Volcano	„	„
11.	„	Antipolo	„	„
12.	Diorite.	Mancayan, Lepanto Province...	„	L. A. Salinger.

TABLE 3.

	1.	2.	3	4.	5.	6	7.
SiO_2	77.21	72.68	72.56	58.54	57.49	60 13	54.10
TiO_2	—.—	0.09	—.—	0.70	—.—	0.44	—.—
P_2O_5	—.—	—.—	—.—	—.—	—.—	0.06	—.—
Al_2O_3	15.38	15.99	15.13	17.62	18.40	18.13	19.01
Fe_2O_3	0.72	0.65	2.54	1.89	5.46	3.25	4.32
FeO	0 93	0.21	—.—	3.33	1.71	0.91	2.45
MnO	—.—	0.16	0.46	0.13	—.—	0.27	—.—
MgO	0.42	0.41	0.95	2.27	3.05	3.35	3.02
CaO	2.18	1.66	2.01	7.25	7.61	6.54	8.90
Na_2O	2.26	3.26	5.06	3.76	3.38	3.78	3.08
K_2O	0.50	2.19	0.56	1.62	1.99	0.77	2.98
H_2O	0.41	2.56	0.96	1.28	1.75	2.35	2.56
	100.01	99.86	100.23	98.39	100.84	99.98	100.42
si	485	423	362	192	171	198.5	153
al	57	55	44.5	34	32	35.5	31.5
fm	12.5	8	18.5	25	30	28	27.5
c	14.5	10.5	10.5	25.5	24.5	23	27
alk	16	26.5	26.5	15.5	13.5	13.5	14
ti	—.—	—.—	—.—	1.77	—.—	1.19	—.—
p	—.—	—.—	—.—	—.—	—.—	—.—	—.—
h	8.68	49.65	15.87	13.98	17.32	25.80	24.07
k	0.12	0.30	0.07	0.22	0.28	0.12	0.39
mg	0.30	0.44	0.39	0.44	0.45	0.59	0.46
c/fm	1.19	1.30	0.58	1.01	0.81	0.84	0.98

TABLE 4.

	8.	9.	10.	11.	12.
SiO_2	53.92	53.06	52.33	50.54	47.98
TiO_2	—.—	0.77	0.31	0.34	—.—
P_2O_5	—.—	0.06	0.07	0.24	—.—
Al_2O_3	18.68	19.95	17.33	21.63	18.94
Fe_2O_3	4.27	3.24	3.51	3.64	7.08
FeO	2.65	4.94	5.73	4.22	3.98
MnO	—.—	0.59	0.24	0.17	—.—
MgO	2.93	3.64	5.30	3.06	7.06
CaO	8.85	9.41	10.71	10.47	11.01
Na_2O	2.92	3.24	3.17	2.88	2.56
K_2O	2.66	0.94	0.94	1.57	0.44
$+H_2O$	2.23	0.06	0.38	0.72	0.70
$-H_2O$	0.44	0.01	—.—	0.19	0.38
	99.55	99.91	100.29	99.88	100.13
si	155	140	128	130	107
al	31.5	31	25	33	25
fm	28	32.5	38	28	42.5
c	27.5	26.5	28	29	26
alk	13	10	9	10	6.5
ti	—.—	0.63	0.59	0.62	—.—
p	—.—	—.—	0.14	0.31	—.—
h	25.52	1.58	3.08	7.89	8.04
k	0.37	0.17	0.17	0.26	0.11
mg	0.45	0.43	0.51	0.42	0.55
c/fm	0.96	0.81	0.74	1.02	0.62

It now appears that the pseudo-tektites show a very close resemblance to these magmatic rocks. For instance 10 of table 2 is to be compared with the andesites 4 and 5, while 11 and 12 of table 2 agree with the basalts 10 and 11 of table 4.

The dacite 2 and the granite 3 belong to the same magmatype as the obsidian and the pseudo-amerikanites of table 2.

From the chemical composition therefore it is to be concluded that the pseudo-tektites agree with terrestrial magmatic rocks from the surroundings where these pseudo-tektites were found.

This also holds good for the pseudo-tektites from Patagonia, though the agreement with rocks from the same territory cannot be ascertained easily as in the case of the Philippines. Yet the difference in the composition between the andesite from the Yate volcano in Patagonia and the pseudo-tektites is not very great.

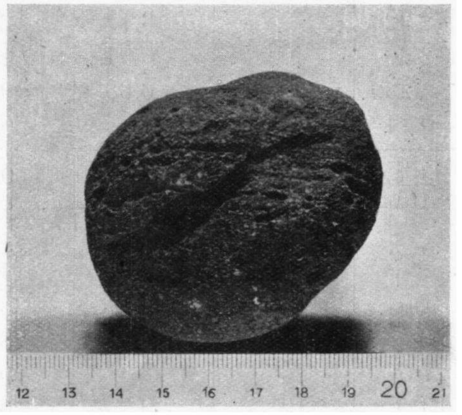

Fig. 7.

Etched pebble of Obsidian from Palembang.

Finally the analyses of the pebbles of obsidian from Palembang and the obsidian from Garoet are given in Table 5.

1. Obsidian from Palembang .... anal. C. M. KOOMANS.
2. „ „ Garoet .... „ „
3. „ „ Goenoeng Kiamis .... „ REIBER.
4. „ „ Goenoeng Kiamis .... „ „

These two analyses are nearly identical and both belong to the engadinitic magmatype, just like the analyses of the obsidian from Goenoeng Kiamis with wich they completely agree (bibl. 6).

TABLE 5.

	1 (L 84)	2 (L 85)	3.	4.
s.g.	2.334	2.341	2.33	2.36
SiO_2	75.46	75.06	75.70	76.40
TiO_2	—.—	—.—	0.09	0.07
P_2O_5	0.11	0.14	—.—	—.—
Al_2O_3	14.15	13.74	13.65	13.01
Fe_2O_3	0.70	0.96	0.62	0.35
FeO	0.57	0.94	0.96	0.78
MnO	0.08	0.06	—.—	—.—
MgO	0.24	0.31	0.32	0.38
CaO	1.26	1.13	1.35	1.42
Na_2O	3.90	3.16	3.33	3.26
K_2O	2.77	4.14	3.94	4.41
$+H_2O$	0.52	0 20	0.08	0.12
$-H_2O$	0.02	0.01	—.—	—.—
	99.78	99.85	100.04	100.20
si	453	440	448	460
al	50	47.5	47.5	46
fm	8.5	12	10	9
c	8.5	7	8.5	9
alk	33	33.5	34	36
k	0.32	0.46	0.43	0.47
mg	0.26	0.24	0.38	0.60
c/fm	1.00	0.59	0.85	1.00

V. DIFFERENCES BETWEEN TEKTITES AND PSEUDO-TEKTITES.

In the preceding chapters it appeared that the only fundamental difference between tektites and pseudo-tektites is the chemical composition. With this difference is connected the difference in specific gravity and refractive index, so that on the ground of these characteristics it is possible to decide whether a darkly-coloured, etched piece of glass must be reckoned among the tektites or among the pseudo-tektites.

The specific gravity increases with the percentage of iron. Owing to this the specific gravity of the real tektites with their high FeO percentage is always higher than of the obsidian and the pseudo-tektites, whose percentage of iron with equal SiO_2 grade is much lower. For the much more basic pseudo-tektites the specific gravity of course rises above that of the tektites.

The same dependence is to be seen in the refractive index. This value is also influenced more strongly by the percentage of iron than by the variation of the SiO_2 percentage. Here too the lowest values therefore occur in the obsidian and the pseudo-amerikanites. The tektites have a higher refractive index and the values of the pseudo-tektites are still higher. Tesch (bibl. 9) had come to the same result on investigating the refractive index of artifically molten rocks.

In connection with the still unknown origin of the tektites the question now arises as to how far the discovery of the pseudo-tektites is of importance. The discoveries on the Philippines, where tektites and pseudo-tektites occur in the same places are of course most significant. If it is accepted that the etching of the tektites takes place in the soil, it is not surprising that other pieces of glass are also etched.

What is indeed remarkable is the discovery of glass of so strongly varying composition. If volcanic glass is spoken of, then obsidian is always meant, that is glass with a high SiO_2 percentage. Of the more basic volcanic products completely glassy rocks are rarely found. Of the pseudo-tektites described here, however, it was already said in chapter II, that they consist almost entirely of glass. Only the pseudo-tektite from Patagonia (no. 6 of table 2) shows symtoms of cristallization.

Several writers (bibl. 4 and 8) have already pointed out the agreement in chemical composition between the tektites and sediments, especially clays. This agreement is so complete, that by remelting of clays, tektites could very well originate (compare the average composition of clays in bibl. 1 and 10 with table 1).

Consequently Linck assumed that the tektites originated from a celestial body where clastic sediments occured. In my opinion, however, it is just as probable that the tektites, like the pseudo-tektites are of terrestrial origin. Why should the material be supposed to have come from so great a distance, an hypothesis that cannot be verified, when products of the same chemical composition are to be found on earth?

After the discovery of the pseudo-tektites with magmatic composition beside tektites with sedimentary composition the possibility of a terrestrial origin becomes considerably more plausible.

The weak point of this supposition lies of course in the question, how these clays could have been remelted. Indeed no answer to this question can be given as yet, but on the other hand no single definite proof has either been given for the celestial origin.

VI. THE COLLECTION OF TEKTITES AND PSEUDO-TEKTITES OF THE RIJKSMUSEUM VAN GEOLOGIE EN MINERALOGIE AT LEIDEN, HOLLAND AT THE END OF 1937.

	number
Tektites of Billiton (Billitonites)	133
„ „ Boengoeran, Natoena islands	2
„ „ Borneo	2
„ „ Java	24
„ „ Philippine islands	92
„ „ French Indo-China	60
„ „ Siam	3
„ „ Bohemia (Moldavites)	200
„ „ West Country, Australia (Australites)	14
„ „ Mt. Darwin (Queenstownites, Darwinglass)	10
Total	540

Pseudo-tektites of Arizona	1
„ „ Olden, Australia	2
„ „ Patagonia	7
„ „ Philippine islands	21
Pseudo-amerikanites of the Philippines	16

Etched pebbles of Palembang.
Etched Glass-slag of Krefeld.
Etched Glass-slag of Gelterkinden.

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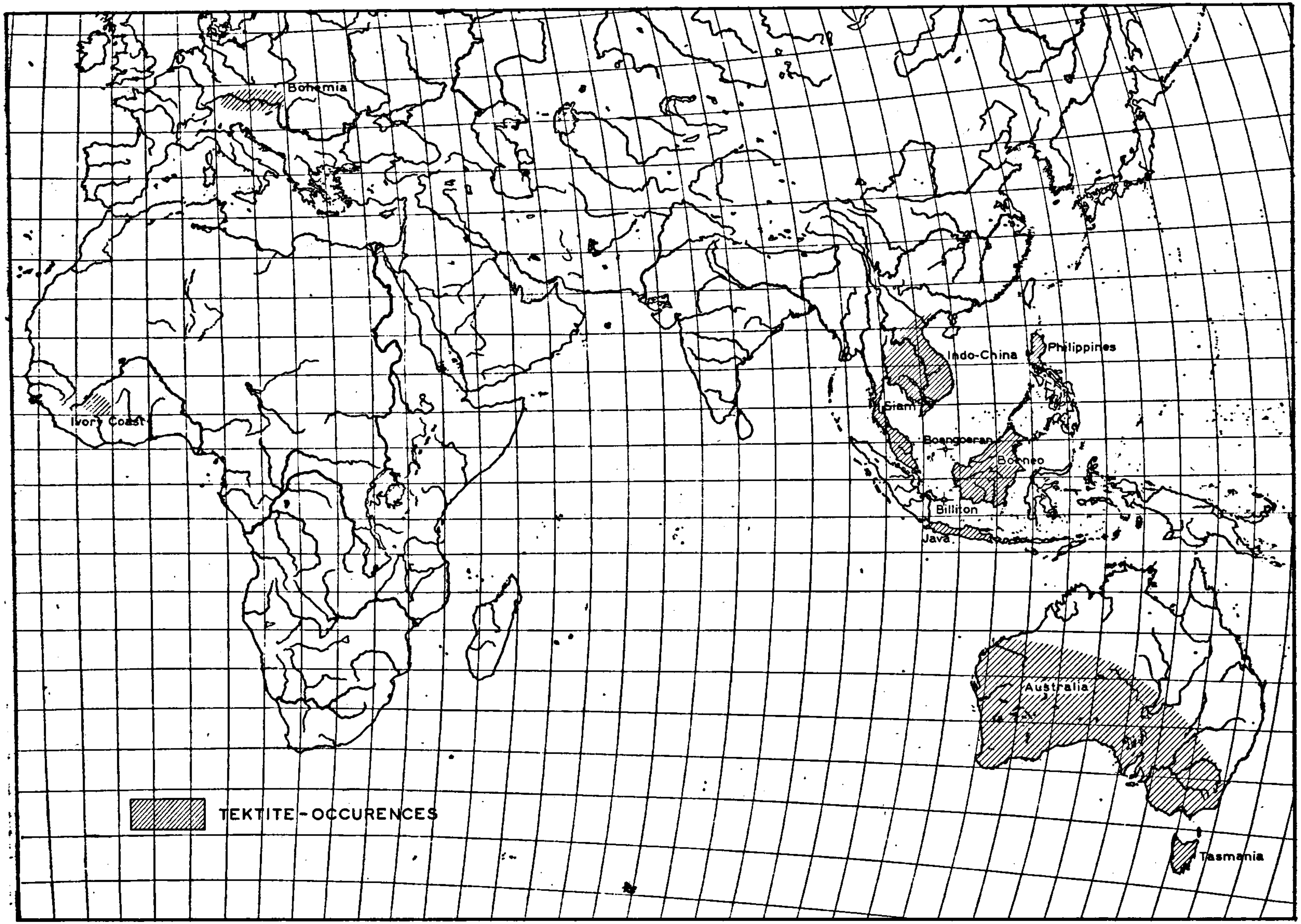

Fig. 8.
Sketch-map of the Tektite-occurences.