

*The occurrence of a mineral hitherto unrecognized in the
phonolites of Dunedin, New Zealand.*

(With Plate VIII.)

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[Read June 11, 1929.]

THE phonolites which are found in the volcanic region of Dunedin, New Zealand, are of a varied character. Some of them are of ordinary types, but others are nephelinitoid, and some of them have sodalite in abundance. Besides the phonolites, there are trachydolerites, some of which also contain sodalite as well as nepheline. There is also an abundance of tinguaite, in all of which nepheline is distinct and sometimes sodalite as well. All petrologists who have worked in this region are therefore perfectly familiar with the minerals sodalite and nepheline in many different associations and conditions.

In the majority of the phonolitic rocks there is, in addition to the nepheline and sodalite, a mineral of ill-defined characters. This was at first considered to be allotriomorphic nepheline.¹ This opinion was based on the solubility of the mineral in acid and on the staining of the mineral with Prussian blue, after gelatinization. Recent examination of this mineral has shown that it cannot rightly be referred to nepheline or sodalite, but in composition and optical properties it approaches microsommite and davyne; though it differs from the former of these in having a far smaller percentage of chlorine, and from the latter in its smaller percentage of lime. It is proposed to call this mineral *ameletite* (from ἀμελής, neglected).

In the majority of trachytoid phonolites of this region, there is no nepheline or sodalite, but *ameletite* is abundant. In one of these

¹ P. Marshall, Quart. Journ. Geol. Soc. London, 1906, vol. 62, p. 402.

rocks—the trachytoid phonolite of Tainui quarry, Anderson's Bay—the mineral has now been found with a definite crystalline form, which makes it possible to give it a definition with greater precision than was possible when the interstitial occurrence alone was known.

The crystal sections are small, 0.15 mm. in diameter. The form is usually rectangular, like that of nepheline, and, as in that mineral, there are occasional hexagonal sections as well. There is a definite cleavage parallel to one pair of the sides of the quadrangular sections, but it is less distinct in the hexagonal sections. The refractive index is very low—less than that of anorthoclase—and far less, therefore, than that of nepheline, but higher than that of sodalite. The birefringence is 0.003, distinctly lower than that of nepheline, and of course much lower than cancrinite, from which in other respects also it is very different. In all of these characters of form and optical relations the mineral closely resembles microsommite; though it seems that microsommite has not been recognized as a normal rock-forming mineral.

It is most noticeable that this mineral is the first of all the constituents of a rock to be affected by the action of percolating water. The first effect is a slight staining by iron oxide. This is yellowish-green at first, but soon becomes yellow, and even brown; and this change in colour will take place without any of the nepheline or sodalite in a section being affected by the action of the solution. When once this fact has been recognized it is often easy to identify ameleite in a section, in the presence of the other minerals that have been mentioned. In the rock at Tainui quarry, as mentioned above, there is no nepheline or sodalite, but ameleite is in considerable quantity both as crystals and as interstitial material. Staining methods at once distinguished the mineral grains that are gelatinized by dilute acid. When these were closely examined it became certain that none of them could be referred to nepheline or sodalite.

A powdered sample of the rock from Tainui quarry was treated with dilute hydrochloric acid and warmed to 60° C. for ten minutes. It was found that 12.5 per cent. of the rock went into solution, and an analysis of this dissolved matter gave the results under I. Analysis II is of the 25.65 per cent. of material that was dissolved from another trachytoid phonolite from North Head, Otago Harbour, in which the same mineral is found more plentifully, though with less definite crystalline form. Analysis III is of the 21.35 per cent. of material dissolved from a trachytoid phonolite from Taipara,

Rarotonga Island, Cook Islands, South Pacific. It will be seen that there is a substantial agreement between these three analyses, which correspond approximately with a formula $12\text{SiO}_2 \cdot 6\text{Al}_2\text{O}_3 \cdot 9\text{Na}_2\text{O} \cdot \frac{1}{2}\text{NaCl}$. But whether this actually represents the composition of ameletite must remain an open question for the present.

	I.	II.	III.	Micro- sommite.	Davyne.	Nepheline.	Sodalite.
SiO_2 ...	36.67	36.40	35.96	32.21	38.76	44.03	38.12
Al_2O_3 ...	34.70	34.70	34.11	29.22	28.10	33.28	31.68
CaO ...	1.80	2.49	2.12	12.60	9.32	1.77	—
Na_2O ...	24.18	24.90	23.03	10.14	15.72	15.44	24.37
K_2O ...	0.86	0.96	0.53	6.79	1.10	4.94	—
SO_3 ...	0.30	—	—	4.43	—	—	—
CO_2 ...	—	—	—	—	5.63	—	—
Cl ...	2.15	3.15	1.58	6.71	trace	—	6.69
	<u>100.66</u>	<u>102.60</u>	<u>97.33</u>	<u>102.10</u>	<u>100.59</u> ¹	<u>100.32</u> ²	<u>100.86</u>

¹ Including H_2O 1.96.

² Including H_2O 0.21, Fe_2O_3 and Mn_2O_3 0.65.

Analyses of microsommite, &c., quoted from Dana's 'System of Mineralogy'.

The percentage of silica is seen to be lower than the amount found in any of the felspar or felspathoid minerals in rocks. In order to be certain that all of the silica of the mineral matter that was attacked had gone into solution, the residue was boiled with caustic potash; but it was found that no more silica was dissolved. In the table given above, analyses of microsommite, davyne, nepheline, and sodalite are quoted for comparison. It is at once seen that the composition of the mineral matter, that was dissolved out of the rock, is notably different from that of the minerals quoted.

It has been previously stated that ameletite responds to the ordinary gelatinizing and staining methods of treatment in the same manner as nepheline and sodalite. A difference, however, is shown when sections of these alkali lavas are treated with dilute silver nitrate at ordinary temperature. Nepheline and sodalite are not affected by the nitrate; but ameletite speedily acquires a deep violet colour, which is caused by the formation of silver chloride. It is clear that in this mineral the chlorine is very loosely held in combination. It was surprising to find that when the powdered rock was boiled in water a considerable portion of the chlorine goes into solution. The treatment of a section with silver nitrate can, therefore, be used to distinguish ameletite from nepheline and sodalite, when other

methods fail, which is rarely or never the case if one has examined many slides that contain these three minerals. The readiness with which ameleitite becomes stained by iron compounds is probably due to the action of the chloride, which is so readily evolved, on the iron carbonate or other compounds of iron which are formed in the soil, and are carried by percolation into the rock.

Ameletite, then, differs from nepheline in its lower refractive index, lower birefringence, content of chlorine, lower percentage of silica, prismatic cleavage, and natural staining with iron compounds. In the laboratory it can be distinguished by staining with silver nitrate solution. From sodalite it can be distinguished by the frequent rectangular sections, birefringence, and by its higher refractive index. Chemically it contains some lime and has far less chlorine than sodalite. Sodalite is far less easily stained by iron compounds in the rock and does not become stained with dilute silver nitrate solution. Microsommitite and davyne appear to resemble ameleitite closely in crystallographic and optical characters, though full descriptions of these in rock slices are lacking. Microsommitite, however, contains more lime, potash, and chlorine, but notably less silica, alumina, and soda. Davyne, too, contains more lime, and has also a considerable percentage of carbon dioxide, which is not present in ameleitite. On the other hand, davyne has no chlorine, and has much less soda. Ameletite is at once distinguished from cancrinite by its much lower birefringence.

In the Dunedin phonolites ameleitite has a very general occurrence. It is found much more frequently than nepheline; and is still more common than sodalite, though that mineral is frequent in many of the rocks. Its occurrence explains the fact that all analyses of trachytoid phonolites from this locality show the presence of appreciable amounts of chlorine, though no sodalite could be found in them. The following may be quoted as typical analyses¹ of the Dunedin trachytoid phonolites:

¹ For analyses and descriptions of Dunedin phonolites, see:

- P. Marshall, *Geology of Dunedin (New Zealand)*. Quart. Journ. Geol. Soc. London, 1906, vol. 62, pp. 381-424.
C. A. Cotton, *Geology of Signal Hill, Dunedin*. Trans. N.Z. Inst., 1909, vol. 41 (for 1908), pp. 111-126.
J. A. Bartrum, *Some rocks of Mount Cargill, Dunedin*. Trans. N.Z. Inst., 1912, vol. 44 (for 1911), pp. 163-179.
P. Marshall, *The sequence of lavas at the North Head, Otago Harbour, Dunedin (New Zealand)*. Quart. Journ. Geol. Soc. London, 1914, vol. 70, pp. 382-408.

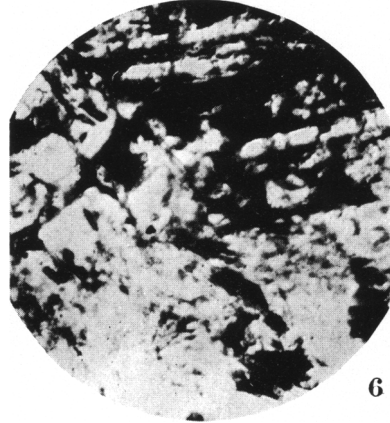
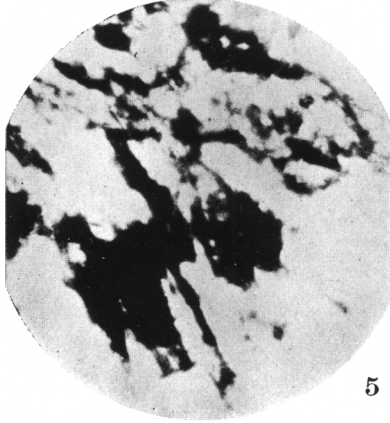
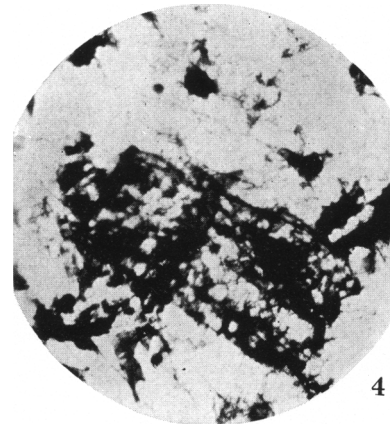
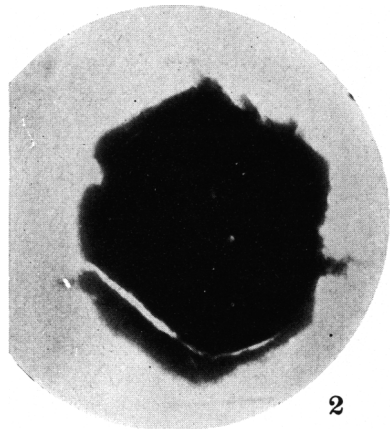
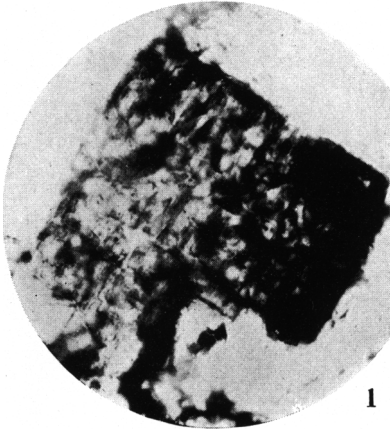
	SiO ₂ .	Al ₂ O ₃ .	Fe ₂ O ₃ .	FeO.	MgO.	CaO.	Na ₂ O.	K ₂ O.	H ₂ O.	Cl.
I.	56.12	21.32	2.59	3.29	0.56	2.30	5.79	4.81	1.54	0.34
II.	54.15	16.09	7.35	4.90	1.61	3.86	5.94	4.41	1.40	0.40
III.	57.00	16.06	5.53	3.22	0.64	1.51	8.00	6.18	2.10	0.45

II, also TiO₂ 0.41, P₂O₅ 0.42. III, also TiO₂ 0.39.

Ameletite is also quite frequent in rocks that contain either or both nepheline and sodalite. It occurs also in trachytoid phonolites of Rarotonga, Cook Islands, and of Huahine and Raiatea in the Society Islands, South Pacific. The very general record of chlorine in the analyses of trachytoid phonolites suggests that ameleite is not restricted to the Dunedin rocks.

EXPLANATION OF PLATE VIII.

1. Trachytoid phonolite. Tainui quarry, Anderson's Bay, Dunedin, New Zealand. A crystal of ameleite stained naturally with ferric hydroxide. Rest of field felspar and irregular cossyrite. The ameleite shows two rectangular sets of cleavages. ×190.
2. Trachytoid phonolite. Tainui quarry. Crystal of ameleite stained deeply with natural deposit of ferric hydroxide. Rest of slice felspar, narrow prisms of aegirine, and grains of magnetite. ×190.
3. Trachytoid phonolite. Tainui quarry. Crystal of ameleite stained deeply by a natural deposit of ferric hydroxide. A prismatic cleavage is shown. Rest of field felspar prisms. ×190.
4. Trachytoid phonolite. Tainui quarry. Crystal of ameleite stained with dilute silver nitrate. Small crystals of aegirine, cossyrite, and magnetite; the rest felspar. ×110.
5. Trachytoid phonolite. Tainui quarry. Interstitial ameleite between felspar prisms. Stained with silver nitrate. ×190.
6. Trachytoid phonolite. Logan's Point, Dunedin, N.Z. The clearer half of the field shows aegirine and cossyrite in an unstained complex of felspar, nepheline, and ameleite. The darker half is stained with dilute silver nitrate. The photograph shows the deeply stained ameleite with laths of felspar and rectangles of nepheline. ×190.



P. MARSHALL: AMELETITE IN PHONOLITE FROM DUNEDIN,
NEW ZEALAND.