The Mineral Tuhualite

By P. Marshall.

[*Read before the Wellington Philosophical Society, June 24, 1936; received by the Editor, July 16, 1936; issued separately, December, 1936.*]

A brief preliminary notice of this new mineral was published by Marshall* in 1932. Since that time the rock in which the mineral occurs has been found *in situ* and idiomorphic crystals of tuhualite have been found and extracted from it. The name of the mineral is derived from Tuhua, or Mayor Island, in the rocks of which it occurs. Features of the geology of Mayor Island have been the subject of papers by Goldsmith, von Wolff, Thomson, Sladden and Bartrum. The work of these authors is mentioned in a paper on the geology of Mayor Island appearing in the present Part of these Transactions. None of them makes any reference to the mineral tuhualite or to the particular rocks in which it has been found.

At first tuhualite was found in a small ejected boulder embedded in a deposit of pumice prominent at Opo Bay. Later it was discovered *in situ* in a lava-flow forming the base of the interior wall of the crater where its south side begins to bear round to the east. Tuhualite was also found in several other boulders at Opo Bay, and in one of these the blue patches of the mineral show clearly in the hand-specimen in the grey groundmass of the rock. In certain parts of this boulder that are soft and almost spongy in structure separate crystals of tuhualite, 1·5 mm. in length and quite idiomorphic, were occasionally found; and it has been possible to prepare oriented sections from some of these. Unfortunately, however, it was not practicable to obtain sufficient of these crystals for analyses; but it will be shown later that the approximate composition of the mineral can be calculated from a comparison of the analyses of rock-samples.

The tuhualite at first obtained consisted of minute fragments with intense pleochroism, which suggested that the mineral was a form of amphibole, and as such it was originally described by me (Marshall, 1932, p. 202). Crystal-measurements and examination of oriented sections have, however, shown that the mineral belongs to the orthorhombic system with moderate elongation in the direction of the vertical axis. The base, macropinacoid, brachypinacoid, prism, one pyramid and two brachydomes are clearly developed. The prismatic faces are relatively narrow and unfortunately slightly rounded, and this reduces the possibility of accurate measurement of the prismatic angle. A striking feature is the frequent parallel growth of crystals, which are united along the plane of the brachypinacoid. The prism of each portion is developed and gives rise to a re-entering angle on the surface of the compound crystal, and this pseudotwinning is evident as a line of division in macropinacoid sections. The extinction is of course simultaneous in the two different portions. Crystals are sometimes twinned with the brachydome as the twinning and composition-plane. Cleavage is good, parallel to the base and to both pinacoids, but none of the

* P Marshall, Notes on some Volcanic Rocks of the North Island of New Zealand, *N.Z. Jour. Sci. and Tech.*, vol. 13, p. 201, 1932.

directions of cleavage is dominant. The macropinacoid often has surface markings of rather duller lustre parallel to the margins of the face. The small size of the crystals together with their cleavage and extreme brittleness prevent an estimate of the hardness. The specific gravity is 2·87.

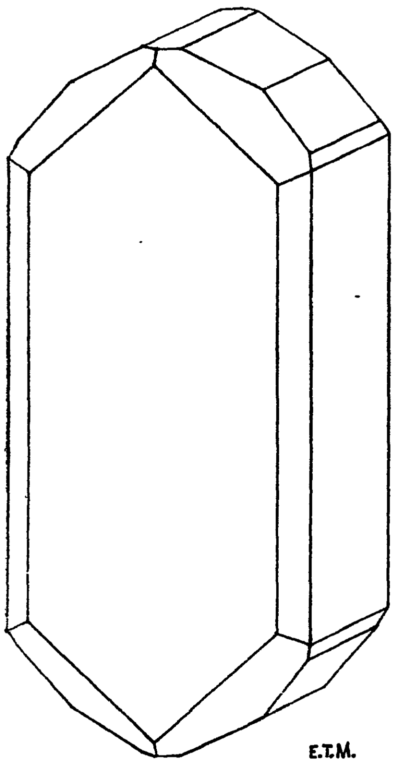

Fig. 1.

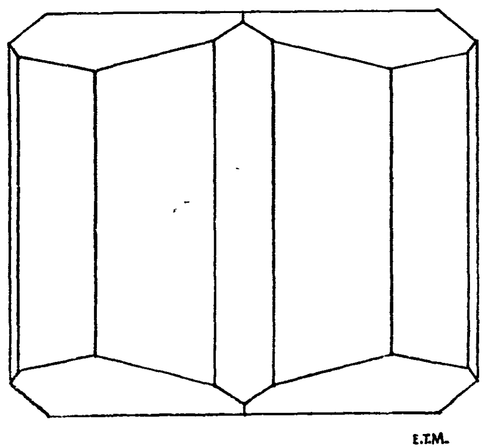

Fig. 2.

Fig. 1.—Crystal of tuhualite drawn in the usual clinographic perspective. This figure does not show the curvature of the prismatic face. Drawn by Mr E. T. Marr.

Fig. 2.—Basal projection of crystal of tuhualite. Drawn by Mr E. T. Marr.

Crystallographic form: As was mentioned previously the horizontal and vertical curvature of the prismatic face makes measurement of the interfacial angles slightly uncertain. With the aid of a Swift stage goniometer the following results were obtained:—

100–110	42·3°	±1·5
010–110	47·7	±2·0
100–111	52·0	±3·2
010–021	39·6	±0·4
021–011	23·0	±0·8
011–001	37·4	±0·6

None of the crystals measured were more than 1·5 by 1·0 mm. in vertical and horizontal measurement. From these angles the lengths of the axes were taken as a = 0·915, b = 1·0, c = 0·512. For the perspective drawing of the crystal (Fig. 1) as well as the drawing of the base (Fig. 2) I am much indebted to Mr E. T. Marr, of the

Department of Architecture, who was good enough to take great interest in the work. The other figures, which are sketches and do not pretend to any great exactitude, are given merely to indicate some of the habits of the mineral.

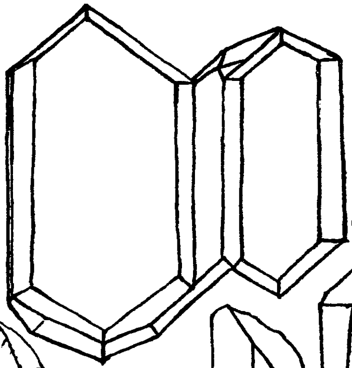

Fig. 7.

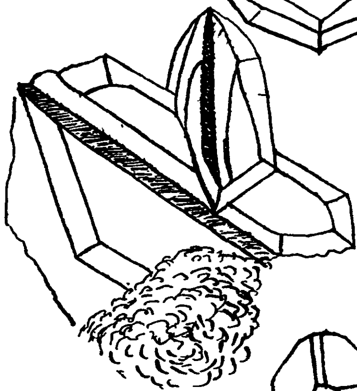

Fig. 6.

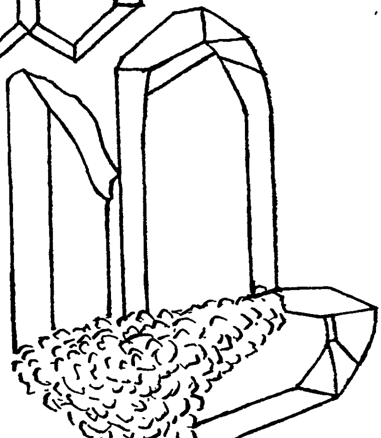

Fig. 3.

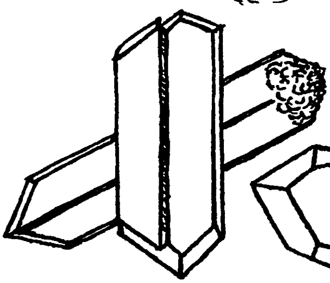

Fig. 5

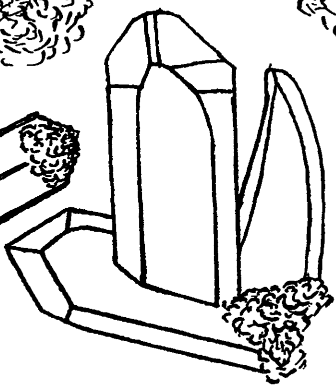

Fig. 4.

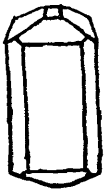

Fig. 8.

The figures 3 to 8 are sketches of crystals of tuhualite lying on the macropinacoid face as seen on the stage of a microscope.

Fig. 3.—A group of three crystals, two of which are twinned. Curvature of the prismatic face is shown.

Fig. 4.—The reverse of Fig. 3. The curvature of the prismatic face is again shown.

Fig. 5.—Two crystals each composed of two portions with parallel growth twinned. The brachydome the twinning and composition face.

Fig. 6.—Two crystals each formed of two parallel grown halves. These show the curvature of the pyramid and prism faces.

Fig. 7.—Two crystals showing parallel intergrowth with a portion of a third.

Fig. 8.—A simple crystal showing a macrodome in addition to the usual faces.

Fig. 9.

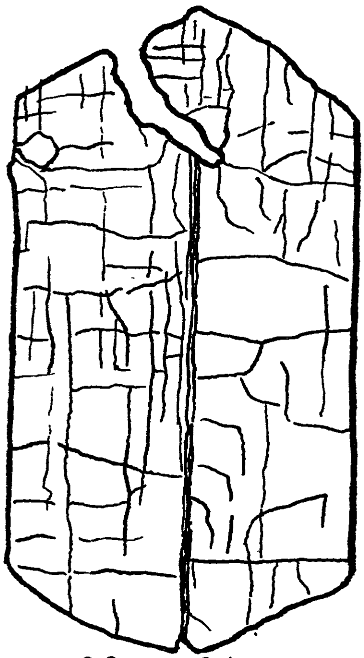

Fig. 10.

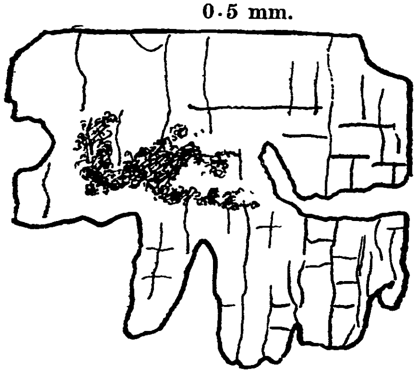

Fig. 11.

Fig. 9.—The terminal portion of a compound crystal. This shows the curvature at the end of the crystal, and the re-entering angle on the macropinacoid face due to the prismatic faces of the adjacent parallel portions. Photo by Dr W. P. Evans.

Fig. 10.—Microsection of crystal of tuhualite parallel to the macropinacoid 0·92 by 0·52 mm. Shows the parallel growth of two crystals and the cleavage. When seen in polarised light with vibrations parallel to the greater axis the colour of the section is deep violet. When at right angles to this axis the colour is bright purple. Thickness 0·016 mm.

Fig. 11.—Microsection of crystal of tuhualite parallel to the brachypinacoid. 0·4 by 0·3 mm. Thickness 0·016 mm.

Colour: Black to very dark blue, lustre sub-metallic. When tuhualite is in very small grains and occurs with light coloured minerals the rock has a distinct blue colour, which is apparent in the hand-specimen even when a very small amount of the mineral is present.

Refractive indices:

$$\alpha = 1{\cdot}601 \quad \pm{\cdot}001$$
$$\gamma = 1{\cdot}607 \quad \pm{\cdot}001$$

I am greatly indebted to Mr C. O. Hutton, M.Sc., for determination of these indices. The measurement was made with white light. as monochromatic light was not available.

Pleochroism: Very striking. X = a palest pink, Z = c deep violet, Y = b purple. Birefringence moderate. It is noticeable in the great majority of sections of all thicknesses that red tints alone appear when sections are seen between crossed nicols. The blue rays that vibrate parallel to Z and to a slight extent those which vibrate parallel to Y are the only blue rays which are doubly refracted when they pass through the mineral. Consequently the blue tints are but slightly seen in the interference colours. These are only occasionally purple, but are generally red or in the thinnest sections yellow, even when a strong blue colour is seen before the nicols are crossed.

Optical sign: Dr Turner, of Otago University, who has been good enough to examine some of the preparations, has determined that $\rho > v$ and that the mineral is negative. He has also found that 2V is approximately 65–70 degrees. I am also much indebted to Colonel Campbell Smith, Keeper of Minerals in the British Museum, for notes on preparations that were sent to him.

It is thought that the peculiarity of the interference colour is due to the high dispersion of the optic axes. Occasional grains of tuhualite are bleached white and the interference tint is then of the nature which is associated with high dispersion. Again a few grains give a sky-blue colour in ordinary light. In this case the mineral appears to be isotropic when the nicols are crossed. This suggests that for blue rays Bxa is zero and that for this light X and Z are almost equal. Obviously an optical examination by a more skilled observer is necessary to determine this matter.

Chemical composition: Mrs F. T. Seelye, of the Dominion Laboratory, has made these fine analyses with the permission of the Director, Mr A. Donovan :—

	A.	B.	C.	D.
SiO_2	72.28	73.55	73.68	72.00
Al_2O_3	9.75	9.63	9.56	9.79
Fe_2O_3	4.44	4.02	4.28	4.95
FeO	1.43	2.11	1.65	0.97
MgO	0.28	0.19	0.15	0.24
CaO	0.44	0.33	0.31	0.37
Na_2O	4.96	4.76	4.64	4.53
K_2O	4.50	3.95	4.13	4.20
H_2O-	1.04	0.05	0.32	0.85
H_2O+	0.68	0.69	0.82	1.76
TiO_2	0.23	0.23	0.23	0.23
P_2O_5	0.04			
S	0.02			
B_2O_3	0.00			
MnO	0.14	0.18	0.15	0.12
NiO	0.00			
BaO	0.00			
SrO	0.00			
ZrO_2	0.03			
Rare earths	0.10			
CO_2	0.00			
Cl	0.02			
F	0.06			
	—0.03 oxygen correction for Cl and F			
Total	100.41	99.69	99.92	100.01

A. Comendite, Mayor Island, New Zealand, with a small amount of tuhualite.

B. Comendite, Mayor Island, New Zealand. Analysis of purplish-blue patches separated from the rest of the rock.

C. Comendite, Mayor Island, New Zealand. Carefully selected blue patches.

D. Comendite, Mayor Island, New Zealand. Same as C, but all blue patches omitted.

If it be supposed, as indeed is suggested by observation, that one half of the sample C consisted of tuhualite and that sample D contained none of that mineral, a simple calculation will show the following composition for tuhualite, but this must be regarded as no more than a mere approximation :—

SiO_2	75·36
Al_2O_3	9·33
Fe_2O_3	3·61
FeO	2·33
MgO	0·06
CaO	0·25
Na_2O	4·75
K_2O	4·06
H_2O-	—0·21
H_2O+	—0·12
TiO_2	0·23
MnO	0·18
Total	100·16*

* Neglecting negative values for H_2O.

This result gives a surprisingly high value for silica. It is clear that there is a little uncertainty in regard to the exact amount of the iron-oxides and to a less extent in regard to the percentage of potash, but there can be no exactitude. The high percentage of silica is, however, in accord with the specific gravity of 2·87, which is low for a mineral that contains nearly 6 per cent. of iron-oxides. In view of the analyses, however, the colour of the mineral and its pleochrism are strange. It would appear that these are due to the iron-oxides, for the amount of manganese and titanium are quite insufficient to affect the tints greatly.

Alteration: There is a frequent occurrence of a greenish-yellow substance with tuhualite in many of the comendite rocks from Mayor Island, and many facts suggest that this material is an alteration product of tuhualite. The exact nature of this mineral has not yet been ascertained. Its appearance is similar to that of serpentine, but as the rock is practically destitute of magnesia serpentine cannot well be present. Its principal optical properties are as follows; habit flaky, but boundaries of grains highly irregular; pleochroic from deep olive-green (Z) to paler yellowish-green (X); lamellar twinning common, symmetrical extinction angle (Z′ to trace of twinning-plane) being 20°–24°; birefringence about 0·01, biaxial, optic axial angle large. For these I am indebted to Dr. Turner. The alteration of tuhualite to this greenish-yellow mineral is not due to weathering, for it appears to be most pronounced in the solid rocks of the crater-wall, while in the isolated blocks exposed to the effect of the weather at Opo Bay the tuhualite is to a considerable extent unaltered. Colonel Campbell Smith informs me that something similar to this mineral occurs in some of the East African comendites.

This description shows that tuhualite has many characters which separate it most definitely from the members of any of the other groups of rock-forming minerals. The number of these that belong to the orthorhombic system is small. Axial ratio, crystal-habit, cleavage, twinning, specific gravity, chemical composition and optical characters, especially pleochroism and extinction colours, severally and collectively confer on tuhualite a very distinct individuality among rock-forming minerals.