MINERALOGICAL MAGAZINE

JOURNAL OF THE MINERALOGICAL SOCIETY

Vol. 32 June 1961 No. 253

Tacharanite and other hydrated calcium silicates from Portree, Isle of Skye.

By JESSIE M. SWEET, M.B.E., B.Sc., with analyses by D. I. BOTHWELL, B.Sc., and X-ray determinations by D. L. WILLIAMS.

Department of Mineralogy, British Museum (Natural History).

[Read 26 January 1961.]

Summary. The vesicles of an olivine-dolerite that occurs as a small outcrop near Portree in the Isle of Skye contain zeolites and some hydrated calcium silicates. These latter include tobermorite, xonotlite, gyrolite, and what is presumed to be a new member of the tobermorite group. An attempt is made to account for the sequence of crystallization of the minerals.

ABOUT half a mile north of Portree in the Isle of Skye on the Staffin road (A855) there is a small exposure of melanocratic olivine-dolerite with phenocrysts of olivine and ophitic augite. The rock is fine-grained and tough owing to the interlocking of the minute plagioclase feldspars. Other exposures in the immediate neighbourhood are of a highly vesicular olivine-basalt that has the normal inclusions of visible crystals of laumontite, mesolite, thomsonite, and analcime. Although there is no exposure showing the junction of the two rocks and the area does not yet appear to have been mapped, it would seem that this occurrence is an intrusion of a later date.

The minerals of the dolerite are of a different type from those of the surrounding rocks and all occur as fine-grained amygdales. These are also normally very tough like the parent rock. In 1959 a preliminary investigation yielded specimens of tobermorite, xonotlite, and gyrolite, with some mesolite. These first specimens have cores of tobermorite that are pale-pink and fine-grained with a rim of mesolite (B.M. 1959, 551–553) or of gyrolite also with a rim of mesolite (B.M. 1959, 555). Another specimen (B.M. 1959, 554) collected at this time needs a little more consideration. The core is a dense pinkish-white mineral surrounded by a thick glassy rim. The inner portion, with refractive index about

1·580, proved to be xonotlite (table I, anal. 1); a dehydration curve (fig. 1A) showed a loss of water beginning at 820° C., and complete at 1 050° C. The outer rim, uniaxial, negative, ω 1·548±0·003, was found to be gyrolite (table I, anal. 2); it is exceptionally hard (H. about 6)

TABLE I. Chemical analyses of hydrated calcium silicates from the Isle of Skye.

	1.	2.	3.	4.
SiO_2	50·1	50·0	41·8	46·17
Al_2O_3	—	3·5	5·6	4·26
Fe_2O_3	0·4	0·1	0·3	—
FeO	—	—	n.d.	0·15
MgO	—	trace	3·2	trace
CaO	46·2	32·3	33·6	35·15
Na_2O	—	0·8	0·6	0·56
K_2O	—	0·2	0·1	0·25
H_2O	3·4	13·1	*15·2	13·47
	100·1	100·0	100·4	100·01

1. Xonotlite, Portree, Isle of Skye. Analyst, D. I. Bothwell. (B.M. 1959, 554.)
2. Gyrolite, Portree, Isle of Skye. Analyst, D. I. Bothwell. (B.M. 1959, 554.)
3. Tacharanite, Portree, Isle of Skye. Analyst, D. I. Bothwell. (B.M. 1961, 163.)
4. Tobermorite, Loch Eynort, Isle of Skye. Analyst, D. I. Bothwell. (G. F. Claringbull and M. H. Hey, Min. Mag., 1952, vol. 29, p. 962.)

* Includes a little CO_2.

compared with normal gyrolite. The dehydration curve is shown in fig. 1B. It regains water lost at 110° C. on exposure to moist air, but no experiments were made to determine whether the water lost above this temperature is also zeolitic as the evidence of A. L. Mackay and H. F. W. Taylor suggests.[1] Both minerals are exceptionally difficult to break. Between the gyrolite and the rock is a thin layer of mesolite. Unfortunately this specimen was the only one of its kind found in either 1959 or 1960, but it does seem as if we have here a natural occurrence of the change-over from tobermorite to xonotlite described by H. F. W. Taylor.[2]

In June 1960 many more specimens were collected and proved rather bewildering in their variety. Some were hammered out of the dolerite; others were lying loose in the cutting, but all showed a chalky coating where exposed to weathering. This weathering had not penetrated far and the amygdales were all quite fresh inside. The minerals recognized are tobermorite, gyrolite, saponite, calcite, mesolite, thomsonite, and what appears to be a new member of the tobermorite group. The amygdales usually consist of two or more of the minerals. Typical examples

[1] A. L. Mackay and H. F. W. Taylor, Min. Mag., 1952, vol. 30, p. 84.
[2] H. F. W. Taylor, Min. Mag., 1959, vol. 32, p. 110.

are a nucleus of one mineral with a rim of another, often not easily discernible in the hand specimen, between it and the parent rock. Thus a core of tobermorite may have a rim of mesolite, gyrolite, or thomsonite. The tobermorite varies from fine-grained to distinctly fibrous material, with a slightly variable refractive index near 1·560, which though

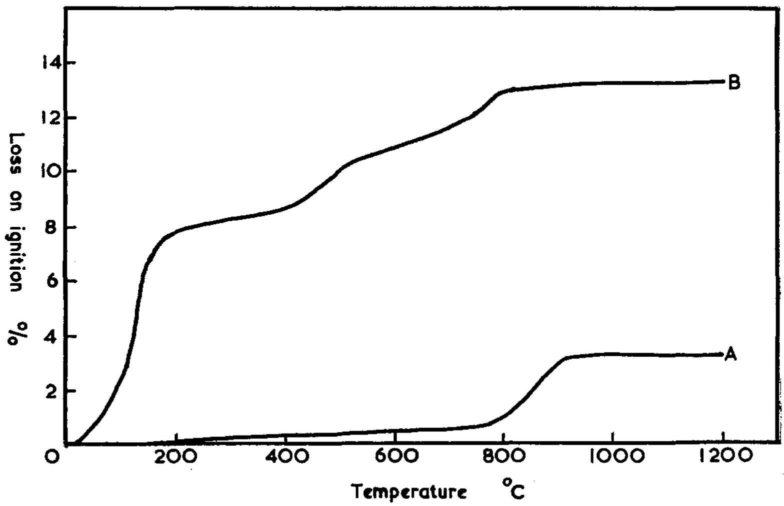

FIG. 1. A, Dehydration curve of xonotlite, Portree, Isle of Skye (B.M. 1959, 554). B, Dehydration curve of gyrolite, Portree, Isle of Skye (B.M. 1959, 554).

matted gives straight extinction. One specimen is penetrated by acicular crystals of yellow calcite (B.M. 1961, 158), while others show an additional mineral in either the core or the rim. Amygdales of gyrolite of varying hardness may be intergrown with mesolite or calcite with rims of thomsonite, mesolite, or tobermorite, or no rims at all. Other specimens consist of mixtures of the two zeolites and gyrolite with rims of gyrolite, tobermorite, or zeolite. One interesting specimen (B.M. 1961, 159) has a cream core resembling xonotlite but proved to be fine-grained calcite with a thick crust of gyrolite. Another specimen (B.M. 1961, 160) has a core of what appeared to be analcime (isotropic, refractive index *c.* 1·487), but an X-ray photograph showed it was a mixture of saponite and tobermorite; and yet another (B.M. 1961, 161) is a mixture of fibrous tobermorite, saponite, and probably cristobalite. This last mixture is white, soft, and earthy in appearance. The mesolite from this occurrence is rather unusual. It is normally finely fibrous and almost isotropic, but can, as is shown in a section from B.M. 1961, 162 (fig. 2), develop into paddle-shaped crystals in optical continuity, with medium birefringence, straight extinction, and positive elongation. It was at first thought that these might have been gonnardite, which has nearly the same optical properties, but X-ray photographs prove both to be mesolite.

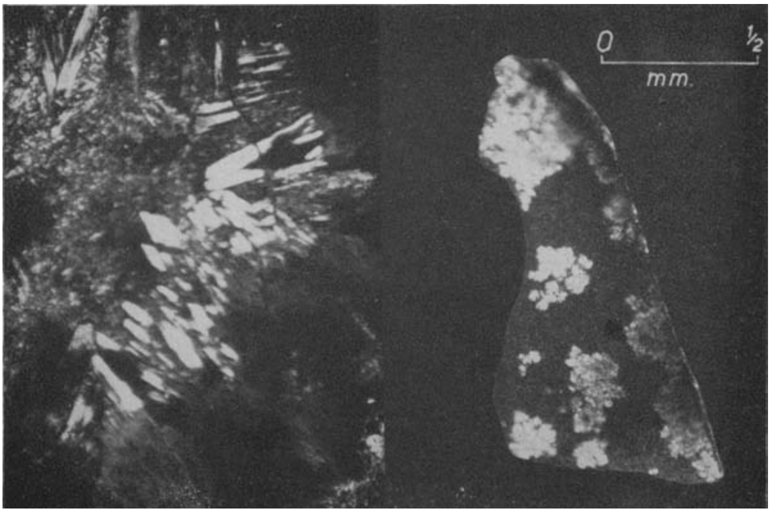

FIG. 2 (*left*). Acicular mesolite terminating in birefringent paddle-shaped crystals penetrating tobermorite, Portree, Isle of Skye. Crossed nicols, × 44 (B.M. 1961, 162).
FIG. 3 (*right*). Tacharanite, almost isotropic, with inclusions of birefringent gyrolite, fragment, Portree, Isle of Skye. Crossed nicols, × 50 (B.M. 1961, 163).

Two specimens deserve special mention. One of them (B.M. 1961, 163) consists of a core of tobermorite associated with a dense white mineral and surrounded by a rim of gyrolite and mesolite. This white mineral did not readily fall into line with any of those previously mentioned. Its refractive index was just less than 1·537 and it appeared to be cryptocrystalline but contained rosettes of another mineral with medium birefringence that proved to be gyrolite (fig. 3). Some of the 'isotropic' material was isolated and gave an X-ray pattern of a mineral in the tobermorite group but distinct from tobermorite or any other member of the group, natural or artificial. An attempt was then made to separate enough for analysis. This was very difficult as not only was the mineral exceedingly tough but it was also contaminated with gyrolite. With great patience Mr. D. L. Williams separated 29 mg. of the material on which all the subsequent work was done. A bulk density determination gave D_4^{23} 2·36, but that of individual fragments varied. This was rather disturbing so some of the fragments were re-examined microscopically. They proved to be fibrous tobermorite with a refractive index just less than 1·560 mixed with some other substance. It was then suspected that the sample obtained was a mixture, but a repeat of the X-ray photograph on some of the original material newly detached confirmed its homogeneity (fig. 4 and table II).[1] Two tiny fragments left from the

FIG. 4 (*upper*). X-ray photograph of tacharanite, Portree, Isle of Skye, 6 cm.-diam. camera (B.M. 1961, 163). (*lower*). X-ray photograph of type tobermorite, Tobermory, Isle of Mull, 6-cm. diam. camera (Heddle collection, Royal Scottish Museum, S.M.C. 435A1, X-ray No. 5418).

TABLE II. X-ray powder data for tacharanite from Portree, Isle of Skye (B.M. 1961, 163). Values from 6-cm. diam. camera, Cu-$K\alpha$ radiation.

d.	*I.*	*d.*	*I.*	*d.*	*I.*
12·7 Å.	**vvs**	**3·05 Å.**	**vs**	2·130 Å.	mw
8·40	m	2·98	vvw	2·080	vwb
7·10	vw	**2·89**	**s**	2·005	m
6·31	vvw	2·79	s	1·952	mw
5·66	mw	2·69	vvw	1·915	vw
5·16	ms	2·59	vvw	1·850	mw
4·16	vvw	2·495	vw	1·820	ms
3·75	w	2·440	m	1·738	mw
3·49	vw	2·375	vvw	1·675	m
3·37	m	2·295	vvw	1·641	m
3·16	vvw	2·185	vw	1·536	msb

first X-ray photograph and since stored in a gelatine capsule enclosed in a glass tube were then examined optically and found to be tobermorite with another mineral. X-rays confirmed that these fragments were in fact now a mixture of tobermorite and gyrolite. Therefore the new mineral on exposure to air obviously breaks down to tobermorite and gyrolite. Having realized this, the analysis was undertaken and gave the following result (table I, anal. 3), with the formula (Ca, Mg, Al) (Si, Al) $O_3.H_2O$.[2] The analysis of tobermorite from Sgúrr nam Boc, Loch

[1] Electron-diffraction work is being carried out by Dr. H. F. W. Taylor.

[2] After ignition the mineral was not gelatinized by concentrated HCl and it was necessary to fuse it with Na_2CO_3.

Eynort, Isle of Skye, is appended for comparison (table I, anal. 4). Dehydration was carried out to 1 050° C. on the sample and gave two distinct breaks in the curve at 350° C. and 650° C. (fig. 5). It is thought that this mineral is sufficiently distinctive to deserve a name of its own and that tacharanite (pronounced TĂ·KHERENAIT) from the Gaelic *tacharan* (a changeling) would be suitable, both from the nature of its behaviour and the wealth of folk-lore associated with the island in which it occurs.

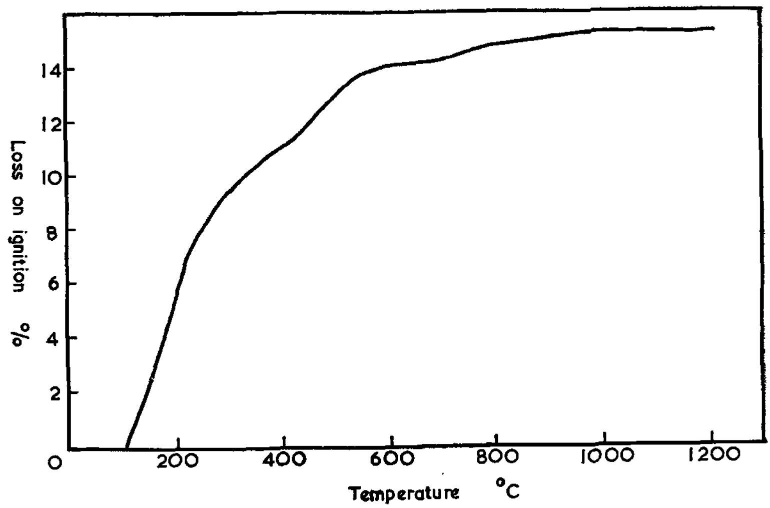

FIG. 5. Dehydration curve of tacharanite, Portree, Isle of Skye (B.M. 1961, 163).

A second specimen (B.M. 1961, 164) suspected of containing tacharanite was sectioned and showed a core of tobermorite surrounded by a zone of tacharanite enclosing radiating spherules of gyrolite and in its turn surrounded by mesolite. The impression is given that the gyrolite probably acts as centres of disintegration when the tacharanite is exposed to the atmosphere, and that tacharanite may be the parent mineral from which tobermorite, gyrolite, and xonotlite are formed.

In an attempt to find a clue to the history of the mineralization a few sections were cut of inclusions surrounded by the parent rock. In some cases there is a clear-cut junction between the amygdales and the rock; in others there has been quite an amount of disturbance. In fact in certain hand specimens there is a visible penetration of tobermorite and mesolite so as to surround some of the augite crystals (B.M. 1961, 165). It is supposed that the dolerite on cooling left vesicles that were later filled by a residual liquid containing calcium, magnesium, sodium,


FIG. 6 (*left*). Radiating acicular mesolite with rosettes of gyrolite and almost isotropic tacharanite grading into tobermorite, Portree, Isle of Skye. Crossed nicols, × 44 (B.M. 1961, 164).

FIG. 7 (*right*). Fibrous tobermorite, probably pseudomorphous after mesolite, Portree, Isle of Skye. Crossed nicols, × 44 (B.M. 1961, 167).


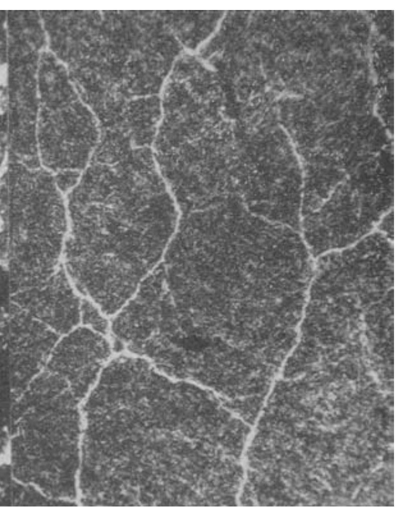

FIG. 8 (*left*). Olivine-dolerite showing a long prism of augite and alteration of feldspar crystals to tobermorite, Portree, Isle of Skye. Crossed nicols, × 44 (B.M. 1961, 167).

FIG. 9 (*right*). Tobermorite, showing shrinkage cracks filled in with isotropic material, Portree, Isle of Skye. Ordinary light, × 44 (B.M. 1961, 164).

aluminium, silica, carbon dioxide, and water—in fact all the constituents of the dolerite except iron, which has somehow disappeared. But this liquid has not simply filled all the vesicles giving the assemblage of zeolites and calcium silicates already noted. In fact there is some slight evidence that the zeolites were there first and the tobermorite appeared at a later stage. This is shown in one section where the fine grains of

TABLE III. The several associations of hydrated calcium silicates, zeolites, &c., observed at Portree, Isle of Skye.

Inner core.	Outer rim.
tobermorite	mesolite
,,	mesolite + gyrolite
,,	mesolite + calcite
,,	thomsonite
,,	thomsonite + calcite
,,	gyrolite
,, + gyrolite	mesolite
,, + gyrolite	thomsonite
,, + mesolite	mesolite
,, + calcite	mesolite
? *pseudom. after mesolite*	mesolite
gyrolite	mesolite
,,	thomsonite
,,	tobermorite
,, + mesolite	thomsonite + calcite
,, + calcite	mesolite
,,	no rim
xonotlite	gyrolite + mesolite
calcite	gyrolite
saponite	mesolite
,,	tobermorite
thomsonite	gyrolite
mesolite	mesolite + tobermorite
,, + thomsonite	mesolite
,, + gyrolite	gyrolite + calcite
,,	no rim

Also intimate intergrowths of thomsonite and mesolite in which either may predominate showing no definite zoning.

tobermorite are arranged in such a way that they seem to be replacing a mineral with radiating acicular structure such as the abundant mesolite (B.M. 1961, 167, fig. 7). In another section the tobermorite has invaded the parent rock and replaced some of the small feldspars (B.M.

1961, 167, fig. 8). In the section that shows the tacharanite the entire core is filled with fine-grained tobermorite revealing shrinkage cracks that have later been filled by an isotropic mineral with a lower refractive index than the tobermorite (B.M. 1961, 164, fig. 9). The tobermorite becomes increasingly fibrous as it reaches the zone containing the tacharanite and gyrolite. From these observations it seems clear that much more investigation is needed before a real idea of the history of the crystallization of these minerals can be formed. Table III shows the variation in association.[1]

Acknowledgements. I should like to thank Dr. M. H. Hey for all his advice and patience and also other members of the Department of Mineralogy for their help, including Miss E. E. Fejer for initial X-ray determinations, Mr. S. E. Ellis for petrological determinations, and Mr. T. D. Handslip for cutting the sections. I am also indebted to Dr. G. P. L. Walker for consultation on the mode of occurrence.

[1] The previous descriptions of Scottish tobermorite give very little information on the mode of occurrence—in fact Heddle only once mentions the parent rock as 'basic eruptive' in 'north-east Mull from Tobermory to Bloody Bay' (M. F. Heddle, Min. Mag., 1880, vol. 4, p. 119; The Mineralogy of Scotland, 1901, vol. 2, p. 83). Here the mineral is minutely granular and pale pink with a rim of mesolite and associated with xonotlite and gyrolite in neighbouring localities. His occurrence at Sgúrr nam Boc, Loch Eynort, Isle of Skye, shows material 'very arborescent and branching' with crystals that 'seem to obscure parallel to their length' (M. F. Heddle, Trans. Geol. Soc. Glasgow, 1892, vol. 9, p. 254).