

Tacharanite from the Gruppo di Voltri, Ligurian Alps, Italy

G. LUCCHETTI AND A. M. PENCO

Institute of Mineralogy, University of Genoa, Italy

SUMMARY. Tacharanite in fractures in metagabbroic rocks filled by zeolitic assemblages has been found in the Gruppo di Voltri, Ligurian Alps. Optical properties, chemical analysis, and thermal data are reported, also mineralogical data on tobermorite found at another locality of the Gruppo di Voltri. Alteration of tacharanite into tobermorite and gyrolite was not observed, nor was an association of tacharanite and tobermorite.

TACHARANITE, a calcium silicate hydrate first described by Sweet *et al.* (1961) from Portree, Scotland, and identified as a member of the tobermorite group has recently been re-examined by Cliff *et al.* (1975), who studied material from Portree and from four other European localities: Mull (Walker, 1971) and Huntly (Livingstone, 1974), both in Scotland; Carneal, Ireland (Sabine and Young, 1972); and Bramburg, Germany (Koritnig, 1972). Recently, Sutherland (1976) has published data on tacharanite from Tasmania and mentions a tacharanite received from Japan.

This mineral has been found for the first time in Italy in the Gruppo di Voltri in the Ligurian Alps along the Olbiccella stream near Tiglieto; it occurs in metagabbroic rocks in fractures filled by zeolitic assemblages, often associated with natrolite and thomsonite. The genesis of the mineralizations has been attributed to hydrothermal fluids, which represent the late thermal phenomena of the Alpine metamorphism (Cortesogno *et al.*, 1975, 1976).

Tacharanite from the Gruppo di Voltri is in the form of very compact aggregates, milky white, with a conchoidal fracture; it can occasionally be vitreous and microcrystalline. Optically it is isotropic or weakly birefringent with $n 1.534 \pm 0.004$; the specific gravity (determined by heavy liquids) for the compact aggregates ranges from 2.21 to 2.26, for a microcrystalline specimen 2.26.

X-ray powder data were obtained using a diffractometer and a Gandolfi camera, both with copper radiation (Table I). Cell dimensions ($a 17.11$, $b 3.65$, $c 28.04$ Å, $\beta 114.13^\circ$, $V 1597$ Å³) were derived by a least-squares computer program using twenty-

TABLE I. X-ray powder diffraction data for tacharanite from the Gruppo di Voltri

| d_{obs} | I_{obs} | d_{obs} | I_{obs} | d_{obs} | I_{obs} |
|------------------|------------------|------------------|------------------|------------------|------------------|
| 12.87 Å | s | 3.411 Å | w | 2.186 Å | vw |
| 8.41 | mw | 3.402 | w | 2.127 | vw |
| 7.70 | w | 3.339 | vw | 1.921 | vw |
| 7.11 | m | 3.203 | w | 1.859 | vw |
| 6.56 | mw | 3.179 | w | 1.824 | mw |
| 5.72 | mw | 3.044 | vs | 1.804 | vw |
| 5.21 | ms | 2.887 | mw | 1.635 | vw |
| 5.10 | vw | 2.853 | mw | 1.457 | vw |
| 4.63 | vw | 2.793 | m | 1.431 | vw |
| 4.25 | vw | 2.780 | m | 1.384 | vw |
| 4.146 | vw | 2.679 | w | 1.311 | vw |
| 3.715 | vw | 2.581 | vw | 1.211 | vw |
| 3.541 | vw | 2.433 | w | 1.188 | vw |
| 3.504 | w | | | | |

one reflections between 3.504 and 1.653 Å indexed by comparison with the data of Cliff *et al.*; the observed spacings and cell parameters agree satisfactorily with the pseudo-cell reported by Cliff *et al.*

A chemical analysis and pseudo-cell contents (calculated on a basis of sixty-nine oxygen atoms, as in the idealized formula of Cliff *et al.*) are given in Table II, and are in good agreement with the empirical cell contents derived using the cell dimensions and the specific gravity.

The chemical data for the Gruppo di Voltri specimens are in reasonable agreement with the analyses of tacharanite from other localities (Sweet *et al.*; Cliff *et al.*; Sutherland). The CaO content matches Sweet's result for Portree material, less well those of Cliff *et al.* for Bramburg and Huntly specimens; the very low MgO agrees with the results of Cliff *et al.*

Differential thermal analysis shows a large endothermal curve in the region 110 to 170 °C, an endothermal peak at about 800 °C, and a sharp exothermal peak at about 860 °C. The specimen

TABLE II

| 1 | | 2 | |
|--------------------------------|-------|----|-------|
| SiO ₂ | 44.40 | Si | 16.22 |
| Al ₂ O ₃ | 5.52 | Al | 2.37 |
| Fe ₂ O ₃ | nil | Fe | — |
| MgO | 0.41 | Mg | 0.22 |
| CaO | 32.99 | Ca | 12.92 |
| Na ₂ O | 0.55 | Na | 0.39 |
| K ₂ O | nil | K | — |
| H ₂ O | 16.12 | H | 39.30 |
| | | O | 69.00 |
| Total | 99.99 | | |

1. Analysis for tacharanite, Liguria (analyst: A. Mazucotelli).

2. Atomic pseudo-cell contents.

was heated successively to 400, 600, 700, 800, 900, and 1000 °C, each for 4 to 5 hours, and after each heating cooled and an X-ray powder pattern recorded. In agreement with Cliff *et al.*, the products cooled from 400 and 600 °C gave unaltered patterns of tacharanite, that from 700 °C a weakened pattern; those from 800 and 900 °C show a progressive shift of the 3.04 Å peak to 2.97 Å, which is the strongest peak of wollastonite; the product cooled from 1000 °C was indeed wollastonite.

In contrast to what Sweet *et al.* reported, we did not find that tacharanite altered spontaneously into tobermorite and gyrolite. Tobermorite does occur in the Gruppo di Voltri, but is not associated with tacharanite. Cliff *et al.* noted that 'tacharanite shows important resemblances to tobermorite, but there are also significant differences'; we therefore think it may be useful to report data for tobermorite, found in a different locality of the Gruppo di Voltri, in close similar zeolitic assemblages.

Tobermorite has been recorded from two Italian localities, Prà da la Stua and Monte Biaena, by Gottardi and Passaglia (1966, 1967); we now record a third occurrence in the Gruppo di Voltri. The new specimens consist of a fine-grained aggregate, transparent, vitreous, or fine aggregates with a silky appearance. Small amounts of optically unresolvable material, probably smectites, are often present interstitial to the tobermorite, which may explain the high MgO found in the chemical analysis: SiO₂ 48.30, Al₂O₃ 2.32, CaO 27.59, MgO 4.90, Na₂O 0.24, K₂O 0.19, H₂O 16.85, sum 100.39%; indeed, as reported by Cliff *et al.*, Mitsuda (1973) concluded that tobermorite cannot accommodate appreciable MgO; moreover, the Al₂O₃ and CaO contents seem rather low.

DTA, IR, and X-ray results agree with those reported by Cliff *et al.*: 'tobermorite does not

contain essential Al, though limited replacement of Si by Al seems to be possible.' Indeed, infra-red absorption spectra for tobermorite from the Gruppo di Voltri shows the two bands at 1207 and 745 cm⁻¹ of unsubstituted tobermorite shifted to lower frequencies, 1170 and 695 cm⁻¹ as a result of aluminium substitution (cf. Diamond *et al.*, 1966). This replacement is confirmed by the basal spacing (11.33 Å) and by the DTA, which shows three endothermal peaks at about 250, 610, and 780 °C and two exothermal peaks at about 830 and 970 °C, the latter very small (cf. Diamond *et al.*).

The X-ray powder pattern obtained for tobermorite from the Gruppo di Voltri was indexed by comparison with JCPDS card 19-1364 for a synthetic tobermorite; using eighteen reflections between 3.53 and 1.372 Å the cell parameters obtained were: *a* 11.27, *b* 7.36, *c* 22.65 Å, β 90°, agreeing well with those reported by McConnell (1954) for a pseudo-cell (body-centred orthorhombic), *a* 5.65, *b* 3.66, *c* 22.60 Å.

For comparison with tacharanite, the tobermorite was submitted to the same programme of thermal treatment: after heating at 400 to 700 °C altered X-ray patterns were obtained (indeed the lines at 11.33 vs. 3.08 s, 2.98 ms, and 2.81 Å ms shift, respectively, to 11.19, 3.05, 2.94, and 2.78 Å, and other lines have disappeared), while a pattern obtained from a specimen heated to about 800 °C shows the lines of wollastonite.

REFERENCES

- Cliff (G.), Gard (J. A.), Lorimer (G. W.), and Taylor (H. F. W.), 1975. *Mineral. Mag.* **40**, 113-26.
 Cortesogno (L.), Lucchetti (G.), and Penco (A. M.), 1975. *Render. Soc. Ital. Mineral. Petrol. (Italy)*, **31**, 673-710.
 ———— 1976. *Period. Mineral.* **45**, 97-108.
 Diamond (S.), White (J. L.), and Dolch (W. L.), 1966. *Am. Mineral.* **51**, 388-401.
 Gottardi (G.) and Passaglia (E.), 1966. *Period. Mineral.* **35**, 197-204.
 ———— 1967. *Ibid.* **36**, 1079-83.
 Koritnig (S.), 1972. *Contrib. Mineral. Petrol.* **35**, 293-301.
 Livingstone (A.), 1974. *Mineral. Mag.* **39**, 820-1.
 McConnell (J. D. C.), 1954. *Ibid.* **30**, 293-305.
 Mitsuda (T.), 1973. [*Cement Concr. Res.* **3**, 71-80], quoted by Cliff *et al.*, 1975.
 Sabine (P. A.) and Young (B. R.), 1972. *Ann. Rep. for 1971, Inst. Geol. Sci. (London)*, 102.
 Sutherland (F. L.), 1976. *Mineral. Mag.* **40**, 887-90.
 Sweet (J. M.), Bothwell (D. T.), and Williams (D. L.), 1961. *Ibid.* **32**, 745-53.
 Walker (G. P. L.), 1971. *West Commem. Vol. (Univ. Saugar, India)*, 181. [M.A. 72-3476.]

[Manuscript received 6 February 1978, revised 20 April 1978]