REFERENCES

ANSILEVSKY (J.), 1966. *Arch. Miner.* **26**, 119–30.
BANNO (S.), 1964. *Jour. Fac. Sci. Univ. Tokyo, Sec II.* **15**, 203–319.
DEER (W. A.), HOWIE (R. A.), and ZUSSMAN (J.), 1962. *Rock-forming minerals*, **3**, London(Longmans).
GÜVEN (N.) and BURNHAM (C. W.), 1967. *Zeits. Krist.* **125**, 163–83.
MIMURO (Y.), 1971. M.Sc. thesis, Kanazawa Univ.
SADANAGA (R.) and TAKÉUCHI (Y.), 1961. *Zeits. Krist.* **116**, 406–29.
SPRY (A.), 1963. *Min. Mag.* **33**, 589–93.
VELDE (B.), 1970. *Bull. Soc. franç. Min. Crist.* **93**, 370–85.

[*Manuscript received 30 May 1974.*]

MINERALOGICAL MAGAZINE, JUNE 1975, VOL. 40, PP. 205–8

Epidote minerals in ophiolites near Coolac, N.S.W., Australia

OCCURRENCES of epidote minerals, and particularly of orthorhombic members of the group, are reported below from the Mooney Mooney Range, near Coolac, south-eastern N.S.W. At this locality an incomplete sub-vertical ophiolite sequence lies between granodiorite and a volcanic-sedimentary series, both of Silurian age (fig. 1). Keratophyres pass down into unaltered basalts admixed with metabasalts containing greenschist facies assemblages. Serpentinite is associated. The underlying augite- and hornblende-gabbros are variably albitized, uralitized, chloritized, saussuritized, and epidotized, in places associated with foliated amphibolite containing plagioclase and hornblende, and in the north are separated from subjacent harzburgite by clino-pyroxenite (Golding, 1969). Harzburgite partly altered to antigorite, talc, and carbonates in the north appears to override higher-level members of the sequence, which occur as thin septa or inclusions within lizardite–chrysotile serpentinite to the south (Golding, 1971).

Epidote minerals. Green pleochroic epidote is restricted to some quartz keratophyres and highest-level metabasalts of the sequence. Colourless clinozoisite is the characteristic epidote mineral of the underlying metabasites and associated epidosite veins but is notably heterogeneous. It forms polygonal granular masses and radiating prismatic groups. The grains, up to 0·5 mm wide, show lamellar twins, common patchy zoning, less common regular zoning, and polarization colours with the frequency: anomalous blue > anomalous brown > anomalous greenish yellow > normal. Diffractograms of vein material (Samples 3 and 5, fig. 1) indicate clinozoisite ± subordinate orthorhombic epidote minerals, but the latter occur to the exclusion of clinozoisite in some metagabbro (Sample 4). This metagabbro contains diopside, chlorite, grossular, and ~ 20 % of orthorhombic epidote mineral grains showing minor zoning and twinning, some doubly terminated sections, and predominantly normal first-order polarization colours.

At the junction of antigoritized olivine clinopyroxenite and saussuritized hornblende gabbro poorly exposed uniformly fine-grained segregations (Sample 1), 20 cm wide, contain zoisite (70–80 %)+prehnite and diopside. At the same junction relict feldspars (Sample 2), 3 to 4 cm wide, between large unaltered clinopyroxene crystals in gabbro pegmatite are completely replaced by an aggregate of zoisite (70–80 %)+prehnite and grossular. In the south, at the junction of variolitic spilite and lizardite-rich serpentinized harzburgite, imperfectly exposed uniformly fine-grained segregations (Samples 6, 7, 8) ~ 30 cm wide, contain zoisite (70–90 %)+prehnite, chlorite, and sphene. The southern segregations are flanked by prehnite rock, foliated grossular-chlorite rock, and trondhjemite.

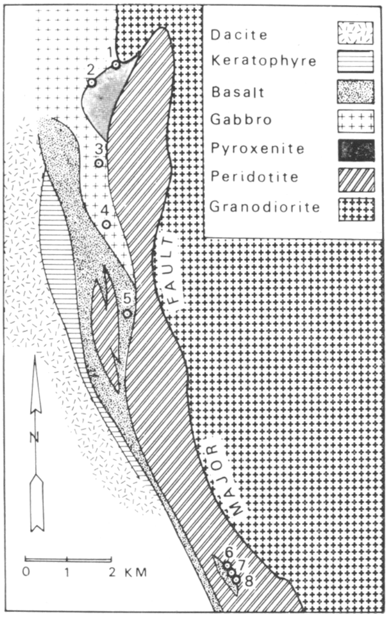

FIG. 1. Sketch map of ophiolites in the Mooney Mooney Range, east of Coolac, N.S.W., showing principal sample locations.

Thin sections of the segregated material exhibit a felt of bladed euhedral zoisite crystals, up to 0·2 mm wide, with prehnite, grossular, or chlorite occupying the interstices (Samples 1, 2, and 8), merging with turbid massive aggregates or dense clusters of radiating needles (Samples 6 and 7). Lamellar twins and zoning are absent, polarization colours are consistently normal first order, β varies from 1·695 to 1·700±0·002, $2V_\gamma$ varies from 20° to 42° and dispersion is $r > v$. The O.A.P. $\parallel$ doubly terminated sections (010) and $\perp$ cleavage (100). These data apply to selected grains mainly in Samples 1, 2, and 8. Diffractograms of Samples 1, 2, 6, 7, and 8 all indicate orthorhombic epidote minerals to the exclusion of clinozoisite. Chemical analyses of impure concentrates (Samples 1, 6, 7, and 8) by X-ray fluorescence spectrometry gave values for total Fe as Fe_2O_3 from 0·39 to 0·69 wt %. The complete analysis (wt % oxides) for Sample 8 (< 5 % impurity) gave: SiO_2 39·85, TiO_2 0·09, Al_2O_3 31·54, total Fe as Fe_2O_3 0·43, MnO 0·07, MgO 0·83, CaO 23·36, K_2O 0·15, P_2O_5 0·31, SO_3 0·04, loss on ignition 3·60. Total 100·27.

Common tabular rodingitic bodies completely enclosed within harzburgite or serpentinite of the principal ultramafic member of the sequence contain grossular (and, or, idocrase)+chlorite±diopside commonly to the exclusion of all epidote minerals.

Zoisite and ferrian zoisite. According to Myer (1966) zoisite contains up to 0·14 atoms of Fe^{3+} (on the basis of 25 oxygens), has the O.A.P. $\perp$ cleavage (100), $\beta \leqslant 1{\cdot}696$ and dispersion $r > v$. Ferrian zoisite contains $> 0{\cdot}14$ atoms of Fe^{3+}, has the O.A.P. $\parallel$ cleavage (100), $\beta > 1{\cdot}696$ and dispersion $r < v$. Recorded analyses and formulae of orthorhombic epidote minerals (Deer *et al.*, 1962; Seki and Kuriyagawa, 1962; Seki *et al.*, 1963; Myer, 1966) suggest that values for total Fe as $Fe_2O_3 < 1{\cdot}1$ wt % indicate zoisite and values $> 1{\cdot}3$ wt % indicate ferrian zoisite. For the Coolac material the optics of selected grains and relative homogeneity of Samples 1, 2, and 8 together with the Fe contents of Samples 1 and 8 indicate that zoisite is the sole or greatly predominant epidote mineral in these samples. Optical data for the turbid and acicular material (Samples 6, 7) is meagre but the respective Fe contents (0·44 and 0·39 wt % Fe_2O_3) preclude the presence of substantial admixed ferrian zoisite. The status of the orthorhombic epidote mineral associated with clinozoisite in the epidosite veins (Samples 3, 5) and of that occurring in the clinozoisite-free metagabbro (Sample 4) as zoisite, ferrian zoisite, or a mixture of both has not been ascertained. The possible presence of grain-inhomogeneities of the types described by Ackermand and Raase (1973) cannot be excluded.

Discussion. Zoisite has been reported from ocean floor (Bonatti *et al.*, 1971) and ophiolitic (Watson, 1942) metabasites and from tectonic inclusions in serpentinite (Seki and Kuriyagawa, 1962). Orthorhombic epidote minerals are relatively common near Coolac where they seem to have formed preferentially within a restricted stratigraphic interval of an ophiolite sequence, namely within lower-level coarse-grained metabasites flanking the principal ultramafic member. They are also locally segregated at gabbro–pyroxenite and spilite–harzburgite junctions.

Apart from the zoisite segregations, and disregarding microscopically dense saussurite, the secondary Ca–Al silicates in the Coolac ophiolites tend to vary with increasing stratigraphic depth as follows: green epidote → clinozoisite → orthorhombic epidote minerals → grossular (idocrase). This mineral series apparently augments that indicated, principally for lower grade metamorphic ophiolites, by Gass and Smewing (1973) and suggests increasing temperature and decreasing P_{O_2} with depth of formation, which accords with sub-seafloor metamorphism (Spooner and Fyfe, 1973).

A pre-emplacement age for the segregated zoisite also seems likely, at least for the northern occurrences. The latter may exemplify recrystallized saussurite (Olsen, 1961). The southern segregations apparently belong to reaction zones (Coleman, 1967) that may define intrusive or tectonic contacts or both. Both axis and off-axis activity (Gass and Smewing, 1973) may have contributed to the formation of the diverse epidote minerals and to the secondary products in general encountered in the Mooney Mooney Range.

Acknowledgements. The authors thank Mr. P. Brown for the loan of thin sections of keratophyre from the Mooney Mooney Range and Mr. G. Melville for draughting the sketch map.

University of New South Wales, H. G. GOLDING
Kensington, New South Wales 2033 A. S. RAY

REFERENCES

Ackermand (D.) and Raase (P.), 1973. *Contr. Min. Petr.* **42,** 333–41.
Bonatti (E.), Honnorez (J.), and Ferrara (G.), 1971. *Phil. Trans.* **A268,** 385–402.
Coleman (R. G.), 1967. *U.S. Geol. Surv. Bull.* **1257.**
Deer (W. A.), Howie (R. A.), and Zussman (J.), 1962. *Rock forming minerals,* **1.** London (Longmans).
Gass (I. G.) and Smewing (J. D.), 1973. *Nature,* **242,** 26–9.
Golding (H. G.), 1969. *Journ. Proc. Roy. Soc. N.S.W.* **102,** 173–87.
—— 1971. *Geol. Soc. Aust. Spec. Publs.* **3,** 321–9.
Myer (G. H.), 1966. *Amer. Journ. Sci.* **264,** 364–85.
Olsen (E. J.), 1961. *Amer. Journ. Sci.* **259,** 329–47.
Seki (Y.) and Kuriyagawa (S.), 1962. *Jap. Journ. Geol. Geogr.* **33,** 15–32.
—— ——, and Horikoshi (T.), 1963, *Sci. Rpts. Saitama Univ.,* **B4,** 193–216.
Spooner (E. T. C.) and Fyfe (W. S.), 1973. *Contr. Min. Petr.* **42,** 287–304.
Watson (K. D.), 1942. *Amer. Min.* **27,** 638–45.

[*Manuscript received 14 March 1974, revised 22 July 1974.*]

MINERALOGICAL MAGAZINE, JUNE 1975, VOL. 40, P. 208

Barrerite, a new natural zeolite

In an earlier paper (Passaglia and Pongiluppi, 1974), we described as 'sodian stellerite' a mineral found at Capo Pula, Sardinia, Italy. This mineral gives a powder pattern very similar to that of stellerite, a Ca-zeolite, of space group *Fmmm*; unlike stellerite, our mineral contains Na > Ca, and its space group is *Amma.*

In view of the uncertain status of the nomenclature of zeolites, at the time of publication we named it provisionally 'sodian stellerite'.

Subsequently, Dr. M. Hey of London and Prof. G. Gottardi of Modena both suggested that this phase should be considered a new mineral species, and we decided to name it Barrerite, in honour of Richard M. Barrer, born in New Zealand—but for a long time active as scientist and teacher in Britain—for his outstanding contributions in the field of the chemistry of molecular sieves. The new mineral name has been approved by the Commission on new minerals and mineral names of the International Mineralogical Association.

Istituto di Mineralogia e Petrologia
Università di Modena, Via S. Eufemia 19
41100 Modena, Italy

E. Passaglia
D. Pongiluppi

REFERENCE

Passaglia (E.) and Pongiluppi (D.), 1974. *Lithos,* **7,** 69–73.

[*Manuscript received 25 October 1974.*]