

atacamite was revealed by X-ray powder diffraction and microprobe methods. A partial analysis by microprobe of cumengéite intergrown with cerussite gave Pb 58.5, Cl 18.5, and Cu 17.7%; silver was not detected. The higher Pb values and correspondingly smaller Cu and Cl analyses with respect to the assumed stoichiometry (Winchell and Rouse, 1974) may be accounted for by the higher lead contribution due to the intergrown nature of the analysed cumengéite with cerussite.

The chloride ion, essential for the formation of cumengéite and atacamite, is clearly derived from sea-water which at high tide covers the section of the vein in which the minerals occur. In this respect, the locality is akin to that at Laurium, Greece, where cumengéite and other rare Pb(II) and Cu(II) halides occur in altered slags which have been dumped in the sea (Yedlin, 1973; Kohlberger, 1976). Cumengéite was first described from the Boleo deposits of Baja California where halite abounds in the rocks surrounding the mineralization, and is presumably the source of the chloride (Wilson and Rocha, 1955).

The new Cornish locality for cumengéite (and that at Laurium) is of some interest since studies of its chemical stability have recently been reported (Humphreys *et al.*, 1980; Abdul-Samad *et al.*, 1981). Chloride ion concentration is about 0.5 molal in sea-water, which has a pH of 8.0 to 8.4 (Krauskopf, 1979); such values are entirely consistent with the stability fields of cumengéite established by the above authors. It is apparent that the thermodynamic model developed by them is applicable to mineral assemblages of this type. Boléite, $Pb_{26}Cu_{24}Ag_9Cl_{62}(OH)_{47} \cdot H_2O$, and epitaxial pseudoboléite, $Pb_3Cu_4Cl_{10}(OH)_8 \cdot 2H_2O$, are also

expected to occur in the same environment should sufficient silver ion be present, but were not observed in the Cornish occurrence.

The presence of phosgenite in the oxidized sequence is also of some interest as its formation in this mineral assemblage confirms that reduced $H_2CO_3(aq)$ activities (Abdul-Samad *et al.*, 1982) are necessary for the formation of the complex halides of Pb(II) and Cu(II).

REFERENCES

- Abdul-Samad, F. A., Humphreys, D. A., Thomas, J. H., and Williams P. A. (1981) *Mineral. Mag.* **44**, 101-4.
 — Thomas, J. H., Williams, P. A., Bideaux R. A., and Symes, R. F. (1982) *Transition Metal Chem.* **7**, 32-7.
 Dean, A. C. (1982) *J. Russell Soc.* **1**, 40-1.
 Dines, H. G. (1956) *The Metalliferous Mining Region of South-West England*, **1**, Geol. Surv. Great Britain.
 Edmonds, E. A., McKeown, M. C., and Williams, M. (1975) *British Regional Geology, South-West England*, 4th edn. HMSO.
 Hill, J. B., and MacAlister, D. A. (1906) *Geology of Falmouth and Truro*, Mem. Geol. Surv. Great Britain.
 Humphreys, D. A., Thomas, J. H., Williams, P. A., and Symes, R. F. (1980) *Mineral. Mag.* **43**, 901-4.
 Kohlberger, W. (1976) *Mineral Rec.* **7**, 114-25.
 Krauskopf, K. B. (1979) *Introduction to Geochemistry*, 2nd edn. McGraw-Hill.
 Stephens, F. J. (1886) *Rep. Roy. Corn. Poly. Soc.* 189-94.
 Wilson, I. F., and Rocha, V. S. (1955) *Prof. Paper U.S. Geol. Surv.* **273**, 1-134.
 Winchell, R. E., and Rouse, R. C. (1974) *Mineral. Rec.* **5**, 280-7.
 Yedlin, N. (1973) *Ibid.* **4**, 262-3.

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Tourmalinites from Belgium and from SE Ireland— a discussion

It has been recently postulated that tourmalinites found as pebbles in Devonian conglomerates in Belgium originated as a result of sub-volcanic

hydrothermal metasomatism of rocks of variable composition and origin (Fieremans and De Paep, 1982). These authors note that their conclusion

remains a little tentative in the absence of any indication of the geological environment from which the pebbles derived; they cannot be traced to the exposed underlying basement and thus appear to be exotic. The pebbles described come from localities that lie adjacent to a number of Cambro-Silurian massifs, notably the Stavelot Massif (op. cit. fig. 1). Studies on similar rock types in SE Ireland suggest that these nearby massifs are, in fact, a very likely source of the pebbles.

Tourmalinites occur in SE Ireland—exactly as they do in Belgium—as clasts in post-orogenic Devonian conglomerates (e.g. Capewell 1957). Palaeocurrent data suggest that the source of such clasts, deposited in one embryonic molasse basin at least, lay in the direction of nearby exposures of Cambro-Ordovician rocks (Penney, 1980). These rocks belong to a Lower Palaeozoic succession in which banded tourmalinites are a distinctive, if minor, feature (fig. 1). The fact that the tourmalinites occur within the aureole of the Leinster Granite suggests pneumatolysis. However,

it is also a fact that they occur in close spatial association with thinly bedded spessartine quartzites (fig. 1). These latter rocks are metamorphosed iron-manganese sediments and are a typical feature of the Maulin Formation of the Cambro-Ordovician Ribband Group in SE Ireland (Brindley, 1954; Brück *et al.*, 1974, 1980).

The association of tourmalinites with spessartine quartzites and of both with sulphide deposits of volcanogenic origin, e.g. at Broken Hill, NSW (Stanton, 1976; Plimer, 1980) provides a basis for understanding the origin of the tourmaline-rich rocks. In the quoted instance, and in others like it, it is probable that anomalously high boron levels, essentially of volcanic origin, existed at the time of original sedimentation (e.g. Ethier and Campbell, 1977; Slack, 1980).

The spessartine quartzites of SE Ireland are coticles as originally defined by Renard (1878). Coticles are an important feature in low-grade metamorphosed shales of Tremadocian age in the Stavelot Massif (Kramm, 1976). In that massif the

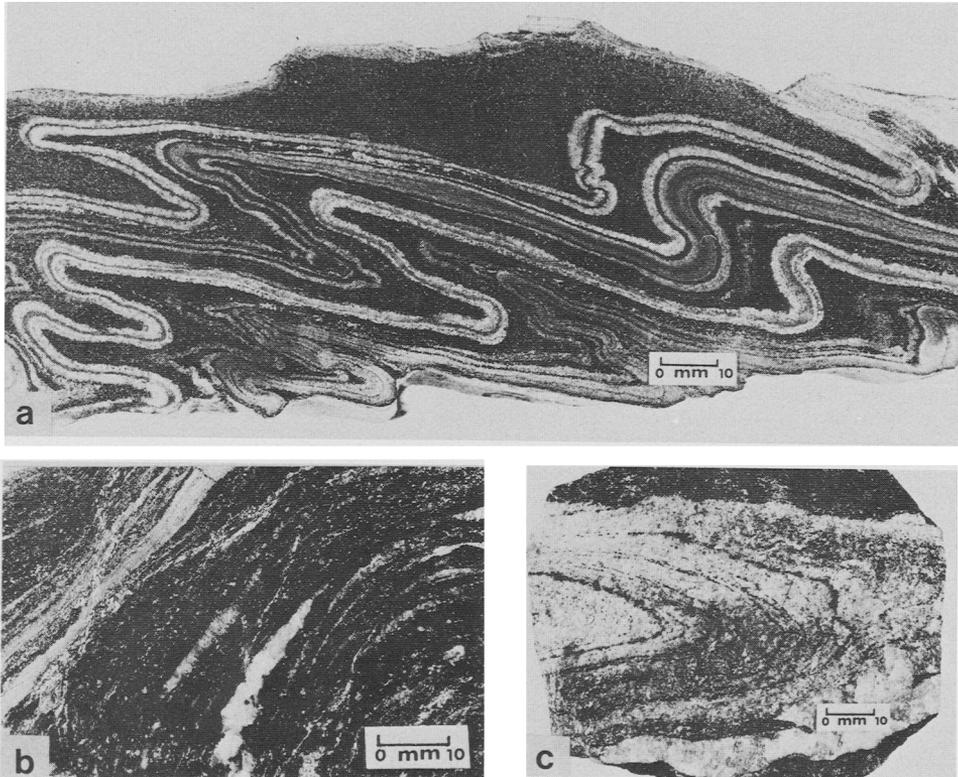


FIG. 1. Coticules (garnet quartzites) and tourmalinites from SE Ireland. (a) Typical thinly bedded coticule layers in siliceous phyllite. (b) Banded tourmalinite with interbedded coticule layers (left). (c) Folded thin tourmalinite layers in quartzite.

presence of tourmaline in quantity—and associated with garnet—has been long since noted (e.g. Lohest, 1911). The Lower Palaeozoic sediments of the Stavelot Massif are, it would seem at a distance, a very possible source of tourmalinite pebbles.

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REFERENCES

- Brindley, J. C. (1954) *Sci. Proc. R. Dubl. Soc.* **26**, 245–62.
 Brück, P. M., Colthurst, J. R. J., Feely, M., Gardiner, P. R. R., Penney, S. R., Reeves, T. J., Shannon, P. M., Smith, D. G., and Vanquestaine, M. (1980). In *The Caledonides of the British Isles—reviewed* (Harris, A. L., Holland, C. H., and Leake, B. E., eds.). Geological Society of London.
 —Potter, T. L., and Downie, C. (1974) *Proc. R. Ir. Acad.* **74B**, 75–84.
 Capewell, J. G. (1957) *Q. J. Geol. Soc. Lond.* **112**, 393–410.
 Ethier, V. G., and Campbell, F. A. (1977) *Can. J. Earth Sci.* **14**, 2348–63.
 Fieremans, M., and De Paeppe, P. (1982) *Mineral. Mag.* **46**, 95–102.
 Kramm, U. (1976) *Contrib. Mineral. Petrol.* **56**, 135–55.
 Lohest, M. (1911) *Ann. Soc. Géol. Belg.* **38**, 11–25.
 Penney, S. R. (1980) *J. Earth Sci. R. Dubl. Soc.* **3**, 155–78.
 Plimer, I. R. (1980) *Mineral. Deposita*, **15**, 275–89.
 Renard, A. (1878) *Mém. Cour. Mém. Sav. Acad. R. Belg.* **16**.
 Slack, J. F. (1980) *Special Economic Studies Series No. 8*. Maine Geological Survey, Augusta. 1–25.
 Stanton, R. L. (1976) *Trans. Inst. Mining Metall.* **B85**, 132–41.

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An isotropic alteration product of cordierite

THE most usual alteration products of cordierite are white mica (pinitite) and chlorite, but there have been several records of brownish and yellowish isotropic alteration products. Analyses of low-potash alteration products are few (e.g. Dana, 1892, p. 421; Chandler, 1975), but they show considerable variety. Examples of brown and yellow isotropic alteration products have been reported in the Cape Province of South Africa (Mathias, 1952); in the Chipata district of eastern Zambia (Vavřda and Vrána, 1972) and nearby in the Mchinji district of Malawi (Haslam, 1980); further north in Malawi, in the Champira Dome (Haslam *et al.*, 1980); in the Loos-Hamra region of Sweden (von Eckermann, 1936); and in NE Scotland (Ashworth, 1976). This communication describes the Champira Dome occurrence, and gives some data for the Mchinji occurrence.

Cordierite is an important constituent of migmatites and banded quartzofeldspathic gneisses in the Champira Dome, Malawi (12° 20' S, 33° 38' E). Minerals commonly associated with it are quartz, orthoclase microperthite, sodic plagioclase, almandine, biotite, sillimanite, magnetite, hercynite, corundum, ilmenite, and hematite (Haslam *et al.*, 1980). Several of the rock specimens examined

contain a yellowish isotropic substance with a glassy appearance. In most instances it is clearly a replacement product of cordierite, initially replacing it along fractures and grain boundaries, but in a few specimens it forms pseudomorphs after biotite.

In thin section the substance is pale yellow and optically isotropic. It has a clear, vitreous appearance and inclusions are generally scarce or absent. It is common for Becke lines to be discernible within the material, indicating a slightly heterogeneous composition. The refractive index is greater than that of quartz, and hand-picked grains from MB 60 showed a refractive index of 1.565 ± 0.005 . A grain from the same specimen had a low specific gravity of 2.51 ± 0.02 , consistent with a loosely packed amorphous structure.

No transitional phases are visible between the isotropic substance and cordierite or biotite, nor are there any reaction textures with other minerals. Its formation was not accompanied by hydrothermal alteration of other minerals. Relic cordierite and biotite are generally fresh, and so are adjacent crystals of feldspar. One specimen (MB 65) shows hydrothermal alteration, and cordierite, feldspars, and isotropic substance alike display