

SHORT COMMUNICATIONS

MINERALOGICAL MAGAZINE, SEPTEMBER 1969, VOL. 37, NO. 287

Tetradymite and wehrlite from Singhbhum Copper-Belt, India

TETRADYMITÉ and wehrlite (of Huot) constitute an interesting mineral pair in the sulphide ores from the Singhbhum Copper-Belt, India. They occur as small subhedral short prismatic to oval grains mostly within chalcopyrite, although their occurrence in pyrrhotine is also noted. Other minerals in the assemblage are: pyrite, marcasite, pentlandite, violarite, cubanite, molybdenite, skutterudite, bismuthinite, sphalerite, galena, millerite, mackinawite, native silver, chalcocite, covellite, cuprite, malachite, native copper, magnetite, ilmenite, and rutile (Dunn, 1937; Rao, 1962; Ghose, 1966; Sarkar, 1963, 1964-5, 1968; Sarkar, Deb, and Basu, 1966). The mineralization is 'hydrothermal' in origin (Dunn, 1937; Sarkar, 1966). The two minerals, tetradymite and wehrlite, occur in very close proximity and often within the limits of a single grain boundary (fig. 1).

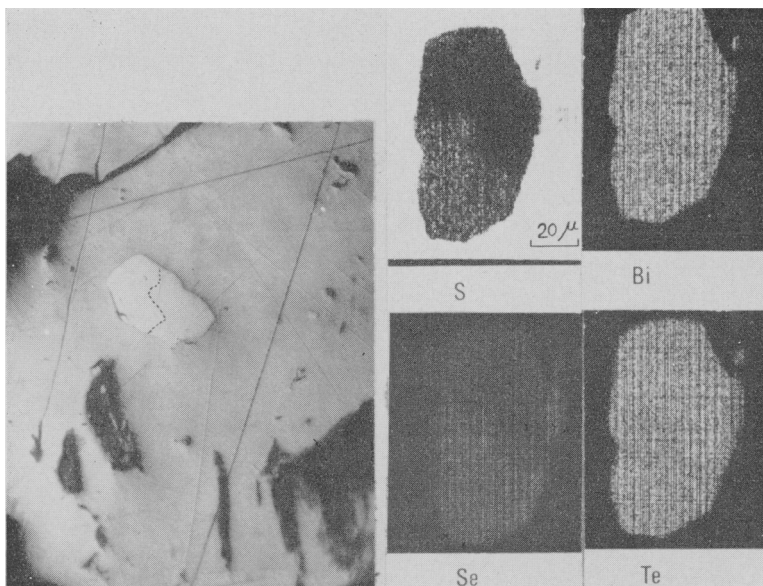
Optical properties. In reflected light the tetradymite is light grey whereas wehrlite is creamy white, has a greater polishing hardness than tetradymite and takes a better polish. Both minerals are softer than chalcopyrite. The reflectivity values given for tetradymite in literature vary over a wide range. The values obtained by the present workers are: O 53 %, E 45.5 %. The measurements were made photometrically under oil with a Leitz green filter (absorption peak approximately at 530 μ), using a carborundum standard. Dry cell batteries were used as the power source. The discrepancies in the reflectivity values obtained by different workers (Ramdohr, 1960) probably emanate from two sources: different workers might have measured different sections of the bireflecting mineral; and the mineral does not take a good polish and its polished surface is often non-planar, so that the reflectivity might vary from place to place on the surface. However, compositional variation such as the presence of selenium in tangible proportion may also affect the value.

Wehrlite has a higher reflectivity than tetradymite. Its bireflectance is not perceptible to the eye, but photometric measurements indicated the value to vary from 58 to 65.5 % in oil. Optically, as noted by Ramdohr (1960), the mineral is not easily distinguished from tellurbismuth and was reported as such by the present authors (1966).

Chemical composition. Electron-probe microanalysis of tetradymite from Singhbhum gave: Bi 62.1, Te 24.4, Se 5, S 5 % corresponding to $\text{Bi}_5\text{Te}_{3.3}\text{Se}_{2.2}\text{S}$. The highest recorded concentration of selenium (2.17 %) in tetradymite known to the authors is that by Shannon (1925). It may be noted that once the element is present in the system it is likely that it will replace tellurium in the structure since the two elements have

similar properties. That selenium has replaced tellurium and not sulphur will be apparent from the above formula.

Wehrlite from Singhbhum gives Bi 67.3, Te 28%. Sulphur and selenium have not been detected in the analysis (fig. 2). Bismuth and tellurium are in the atomic ratio Bi_3Te_2 , but only add up to 95.3%; keeping in mind the possibility that the missing



FIGS. 1 and 2: FIG. 1 (left). Tetradymite (light grey) and wehrlite (white) within a single grain boundary, in a chalcopyrite base. $\times 260$. FIG. 2 (right). Scanning pictures of the above two minerals for S, Bi, Se, Te, obtained in electron-probe microanalysis.

4.7% may be either bismuth or tellurium it will be safe to suggest that the formula lies somewhere between Bi_3Te_2 and $\text{Bi}_3\text{Te}_{2.4}$ (i.e. between 55 and 61 atom. % Bi). This composition compares closely with that from the Ilkovitsky-Podulki area, U.S.S.R. (Lazarenko *et al.*, 1963).

Discussion. Brown and Lewis (1962) have shown that an unbroken mix-crystal series exists from 32 to 60 atom. % Te (Bi_2Te to Bi_2Te_3), and possibly further. Hedleyite, with 30 atom. % Te, has been shown to have a superstructure (Warren and Peacock, 1945) and it is possible that other compositions with simple Bi:Te ratios, such as BiTe and Bi_3Te_2 may also form ordered phases. Lazarenko *et al.* (1963) were able to index a X-ray powder pattern of the mineral on the simple tellurbismuth cell, but the existence of an ordered Bi_3Te_2 phase, suggested by their analysis and that of the Singhbhum mineral, cannot be ruled out until single-crystal data are available.

Acknowledgements. The authors are grateful to M. Claude Guillemain, Chef des laboratoires BRGM, Orleans, France, for having kindly analysed the minerals with electron microprobe.

They are also thankful to Dr. G. Kullerud of the Geophysical Laboratory, Washington, for critically reading the first draft of the paper.

*Department of Geological Sciences
Jadavpur University
Calcutta-32, India*

S. C. SARKAR
M. DEB

REFERENCES

- BROWN (A.) and LEWIS (B.), 1962. *Jour. Phys. Chem. Solids*, **23**, 1597-1604.
 DUNN (J. A.), 1937. *Mem. Geol. Surv. India*, **69**, Pt. 1.
 GHOSE (A.), 1966. *Proc. 53rd Ind. Sci. Cong.* 184-5.
 [LAZARENKO (E. K.), LAZARENKO (E. A.), BARYSHNIKOV (E. K.), and MALYGINA (O. A.)] Лазаренко (Е. К.), Лазаренко (Э. А.), Барышников (Э. К.), и Малыгина (О. А.), 1963. Мин. Закарпаття (*Min. of Transcarpathia*), изд. Львов. унив.
 RAMDOHR (P.), 1960. *Die Erzminerale und ihre Verwachsungen*. Berlin (Acad.-Verlag).
 RAO (K. K.), 1962. *Current Sci.* **5**, 192-3.
 SARKAR (S. C.), 1963. Вест. Москов. Унив. Сер. 4, **5**, 37-43.
 ——— 1964-5. *Proc. 51-52nd Ind. Sci. Cong.* 183.
 ——— 1966. *Contributions to the Geology of Singhbhum*. Jadavpur Univ. Publ., 91-101.
 ——— 1968. *Proc. 55th Ind. Sci. Cong.*, 210-11.
 ——— DEB (M.), and BASU (D. K.), 1966. *Symp. Base Metals (Abstr.)*, Geol. Surv. India, 16.
 SHANNON (E. V.), 1925. *Amer. Min.* **10**, 198-9.
 WARREN (H. V.) and PEACOCK (M. A.), 1945. *Univ. Toronto Stud., Geol. Ser.* **49**, 55-69.

[Manuscript received 24 September 1968]

MINERALOGICAL MAGAZINE, SEPTEMBER 1969, VOL. 37, NO. 287

Delafossite from Mina Remolinos Nuevo, Atacama province, northern Chile

FEW natural occurrences of delafossite, CuFeO_2 , have been adequately documented, and, in view of recent interest in this oxide (Hey, 1968; Wiedersich *et al.*, 1968), it seems worthwhile to describe briefly a new occurrence at Mina Remolinos Nuevo, Atacama province, northern Chile. A detailed study of this small copper-gold mine was carried out as part of an investigation of the mineralogy and controls of the supergene mineral alteration of copper deposits in the southern Atacama Desert (Sillitoe, 1969).

Mina Remolinos Nuevo exploits one of a group of over ninety tourmaline breccia pipes of Palaeocene age, located in the vicinity of the eastern margin of the early Tertiary or Upper Cretaceous Cabeza de Vaca granodiorite intrusion (Parker *et al.*, 1963). The approximately elliptical pipe has a vertical extent of at least 100 m, and contains hydrothermally altered blocks of granodiorite, which were initially cemented by tourmaline and quartz, paragenetically followed by chalcopyrite and pyrite, and