atoms are less restricted and their vibrations parallel to the *c* axis are bigger than those in the (001) plane. Sass *et al.* (1957) reports a rms displacement for oxygen in $CaCO_3$ of about 0.09 Å parallel to *c* which is in good agreement with the value reported in this investigation. Their two anisotropic displacements in the (001) plane, 0.06 Å and 0.11 Å, respectively parallel and perpendicular to the *a* axis, bracket the value of 0.086 Å of Table 2.

ACKNOWLEDGMENTS

The writers wish to express their appreciation to Dr. A. S. Ginzbarg and Miss E. E. Allen who wrote the programs for the three-dimensional Fourier and least-squares computations and to Dr. R. A. Rowland for his critical reading of the manuscript.

REFERENCES

BRADLEY, W. F., BURST, J. F., AND GRAF, D. I. (1953), Crystal Chemistry and Differential Thermal Effects of Dolomite: *Amer. Mineral.*, **38,** 207.

SASS, R. L., VIDALE, R., AND DONOHUE, J. (1957), Interatomic Distances and Thermal Anisotropy in Sodium Nitrate and Calcite: *Acta Cryst.*, **10,** 567.

WYCKOFF, W. G., AND MERWIN, H. E. (1924), The Crystal Structure of Dolomite: *Amer. J. Sci.*, **8,** 447.

THE AMERICAN MINERALOGIST, VOL. 44, MAY–JUNE, 1959

OCCURRENCE OF JORDANITE IN THE OTAVI MOUNTAINS, SOUTH WEST AFRICA

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An interesting occurrence of jordanite ($Pb_{14}As_7S_{24}$?) has recently been found at Kupferberg in the Otavi Mountains of South West Africa. The following brief note describes its mode of occurrence and chemical composition.

The Kupferberg copper prospect lies in the Otavi Valley about 40 miles South West of Grootfontein. Dolomites of the Lower (?) Tsumeb Stage of the Otavi System make up the country rock which is characterised at Kupferberg and elsewhere by widespread and intense calcite replacement. Such calcite may be fine-grained, in which case the original grain size and texture of the dolomite is largely preserved, or coarsely-crystalline with cleavage rhombohedrons up to several centimetres in dimension. Sulphide mineralisation is restricted to the coarse-grained variety of calcite.

DESCRIPTION

Primary sulfide minerals at Kupferberg include sphalerite, tennantite, pyrite, galena, enargite and jordanite with but trace amounts of chalcopyrite, bornite and digenite. Chalcocite and covellite are present as secondary sulfides. The associated minerals are malachite, conichalcite, duftite, mottramite, descloizite, dioptase, plancheite, smithsonite and cerussite. The mineralisation has many similarities to that of the nearby Tsumeb Mine, the sulfide ores being characterised by an abundance of arsenic.

Jordanite itself occurs in irregular masses up to 1 cm. in width, intimately associated with other sulphide minerals. It shows no trace of crystal form. Polished section study reveals three prominent mineral assemblages

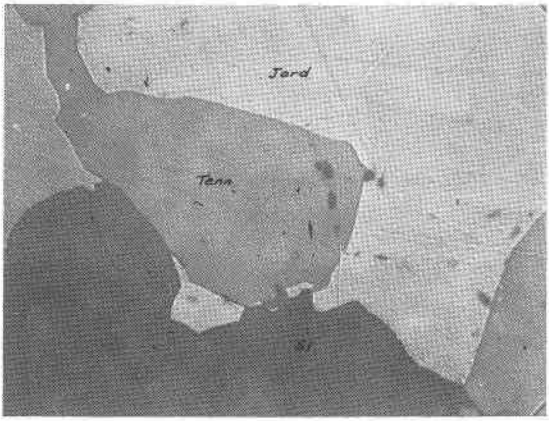

FIG. 1. The assemblage jordanite-tennantite-sphalerite. ×80.

1. Jordanite-tennantite-sphalerite.
2. Jordanite-galena-tennantite.
3. Jordanite-galena-enargite.

Pyrite may accompany these three assemblages, though many of the pyrite crystals are seen to have suffered partial replacement by tennantite and jordanite. Assemblage 1 is perhaps the most commonly observed. The three minerals show quite broad textural outlines (Fig. 1) and no evidence of replacement or the development of fine-grained intergrowths has been observed. Assemblage 2 is similar and between jordanite and galena there is again a broad textural contact (Fig. 2). Assemblage 3 is characterised by narrow veinlets of galena, frequently accompanied by enargite, that intersect masses of jordanite. The textural

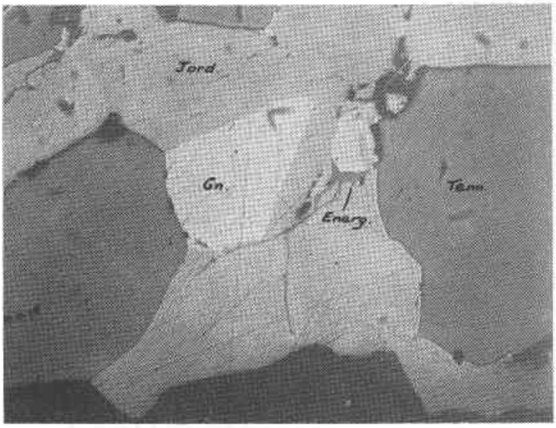

FIG. 2. The assemblage jordanite-galena-tennantite with veinlet of enargite. ×80.

evidence suggests later replacement of jordanite by galena and enargite. A similar texture may be observed in neighbouring tennantite grains wherein cross-cutting enargite veinlets are present. The optical properties of Kupferberg jordanite are in full agreement with those listed by Ramdohr (1955).

CHEMICAL COMPOSITION

A sample of jordanite was carefully hand-picked from crushed ore fragments and submitted for analysis. The results are as follows:

Pb=68.34%
As=12.75%
Sb= 0.02%
S=18.47%
Total 99.58%

Analysts: Gold Fields Laboratories, Johannesburg.

The remainder, determined spectrographically, includes Fe (0.05%) Cu (0.04%), Ag (0.007%), Mn (0.002%) and Al (0.002%).

The results indicate that Kupferberg jordanite is essentially antimony-free, its composition agreeing closely with that of jordanite from the Binnental, Valais, Switzerland (Palache, Berman and Frondel, 1944).

X-RAY DATA

Powder photographs of Kupferberg jordanite have been taken using Co Kα radiation. The *d*-spacings and line intensities agree fairly well with those listed by Douglass, Murphy and Pabst (1954) for jordanite from Wiesloch, Baden. Spacings and intensities of the strongest lines are 2.23 (10), 1.822 (8), 3.17 (7), 2.98 (7) and 2.10 (6).

ADDITIONAL LOCALITIES

Jordanite has also been noted in sphalerite-rich sulphide ores from the nearby Abenab West and Berg Aukas Mines but it is of rare occurrence and only visible microscopically. The mineral association is again with galena, tennantite, sphalerite and enargite.

ACKNOWLEDGMENT

The author is indebted to the Management of The South West Africa Company for permission to publish this note.

REFERENCES

DOUGLASS, R. M., MURPHY, M. J., AND PABST, A. (1954), Geocronite. *Am. Mineral.*, **39,** 908–928.

PALACHE, C., BERMAN, H., AND FRONDEL, C. (1944), The System of Mineralogy. Seventh Edition, Vol. 1, Wiley & Sons, New York.

RAMDOHR, P. (1955), Die Erzmineralien und ihre Verwachsungen. Akademie Verlag, Berlin.

THE AMERICAN MINERALOGIST, VOL. 44, MAY-JUNE, 1959

THE PYRITE-MARCASITE RELATION—A BELATED COMMENT

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Twenty five years ago M. J. Buerger (1934) wrote:—"The control of the precipitation of pyrite and marcasite by chemical environment suggests that these two minerals are not a dimorphous pair in the usual sense of the term, but rather that they are chemically distinct compounds. A critical study of all available analyses indicates that pyrite corresponds closely to an ideal FeS_2, but that marcasite is definitely sulfur-low." This statement was recently quoted by Kopp and Kerr (1958) without comment.

Buerger tabulated 20 analyses of pyrite and 8 of marcasite. After critical consideration there remained 7 superior analyses of pyrite and 4 of marcasite. The S/Fe ratios for these are plotted in Fig. 1A in a fashion similar to that of Buerger. He concluded that these figures indicate that marcasite is "definitely sulfur-low." Considering the density of marcasite, Buerger decided that the departure from a simple S/Fe ratio is due to "proxy solution" and that the composition is best expressed by $Fe(Fe_x, S_{2-x})$, where x is a small fraction in the neighborhood of .004. This value of x corresponds to an S/Fe ratio of 1.988. Buerger gives this as 1.985 "or thereabouts." Hiller and Probsthain (1956) give it as 1.885 (probably a misprint for 1.985) and consider this to be "within the range of homogeneity of pyrite."