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MINERALOGICAL REPORT ON A MANGANESE ORE FROM GHANA, WEST AFRICA

by

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EXTRACTION METALLURGY DIVISION

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SUMMARY

Cryptomelane, lithiophorite and pyrolusite are the manganese oxide minerals in three samples of ore from Ghana, West Africa. They are very abundant in Lot 1, occurring as fracture and cavity fillings and as dense intergrowths with a very fine-grained groundmass composed mainly of quartz, kaolin and earthy goethite. The manganese oxide minerals are less abundant in Lots 2 and 3 and they occur in a groundmass which is similar in composition to that in Lot 1 but also contains abundant fine crystals of the manganese garnet, spessartite. The manganese oxide minerals in Lots 2 and 3 are concentrated, in varying degrees, in thin sub-parallel bands in the groundmass. Pyrolusite in all lots is a minor constituent compared to cryptomelane and lithiophorite. Massive goethite, intimately intergrown with cryptomelane, contains much of the iron in Lot 1. Earthy goethite in the groundmass is the major iron mineral in Lots 2 and 3.

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INTRODUCTION

In April, 1959, the Mines Branch received a request from the National Research Council of Ghana through the Department of External Affairs for an investigation of a manganese ore to determine if it could be upgraded and to see whether an economic extraction of the manganese was possible. For the initial test work small test samples were suggested and three samples of ore, marked Lots 1, 2, and 3, and weighing 400-500 lbs each, were subsequently received in November, 1960.

Partial chemical analyses of the three samples gave the following results.

Lot No.	Analysis %			
	SiO_2	Mn	Fe	CaO
1	9.27	38.6	9.72	0.38
2	47.4	13.5	6.13	0.64
3	33.8	23.0	4.78	0.30

Selected specimens from each lot were submitted to the Mineralogical Section and were given the reference No. 2/61-9. The purpose of the mineralogical investigation was to determine the nature of occurrence of the manganese ore minerals and their relationship to the iron-bearing mineral constituents. The investigation consisted of an ore microscope study of 20 polished sections of chip specimens with identification of the minerals by x-ray diffraction methods.

MINERALOGY

General

Three manganese oxide minerals, cryptomelane, lithiophorite and pyrolusite are present in the Ghana ore samples. Pyrolusite is MnO_2, commonly with a little water. Fleischer and Richmond[1] give the formula KR_8O_{16} for cryptomelane, where R is chiefly Mn^{IV}, also Mn^{II}, Zn and Co, and for lithiophorite, $Li_2 (Mn^{II}, Co, Ni)_2 Al_8 Mn^{IV}_{10} O_{35} \cdot 14 H_2O$ (?). In the present study the identification of these minerals was made by means of their x-ray diffraction patterns using the measurements given by Sorem and Cameron[2] and by Ramdohr[3] as reference standards.

Cryptomelane is the most abundant of the three minerals, particularly in the sample designated Lot 1. Lithiophorite is more abundant in Lots 2 and 3 than in Lot 1 while pyrolusite was only observed in Lots 1 and 3. The only other metallic mineral identified in the ore samples is massive goethite which, like cryptomelane, is most abundant in Lot 1.

Quartz, the most common non-opaque mineral, usually forms a very fine-grained groundmass with varying amounts of kaolin and earthy goethite. Occasionally, coarser grains of quartz are present. Crystals of garnet, around 30 to 40 microns in diameter, are abundantly disseminated through Lots 2 and 3 and only sparingly in Lot 1. It was identified as spessartite, $Mn_3Al_2(SiO_4)_3$, the manganese-aluminum member of the garnet series. The determination was based on the cell edge of 11.62 Å calculated from measurements of x-ray diffraction photographs.

The occurrence of the manganese oxide minerals is discussed separately for each of the three ore samples.

Lot 1

The manganese oxide minerals are much more abundant in Lot 1 than in Lots 2 and 3. Cryptomelane is by far the most common of these, lithiophorite and pyrolusite being rather scarce. The minerals are present in a fine-grained groundmass of quartz, kaolin and earthy goethite.

Much of the cryptomelane shows colloform texture and occurs as fracture or cavity fillings or massive replacement of the groundmass (Figure 1). The cryptomelane also occurs as fine intergrowths with the quartz, kaolin and earthy goethite in the groundmass. Small garnet crystals occur occasionally in the groundmass and some are partly replaced by cryptomelane. A minor amount of the groundmass contains little or no manganese oxide minerals; barren areas up to 2 mm across have been observed.

Cryptomelane observed in polished sections of Lot 1 exhibits several shades from white to grey. This is particularly noticeable where colloform bands occur as cavity and vein fillings (Figure 1) and to a lesser extent where cryptomelane is intergrown in the groundmass. While it was thought at first that this variation in colour might be caused by the presence of another mineral, none was identified by x-ray diffraction methods. Under high magnification (X 2000) the lighter areas are found to consist of sub-spherical grains up to about one micron in diameter which appear to decrease in size in the grey areas. It was also observed that pleochroism and anisotropism decrease in the grey areas which would be expected with finer-grained material. The lower reflectivity thus indicated in the finer grained areas may be the reason for the variation in shade of the cryptomelane.

Massive goethite, intergrown with cryptomelane in many places, is sometimes the major component in such intergrowths. Where present in a large mass of goethite, cryptomelane occurs as irregular or colloform blebs and as fine threads (Figure 2). In one unusual occurrence goethite replaced garnet crystals in cryptomelane (Figure 3).

Lithiophorite, observed in only a few specimens from Lot 1, occurs in the central parts of fracture fillings (Figure 4). Pyrolusite was identified in one specimen in which it occurs as clusters of lath-like crystals intergrown with cryptomelane (Figure 5).

In a specimen in which cryptomelane is densely intergrown with garnet-rich groundmass, light brownish-grey grains similar in size to the garnet crystals are present. These grains are strongly anisotropic yellowish-orange to deep blue. They are too fine and widely scattered to be identified by x-ray diffraction methods.

Lot 2

The manganese oxide minerals are much less abundant in Lot 2 than in Lot 1. While cryptomelane is still the most abundant manganese oxide mineral there is a much higher proportion of lithiophorite. Pyrolusite was not observed.

The quartz-kaolin-earthy goethite groundmass in these specimens is profusely intergrown with small garnet crystals around 30 to 40 microns in diameter. The manganese oxide minerals are usually concentrated into fairly regular bands or layers of varying density and ranging in thickness from a fraction of a millimeter to several millimeters. In such bands cryptomelane has usually replaced garnet crystals but may occur as irregular intergrowths with lithiophorite (Figure 6). Lithiophorite, however, is almost always massive and was only once observed as replacements of garnet crystals (Figure 7).

Lot 3

The banded texture of the rock is made more apparent in Lot 3 by a higher content of manganese oxide minerals (Figure 8). As in Lot 2, cryptomelane and lithiophorite are the most common manganese oxide minerals although pyrolusite was identified in some specimens. In contrast to Lot 2 where cryptomelane frequently replaces garnet crystals, there is little evidence of such replacement in specimens from Lot 3 (Figure 8). In addition to banded intergrowths of massive cryptomelane and lithiophorite (Figure 9), similar intergrowths of pyrolusite and lithiophorite or goethite are to be found occasionally (Figure 10). In one specimen the banded appearance was partially destroyed by coarse, irregular masses of cryptomelane and lithiophorite.

DISCUSSION AND CONCLUSIONS

The occurrence of the manganese oxide minerals cryptomelane, lithiophorite and pyrolusite is quite complex in the Ghana ore samples described in this report. In Lot 1, which has the highest content of manganese oxide minerals, they are not only found in fractures and cavities up to several millimeters in width but in large part are densely intergrown in the surrounding groundmass composed of very fine grained quartz, kaolin and earthy goethite. Only minor upgrading of Lot 1 would be obtained by elimination of the small fraction of the groundmass which is free of manganese oxide minerals. The Mn:Fe ratio is not likely to be increased very much, since massive goethite is intimately intergrown with the manganese oxide minerals.

In Lots 2 and 3, where the manganese oxide minerals are segregated into layers or bands in garnet-rich groundmass, upgrading might be more successful. Most of the iron appears to be contained in earthy goethite in the groundmass. Separation of the groundmass from the manganese rich layers might therefore reduce the iron content of the manganese concentrate.

The possibility of upgrading by physical separation of the manganese oxide bands in Lots 2 and 3 from the intervening layers of groundmass may be reduced to some extent by the spessartite content of the groundmass.

In a paper by Sorem and Cameron(2) a detailed description is given of a manganese ore from Nsuta, Ghana. The exact source of the present ore samples is not known, but it appears likely that they originate from the same deposit. The ores are similar in mineralogical composition except for one notable difference: the most abundant manganese oxide mineral found in the Nsuta ore, and designated as "Nsuta MnO_2" by Sorem and Cameron, was not observed in the present samples.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made of the analytical work carried out under the direction of Mr. J. C. Ingles, principally by the group headed by Mr. A. Hitchen.

REFERENCES

1. Fleisher, M., and Richmond, W., 1943. The Manganese Oxide Minerals; A Preliminary Report: Econ. Geol. Vol. 38, p. 272.

2. Sorem, R.K., and Cameron, E.N., 1960. Manganese Oxides and Associated Minerals of Nsuta Manganese Deposits: Econ. Geol. Vol. 55, p. 278.

3. Ramdohr, P., 1960. Die Erzmineralien und ihre Verwachsungen, 3rd ed., p. 947.

MRH/SK/dm

PHOTOMICROGRAPHS

The squares in the lower right corner of each photomicrograph are 65 mesh with the exceptions of Figure 1 which is 20 mesh and Figures 3 and 5 which are 325 mesh.

Figure 1. Lot 1. Colloform banded cryptomelane (cry) in cavities, and irregular intergrowths of cryptomelane in the surrounding groundmass. The black areas in the centres of the cavity fillings are voids or pits. X15.

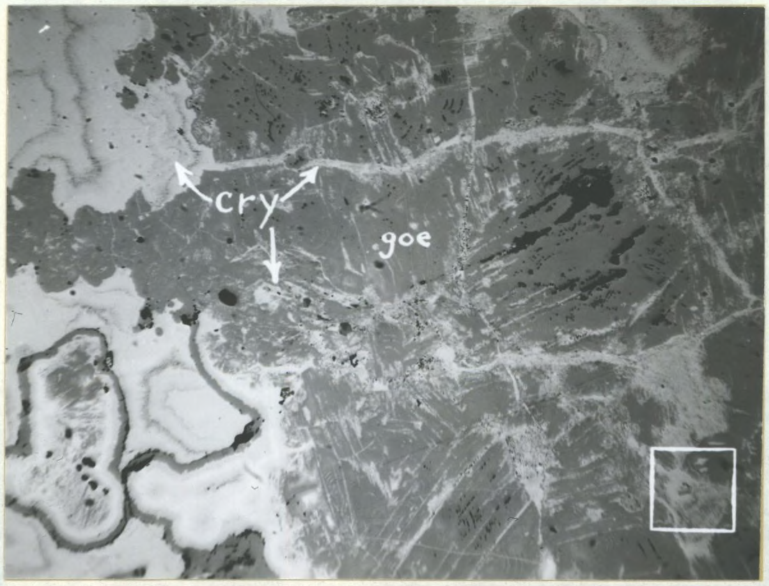

Figure 2. Lot 1. Colloform and irregular masses of cryptomelane (cry) intergrown in massive goethite (goe). Both irregular and regularly arranged threads of cryptomelane are present. X50.

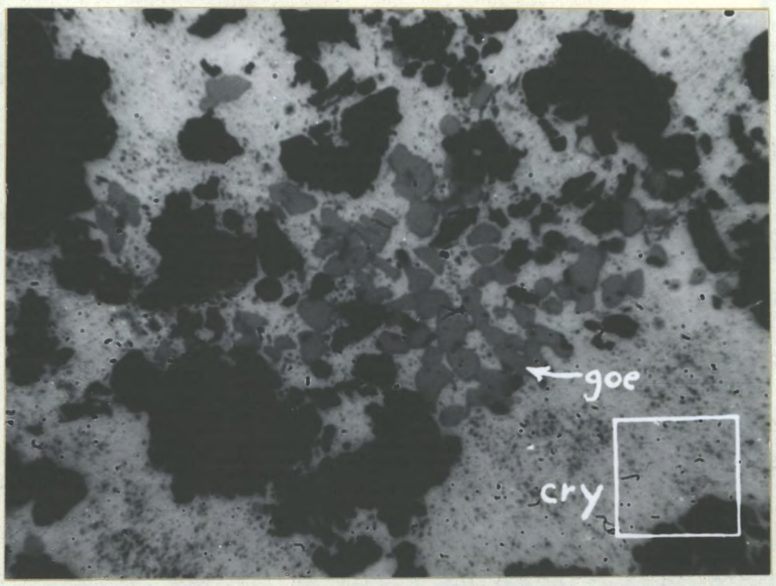

Figure 3. Lot 1. Goethite (goe) replacement of garnet crystals in cryptomelane (cry). The black areas are the groundmass. X350.

Figure 4. Lot 1. Lithiophorite (li) and cryptomelane (cry) filling a fracture. Cryptomelane is also intergrown with the surrounding groundmass. X50.

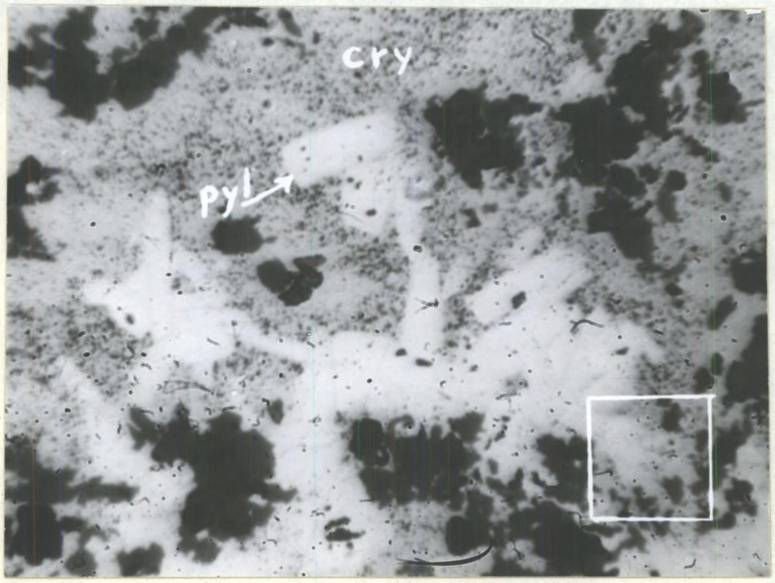

Figure 5. Lot 1. Pyrolusite (pyl) intergrown in cryptomelane (cry) in a garnet - rich groundmass (black). X350.

Figure 6. Lot 2. Cryptomelane (cry) partly or completely replacing garnet crystals above and below a layer of lithiophorite (li). The lithiophorite is rimmed and intergrown with cryptomelane. The black areas are the groundmass. X50.

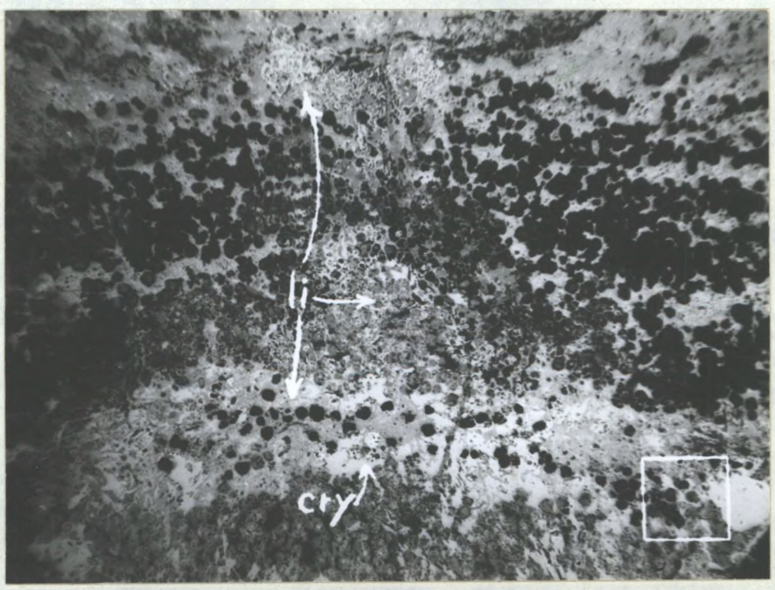

Figure 7. Lot 2. Massive lithiophorite (li) replacing garnet crystals. The black grains are unreplaced garnet crystals. Cryptomelane (cry) is intergrown with the massive lithiophorite. X50.

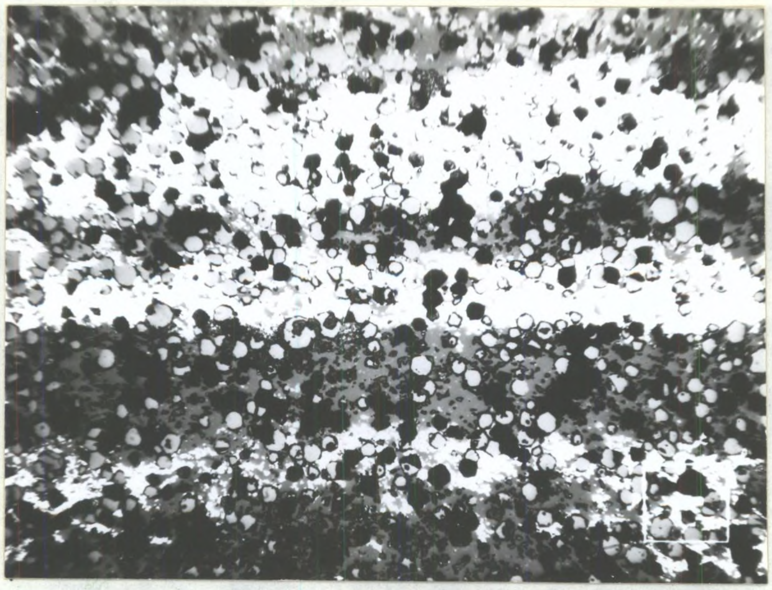

Figure 8. Lot 3. Layers or bands of cryptomelane (white) in garnet-rich groundmass. The garnet crystals are light grey and the groundmass dark grey. The black areas are pits in the section. X50.

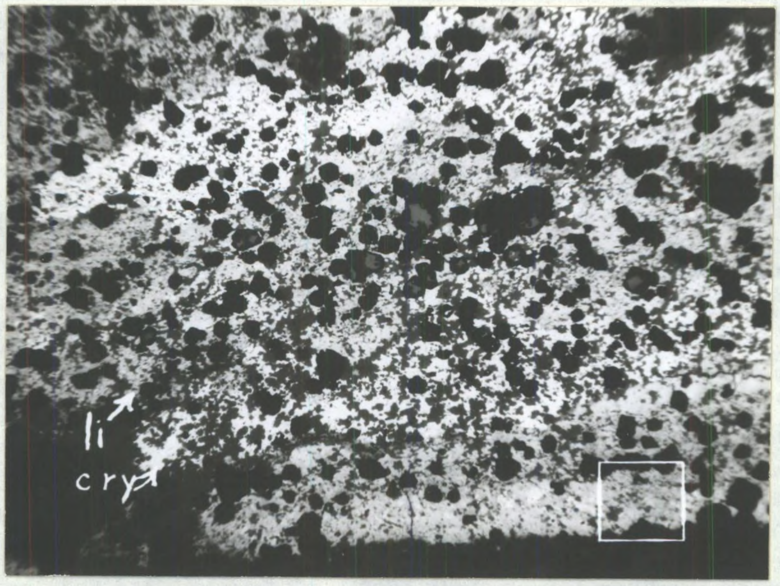

Figure 9. Lot 3. Intermixed layers of cryptomelane (cry) and lithiophorite (li). X50.

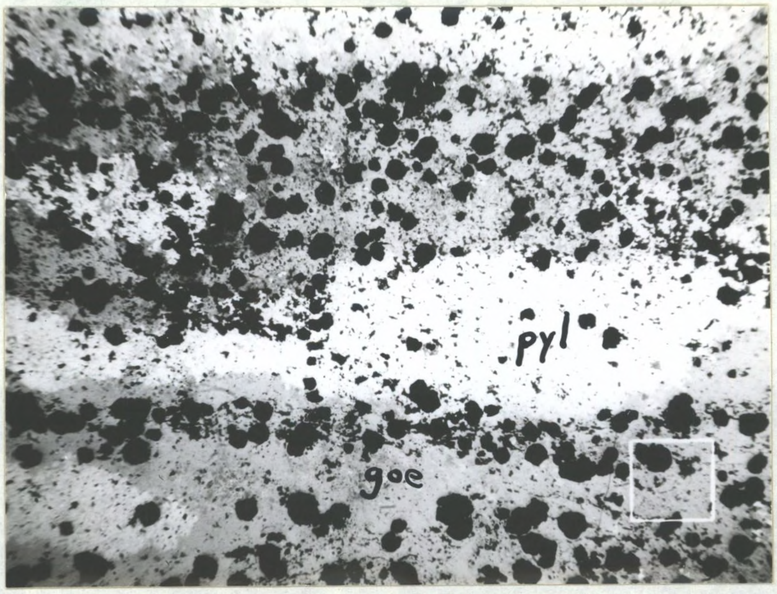

Figure 10. Lot 3. Alternating layers of pyrolusite (pyl) and goethite (goe). X50.