ORE-MICROSCOPIC STUDIES OF THE MANGANESE ORE-MINERALS OF OLD M.P.

I. Dongribuzurg, Bhandara District

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INTRODUCTION

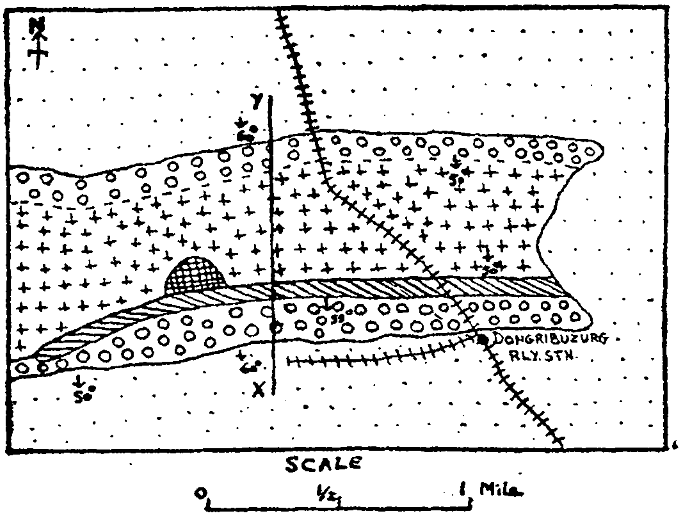
AN attempt is made here to give a systematic account of the ore-microscopic studies of the manganese ore-minerals collected from the Dongribuzurg manganese mine of the C.P.M.O. Co., in Bhandara District. The area forms a part of the topographical sheet No. 55–0/10 and is situated about a furlong west of the Dongribuzurg railway station, which is nearly 14 miles north of the Tumsar railway station on the Tumsar Road-Tirodi branch of the South Eastern Railway. The deposit consists almost entirely of secondary manganese minerals like Pyrolusite and Psilomelane associated with highly metamorphosed rocks like Gondite (Spessartite-Quartz rock), Sillimanite-Garnet-schist and Gneisses. It is interesting to note here that other deposits, on the same line of strike and situated about 2–3 miles away, consist of manganese ore-minerals of medium to high grade regional metamorphism like Bixbyite, Hollandite and Braunite.

GEOLOGY OF THE AREA

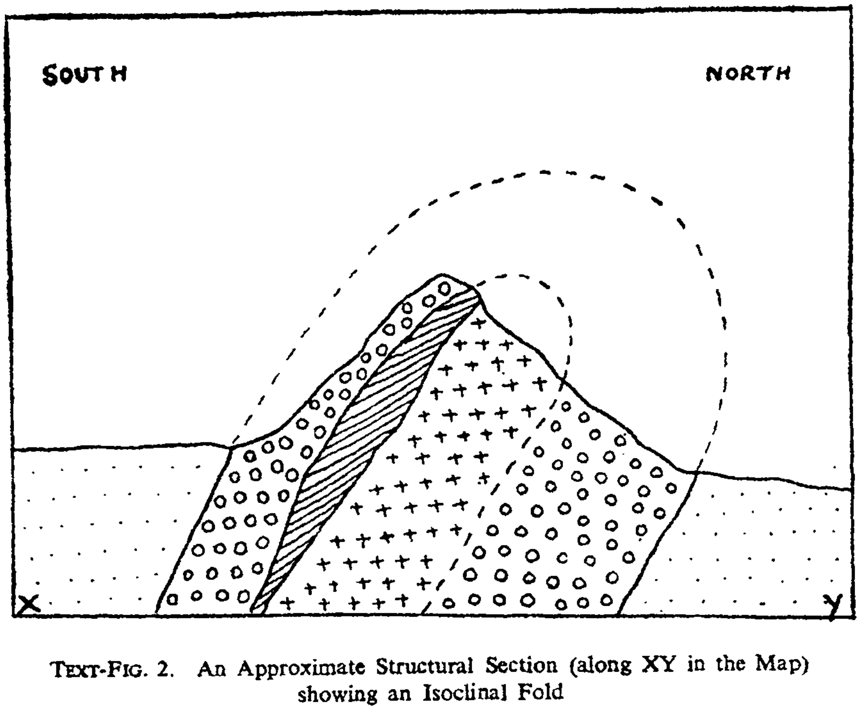
The deposit forms a ridge running approximately east-west and is about 1¼ miles long. The ore-band forms a consistent horizon running WSW-ENE except at the west end where the strike changes to E-W. It has a dip of about 50°–60° south. The foot-wall consists of coarse-grained muscovite schist with garnet and sillimanite and with numerous veins of quartz running parallel to the strike. The hanging wall is a felspathic mica schist while further south, a medium-grained biotite gneiss overlies it. The rocks belong to the Sausar series of the Dharwars. A granitic intrusion is present near the ore-body in the western portion. The geological map of the area and a structural section is given (Text-Figs. 1 and 2).

NATURE OF THE ORES

The ores are predominantly a mixture of Psilomelane and Pyrolusite occurring partly in botryoidal, stalactitic, mammillary and concretionary



TEXT-FIG. 1. Geological Map of Dongribuzurg Area.



TEXT-FIG. 2. An Approximate Structural Section (along XY in the Map) showing an Isoclinal Fold

SUCCESSION

Granite	Gondite and Manganese Ore
Muscovite-Biotite Schistose Gneiss	Coarse Muscovite Schist with Garnet and Staurolite
Felspathic Schist and Quartzite with Vein Quartz	

forms. At places the ore is compact and crystalline and associated with some hematite. Braunite, the typical ore-mineral usually associated with gondites, is also found as a subsidiary associate with Pyrolusite and Psilomelane.

A detailed study of a number of polished sections prepared from carefully selected samples has revealed the following ore-minerals: (1) Psilomelane, (2) Pyrolusite and Polianite, (3) An unidentified new (?) mineral, (4) Braunite, (5) Hematite. The reflectivity values in air were determined by the help of the Berek's Slit-microphotometer using green light.

A descriptive account of the ore-minerals is given below.

Psilomelane

This appears to be the most important constituent of the ores along with Pyrolusite. It occurs in a variety of forms—botryoidal, stalactitic, mamillary, in the form of concentric layers alternating with those of Pyrolusite and rounded lumps, all suggesting deposition from a colloidal state, and as veinlets replacing Braunite. At one place, a fibrous variety of Psilomelane is found veining ordinary Psilomelane (Plate VII, Fig. 6). It is quite coarse-grained and clearly exhibits pleochroism and high anisotropism with grey, yellowish, bluish grey and white colours and undulatory extinction. The reflectivity value (28·5) is higher than that of Psilomelane. The characteristics of this fibrous vein mineral recalls the description of Romanéchite. According to Uytenbogaardt (1951), some of the material found at Romanèche, France, is Psilomelane while some is Cryptomelane. The identity of the mineral can only be established after an X-ray diffraction analysis, which will be undertaken later on.

The properties of Psilomelane are as follows:—

It takes a good polish. Colour: Grey to bluish grey. Reflectivity: Moderate, the value for green light varying from 27 to 30 (usually 28). Pleochroism: Distinct in shades of grey and bluish grey under high power. Anisotropism: Strong. It cannot be observed easily due to the very fine-grained nature but under high power, the mineral seems to be composed of highly anisotropic needles showing straight extinction.

The mineral is usually found in aggregates of extremely fine needles. It also forms botryoidal masses consisting of concentric alternating layers of Pyrolusite, intimate mixture of Pyrolusite and Psilomelane and pure Psilomelane. It alters to Pyrolusite and every stage in this alteration is met with. Shrinkage cracks in these concentric layers are filled up with fine-grained

Pyrolusite (Plate VII, Fig. 1). Psilomelane also veins and replaces Pyrolusite in a Pyrolusite-Braunite ore.

Etch reactions

Positive.—HNO_3—Stains light brown or negative. Fumes tarnish. HCl—Permanently tarnishes light brown. Fumes tarnish. $FeCl_3$—Light grey stain. H_2O_2—Effervescence. Surface unaffected. $SnCl_2$ (saturated) + HCl (concentrated)—Stains black. Effect less on coarse fibrous variety. H_2O_2 (concentrated) + H_2SO_4 (concentrated)—Stains completely black. Effect stronger on fine-grained aggregates.

Negative.—KCN, KOH, $HgCl_2$, H_2SO_4 (concentrated), Aqua regia.

Pyrolusite

This mineral is nearly as abundant as Psilomelane. It does not take a good polish because of its inferior hardness. Colour: White with a distinct yellow tint in oil. Reflectivity: High, the value in green light varies from 30–34 for fine-grained aggregates and from 34–39 for coarse crystals. Pleochroism: Distinct. Greyish white to yellowish white. Anisotropism: Strong. Yellowish, yellow-brown, greenish blue and grey colours. Extinction is straight with four distinct extinctions per revolution. Prismatic (one direction) cleavage is distinct especially in bigger crystals.

The mineral occurs as fine to very fine-grained aggregates of prismatic needles which are sometimes radiating and sometimes fibrous (Plate VII, Fig. 5). Coarse prismatic needles occur interpenetrating each other or in parallel bands, the orientation of the needles between two adjacent bands being different (Plate VII, Fig. 2). Layers of prismatic needles are also found in concentric layers of Psilomelane. In these layers, the needles are usually radiating and are arranged at right angles to the concentric layers. Pyrolusite in the outer layers is more coarse-grained than that found in the inner layers. Shrinkage cracks in Psilomelane are filled with medium to fine-grained Pyrolusite and the latter also irregularly veins the Psilomelane (Plate VII, Fig. 1). Fine-grained Pyrolusite is often found intimately intergrown with coarse-grained Hematite, which it veins and replaces along with Psilomelane. Coarse-grained Pyrolusite also occurs with coarse-grained Hematite. This Pyrolusite (Polianite) may perhaps be regarded as the first generation Pyrolusite crystallising along with Hematite, in order to distinguish it from that formed by the crystallisation of the colloidal Psilomelane. Interlocking crystals of medium-grained Pyrolusite and Braunite have been noticed in one section (Plate VII, Fig. 4). This Pyrolusite also is probably to be regarded as of first generation.

Etch reactions

Positive.—HNO_3—Stains light brown on very fine-grained specimens probably mixed with Psilomelane. Otherwise negative. HCl—Stains some specimens brown. H_2SO_4 (concentrated)—Permanently tarnishes some specimens. $FeCl_3$ (saturated)—Tarnishes some specimens grey-brown. $SnCl_2$ (saturated) + HCl (concentrated)—Blackens instantaneously. H_2O_2—Vigorous effervescence. Tarnishes some coarse-grained specimens. H_2SO_4 (concentrated) + H_2O_2 (concentrated)—Stains completely black.

Negative.—HNO_3, HCl, KCN, KOH, $HgCl_2$.

An Unidentified New (?) Mineral

This mineral occurs along with Pyrolusite, Psilomelane and Hematite. Its properties do not correspond to those of any known manganese mineral.

It takes a fairly good polish. Colour: Grey to dark brownish grey. Reflectivity: Very low. The value cannot be determined accurately because of its fine-grained nature and rarity of occurrence, but it is distinctly lower than that of Sphalerite and is about 14–15. Pleochroism: Clearly distinct in shades of grey and brownish grey. Anisotropism: Very high but without any typical colours. Yellowish or white. Extinction is undulose and patchy because of radiating texture. No internal reflections are visible even in oil.

It occurs as aggregates of small grains, each grain containing crystals with radiating texture. It is sometimes associated with Psilomelane and in one section it probably forms a vein along with it (Plate VII, Fig. 3).

Etch Reactions

Positive.—$SnCl_2$ (saturated) + HCl (concentrated)—Faintly tarnishes brownish.

Negative.—HCl (concentrated), H_2SO_4 (concentrated) + H_2O_2 (concentrated).

This mineral exhibits properties resembling those of Hausmannite, Manganite and Hetaerolite but differs from them in not showing red internal reflections and in being negative to almost all important etch reagents. X-ray diffraction studies to be shortly undertaken may reveal the identity of the mineral.

Braunite

This mineral is present in subordinate quantities associated with Pyrolusite and Psilomelane.

It takes a good polish. Colour: Grey with a faint brownish tint. Reflectivity: Low. The value varying from 18·5–19·5. Pleochroism: Very weak. Anisotropism: Weak but distinct. Grey and brown colours.

It forms medium to fine-grained granular masses and interlocking crystals with medium-grained Pyrolusite. Both these minerals are excessively veined and replaced by Psilomelane (Plate VII, Fig. 4).

Etch Reactions

Positive.—H_2O_2—Slow effervescence. No stain. $H_2O_2+H_2SO_4$ (concentrated)—Faster effervescence. Darkens and produces etch scratches. After 4 minutes develops parting planes. $SnCl_2$ (saturated) + HCl (concentrated)—Tarnishes permanently brown and develops etch scratches. After 4 minutes strong action.

Negative.—HNO_3, HCl, KCN, $FeCl_3$, KOH, $HgCl_2$, Aqua regia.

TEXTURAL FEATURES

The characteristic feature of the ores is the colloform texture exhibited by Psilomelane. Concentric bands, composed of Psilomelane, Pyrolusite and their intimate mixtures, alternate. This suggests a gel origin. Edwards (1947) remarks that "Where the original gel has crystallised, it results in the formation of radially arranged columnar crystals, whose long axes are normal to the outer (free) surface of the layer. A free surface, if present, is typically smooth, commonly with a high gloss or lustre, corresponding to the smooth 'skin' of a gel, and is distinct from the rough surface resulting from the co-termination of a growth of radially arranged crystals .... ". Both these points are very clearly exhibited by the minerals. Pyrolusite, which crystallises after the dehydration of the gel, occurs as radiating columnar crystals whose long axes are normal to the free surface or the concentric rings. Moreover, the gel origin is supported by the cryptocrystalline character of Psilomelane and the shrinkage cracks in it which are perpendicular to the concentric lines and are filled with secondary Pyrolusite. The shrinkage cracks are obviously formed at the time of the dehydration of the gel.

Fine-grained Pyrolusite veins and replaces coarse-grained Hematite and remnants of Hematite with similar optic orientation are found scattered in a matrix of Pyrolusite. It also forms coarse-grained aggregates along with coarse-grained Hematite.

Medium-grained Braunite and Pyrolusite form interlocking crystals suggesting contemporaneous crystallisation. Both are excessively veined and replaced by Psilomelane.

Paragenesis

It is rather difficult to arrive at any definite conclusion about the paragenesis because the various minerals found in the area do not occur in one section (probably because they belong to slightly different suites) and hence their relationships are not very clear.

It is obvious that Braunite and Hematite are the first formed minerals. Some of the Pyrolusite which forms interlocking crystals with both Braunite and Hematite seems to have been formed contemporaneously. Braunite is veined and replaced by Psilomelane, and Hematite has been replaced by fine-grained second generation Pyrolusite and Psilomelane. Psilomelane exhibiting colloform texture has probably been formed after the solution and redeposition of the earlier formed metamorphic manganese minerals and probably also the first formed minerals like Braunite and Pyrolusite in the present association. Pyrolusite veins and replaces Psilomelane and is evidently secondary after it. The relation of Pyrolusite and Psilomelane with the unidentified mineral is obscure. But at one place it looks like a vein mineral along with Psilomelane. Its smaller grain size and fibrous nature also support this conclusion.

The probable sequence of formation appears to be as follows: Braunite, Hematite and Pyrolusite; colloform Psilomelane; Pyrolusite, the unidentified new (?) mineral and Psilomelane.

Origin of Pyrolusite

The occurrence of large quantities of Pyrolusite and Psilomelane with subordinate amounts of Braunite, associated with high grade metamorphic rocks like Gondite and Garnetiferous mica-sillimanite schist, is very interesting (Text-Fig. 1). Pyrolusite and Psilomelane are definitely epi-zone minerals. Their textures—mamillary, stalactitic, colloform—clearly indicate deposition from colloidal solutions. The structure of the area, perhaps, can offer a possible clue. The ore-band and the associated rocks form the crest of a compact isoclinal fold (Text-Fig. 2). It is known that the crests of folds in general and especially those of isoclinal folds are very unstable structures and are also more vulnerable to denudation. This weakness can produce a lot of cracks which can act as channels for subsurface waters which (charged with reagents like Carbon dioxide and the alkalies) might have dissolved and redeposited the ores to form Pyrolusite and Psilomelane. This process could have continued for a long time—even before the area was exposed to the surface by denudation—and could have completely changed the original nature of the minerals. The Sitasaongi and Chikhla ore-bands, about 3–4 miles to the east, and which more or less form a continuation of the Dongribuzurg band, have an overturned sequence and form troughs of more gentle folds. These areas contain manganese ore-minerals like Sitaparite, Hollandite and Braunite which are characteristic minerals of medium to high grade regional metamorphism. This fact supports the view that the original deposit at Dongribuzurg might have consisted of high grade metamorphic ores which subsequently gave rise to Psilomelane and Pyrolusite after solution and redeposition.

SUMMARY

The paper gives an account of the ore-microscopic study of the manganese ore-minerals collected from Dongribuzurg, Bhandara District, Old M.P. The following are the ore-minerals that have been identified in polished sections: Psilomelane, Pyrolusite, Polianite and Braunite. The characters of these ore-minerals under reflected light are given along with their etch reactions and reflectivity values. In addition, a mineral showing properties different from those shown by any known manganese ore-mineral has been described. The identity of this mineral could only be established on chemical and X-ray studies which are now in progress. Interesting microstructures, like the colloform texture shown by Psilomelane, have been fully described, and the mineral paragenesis based on textural features is given. A note has been added on the origin of Pyrolusite, since the occurrence of large quantities of this mineral in association with highly metamorphosed rocks is curious and interesting.

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EXPLANATION OF PLATE VII

FIG. 1. Colloform texture exhibited by Psilomelane (Ps, grey). Pyrolusite (Py, white) fills the shrinkage cracks in Psilomelane and also veins it, $\times 60$.

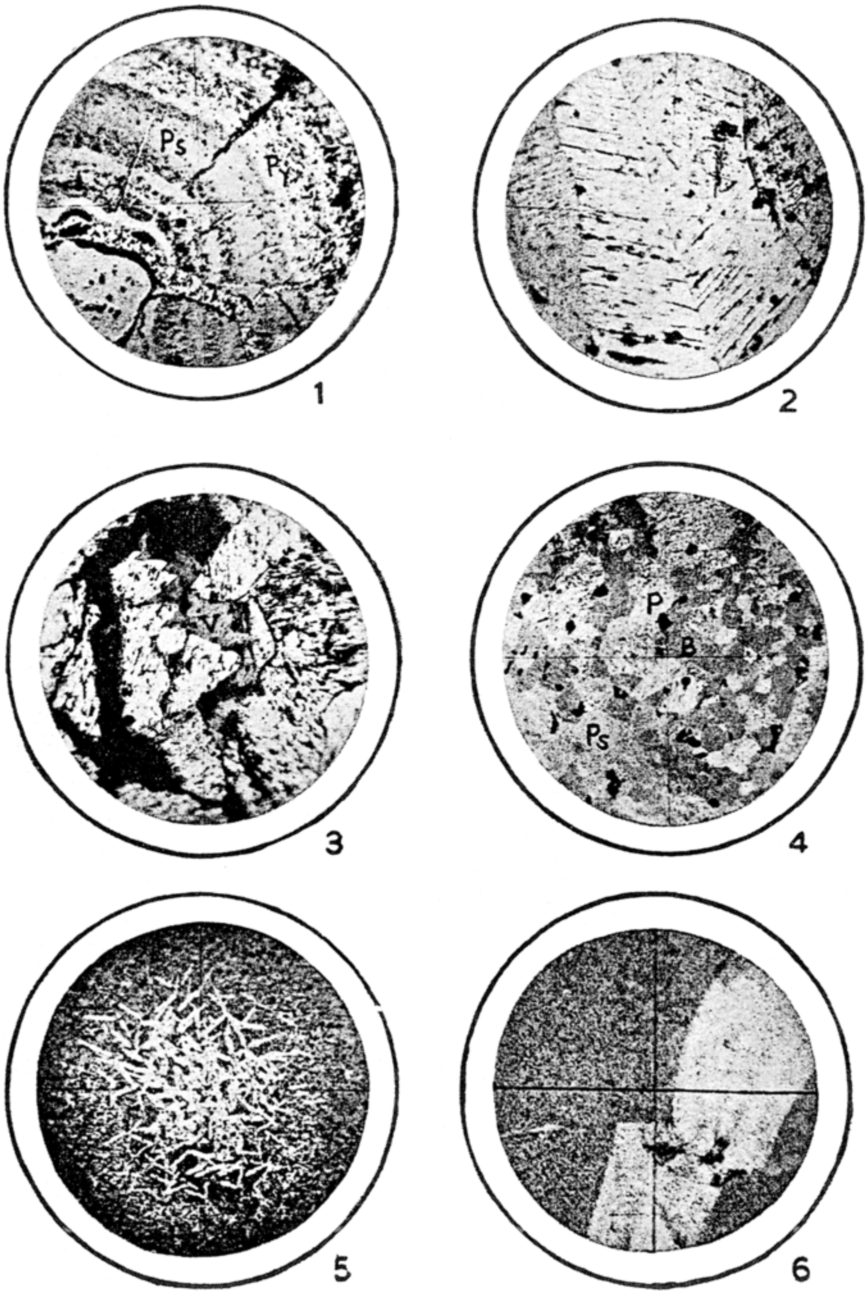
FIG. 2. Coarse-grained Polianite showing prismatic cleavage, $\times 60$.

FIG. 3. A vein of the unidentified mineral (dark grey, V, in the centre) traversing Polianite (white), $\times 60$.

FIG. 4. Braunite (B, dark grey) forming interlocking crystals with Polianite (P, white). Psilomelane (Ps, grey) replaces and veins both these minerals, $\times 60$.

FIG. 5. Swarm of Pyrolusite needles (white) in Psilomelane (grey). Etched with HCl, $\times 60$.

FIG. 6. Fibrous Psilomelane (white, showing strong anisotropism) veining ordinary Psilomelane (greyish black). Crossed Nicols, $\times 140$.



FIGS. 1–6