

ORE MICROSCOPIC STUDIES OF THE MANGANESE MINERALS OF JAMDA VALLEY, KEONJHAR

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INTRODUCTION

THE area under consideration in this paper lies in the topographical sheet No. 73 F/8 and is situated about 250 miles away from Calcutta, on the Tatanagar-Gua line of the Eastern Railways. The Jamda-Koira Valley extending southwards from Barajamda Railway Station is crowded with iron and manganese deposits of variable size and quality. These deposits occur as scattered pockets, associated with phyllites or cherts and cherty quartzites in the Iron Ore Series. The types of ore found, their quality and origin have already been discussed by the author in his communication to the Indian Science Congress (1954-55) and hence they will not be dealt with in this paper. In the following paragraphs the author will attempt to put forward the results of the ore microscopic studies of these manganese ore minerals.

PREVIOUS WORK AND DISCUSSION

Among the previous workers in this area only Dr. E. Spencer (1948) and Mr. B. Sen (Discussions, 1948 and 1951) discussed the probable mineralogical composition of the ores. Dr. Spencer seemed to be very much dogmatic about his idea that all the manganese ores of this area are pyrolusites. He based his conclusions on the study of a few samples submitted by him to Dr. Bannister of the British Museum who identified all of them to be pyrolusite by X-ray powder analysis. But whether all the varieties of ores found in this area (there are a number of varieties present) were subjected to X-ray powder analysis or whether any other method, *viz.*, chemical analysis, ore microscopic study, etc., was applied, about that Dr. Spencer chose to be silent.

Mr. B. Sen, in his discussion on Dr. Spencer's paper, suggested that all the ore minerals might not essentially be pyrolusite, rather the majority of

them may be psilomelane with pyrolusite, manganite and was associated intimately with it. Particularly the stumpy needles with bronzy lustre giving out about 2% water on heating, was identified to be manganite by Mr. Sen. In a further communication (1951) Mr. Sen reports as many as five manganese minerals from the area, viz., psilomelane, pyrolusite, manganite, wad and rhodocrosite, of which the psilomelane was suggested to be the most abundant mineral while pyrolusite and manganite are secondary formed in the cavities of psilomelane.

Under the above circumstances a very reliable account cannot be formed about the mineral composition of these manganese ores. The author has, therefore, taken up the problem in an attempt to solve the controversy and his observations will be put forward in the following pages.

MANGANESE MINERALS

Samples of ore minerals for study under the reflected light were carefully selected from different mines and virgin ore bodies mainly leased out to Messrs. Bird & Co. The specimens were then polished and studied under reflected light. The following minerals were then identified under the ore microscope:—(i) Psilomelane, (ii) Pyrolusite, (iii) Manganite, (iv) Polianite and (v) Romanéchite. These are sometimes associated with hematite, limonite and goethite. The identifying characters and the distribution of the ore minerals will now be taken up one by one.

(i) *Psilomelane*.—This is the principal mineral present in the manganese ore bodies of the area. These are hard (hardness above 5) steel grey minerals exhibiting botryoidal, mammillary and stalactitic structures and take a fairly good polish. Reflectance is moderate and with the aid of Berek's slit microphotometer it was estimated to be about 23·07 in green light in air. The mineral is non-pleochroic bluish grey and is isotropic between crossed nicols. But in most cases the psilomelane is more or less altered to pyrolusite and therefore some anomalous anisotropism is noticed at places. The mineral exhibits colloform texture forming concentric layers and this points to their deposition from a gel. In most cases dehydration and subsequent alteration to pyrolusite has started and the shrinkage cracks developed in the concentric layers of psilomelane, are sometimes filled up with pyrolusite. From the widespread alteration of psilomelane to pyrolusite and the occurrence of manganite, polianite and romanéchite in the cracks and vugs in the psilomelane, it is almost definitely established that psilomelane was the earliest and principal manganese mineral to be deposited.

Etch Reactions:—

Positive	..	HNO ₃	—	Stains light brown, fumes tarnish.
		HCl	—	Stains brown.
		Aq. Reg.	—	Darkens.
		H ₂ O ₂	—	Effervesces. Surface unaffected.
		H ₂ O ₂ + H ₂ SO ₄	—	Stains sooty black.
		SnCl ₂	—	Blackens.

Negative .. KCN, KOH, HgCl₂, FeCl₃.

(ii) *Pyrolusite*.—Pyrolusite is considered to be a secondary mineral here which has been formed by alteration of psilomelane and manganite. It occurs in the concentric layers of psilomelane and also as pseudomorphs after manganite. It is almost white in colour, non-pleochroic and exhibits strong anisotropism in shades of yellow to grey. The reflectance is fairly high and comes to about 32 in air and in green light of Berek's slit microphotometer. This value is greater than that of all other manganese minerals and is higher than hematite with which it is intimately associated at places.

Etch Reactions:—

Positive	..	H ₂ SO ₄ (Conc.)	—	Tarnishes.
		SnCl ₂ (in HCl)	—	Blackens instantaneously.
		H ₂ O ₂	—	Effervesces vigorously, surface unaffected.
		H ₂ O ₂ + H ₂ SO ₄	—	Stains sooty black.

Negative .. HNO₃, KCN, KOH, HgCl₂.

(iii) *Polianite*.—Aggregates of this mineral are located in some of the specimens. The mineral is non-pleochroic, yellowish white in colour and exhibits strong anisotropism from pale yellow to violet grey. This mineral forms starlike bodies within the concentric layers of the psilomelane (Pl. VII, Fig. 5) and is fairly coarse-grained. The reflecting power is quite high and comes to 34.4 in air in green light of Berek's microphotometer.

Etch Reactions:

Positive	..	HCl (1:1) (5 mins.)	—	Blackened.
		HCl (Conc.) (1 min.)	—	Blackened.
		H ₂ SO ₄ (Conc.)	—	Feebly tarnished.
		FeCl ₃ (20%)	—	Persistent tarnish.
		H ₂ O ₂ (100 vols.)	—	Violent effervescence.

The name pyrolusite is sometimes employed by others as a synonym for polianite. Schneiderhohn and Ramdohr used the name polianite to describe the varieties of larger grains of MnO_2 and used the term pyrolusite for very fine aggregation of minerals of this composition. Dunn (1936) maintains this term to describe these manganese dioxides. On the contrary Orcel follows Lacroix (1931) in ignoring the name pyrolusite for describing MnO_2 and recommends the unique application of the name pyrolusite only where the mineral is pseudomorphous after manganite. The author accepts the nomenclature set in by Schneiderhohn and Ramdohr in identifying polianite.

(iv) *Manganite*.—Manganite is another common mineral found associated with the pyrolusite and psilomelanes. It is present both as minute needles (Pl. VII, Fig. 1) and as well-defined euhedral to anhedral grains (Pl. VII, Fig. 2). The needle-shaped minute crystals are often formed in the cavities of psilomelane. These needles of manganite are often replaced by pyrolusite and pseudomorphs of pyrolusite after manganite are also fairly common.

The minerals are greyish white in colour and in some grains they exhibit distinct reflecting pleochroism from greyish white to light brown. They show strong anisotropism in shades of grey. The reflectance is much lower than polianite and pyrolusite, the value recorded in Berek's slit microphotometer being 18.5 in green light in air (in the case of a section almost \parallel to C). It exhibits straight extinction and brick-red internal reflection.

Etch Reactions:—

Positive	..	HNO_3 (Conc.)	—	Fairly strong attack.
		HCl (Conc.)	—	Strong etching.
		SnCl_2 (Sat.)	—	Darkens.
		$\text{H}_2\text{O}_2 + \text{H}_2\text{SO}_4$	—	Etches, bringing out cleavage lines.

Negative .. HNO_3 (1:1), HCl (1:1), Aqua Regia, H_2SO_4 , KCN , FeCl_3 , KOH , HgCl_2 .

The pseudomorphic replacement of manganite by pyrolusite has been noticed in many cases and the polianite crystals in manganite have also been sighted. The pseudomorphous replacement generally proceeds in the cleavage direction of the manganites and the gradation from pure manganite to pure pyrolusite, the latter distinguished by high reflectance and different etch reactions, may easily be recognised. Fig. 1 (Plate VII) indicates the nature of pseudomorphic replacement of manganite needles.

(v) *Romanéchite*.—Fine veinlets of this mineral have been identified traversing through the psilomelane. The mineral is greyish white in colour and shows strong anisotropism. The reflecting power is much less than polianite but higher than psilomelane and manganite and came to about 22.7 in air and in green light of Berek's slit microphotometer. In high power the mineral shows fine fibrous structure.

Etch Reactions:—

Positive	..	HCl (Conc.)	—	Feeble attack.
		H ₂ SO ₄ (Conc.)	—	Blackens excessively.
		SnCl ₂ (Sat.)	—	Clear attack.
		H ₂ O ₂ + H ₂ SO ₄	—	Clear attack.
Negative	..	HCl (Dil.), FeCl ₃ , H ₂ O ₂ (100 vols.).		

TEXTURAL RELATIONSHIP

The most notable texture exhibited by these minerals is the colloform texture in which concentric bands of psilomelane present a characteristic picture (Pl. VII, Fig. 3) pointing out to its origin from a gel. Lindgren regards such texture as "the best criterion of a gel state, especially when they are emphasised by a successive deposition of the concentric layers of slightly different appearance". Bastin (1950) also regards such textures to have originated from a gel. These concentric bandings may be due to the surface tension acting on the gel. Thiel (1928) suggests that the bandings have been formed due to the filling up of the concentric shrinkage cracks in earlier formed psilomelane by a later generation of the same mineral, thus giving rise to a difference in hardness in the two and correspondingly a difference in polish. The shrinkage cracks, perpendicular to the concentric lines, are also examples of origin of psilomelane from a gel. These cracks are subsequently formed by the dehydration of psilomelane and consequent shrinkage and tension.

'Carries' have been formed in the contact of psilomelane and pyrolusite where the latter replaces the former, as revealed from the marginal relations. Pyrolusite also replaces the manganite along the elongated direction of the latter (Pl. VII, Fig. 1).

Polianite forms star-like bodies completely enclosed in the innermost layer of the colloform psilomelane (Pl. VII, Figs. 4 and 5) whereas romané-chite forms veins traversing through psilomelane and pyrolusite (Pl. VII, Fig. 6).

In one specimen polianite and manganite exhibit mutual boundary (Pl. VII, Fig. 2) suggesting contemporaneous deposition.

MINERAL PARAGENESIS

The paragenesis of the ore minerals has been drawn up based on the textural relationship of the ore minerals. The psilomelane is obviously the first mineral to be deposited from a gel, as the colloform texture will indicate. Manganite and polianite showed mutual boundaries and the former occurs in the cracks and crevices of the psilomelane and hence younger than that. No replacement relation has, however, been noticed among psilomelane, manganite and polianite. Pyrolusite replaces psilomelane and manganite, the latter pseudomorphically, and hence is younger than both of them. Roman  chite veinlets traverse both psilomelane and pyrolusite and therefore is the youngest mineral to form.

Therefore the sequence of formation of the ore minerals is as follows:—psilomelane, manganite and polianite, pyrolusite, roman  chite.

CONCLUSION

In the preceding pages the author has ventured to put forward a detailed mineragraphic description of the manganese ore minerals of Jamda Valley, Keonjhar. He does not agree with Dr. Spencer (1948) regarding the mineral composition of these ores which, the latter concluded to be comprised of pyrolusites only. The author agrees with B. Sen (1951) that most of the manganese ores of Keonjhar are psilomelane with some manganite. Pyrolusite is of course abundantly present as a replaced product from psilomelane. In addition to these, polianite and roman  chite are present. The latter was first described by Dr. S. Deb (1939) from a lateritoid manganese deposit of Belgaum District, S.W. India. Wad is also present in this area but as these do not take the minimum polish necessary for ore microscopic study, are excluded from this investigation.

The mineral paragenesis, based on the textural relationship of the ore minerals, has been drawn up as follows:—

Psilomelane, polianite and manganite, pyrolusite and roman  chite.

ACKNOWLEDGEMENT

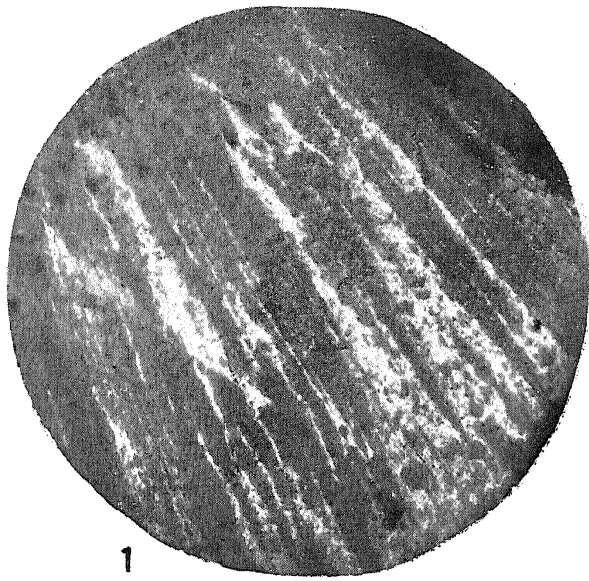
The author is indebted to Prof. N. N. Chatterjee, Head of the Department of Geology, Calcutta University, for his guidance and valuable suggestions. He is also indebted to Dr. S. Deb and Prof. B. C. Mukherjee of the College of Engineering and Technology, Bengal, for helping the author in the measurement of reflectance of the ore minerals and also for the interest they have taken in the work.

SUMMARY

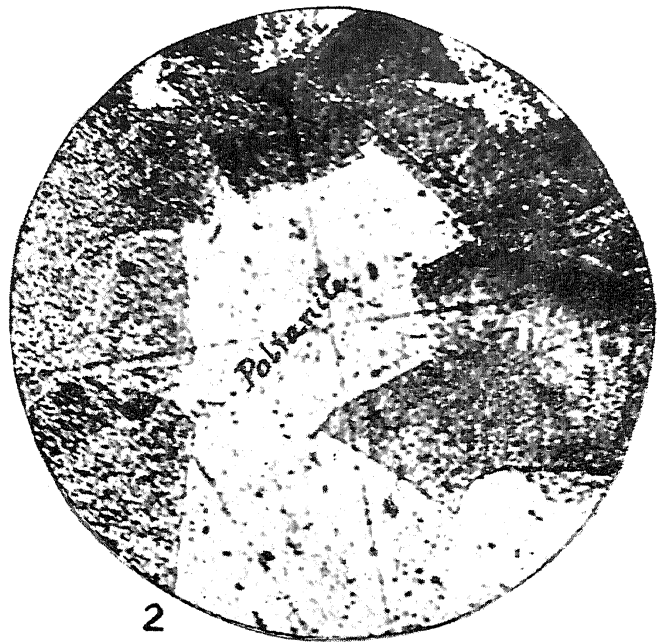
In this paper the author has put forward the results of his study of the manganese ore minerals of Jamda Valley under the reflecting microscope. He differs from Dr. Spencer (1948) who suggested that the ores are entirely composed of pyrolusite, and has identified five different manganese minerals under the microscope. These are: Psilomelane, Pyrolusite, Manganite, Polianite and Romanéchte. In addition to the etch reactions and the general optical criteria, the reflectance for each of the mineral was measured and they read as follows:—Psilomelane—23.07, Pyrolusite—32, Polianite—34.4, Manganite—18.5 and Romanéchte—22.7. All these readings were taken in Berek's slit microphotometer in green light and in air. The psilomelane is the first and principal mineral to be deposited. It exhibits colloform textures and shrinkage cracks and has deposited from a gel. Manganite and polianite, the two minerals showing mutual boundary with each other, were deposited after psilomelane and the manganite occupies the cracks and crevices of psilomelane. Pyrolusite which replaces both psilomelane and manganite is an alteration product and was formed after the manganites, while romanéchte which cuts the psilomelane and the pyrolusite in the form of veinlets, is the youngest mineral to be deposited.

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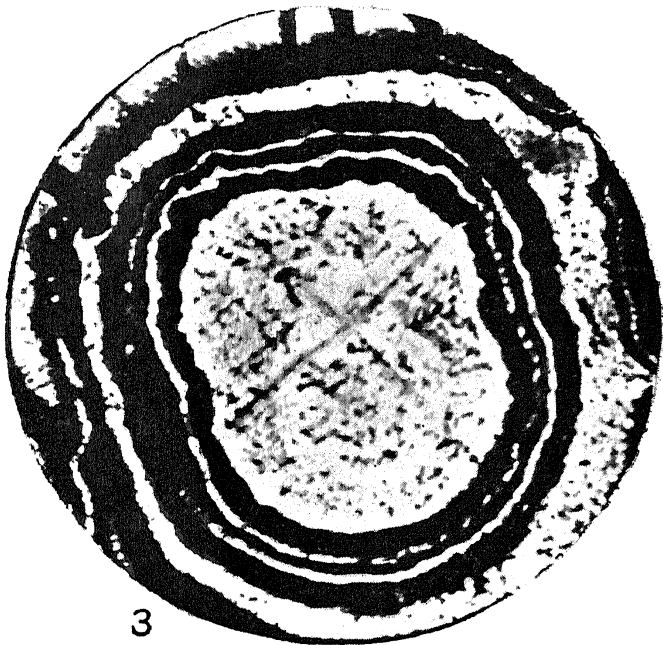
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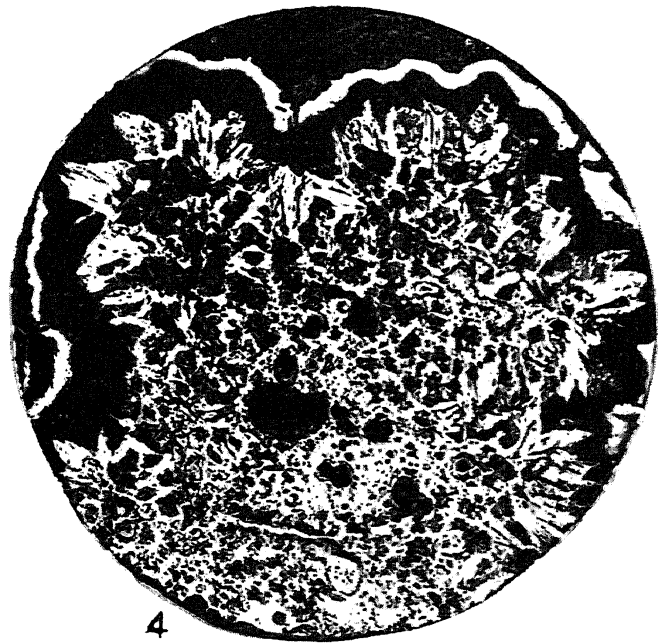
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DESCRIPTION OF FIGURES

- FIG. 1. Needles of manganite (Greyish Black) being replaced by Pyrolusite, $\times 50$.
- FIG. 2. Euhedral grains of manganite (greyish black) showing mutual boundary relation with polianite (white), $\times 80$.
- FIG. 3. Colloform texture exhibited by psilomelane, $\times 80$.
- FIG. 4. Crystal aggregates of polianite crowded in the concentric layers of psilomelane (curved lines bordering the crystal aggregates), $\times 80$.
- FIG. 5. Star-like bodies of polianite (P) surrounded by psilomelane bands (PS), $\times 80$.
- FIG. 6. Vein of romanéchite traversing psilomelane (P) and pyrolusite (PY), $\times 80$.