THE GEOLOGY OF THE MANGANESE ORE DEPOSITS OF TALWARA, DISTRICT BANSWARA, RAJASTHAN

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Received January 15, 1963

(Communicated by Prof. L. Rama Rao, F.A.S.C.)

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ABSTRACT

Talwara (23° 34’: 74° 22’) is a small Manganese-producing locality in the district of Banswara, Rajasthan. From the Banswara Town, Talwara can be reached by a motorable road. In the past, the Manganese ores of the locality have drawn very little attention of the geologists.

The ores of Manganese, being associated exclusively with the Aravalli limestone of Rajasthan, occur in the form of scattered masses occupying solution cavities, fissures, etc., in limestone. Aravalli quartzites, conglomerates, phyllites and slates also occur in the vicinity of Talwara,
The white limestone with a mosaic structure is of common occurrence and is composed of calcite and dolomite with some magnetite. The impurer varieties of limestone are characterised by the presence of tremolite, hornblende and quartz with a little of biotite. Schistosity is developed only in a calc-amphibole rock having alternating bands of hornblende and limestone. Crush-breccia is noticed occurring in association with manganiferous limestone at a distance of about 2 miles west of Talwara. This breccia might have originated due to severe local crushing of the country-rock. The limestones seemed to be a product of low-grade metamorphism of a calcareous sediment.

Fresh ores are generally hard and cavernous but on weathering they become softer and soily. Fragments of unreplaced limestone are occasionally present in the ore-bodies. This limestone has also been replaced by the Manganese ores to a greater or lesser extent, depending on the structural characters of the host rock.

The ores are composed largely of massive and colloform cryptomelane. Pyrolusite forms an insignificant part of the ores. There are two generations of cryptomelane, of which, the earlier colloform one is veined by the later generation of cryptomelane.

There are also examples of pseudomorphous replacement of limestone by cryptomelane. Most of the pyrolusite was derived from the supergene alteration of cryptomelane. From their nature and mode of occurrence the Manganese ores are classified as outcrop secondary ores formed in cavities in crystalline limestones belonging to the less metamorphosed type of Dharwar.

**INTRODUCTION**

The paper presents some recent observations made by the authors regarding the nature and mode of occurrence of Manganese ores of the Talwara area (23° 34′: 74° 22′), District Banswara (23° 33′: 74° 27′), Rajasthan. The ores are associated with dolomitic limestones of Aravalli age. It is not the purpose here to deal with the subject in great detail, since the junior author, who has been working on the different Manganese ore deposits of Banswara, would submit his findings finally in the form of Ph.D. thesis in due course of time.

Talwara is situated about 12 miles east of Banswara and is approachable from Ratlam via Banswara by a motorable road. The Manganese workings of Talwara are mostly in the form of small and scattered quarries and trial pits, which are not at present very promising. The quarries are located about 2 to 3 miles west and north-west of Talwara village. All the workings
are now abandoned. The observations, presented herewith, are based chiefly on field studies and examination of thin and polished sections of the host rock and ore respectively.
No serious attempt has been made to investigate the geology of the Talwara region in the past. Fermor (1909) did not refer to the Manganese ore deposits of Talwara in his classic works on "The Manganese ore deposits of India". In response to a request by the Government of Rajasthan, Dr. B. C. Roy paid a brief visit to the Manganese ore workings of the Banswara district in 1952, with a view to explore the future prospecting operation for the Manganese ores occurring therein. Roy (1957), apart from describing the Talwara workings, held the view that the Manganese ores were concentrated in the bedding planes, fissures and solution pockets in ferruginous dolomitic limestone, possibly due to leaching and infiltration by ground waters.

**Geology of the Area**

The Manganese ores of Talwara occur exclusively in the dolomitic limestones, belonging to the Aravallis of southern Rajasthan. The limestones are conformably overlain and underlain by the Aravalli phyllites and slates, and gritty quartzites and conglomerates respectively. The quartzites and conglomerates are exposed conspicuously along a ridge very close to Talwara. Phyllites occupy mostly the low-lying land just to the west of Talwara and the hilly and elevated undulating country further to the west is formed of limestones (Text-Fig. 1). They are generally thick-bedded and crystalline (Gupta and Mukherjee, 1938) and the part of the country occupied by limestones has a rugged appearance as the outcrops are formed mostly of projected and dislocated blocks of limestones.

Some of the best exposures of the limestones crop out to the west of Talwara. They generally occupy small hills or undulating plains striking NNW-SSW. The quartzite, limestones and phyllites of the region are surrounded on three sides, viz., north, west and south, by older gneissic complex of pre-Aravalli age (Text-Fig. 1). Limestones occupy a considerable area in the south-eastern portion of Talwara and spread southward upto Sagrod (23° 27': 74° 21'). In the north-west, the outcrops gradually die out and ultimately disappear about ten miles away from Talwara.

The limestones are generally hard and saccharoidal and have various shades of colour, such as white, grey, brick-red and brown. The white limestone is the most common variety seen in the area under investigation. The darker varieties of limestone are relatively uncommon. The brick-red variety, in which hematite and limonite occur in a disseminated state, is sometimes highly ferruginous. Some of these limestones are used as building materials locally. They are invariably crystalline and composed of fine to
medium grained crystals of calcite and occasionally of dolomite. Irregular fractures and joints in the rock are abundantly developed. A variety of calc-amphibole schist was also recorded from some localities near Talwara. The schistose limestone is characterized by bands of very coarsely crystalline dark-green hornblende alternating with limestone. Due to differential weathering of the rock, the bands of hornblende were made very prominent. There is another variety of granular limestone in which platy green amphibole of the tremolite-actinolite series occurs abundantly. On weathered outcrops the coarsely crystalline amphiboles are prominently displayed.

The Manganese ores are distributed very irregularly in the dolomitic limestones and they do not show any structural conformity with the country-rock. Field evidence shows that the concentration of workable Manganese ore had taken place in large solution-cavities, joints and fissures in the limestones and this had probably prevented the ores from being systematically prospected and mined in the past.

At Kanji Kotaria, a small locality situated about two miles east of Talwara, the limestone is associated with a rock which, on close examination, appeared to be crush-breccia. The breccia is composed of fragments of hematite, limestone, quartzite, quartz and chert, and consists of a calcareous matrix. Often pieces of limestone measuring up to 2 to 3 feet in diameter were recorded in the breccia. The matrix is somewhat replaced by manganese oxide. Yellow and red ochres, formed as a result of weathering of the ferruginous constituents of the breccia, have largely turned the breccia ochreous. The breccia does not form a distinct horizon but occupies a restricted zone in the manganiferous limestone of Kanji Kotaria. Judging from its composition and discordant nature, it appears that the breccia originated as a result of intense crushing and brecciation of the country-rock prior to the deposition of Manganese ore.

Mode of Occurrence of Manganese Ore

The Manganese ores of the area, under investigation, occur in the form of small localised deposits distributed over an area of about 3 to 4 square miles around Kanji Kotaria. The biggest working of the area lies at Kanji Kotaria, from where a large portion of the ore had been worked out by open-pit method and also to some extent by tunnelling. About ½ mile south-east of Kanji Kotaria, there is another small open-cast working which had also yielded appreciable quantity of ore. There are also some more small workings of similar nature within a radius of about 1 mile of the Kanji Kotaria workings. Besides these, innumerable trial pits were sunk at many places
without much success. All these workings were closed down nearly three years back.

Generally, the ores are hard, colloform and cavernous and not much altered (Plate IX, Fig. 1). The outcrop ores, which have been weathered, are transformed into powdery pyrolusite and wad with varying amounts of red and yellow ochres. Small lenticles of ore in ferruginous limestone is fairly common (Plate IX, Fig. 2). Often fragments of unreplaced limestone occur abundantly in the ore. The extent of replacement of the country-rock varies within wide limits and depends upon the local structural conditions of the host rock. There is adequate field evidence to show that the steeply inclined fissures and the zones of brecciation provided easier access to the ore-bearing solution (see Newhouse, 1942).

PETROGRAPHY OF LIMESTONE AND THE ASSOCIATED BRECCIA

The limestones, which are often dolomitic and ferruginous, do not show much variation in their petrological characters with the exception of some impure varieties. The purer variety is essentially composed of calcite and dolomite with very little of Magnetite (Plate IX, Fig. 3). It is fine to medium-grained and has a mosaic structure. Most of the crystals have polysynthetic twinning and rhombohedral cleavage.

One variety of impure limestone contains minor amounts of quartz, magnetite and sometimes, biotite occurring as minute flakes. Quartz is characteristically intergrown with the limestone in a subgraphic aggregate and often replacing the latter (Plate IX, Fig. 4). There is another variety of impure limestone which is characterised by the abundance of platy tremolite. No mosaic structure was seen in the tremolite-bearing limestone. This variety of limestone had also been reported from the Aravalli limestone of Central Mewar (Gupta, B.C., 1934).

The calc-amphibole schist is characterised by the presence of alternating bands of dolomitic limestone and green hornblende with abundant Magnetite (Plate IX, Fig. 1). Small crystals of quartz occur in the rock in a vermicular aggregate. Schistosity is well developed and the crystal aggregates of calcite and hornblende are oriented parallel to the schistosity of the rock (see Heinrich, E. Wm., 1956).

A wide range of replacement could be seen in the manganiferous variety of limestone. During the earlier period of replacement, the Manganese ore had replaced the limestone constituents mostly along their grain boundaries (Plate X, Fig. 2). There is another example of similar replacement in
which Manganese ore, in a feather-like form, had invaded the limestone along the intergranular boundaries of calcite (Plate X, Fig. 3). Plate IX, Fig. 2 confirms that there is a distinct gradation of replacement in limestone. In the centre of the figure, the lenticle, having a narrow solution channel, represents a completely replaced part of the limestone, whereas the darker portion surrounding the lenticle is replaced partly. The outermost slightly brighter area in the limestone bears no sign of replacement as it is clear from the figure.

Considering the lithological and petrological characters of the dolomitic limestones, it may be suggested that they were probably formed due to low-grade metamorphism, equivalent to the albite-epidote-amphibolite facies (Heinrich, E. Wm., 1956, Table 7, p. 174), of a sedimentary limestone having some original impurities, from which the accessory minerals such as tremolite, hornblende, biotite, quartz, etc., were derived (see Middlemiss, C. S., 1915). Fermor (1909, p. 301) has also expressed similar views regarding the origin of manganiferous crystalline limestones of the Sausar series.

The crush-breccia, which is of local occurrence and associated only with the manganiferous limestone of Kanji Kotaria, consists of angular to sub-rounded fragments of quartzite, quartz, limestone and hematite—all lying embedded in a finely ground matrix of crystalline limestone (Plate X, Fig. 4). Occasionally, the matrix shows schistosity due to the development of Talc or Sericite. The rounded to sub-rounded shape of some of the quartzite fragments might be due to mutual attrition during brecciation (Harker, A., 1939). Nearly all the fragments of quartzite show undulatory extinction and the fractures in some of them are filled with sericite. Often the breccia is manganiferous and ochreous. The ochreous and manganiferous breccia shows partial to complete replacement of its calcareous groundmass by limonite and pyrolusite, whereas the siliceous fragments remained completely unaffected (Plate XI, Fig. 1). The richest concentration of the Manganese ore deposits at Kanji Kotaria was most probably due to the presence of crush-breccia that served as an easy channelway to the ore-solution.

**MINERALOGY OF THE MANGANESE ORES**

Mineragraphic study of a representative collection of Manganese ores of Talwara was made with a view to ascertain the paragenetic sequence of the ore minerals and their assemblage. The ores are composed mostly of hard cryptomelane having black to steel-blue colour. The occurrence of pyrolusite is rather very restricted. It is very soft and powdery.

*Cryptomelane.*—It occurs in massive, botryoidal or pisolitic form and replaced the country-rock to varying degrees. The colloform ore is banded
concentrically and formed of accicular and radiating crystals of cryptomelane with little or no gangue (Plate XI, Fig. 2). Colour—greyish-white; reflecting power—moderate; anisotropism—fairly strong in shades of grey.

**Etch Reactions**

Positive $\text{HNO}_3 = \text{Stains light brown}$

$\text{HCl} = \text{Stains brown to black}$

$\text{H}_2\text{O}_2 = \text{Turns black}$

$\text{SnCl}_2 = \text{Blackens immediately}$

Negative $\text{H}_2\text{SO}_4$, KOH, KCN, HgCl$_2$, etc.

**Pyrolusite.**—It constitutes but a minor part of the ore. Pyrolusite is massive and soily, and due to its softness the mineral crumbles very easily. Practically no crystalline particle of pyrolusite could be seen in the ores.

In reflected light, the colour of pyrolusite is white with a characteristic yellow tinge. When highly magnified, pyrolusite appears to be finely granular. Pleochroism is not distinct; reflecting power high; anisotropism fairly strong in shades of bright yellow. It is very often associated with abundant gangue.

**Etch Reactions**

Positive $\text{FeCl}_3 = \text{Darkens lightly}$

$\text{H}_2\text{O}_2 = \text{Effervesces, surface unaffected}$

$\text{H}_2\text{SO}_4 + \text{H}_2\text{O}_2 = \text{Stains black}$

$\text{SnCl}_2$ (Sat.) = Turns black

Negative HCl, KOH, HgCl$_2$, etc.

**Texture.**—The ores do not show much variation in their texture as they are largely composed of cryptomelane. The colloform and replacement textures characterise most of the ores. The colloform ores consist of successive bands of accicular cryptomelane. Micro-vug is conspicuously absent and so is the case with shrinkage cracks.

The replacement is sometimes pseudomorphic and in such cases, the invading mineral assumed the mosaic structure of the crystalline limestone leaving thin bands of intergranular gangue around every pseudomorph (Plate XI, Fig. 3). There are few ores in which a second generation of massive cryptomelane was seen replacing the first generation of cryptomelane distinctly along veins (Plate XI, Fig. 4) and fractures.
Based mainly on their textural evidence, given above, the paragenesis of the Manganese ore minerals is determined as follows:

| Time | Cryptomelane | Pyrolusite |

CONCLUSION

The nature of the ores, their mode of occurrence and structural relation to the host rock, crystalline limestone, undoubtedly suggest that the ores are of epigenetic origin. The ores were largely brought in by meteoric water, deposited them largely in solution-cavities and pockets after circulating through the crushed zone, fissures and joints in the limestone. Therefore, it may be concluded that these ores originated in a way much different from those occurring in the metamorphosed crystalline limestone of the Sausar series in the districts of Nagpur and Bhandara (see Hayden, H. H., 1921). Accordingly, the Manganese ores of Talwara, which occur mostly in solution-cavities and pockets in limestone, may be designated as outcrop secondary ores.

REFERENCES

EXPLANATION OF PLATES

PLATE IX

Fig. 1. A handspecimen of cavernous and colloform manganese ore, ×4.
Fig. 2. A handspecimen of manganiferous limestone showing various gradations of replacement ×4.
Fig. 3. Mosaic structure in limestone having a few crystals of magnetite, ×56.
Fig. 4. Impure variety of limestone showing subgraphic intergrowth of quartz with calcite, ×56

PLATE X

Fig. 1. Calc-amphibole schist with alternating bands of limestone and hornblende together with some magnetite, ×18.
Fig. 2. Manganiferous limestone showing partial replacement of calcite along their grain boundaries, ×56.
Fig. 3. Manganiferous limestone with feather-like manganese-ore replacing calcite incompletely, ×34.
Fig. 4. Crush-breccia showing angular fragments of quartzite, quartz and limestone, embedded in a fine-grained calcareous groundmass, ×20.

PLATE XI

Fig. 1. Manganiferous crush-breccia showing complete replacement of the matrix by manganese ore and unaffected quartz and quartzite fragments, ×18.
Fig. 2. Polished section of colloform manganese ore showing accicular and radiating cryptomelane in the bottom right-hand side of the figure, ×19.
Fig. 3. Polished section of manganese ore showing pseudomorphs of cryptomelane after calcite, ×52.
Fig. 4. Polished section of manganese ore showing a second generation of cryptomelane veining through cryptomelane of the first generation, ×18.
Figures 1-4