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Research Article

Iron Ore Mineralization of Ramagiri Greenstone Belt, Anantapur District, Andhra Pradesh, India

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Abstract Archaean provinces have rocks of 2500 Ma to 3000 Ma that contain, i. the granite – greenstone association, ii. The high-grade association and the cratonic basin association. Amongst the above said features, the granite - greenstone association is more in abundance and is characterized by the presence of mafic volcanic that has dominated the other units and is known as greenstone belts. These belts are surrounded by variant granitoids. These rocks are metamorphosed to greenschist to amphibolites facies and are hosts for mineralization of gold, copper, silver and iron etc. The main thrust in respect of mineralization is on the iron ore that is associated with the belt. It is mainly of “Algoma” type having alternate bands of magnetite and chert. The mineralization is in the Banded Iron formation of the Ilkal formation (Greenstone Group) and is very proximal to Ramagiri village. The thesis deals with all the details like distribution, possible origin and economic viability of the iron ore.
Keywords *Hypothesis for origin of early Proterozoic iron – formation; Mineralization of iron ore; Ramagiri Greenstone belt*

1. Introduction

Presence of Iron ore in the Greenstone belts is not uncommon, but the quality and intensity may not that much when compared with the association of Iron from the sedimentary rocks.

Iron also occurs in the Precambrian period, i.e., Archaean - Proterozoic. The Iron Formations of this period are divided into two types’ viz., Algoma and Superior types (Gross, 1965).

The Algoma Type is named after the place Algoma of Ontario. The associated rocks are of volcano - sedimentary sequence. This type of Iron formation is associated with gray or red jasper cherts, interbedded with magnetite and hematite rich layers. Further, siderite and pyrite are also common. The association with the volcanic rocks possibly indicates the volcanic nature of the iron formation. The iron formation runs into number of kilometers in length.

The Superior Type, named after the Lake Superior of the United States and Canada and also known to occur in Labrodar trough. The rocks are thinly bedded cherty rocks with granular and oolitic texture. Cherty magnetite and hematite and cherty iron silicates and carbonates rocks form into different stratigraphic units. The associated rocks are quartzites, dolomites, black cherts, black ferruginous shale/slate and volcanic rocks. The beds are few hundred feet thick and extend for reasonably long distances.

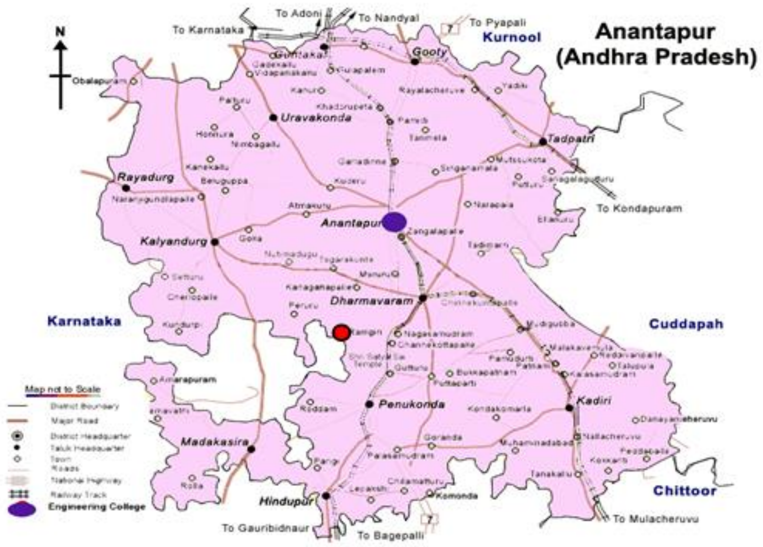

Figure 1: *The location map of Ramagiri (.) area*

1.1. Study Area

The village Ramagiri is located in the topographical map of 57/F11, of Survey of India. It is at the intersection of 14^{0} 26' 30" North latitude and 78^{0} 38' 20" East longitude. The villages of the Ramagiri Mandal area are located in both the topographical maps of 57 F/ 7 & 11(1:50,000), of Survey of India.

Ramagiri is accessible from Anantapur, the district headquarters. Anantapur can be reached either by South - Central Railway from Hyderabad, the state capital of Andhra Pradesh. The town Dharamavaram and Penukonda are the nearest locations and these can be approached by South - Central Railway. The said places can also be approached from Hyderabad by road. The Andhra Pradesh Road Transport Corporation runs number of buses from Anantapur, Dharamavaram and Penukonda to all the rural areas.

Ramagiri is the central place of the investigation and the adjacent villages are all well connected by all-weather roads from all the places.

2. Methodology

2.1. Iron Ores of Anantapur District

Iron ore occurs basically at two places, viz., one in the Oblapuram area of Rayadurg taluka and the other at Ramagiri of Ramagiri taluka. In both the cases the ore is with the greenstone belts. The ore at Oblapuram is with the Bellary greenstone belt i.e., the eastern arm of the Sandur-Bellary greenstone belt. The southern part of it extends into the Anantapur district. The Ramagiri iron ore is with the Ramagiri greenstone belt. This extends towards north into the Karnataka State. Both the greenstone belts run almost parallel to each other.

Similarities and Dissimilarities of Iron Oreat Obulapuram and Ramagiri

This can be studied under the following heads:

1. Geological setting
2. Nature of the ore
3. Chemistry/Grade of the ore

1. Geological Setting

The iron ore at Oblapuram is associated with the greenstone belt having amphibolites, meta-basalts with bands of phyllite and BIF. The BIF was earlier recognized as ferruginous quartzite. Chert is insignificant. The set up appears to be mainly sedimentary where the iron ore is seen. But higher up in the stratigraphy the above stated metamorphic are observed. This set up is intruded by younger granitoids.

The iron ore at Ramagiri is associated with the greenstone belt having amphibolites, meta-basalts with bands of phyllite and BIF. The BIF was earlier recognized as ferruginous quartzite. This set up is intruded by younger granitoids.

2. Nature of the Ore

The iron ore at Oblapuram though associated with the greenstone belt can be considered as 'Superior' type as it exhibits more sedimentary association. As stated earlier, the metamorphics of the greenstone are noticed at lower level in the stratigraphy. Evans (1993) describes similar set up and qualifies the ore as 'Superior' type. But the ore at Ramagiri is considered as 'Algoma' type as it is associated with the greenstone belts. The ore at Oblapuram is hematite and at Ramagiri it is magnetite. Chert percentage is more at Ramagiri compared to Oblapuram. The thickness at Oblapuram is much more than at Ramagiri. Extensive mining is being done at Oblapuram whereas no mining activity is seen at Ramagiri.

3. Chemistry/Grade of the Ore

The ore at Obulapuram has indicated the grade as 56.63% to 63.88% as Fe%. The ore at Ramagiri has 37.10% to 64.96% as Fe% in the western band and 23.24% to 34.72% as Fe% in the eastern band. As the ore at Ramagiri is mainly magnetite, pellitisation may be helpful in using the ore in different industries.

2.2. Ironstone and Iron Formation

Ironstone

Iron ore occurs in the form of Ironstones in the Phenerozoic Era. These ironstones are classified as Minette Type, named after the Minette beds of Jurassic age in the eastern France and the Clinton Type, called after the Clinton iron ores of Silurian age in the area south of Alabama, in the region of New York.

The Minette types of ironstones are main constituted by the chamosite and siderite. These are oolitic ores but oxides are less important.

The Clinton Type is deep red to purple, massive hematite - chamosite-siderite with oolitic textures. These ores contain 50% of iron. They also contain fairly high content of clastics including quartz.

Iron Formation

Iron formation has alternating layers of chert and iron. Hence it called Banded Iron Formation (BIF). It occurs in four different facies (Evans, 1992).

i. **Oxide Facies-** This is the most important facies and it can be divided into hematite and magnetite sub-facies. Carbonates may be present. Chert varies in percentage in sub-facies. The magnetite sub-facies show more of alternate banding of magnetite and chert.

ii. **Carbonate Facies-** This is interbanded with chert and siderite in equal proportions. If magnetite is also present in the bands it grades into oxide facies. If pyrite is present it may grade in to the sulphide facies.

iii. **Silicate Facies -**If the bands of magnetite-siderite chert are associated with iron silicate, it forms silicate facies. It is difficult to study this facies because of the complexity of the iron silicates. This has very low economic interest.

iv. **Sulphide Facies-** This will have pyritic carbonaceous argillites. It is thinly banded. The carbon content will be 7-8% and the pyrite will be 37%. This will be normally mined for its sulphur content.

The differences between Ironstone and Iron Formation (James, 1966) are documented as Table number 2 for better understanding.

Figure 2: *Algoma Type - Ramgiri Area (Anantapur District); the dark colored bands are magnetite and the light colored bands are that of chert*

The examples of Iron Formation from Andhra Pradesh are that the iron formation of the Ramagiri area is of Algoma type (Figure 2) and the one from Pendlimarri Mandal of the Kadapa district is of the Superior Type (Figure 3).

Figure 3: *Lake Superior Type – Gangannapalli -Pendlimarri Area (Kadapa District); the dark reddish colored material is iron, light brown is the dolomite and the rest is chert*

Figure 4: *The iron formation or BIF (western band) running and crowning the schistose hills of the Ramagiri West Reserved Forest*

2.3. The Ramagiri Iron Ore

Nature of Occurrence

Iron formation occurs in two independent blocks in the Ramagiri area. One is in the western limit of the greenstone belt in the Reserved Forest and the other in the eastern limit of the greenstone belt.

Ramagiri West Reserved Forest

The iron formation or BIF occurs as a thick band running for nearly 8km and crowning the schistose hills of the Ramagiri West Reserved Forest (Figure 4). It has alternating magnetite and chert bands (Figure 2).

Figure 5: *Reflection of the depth persistence and steep dip*

Figure 6: *Easterly dipping Iron ore along with chert*

Structure

The strike of the Banded Iron Formation is NW - SSE that is in conformity with the schistosity of the associated schists. It dips westerly and occasionally easterly at a steep angle of 80^0 to 85^0. The formation being a steep dipping, the width can be considered as thickness. In the present situation the thickness can be considered as 9 meters on average. The depth persistence of the Banded Iron Formation appears to be considerable. In one of the exposed section, it was found that the ore body was extending beyond 10 meters (Figure 5). It is assumed that it will extend beyond 20 meters depth.

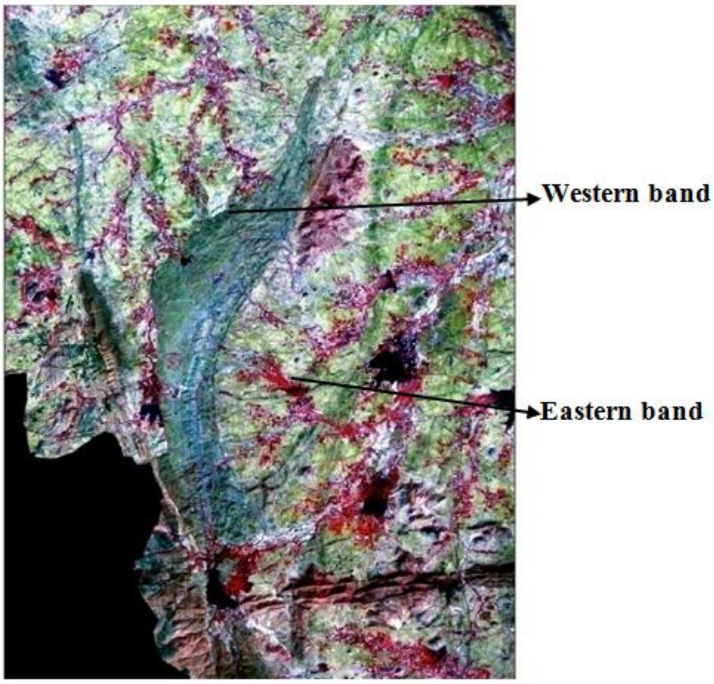

Figure 7: *Cherlopalle dome with the wextern and eastern iron bands*

Figure 8: *Minor warp in the iron formation in the eastern band*

The BIF dips easterly with 250 to 450. Sometimes the dip grades between 450 to 600 (Figure 6).

The iron formation extends north wards beyond the reserve forest area, occurring on top of a small mound. It runs for a distance of 2.75 km along the strike. The terrain from the reserve forest boundary up to a distance of 1 km is covered. A trench has been excavated in the covered and the continuity of the BIF is found.

In fact, the continuity of the iron formation can be established even without digging a trench, as the iron formation is steeply dipping, it will definitely continue in the strike direction unless affected by faulting.

On the Eastern Side

In the area around Cherlopaplle (57F/11), the iron ore occurs like a neck-lace around a gneissic elongated dome called Cherlopalle Dome (Figure 7). This makes the iron formation devisable into two, the western band and eastern band (Figure 7). Both the bands are similar in nature. The eastern band is more quartrzitic. It has two bands within it.

The western one runs for nearly 12 km and the eastern one extends for about 6.5 km. The iron ore formation reflects minor warps (Figure8), as observed in the eastern band.

Table 1 indicates that the western band has more Fe% than the eastern band. The scrutiny of literature suggests that there are number of hypothesis for the origin of Proterozoic iron formation. These are presented in the following Table 2.

Table 1: *Analysis of the iron ore*

Western band			Eastern band		
S. No	Iron as Fe_2O_3 %	Iron as Fe %	S. No	Iron as Fe_2O_3 %	Iron as Fe %
1	52.80	36.96	1	40.70	28.49
2	82.60	57.82	2	33.20	23.24
3	55.80	39.06	3	49.60	34.72
4	92.80	64.96	4	48.80	34.16
5	55.20	38.64	5	47.00	32.90
6	66.60	46.62	6	35.60	24.92
7	57.80	40.46	7	42.40	29.68
8	53.00	37.10	8	40.00	28.00

The exhalative origin of numerous Archaean iron – formations have been convincingly established, (Gross, 1980). But numbers of other theories have gained momentum. Hydrothermal model is supposed to be the modern one.

2.4. Origin of the Ramagiri Iron Ore

The origin of the Precambrian iron ore is highly debatable. The knowledge of the origin of the iron ore helps in planning mining and will also yield considerable useful information on the grade of the deposit.

The Ramagiri Iron ore is associated with the green schist grade of metamorphic rocks. The parentage for these schistose rocks is the basic volcanics. Hence, there is an opnion in respect of origin, is that, it (iron) is volcanic in origin. The differenciation of basic magma rich in magnesium starts with komatitic basalt and gradullay goes to iron rich tholeiites. If this is considered as a clue, then volcanic origin can be acceptable. In fact, there are volcanic cherts also. Hence, both the iron and chert of Ramagiri can be volcanic. However, these iron formations are banded giving a sedimentary look to the rock.

The Banded Iron Formation, (BIF), as it is popularly called, is an indicative of one cycle of magma eruption. In certain schist belts number of Banded Iron Formation are observed. This type of set up reflects that there are number of volcanic cycles in the schist belt. This can also be verified by calculating the Mg. No (beyond the scope of the present work) of the volcanics lying immediately above any BIF. If the Mg. No, crosses 60, it indicates that the magma is primary and a new volcanic cycle has started. This concept is valid and proved. However, in the present situation, there are two locations of the bands of BIF. The extensive extension of the iron - formation of Ramagiri, indicates that it is possibly related to the volcanic activity.

Table 2: *Hypothesis for origin of early Proterozoic iron – formation*

Model	Suggested cause of IFM deposition	Reference
Lacustrine	Deposition in deep stratified or ephemeral Saline lakes	*Cowell, 1966 & Eugster & *Chou, 1973
Continental	Iron released during normal weathering	*Garells & others, 1973
Weathering	Under anoxic atmosphere precipitated in restricted marine basins	*Schidlowski, 1976
Evaporative	Iron and silica precipitated from sea water As a result of evaporative concentration	Trendall, 1973 *Button, 1976
Biological	Iron and silica precipitated from sea water As a by – product of metabolic activity	*Cloud, 1973 *LaBerg, 1973
Upwelling	Iron and silica precipitated from marine Bottom waters as a result upwelling	*Holland, 1073 *Drever, 1974
Hydrothermal	Sea water enriched in iron and silica by Sea floor hot spring to point of precipitation	*Gross, 1980 *Simonson, 1982a

IFM = Iron Formation
*Referenced by Cross references.

Use of the Mineral

The analysis when compared with the standards (Table 1), the ores of Ramagir, Nossannakota has the Fe range “between” 30% - 60% have higher percentage of silica. The fines can be used in the Sintering industry where the Fe required is 56% - minimum. Beneficiation sand pelletisation may increase the chance of its utility. Higher percentage of SiO2, i.e., up to 6% is used in the Durgapur Steel Plant.

3. Conclusion

Iron is associated with the greenstone belts. In Anantapur district iron is (part of Bellary greenstone belt) in Obulapuram - Rayadurg taluk and with the Ramagiri belt in the Ramagiri area. In the Ramagiri area, the ore occurs in two different styles. On the western side nearer to Ramagiri it is mainly “Algoma” type. The iron ore is magnetite occurring as bands alternating with chert bands reflecting sedimentary nature. In the opinion of the author, both the iron and chert are of igneous origins that have formed at the end of differentiation of the basic magma. This set up can be called as Iron Formation. On the eastern side of the belt iron occurs in the form of a necklace around Cherlopalle dome. Each arm of the necklace has two bands. These bands are like ironstones rather than iron formation. The differences between the iron formation and ironstone are documented clearly. The different concepts expressed on the origin of iron are also presented for reference. The chemistry and the use of the mineral are also given to understand its suitability in different industries.

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