

Geochemistry of Metamorphism in the Malikhera-Mokanpura Area of Dariba-Rajpura-Bethunmi Polymetallic Sulphide Belt Rajasthan

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Abstract: *The present paper deals with geochemistry of metamorphic aspect of the rocks of the Malikhera-Mokanpura area. The rocks are metamorphites in nature and are characterized by a varied key metamorphic minerals and mineral assemblages. An attempt has been made to work out the various mineral assemblages to ascertain the metamorphic facies and zones. Estimates of pressure and temperature conditions operating during the formation of metamorphic assemblages have been made. The lowest grade of metamorphism attained by these rocks rajpura-Dariba area is of quartz-albite-biotite sub facies of the green schist facies The highest is staurolite-almandine sub facies of amphibolite facies in the Barrovian type of metamorphism*

Keywords: Rajpura-Dariba polymetallic belt, Malikhera-Mokanpura Area, Regional metamorphism, green schist facies, amphibolite facies

1. Introduction

The Malikhera-Mokanpura area is adjacent area to the Rajpura mineralized block of Dariba-Rajpura-Bethunmi polymetallic sulphide mineralized belt. The belt is almost 17 kms. long with Dariba as its southern end and Bethunmi as its northern end. The proposed area of study is northern extension of well known Rajpura-Dariba polymetallic sulphide deposit. The Malikhera-Mokanpura area (Latitude 74°07' to 74°11' and Longitude 24°57' to 25°00') is part of Survey of India Toposheet No. 45 K/4 and 45 L/1. The area is part of newly created Rajsamand district. Earlier, it was part of Udaipur district. In fact it is a junction of three political districts, Rajsamand, Chittorgarh and Udaipur within the radius of 15 kms. The topographical map of the area has been prepared by the author (Fig. 1) which has served as base map to prepare a geological map of the area. The map of various zone of metamorphism of the area prepared by the author has been presented as Fig. 1.

2. Metamorphism Assemblage

The pelitic metasediments in the study area are characterized by the following mineral assemblages:

- 1) Biotite-muscovite-sericite-chlorite-quartz.
- 2) Biotite-muscovite-sericite-almandine-quartz.
- 3) Biotite-muscovite-graphite-almandine-quartz.
- 4) Biotite-muscovite-graphite-almandine-Kyanite-quartz.
- 5) Biotite-muscovite-graphite-almandine-Kyanite-Staurolite-quartz.

Impure carbonate metasediments are represented mineral assemblages

- a) Calcite-dolomite-quartz.
- b) Calcite-tremolite-quartz.
- c) Dolomite-calcite-tremolite-quartz.

3. Distribution of Metamorphic Zones

The rocks of the Malikhera-Mokanpura area have undergone progressive regional metamorphism of the Barrovian type

showing an upward increase in grade of metamorphism from chlorite to kyanite and staurolite. The metamorphic mineral assemblages of each zone has been studied petrographically.

The lowest grade of metamorphism attained by Rajpura-Dariba area is of quartz-albite-biotite sub facies schist facies. The highest is staurolite-almandine sub facies facies in the Barrovian type of metamorphism. Impact metamorphism along with dynamothermal metamorphism is certainly present in the area, but the progressive nature of metamorphism east ward indicate effect of intrusive body, beneath There is clear 'metamorphic doming' atleast at a side or half of the same is F exposed. Presence of such intrusive body has also evident in underground 400 level at 65° N where neo-magma has already been reported (Shrivastava, 1992). Winkler (1967) has assigned 400°C to 550°C temperature range to the green schist facies and 550°C-670°C to the amphibolite facies. 650°C is the temperature where anatexis starts. The beginning of anatexis in the area is further supported by gravity survey (Reddi and Remakrishna, 1988). Five major metamorphic zones have been recognized on the basis of specific mineral reactions.

These zones are separated by four isograds which runs almost in N-S direction. Out of these three isograds are making typical Barrovian type metamorphism of pelitic sediments and last one separating calcareous rocks dolomitic marble from pelites., showing various zones of metamorphism. The assemblage of sillimanite zone have not been encountered.

Zone I : Quartz-Chlorite zone.

Zone II : Garnet zone (Graphite-Almandine-Muscovite-Biotite).

Zone III : Kyanite zone (Kyanite-Graphite-Almandine-Muscovite-Biotite).

Zone IV : Staurolite zone (Staurolite-Kyanite-Graphite-Almandine-Muscovite-)

Zone V : Calcite-dolomite-Tremolite-Actinolite zone.

Zone I : Quartz, chlorite zone

Chlorite in coexistence with biotite, muscovite and quartz are grouped in this zone. The rocks of this zone, are comprised of quartzite and chlorite schist (with little biotite).

The quartz chlorite-biotite zone falls under the greenschist facies. the main mineral assemblages of this zone established on the basis of petrography. These mineral assemblages show progressive metamorphic reactions and also retrogressive metamorphic event. The generation of chlorite and biotite are recognised under thin section. The first generations of chlorite and biotite are represented by large flakes of green and brown colour respectively, which are oriented parallel to the main foliation plane (S1). The chlorite and biotite of second generation are aligned at an angle to the foliation plane. The biotite of second generation occurs as porphyroblast across the foliation which also defines the crenulation cleavage (S2).

The appearance of biotite marks an increase in rise of P-T conditions. It is formed largely at the expanse of the chlorite and muscovite as is evidenced by patchy distribution of chlorite and porphyroblastic development of biotite (Plate 1 Figure:1).

The possible reactions suggested are :

1. 3 muscovite + 5 chlorite \rightarrow 3 Biotite + 4 Al rich chlorite + 7 quartz + H₂O (Winkler, 1967)
2. Chlorite + muscovite + hematite \rightarrow Biotite + H₂O + O₂ (Heitanen, 1967).

According to Winkler (1967), the beginning of the green schist facies is marked by the reaction involving break down of kaolinite. The equilibrium temperature of the reaction is 390°C \pm 10°C at 2 kb PH₂O and 405°C \pm 10°C at 7 kb PH₂O (Althaus, 1966). Furthermore, Winkler (1965) experimentally demonstrated that pyrophyllite, paragonite and chlorite can crystallize by heating mixtures of clay minerals and quartz to temperatures of about 400°C at PH₂O = 2kb. Thus, according to him greenschist facies begins at temperature of 400°C.

Zone II : Garnet zone

This zone succeeds the chlorite-biotite-quartz zone. The first appearance of almandine in the area defines the assemblage Graphite-Almandine-Biotite-Muscovite and quartz.

Almandine is typical garnet of the garnetiferous schists resulting from regional metamorphism of argillaceous sediments, and as such it is used as a zonal mineral in regions of progressive metamorphism of these rocks (Plate 2 Fig. 2). The almandine may be developed from the chlorite grades although, not all chlorites have an appropriate FeO/MgQ ratio for the production of almandine. In higher grades of regional metamorphism almandine may also be produced from the breakdown of mica to give garnet and potassium feldspar and from the reaction of staurolite with quartz to give garnet and potassium feldspar and from reaction of staurolite with quartz to give garnet and Kyanite or Sillimanite (Chapman, 1952). The rise in the Mg/Fe ratio in the Adirondack garnets with increasing grade of metamorphism is believed to be the result of partitioning of

Mg and Fe between the garnets and the coexisting biotites at high temperatures and pressure (Compare, however, Miyashiro, 1956) Although typically a mineral of regional metamorphism, almandine may also occur as a product of thermal or contact metamorphism. It occurs only in certain aureoles, which typically contain white mica and which lack potassium feldspar, suggesting that it is restricted to relatively wet aureoles. Yodder (1955), in the light of experimental data on the almandine stability field, suggested for these occurrences of almandine that either (a) the contact is wet and the temperature is higher than the upper stability limit of the hydrous minerals, yet lower than the breakdown temperature of garnet, or (b) the contact is dry and therefore, the garnet would be preserved at any temperature below its breakdown curve or (c) the water content of the rock is so low that the bulk composition lies in the water deficient region, and hence garnet is stable with hydrous minerals in the absence of free water at temperature below the breakdown temperatures of the hydrous minerals.

Zone III : Kyanite zone

The transition from zone II to III is observed by the appearance of kyanite (Plate 3 fig 3). The rocks of this zone are composed of Kyanite-Graphite-Almandine-Biotite-Muscovite-Quartz schist.

Kyanite occurs typically as a mineral of regional metamorphism of pelitic and more rarely psammitic rocks. It has been used as a zonal mineral developing before sillimanite with increasing grade of metamorphism. Francis (1956) has shown that Staurolite (\pm Kyanite) pelites occur in the epidote-amphibolite facies, while staurolite free kyanite pelites are found in the amphibolite facies. Kyanite may arise also from the dehydration of paragonite with the addition of quartz and from the inversion of andalusite in areas where a regional metamorphism is superimposed on a normal thermal metamorphism (Harker, 1954). Stress of rising pressure during a fall in temperature may bring about the inversion of sillimanite to Kyanite (Hietanen, 1956). Its occurrence together with staurolite and sillimanite in a thermal aureole has been noted by Mc Call (1954) who described porphyroblastic Kyanite in a narrow zone along a granite margin where pelitic schist have been invaded by numerous granite sheets.

Zone IV: Staurolite Zone

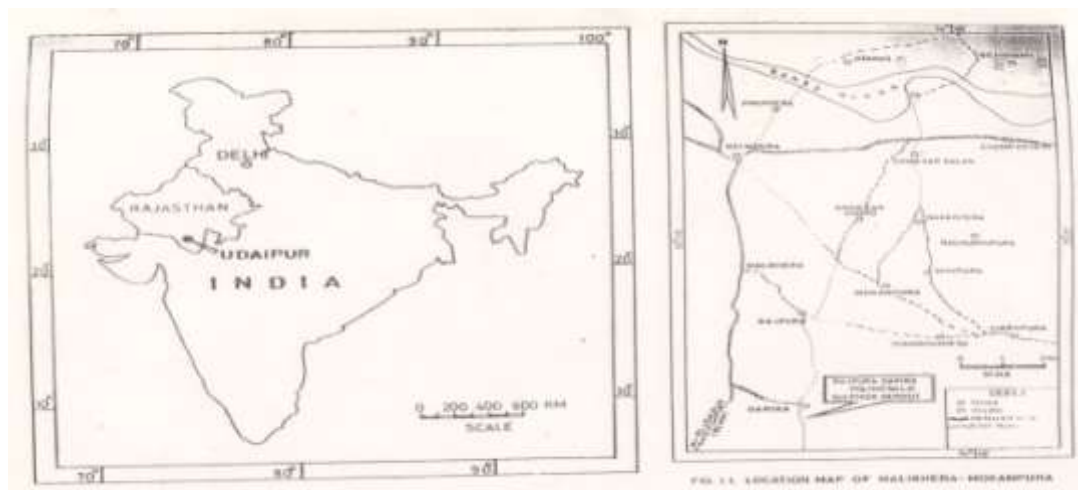
The next higher grade of metamorphism is represented by staurolite zone. The rocks of this zone consisting of staurolite schist. The first appearance of porphyroblast of staurolite marks the beginning of staurolite zone. The isograd of this zone is parallel to subparallel to the regional trend of the country rock.

Staurolite occur as porphyroblasts and are wrapped by the micaceous minerals defining the schistosity (S1). The staurolite may contains the inclusions of quartz. Staurolites are commonly twinned in cross fashion.

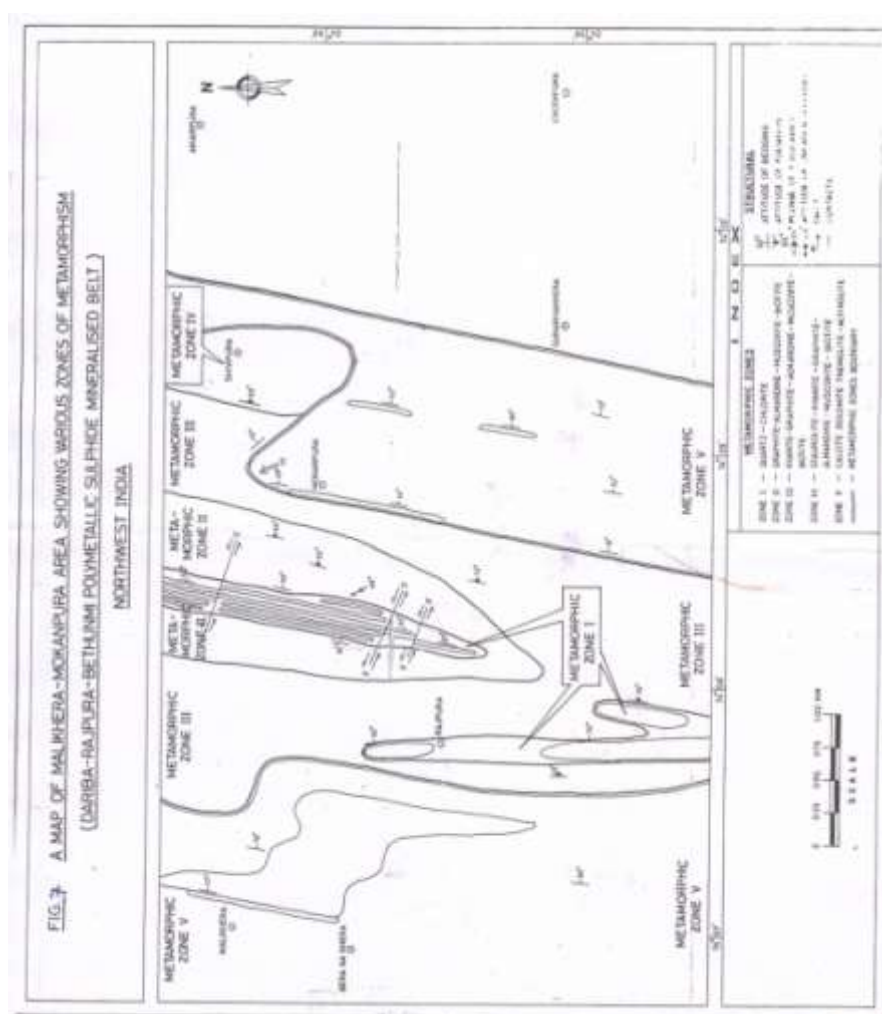
Staurolite is a common product of regional metamorphism and is particularly characteristic of medium grade schists derived from argillaceous sediments. In such mica schists, staurolite is associated particularly with almandine garnet, muscovite, Kyanite and quartz. Staurolite as formed also at a

interfacial tension by producing a stable configuration of 1200 triple point junction. The theory (Shrivastava and Shrivastava, op cit) further state that the histograms occur nearer to 1200 tripple point, while plotting triple point angles as abscissa with distribution frequency as ordinate, will prove the superiority as regards the subgrade. All the photomicrographs from Malikhera marble shows a great deviation from 120° triple point junction, thus are of poor quality as for as degree of crystallinity is concerned.

Further, heterogenity of grain size ranges from fine grained to coarse grained texture even in a single photomicrograph. It shows a poor degree of recrystallisation during thermal metamorphism of the parent sedimentary rock. Apart from absence of homogenity in the degree of crystallinity, effect of deformation is also evident at Malikhera alongwith metamorphism resulted in producing linear alignment and elongation of the grains.



Location Map of Malikhera-Mokanpura



Map of Malikhera-Mokanpura Area Showing Various Zone of Metamorphism

4. Conclusion

According to geochemical study of metamorphism of the rocks of the Malikhera-Mokanpura area have undergone prograde regional metamorphism of the Barrovian type showing an upward increase in grade of metamorphism from chlorite to kyanite and staurolite there are five various metamorphic zones marked in the metamorphic. The metamorphic mineral assemblages of each zone has been studied graphically. The lowest grade of metamorphism attained by these rocks in the Rajpura-Dariba area is of quartz-albite-biotite sub facies of the green schist facies. The highest is staurolite-almandine sub facies of amphibolite facies in the Barrovian type of metamorphism.

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