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GEOLOGICAL EXCURSION TO EASTERNGHATS MOBILE BELT OF GANJAM DISTRICT ,ODISHA, INDIA.

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ABSTRACT

The geological excursion was carried out around Athagadapatna-Taratarini-Bhabandha area, Ganjam district, Orissa. The area under geological investigation forms a part of the Easternghat Group of rocks in India This area has been selected for structural and lithological mapping. Athagadapatna-Taratarini-Bhabandh areas constitute a complex tecotonic setting and polymetamorphic terrain of Easternghats. The region comprises high grade granulitic facies assemblages of Archean age with typical gneissic structure. Gneissic banding within the rocks has a general NE-SW trend with westerly dip. The important rock types of this area are khondalitic and charnokitic suites of rocks along with granitic gneiss, Calc-granulite and quartzite. Augen gneiss contains large elongated feldspars and augen surrounded by biotite flakes defining foliation. Migmatisation within the gneiss is a common phenomenon. At some places, charnockite occurs as dyke. The rocks of the study area have been subjected to different episodes of structural disturbances. Being a granulitic terrain, the rocks are subjected to polyphase folding, faulting & shearing. Foliation and lineation of tectonic origin are the prominent structural element in the area. The different petrogenetic processes that are clearly visible in this area include Feldspathisation Lateritisation, kaolinisation and Manganese mineralization. The minor occurrence of manganese in this area can not be an economical deposit, but from academic pint of view this is significant because the manganese formation in this area is mineralization of neogenic event.

Key Words: khondalite, Charnockite,, Foliation,Lineation,Granulite

Introduction :

C during winter. The study area is covered by reserve forest in AthagadaPatna and Taratrini area. The forest is composed of thick throny bushes which make the area almost inacc The geological excursion was carried out around Athagadapatna-Taratarini-Bhabandha area, Ganjam district, Orissa. The area under geological investigation forms a part of the Easternghat Group of rocks in India and falls in the Survey of India toposheet no 74 ^{A}/14, 74 ^{A}/15 .This area has been selected for structural and lithological mapping. The area experiences a humid sub tropical climate receiving annual rainfall by SW monsoon between June and October. Retreating Monsoon also occur. The annual rainfall is around 1500mm. the temperature varies from 32º to 40º C during summer. The temperature may go upto 18º essible. Sala, Piasala, Asam, Kendu and Teak constitute the main flora alongwith different type of bamboo bushes in many parts of terrain. Teak plantation has been taken up by the forest department. Amongst the Fauna, Beer, Wolf & Deers are seen occasionally. The area is visited by Leopards & Elephant. Besides this, the area is infected with poisonous snake like cobra, krate & stripped krates etc.

The study area belongs to the granulitic facies of metamorphism[1,2]. The hill ranges form the Precambrian granulitic terrain and all the hills and rock types trend in the direction of NE – SW which is similar to the general regional strike trend of Easternghats. The disposition of the rocks are parallel to the East coast. The rocks are highly deformed & metamorphosed into different grades with complex lithological interrelationship [3,4]. The rocks are complicated in their mode of occurrence. The important lithounits include Khondalite, Charnockite, Leptynite, Granitic gneisses and number of different types of younger granites. Structurally, the rocks have been deformed into complex type of folding, faulting and shearing as well as different generation of granitic activity and anatexis have made the rocks more complicated. Ample evidences of faulting and folding are seen in the field. Almost all the rocks have been subjected to migmatisation into different magnitude. In many cases Charnockites, khondalites, Calcgranulites, even granite show distinct quartz, feldspar and feldspathic veins. This has changed the colour, texture and composition of the rocks. This process of feldspathisation has produced different types of migmatites.)

Methodology:

The toposheet number 74 A/14 & 74 A/15 of 1: 50, 000 scale was used for geological mapping. The important topographic features have been recoded in these toposheets. Field work has been carried out by taking traverse across the general strike to get aquanted with the rock types.General procedure of back bearing method has been adopted to locate the different rock types on the toposheet. GPS is used to locate the exact position of the outcrop in the topographic maps. The attitude of planner and linear structures have been recorded with the help of Brunton Compass. About 50 rocks samples of suitable sizes have been collected for petrographic studies in the laboratory.Petrographical and mineralogical studies has been carried out using 20 thin sections and 10 polished sections. Field photographs are taken.

Geological Setting & Field Relation of Rocks

The geology of the study area constitute a complex tectonic setting & poly metamorphic terrain of Easternghats[5,6]. The region comprises of high grade granulite facies assemblages with typical gneissic structures. Gneissic banding within the rocks has a general NE-SW trend with westerly dip. The important rock types of this area are Khondalite, Charnockite, Granite gneiss, Calcgranulite & Quartzite, Augen gneiss contains large elongated feldspar & augen surrounded by biotitic flakes defining foliation (Figure-1). Migmatisation within the gnesis is a common phenomenon and has resulted in the development of diffusive bodies of pegmatite and/or granite often enclosing crystals of granet. These bodies are parallel to the foliation. From the field observation it is inferred that there are charnockites of three generations[7]. Charnockites containing garnet and sillimanite are believed to be the oldest. Charnockite containing only garnet may be of intermediate but those are without grarnet and sillimanite are younger. The later type do not exhibit any foliation are basic in nature and mostly occur as intrusive bodies in the granitic gneiss. A Charnockite dyke is found intruded into the garnetiferous granitic gneiss (Figure-2) near Athagada Patna. Khondalites are mainly three types. The khandalite which are in contact with quartzite seems to contain more quartz and sillimanite. The Taratarini hill range is composed of khandalitic rocks. The rocks are highly weathered. Biophysical weathering is distinct**.** The process of granitisation is seen in the top of the hill. The second type are in close association with charnockite and calc-granulite are reddish in color, containing more garnet. The third type containing graphite are foliated as well as lineated, dark brownish in color.Calc-granulite are typically highly weathered with

prominent puckers due to leaching out of chemically less resistant minerals. Characteristic banding , feldspathic veins are found in calc-granulite of Bhabandh and Athagada Patna area .This rock exhibit ptygmatic folding, chevron fold and flow folding). The quartzites are found in many places. The important place is Bhabandha and it occurs as veins or as dyke like bodies in the granitic gneiss in the eastern and western sector of proper Athagadapatna hill. These quartzite are fresh, showing granoblastic texture. The quartizite are faulted at some places. Closed spaced jointing seen in quartzite body. The granitic rocks of the study area exhibits wide textural and mineralogical variation. On the basis of texture, the different granitic rocks are:Porphyroblastic granitic gneiss,Streaky gneiss,Augen gneiss,Garnetiferous-granitic gneiss,Biotite-granite and Pink-Granite.

Figure 1: Augen Gneiss in Bhabandh area

Figure 2: Charnockite Dyke

The study area is bounded by a number of NE-SW trending hill ranges belonging to the Easternghat group of rocks. The chief geomorphic features are irregular, discontinuous hill ranges, hill slopes, lateritic plain land. The prominent positive landform are displayed by granitic gneiss rocks in proper Athagada patna and nearby hills, Khondalitic ricks in Taratarini hills and Khondalitic rocks and granitic gneiss in Bhabandha area. Granitic hills are generally curved shape, even pointed in the low level. The Khondalitic hills are generally smooth (crest). Calc-granulitic rocks are highly weathered from which carbonate have been leached out leaving behind the slica rich portion. Therefore, they form ribs, grooves and puckers.

Charnockite generally form low-lying hills or found at the base. The formation of Kankar and Laterite can be ascribed to the weathering process.

Petrography

Charnockite: Holland (1892) defined Charnokite as hypersthene bearing granite associated with granoblastic rocks and is of igneous origin. The name was coined after job Charnok. Rosenbush (1910) accepted the view of Holland. Crookshank (1939) studied the charnockite of the Easternghat and he identified these to be of intermediate type. It has been agreed that the charnockite series of India is a group of diverse hypersthene-granite with an even grained granulitic texture. Compositionally it is a quartz-feldspar hypersthene bearing rock. The charnockite of Athagada Patna are coarse grained, porphyritic with fine interstitial materials and minor ferromagnesian minerals. There are three varieties of charnokites as has been observed in the field. They differ from one another in the proportion of light to dark colour constituents. Acid charnockites are more felsic with more Sio_2 content. Gradually the colour index increases from intermediate to basic charnokite which is melanocratic. Quartz gradually diminishes from acid to basic type. The mode of the occurrence of the charnockite of the area go in favour of magmatic type. Around Athagada Patna, Badagula, west of Sagadaguli, Raghunath palli, and Pithapur in the western and north west part of the area and on the hill ranges stretching from Tiyadipalli in the south of Ballighaipalli and Barigaon along the hill slopes on both the sides of the Sonapatapur and almost in the entire area the charknockite occurs in association with older granitic gneisses, calc-granulites and younger gneissic rocks. At several localities, charnockite is dominantly developed in granitic gneisses. Charnockite occur as network of veins which shows N-S trend. Occasionally charnockites are found as circular patches.

Calc-Granulite: Calc-granulites are greenish white to dark colour rocks often showing irregular weathered surfaces and hollow structure. These grooves are due to leaching out of calcareous substances. These occur along with the granitic gneiss and charnockites as massive lenticular and irregular isolated masses of varying sizes. These are distinctly seen in the close proximity of Bhabanda and Tiyadipalli area. Calc-granulite shows granoblastic texture. Ptygmatic folding are very prominent(Figure-3). Evidences of polyphase folding is seen in Calc-granulite.

Augen Gneiss: Gneissic rocks are exposed just above the charnockites and below khondalites on the hill top. There is no distinct boundary amongst them and they intermingle with one another. Texturally they are heterogeneous. Augen composed of feldspars have been deformed into different magnitude **.** Their extension is in the direction of general strike trend. Augen are aligned in the direction of extension excepting the localities of faulting. Good exposures of granitic gneisses, charnockites, khondalite, leptynites and basic granulites helped to map the rocks in detail. The hills are not continous but isolated. The area has been subjected to several deformations which have been evidenced from the joint pattern. The process of granitisation of basic Charnockite is evidenced by small Island of Charnockite with the granitic gneiss

Granitic Gneiss: Granitic gneisses represent the oldest metamorphic rocks and form the basement in the hills and in the other parts these are covered by alluvium starting from SW of Tiyadipalli and Chandaratnapalli through Borigaon in the east and proper Athagada Patna. In the west of the hill range to Sanapetaput in the north and NE the earlier granitic rocks have been exposed throughout the entire hills and in the intervening valleys. These gneisses are leuco to mesocratic and have been foliated with tabular or elongated k-feldspars megacrysts (40 mm size). The K-feldspar are aligned in the planes of foliation. Sometimes the foliation has been defined by quartz especially, in the northern end of the area under investigation.

Quartzites: White, grey white, reddish brown and greenish white coloured, massive, hard, compact, dense quartzites have been encountered above the granitic gneisses. Some of the quartzites are vein like. Hence they may be called as orthoquartites because of their pure physical appearance and containing only translucent quartz as the main constituent mineral. Quartzite showing beded character have been deposited on the earlier gneissic rocks may be placed into paraquartzite. These quartzites stretch as narrow bodies throughout the hill range but intermingled in between Calc-granulite and charnokites in the village Athagada Patna close to the valley (near the Thakurani Temple). Quartzites of Athagada Patna hill range are exposed along the northern and southern flanks of the hills, just above the older granitic gneisses, but below the Calc- granulites. As per the geological setting, it seems the quartzites are ortho type. The field evidence goes in favour of residual liquid crystallization. The rocks are massive, equigranular and showing granoblastic exture. Mineralogically quartz constitutes about 90-98 % (eye estimation) of the rock. Other constituents are feldspars and muscovites. The greenish type may be due to chromium rich solution or chromium bearing muscovite.

This quartzite has been metamorphosed on a regional scale because this micaceous mineral has been aligned in the direction of regional foliation of other rocks.

Pink Granite: Pink granites are massive, comparatively fresh and batholithic in dimensions. The granite is homogeneous and display a deformational fabric in the orientation of pink feldspars. The pink feldspars have been curved and bent. These feldspars are lense shaped and the lenses are enclosed by grey and dark coloured feldspars mostly plagioclase and pyroxenes.This granite is later formed and probably represent the youngest rock units. Preliminary observation suggested that along the fault plane this has been intruded because it has an elongated shape and only confined to the valley. This intrusion has helped in the granulation of the old granite gneisses, charnokites, calc-granulite, and quartzites as well as other gneisses. The geographic location of the pink granite is given in the map **.**

Quartzo Feldspathic Gneiss: The occurrence of leucoratic to mesocratic quartz feldspar rocks with gneissic structure are identified to be the quartzo-feldspathic gneiss. It is a coarse granitic gneissic rock. Quartz and felspars are usually dominant constituents. The greyish white subvitreous grains identified to be the plagioclase. The potash feldspars is microcline. In some localities the content of feldspars are more than that of quartz. The dark green small prismatic and needle shaped minerals may be hornblende. Garnets have been distributed randomly identified by their deep brown colour. These rocks show well developed planer orientation of their mineral, specially the hornblende and mica. Feldspars and quartz are also paralleled to the gneissic banding. Feldspathic and mafic bands are well marked. In few localities that is the north-east of the hill range these rock show slight variation in texture. Quartz grains show sutured margin indicating deformation. The rocks have been metamorphosed on a regional scale into high grade granulitic facies.

Granulites: Granulites are granoblastic metamorphic rocks composed of quartz, feldspars and lesser amount of garnet, sillimanite and other accessories. In this area granulite do not show any sharp distinction from quartz feldspars gneisses. It consists of chiefly minerals like plagioclase, pyroxene and garnet. The basic varieties can be named as pyroxene granulites and these look like a basic charnokite. There are some occurrence where granulitic are xenomorphic or granoblastic. The banded varieties show flattened or lenticular quartz grains

aligned parallel to the foliation. Local cataclastic effect have been observed for which these rocks are granulated.

Khondalites and Leptynites: Khondalite has been defined as metamorphic rock of granulitic facies because mineralogically these contain quartz-feldspars-garnet sillimanite[8,9,10]. The association of garnet and sillimanite put the rock in to the high grade.The Khondalites are brown to red colour and medium to coarse grained. The texture is granoblastic having gneissose structure. Three to Four sets of joints are developed in Khondalite. These rocks are intensely folded, faulted and jointed. These rocks occur on the hill top in association with other rock types. Khondalite has been reconstituted due to intense metamorphism into leptynite- a hard, compact, massive rock. Garnetiferous Leptynite are normally cream-coloured and comprising of quartz-perthite-garnet. Subramanium considered them as recrystallised Khondalite. Garnet is present as small friable grains sometimes aligned along the foliations.

Laterites: Laterites occur as a small patches over the charnokites but do not show any development from the older granite rock. These lateritised bodies are formed under sub-tropical climatic conditions. The laterite are highly porous & deep brown in colour.

Structure

The area under investigation forms a polymetamorphic terrain resulted by the poly-tectonic events[11,12,13]. From the mode of occurrence and disposition of the rocks it is marked that the rocks are subjected to different episode of structural disturbance. Being a granulitic terrain the rock are subjected to the folding, faulting and shearing therefore the hills are dissected by longitudinal and transverse faults. Megascopic foldings are inconspicuous in the main Athagada Patna hills but towards the south in the East of Badagula, granitic rocks prominently display large scale antiformal and synformal folds. These folds are asymmetrical and stretch over a length of near about 2km and finally merge below the alluvium. Small scale isoclinal, asymmetrical, recumbent, sheath and ptygmatic folds are commonly found in granitic gneiss, khondalites and calc-granulite. In granite gneisses and Khondalites, the folds are displayed by curved pattern of feldspathic vein feldspars and quartz minerals(Figure-4). Foliations often show distinct folding. Megascopic folds also occur in the quartzite, sillimanite bearing quartzite and khondalites and these folds are asymmetric. In the pink granite close to

Pathuriapalli, the augen clearly show rootless irregular, asymmetric folds of different magnitude. Such features are not seen towards the South. Most of the khondalites, charnockites show cataclastic zones. This zone are composed of large scale fragmentated, irregular, small boulders. Such a feature is seen upto a depth of 4 to 5ft. Below the alluvium, of course, this is not visible but in the excavated portions of the quarry the cataclastic are seen. Therefore, it is believed that a tangential force or the effect of shearing has a significant role in the granulation of the rocks. The chief structural event may be ascribed to faulting. Large scale mega-faults are seen in almost every locality but evidence of faulting are preserved in certain localities like escarpments, steep slope mountains and the intermittent valleys filled up with large irregular boulders and alluvium. Slickenside, grooving, mylonites and pseudotachylite**,** silicification, sudden change in strike of the rocks, repetition & omission of beds, fault breccias are the chief imprints of faulting. Besides there is clear evidence of shearing, marked by compression of rocks, crumbling of rocks, intermingling of the rocks and transposition of the rocks.

Figure 3: Folded Calc- Granulite

Figure 4: Chevron folding

Foliation: These are the most prominant planner features displayed by almost all the rocks. In granites and granitic rocks, quartz and feldspar have been flattened & elongated and define foliation. In the biotite rich rocks, biotite defines foliation but in the granetiferous types garnets display very weak foliation. In the augen gneiss, elongated augen define foliation. In Khondalites, biotites, garnets & sillimanities cause foliation. In charnokites, foliations are present specially in the basic types but in intermediate & acid type foliations are indistinct. Wherever charnockites have been granitised, foliations are displayed by quartzofeldspathic

minerals. In calc-granulites the weathered layers sometimes show foliation. The trend of foliation are different from place to place indicating different periods of structural history. Even there are rocks devoid of foliation.Fracture cleavage have been developed in quartzite around Athagadpatna area. The attitudes of S- planes have been recorded in the structural geological map .

Lineation: These are prominently displayed by roddings, feldspars, feldspathic veins, quartz ribs, garnets, crenulations & intersection of foliation planes. These lineations also strike differently & plunge differently indicating polyphase structural events. The different attitude of foliations & lineations are shown in the structural geological map **.**The linear structures developed in these rocks are of the following typesLineation has been developed due to the intersection of two S-planes. Mineral lineation is observed in granitic gneiss. Striation lineation (grooving) are also present due to the differential movement of rocks along the zone of faulting in Khondalitic rocks of Taratarini hills. Strike is 240º. Plunge is 40º

Joint : There are different sets of joints in different rocks. Granites contains mural, master & inclined joints but prominently the older granitic rocks displays 3 sets of N-S, E-W, & horizontal joints**.** The first two types of joints are vertical. Charnockites display 4 sets of joints in Bhabandh area. Thereby some of thecharnockites specially those occur in the valley are considered to be older than the granitic rocks. The younger charnockites neither display foliation nor lineation. In Khondalite 4 to 5 sets of joints are present. Khondalite, therefore, considered to be the oldest rock unit of the investigated area. In quatzites 4 sets of joints are also found. Calc-granulites do not exhibit any joints. In joint planes, feldspathic solution, iron solution & manganese solution are deposited in different proportion which indicate there is grantic activity after the formation of these joints. The iron solution or the manganese solution are the capillary deposition in the joints planes. The attitude of different joints are recorded in the structural geologic map

Fault: At the extreme end of the Athagada Patna hill range (North End) the mountain has been faulted, and the hanging wall side has gone down near about 500 feet. Faulting of the entire rock units has been clearly marked at the Karneswari location as the evidence of faulting (slicknsides) have been noticed. Frictional planes containing fine cement like surface identified to be mylonites occur in all the places where faulting is suspected. The sudden break

in the strike, nature of displacement, vertical wall like escarpment indicate a dip fault because both the block are lithologically similar & composed of garnetiferous granitic gnesis, and charnokites. The fault plane is covered by regular & irregular fragments. In between these two blocks a forest road has been made along the fault plane which is a significant feature of faulting. A stream is flowing all along. The cause of the tectonic deformation has been controlled by faulting.

Stratigraphy

The stratigraphic account of the area is difficult to state simply because it is a high grade polyphase metamorphic terrain. Neither significant sedimentary features nor relevant igneous characters are present in the rocks. Mainly there are two groups of rocks, one belonging to the khodalite series & the other charnockite series. The khondalite series include khondalite-quartz-sillimanite-quartzites & the charnockite series includes the different charnockite types & granitised charnockite. Depending on joint pattern of the rocks, the stratigraphy can be suggested as khondalite is the oldest followed by charnockites & the finaly granitic rocks[14]. Similarly charnockite contains sillimanite & garnets in one type, on the others only garnets are present, in the third type garnet & sillimanities are not present. Field relation reveals intrusive nature of the charnockite. Therefore, it becomes difficult to ascertain the chronological sequence of the rocks.

Petrogenetic Processes

Feldspathisation: Some of the granitic rocks of Athagada Patna area have been formed due to granitisation and feldspathisation. In the field, the rock exposures are heterogeneous in characters. There are segregation of patches of feldspathic solution on the cross section. This type of textural variation indicates that the granitic might have been formed due to feldspathisation. The feldspathic solution are not magnetic but locally might have been generated due to intense metamorphism. The occurrence of pink granite in the valley along a fault plane also indicate intrusion of magma from which its feldspathic solution might have permeated through foliation planes of the pre-existing rocks.

Lateritisation: Evidences of lateritisation occur towards the North West corner, close to Pathuriapalli. The Charnokites, Khondalites and Granites are peculiarly weathered under sub-

tropical climatic conditions producing detached granular blocks of iron laterite. They form a capping formation on the pre-existing rocks. The rocks are reddish brown at some places, coarse, irregular grains and rich in iron. Their occurrence is limited to this area and also a few patches on charkonite on the hills of Athagada Patna. The lateritic patches have been confined to the charkonite strips. Here the granitic rocks have not been affected by this process. The name laterite has been suggested simply because of the iron red in colour with pisolitic texture.

Kaolinisation: Kaolinisation is a metamorphic processes chiefly due to superheated steam aided by a little fluorine and boron. The feldspars of the granite are attacked with the formation of the mineral Kaolinite ($A1_2$ O_3, $2SiO_2$, $2H_2O$). In this area, this process is evidenced in the pink granite terrain. This is due to chemical weathering of feldspar in pink granite by subaerial processes.

Manganese Mineralisation: Manganese ores like pyrolusite and psilomelane in the form of nodules and nuggets occur in the north of the pink granite and south of Athagada Patna and from the valleys in between the hillock. Manganese mineralization is a process in this area.The manganese mineralization have a significant mode of occurrence in the valley indicating it has a definite relation with the ground water. The rocks of the locality chiefly belonging to granulitic facies of the Pre-Cambrian time forming a part of the Easternghat and comprising of granitic gneisses, charnokite, khondalitic suites of rocks & migmatitic rocks. The rocks are highly deformed, affected by polyphase tectonic events. Minerologically the rocks are rich in orthopyroxene and garnet. Manganese mineralization is confined to the garnet orthopyroxenes. It seems that these minerals are responsible for the formation of manganese under tropical to subtropical temperature conditions. The garnets and orthopyroxenes break down into different oxides in contact with ground water. The stray occurrence of Manganenese ores can not be considered economic because of insignificant but the area is significant from the academic point of view to know the process of manganese occurrence as epigenetic and the mineralization is a neogenic events.

Conclusion

Athagadapatna-Taratarini-Bhabandh areas constitute a complex tecotonic setting and polymetamorphic terrain of Easternghats. The region comprises high grade granulitic facies assemblages of Archean age with typical gneissic structure. Gneissic banding within the rocks has a general NE-SW trend with westerly dip. The important rock types of this area are khondalitic and charnokitic suites of rocks along with granitic gneiss, Calc-granulite and quartzite. Augen gneiss contains large elongated feldspars and augen surrounded by biotite flakes defining foliation. Migmatisation within the gneiss is a common phenomenon. At some places, charnockite occurs as dyke. The rocks of the study area have been subjected to different episodes of structural disturbances. Being a granulitic terrain, the rocks are subjected to polyphase folding, faulting & shearing. Foliation and lineation of tectonic origin are the prominent structural element in the area. The different petrogenetic processes that are clearly visible in this area include Feldspathisation Lateritisation, kaolinisation and Manganese mineralization. The minor occurrence of manganese in this area can not be an economical deposit, but from academic pint of view this is significant because the manganese formation in this area is mineralization of neo-genic event.

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