STRUCTURAL CONTROL OF DIAMOND MINERALIZATION IN BASTAR

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ABSTRACT

The regional structural and tectonic environment is an important factor in a mineralogical province. The localization of all mineral deposits and their mode of occurrence and origin are defined by a specific structural control. The diamondiferous horizon of Bastar Craton is one of the classic examples of the structural control. These diamondiferous deposits are mostly located at the intersection of major mega and kimberlitic intrusive dykes express intermediate lineaments and them. Manipur Kimberlite Field (MKF) as intrusive dykes within the Late Proterozoic Indravati and Khariar Group at Tokapal and Manipur are great examples. Their emplacement follows the NW-SE trend of Bhamargarh lineament and E-W trending Garchiroli lineament. The generally high density of major mega and intermediate lineaments in the form of igneous intrusives and faults, mostly following either Mahanadi-Godavari trend or (NW-SE) or Narmada Son trend (E-W), a very rich potential of hidden diamondiferous mineralization is probable in the Bastar region in similar litho-structural environment. An attempt is being made explore such horizons by incorporating both conventional and unconventional methods. The emphasis will be on the evaluation of positive field indications as revealed by conventional methods such as geochemecial, geobotanical, geozoological, and geophysical investigations and unconventional methods like historical facts, ancient texts and literatures. Application of thermodynamics may be a vital tool for the appropriation of fertile horizons. As a matter of facts the kimberlite deposits have been reported to occur in clusters in all parts of the globe and that gives us a good reason to believe that the Bastar region is very promising because it lies between the fertile zones on either side.

INTRODUCTION

Diamond, being one of the most precious minerals, plays a key role in strengthening the economy of a nation. A well-known example is that of South Africa. This fact makes diamondiferous deposits, highly sought about by every nation. Diamonds in India were firstly discovered some four centuries ago in the alluvial placers of near Golkunda Fort, from where some world famous diamonds like *Kohe-Noor,* Orloff, Shah, Hope, Dressden*, Regent* and Florentine were discovered. Since the discovery of Majhgawan Kimberlite pipes in 1930, India has earned great recognition in
the field of diamond exploration. Later, many new horizons were discovered in Rajasthan, Madhya Pradesh and Karnataka and Chattisgarh.

The common modes of occurrence of diamonds are alluvial placers, conglomerate beds and kimberlite pipes. However, the most likely sites of primary diamond mineralization are kimberlite pipes, igneous intrusives as sills and dykes associated with mantle-derived rocks. These rocks are localized around the weak tension zones such as deep mantle reaching faults and other major lineaments. These fault/lineaments provide favorable environment for the rise of kimberlite bearing magma.

The southern Bastar region falls in a very remote location in the southernmost part of Chattisgarh. The nearest railway connection is Raipur, the Capital of Chattisgarh state. It is nearly 300 kms from the study area. The only developed township nearby is Jagadalpur that is 60 kms away from the study area. Dense forests and un mixing and mysterious tribal population renders the region, very difficult to study. However, the very first attempt has been made by the author to carry out a detailed mapping and study of mafic dyke swarms of southern Bastar region (Srivastava *et. al.,* 1996; Srivastava and Verma, 1998; Verma., 1998). The research results indicate that Bastar Craton has favorable geotectonic environment for diamond mineralization.

REGIONAL GEOLOGY

Crookshank gave the regional geology of Bastar in 1963, which gives an account of Southern Bastar and Jaypore area from Bailadila Hill Range to Eastern Ghats (Fig.1).

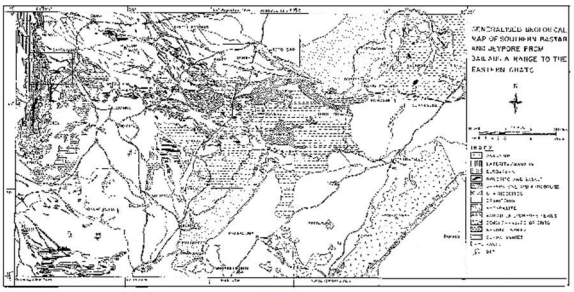

FIG.1

The geological succession as given by Crookshank (1963) reveals that sedimentary rocks belonging to the Cuddapahs unconformably overlie the older members, which include various acidic and basic intrusives igneous rocks and Archaean metamorphites. Soils and laterites/ferruginous laterites form the uppermost formation, which overlies the Cuddapahs. The metamorphites are divided into three successively older series viz. Bailadila Series, Bengpal Series and Sukma Series. The three-fold division is purely on local basis and no definite boundaries between these units have been demarcated yet. The generalized geological succession in South Bastar and Koraput district, after Crookshank (1963), is given in Table.1.

GEOTECTONIC SETUP OF BASTAR CRATON

The Bastar Craton also known as Bhandara Craton is bordered by the Godavari rift on the southwest, the Narmada rift on the northwest, the Mahanadi rift on the northeast and the Eastern Ghat front on the southeast (Fig.2).

TABLE.1

(Geological Succession in South Bastar and Koraput)
(after Crookshank, 1963)

Purana Limestones, Shales, Slates
Sandstones and shales, quartzite, grits, Conglomerates
---------- Unconformity ----------
Dolerite, Pegmatites
Charnockite Series
Igneous Rocks Granites
Greenstones
Granitic gneisses and pegmatites
---------- Unconformity ----------
Bailadila Banded haematite quartzites (BHQ) and iron ores,
grunerite quartzites, chloritic ferruginous
phyllites,carbonaceous shales
Iron-Ore
Series White quartzites
---------- Unconformity ----------
Ferruginous schists, schistose conglomerates,
Basalts and tuffs
Bengpal Andalusite phyllites, schists, gneisses and quartzites
Series Grunerite- garnet schists, BHQ, granet- andalusite
quartzites sericite quartzites and sandstones
---------- No clear dividing line ----------
Sillimanite quartzite
Sukma Magnctitc quartzitc, gruncritc schists
Series Diopside gneiss
Hornblende schists
Cordierite-biotite gneisses, cordierite-anthophyllites

It is rectangular in shape and is also known as Bhandara Craton or Central Indian Craton (Naqui and Rogers, 1987) An interesting feature can be revealed from the map that majority of the dykes trend NNW-SSE or NW-SE in correspondence to the major trend of Godavari and Mahanadi rifts viz. NW-SE (Fig.1). This set up has played a key role in the structural control of diamond mineralization.

Bastar Craton is bounded by mega-lineaments, which have bisected the Craton and are also responsible for the preservation of Bastar plateau. Bhate (1980) has described some of the mega lineaments fringing the Bastar Craton and these are NNE-SSW trending Eastern Ghat lineament in the east, Godavari lineament in the southwest and Kotri lineament in the northwest. Northern margin of Bastar Craton is dissected by a major ENE-WSW trending Kondagaon lineament passing through north of Kanker and extending ENE up to Bolangir in Orissa.

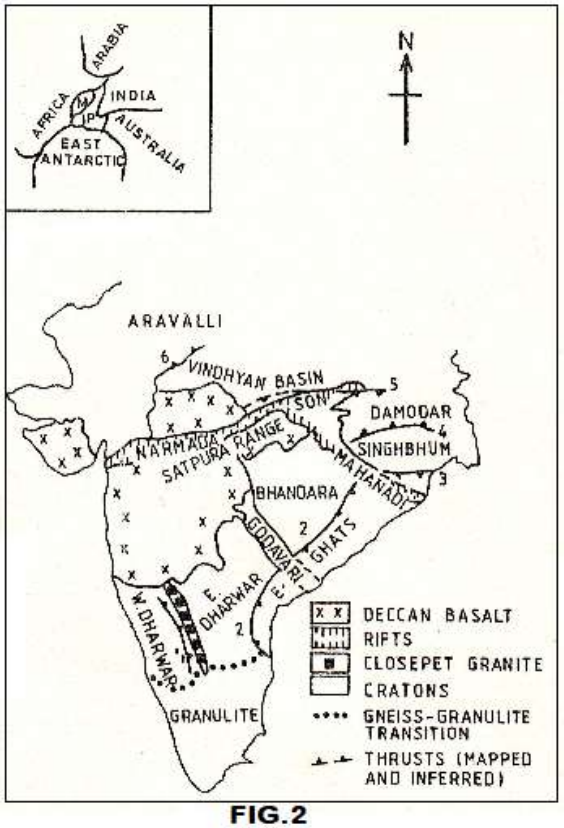

FIG.2

Another major lineament fringes the southern margin of Bastar Craton, which is almost parallel to the Kondagaon lineament. The other significant lineaments are WNW-ESE trending Bodhghat and Darbha lineaments, which are supposed to be responsible for the uplift and preservation of Tulsi Dongar massif.

There is a major N-S trending Kotri lineament, which is related with the Bailadila orogeny. Recently, Rajurkar et al. (1990) have presented a review on the lineament fabric of Central and a part of Western India, based on the study of LANDSAT imagery (Fig.3). The density of lineaments is generally high over the Archaean basement as compared to over the Bastar plateau comprising of Archaean and Early Proterozoic rocks. Both mega and intermediate-lineaments occur over the Bastar plateau. Distinct lineament pattern, trending NW-SE, occurs across the whole of Bastar plateau and are recognised as the Godavari group of lineaments (Rajurkar *et. al.,* 1990).

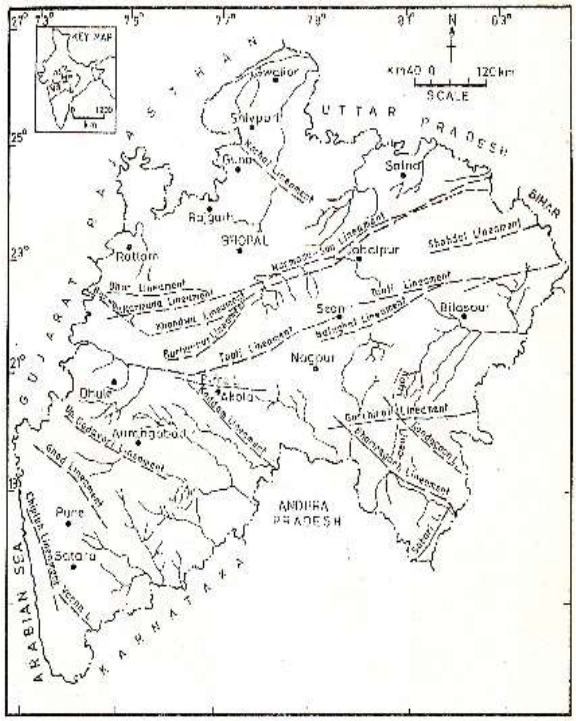

FIG.3

An interesting feature emerging from the study of lineament patterns is that none of the NW-SE trending lineaments of Godavari group cross the Tapti lineament. They all terminate short, abruptly, at the Tapti lineament. The Godavari lineament represents a group of several mega- and intermediate lineaments. Two NW-SE mega-lineaments, viz. Bhamargarh and Kondagaon, are well recognised (Fig.3) over Bastar plateau. The Bhamargarh lineament extending more than 300 km has an overall NW-SE trend. Other mega-lineaments, recognised over the Bastar Craton, are Kotri (N-S), Garchiroli (E-W), and Sarbari (NE-SW). These three lineaments cannot be considered as lineaments of Godavari trend, as these show a total departure from the NW-SE Godavari trend (Rajurkar *et. al*., 1990). Bhate (1980) has considered that Bhamargarh-, Kotri- and Garchiroli-lineaments have played a significant role in the evolution of the Bastar plateau and that

the plateau owes its uplift to vertical movements along these fault lineaments. The mafic/ ultramafic intrusives of the Fire Lake formation, Finlayson Lake region, Yukon, Canada (ca. 365–360 Ma) represent variable mixtures of asthenospheric (MORB-type) mantle, subarc mantle wedge, and lithospheric (OIB-type mantle. Geologic relationships in this region suggest that deposition of the formation and intrusion were controlled by normal faulting (Piercey et. al., 2004)

STRUCTURAL CONTROL ON MINERALIZATION

As we know that the major faults/lineaments are the weak zones representing the common expression of crustal extension. The mafic/ultramafic magma from depths approximately 150 kms upwells from mantle to the upper crust through these tension zones. These upwelling magmas may host many precious minerals and metals. This magma originates at great depth in very high T-P conditions beneath. Such a high P-T is very likely to favour diamond formation in the mantle. If the magma is of kimberlitic nature, it may be the probable careers of diamond. It is evident that all over the world, majority of the kimberlite intrusives are emplaced in ancient cratonic blocks (Clifford, 1966) or where Archaean basement is underlain by deep lithospheric keels (Haggerty, 1986) .

Diamond mineralization is most likely to be localized at the intersection of lineaments. The generally high density of mega and intermediate lineaments in the Bastar Craton fortunately reflects most favourable geotectonic set up for diamond mineralization. (Figure .4)

Recently, diamondiferous kimberlites in Manipur Kimberlite Field (MKF) as intrusive dyke within Late Proterozoic Indravati and Khariar Group rocks have been discovered at Tokapal and Manipur (Datta Manikar *et. al.,* 1999). These supra-crustal Cratonic basins are in contact of the Eastern Ghat Mobile Belt. A major tectonic corridor has developed around the prekimberlitic Sandur Fault and its parallel associates. Due to the tectonic activities of the Eastern Ghat Mobile Belt (EGMB), a criss-cross arrangement of lineament fabric has developed obliquely. These lineaments are intruded by numerous basic and acid intrusives, hence represent a zone of high permeability. Number of transverse lineaments have also developed parallel to the Garchiroli lineament and are intruded by numerous basic and acid intrusives as well. Overlying Middle to Late Proterozoic sedimentary basins have augmented favourable geological conditions for kimberlitic emplacement. The criss-cross arrangement of lineament fabric has a highly permeable mineralized zones that is related to the intersective relation of NW-SE trending Bhamargarh lineament and E-W trending Garchiroli lineament. Five more diamond bearing kimberlite pipes in Raipur District have been found in area located 150 km SE of Raipur town. Two are found at Payalikhand West and Payalikhand East (Latitudes 20o9’45’ and Longitudes 82o20’20’’E; Toposheet No.64L/8). Other three are at Jangra (20 o 11’: 82 19’), Kodmali (20 o 11’35’’: 82 o 14’; 64 L/4) and Barhadih (20 o 13’: 82 12’; 64L/4). Kimberlites bodies occur as intrusives in Bundeli Granitoids and contain fragments of basal Khariar Group of sediments. Recently three kimberlitic and few other ultramafic and ultrapotassic bodies were discovered in Bastar Craton (GSI- CR News, Mishra *et. al.,* 1997; Acharya, 1997) These kimberlite bodies were reported at Tokapal (BC-1), Dungapal (BC-2), Bhejripodar (BC-3) and Parikot (BC-4). These pipes are located between latitudes19◦ 00’ to 19◦ 03’ and longitudes 81◦ 51’ to 81◦ 54’ and are contained in the toposheet no.65E/16. All these findings are very strong evidence of structural control of diamond mineralization.

CONCLUSION

Few diamondiferous kimberlite discoveries have inspired the researchers to scan the entire Bastar Craton to demarcate similar litho-structural environments in the region by using most modern means of remote sensing data and LANDSAT imagery aided by detailed exploratory methods of geophysical, geochemical, geobotanical, geozoological, prospecting. The pre conditions of diamond mineralization are mainly The author has carried out a firsthand study of the petrological and geochemical specifications of the mafic dyke swarms of the Bastar Region and successfully divide them into two distinct swarms. Older BD1 (low-Ti, Fe-rich olivine to quartz tholeiites) swarm consisting mainly of amphibolite dykes, and the younger BD2 ((high Fe-Ti quartz tholeiites) swarm comprising amphibolite, dolerite/meta-dolerite and minor diorite dykes.

Geochemical characteristics, particularly negative Nb anomaly, of mafic dykes and several regional field observations suggest that southern Bastar mafic dykes are emplaced in the rift setting tectonic environment.

On the basis of results obtained from the petrogenetic modelling together with other data, it is concluded that mafic dykes of the southern Bastar (i.e. BD1 and BD2 dykes) are derived from 10-30 % batch melting of a lherzolite mantle source at depth of about 100-125 km.

All petrological and geochemical evidences such as generally high REE enrichment of elements such as Ni, Cr, V, Sr, Zr , positive geobotanical growth, favorable geotectonic environment and suitable P-T and depth conditions of these dyke swarms of the region, indicate a fair chance of discovering more diamondiferous horizons in the region.

The region being mostly unexplored with such an objective has ample scope of further search and research of rare and precious metals and non-metals. So, it is high time that sincere efforts are made in this direction. Any new discovery will be a valuable contribution in the country's economic growth.

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