KIMBERLITES OF SOUTHEASTERN RAIPUR KIMBERLITIC FIELD, RAIPUR DISTRICT, MADHYA PRADESH, CENTRAL INDIA

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Location

The Southeastern Raipur Kimberlitic Field (SRKF) is one of three diamond bearing kimberlitic provinces in peninsular India, the other two being Panna in northern Madhya Pradesh and Wajrakarur in Andhra Pradesh. SRKF (20°11'N, 82°16'E) is located in the southeastern part of Raipur District in the state of Madhya Pradesh in Central India, 135 km SE of Raipur city. Five kimberlitic diatremes have been located in this field viz., Payalikhand I and II, Bahradih, Jangra and Kodomali, the first three being diamond bearing (Jha et al., 1995). Exploration activities by Geological Survey of India have led to identification of more than 40 kimberlitic indicator anomaly zones in the SRKF most of which are likely to be associated with distinct kimberlitic dykes.

Tectonic Setting

SRKF is located within the Eastern Indian Shield close to the contact between granite greenstones of the Archean Bastar cratonic nucleus (BC) in the west and granulite terrain of the lower to Mid Proterozoic Eastern Ghats Mobile Belt (EGMC) in the east. This contact is also marked by occurrences of Middle to Late Proterozoic alkali syenite complexes. The Bastar cratonic nucleus is overlain by Late Proterozoic platform sediments, the Chattisgarh Supergroup, deposited in two cycles of 1100 - 900 Ma and 700 - 450 Ma in different sub-basins uplifted to syneclises. Xenolith evidence suggests the kimberlite intrusives are stratigraphically sandwiched between these two cycles of sediments along the western shoulder of the Khariar syncline. This implies a possible Precambrian emplacement age some 200-400 Ma years younger than the diamond pipes at Panna (1067±31 Ma) and Wajrakarur (1091±20 Ma) (Kumar and Gopalan, 1992).

Analysis of the gravity field indicates a sharp gradient of anomalies at the BC - EGMB boundary suggested as due to a mantle-reaching faulted contact between the two. An easterly dipping double MOHO in the immediate vicinity of this contact has been interpreted from available DSS studies. This has been explained in terms of overthrusting of EGMB over the Bastar Craton and possible delamination of the EGMB at the crust - mantle boundary during Early to Mid Proterozoic times. Fracture pattern analysis of SRKF indicates that all the kimberlites occur on intersections of N-S and E-W trending fractures with a NW-SE trending lineament, named the Bahradih - Payalikhand (BP) lineament. Heat flow data indicate that SRKF currently lies on the zone of lowest heat flow in the subcontinent at 40 mW/m^2, implying the existence of cool, rigid and stable continental crust, brittle enough to sustain deep reaching fractures.

Kimberlite - Occurrences

The kimberlite diatremes of the SRKF are approximately circular in plan, varying in diameter from 300 m (Bahradih, Kodomali) to 100 m (Payalikhand I) to 50m (Jangra, Payalikhand I). Most of the kimberlites are weathered near surface to "green earth", a smectite rich clay, because of prevailing semi-humid tropical conditions. All the occurrences expose diatreme facies kimberlite breccia and tuff-breccia except Kodomali, which has been interpreted as a hypabyssal facies intrusive. The rocks contain abundant xenoliths which include country rocks, sunken pyroclastics, autoliths of precursor kimberlite, and peridotite mantle nodules. Features like pelletal lapilli and nucleated autoliths have also been recognised.

Petrography

All the diatremes exhibit gross clast-matrix texture, with macrocrysts of olivine of two generations, phlogopite, spinels, clino- and ortho-pyroxenes. Other macrocrysts include pyrope, diamonds, and extremely rare picro-ilmenite. The clasts and macrocrysts are embedded in a matrix of fine groundmass serpentine, plus minor or accessory spinel, phlogopite, perovskite and microlytic clinopyroxene. At Kodomali the groundmass is dominated by fine laths of clinopyroxene with patches of phlogopite and rare tetra-ferri-phlogopite, whilst groundmass olivine or serpentine is totally absent. A feature of Kodomali is the occurrence of syenite xenoliths, often showing alteration rims suggestive of reaction with the surrounding kimberlite. Noticeably absent from SRKF are any minerals characteristic of lamproite such as richterite, priderite, wadeite.

Mineral Chemistry

The pyrope chemistry is dominated by a calcic lherzolitic variety corresponding to cluster group G9 of Dawson and Stephens (1975). Between 1% and 5% of garnets in the kimberlites belong to the low Ca harzburgitic (G10) category. Other species present include a few eclogitic (G3, G4, G5) and iron-titanian-low calcium (G1 and G2) garnets.

Brown red to opaque macrocrystal spinels and primary groundmass spinels are observed in all the kimberlitic occurrences. A minor content of spinel formed as reaction or replacement products during serpentinisation of olivine. The spinels vary in composition from magnesiochromite to chrome spinel, typical of kimberlites. About 10 to 15% of the macrocrysts from Bahradih and Payalikhand resemble in their high chrome chemistry spinels from diamond inclusions and intergrowths. Chrome content varies from 25% to about 65% indicating probable derivation from a large depth range within the Upper Mantle. Most of the macrocryst spinels are zoned with rims exhibiting increased TiO_2 (up to 4%) and Fe_2O_3 (up to 15%) with associated decrease in Al_2O_3 but relatively little change in Fe2+/Mg ratio.

The clinopyroxene assemblage is dominated by an emerald green to bright grass green coloured calcic variety. A small proportion (about 10 to 15%) of the calcic clinopyroxenes are of the MARID type. Subcalcic clinopyroxene occurs in noticeable numbers in Payalikhand I (approx. 40%). Megacryst facies clinopyroxenes are rare and are subcalcic in nature.

Orthopyroxenes (mg 0.905-0.938; Al_2O_3 0.62-3.91%) are pale green, depleted low temperature lherzolitic varieties similar to those in xenoliths from lithospheric upper mantle. Numerous dull bottle green megacrystic enstatite have been recognised in the Kodomali kimberlitic diatreme.

Macrocryst olivine grains of pale green colour are forsteritic with a restricted range of composition indicating derivation from peridotitic or mantle sources.

Ilmenite is extremely rare in SRKF and has chemistry similar to those from metasomatised upper mantle peridotite.

Kimberlite - Geochemistry

Available analyses of the diatreme rocks are of intensely weathered near-surface "green earth" material. Nevertheless, the major element bulk geochemistry is within the range for kimberlite, except for high SiO2 (up to 45%), which may represent contamination by crustal materials. Fresh magmatic rock was analysed from Kodomali where the elevated SiO2 content (43%) parallels the modal dominance of clinopyroxene in the groundmass mineralogy. These rocks are distinctively richer in $Si0_2$ than average kimberlite, and higher than the Indian occurrences of Panna, Maddur and Wajrakarur. Low CaO and $C0_2$ values rule out classification as an ultramafic lamprophyre (as defined by Rock, 1991) and reflect the lack of carbonates as also evidenced in the petrography of these rocks.

SRKF compatible trace element geochemistry is within the normal kimberlite range and analytical variations correlate with modal proportions of olivine and spinel. Most incompatible trace elements show values comparable with kimberlite and are not as elevated as for lamproite. However, highly incompatible elements like Ba, Rb and Th show positive spikes with respect to average kimberlite data. The chondrite normalised REE data of SRKF kimberlites are all light REE enriched and heavy REE depleted as in most potassic/ultrapotassic mantle derivatives.

Discussion

SRKF kimberlites were intruded during a world wide kimberlite emplacement event in the early part of the Late Proterozoic in a characteristic geotectonic setting which includes stabilised Archean craton, supracrustal platform sedimentary rocks overlying cool, rigid lithospheric keel with deep reaching fractures. A tensional stress regime following the deposition of the platform sediments facilitated the upward movement of kimberlite magma and its emplacement into fracture and fault-controlled lineaments in the upper levels of the crust. These kimberlites occur close to the junction of BC with overthrust EGMB, the latter possibly being delaminated from the mantle at depth. Xenocryst chemistry shows evidences of sampling from asthenospheric upper mantle upwards. Enigmatic syenite xenoliths in the Kodomali kimberlite suggest a possible genetic alliance between the kimberlites and Middle to Late Proterozoic alkali syenite occurrences nearby along the EGMB - BC junction. The SRKF rocks are tentatively classified as kimberlite, but as this identification is largely based on petrography, mineralogy, and geochemistry of highly weathered material, final identification must await availability of fresher samples, especially from the diatreme occurrences.

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