Singhbhum Protocontinent

Presentation by

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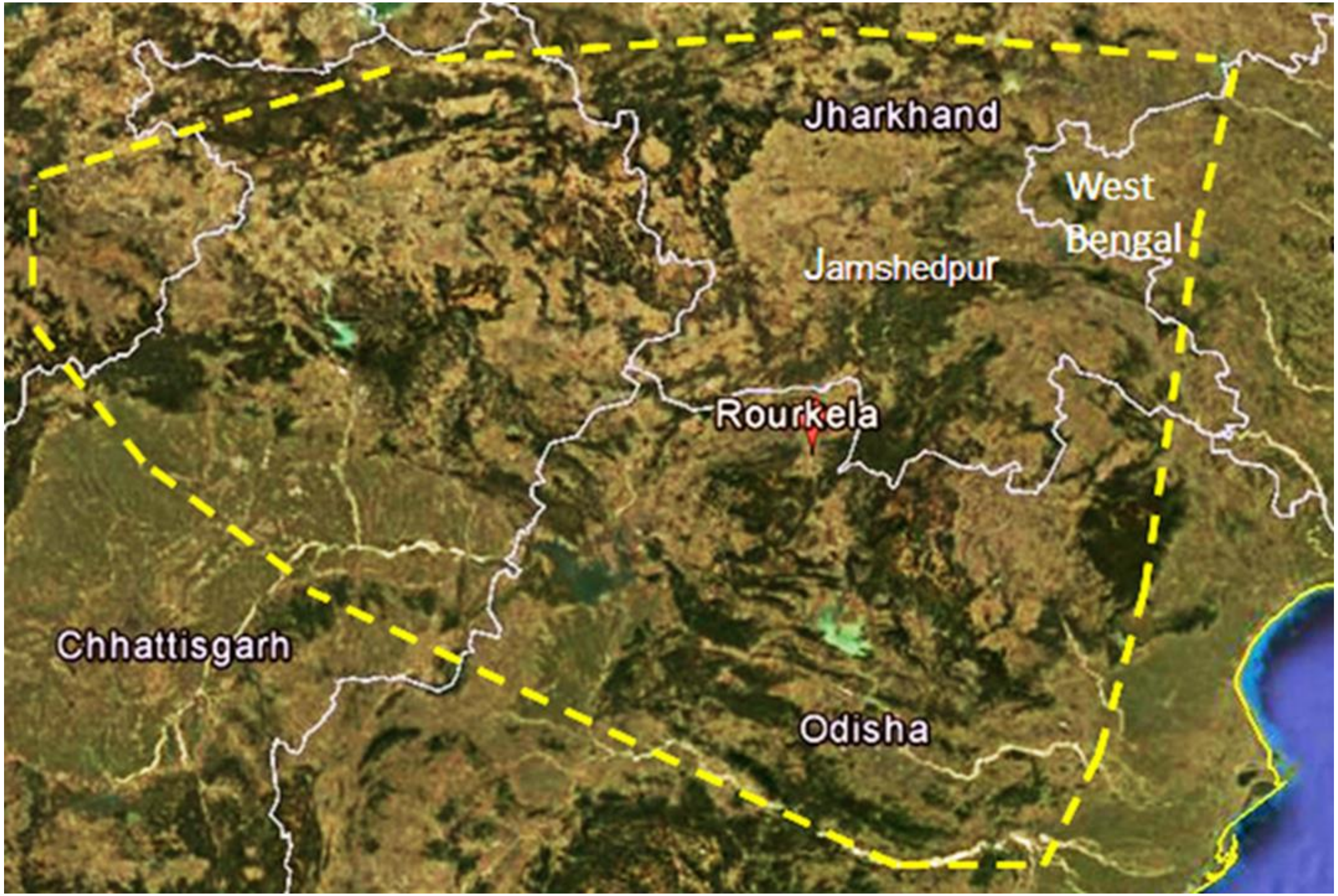
Distribution:

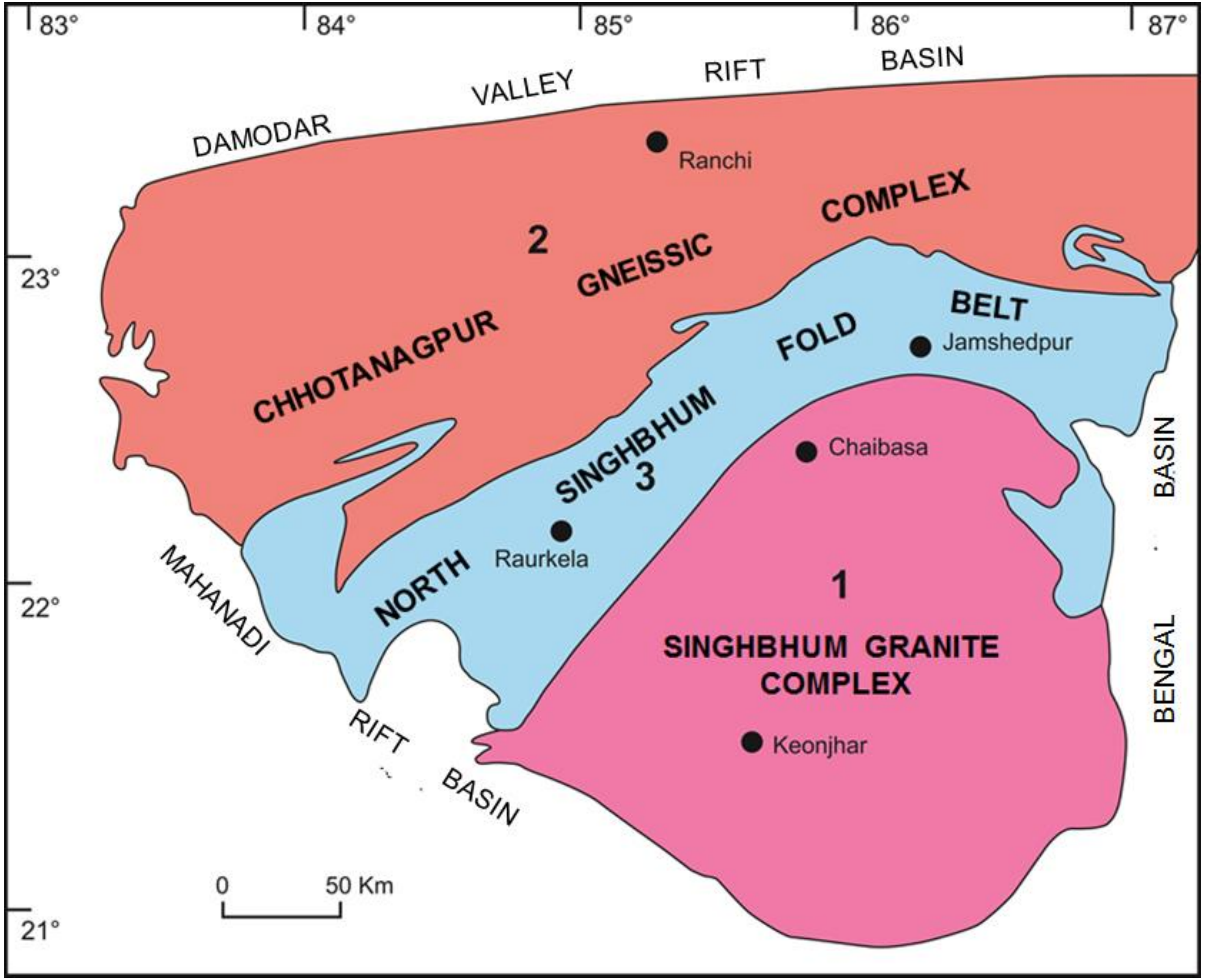
- Singhbhum Protocontinent occupies a triangular area bounded between the Eastern Ghats Granulite belt in the south and Mahanadi Lineament (Rift Basin) in the southwest, the Damodar Valley Rift Basin in the north, and the youngest the sediment-filled Bengal Basin in the east.
- Though named after the ‘pristine’ district of Bihar in ‘British-India’, the region covered under the Singhbhum Protocontinent includes significant parts of three adjacent States of Odisha (pristine ‘Orissa’), Chhattisgarh, Jharkhand and West Bengal



Jharkhand
West
Bengal
Jamshedpur
Rourkela
Chhattisgarh
Odisha

Introduction:

- The Protocontinent comprises three major litho-tectonic blocks: the Singhbhum Granite Complex in the south, the Chhotonagpur Gneissic Complex in the north, and the North Singhbhum Fold Belt in the middle.
- Like all other Protocontinents of the Indian Shield, the geological understanding of this Precambrian crustal block remained hazy, marred with disagreement and debate.
- The array of suggested tectono-stratigraphic models proposed by different workers (Mahadevan, 2002; Ramakrishnan and Vaidyanadhan, 2008; Sarkar and Gupta 2012; Valdiya, 2010, to cite a few) stand testimony to the misunderstanding and misconceptions that surround the geological growth history of this terrane.


83°
84°
85°
86°
87°
23°
22°
21°
DAMODAR VALLEY RIFT BASIN
Ranchi
2
CHHOTANAGPUR GNEISSIC COMPLEX
NORTH SINGHBHUM FOLD BELT
3
Jamshedpur
Raurkela
Chaibasa
1
SINGHBHUM GRANITE COMPLEX
Keonjhar
MAHANADI RIFT BASIN
BENGAL BASIN
0
50 Km

1. Singhbhum Granite Complex:

- The Singhbhum Granite Complex (also described as the Singhbhum Archaean Craton, Roy and Bhattacharya, 2012) includes certain characteristic features which make this crustal block geologically distinctive.
- Firstly, it provides information on the existence of very old sialic Crust (~3800 Ma or older) which constituted the possible earliest basement over which the oldest supracrustals were deposited (Basu et al.1981).
- The Singhbhum Granite Complex cratonized early by around 3100 Ma (Roy and Bhattacharya, 2012), which is very much unlike most of the Archaean basement rocks in other Protocontinents of the Indian Shield.
- Subsequent to that there is no record of any tectono-metamorphic and granitic activity in the rocks till the end of the Archaean barring imprints of some younger thermal events.

1a Granitoids in Singhbhum Granite Complex

- For understanding the geology of the Singhbhum Granite Complex, it would be useful to include different bodies of ‘granitoid’ like those of Nilgiri, Bonai, Palla Lahara, Mayurbhanj, Kapdipara, etc. which possibly represented several separate magmatic events, under the single head ‘Singhbhum Granite’ (Saha, 1994).
- In addition to these larger bodies, there are also a number of xenolithic enclaves of different dimensions comprising older tonalite-trondhjemite-granodiotite gneisses.
- Petrographically, the granitic rocks include biotite-granodiorite grading to adamellitic-granite, biotite-trondjhemite and leuco-granite. Patches of chlorite- and epidotic-rich granodiorite are observed in the areas close to the shear zones bordering the Singhbhum Granite Complex (Saha, 1994).

(a) Banded gneiss representing trondhjemite-tonalite-granodiorite association locally occurs as enclaves within porphyritic granite. (b) Thick band of dioritic gneiss alternating younger bands of leucogranite.

Granitic intrusions:

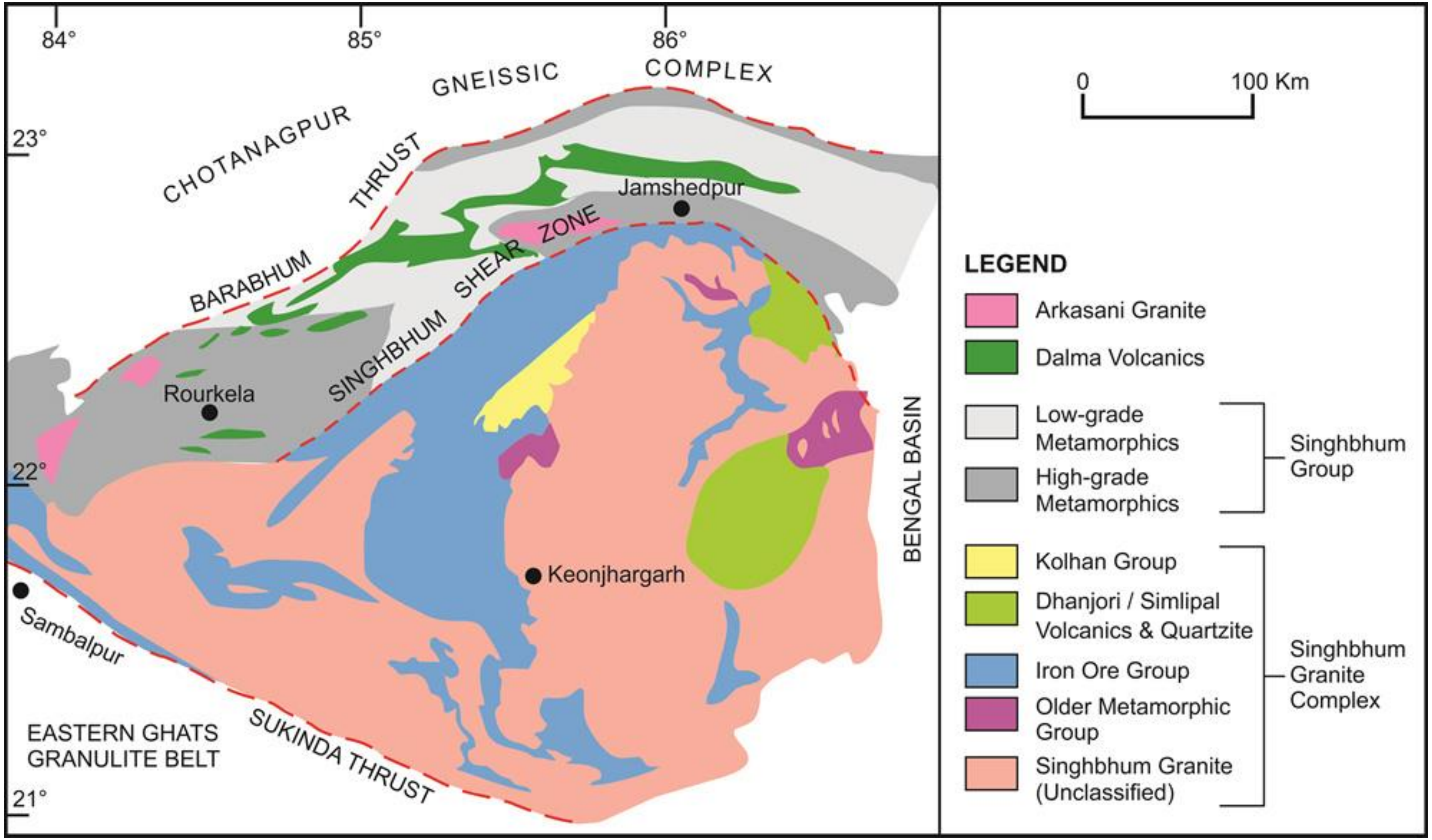
- Saha (1994) recognised three different phases of granitic intrusions in the Singhbhum Granite suite based on the petrochemical data.
- The phase-I intrusions are relatively K-poor granodiorite grading to trondhjemitic diorites.
- The phase-II and phase-III granitic rocks range in composition between granodiorite and adamellite-granite.
- The older granitic bodies which are compositionally similar to tonalite gneisses show gently sloping REE pattern with moderately enriched LREE, flat HREE without demonstrating Eu anomaly.
- The other varieties of granitic rocks are moderately enriched in LREE showing flat HREE pattern and negative Eu anomaly.

Ages of Granites

- Pb-Pb whole rock isochron dates from phase-I and phase-II granites show ages between 3442 ± 26 Ma and 3298 ± 63 Ma (Ghosh et al., 1996).
- Basu et al. (1981) reported a 9 point Sm-Nd isochron date of 3775 ± 89 Ma from the tonalitic gneisses, considered by the authors as intrusive into the oldest supracrustal rocks. This is the oldest date so far reported from the Singhbhum Granite Complex.
- The age of detrital zircons from the oldest supracrustal in the central part of the Singhbhum Granite Complex range between 3628 ± 38 Ma and ~3550 Ma (Goswami et al. 1995; Mishra et al. 1999).
- Closest to the detrital zircon dates is the report of 3664±79 Ma Pb-Pb isochron age from the tonalitic gneiss of the same region by Ghosh et al. (1996).

Crustal evolution of the granitic complex:

- Apart from the occurrences of different types of granites and gneisses, there are several supracrustal bodies which vary between small rafts and smaller enclaves and large bodies within in the Singhbhum Granite Complex.
- A multi-staged evolution of the Singhbhum Granite Complex has been suggested based on the petrochemical as well as geochronological studies of the different lithotectonic/stratigraphic ensembles (Saha et al 1988; Saha 1994; Mishra et al. 1999; Misra, 2006; Nelson et al. 2014).
- Roy and Bhattacharya (2012) explicated a coherent crustal evolutionary history of the Singhbhum Granite Complex based on the reappraisal of field relationships between the different lithological ensembles taking due note of the tectono-metamorphic, magmatic and sedimentation history of the different litho-tectonic associations, including the granites and gneisses of different ages.


84°
85°
86°
23°
22°
21°
CHOTANAGPUR GNEISSIC COMPLEX
THRUST
BARABHUM
SINGHBHUM SHEAR ZONE
Jamshedpur
Rourkela
Keonjhargarh
Sambalpur
EASTERN GHATS GRANULITE BELT
SUKINDA THRUST
BENGAL BASIN
0
100 Km
LEGEND
Arkasani Granite
Dalma Volcanics
Low-grade Metamorphics
High-grade Metamorphics
Singhbhum Group
Kolhan Group
Dhanjori / Simlipal Volcanics & Quartzite
Iron Ore Group
Older Metamorphic Group
Singhbhum Granite (Unclassified)
Singhbhum Granite Complex

1b: Older Metamorphic Group:

- The oldest supracrustal ensembles are known as the Older Metamorphics.
- Lithostratigraphically described as the Older Metamorphic Group, it includes amphibolite, calc-silicate rock and mica schist along with minor bodies of fuchsite-bearing quartzite.
- These bodies show evidence of intense ductile deformation and shearing, and penetrated by intrusive granites of different ages.

(a) Evidence of complex deformation pattern in the calc-silicate rocks of the Older Metamorphic Group showing intricately folded, detached isoclines separated by irregular gneissic rafts and bands.
(b) Intrusion of massive granitoid into the calc-silicate bodies belonging to Older Metamorphic Group.

1c: Iron Ore Group

- The banded iron formation bearing ensembles constitute the Iron Ore Group (the lithostratigraphic term ‘Group’ replacing ‘series’ of early workers like Jones, 1934; Dunn and Dey, 1942) which is the most commonly occurring supracrustals in the Singhbhum Granite Complex.
- The major outcrops of the banded iron formation occur in three different basins.

  (1) the western Koira-Jamda Basin,

  (2) the eastern Gorumahisani-Badampahar Basin, and

  (3) the southern Daitari-Palla Lahara Basin.
- A common trait amongst the three basins is the occurrence of the banded iron formation hosting huge iron ore deposits. The BIF shows subhorizontal beds.
- Elsewhere, the tilted and folded beds are associated with brittle deformation resulting from down-sagging or ‘caved-in’ gravity induced collapse of the litho-formations.
- The formation of loose ‘blue dust’ type iron ore concentration (Figure 6.6b) took place during such karst-related weathering processes.

(a) Banded iron formation showing subhorizontal layering
(b) Banded iron formation showing local warping and other karst-related deformation.

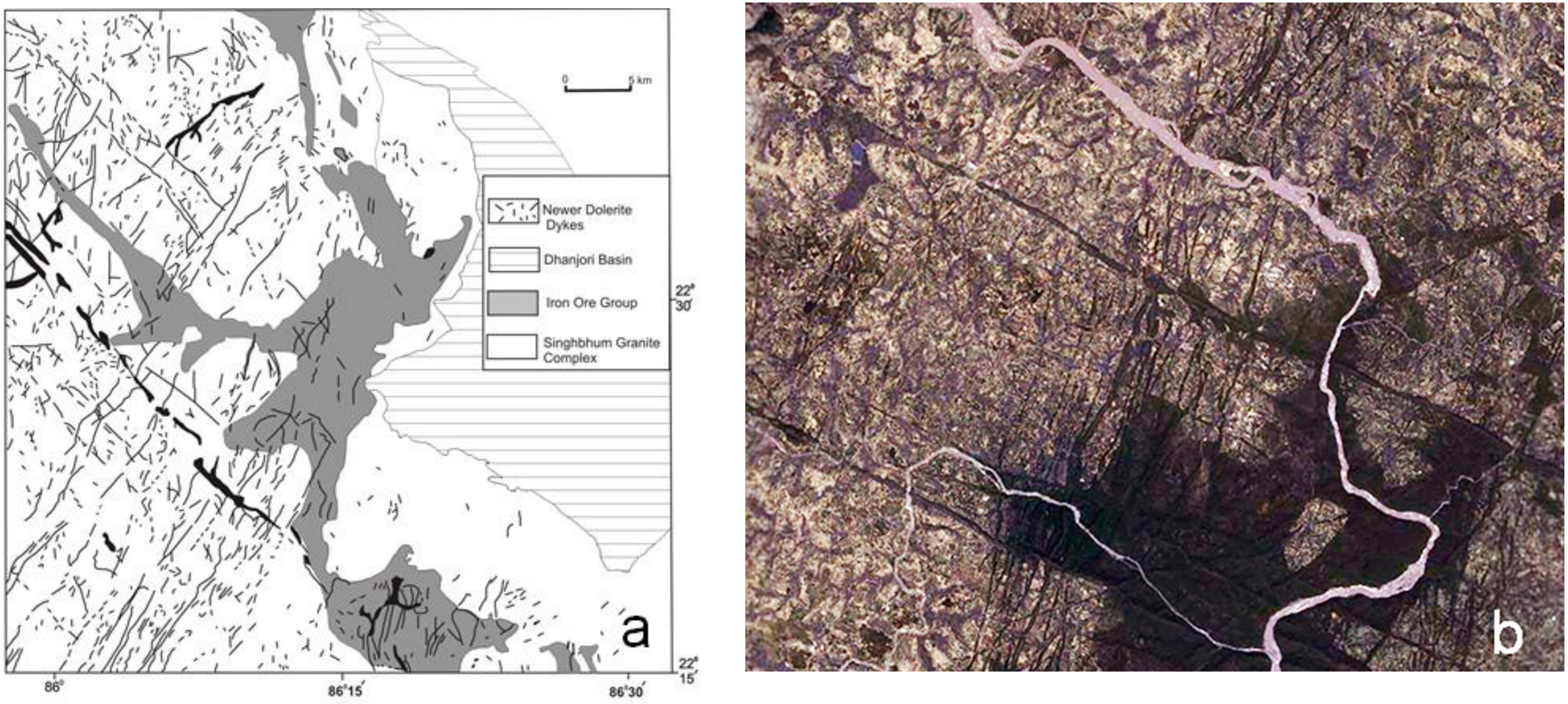
- The metasedimentary rocks in the Iron Ore Group include quartzite, conglomerate (locally with quartz-pebble), and shale with minor bodies of calc-silicates, marble and mafic meta-volcanics.
- One such ensemble in the western part of the Singhbhum Granite Complex is known as the Darjing Group. This poorly known rock association consists of conglomerate, arkosic quartzite, black shale facies rocks and some calcareous meta-sediments showing amphibolite facies metamorphism. Correlation of these rocks with the Iron Ore Group is based on the evidence of intrusion of the ~2800 Ma old Tamperkola Granite (Bandhopadhya et al. 2001) into the Darjing Group rocks. Unlike most of the banded iron formations, the Darjing rocks show evidence of multiple deformations.
- An important component of the Iron Ore Group is the ultramafic rocks hosting chromite and platinum group minerals. The chrome-bearing ultramafic rocks occur in the southern Daitari-Palla-Lahara basin, around Sukinda in Odisha and Jojuhatu in the Koira-Jamda area in Jharkhand.
- The chromitite deposits of the Nuasahi and Sukinda massifs constitute a part of layered ultramafic bodies that include dunite, and associated orthopyroxenite. Apart from chromite, the ultramafic bodies in the southern part the Singhbhum Granite Complex are the hosts of the 'lone' Platinum group mineral deposits in India (Haldar 2017).

- The field relationship, however, provides a clear indication that the ‘Iron Ore Group’ basins formed after the closing (cratonization) of the Older Metamorphic Group.
- Lithostratigraphically, overlying the Iron Ore Group and the youngest group of ca. 3100-3200 Ma old granitoids occurs the Simlipal volcanics which together with intertrappean sediments constitute the Simlipal Group (Majumdar, 1996).
- The Simplipal Group forms a spectacular oval-shaped outcrop in the southeastern part the Singhbhum Granite Complex. The Simlipal Basin has been described as a volcano-sedimentary basin evolved over a Plume head (Banerjee and Ghosh 1994).
- The strong lithological similarity between the Simlipal and Dhanjori is implied in the chemical character of the two volcanic formations. Misra and Johnson (2005) reported Pb-Pb and Sm-Nd whole rock isochron ages of 2794 ± 270 Ma and 2787 ± 270 Ma respectively from the Dhanjori volcanics. In spite of the high error factor, we may presume that the Simlipal and Dhanjori volcano-sedimentary basins were coeval in the late–Archaean time, post-dating the deposition/formation of the Iron Ore Group.
- The age comparable to the formational age of the Simlipal and Dhanjori volcanics is known from the Tamperkola Granite in the western margin of the Singhbhum Granite Complex. Pb-Pb zircon ages of Tamperkola granitoid body are 2809 ± 12 and 2822 ± 67 Ma (Bandopadhyay et al., 2001).

1d: Dykes and Kolhan Group

- A system of dominantly mafic dykes called Newer Dolerite occurs within the Singhbhum Granite Complex, cross-cutting both the granitic rocks and the associated supracrustal rocks.
- The dykes show two distinct orientations trending NNE-SSW and NW-SE. The strict regularity in the orientation of the two sets of dykes provides proof of their intrusion along a conjugate set of vertically oriented fracture systems.
- The opening of the N-S trending Kolhan Basin post-dating the emplacement of the crosscutting Newer Dolerite dykes has been suggested by Roy and Bhattacharya (2012) on the assumption of continuity of the E-W extension-related tectonic regime after phase of dyke intrusions.
- Its end-Archaean age is based on the consideration of the conformable stress pattern responsible both for the basin opening and the development of the conjugate fracture system in the Singhbhum Granite Complex at around 2600 Ma.

(a) Geological map of a part of the Singhbhum Granite Complex showing dominantly conjugate pattern of intrusion of Newer Dolerite. Dunn and Dey (1942).
(b) Google-Earth Imagery scene between lat. 21°27' and 21°37', and long 85°52' and 86°04' showing a conjugate pattern of the Newer Dolerite dyke system in a part of Singhbhum Granite Complex.



Tectonostratigraphic and geochronologic framework of the Singhbhum Granite Complex (After Roy and Bhattacharya, 20012)

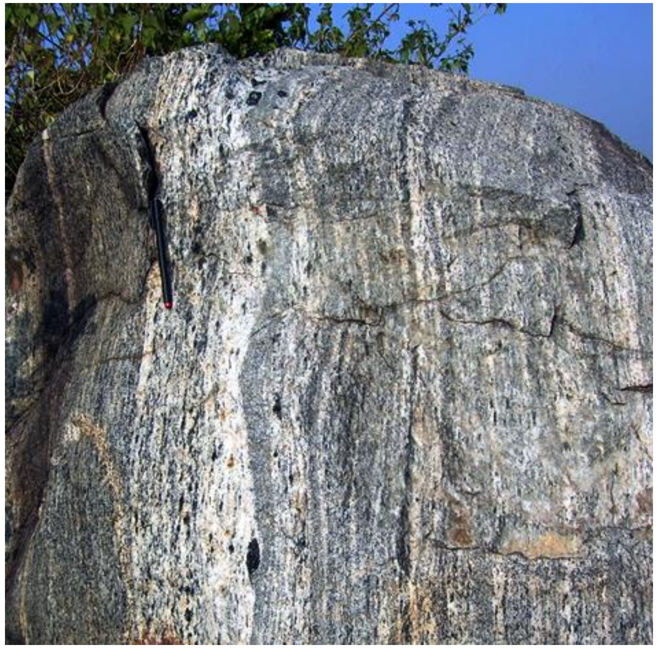
Tectono-stratigraphic units	Tectonic framework	Age in million years (Ma)
Kolhan Group	Half-graben type cratonic basin	**<2600 to ~2500 Ma**
Newer Dolerite	Fracturing of rigid Crust and dyke intrusions	**~2600 Ma**
Dhanjori Group and Simlipal volcanics, granitoid plutons	Plume related magmatism & sedimentation	**~ 2800 Ma**
Iron Ore Group (including Darjing Group & Kunjer Group)	Greenstone belt evolution over stabilised sialic Crust	**~3000 Ma**
Crust building granitic activities	Late synkinematic intrusion	**~3200 Ma to ~ 3100 Ma**
Older Metamorphic Group	Early Greenstone belt development	**~3380 to ~3285 Ma**
Formation of early sialic Crust		**> 3800 to ~.3400 Ma**

2. Chhotanagpur Gneissic Complex

- It occupies a large area in the northern part of the Singhbhum Protocontinent between the Singhbhum Fold Belt in the south and the Damodar Valley Rift Basin in the north.
- It includes predominantly gneisses and granitoids of diverse petrological composition and age.
- The gneisses show typical banded character which looks quite similar to those constituting the ancient basement rocks in different parts of the Indian Shield.
- Petro-chemistry of these rocks matches with the trondhjemite-tonalite-granodiorite suite. There are a few gneissic bodies which are compositionally more mafic in character and are described as the diorite gneiss.
- The amphibolite, also described as the hornblende gneiss occurs locally as enclaves of various shapes and sizes within the gneiss-granite complex.
- Some of the gneissic rocks show the development of uniformly layered, planar shape fabric of secondary origin which may be described as mylonite gneiss. These are the reconstituted gneissic rocks.
- These reconstituted gneisses bear evidence of synkinematic reconstitution of the pristine gneisses through the development of secondary foliation which is locally disturbed by the growth of ‘eye-shaped’ feldspar porphyroblast.

Outcrops of Chhotanagpur Gneiss showing banded character.

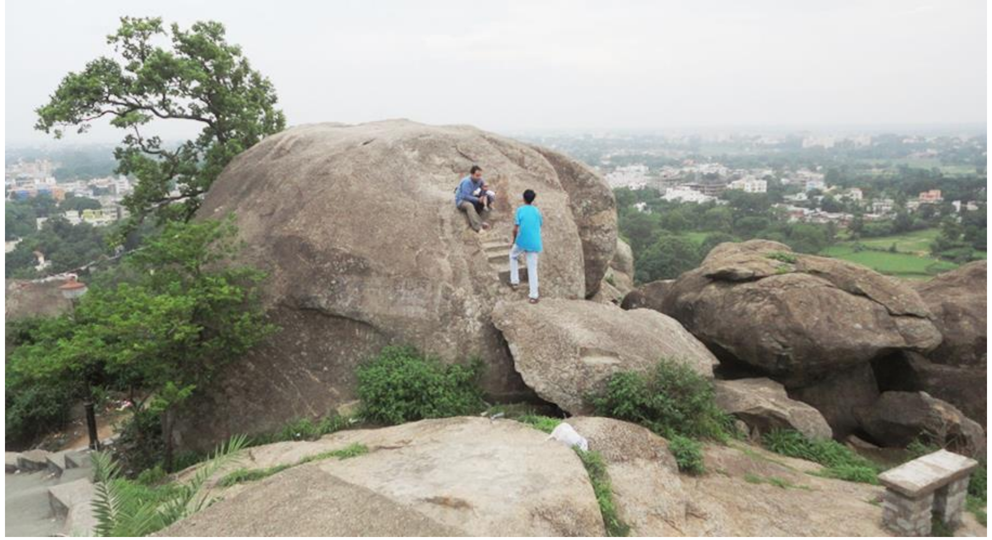
A mylonite gneiss showing uniformly planar foliation. The ‘eye-shaped’ outcrop of a large porphyroclast of feldspar has grown pushing aside the foliation surfaces.



2a Granite bodies

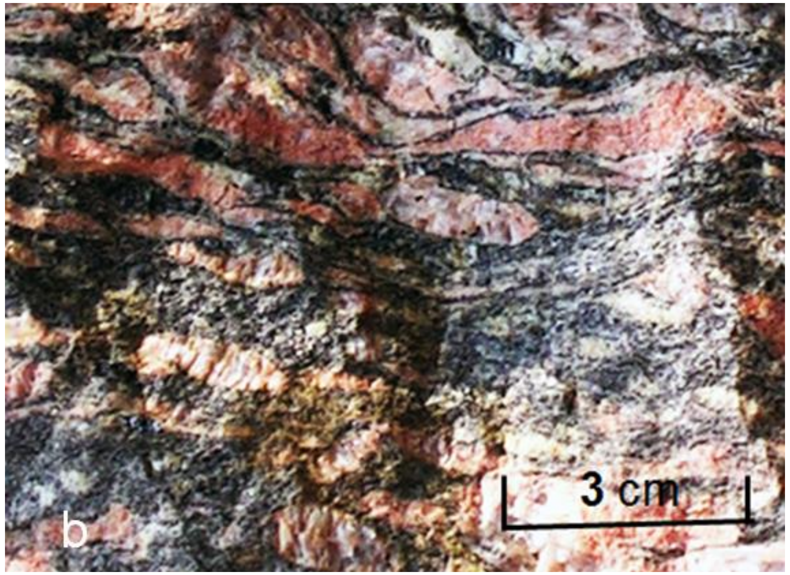
- The granites are coarse grained, porphyritic type showing tendency to weather into rounded, dome-like bosses, and tors.
- The granites are divided into two different categories:

1. The grey granites which have evolved from the melting of tonalite-trondjhemite-granodiorite gneisses.
2. The Pink granites are the youngest intrusive bodies within the gneissic complex. Migmatitic nature of some of these granites is indicated by the growth of pink coloured feldspar between the dark protolithic layers.



Granite occurs in the form of isolated tors amidst flat country.

Pink granite showing dominance of pink coloured K-feldspar. And Migmatitic nature of the pink granite is manifested through the growth of pink feldspar in between dark protolith layers.

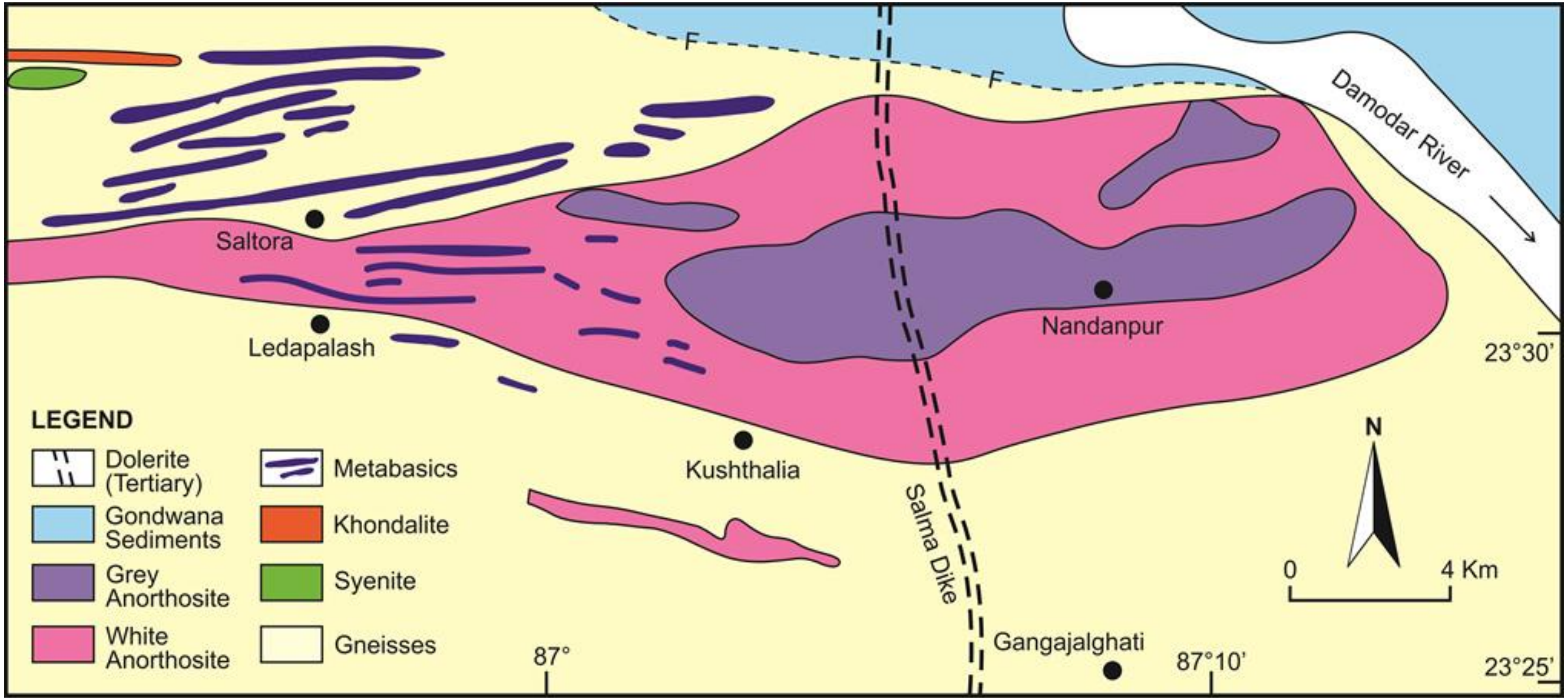


2b Supracrustals in Chottanagpur Gneissic Complex

- Several bodies of supracrustal rocks (mainly metasedimentary and metavolcanic rocks) occur as enclaves within the gneissic rocks. These include mica schists, banded iron formation, marble and quartzite along with patches of mafic and ultramafic rocks. They show low grade metamorphic character varying between greenschist and amphibolite facies.
- The high-grade granulite facies rocks have localized occurrence, mainly along two belts: (i) in the eastern part in the Purulia District of West Bengal and (ii) in the Ranchi-Palamau area in Jharkhand.
- The granulite assemblages are represented by khondalite (garnet-sillimanite ± graphite), calc-silicate granulite (scapolite-wollastonite-calcite-garnet±quartz), charnockite (hypersthene-granite), two-pyroxene granulite with or without garnet, hornblende granulite and liptinite.
- All occur in the form of dismembered bands within granitic gneisses.

2c Anorthosites in CGS:

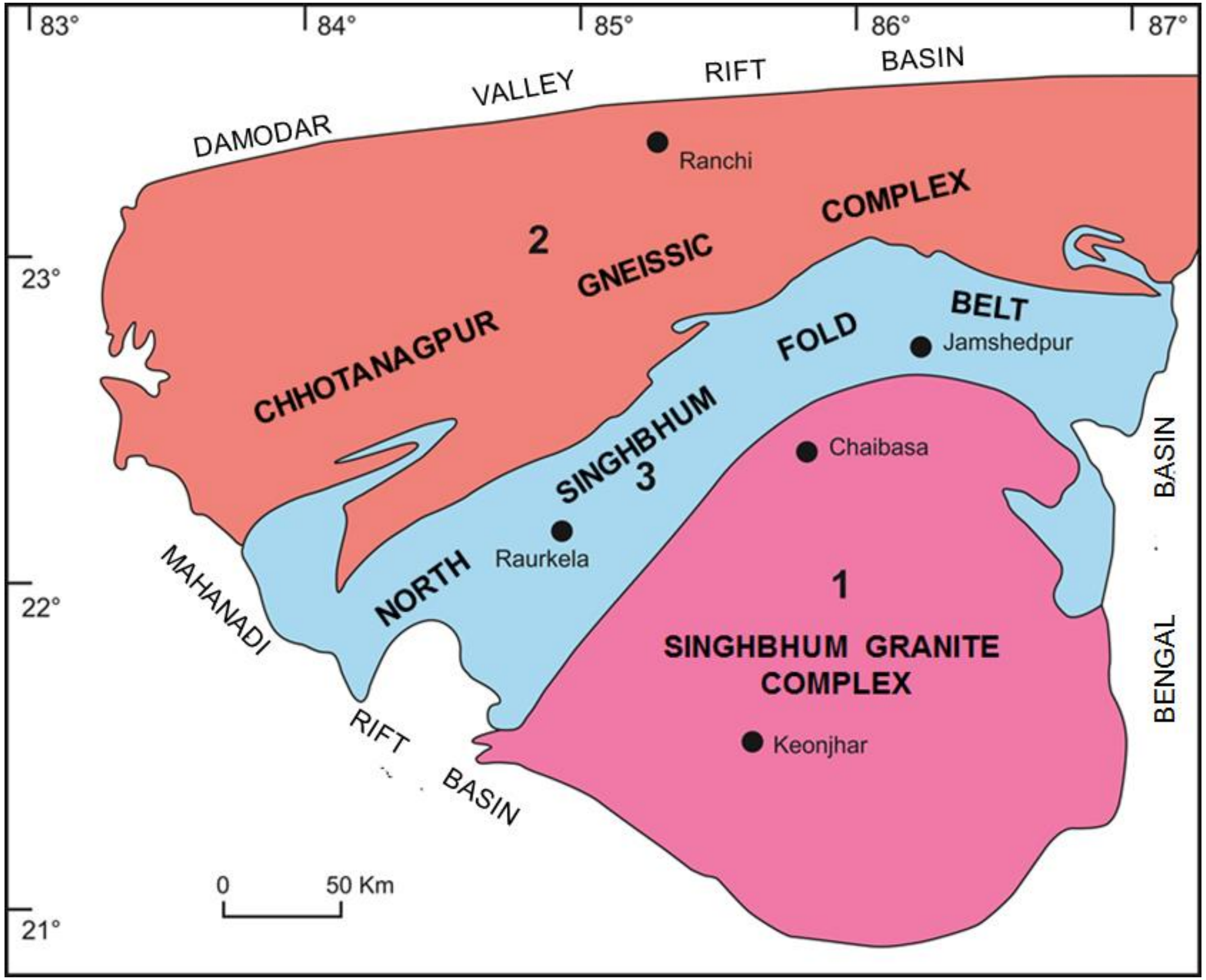
- The most significant feature of the Chhotanagpur Gneissic Complex is the occurrence of lenticular or elliptical bodies of anorthosite, locally associated with thin lenses of syenite.
- The largest body of anorthosite occurs at the eastern margin of the Singhbhum Protocontinent. Known as the Bengal Anorthosite, this, about 40 km long “tadpole-shaped” intrusive body and is enveloped predominantly by pelitic granulites and felsic gneisses.
- The core of the anorthosite body consists of ‘grey anorthosite’ which is bordered by medium-grained, equigranular ‘white anorthosite’. The grey anorthosite comprises coarse-grained plagioclase megacrysts which show magmatic flow-related alignment.
- Supracrustal enclaves within the anorthosite body include patches of sillimanite-bearing mica schist, khondalite, quartzite, quartz-magnetite rock and calc-silicate gneiss. A few inclusions of relict basement complex occur within the anorthosite body which comprises of quartzo feldspathic gneiss, biotite/hornblende gneiss, charnockite, and leptynite.


F
F
Damodar River
Saltora
Ledapalash
Nandanpur
Kushthalia
Salma Dike
Gangajalghati
23°30'
23°25'
87°
87°10'
N
0
4 Km
LEGEND
Dolerite (Tertiary)
Gondwana Sediments
Grey Anorthosite
White Anorthosite
Metabasics
Khondalite
Syenite
Gneisses

- The evolutionary history of the Chhotanagpur Gneissic Complex is much prolonged extending from Meso-Archaean to the early Neoproterozoic. A tentative lithostratigraphic-geochronologic framework of the Chhotanagpur Gneissic Complex:

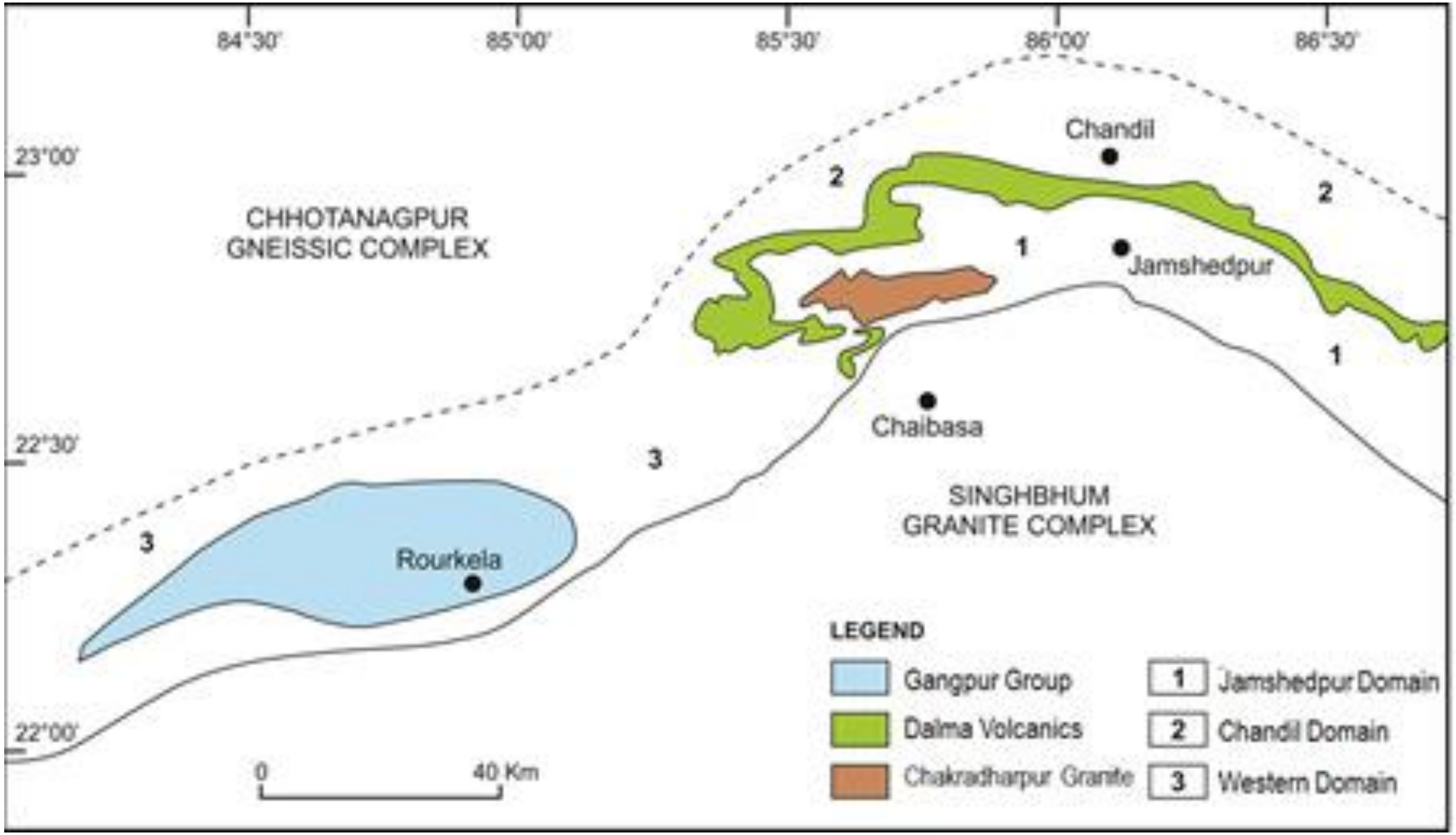
Tectono-thermal events	Age (probable)	Reference
Emplacement of Pink Granites	850-800 Ma	Singh and Krishna, 2009
Emplacement of Grey Granites	1000-950 Ma	Singh and Krishna, 2009
Granulite facies metamorphism	~1000 Ma	Chatterjee et al. 2008
Intrusion of anorthosite bodies	~1550 Ma	Chatterjee et al. 2008
Development of greenstone belts	Late-Archaean (?)	-------------
Development of early sialic Crust	Meso-Archaean (?)	-------------

3. North Singhbhum Fold Belt:



Distribution

- The North Singhbhum Fold Belt is a relatively narrow belt of folded sequence comprising dominantly of metasedimentary rocks along with the volcanics and some granitoids.
- The southern boundary of the Chhotanagpur Gneissic Complex with the North Singhbhum Fold Belt is transitional, because much of the southern part of the belt included in the gneissic complex is reported to include the fold belt rocks, mica schists and some other metasedimentary bodies, which have undergone 'migmatization' during late Palaeoproterozoic time.
- The entire belt of metasediments and volcanics of the North Singhbhum Fold Belt is divided into 3 domains
- 1 The Jamshedpur Domain including the Dalma Volcanics which bound the metasediments (mica schist phyllite and quartzite) in the north and west
- 2. Chandil Domain, occurring between the Dalma Volcanics in the south and the Chhotanagpur Gneissic Complex in the north
- 3. The Western Domain includes the Gangpur Group. Apart from the meta-sedimentary ensembles and volcanics, the North Singhbhum Fold Belt includes patches of granites and gneissic rocks of diverse ages in all the three Domains. The largest body is that of the Chakradharpur Granite.


84°30'
85°00'
85°30'
86°00'
86°30'
23°00'
22°30'
22°00'
CHHOTANAGPUR
GNEISSIC COMPLEX
Chandil
Jamshedpur
Chaibasa
Rourkela
SINGHBHUM
GRANITE COMPLEX
0
40 Km
LEGEND
Gangpur Group
Dalma Volcanics
Chakradharpur Granite
1 Jamshedpur Domain
2 Chandil Domain
3 Western Domain

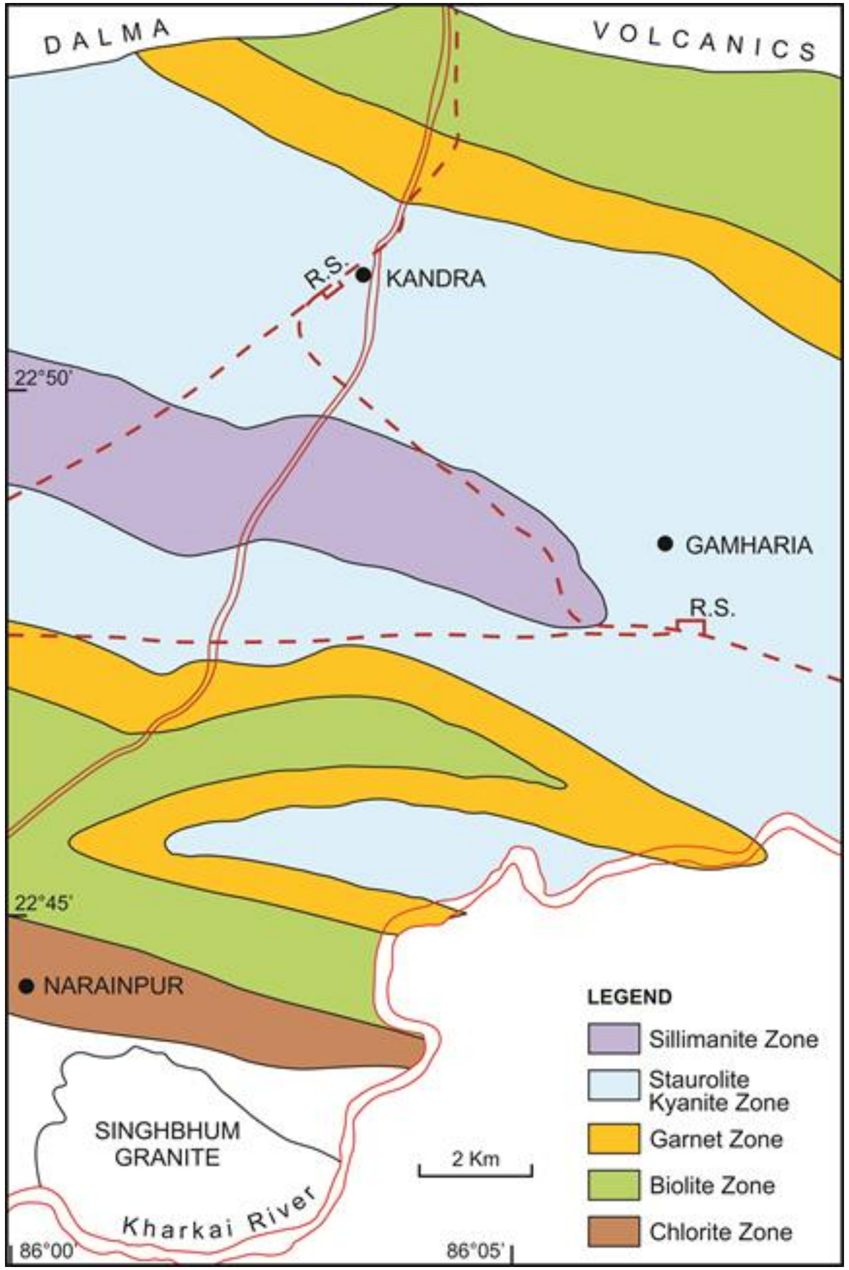
3a Singhbhum Group

- The term Singhbhum Group proposed by Sarkar and Saha (1962) is retained, but only for the metasedimentary ensembles of the Jamshedpur Domain that occur between the Dalma Volcanics in the north and west and the Singhbhum Granite Complex in the south. For the similar lithologic associations that occur in the north of the Dalma Volcanics, the term Chandil Group is used.
- Dominantly comprises metamorphosed shale-sand bearing assemblages with some linear bodies of amphibolite. This arcuate belt of metasediments is bounded between the outcrops of the Dalma Volcanics in the north and west, and late Quaternary laterite cover in the east.
- In the south, the belt is truncated by a very prominent shear zone which passes close to the northern boundary of the Singhbhum Granite Complex. Isolated bodies of conglomerate (e.g. Bisrampur Conglomerate) along with arkosic sandstone and shale occur south of the shear zone bordering the Singhbhum Granite Complex.

- The Singhbhum Group is divided into an upper Dhalbhum Stage and a lower Chaibasa Stage by Sarkar and Saha (1962) is debatable.
- The overall structure of the folded rocks of the Singhbhum Group rocks has been designated as the Singhbhum Anticlinorium by Sarkar and Saha (1962) following the earlier suggestion of Dunn and Dey (1942).
- The broad geometry of the large-scale flattened elongate broadly dome-shaped low-plunging antiform that occur south of the Chandil Domain may be redefined as the Singhbhum Antiform plunge to both southeast and west on the eastern and the western sides respectively.
- A prominent shear zone that developed along the southern limb of the antiform has been traditionally described as the Singhbhum Shear Zone marked by a wide zone mylonite and mylonitic phyllite.
- Sarkar and Saha (1962) described it as the Copper-belt Thrust as it truly marks a zone of thrusting along which the northern fold-belt rocks are thrust over the Singhbhum Granite Complex.

Metamorphism

- A typical Barrovian type metamorphic character has been recorded in the belt.
- Studies in the central part of the Singhbhum antiform have highlighted progressive nature of the metamorphism marked by successive development of prograde regional metamorphic minerals from chlorite to sillimanite zone through biotite, almandine garnet and kyanite/staurolite zones.
- Microstructural studies have helped to provide proof of progressive regional metamorphism in the main part of the fold belt coevally with the major folding of the belt. This was followed at a later stage by retrogressive metamorphism concomitant with the phases of shearing both along the northern and southern shear zones.


DALMA VOLCANICS
R.S.
KANDRA
22°50'
GAMHARIA
R.S.
22°45'
NARAINPUR
SINGHBHUM GRANITE
2 Km
Kharkai River
86°00'
86°05'
LEGEND
Sillimanite Zone
Staurolite Kyanite Zone
Garnet Zone
Biolite Zone
Chlorite Zone

3b Chandil Domain

- The belt comprises dominantly of pelitic schists and other metasediments intermixed with tuff and related volcanic components. Several bodies of chert and carbonaceous shale in rhythmically banded form occur along with the impure limestone and/or dolomite mainly in the southern edge close to the outcrops of the Dalma volcanics.
- Sporadic occurrences of base metal sulphide along with phosphorite occurrences are known locally in this belt. There are thick bands of quartzites which are thought to be chemically precipitated silica (meta-chert).
- The pelitic rocks mixed with the volcanic tuffs show low to very low grade of metamorphism. The metamorphic grade increases eastward from near Chandil reaching up to staurolite-kyanite grade of Barrovian metamorphism.

- Some occurrences of felsic volcanics like rhyolite have been reported from a number of places.
- There are isolated bodies of alkali syenite with nepheline and sodalite occurring in thin bands.
- Mafic-ultramafic rocks represented by chlorite schist, talc schist, amygdaloidal basaltic flows and ultramafic intrusives are more common in the eastern sector than in the western where they form elongate ‘strike–ridges’.
- The pelitic dominant Chandil Domain shows some features which make it distinctive from the Jamshedpur Domain in the south.
- Both the domains were included in the ‘Singhbhum Anticlinorium’.

Some features which make the Chandil Domain distinctive:

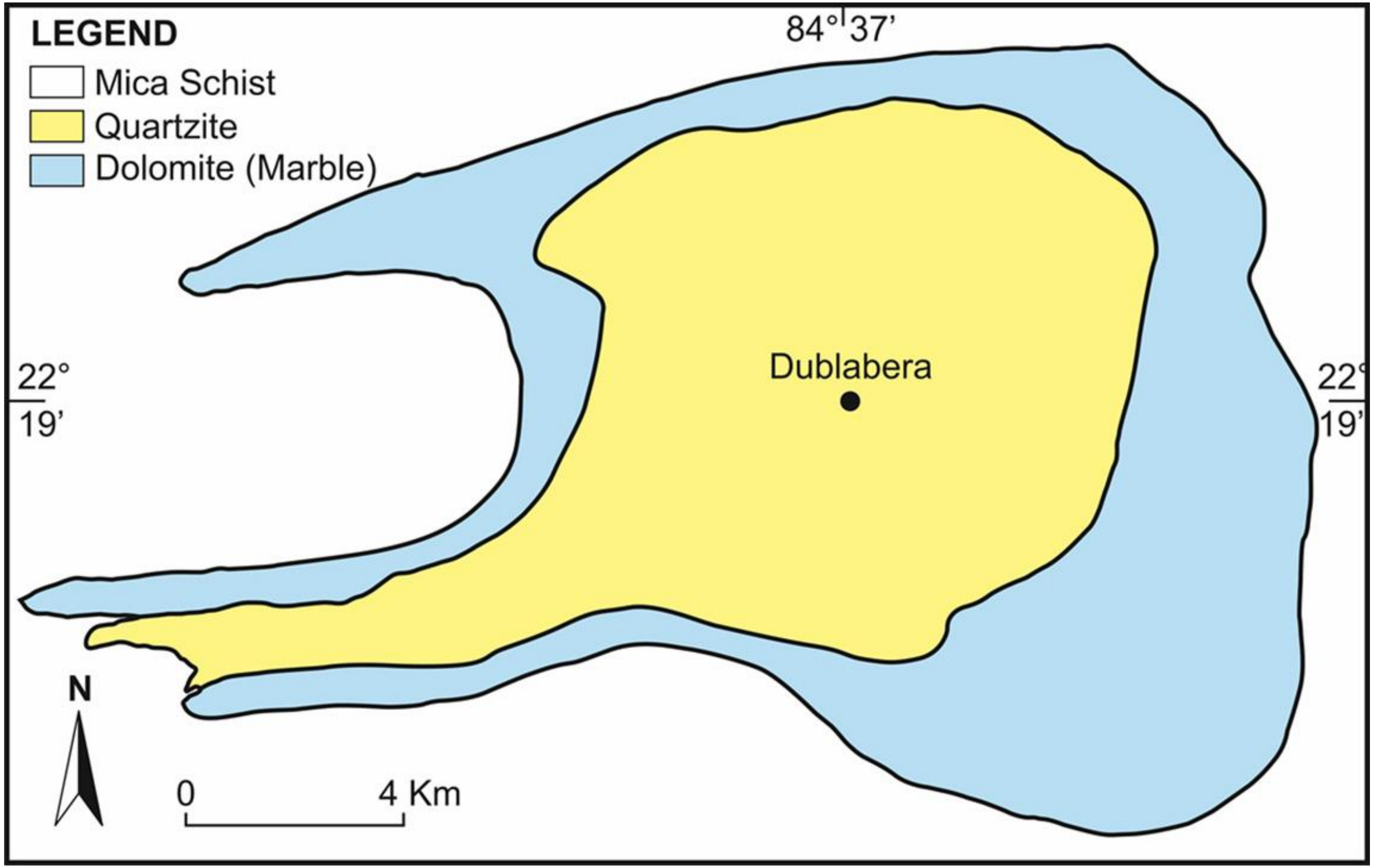
- (i) The metapelites are generally of low metamorphic grade,
- (ii) There is abundance of chert and carbonaceous shale-chert rhythmites along with bodies of limestone/dolomite
- (iii) There are large bodies of mafic-ultramafic rocks, as well as abundance of felsic volcanics, along with syenite and nepheline syenite,
- (v) Carbonatites are seen along the Tamar-Porapahar Shear Zone in the north.

3c Gangpur Group

- It has a distinctive lithostratigraphic ensemble that occurs in the western part of the North Singhbhum Fold Belt.
- Mn and carbonate bearing ensemble has been described as an anticlinorium having an E-NE to W-SW trending axis.
- Krishnan (1937) has divided the ensemble into the younger Iron-ore series and the older succession Gangpur Series.

Iron-ore Series	**Phyllites, Slates and Lavas** **Raghunathpur Conglomerate**
Gangpur Series	Phyllites and mica schists Upper carboniferous phyllites Calcitic marbles Dolomitic marbles Mica schists and phyllite Lower carbonaceous quartzites and phyllites Gondites with associated phyllites -- (Basement not exposed)

- The major Gangpur structure represents a ‘synclinorium’. Banerjee (1967) detected a large scale inversion of the Gangpur structure. The large scale Gangpur Fold represents an antiformal structure but with an inverted stratigraphy.
- Later Chaudhuri and Pal (1983) proposed that the large scale Gangpur structure is a prototype of the geometry of the Dublabera fold. The authors advocated a stratigraphic continuity of the different ensembles in the region forming a single continuous sequence without a many major break. It is to note that the geometry of the Dublabera fold appears like ‘mushroom’ type fold interference. If the large scale Gangpur fold truly follows the geometry of the Dublabera fold, it may appear a far-fetched assumption to conclude that the total stratigraphy of the Gangpur is inverted.
- In absence of any detailed information on the fold geometry, it may be rational to consider the stratigraphic succession erected by Krishnan (1937) as a workable stratigraphic succession for the future work.


LEGEND
Mica Schist
Quartzite
Dolomite (Marble)
84° 37'
22° 19'
22° 19'
Dublabera
N
0
4 Km

Stratigraphic status of Gangpur Group

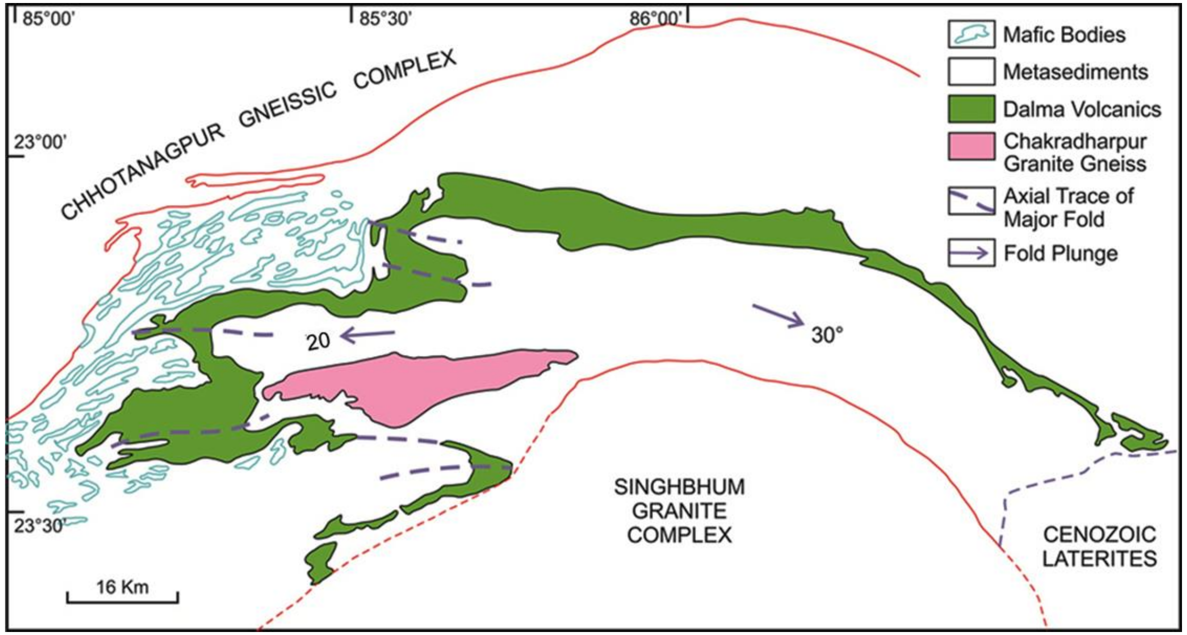
- The debate continues on the understanding of the stratigraphic relationship of the Gangpur Group with the other components of the North Singhbhum Fold Belt.
- However, based mainly on the metallogenic consideration, the Gangpur Group having manganese bearing horizon associated with the calcitic and dolomitic carbonates may be correlated with the Sausar Group that occur in the adjacent Bastar Protocontinent.
- But unlike the evidence of 'snowball Earth' in the manganese-bearing rocks of Sausar, there is hardly any study done on the similar line on the Gangpur Group of the Singhbhum Protocontinent.
- .

3d Dalma Volcanics

- The Dalma Volcanics, also called as the Dalma Lavas (lithostratigraphically as the Dalma Group) occupies the median zone in the eastern part of the North Singhbhum Fold Belt.
- Topographically, the Dalma Volcanics consist of rows of hill ranges which, at places, attain precipitous heights.
- The outcrops of the Dalma volcanics do not extend beyond the half-way mark of the total outcrop length of the fold belt.
- The outcrops of volcano-sedimentary rocks known as the Ongabira lavas have been included in the domain of the Dalma Volcanics based on the observed similarities on the structural, petrological and geochemical characteristics.
- The bulk of the lava pile is made of basalt flows (now in lowly metamorphosed state) preserving a strong compositional bimodality. In general, the highly magnesian picritic volcanics have developed at the base; whereas low-K tholeiite basalt flows occur in the upper part of the volcanic sequence.

Map showing the outcrop pattern of the Dalma Volcanics and associated litho-formations of the North Singhbhum Fold Belt (After Sarkar, AN, 1982).

Dalma Volcanics form prominent hill ranges which at places attain precipitous heights.



Lithoassembalges of Dalma Volcanics

- The Dalma Volcanics show patches of volcanic breccia and agglomerate, which presumably provide evidence of the close proximity of volcanic foci.
- The agglomerates in particular are made almost entirely of ejected boulders some of which are quite large in dimensions.
- Locally, thin beds of rhythmically bedded carbonaceous phyllite occur within the lava flows, which are thought as tuff beds.
- There are also some phyllite-like ‘enclaves’ enclosed in the volcanic flows which have been interpreted as ‘inliers’ of the underlying rocks.

Division of Dalma Volcanics

- The Dalma Volcanics (Dalma Group) is divided into lower and upper formations.
- A brief hiatus between the two is indicated by the occurrence of reworked agglomerate and at some place by the presence of weathered rocks like metamorphosed chlorite phyllites on the top of the lower succession.
- Lithologically, the lower formation consists of tuff (carbon-phyllite) and quartzite interlayered with volcanics.
- Upper formations of the Dalma Volcanics are made up of mafic flows and agglomerates with Mg-rich volcano-clastics grading between picrite and komatiite along with co-magmatic intrusions.

Origin and structure

- Based on trace elements, REE geochemistry and Sr-Nd isotope systematics, Roy et al. (2002) suggested a Mantle Plume origin of the gabbro-pyroxenite bodies in the Dalma Volcanics.
- Structurally, the Dalma Volcanics has been visualized as isoclinally folded fold (Sarkar and Saha 1962) refolded on a later westerly plunging antiformal fold with broadly east-west axial trace.
- The outcrop pattern of the Dalma Volcanics near the western end defines a major westerly plunging antiformally folded closure with east-west axial trace. There are several subsidiary asymmetric folds which have developed on either side of the hinge region.
- On northern limb the subsidiary folds define S-shaped sinistral folds. The fold geometry on the southern side (assuming that Ongabira lavas constitute a part of the Dalma Volcanics) has Z-shaped or dextral fold geometry.
- The overall fold geometry of this westerly plunging antiform represents a classic example of flexural slip folding on a very large scale. The apparent detachment of the Ongabira part from the main body is because of the movement along the Shear Zone tearing off the ‘Ongabira lava’ part of the Dalma Volcanics from the main body.

3e Chakradharpur Granite

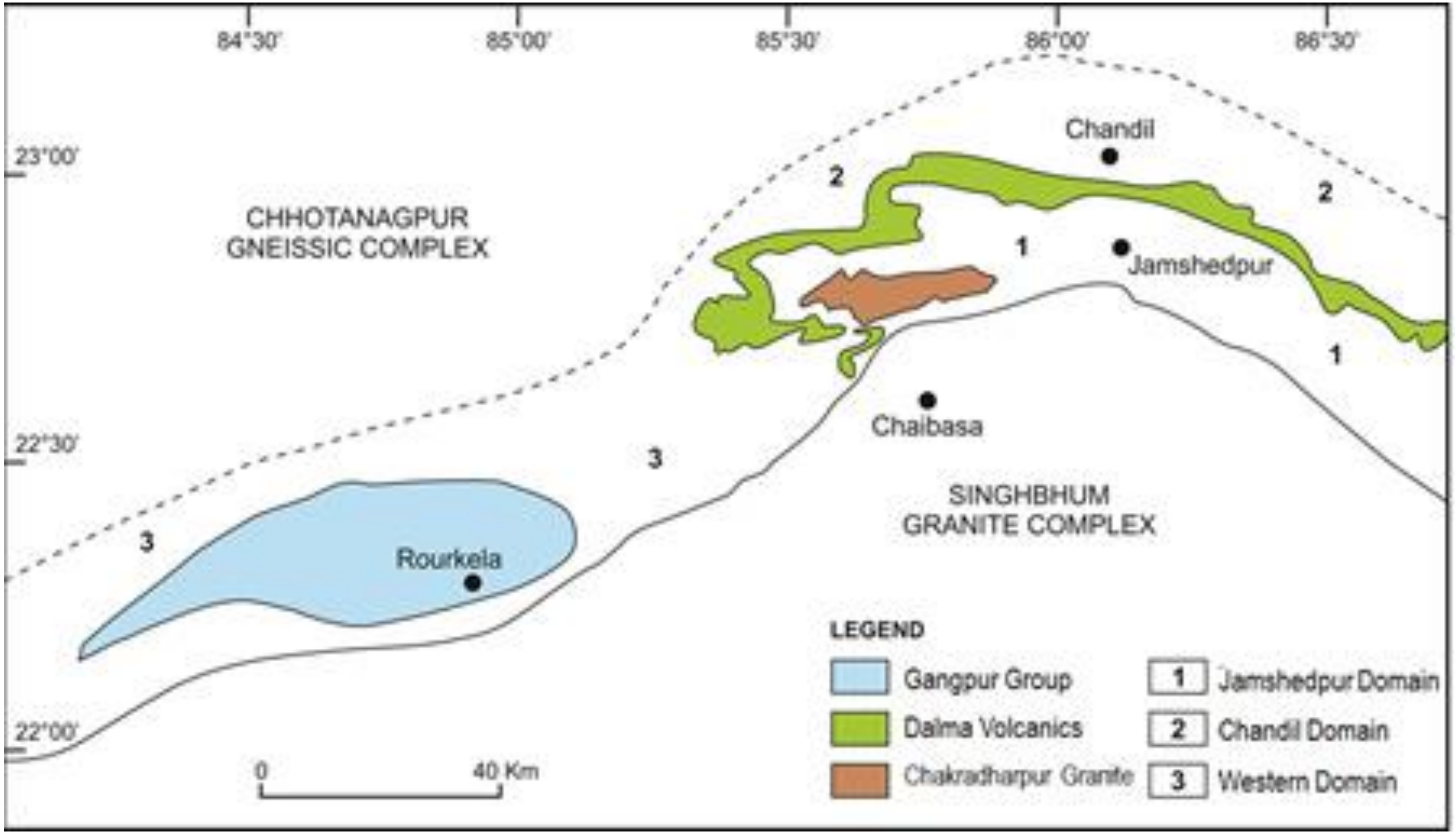
- Patches of granitic rocks of various compositions are observed in the southern part of the Singhbhum Shear Zone mainly in the central part. The largest of these bodies is known as the Chakradharpur Granite or Gneiss.
- It is an elongate body of granitic gneiss occurring in the southwestern part of the Singhbhum Antiform, close to the western folded outcrops of the Dalma Volcanics.
- Chakradharpur Granite is studied for the part of the granitic rock (much of which is gneissic in character) which forms a large outcrop west Rajkharswan (22° 44′:85º 49').

Chakradharpur vs. Arkasani Granite

- The different types of the Arkasani Granite are compositionally comparable to the western body of Chakradharpur Granite.
- Petrologically, both the Chakradharpur Granite and the Arkasani Granite includes two major types: (i) the trondjhemite-tonalite-granodiorite gneiss which covers the largest aerial extent and (ii) the coarse grained, massive granodiorite grading to granite.
- The massive granite in which albite constitutes the dominant feldspar have been described as the Soda-Granite by the early workers.
- The eastern outcrops of the Arkasani Granite include a special textural type called ‘granophyric’ in which the groundmass shows an intergrowth of alkali feldspar (mostly albite) and vermicular (worm-like) quartz.

Ages of two granites

- An age of ~ 2800 Ma has been suggested for the trondjhemite gneiss bodies of the Chakradharpur Granite (Bandopadhyay et al., 2001).
- The Proterozoic age of the Arkasani Granite/Granophyre rocks from the Singhbhum Shear Zone has been reported by Bhattacharya et al. (2014) based on the SHRIMP U–Pb zircon date of 1861± 6 Ma.
- Pal et al. (2011) reported from the Singhbhum Shear Zone rocks U-Pb ICP-MS laser ablation ages suggesting 1882± 23 Ma and 1.885± 31 Ma.
- However, from the occurrence of typical banded gneissic rocks it appears that much of the Arkasani Granite, in all probability, have Archaean antiquity, as indicated by the TD_M model ages as also by the Sm-Nd ages quoted by Ramakrishnan and Vaidyanadhan (2008).
- The massive granites must have evolved post-dating the tectonism related to the shearing and thrusting along the Singhbhum Shear Zone around 1861±6 Ma.
- The report of ~1.0 Ga Rb/Sr isochron age determined by Sengupata et al. (1994) could possibly be related to the youngest thermal event reported from the Singhbhum Shear Zone.



84°30'
85°00'
85°30'
86°00'
86°30'
23°00'
22°30'
22°00'
CHHOTANAGPUR
GNEISSIC COMPLEX
SINGHBHUM
GRANITE COMPLEX
Chandil
Jamshedpur
Chaibasa
Rourkela
1
2
3
0
40 Km
LEGEND
Gangpur Group
Dalma Volcanics
Chakradharpur Granite
1 Jamshedpur Domain
2 Chandil Domain
3 Western Domain

Arkasani Granite

- Almost in continuation of the Chakradharpur Granite in the east occur several narrow, linear outcrops of granitic rocks within the Singhbhum Shear Zone. These bodies are known as the Arkasani Granite (also described as the Arkasani Granophyre) or Soda-Granite. In fact, the earlier workers (Pascoe, 1973) preferred to use the term Arkasani Granophyre for all granitic rocks occurring in the Singhbhum Shear Zone.
- The term Arkasani Granite is used for all the granitic rocks that occur in the Singhbhum Shear Zone east of Rajkharswan. The main body of the Arkasani Granite southwest of Jamshedpur shows a sinuous outcrop pattern with long finger like projections, and set within extremely sheared mylonitic rocks.