Intracratonic Basins/ Purana Basins of Dharawar Protocontinent

Presentation by

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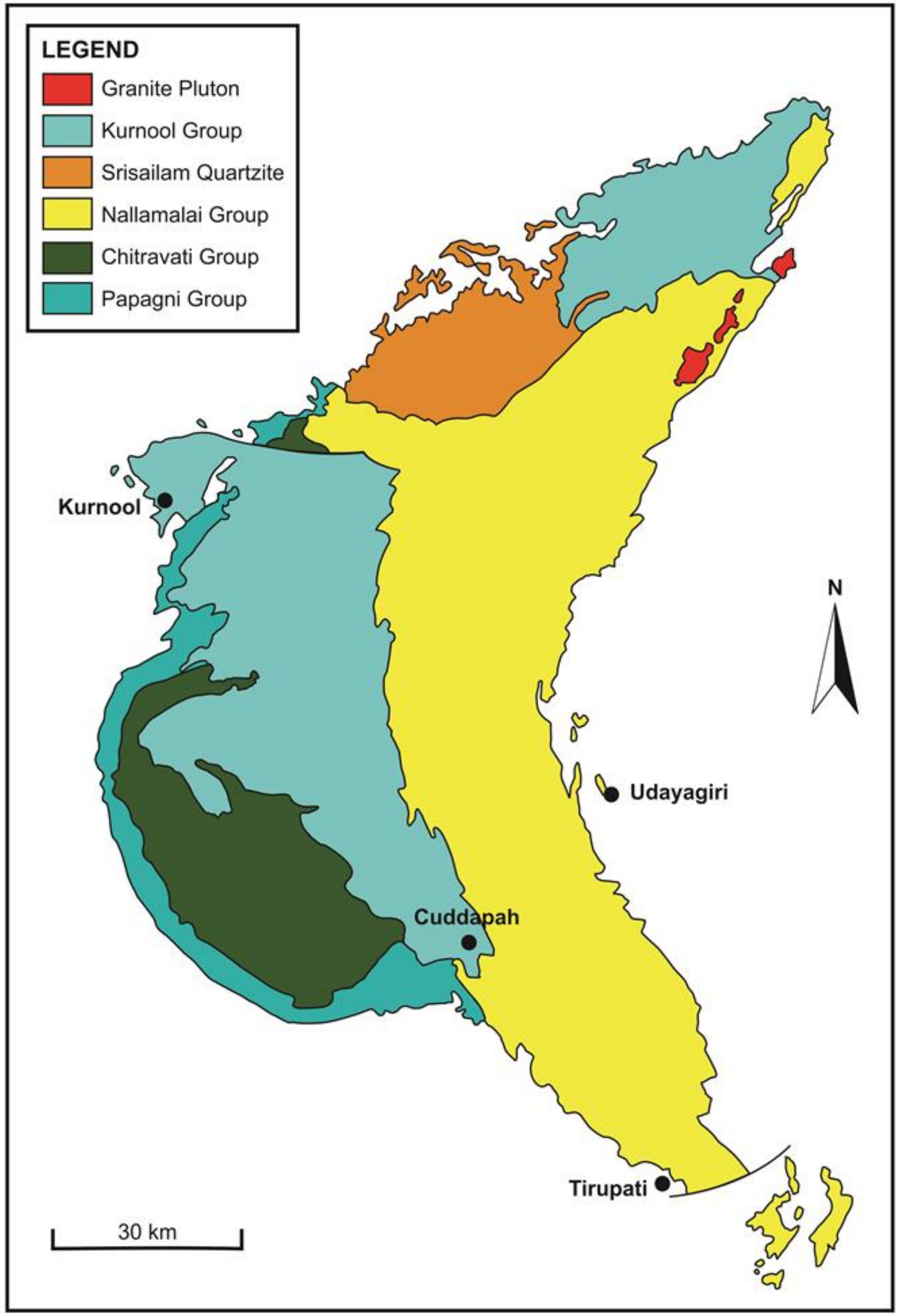
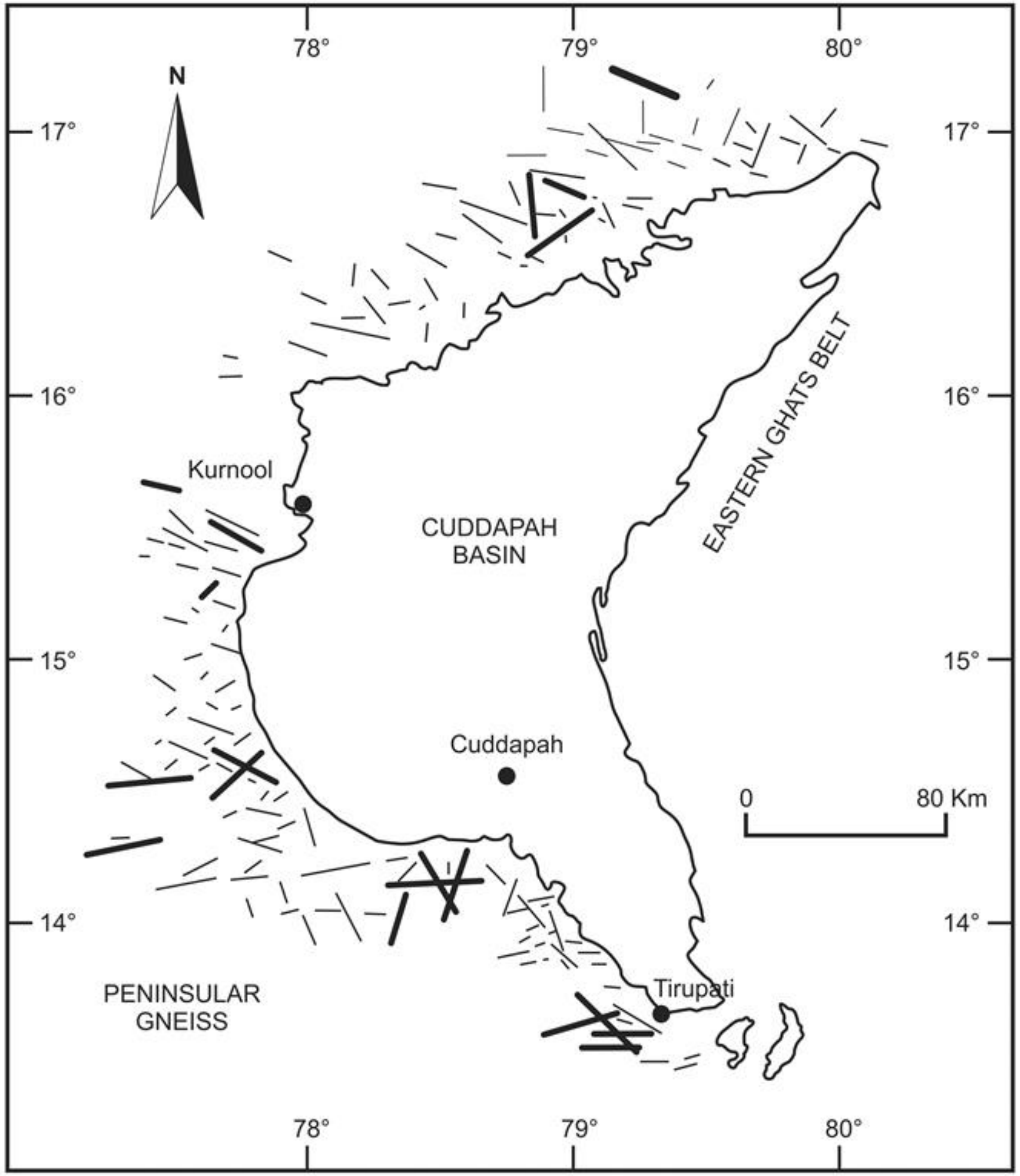
Cuddapah Basin:

- The Cuddapah Basin with its signature crescent shaped map pattern is the oldest and the largest Proterozoic intra-cratonic basin in the Indian Subcontinent.
- The aggregate total stratigraphic thickness is over 12 km.
- The concave outline of the eastern margin of the Cuddapah outcrop matches with the corresponding part of the eastern coast line of the India.
- Area wise the basin occupies about 44,000 sq. km.
- Thick sedimentary cover succession along with some volcanics and rare intrusions.
- The entire western part the basin overlies the Archaean granite-gneiss-greenstone rocks.
- The pronounced cross-cutting relationship between the Cuddapah and Archaean Dharwar belt rocks is described in the early literatures as ‘Eparchaean Unconformity’ making the Archaean-Proterozoic Boundary.
- On the eastern side occurs some ‘high grade schists’ belonging to Nellore-Khammam Schist belt which is now correlated with the Eastern Ghats Granulite belt.


LEGEND
Granite Pluton
Kurnool Group
Srisailam Quartzite
Nallamalai Group
Chitravati Group
Papagni Group
Kurnool
Udayagiri
Cuddapah
Tirupati
N
30 km

Dykes around Cuddapah

- The Dharwar Protocontinent was invaded by mafic dyke swarms most of which was in the eastern part.
- The intrusion of mafic dykes took place in three different stages during the period between 2369 and 2177 Ma.
- The dyke swarms are thought as the initial reflection of the thermal perturbation in the Mantle prior to the opening of the basin.
- Geophysical investigations suggest the presence of a large asymmetrical, lopolithic mafic pluton along the base of the basin.
- The evolution of Cuddapah Basin is linked with the cooling of the heat source in the deeper Crust.



78°
79°
80°
N
17°
16°
15°
14°
Kurnool
CUDDAPAH
BASIN
EASTERN GHATS BELT
Cuddapah
0
80 Km
Tirupati
PENINSULAR
GNEISS

Cuddapah Basin Evolution

- The Cuddapah Basin shows basin asymmetry in the depth of the basin-fills from east to west. The thin western beds show eastward increase in thickness to 6 km.
- The eastern margin of the Cuddapah Basin is marked by the prominent Ductile Shear Zone which has been interpreted as the zone thrusting.
- According to Singh and Mishra (2002), the eastern boundary of the Cuddapah Basin represents a ‘cryptic’ Suture Zone evolved during the amalgamation two different crustal provinces.
- Structurally, there is a wide a variation from in the nature of deformation from gentle, monoclinally tilted beds in the west to the arcuate pack of westerly overturned folds associated with thrusting and ductile shearing in the eastern beds.
- The eastern folded zone is known as Nallamalai Fold Belt. This eastern fold belt has been interpreted as an ‘indentation’ tectonic feature resulting from the collision of Dharwar Protocontinent with the Eastern Ghats tectonic front.

Lithostratigraphy of Cuddapah Basin

- The Cuddapah Basin includes two different lithostratigraphic ensembles, the older Cuddapah Supergroup overlain by the younger Kurnool Group.
- The Cuddapah Supergroup consists predominantly of clastic and chemogenic sedimentary rocks with minor intercalations of alkali to sub-alkali basaltic flows, mafic/ultramafic sills and ash fall tuffs in the lower part of the succession.
- The four-fold division of the Cuddapah depositories, overlain by a younger but similar sedimentary succession.
- Multiplicity in the proposals of lithostratigraphic succession of the basin prompted Ramakrishnan and Vaidyanadhan (2008) to comment on the ‘stratigraphic riddle’ in correlating rocks having similar lithological attributes and sedimentary structures in rocks deposited at different times in the various proposition of stratigraphic framework by different authors.
- Additional problems cropped up because of the observed movements noted in the outcrops along the criss-cross faults, much of which took place during the strong neotectonic (predominantly Quaternary) activities.

Neotectonism in Cudappah

- A sharp scarp face north of Tirupati, at the foot of the Tirumala Hills.
- The feature is a clear indication of neotectonic (Quaternary) deformation near the southeastern tip of the Cuddapah Basin.

	Group	Formation	Lithology
Cuddapah Supergroup	Krishna Group	Srisailam Formation (300 m)	Quartzites and slates
Cuddapah Supergroup	Nallamai Group	Cumbum (Pullampet) Formation (2000 m) Bairenkonda (Nagari) Formation (1,500-4,000 m)	Phyllite, Slate, quartzite, dolomite Quartzite, Shales, conglomerate with intrusives
Cuddapah Supergroup	Chitravati Group	Gandikota Formation (300 m) Tadpatri Formation (460 m) Pulivendla Formation (1-75 m)	Quartzite and Shale Shales, quartzite, dolomite, tuff, intrusives Conglomerate and quartzite
Cuddapah Supergroup	Papaghni Group	Vempalle Formation (1,900 m) Gulcheru Formation (28-210 m)	Stromatolitic dolomite, chert-breccia, quartzite, lavas and pyroclastics Conglometare, arkose, quartzite and shale
Dharwar gneisses, granite and schist belts			

Ages of Cuddapah Group

- There is no definite information on the precise age of development of the Cuddapah Basin.
- Based on the study of uranium mineralization in the Vempalle and Tadpatri Formations of the Cuddapah Supergroup, it is suggested that the deposition of these rocks was during 1756±29 Ma (Zachariah et al.,1999).
- A similar conclusion was drawn earlier by Bhaskara Rao *et* al. (1995) based on an age of 1817±24 Ma for the Pulivendla mafic sill. More precise date for the mafic sill intruding the Vempalle Formation comes from the U–Pb (baddeleyite) dating of 1885.4 ± 3.1 Ma (French et al. 2008).
- Earlier Anand et al. (2003) based on ^{40}Ar–^{39}Ar laser-fusion determinations on phlogopite mica, from the mafic–ultramafic sill-type intrusion in Tadpatri Formation had suggested that the initial phase of extension and volcanism in the Cuddapah Basin was at 1·9Ga.

On ages of Cuddapah

- An interesting study was made by Sai et al. (2016), who looking into the dominance of red beds in different Cuddapah formations inferred that the Gulcheru red beds (the oldest Cuddapah formation) overlying the basal conglomerates were deposited at around 2.1 Ga; a period that corresponds to the global oxygenation event and a period that witnessed deposition of red beds in the platform type of Proterozoic basins in the world.
- In absence of any definitive high precision age of the basin evolution of the Cuddapah Basin, we may assume that the opening of the Cuddapah Basin was around this date or little later correlatable with the Aravalli Supergroup in the northwestern part of the Peninsular India.

Cuddapah Basin Closing

- There is no information about the time of basin closing.
- However, information on folding and deformation event in the eastern most Nallamalai Fold Belt comes indirectly from the correlation of the deformation in the eastern part of the Cuddapah Basin with the event of collision between the Dharwar Protocontinent in the west and the Eastern Ghats Granulite Belt in the east. The timing of this event as suggested by Valdamani et al. (2012)based on the single zircon dating is 1.78 Ga. We may, therefore, logically conclude that 'inversion' of the Cuddapah Basin was earlier to this date.
- The Cuddapah Basin subsequent to the folding and shearing in the eastern Nallamalai Fold Belt was affected by some post-tectonic granite intrusions. One of these is the intrusion of the Vellaturu Granite in the north-eastern margin at around 1575 Ma.
- A unique feature known as 'Iswarakuppam Dome' in the central part of the Nallamalai Fold Belt. The broadly north-south dome shaped structure does not show parallelism with the fold trends in the Nallamalai Fold Belt. This feature could be the result of diapiric uprise of a (unexposed) granitic body.

Table 5.6. Lithostratigraphy of Cuddapah basin

			Formation	Lithology
	Kurnool Group (200-450)	Kundair Subgroup (75-150)	Nandyal Shale (50-100)	Shale, partly calcareous
			Koilkuntla Limestone (15-50)	Siliceous, shaly limestone with quartzite interbeds
			Paniam Quartzite (10-35)	Massive and pinnacled quartzite, siliceous shale, basal pebble bed
			-Paraconformity-	
		Jammalamadugu Subgroup (120-260)	Auk Shale (10-15)	Laminated shale, mostly ochreous with siltstone interbeds
			Narji Limestone (100-200)	Flaggy grey limestone, glauconitic sandstone interbeds
			Banganapalle Quartzite (10-50)	Oligomict conglomerate, 'grit', quartzite, shale
			-Unconformity-	
	(300)		Srisailam Quartzite (300)	Glauconitic ferruginous quartzite with shale
			-Unconformity-	
CUDDAPAH SUPERGROUP	Nallamalai Group (3500-6000)		Cumbum Formation (2000)	Mainly slate and phyllite, chert, dolomite
			Pullampet Formation (2000)	Shale, felsic tuff, barytes, dolomite, quartzite
			Bairenkonda Quartzite (1500)/	Quartzite, quartz wacke, shale
			Nagari Quartzite (4000)	Quartzite, quartz wacke, shale, basal conglomerate
			-Angular unconformity-	
	Chitravati Group (4900-5000)		Gandikota Quartzite (300)	Shale-quartzite alternations, glauconitic quartzite interbeds
			Tadpatri Formation (4600)	Shale, felsic tuff, basic sills and flows, chert, stromatolitic dolomite, quartzite
			Pulivendla Quartzite (1-75)	Quartzite and conglomerate
	Papaghni Group (2100)		Vempalle Formation (1900) with Kuppalapalle Volcanics	Stromatolitic dolomite, chert, quartzite, basic sills and flows
			Gulcheru Quartzite (30-210)	Basal conglomerate, arkose, quartzite with shale interbeds
			Crystalline basement of Dharwar craton	

*Numbers in parenthesis refer to thickness in metres

Deposition of Kurnool Group

- The deposition of the Kurnool Group ushered in a new phase of sedimentation in the Cuddapah Basin during the Neoproterozoic with a prolonged hiatus (Collins et al., 2014).
- The basal conglomerate of the Kurnool Group is known for occurrence of diamond. The source rock for the diamond is the diamond bearing kimberlite pipes located at Wajrakarur and some other areas surrounding the Cuddapah Basin. T
- he emplacement of these kimberlites, according to Chalapathi Rao et al. (2009) was during 1.1 Ga. We may therefore conclude that the deposition of the basal conglomerate of the Kurnool Group could only have taken place during early Neoproterozoic.

Bhima Basin

- The northeast-southwest oriented Bhima Basin consisting dominantly of carbonate cover is situated in the northwest of the Cuddapah Basin.
- The Bhima Basin also evolved over the Archaean granite-gneiss-greenstone sequence with a profound unconformity. The basin shows faulted contact with the basement at several places.
- The Bhima Group was deposited in the shallow marine and to the near shore environment in narrow depressions in the basement.
- The succession begins with a thin conglomerate horizon passing upward to the gritty arkosic sandstone to more mature sandstone. The succeeding formation includes repeated occurrence of limestone with some shale and cherty layers.

Lithostratigraphy of Bhima Basin

- Divided it into the lower Muddebehal Sandstones and the upper Talikote Limestones.
- The recent formal lithostratigraphic nomenclature was adopted by Janardhana Rao et al. (1975), who assigned this sequence the status of a 'Group', dividing it into the Rabanpalli Formation and Shahabad Formation.
- The lithostratigraphic details of the Bhima Group have been provided by Kale et al. (1990) who recognized two formations, namely the Rabanhalli clastics and Shahabad limestone.
- Two formations seem to represent two major sedimentological facies types showing gradational contact between them.
- The Rabanhalli clastics and Shahabad limestone are products of coeval sedimentation under two different depositional environments. Based on this correlation, the aggregate thickness of the basin depositories has been reduced from the earlier estimate of 270 m to about 150 m.
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Kaladgi Basin

- The east-west oriented Kaladgi Basin occurs in the northern part of the Archaean Dharwar Protocontinent unconformably overlying the Archaean gneiss-schist rocks in the south.
- The northern part of the basin is covered under the Deccan Trap.
- The exposed basin covers about 830 sq. km accommodating over 4,500 m thick sediments of the stand-shale-carbonate association with minor cherts (associated with fault breccia) and conglomerates deposited in continental, transitional and shallow-marine environments.
- Viswanathiah (1977) revised the stratigraphy describing lower formations as the Baglakot Group underlying the Badami Group.
- Later, Jayaprakash et al. (1987) provided further details on structure and stratigraphy of the basin. The geological map prepared by the authors, shows occurrence of the two groups in separate basins.
- The older Bagalkot Group which occurs in the central part is flanked by the younger Badami Group both in the north and in the south.

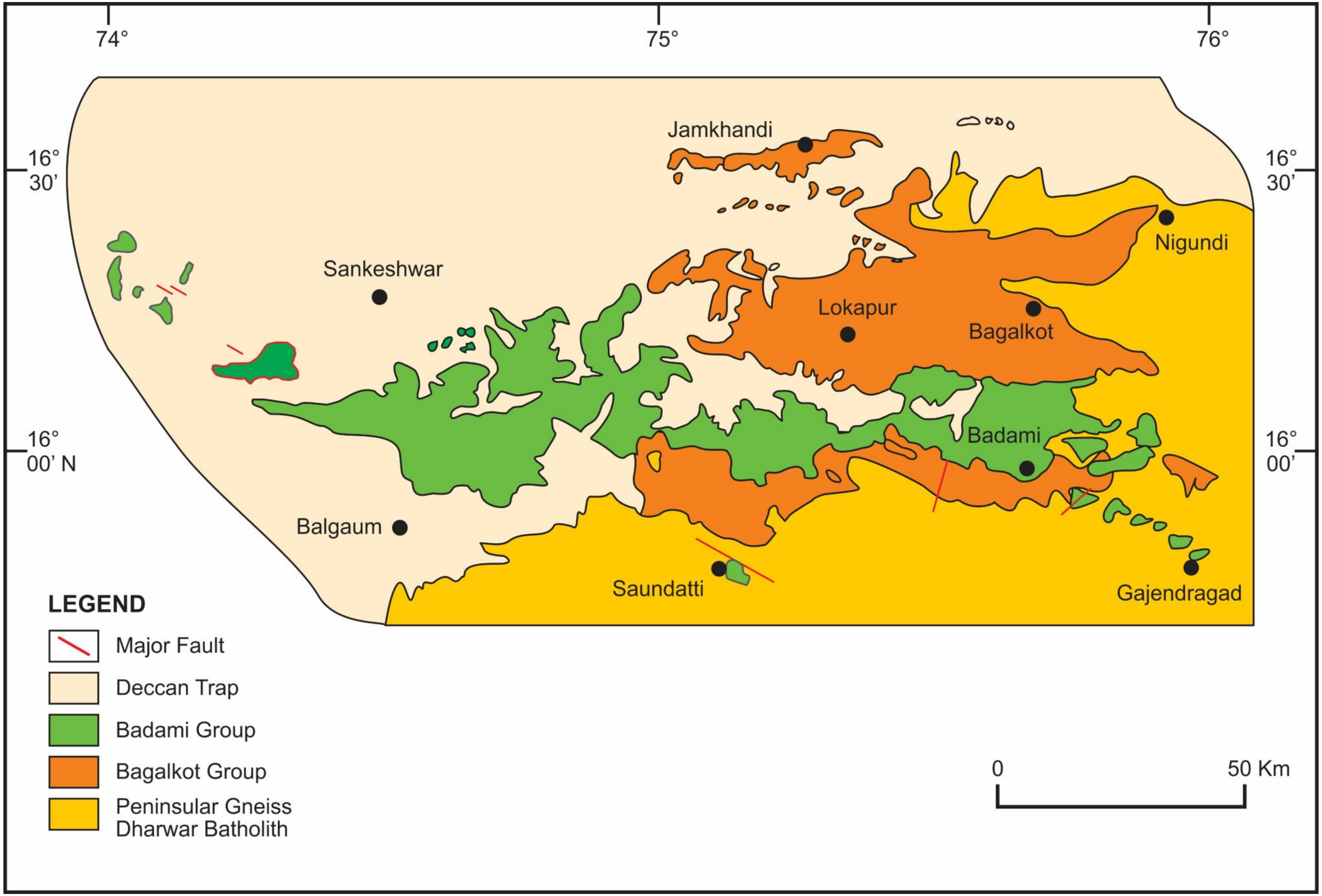
74°
75°
76°
16° 30'
16° 00' N
16° 30'
16° 00'
Jamkhandi
Sankeshwar
Lokapur
Bagalkot
Nigundi
Badami
Balgaum
Saundatti
Gajendragad
LEGEND
Major Fault
Deccan Trap
Badami Group
Bagalkot Group
Peninsular Gneiss
Dharwar Batholith
0
50 Km

Table 5.7. Lithostratigraphy of the Kaladgi basin

	Badami Group (285)	Katageri Limestone (150)	Limestone, shale
		Kerur Arenite (135)	Conglomerate, arenite, shale
		------ Angular Unconformity ------	
	Intrusives	Quartz veins, pegmatites, dolerite dykes	
BAGALKOT GROUP	Simikeri Subgroup (1150)	Hosakatti Argillite (700)	Argillite
		Arlikatti Dolomite (130)	Dolomite, hematite bed
		Niralkeri Breccia (40)	Chert breccia
		Kundargi Quartzite (280)	Conglomerate, quartzite, argillite
		------ Disconformity ------	
	Lokapur Subgroup (2750)	Yadahalli Argillite (60)	Argillite
		Muddapur Dolomite (565)	Dolomite, limestone, argillite
		Chikshellikeri Limestone (800)	Limestone, shale
		Yargatti Argillite (720)	Argillite, dolomite
		Mahakut Breccia (130)	Chert breccia
		Saundatti Quartzite (475)	Conglomerate, quartzite, shale
		------ Nonconformity and Angular Conformity ------	
		Gneisses/Granites and Schist Belts of Dharwar craton	

N.B. Thickness in metres is given in parenthesis

Bagalkot Group

- The lower Bagalkot Group start with conglomerate overlying the Archaean basement rocks with a pronounced erosion unconformity.
- A repeated fining upward sequence capped by carbonates overlies the basal conglomerate. The lower carbonate sequence shows development of stromatolitic dolomite in the middle part which is the thickest in the entire succession.
- Another characteristic feature of the upper sequence is the development of banded hematite quartzite in its succession. The Bagalkot Group is affected by intrusion of pegmatite and quartz veins, and a few dolerite dykes.

Deformation in Bagalkot Group

- The Bagalkot Group occurring in the middle of the basin shows folding having west northwest-east southeast axial trace. Rarely the folds are superposed by the north-south trending cross folds
- Though some east-west (or more precisely east southeast-west and northwest) trending folds have been described from the Bagalkot rocks, very little is known about the geometry of the folds described from the rocks of the Bagalkot Group.
- Available information, however, preclude the possibility that the folds originated by any crustal shortening process.

Bagalkot deformation contd.

- Mukherjee et al. (2016) have, however, explained that the folds have resulted due to the process of gravity gliding along inclined surfaces. The occurrence of seismites in the succession along with evidence of penecontemporaneous deformation in different sedimentary layers suggests the possibility of movement along active faults (Kale and Phansalkar, 1991), which may be indirectly support the suggestion made by Mukherjee et al. (2016) about gravity gliding on tilted surfaces.
- The map pattern of Bagalkot indicates that the ‘deformed’ Bagalkot rocks are flanked by ‘sub-horizontal beds’ of the Badami Group.
- The deformation in the Bagalkot rocks predated the deposition of the Badami Group. From the present disposition of the two sedimentary sequences showing occurrence of the two group of rock ensembles at the same level it may be suggested that the older Bagalkot rocks were vertically lifted by a system of vertical faults.

P-G Valley

- Simplified Geological map of Pranhita Godavari Valley showing distribution of Lithotectonic components