



# Pictorial Atlas of **Cuddapah Basin**

**Geological Survey of India**  
**2020**



# Pictorial Atlas of **Cuddapah Basin**

**Geological Survey of India**  
**2020**



# Pictorial Atlas of **Cuddapah Basin**

**Compiled by**  
Santanu Bhattacharjee  
V. V. Sesa Sai  
Vikash Tripathy

**Geological Survey of India**

**PUBLISHED BY ORDER OF THE GOVERNMENT OF INDIA**  
2020



## PICTORIAL ATLAS OF CUDDAPAH BASIN

© INDIA, GEOLOGICAL SURVEY (2020)

### **Compiled by**

Santanu Bhattacharjee, Director, Petrology Division, GSITI, Hyderabad

V. V. Sessa Sai, Director, SU: Maharashtra, GSI, Nagpur

Vikash Tripathy, Senior Geologist, Petrology Division, GSITI, Hyderabad

### **Overall guidance**

Shri Ch. Venkateswara Rao, Dy. Director General and Head M-V GSITI

### **Published by**

The Director General

Geological Survey of India

27, Jawaharlal Nehru Road

Kolkata- 700 016

**Front Cover:** Gandikota Quartzite, Gandikota Gorge along Penna River, Andhra Pradesh.

Photo by Dr. Santanu Bhattacharjee

**Inside back cover:** Gulcheru Quartzite nonconformably overlying over the Peninsular Gneiss, Kadiri-Rapur highway. Photo by Dr. Vikash Tripathy

**Back Cover:** Folds in Nallamalai Fold Belt, Kadiri-Rapur Highway, Andhra Pradesh.

Photo by Dr. Vikash Tripathy

### **Printed in India by**

K.V. Xerox

S.R Complex, Habsiguda Metro Station

Habsiguda, Hyderabad, Telangana 500007

# CONTENTS



Preface	i
Acknowledgment	iii
Introduction	1
Papaghni Group	7
Chitravati Group	29
Nallamalai Group	51
Srisaïlam Quartzite	79
Kurnool Group	83
Epilogue	113
Bibliography	115



**Tight overturned Cumbum quartzite east of  
Petasannigandla, Guntur district, Andhra Pradesh**



## Foreword

**A** lot has been said and searched in Cuddapah Basin for the past 150 years. The understanding of the stratigraphy, structural disposition, mineral deposits, arcuate nature of the basin, volcanic activities and its relation to sedimentation and age, relation between sub-basins, relation to adjacent mobile belt and to other similar sedimentary basins of India and many more aspects were dealt by some of the greatest mappers and geologists to unravel the unknowns.

Accounts from Colonel Colin Mackenzie in 1794 about diamond horizons of Kurnool district were the first geological records. The classical memoir by William King in 1872 records the pioneer works of the Geological Survey of India by the greats like Charles Oldham, William King and R. Bruce Foote that includes the stratigraphy of the basin - untouched except for minor modifications by later workers namely Meijerink et al., 1984; Nagaraja Rao et al., 1987 etc. With the advancement of technology and availability of instruments, radiometric dating of various units of Cuddapah basin were undertaken (e.g., Vempalle Formation 1.9-2.0 Ga, Rai et al., 2015). The basin not only hosts world's best barytes deposit in the Nallamalai Fold Belt but also hosts one of the largest low grade uranium deposits at Tummalapalle in Andhra Pradesh.

In pursuit of showcasing the Indian Geology at the 36th International Geological Congress, 2020 and for displaying the geological wealth of the nation to the global researchers and new budding geoscientists, this Pictorial Atlas of Cuddapah Basin is a sincere attempt by the authors. This publication will definitely attract the scientific community visiting India on the occasion of IGC, 2020. I congratulate the authors for their endeavour and sincere hard work which deserves appreciation for producing a pictorial presentation of various rocks and structures in one of the largest Proterozoic sedimentary basins in India.

**M. Sridhar**  
Director General  
Geological Survey of India



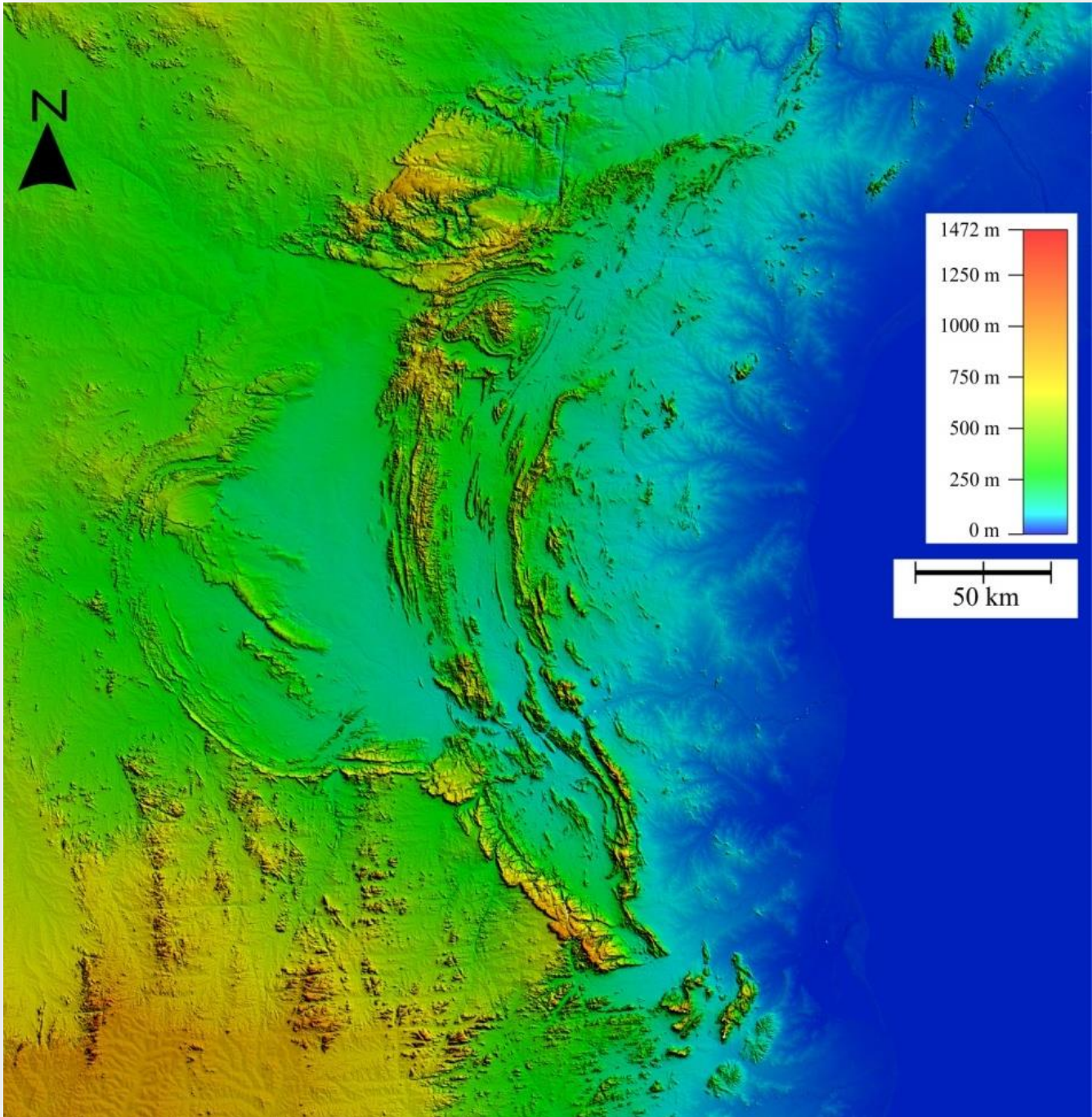
**Pyroclastic rocks in Vempalle Formation, Lingala,  
Cuddapah district, Andhra Pradesh**



## Acknowledgment

The initiative to prepare the Pictorial Atlas on Cuddapah Basin is an attempt by the Geological Survey of India to display one of the largest Proterozoic sedimentary basins of India. The authors sincerely thank the Director General, Geological Survey of India for giving the responsibility of writing the document, providing administrative and financial support for preparation of this atlas. The authors are also grateful to the Shri Ch. Venkateswara Rao, Dy. Director General and Head M-V GSITI for providing administrative support and encouragement in this endeavour. Shri M. Raghupathy, DDG, IA & IGC and Shri Basudev Roy, Director (Retd.) are also thanked for facilitating this work. Authors are grateful to Shri Bhriugu Shankar, Supdtg. Geologist, CHQ, Kolkata for his constructive suggestions that benefited the atlas. We sincerely acknowledge the efforts put by the team of Publication Division of Central Headquarters, GSI Kolkata for providing all the necessary support in this endeavour.

The Atlas is a compilation of field photographs taken by the authors during their fieldwork and by a number of contributors who readily provided classical representative field photographs from various parts of the Cuddapah Basin. We sincerely thank all the contributors mentioned in the exhaustive list for their passion for the Cuddapah Basin which includes Prof. Dilip Saha, Professor, Indian Statistical Institute, Kolkata, Dr. K.N. Srinivasan, Director (Retd.) GSI, Shri K.J. Babu, Supdtg. Geologist, GSI, Shri S.T. Narahari, Supdtg. Geologist, GSI SR, Hyderabad, Shri Praveer Pankaj, Supdtg. Geologist, GSI, CR, Nagpur, Shri Satyapal, Senior Geologist, SU: Rajasthan, GSI, WR, Jaipur, Dr. Rimpal Kar, Senior Geologist, GSI, SR, Hyderabad, Shri J.K. Aravind, Senior Geologist, SU: Assam, Guwahati, Shri Rohit Gajbhiye, Senior Geologist, GSI, NER, Shillong, Ms. Parvathy R Krishnan, Senior Geologist, GSI, Bangalore, Ms. Praseetha Sugathan, Senior Geologist, SU: K&G, Bangalore, Shri Sankha Das, Senior Geologist, CHQ, GSI, Kolkata, Ms. Shampa Khan, Senior Geologist, CPL, CHQ, GSI, Kolkata, Shri Gopakumar B, Senior Geologist, MCSD, GSI, Mangalore, Ms. Nibedita Sahoo, Senior Geologist, SU: TN & P, GSI, Chennai, Ms. Munmun Chakraborty, Senior Geologist, SU: Telangana, GSI, SR, Hyderabad and Shri Vikas Mistry, Geologist, SU: Gujarat, GSI, WR, Gandhinagar.



**Shuttle Radar Topography Mission (SRTM) 30m Digital Elevation Model (DEM) of Cuddapah Basin. Source: earthexplorer.usgs.gov**

## INTRODUCTION

**T**he Cuddapah Basin is a crescent shaped Proterozoic intracratonic basin, overlying non-conformably on the Eastern Dharwar Craton.

The basin has a strike length of about 440 km and about 200 km wide occupying 44,000 sq. km having cumulative sedimentary thickness of >12 km.

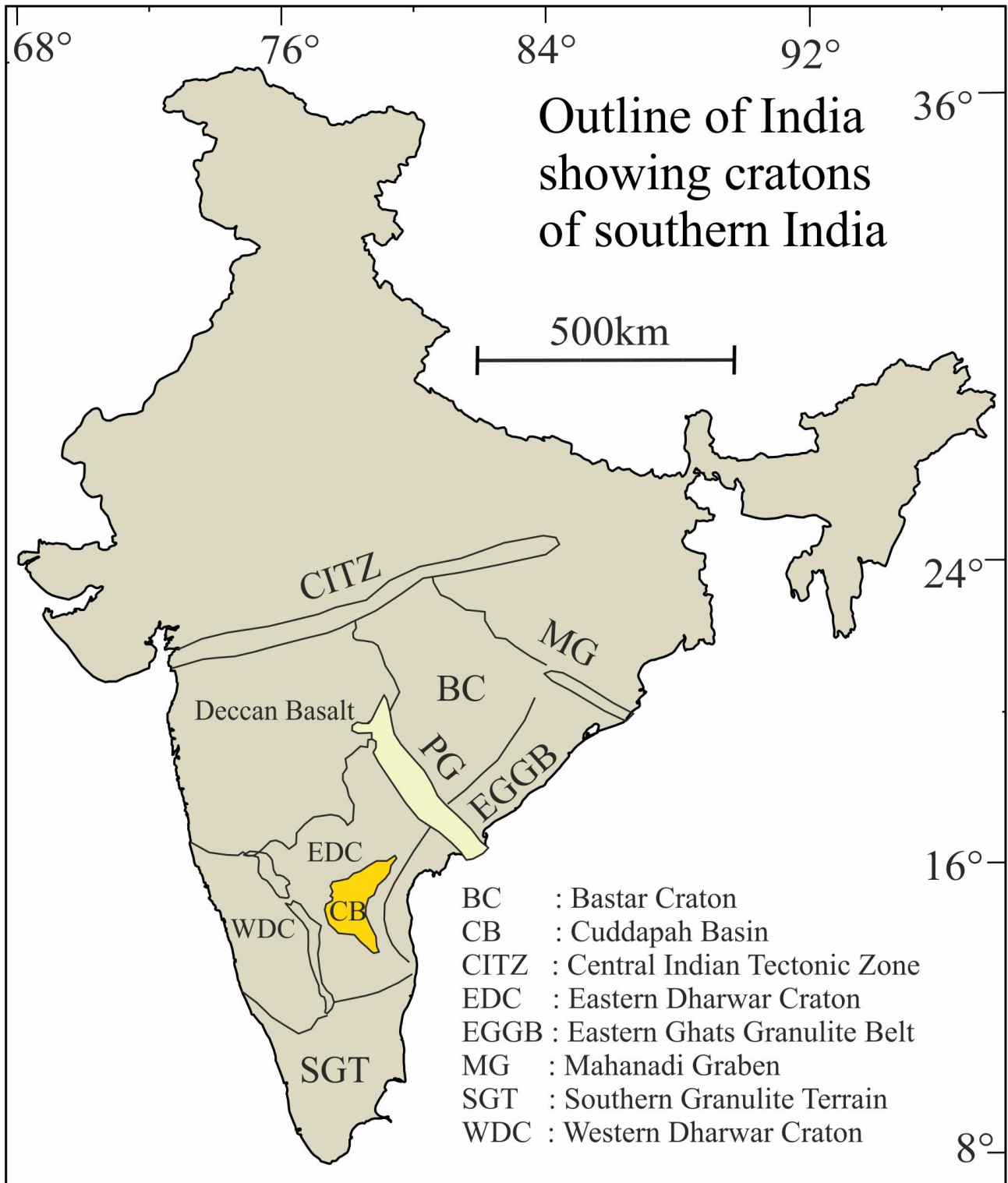
The basin comprises the Cuddapah Supergroup and the Kurnool Group of sediments.

The basin is bordered by Eastern Ghat Orogen along the eastern margin and Dharwar Craton on all the other sides.

The eastern margin of the basin has an easterly dipping thrust over which the lithounits of the Nellore Schist Belt act as hanging wall.

The basin is sub divided into

- (a) Papaghni sub-basin
- (b) Nallamalai sub-basin
- (c) Srisailam sub-basin
- (d) Kurnool and Palnad sub-basins





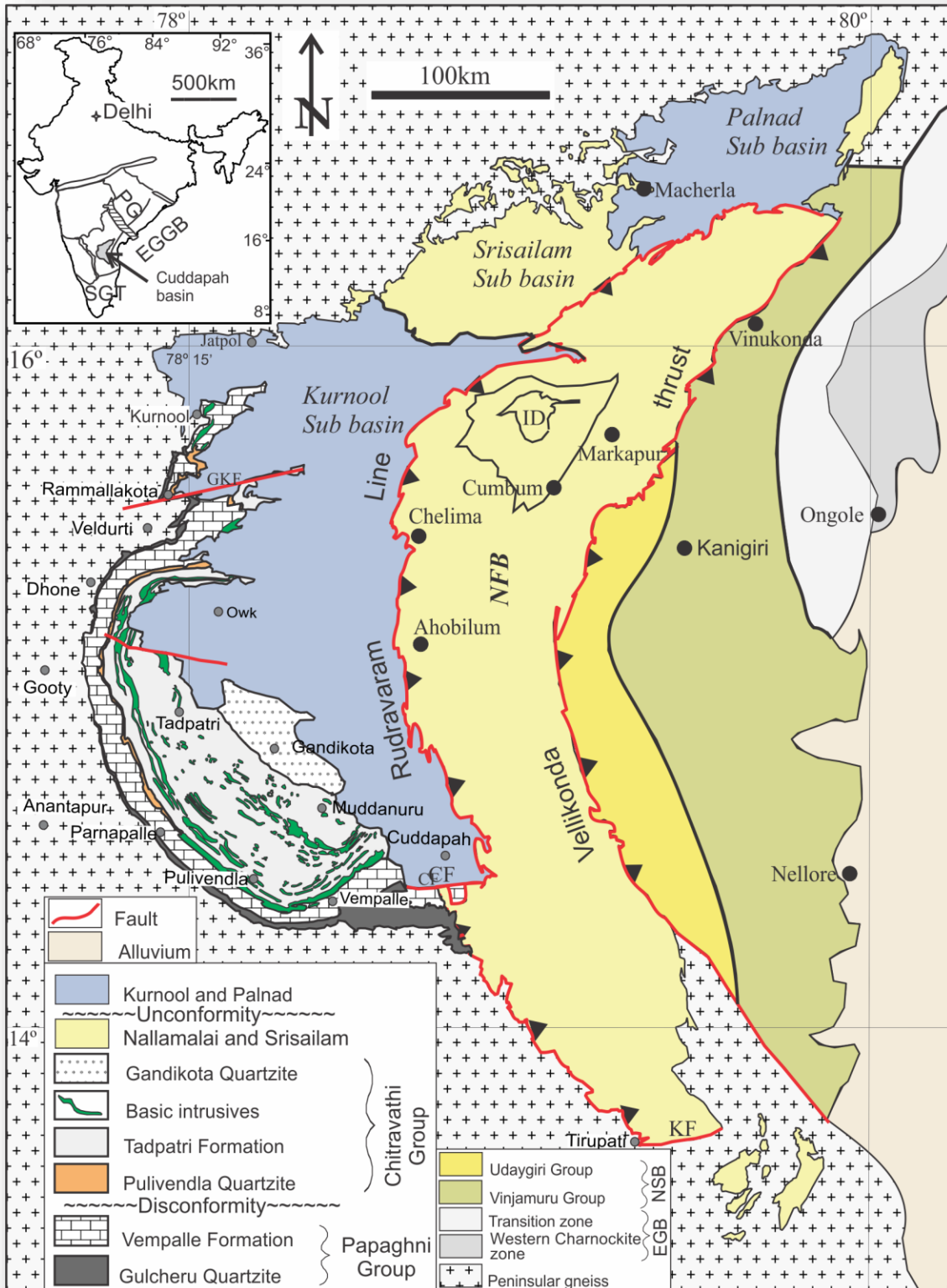
*The Cuddapah Supergroup is subdivided into four sequences namely Papaghni, Chitravati and Nallamalai groups and Srisailam Formation which are separated by unconformities.*

*The Cuddapah Supergroup, is composed dominantly of argillaceous and arenaceous sedimentary rocks with subordinate calcareous deposits and minor intercalations of alkali to sub alkali mafic flows, mafic to ultramafic sills and ash falls.*

*The basal Papaghni Group of the Papaghni sub-basin is exposed as a narrow, arcuate strip along the western and southwestern margin of the basin and comprises the lowermost Gulcheru Quartzite (28-250 m thick) overlain conformably by the Vempalle Formation (up to 1500 m thick).*

*The Chitravati Group consists of Pulivendla Quartzite (75m), Tadiatri Formation (4600m) and Gandikota Quartzite (300m) and the Nallamalai Group consists of Bairenkonda Quartzite (3200m) and Cumbum Formation (1600m).*

*Stratigraphically, the Cuddapah Supergroup is unconformably overlain by the Kurnool Group, a 500 m thick orthoquartzite-carbonate-shale association with a basal conglomerate.*



**Simplified geological map of the Cuddapah basin, modified after Nagaraja Rao et al., (1987) and Geological Survey of India (1990), Geological quadrangle map 571. Abbreviations: CF=Cuddapah fault; GKF=GaniKalva fault; ID=Iswarakuppam dome; KF= Karkambadi fault; NFB=Nallamalai fold belt**



Group	Formation (max. thickness)	Unit	Age
Kurnool Group	Nandyal Shale (100m)	Shale	
	Koilkuntla Limestone (50m)	Limestone	
	Paniam Quartzite (35m)	Quartzite	
	Owk Shale (15m)	Shale- Ocherous	
	Narji Limestone (200m)	Limestone	
	Banganapalle Quartzite (50m)	Conglomerate, quartzite	
~~~~~ Unconformity ~~~~~			
	Srisaillam Quartzite (300m)	Quartzite and Shale	
~~~~~ Unconformity ~~~~~			
Nallamalai Group	Cumbum (Pullampet) Formation (1600m)	Phyllite, slate, quartzite, dolomite and shale, felsic and mafic intrusives	Chelima lamproite (1350 ± 52 Ma) (Chalapathi Rao et al., 1996)
	Bairenkonda (Nagari) Formation (3200m)	Quartzite, shale, conglomerate.	
~~~~~ Unconformity ~~~~~			
Chitravati Group	Gandikota Quartzite (300m)	Quartz arenite and shale	
	Tadpatri Formation (4600m)	Shale with arenite, dolomite, limestone, chert, tuff and ultramafic, mafic intrusions and flows	Felsic tuff - 1862 ± 9 Ma (Sheppard et al., 2017). Ultramafic sill 1817±24 Ma Rb-Sr Bhasker Rao et al. (1995). 1.9 Ga <sup>40</sup> Ar- <sup>39</sup> Ar, (Anand et al., 2003). 1885.4±3.1 Ma U-Pb (French et al., 2008)
	Pulivendula Quartzite (75m)	Matrix supported polymict conglomerate, quartzite	
~~~~~ Disconformity ~~~~~			
Papaghni Group	Vempalle Formation (1900m)	Dolomite with chert, siltstone with basic flows and intrusions	1841±71 Ma K-Ar (Murty et al., 1987) 1900 - 2000 Ma Pb-Pb (PbSL) (Rai, et al., 2015)
	Gulcheru Quartzite (210m)	Arenite with minor shale, Matrix supported, polymict conglomerate, arkose, quartzite.	
~~~ Nonconformity (western margin) ~~~		~~~ Tectonic contact (Eastern margin) ~~~	
Dharwar (Archean): Gneiss, schist belts, dykes, volcanics etc		Eastern Ghats, Nellore Schist Belt (Proterozoic)	
			Archean

### Stratigraphy of Cuddapah Basin after Nagaraja Rao et al., (1987)



**The Gulcheru Quartzite overlying nonconformably over the Peninsular Gneiss  
Tandrapadu, SE of Kurnool, Andhra Pradesh**

## PAPAGHNI GROUP

### Gulcheru Quartzite

The Gulcheru Quartzite is widespread along the west of the preserved basin margin, where it overlies a variety of Peninsular gneisses and Dharwar greenstone belts of Archaean age above a distinct angular unconformity. The lower Gulcheru member, a conglomerate and quartzite, with intercalations of shale and ferruginous bands, overlies the Archaean unconformably in the northern half of the sub-basin, but in the southern half there is little trace of the conglomerate. The thickness of the quartzite member is not uniform; it increases towards the southern end of the preserved sub-basin.

The basal conglomerate grades to pebbly sandstone/sandstone. Several such cycles can be seen in the basal beds. The conglomerate displays a variation in the clast composition from north to south reflecting a variation in provenance. Vein quartz is the dominant lithoclast in the Gulcheru conglomerate and therefore are termed as quartz pebble conglomerates. Besides vein quartz, chert is predominant in the north; jasper and granite clasts are



*conspicuous in the west and southwest. Clay, silt and sand constitutes the matrix.*

*Above the conglomerate unit lies the pebbly quartzite/quartzite unit displaying planar/trough cross bedding and asymmetrical ripples. The Palaeocurrent rose diagrams in the Gulcheru Quartzite are unimodal. Along Kurnool, Veldurti and Dhone sections the palaeocurrents are generally east directed, in the Pyapili section it is towards northeast, in the Nayanapalli section it changes to southeast and further in south along the Kadiri - Pulivendla section it swings to northeast/north northeast direction.*



**Nonconformity between the Gulcheru Quartzite and basement Peninsular gneiss, Namalagundu Temple, along Kadiri-Pulivendula highway, Andhra Pradesh**



**Nonconformity between the sub-horizontally lying Gulcheru Quartzite and sub-vertical Banded Iron Formation (BIF) of the Gadwal schist belt, Jaganathgutta section (N15°44'41.59": E78°01'54.58", Narnuru and Kurnool-Hyderabad highway)**

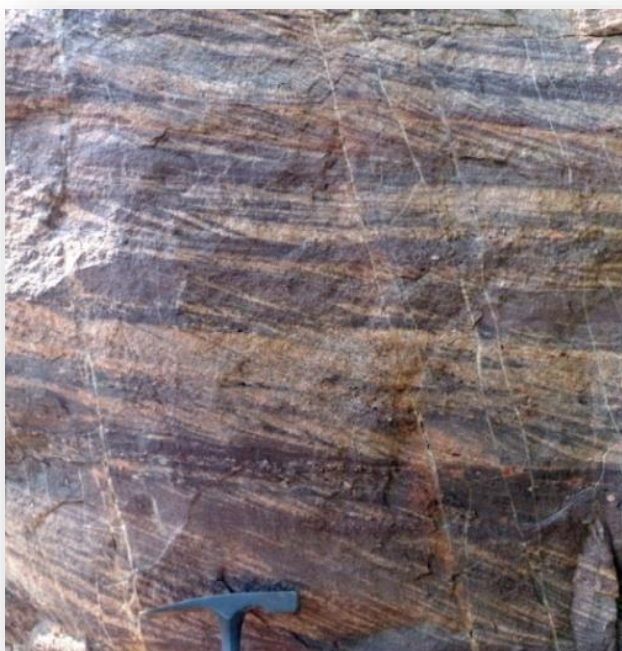


**Gulcheru conglomerate, near Jaganathkonda near Kurnool, Andhra Pradesh**

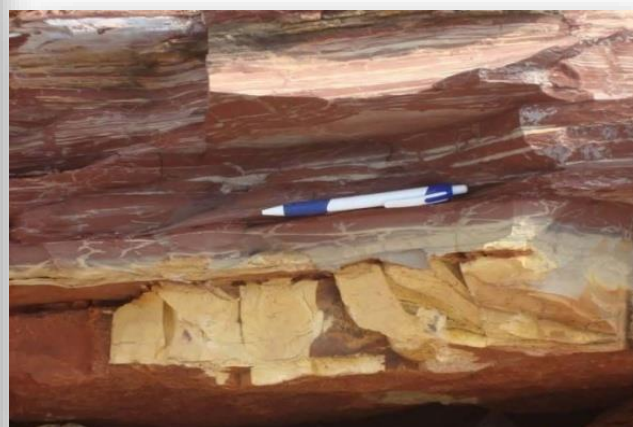
*The lower part of the Gulcheru Quartzite shows fining upward sequences of sediments which is understood to have deposited in an alluvial fan with high energy sheet flows or lateral movement of alluvial fans. The presence of asymmetrical ripples suggests a unidirectional flow of current as seen in fluvial system. Therefore, Gulcheru Quartzite is interpreted to represent an alluvial fan to fluvial depositional setting.*



**Gulcheru conglomerate having mafic clasts, Tandrapadu section, Kurnool district**



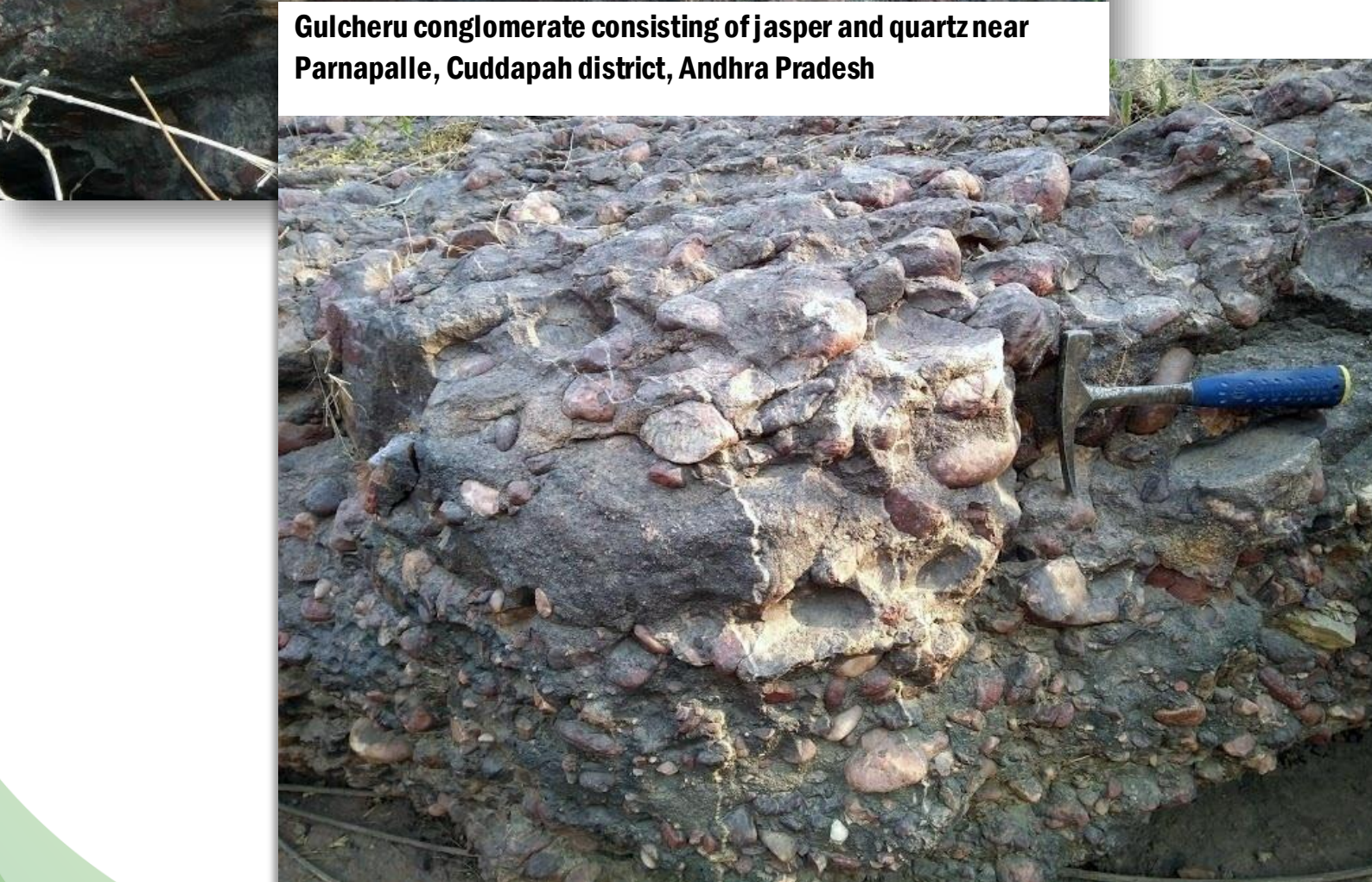
**Cross bedding in Gulcheru Quartzite along Kadiri-Velpula road section, Andhra Pradesh**



**Intercalated red shale in Gulcheru Quartzite near Vangapalle, Dhone, Kurnool district, Andhra Pradesh**



**Gulcheru conglomerate consisting of jasper and quartz near Parnapalle, Cuddapah district, Andhra Pradesh**

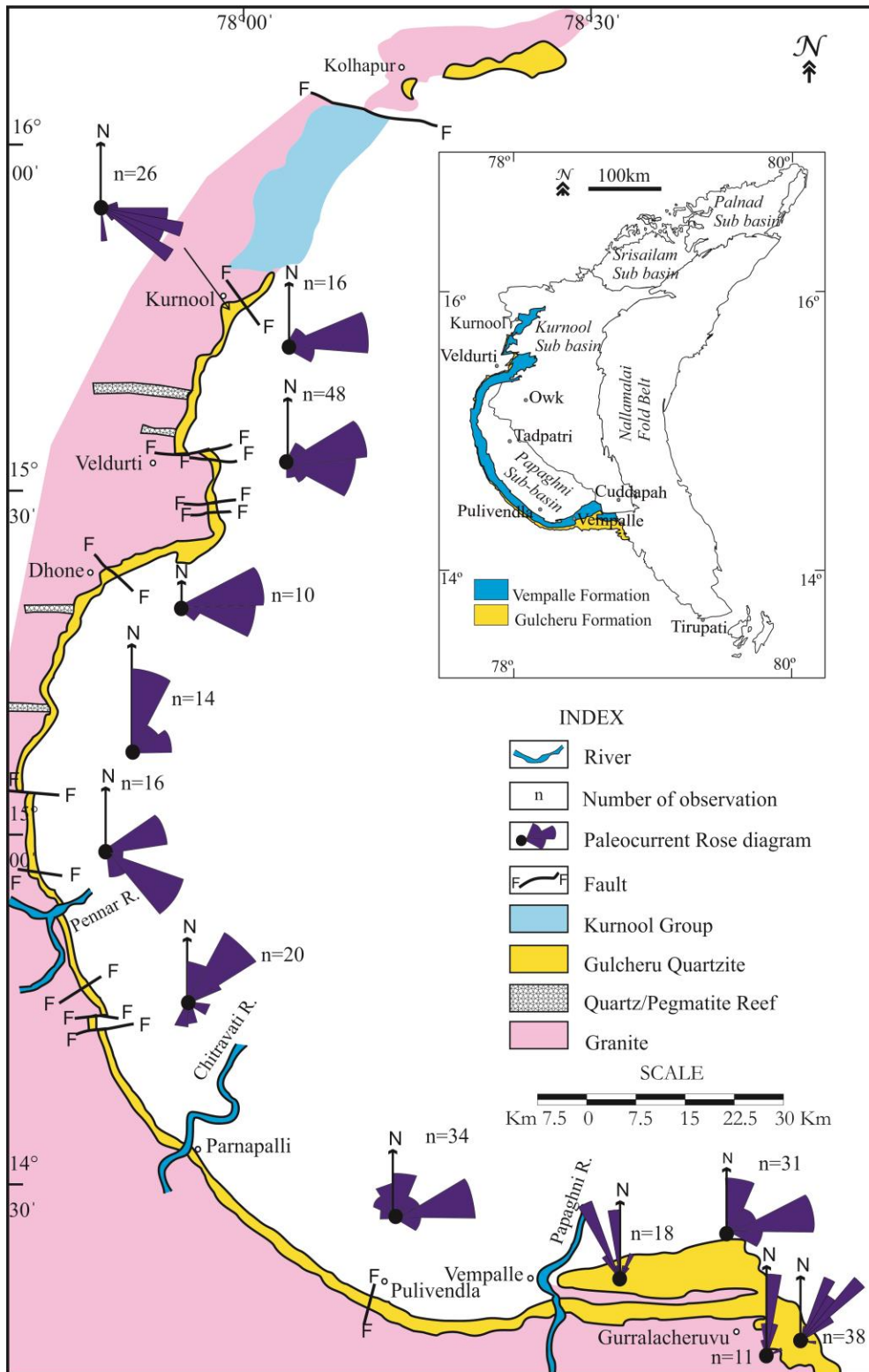




**Pebbly arenite in Gulcheru Quartzite Kurnool section, Andhra Pradesh**



**Cross bedded Gulcheru Quartzite Motnupalalle section, Andhra Pradesh**



**Rose diagram of paleocurrents as recorded from Gulcheru Quartzite from western part of the Cuddapah Basin. Data from Lakshminarayana et al., 2001 and Saha and Tripathy, 2012**



**Summarised lithologs of Gulcheru Quartzite from various locations (from Lakshminarayana et al., 2001)**



**Minor fault within the Gulcheru conglomerate horizon, Tandrapadu, SE of Kurnool**

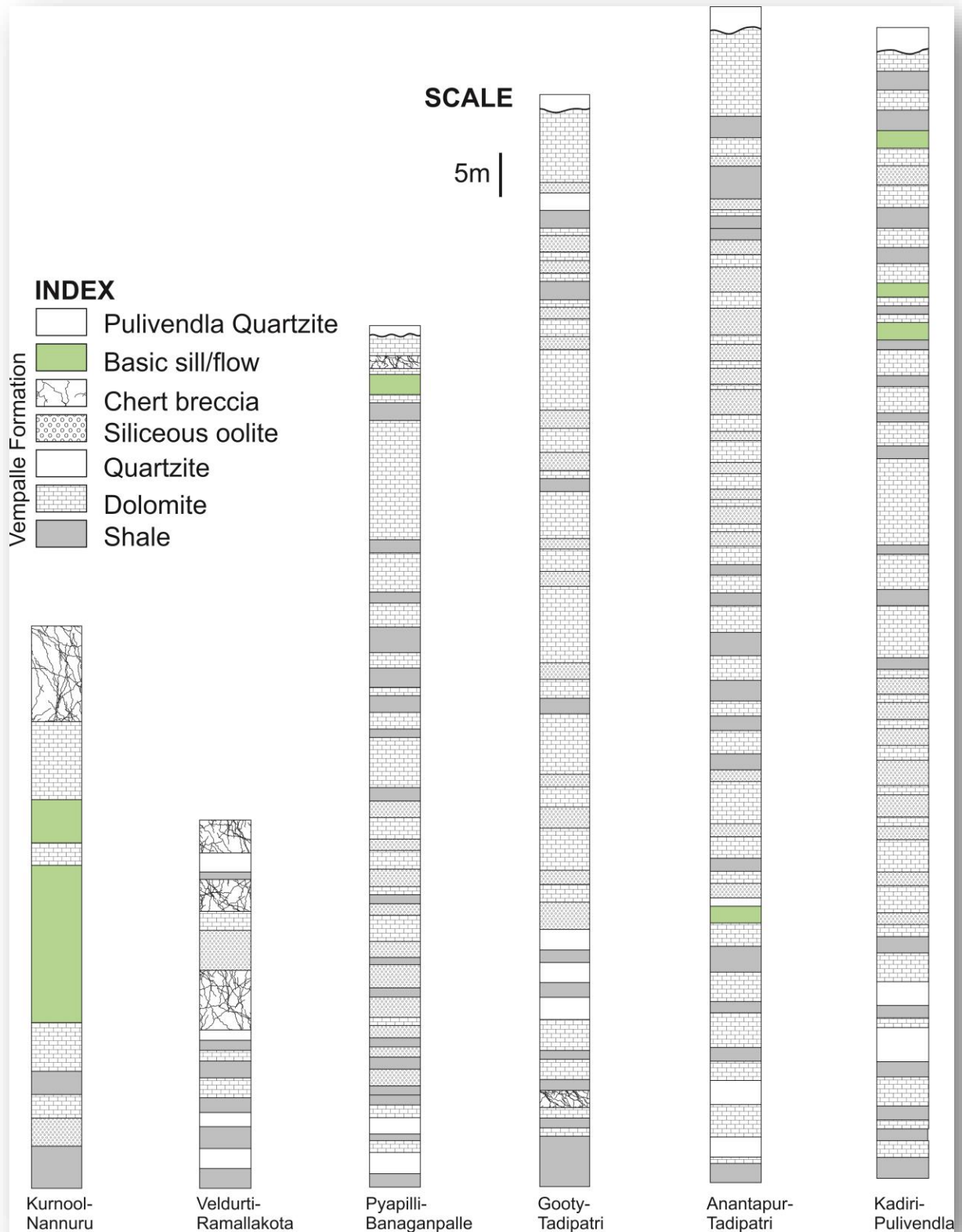


**Polymictic paraconglomerate, extraformational jasper dominated, rounded to subrounded granitic clasts in Gulcheru Quartzite**



## Vempalle Formation

The Vempalle Formation conformably overlies the siliciclastic Gulcheru Quartzite and consists essentially of shale, stromatolitic dolomites, siliceous oolite, calcareous sandstone and chert/chert breccia. It also crops out along the western and southwestern margins of the basin. Basic sills and volcanic flows are found associated with the Vempalle dolomites. Barytes, asbestos, pyrophyllite mineralization occurs at the contact of the dolomite with these mafic flows. The basal Vempalle Formation comprises a litho assemblage of shale, siltstone, calcareous sandstone and stromatolitic dolomite. The basal units are associated with uraniferous and phosphoric horizons. Cyclic sequences of siliceous oolites and dolomite are the prominent units of the middle part of the Vempalle Formation. Siliceous oolite beds are made of mustard seed size well rounded siliceous oolite grains displaying tabular, trough, flaser and herringbone cross stratification. SEM and EPMA studies indicated that the oolites were deposited as calcareous and later silicified. The dolomite beds of the middle sequence vary in thickness from few cm to over 3 m and are extensively quarried for industrial use and is abundant in stromatolites viz., *Colonella* Fm, *Cryptozoon* Fm, *Colonophyton* Fm and *Jacutophyton* Fm.



**Lithologs of Vempalli and Pulivendla Quartzite at various locations (from Lakshminarayana et al., 2001)**



**Vempalle dolomite conformably overlying Gulcheru Quartzite, Motnutalapalle, Cuddapah district**

*The upper part of Vempalle Formation consists of dolomite with shale and chert beds. The chert beds are found to contain lenses and laminations of quartz arenite displaying transformation from the detrital quartz grains to chert. The dolomite displays Omchtenia Fm, Sratifera Fm, Kuisella Fm, Jurusania Fm, Anabaria Fm, Zymnosolen Fm, Conophyton Fm and Inzeria Fm. The regional palaeocurrent direction was towards east during Vempalle sedimentation.*

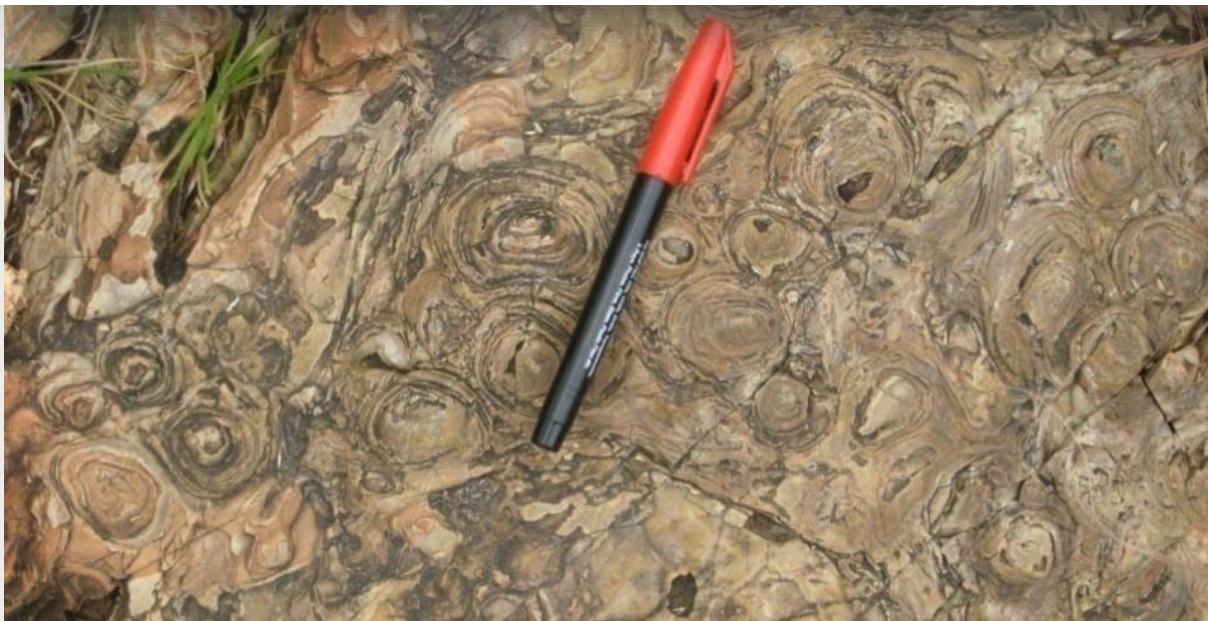
*The Vempalle Formation begins with fine clastics indicating a low energy depositional environment viz., lagoonal/deep marine. The initial depositional setting seems to represent a*



*period of either relative sea level rise or a loss of sediment source. The middle units displaying herringbone cross stratified siliceous oolite beds together with chert indicate a tidal environment. The chert beds represent erosional surfaces indicating periods of exposure.*



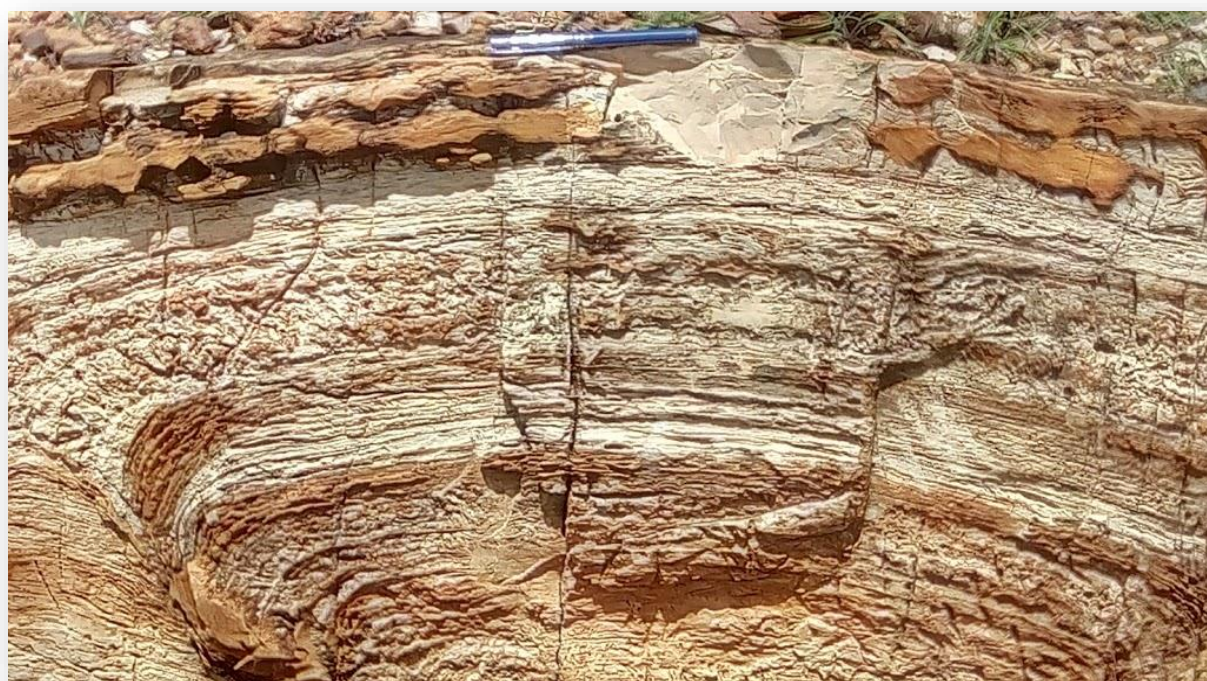
**Stromatolitic dolomite in Vempalle Formation, Betamcherla-Kumool Road, Andhra Pradesh**



**Stromatolitic dolomite Vempalle Formation, NW of Pulivandula, Chinnakudala, Cuddapah district, Andhra Pradesh**



**Stromatolitic dolomite in Vempalle Formation, Kalvabugga-Paniam Road section**



**Stromatolitic Vempalle dolomite with chert bands (upper part of the photograph)**



**Pillowed basalt fragments in mafic agglomerate Vanambayi section, SW part of Cuddapah Basin**



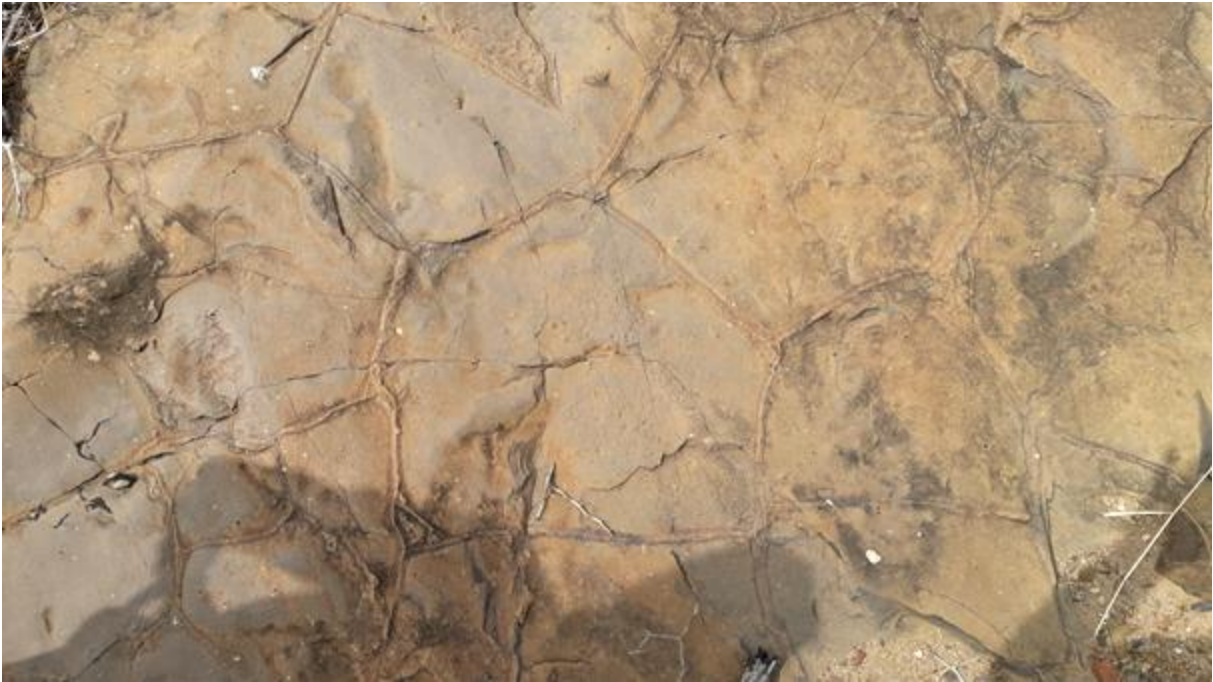
**Basic flow over Vempalle dolomite, east of Bavipalli Village, Peapully, Kurnool District, Andhra Pradesh**



**Pillow structure in basaltic flow near Malkapuram**



**Vesicular basic flow in Vempalle Formation, east of Motnutalapalle, SW part of the Cuddapah Basin**



**Columnar basalt in Vempalle Formation, Lingala, Cuddapah district, Andhra Pradesh**



**Pyroclastic breccia, Vempalle Formation, Lingala, Cuddapah district, Andhra Pradesh**



**Intercalated Chert in Vempalle dolomite near Namalagundu section, Anantapur District, Andhra Pradesh**



**Siliceous oolitic dolomite in Vempalle Formation, west of Velpula (N14°21'54.12": E78°15'00.27"). Photomicrograph showing the spherical to oval shaped oolites**



**Nodular Baryte in intercalated red shale signifying evaporate conditions near Lopatnutula**



**Sorting of Baryte at the Baryte mine NW of Velpula; N14°22'06.64": E78°16'03.63"**



**Chrysotile asbestos at the zone of serpentinization between dolerite sill and dolomite in Vempalle Formation, SW of Pulivendula; N14°24'32.66": E78°11'53.63").  
Inset: alternate bands of chrysotile and serpentine**

*The Tummalapalle uranium deposit is hosted in dolomite of Vempalle Formation is a syn-sedimentary deposit with discrete uranium phases of pitchblende and coffinite. It is estimated to have >100,000 tonnes of uranium with average grade of 0.045%  $U_3O_8$  (Goswami et al., 2017). The mine is located in Tumalapalli village located in Cuddapah district, Andhra Pradesh and is run by Uranium Corporation of India (UCIL). Pb-Pb radiometric dating of Vempalle dolomite by Rai et al. (2015) suggests their deposition at around 2000 Ma while the diagenesis, dolomitization and syn-diagenetic uranium mineralisation to be happening till 1900 Ma.*



**Tummalapalle uranium mine (photo from <http://www.ucil.gov.in/tummalapalleproject.html>)**



**The Brahmagundam Iron Ore mine, Veldurthi, Kurnool district, Andhra Pradesh is a high-grade hydrothermal deposit of specular haematite occurring along Gani-Kalva fault zone that cuts through the Cuddapah Supergroup and Kurnool Group. A total reserve of 3.7 Mt of ore with 50% to 60% Fe is estimated in the area.**



## CHITRAVATI GROUP

The Chitravati Group has a similar distribution along the preserved western Cuddapah Basin margin to the basal Papaghni Group as its lower counterparts. It consists of three formations Pulivendla Quartzite, Tadpatri Shale and Gandikota Quartzite disconformably overlying the Papaghni Group. The end of Vempalle sedimentation is marked by an episode of volcanic activity exposed in Betamcherla, Parnapalle and Kuppalapalle. The 20 - 40 m thick Pulivendla Quartzite unconformably overlies the mafic lava flows.

### Pulivendula Quartzite

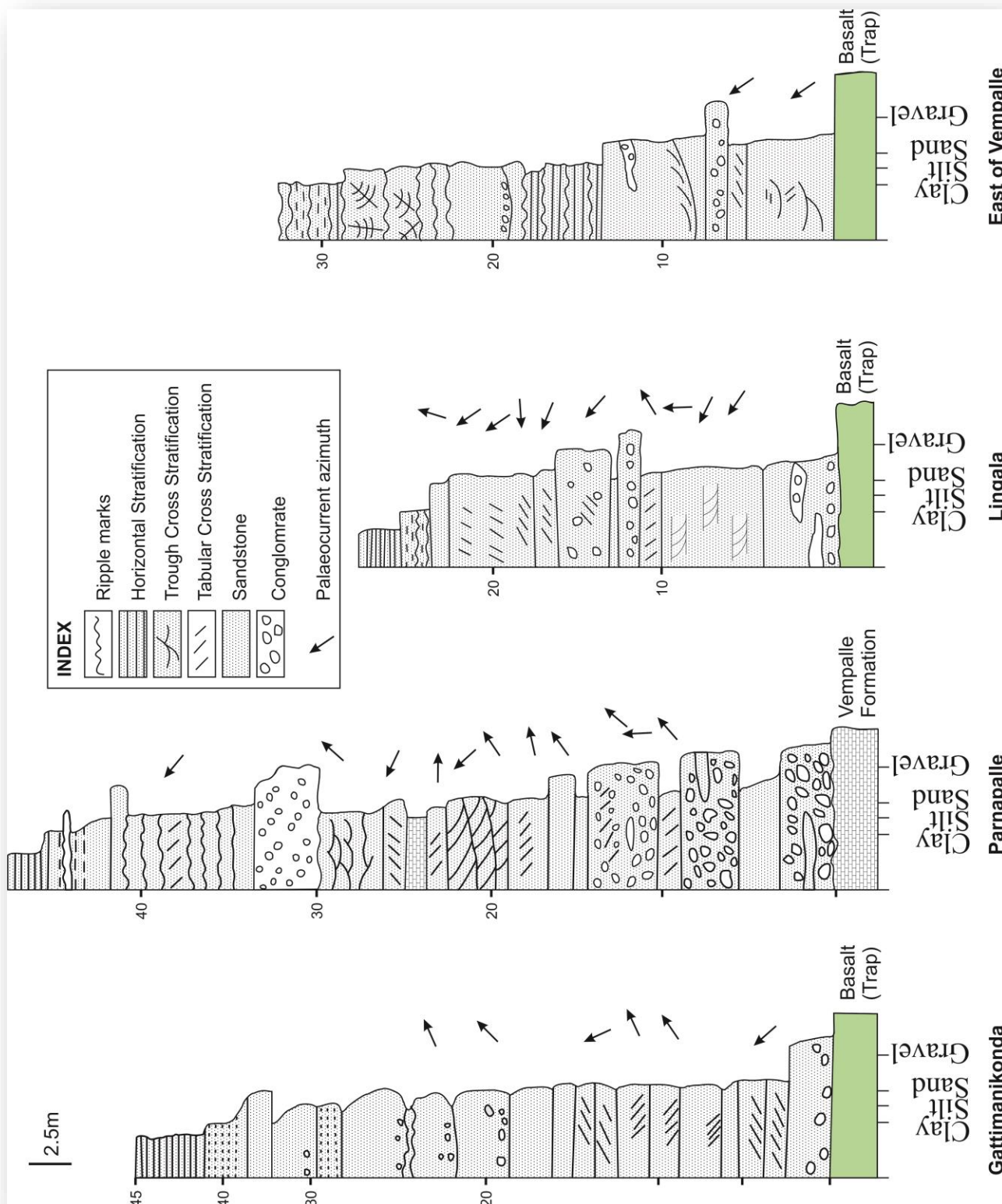
The Pulivendla Quartzite is made of conglomerate, quartzite, siltstone and flagstone. The conglomerate occurs at the base as well as in different stratigraphic levels of the formation. These are clast supported in the base and matrix supported towards top. The clasts are sub angular to sub rounded and made of chert, siliceous oolite, dolomite, jasper and vein quartz. Quartzite is reddish brown to light brown in colour,



*medium to coarse grained moderate to well sorted, sub rounded and made of quartz (> 95%) and lithic fragments. It displays planar, trough and herringbone cross stratification, reactivation surfaces, symmetrical ripples and parting lamination. The Pulivendla Quartzite displays a bi directional (North - South) palaeocurrent and is interpreted to have been deposited in a high energy shallow subtidal environment.*



**Pulivendula Quartzite, south of Velidandla, N14°32'43.67": E78°03'11.51"**

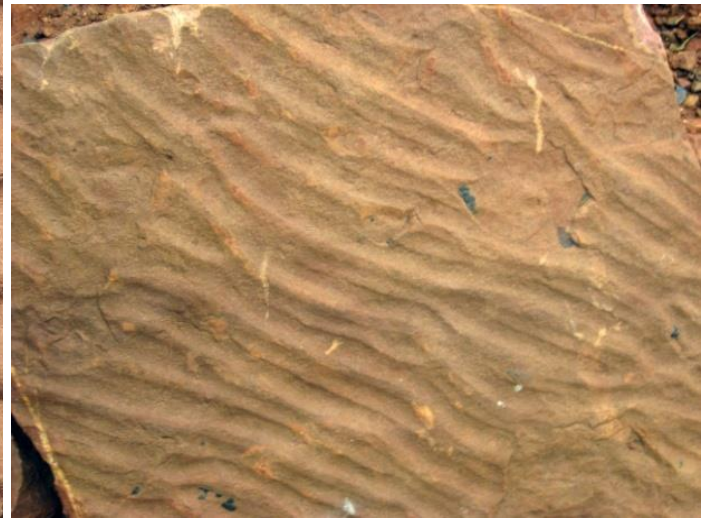


**Comparative lithologs of Pulivendla Quartzite from different locations (from Lakshminarayana et al., 2001)**

**Ripple marks in Pulivendla arenite, Velidendla, Cuddapah district, Andhra Pradesh**



**Ripple marks in Pulivendla arenite, Lingala, Anantpur district, Andhra Pradesh**



**Pulivendula conglomerate Lingala section, Cuddapah district, Andhra Pradesh**

## Tadpatri Formation

The Tadpatri Formation conformably overlies the Pulivendla Quartzite. It has a thickness of > 4000 m comprising of shale intercalated with siltstone, sandstone, volcanoclastics and stromatolitic dolomite which are in turn intruded by ultramafic-mafic sills. The fine grained sandstone of Pulivendla Quartzite grades to a shale/sandstone intercalated sequence in the lower Tadpatri which develops into a continuous shale sequence later. The upper sequence displays stromatolitic dolomite intercalated with shale and tuff.

Along the Pulivendla- Muddanuru section the Tadpatri Formation display several ultramafic - mafic sills running for kilometers. Felsic crystal tuff described as porcellanite is also exposed along with shale and sandstone. This felsic tuff comprises mainly of fine grained albite and allanite.

The transition from a arenaceous sequence to a dominantly argillaceous sequence at the base of the Tadpatri Formation

may indicate a rise in sea level or a loss of sediment source. The presence of stromatolitic dolomite in the upper stratigraphic levels suggest a shallow sub tidal environment with little or no sediment supply. Overall the Tadpatri Formation represents a low energy shallow marine environment.



**Intercalated chert in Tadpatri dolomite, NE of Thondur, Cuddapah district, Andhra Pradesh**



**Jasper bed intercalated within dolomite of Tadpatri Formation, Mallela section, Cuddapah district, Andhra Pradesh**



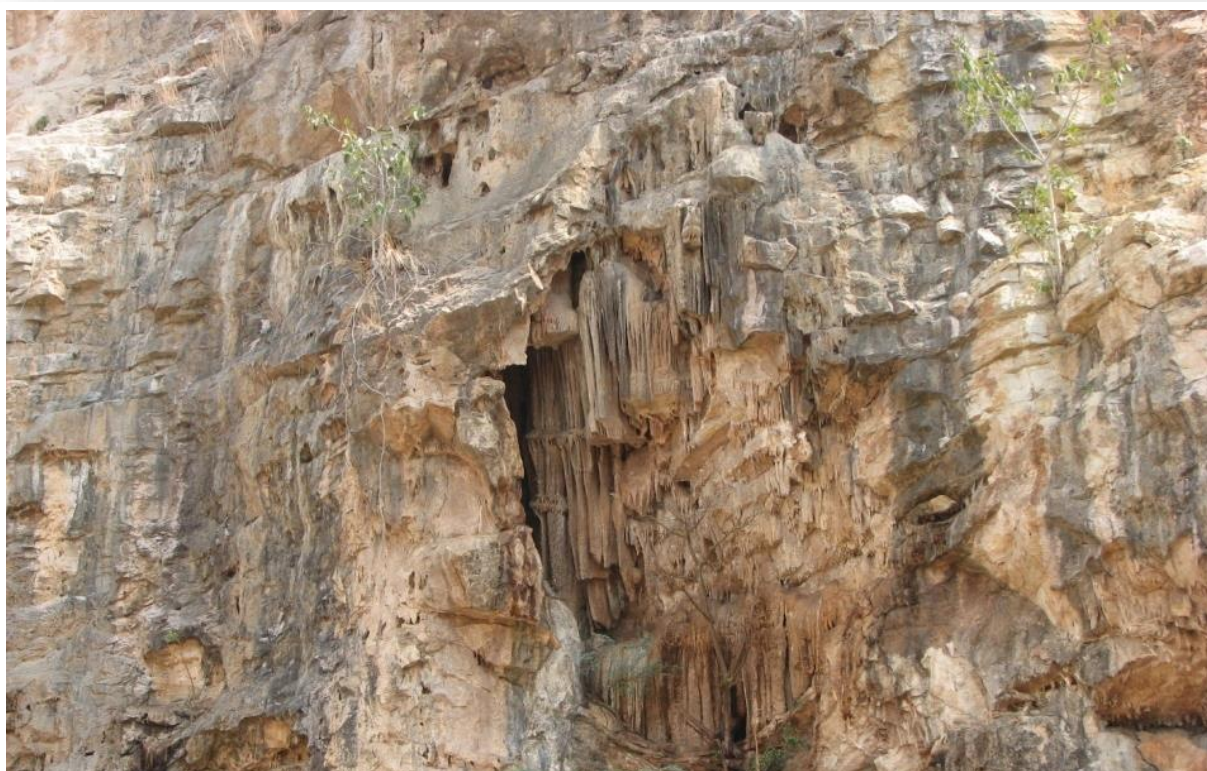
**Splintery Tadpatri Shale, NE of Mallela , Cuddapah district, Andhra Pradesh (N14°37'22.42": E78°20'16.21")**



**Thinly bedded Tadpatri shale exposed in Mallela, Cuddapah district, Andhra Pradesh**



**Tuff bed in Mallela section, on Pulivendela-Muddanuru road, Andhra Pradesh**



**Development of stalactite in cave present in limestone of Tadpatri Formation, Kona, Anantapur district, Andhra Pradesh**



**Shale-phyllite of Tadpatri Formation overlain by dolerite sill, Kona, Anantapur district, Andhra Pradesh**



**Melanocratic porphyritic mafic igneous dyke, Tadpatri Formation, NE of Thondur (N14°37'9.60": E78°20'12.55"), Cuddapah district, Andhra Pradesh**



**Fine grained felsic volcanic band in Tadpatri shale, NE of Mallela, N14°37'12.37": E78°20'13.77", Cuddapah district, Andhra Pradesh**



## **Ultramafic sill of Tadpatri Formation**

Olivine bearing ultramafic sill, known as the Pulivendla sill is well exposed in the Loyala College section, Pulivendla. Detailed petrographic account along with the mineral chemistry of the constituent mineral phases of the ultramafic sill has been presented in details (Sesha Sai, 2011; Sesha Sai et al., 2017). Geochronological studies of the ultramafic sill by  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  method (Anand et al., 2003) gave a Paleoproterozoic age of 1.9 Ga, while radiometric dating by U-Pb method gave an age of  $1885.4 \pm 24$  Ma (French et al., 2008). Stratigraphically, it is confined to the lower part of the Tadpatri Formation, the 'Pulivendla' ultramafic sill, is exposed as low lying mounds from Peddakudala in NW to Velpula in SE over a stretch of 12 km in the SW part of Cuddapah Basin. Megascopically the ultramafic sill is dark grey, hard and compact and on the surface it shows characteristic pitted weathering on the surface. Mineralogically the rock is made of olivine, enstatite, phlogopite, augite and plagioclase as the



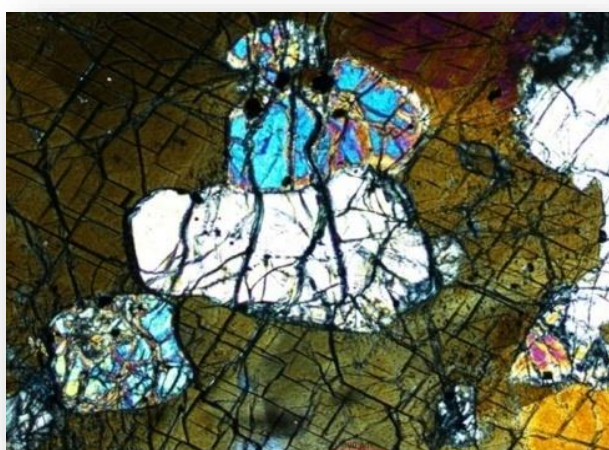
*essential mineral phases, while magnetite and chrome spinel are the opaque oxide phases that are noticed in sub ordinate amounts. In the IUGS Olivine-Pyroxene-Plagioclase diagram (Streckeisen, 1976), it has been classified as plagioclase bearing ultramafic to olivine norite (Sesha Sai, 2017). Olivine is altered to serpentine along the cracks.*



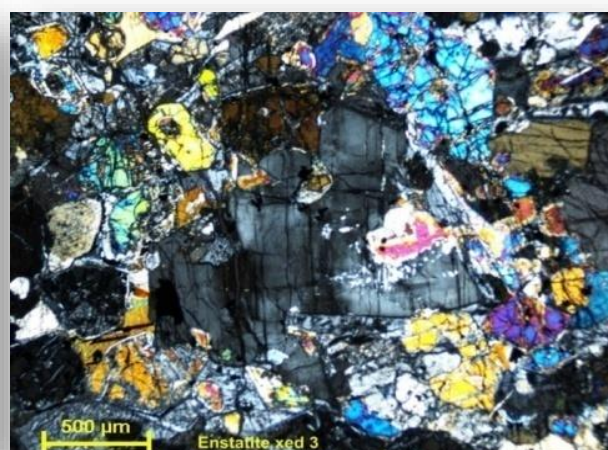
**Olivine rich melanocratic ultramafic rock near Loyala College section, Pulivendla. (N14°24'38.90": E78°14'24.16"), Cuddapah district, Andhra Pradesh**



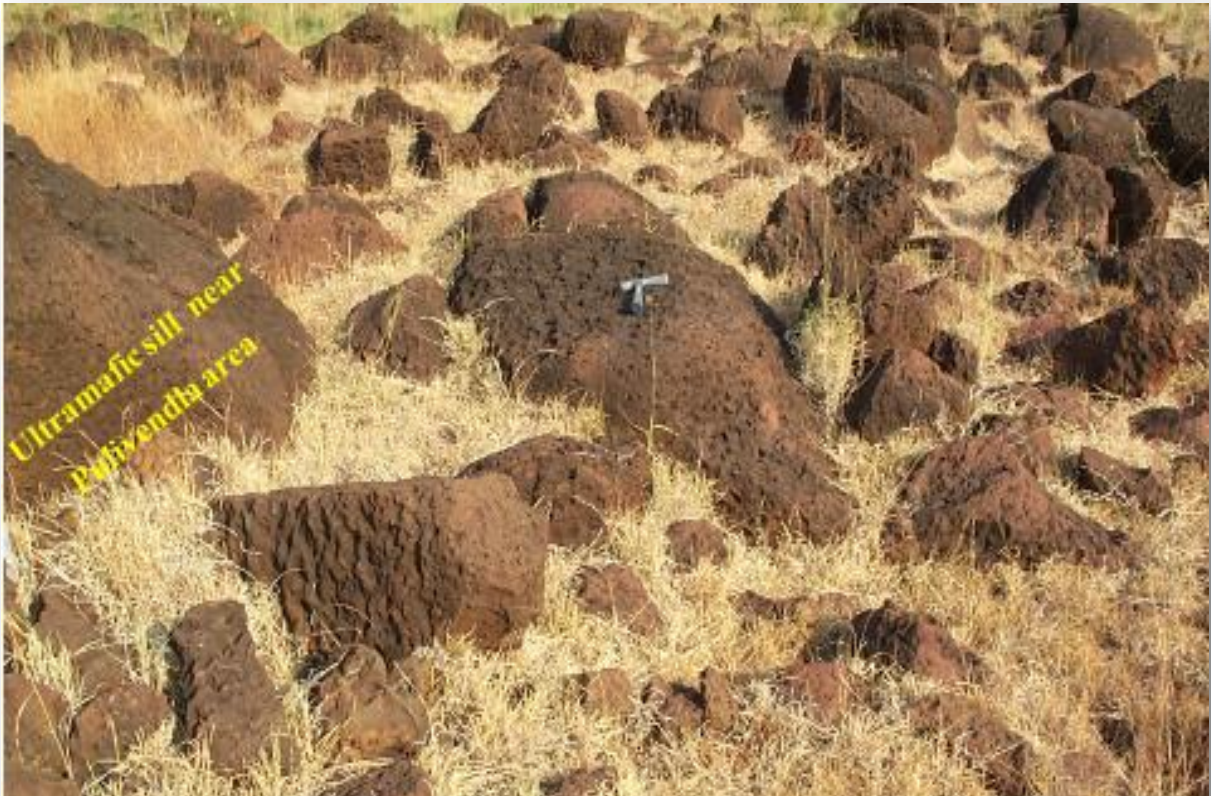
**Ultramafic sill exposed in the Loyala College section, Pulivendela. Note the characteristic pitted weathering on the surface (N14° 24' 38.9": E78° 14' 24.16")**



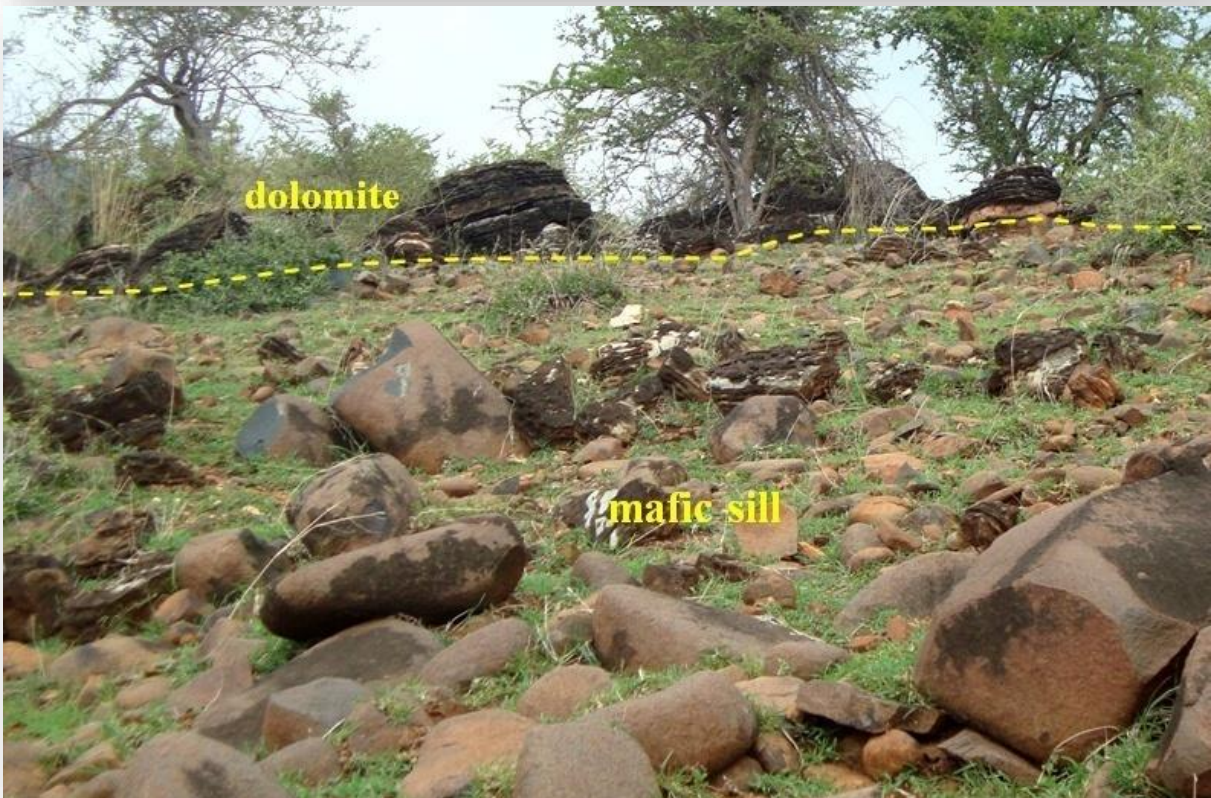
**Photomicrograph under crossed nicols showing olivine grains in clinopyroxene having poikilitic texture in ultramafic sill**



**Photomicrograph under crossed nicols showing enstatite and olivine in ultramafic sill**



**Ultramafic sill in Tadpatri Formation, YSSR, Loyala college, SW part of Cuddapah Basin, Pulivendla, Cuddapah district, Andhra Pradesh**



**Mafic sill within the dolomite, Mallela section, Cuddapah district, Andhra Pradesh**



**Volcanic bomb in ashfall/tuff, Pulivendla branch canal near Simhadripuram, Cuddapah district, Andhra Pradesh**



**Steep N-S trending strike-slip fault cut by gently east dipping reverse fault within Tadpatri Shale near Kona (N15°08'40": E77°54'25"), Anantapur district, Andhra Pradesh**



**Type area for Gandikota Quartzite exposed in the Penna River section,  
Gandikota gorge, Gandikota, Cuddapah district, Andhra Pradesh**



## **G**andikota Quartzite

*The Gandikota Quartzite consists of a lower 40 - 45 m thick shale - siltstone - quartzite intercalated unit and an upper 140 -190 m thick quartzite unit. The lower unit display flaser, lenticular, hummocky cross stratification within shale and siltstone and channel quartzite indicating coarsening upward. The upper member consists of around 8 nos. of cross stratified quartzite sheets of 15 - 25 m thickness each.*

*The Gandikota Quartzite with its type area located near Gandikota fort displays tabular, trough, herringbone cross stratification and asymmetrical ripples. The huge quartzite sheets with large scale cross stratification and asymmetrical ripples provides an evidence for marine dunes in a near shore environment. Presence of glauconite, high textural and mineralogical maturity of quartzite too suggest a shallow marine to near shore environment of deposition. The palaeocurrent was mainly towards northwest but easterly and bi-directional patterns are also recorded.*



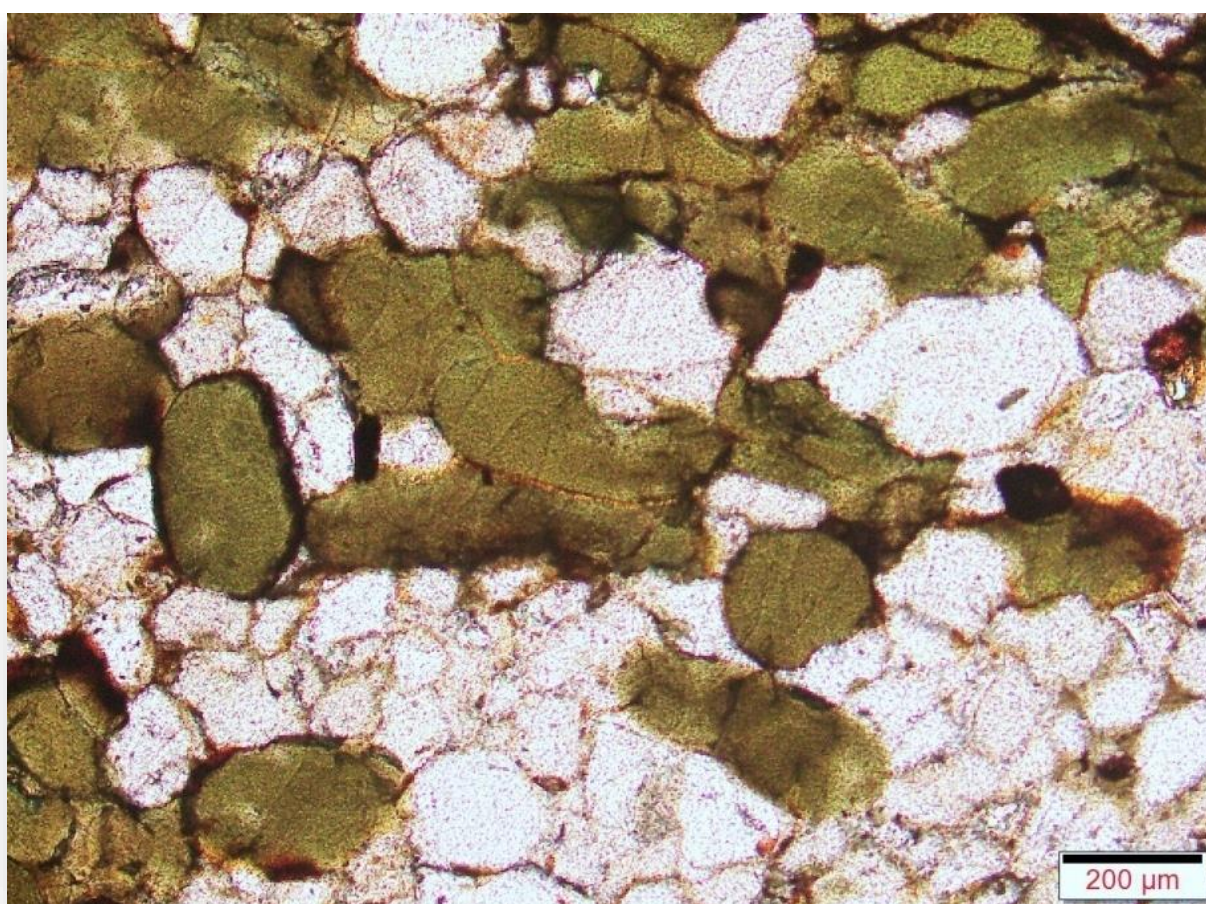
**Orthoquartzite of Gandikota Quartzite exposed in Muddanuru-Jammalamadugu Ghat Section, Cuddapah district, Andhra Pradesh**



**Gandikota Quartzite conformably overlying Tadpatri shale, Penneru River gorge, view from Gandikota Fort, Cuddapah district, Andhra Pradesh. It is an important geoheritage site**



**Glauconitic ferruginous Gandikota Quartzite, south of Vemaguntapalle  
(N14°46'43.13"; E78°21'59.44")**



**Photomicrograph showing greenish glauconite grains within the glauconite bearing sub arkosic arenite of Gandikota Quartzite**



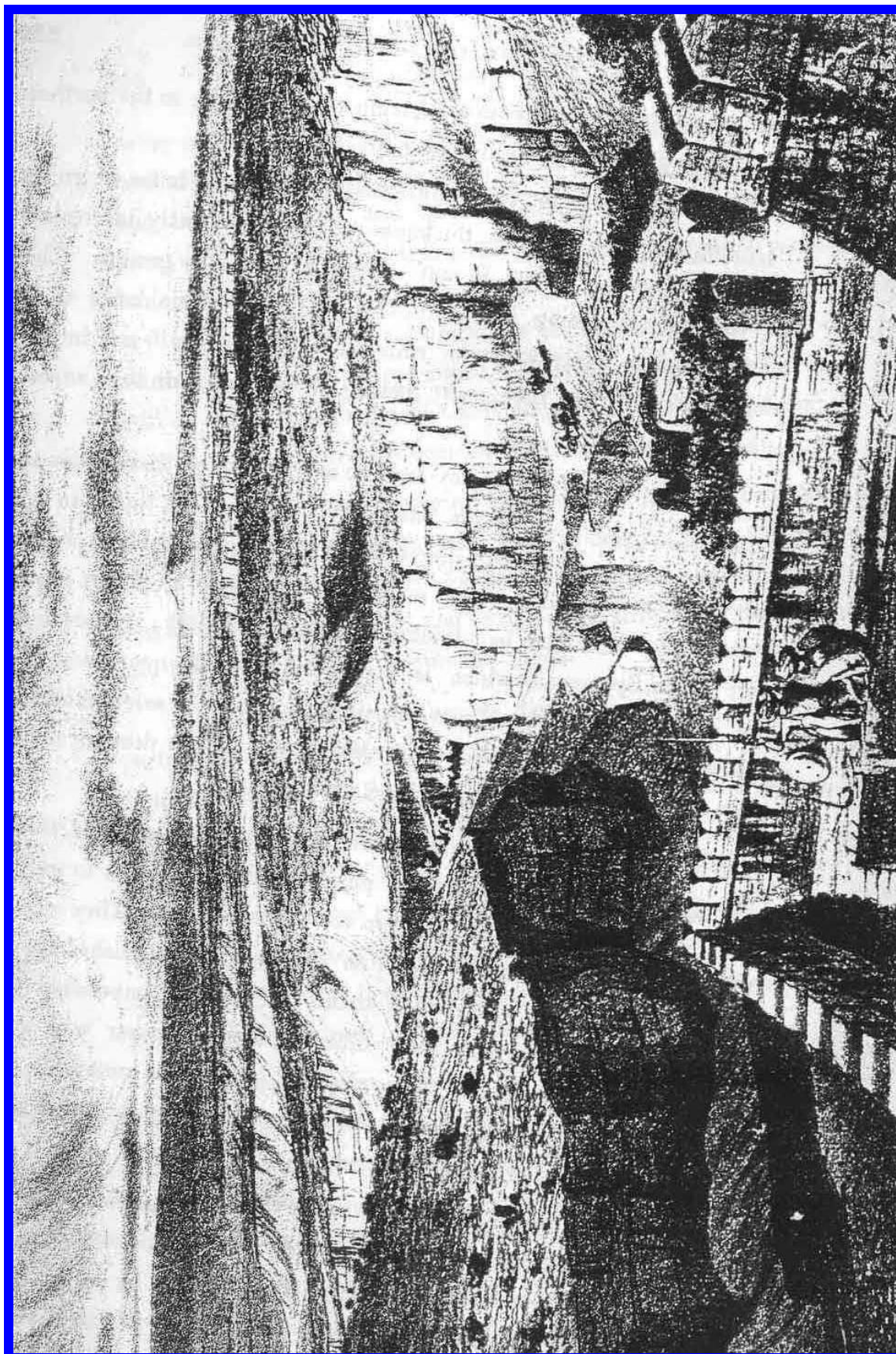
**Symmetrical ripple marks on Gandikota Quartzite**



**Asymmetrical ripple marks on Gandikota Quartzite**



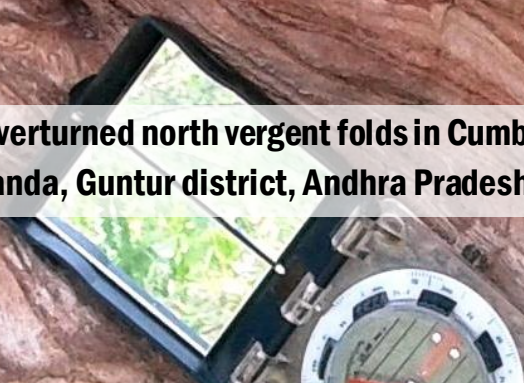
**Tabular cross stratification in Gandikota Quartzite**



**Gandikota Gorge as viewed by William King from Gandikota Fort (King, 1872)**



**Overturned north vergent folds in Cumbum phyllite east of Sanigandla Tanda, Guntur district, Andhra Pradesh (Tripathy et al., 2019)**

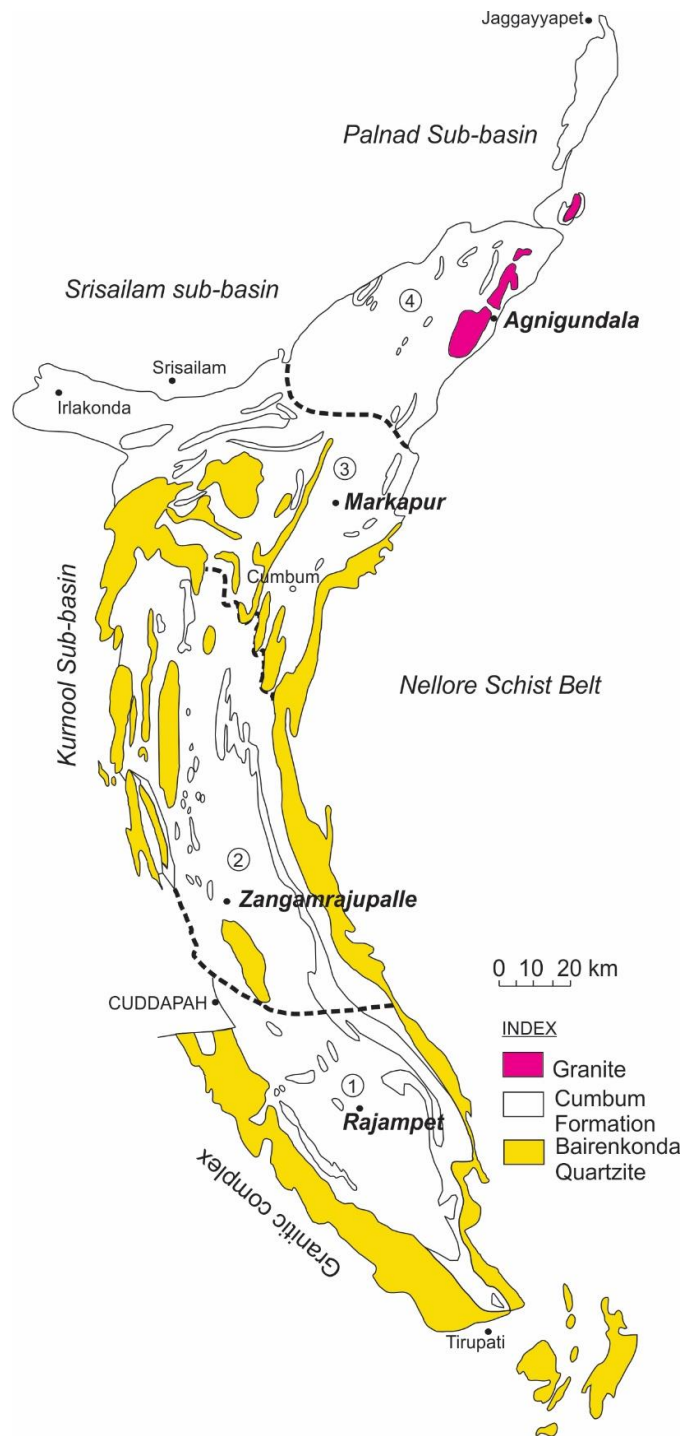


## NALLAMALAI GROUP

Stratigraphically, the Nallamalai Group unconformably overlies the Chitravati Group, and is restricted to the eastern part of the Cuddapah Basin within the Nallamalai Fold Belt (NFB). The discordant relationship between the western part of Cuddapah Basin and the Nallamalai Group may be explained as being due to a thrust contact. The NFB is a 400 km long poly-deformed Mesoproterozoic arcuate orogen, whose eastern and western boundaries are bounded by thrust zones. The NFB is thrust to the western part of the Cuddapah Basin along Nallamalai thrust/Rudravaram line and in the East by the Nellore Schist Belt (NSB) along Vellikonda thrust. The Paleoproterozoic to Mesoproterozoic sedimentation of the Nallamalai Group is restricted within the NFB and consists of the lower Bairenkonda Quartzite (Nagari Quartzite of southern NFB) dominated by arenaceous unit and the upper argillaceous dominant Cumbum Formation (Pullampet Formation of southern NFB).



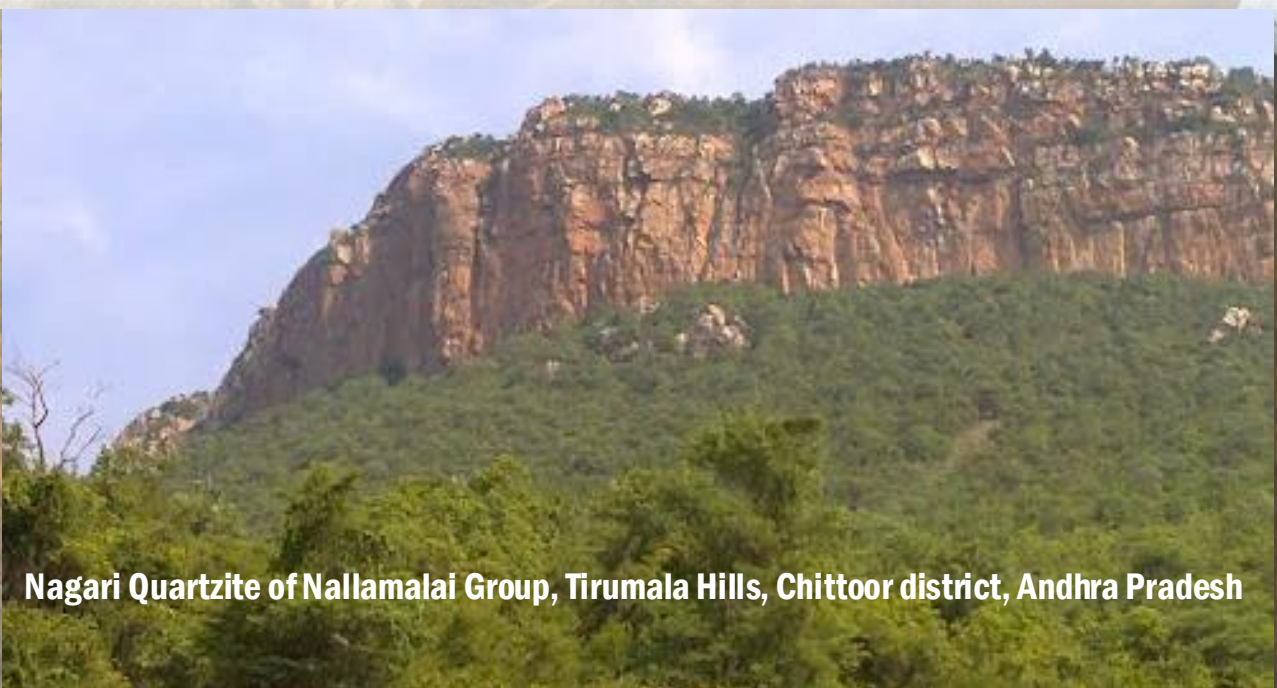
Base metal mineralization also differentiates the fold and thrust belt from rest of the Cuddapah Basin. The distribution of base metal mineralization, lithological assemblage, and incidence of carbonates forms the basis for recognition of four minor sub-basins within the NFB



(1) Rajampet, (2) Zangamrajupalle, (3) Markapur and (4) Agnigundala from south to north.

## **B**airenkonda (Nagari) Quartzite

The lowest unit, the Bairenkonda Quartzite (an essentially arenaceous unit with volcanic flows, sills and other intrusives; Nagaraja Rao et al. 1987) has been extensively deformed into the Nallamalai fold belt. The Nagari Quartzite (age equivalent to Bairenkonda Quartzite and a predominantly arenaceous unit with a basal oligomictic conglomerate) is exposed mainly in the southern part of the Cuddapah Basin, where it overlies the Papaghni Group with a profound angular unconformity in the area south of Cuddapah; further south, it rests directly on the granitic basement.



**Nagari Quartzite of Nallamalai Group, Tirumala Hills, Chittoor district, Andhra Pradesh**



**The Natural Arch, in Nagari Quartzite, Tirumala hills, Chittoor district, Andhra Pradesh**



**Bairenkonda Quartzite showing two antiforms juxtaposed along a possible thrust, at the western boundary of NFB, West of Ahobilum temple, Kurnool district, Andhra Pradesh (Tripathy, 2010).**



**Longitudinal ripple marks in Bairenkonda Quartzite**



**Open fold in Bairenkonda Quartzite, near railway bridge on Nandyal-Giddalur section, Nallamalai Fold Belt.**



**Mesoscopic F1 fold in Bairenkonda Quartzite, south of Musalareddipalle, Cuddapah district (57I/16), (Tripathy, 2010)**



**Mesoscopic west vergent overturned isoclinal F1 fold in Bairenkonda Quartzite, along road section west of Rajasahebpetta, Cuddapah district (57N/1), (Tripathy, 2010)**



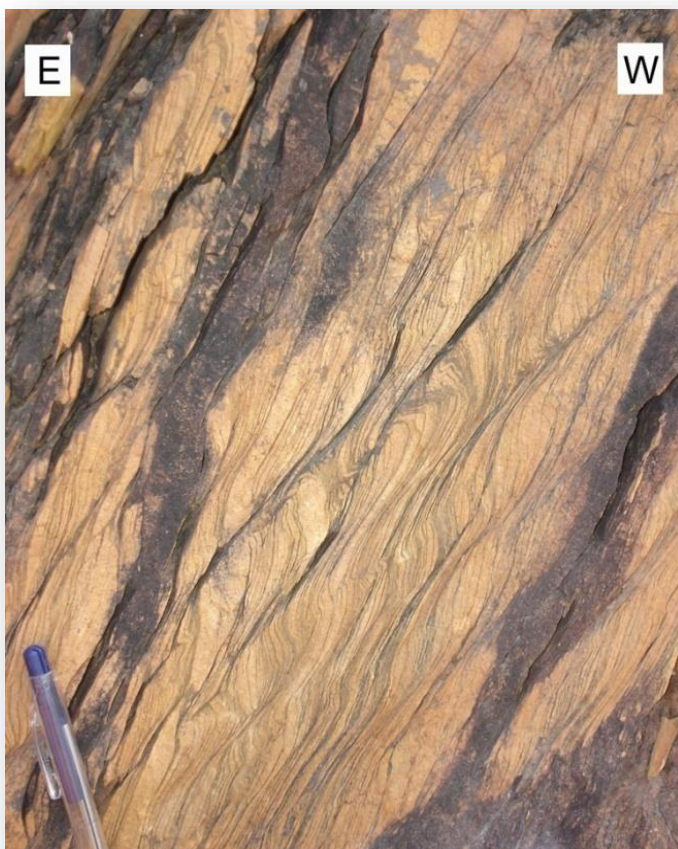
**Mesoscopic  $F_2$  fold in quartz-phyllite of Bairenkonda Quartzite, east of Tekurupeta, Cuddapah district (57M/4), Andhra Pradesh (Tripathy, 2010)**



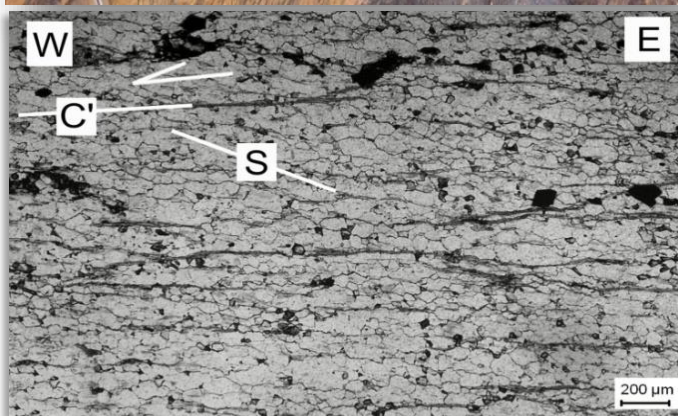
**Phyllonite along rock section in Velikonda range, west of Seetharamapuram, Prakasam district, Andhra Pradesh (Tripathy, 2010)**



*This formation is thick bedded massive quartzite with minor argillaceous intercalations and is well exposed in Iswarakuppam dome, Nallamalai range along Giddalur and Porumamilla and Velikonda range flanking the eastern margin of the basin.*



**Shear bands with a reverse sense of shear on heterolithic quartzite-phyllite affecting the  $S_1$  foliation, west of Porumamilla Tank, Cuddapah district, (Tripathy and Saha, 2010)**



**Sinistral sense of shear in heterolithic quartzite-slate, section parallel to the strike of schistosity,  $S_1$  west of Porumamilla Tank, Cuddapah district (Tripathy and Saha, 2010)**



**Hanging wall cutoff on thrust fault with top-to-South tectonic movement, Srisailam-Dornala road section (Tripathy, 2010).**



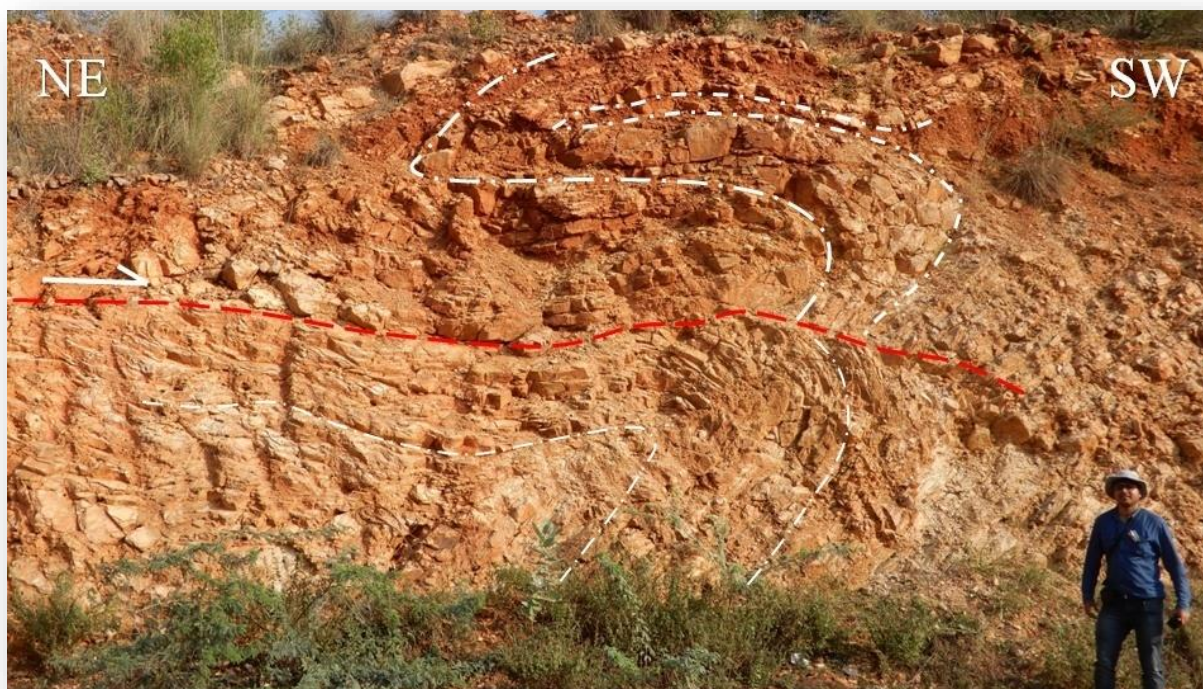
**Displacement of a quartz tension gashes along a thrust fault with top-to-west movement, Srisailam-Dornala road section (Tripathy, 2010)**



**West vergent asymmetric folds in intercalated quartzite-phyllite sequence of Bairenkonda Quartzite, close to Velikonda thrust front, Sitarampuram-Porumamila section, Cuddapah district, Andhra Pradesh**



**Conglomerate in Nagari Quartzite, Maddimadugu section, Andhra Pradesh**



**Nagari Quartzite displaying tight to isoclinal folds riding over a thrust plane on Khajipet-Badvel highway (N14°41'04": E78°47'47") western boundary of Nallamalai Fold Belt, Cuddapah district, Andhra Pradesh**



**Thrusting of Nagari Quartzite over Koilkuntla Limestone (Kurnool Group), Khajipet-Badvel highway, western boundary of Nallamalai Fold Belt, Cuddapah district, Andhra Pradesh**



**Intercalated dolomite with phyllite in Cumbum Formation showing Southeast dipping overturned isoclinal folds, North of Mekaladinne, Guntur district, Andhra Pradesh. Outcrop facing SW (Tripathy et al., 2019).**



## Cumbum (Pullampet) Formation

The Cumbum (Pullampet) Formation is an argillaceous unit with intercalations of quartzite and dolomite at various levels and hosts base metal mineralization. The Cumbum Formation also hosts the world famous barite deposit at Mangampeta. The arenaceous Srisailam Quartzite overlies the Nallamalai Group and is a glauconite-bearing ferruginous quartzite occurring geomorphologically in the form of a plateau. The Cuddapah Basin has been divided into two broad structural sectors separated by the Rudravaram line (Meijerink et al. 1984), a boundary fault (thrust fault) on the western side of the Nallamalai Group.

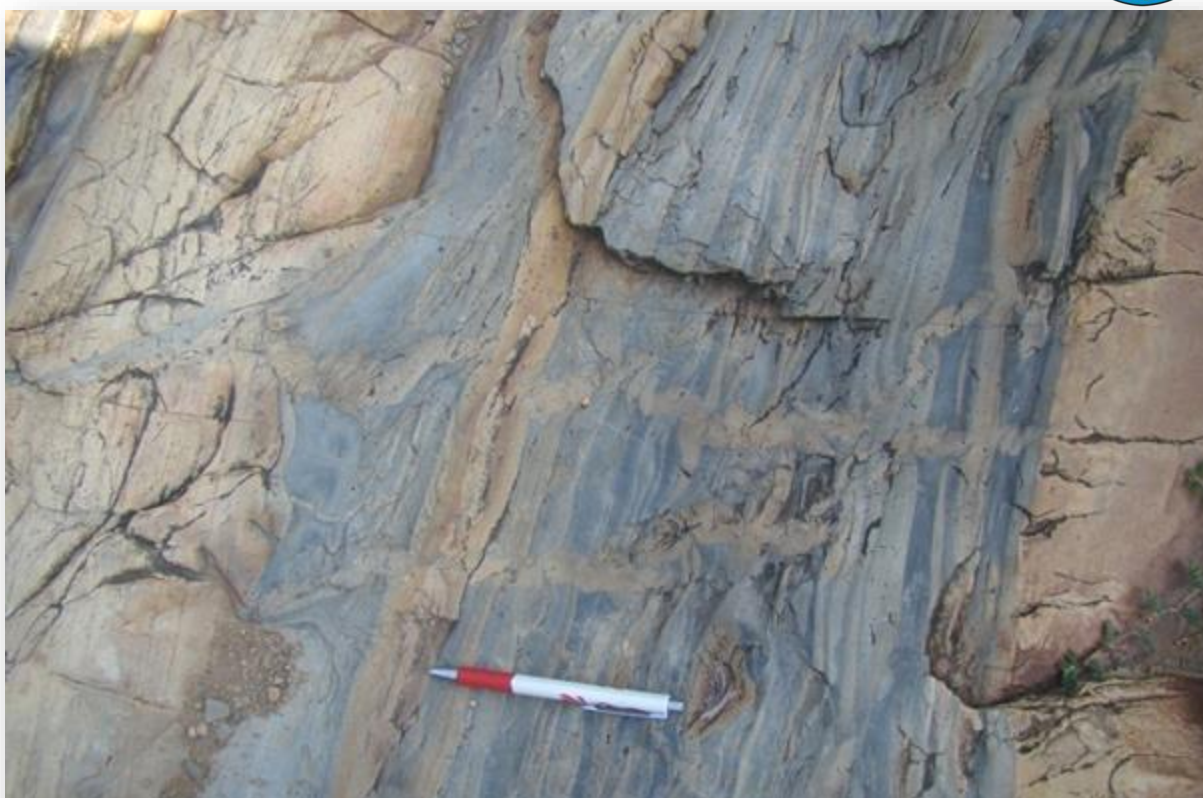
The deep structure of the Cuddapah Basin as interpreted from geophysical data (Kaila et al. 1979; Kaila and Tewari 1985) suggests that the basin can be divided into several blocks separated by deep faults. The Cuddapah Basin is characterized by a gravity low towards the eastern side, and a gravity high towards the southwestern side (Singh and



Mishra 2002). This gravity high is modelled as a high-density basic lopolith at a depth of 7-8 km, which was most likely primarily responsible for the various sills exposed in this area (Bhattacharji and Singh 1984; Mishra et al. 1987). The gravity low in the eastern part of the basin is modelled with thick sediment and a thick crust of about 40 km.



**Trough cross bedding in Cumbum quartzite at road section East of Venkatarreddipuram, Guntur district, Andhra Pradesh**



**Sand dyke in intercalated quartzite and shaly beds, west of Inumella, Guntur district, Andhra Pradesh**



**Sand dyke with brecciation in Cumbum quartzite North of Chakramalaaya, Guntur district, Andhra Pradesh**



**Overturned Cumbum phyllite, north of Inuparati Konda (South of Durgi), Guntur district, Andhra Pradesh**



**Asymmetrical folds in Cumbum dolomite, South of Nekarikallu, Guntur district, Andhra Pradesh**



**Asymmetrical folds in Cumbum phyllite, East of Petasannigandla Guntur district, Andhra Pradesh**



**Photomicrograph of Cumbum phyllite showing orthogonal relationship between  $S_0$  and  $S_1$ , south of Lalipuram, Guntur district, Andhra Pradesh**



**Cumbum quartzite having tension gashes with left lateral shear sense, N of Inuparti Konda (South of Durgi), Guntur district, Andhra Pradesh**



**Cumbum quartzite having conjugate tension gashes with left lateral shear sense, North of Inuparti Konda (South of Durgi), Guntur district, Andhra Pradesh**



**Tight overturned Cumbum quartzite East of Petasannigandla, Guntur district, Andhra Pradesh**



**Liquefaction in Cumbum quartzite Kakirala Konda in Kakirala Reserved Forest, Guntur district, Andhra Pradesh**



**Panoramic view of the Kuchchula Bodu showing imbricate thrust sequence in Cumbum phyllite, East of Mekaladinne, Guntur district, Andhra Pradesh**



**Sheared phyllite showing S-C tectonite, Southeast of Ayanapalem, Guntur district, Andhra Pradesh**



**Old working for basemetal in Karempudi block of Agnigundala mineralised minor basin, Guntur district, Andhra Pradesh**



**Mineralised dolomite showing profuse steep quartz veinlets, in the eastern part of the northern dolomite band, Karempudi block of Agnigundala mineralised minor basin, Guntur district, Andhra Pradesh**



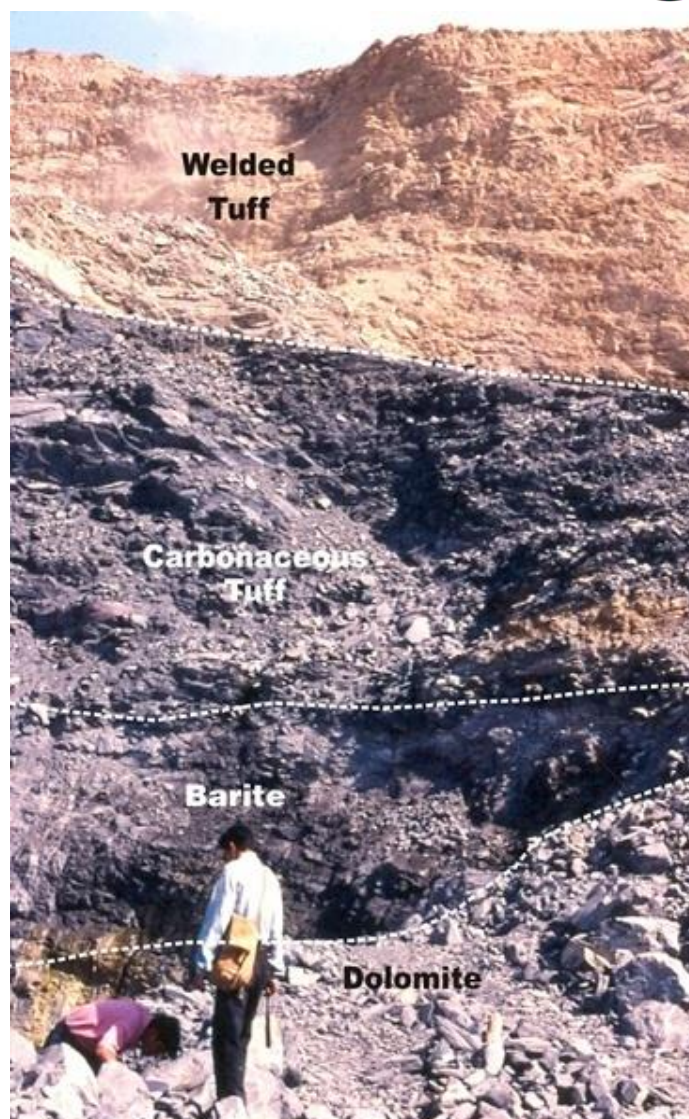
*The Mangampeta barytes deposit is associated with tuff and crystal tuff sequence of the Pullampeta ( $\approx$ Cumbum) Formation. This is the single largest deposit in the World with over 25% of the reserves of about 65 million tons of barytes and holds about 98% of the total reserves of the Cuddapah Basin and 87% of the country's reserves.*



**Mangampeta barytes mine, Cuddapah district, Andhra Pradesh**

*Andhra Pradesh Mineral Development Corporation (APMDC) has been mining barytes from its leaseholds in Mangampeta village, Obulavaripalli Mandal in Cuddapah district since the year 1975 as open cast mining.*

**A geological profile of the northern lens of Mangampeta barytes mine**



**Barytes lens at Mangampeta barytes mine**



The baryte resource is both vein and bedded type and is closely associated with carbonaceous tuff overlying dolostones.

The deposit occurs in the form of two lensoid bodies separated by a distance of about 700 m. Baryte occurs intimately associated with minor quantities of pyrite, mainly as bedded, grey, granular masses or in lapilli or rosette forms; veins, fracture-filling and replacement patches also occur sporadically. Occurrence of fullerenes having composition of  $C_{60}$ ,  $C_{70}$  and  $C_{84}$  are reported earlier from Mangampeta area in black tuff samples.



**Crenulation cleavage in phyllite at Mangampeta, Cuddapah district, Andhra Pradesh**



**Folding in quartzite interbedded with carbonaceous shale at Mangampeta Mines, Cuddapah district, Andhra Pradesh**



**Pseudotachylite in dolomite, Mangampeta mine, Cuddapah district, Andhra Pradesh**



**Lapilli baryte in carbonaceous shale, Mangampeta mines, Cuddapah district, Andhra Pradesh**



**Secondary baryte crystals within dolomite Mangampeta mine, Cuddapah district, Andhra Pradesh**



**Rosette baryte of Mangampeta mines under cross polar , Cuddapah district, Andhra Pradesh**



**Carbon spherule within dolomite, Managampeta, Cuddapah district, Andhra Pradesh**



**Nagarjuna Sagar Dam, constructed from 1955 to 1967 is situated across the Krishna River boarding the Guntur district, Andhra Pradesh and Nalgonda district, Telangana. The river cuts through the Srisaillam Quartzite and the basement Peninisular Gneissic Complex (PGC). The dam was the tallest masonry dam in the world at that time.**

## SRISAILAM QUARTZITE

*Srisailam Quartzite is exposed in the Srisailam sub-basin having sub-horizontal dips towards southeast. It is glauconite bearing ferruginous quartzite overlying the basement granitic gneiss, schist belt, Papaghni and Nallamalai Groups with unconformity. Basal conglomeratic horizon is of local nature and minor shale intercalations are found within the quartzite. The quartzite is understood to have deposited in shallow marine to tidal flat environment.*



**Cross bedded ferruginous arenite of Srisailam Quartzite, Eagalapenta, Srisailam dam section, Mahaboobnagar district, Telangana**



**Srisailam Quartzite unconformably overlying the granitic gneiss of Peninsular gneiss, Nagarjuna Sagar left bank canal, Northnorthwest of Nandikonda, Hyderabad-Macherla highway, Nalgonda district, Telangana**



**Laminated ferruginous arenite of Srisailam Quartzite, Eagalapenta, Srisailam dam section, Mahaboobnagar district, Telangana**



**Chocolate brown siltstone in lower part of Srisailam Quartzite, Eagalapenta section, Mahaboobnagar district, Telangana**



**Cyclic sequence of beds of chocolate brown siltstone in lower part of the Srisailam Quartzite at eastern part of the Srisailam Dam**



**Sub-horizontal Srisailam Quartzite at the Ettipotala waterfall, Guntur district, Andhra Pradesh**

## KURNOOL GROUP

*After a hiatus of 500 My, Kurnool Group ( $\approx$ 450m thickness) of sediments defined by two cycles of siliciclastic- carbonate-argillaceous sequence deposited in two sub-basins, viz. Kurnool and Palnad. Basement for Kurnool Group is defined by a varied group of rocks of contrasting stratigraphy. On map scale it is explicit that the Kurnool Group of rocks are deposited over Peninsular gneiss, schist belts, Papaghni, Chitravati and Srisailam groups. The unconformable contact between the Kurnool Group and the Srisailam Quartzite is exposed in the Palnad area, 3-4 km north of Maddimadugu.*

## **B**anganapalle Quartzite

*The Banganapalle Quartzite is understood to have deposited in a rift related basin which followed stable shelf and shallow platform setup. The Kurnool Group of sediments are devoid of*



any igneous activities and thus a proper radiometric age constrain is not yet achieved. It is argued that the source for the diamondiferous conglomerate of the Banganapalle Quartzite are the ~1090 Ma old kimberlite pipes west of the basin margin. Use of  $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$  and  $^{87}\text{Sr}/^{86}\text{Sr}$  values from Palnad sub-basin and comparison with world-wide Neoproterozoic carbonate platforms indicate an age of 700-500 Ma.



**Polymictic conglomerate of Banganapalle Quartzite outcropped near Narnuru in Kurnool-Nandyal section, Kurnool district, Andhra Pradesh**



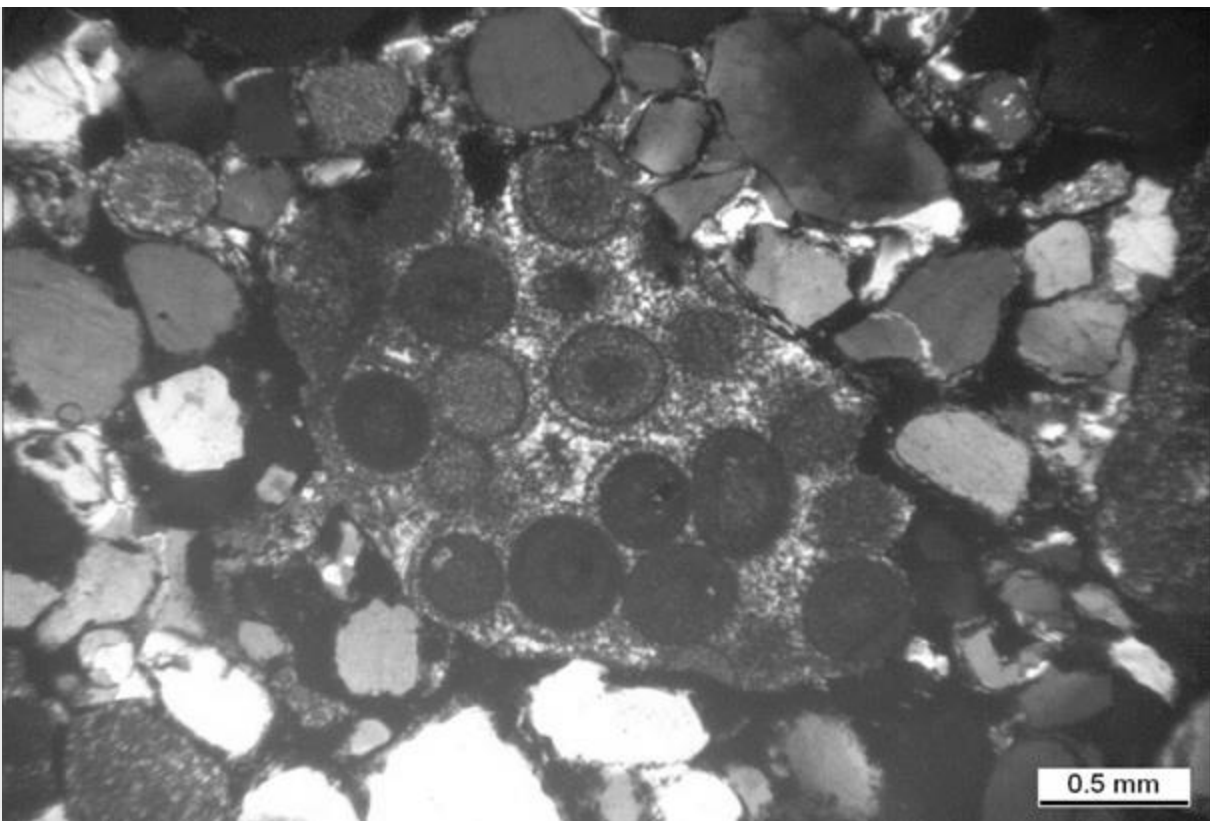
**Subangular to subrounded pebbles in Banganapalle Quartzite.**



**Chert clasts in Banaganapalle conglomerate, Yambayi, Kalava-Ramallakota section, Kurnool district, Andhra Pradesh**



**Oolitic chert clast in Banaganapalle Quartzite, Yambayi, Kalava-Ramallakota section, Kurnool district, Andhra Pradesh**



**Photomicrograph of the oolitic chert clast in Banaganapalle Quartzite, Yambayi, Kalava-Ramallakota section, Kurnool district, Andhra Pradesh**



**Banganapalle conglomerate with boulders, south-west of Petnikota village, Kurnool district, Andhra Pradesh**



**Steeply dipping sinistral tension gashes affecting the Banganapalle Quartzite, South of Kalva, Kurnool district, Andhra Pradesh**



**Sand dyke in Narji Limestone South of Kalvabugga, Kurnool district, Andhra Pradesh**

## Narji Limestone

*This formation is a significant carbonate facies deposited in Kurnool and Palnad sub-basins with a gradational contact with Banganapalle Quartzite. The limestone is physically divided in three horizons viz. thinly bedded limestone, massive limestone and flaggy limestone. It has a stratigraphic thickness of about 200m. The flaggy variety has individual bed thickness ranging from 4-8 cm to 12-15 cm are extensively used as building material.*

**Narji Limestone having sub-vertical dips exposed along the Gani-Kalva fault, East of Kalvabugga, Kurnool district, Andhra Pradesh**



**Gravel sized Banganapalle Quartzite having transitional contact with Narji Limestone beds near Kolimigundla, Kurnool district, Andhra Pradesh**



**Variegated sequence of limestone in lower part of Narji Limestone, Kurnool Group, Bethamcherla, Kurnool district, Andhra Pradesh**



**Flaggy variety of limestone from middle part of Narji Limestone, Bethamcherla, Kurnool district, Andhra Pradesh**



**Development of Stalactite, flaggy Narji Limestone, Betamcherla-Banganapalle state highway, Kurnool district, Andhra Pradesh**



**Sectional view of the sub-horizontal Narji Limestone having bedding parallel shear, close to thrust zone with Nallamalai Fold Belt, Southeast of Sanigandla Tanda, Guntur district, Andhra Pradesh**



**Dark purple Narji Limestone near Reddipalem village, Guntur district, Andhra Pradesh**



**Fringe structure of pyrite and fibrous calcite strain fringe in Narji Limestone close of the thrust zone, Palnad sub-basin near Kakirala, Guntur district, Andhra Pradesh**



**Cleaved Narji Limestone showing near orthogonal relation between  $S_0$  and  $S_1$ , Palnad sub-basin, near Kakirala, Guntur district, Andhra Pradesh**



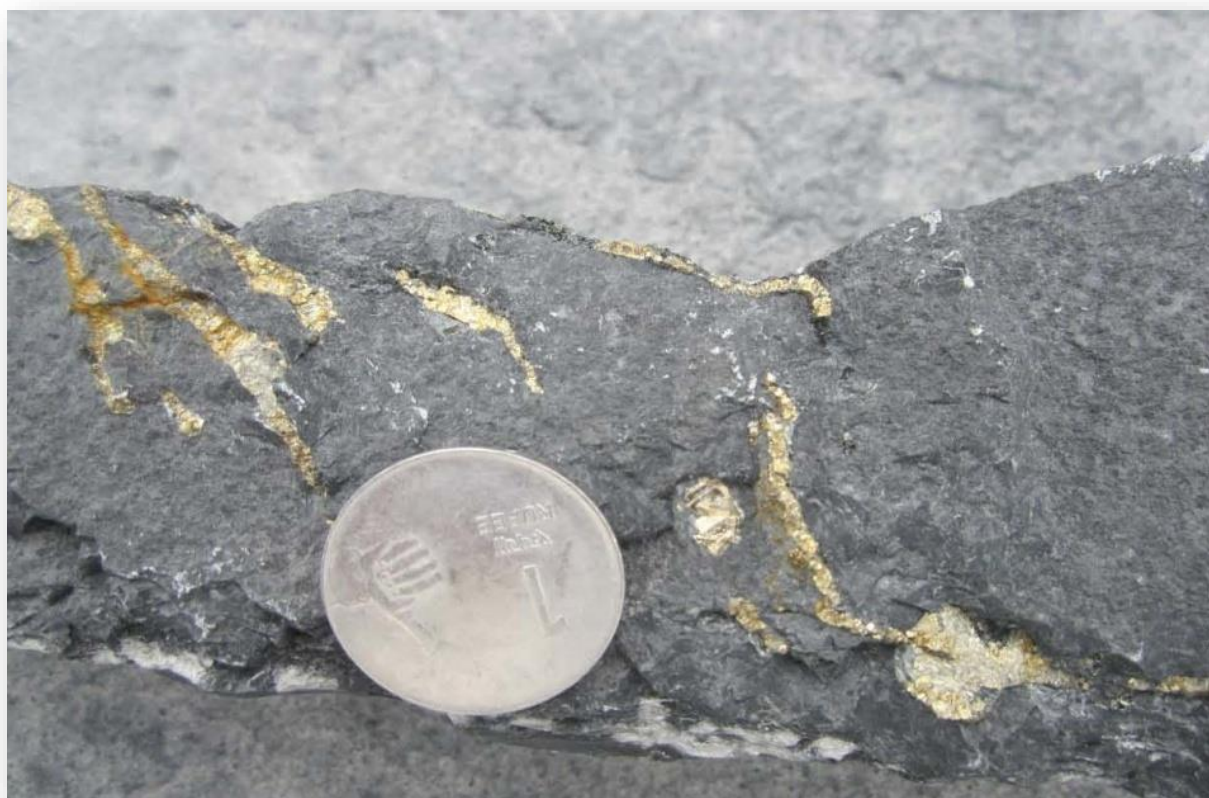
**Sub-horizontal Narji Limestone exposed as window, surrounded by folded Cumbum phyllite, East of Gajapuram, Guntur district, Andhra Pradesh**



**Slump fold in Narji Limestone, Southeast of Karempudi, Guntur district, Andhra Pradesh**



**Dark grey massive Narji Limestone with prominent horizontal stylolite**



**Pyrite veinlets in Narji Limestone near Madanantapuram village, Kurnool district, Andhra Pradesh**



**Sink hole in Narji Limestone at Belum Caves. It is one of the largest and longest cave system in India and an important geoheritage site, Kurnool district, Andhra Pradesh**



**A cavern in Belum Cave, Kurnool district, Andhra Pradesh**



**Stalactite in Narji Limestone, Belum caves, Kurnool district, Andhra Pradesh**



**Sink hole development in progress in Narji Limestone, Belum caves, Kurnool district, Andhra Pradesh**



**Owk Shale along Ramalakota-Kalvabugga section, Kurnool district, Andhra Pradesh**



## Owk Shale

Named after a town situated SW of Banganapalle in Kurnool district Andhra Pradesh. An argillaceous unit with minor local calcareous horizons has gradational contact with underlying Narji Limestone. It is variegated having khaki green, creamy, purple to brown colour and is characterised by presence of yellow to white ochers. Phosphatic bands are reported from this formation. It attains a maximum thickness of 15m at type area around Owk village in Banganapalle-Kolimigundla section.

**Owk Shale exposed along Ramlakota-Kalvabugga, Kurnool district, Andhra Pradesh**



**Contact of Owk Shale with overlying Paniam Quartzite, Orvakallu, Kurnool-Nandyal section, Kurnool district, Andhra Pradesh**



**Phosphorite band intercalated in Owk Shale, Kalinakonda, Kurnool district, Andhra Pradesh**



**Thinly laminated variegated Owk Shale, Northeast of Kakirala, Guntur district, Andhra Pradesh**



**Folded Owk Shale of Palnad sub-basin, underlying the folded and thrustured Cumbum quartzite, Southwest of Kakirala, Guntur district, Andhra Pradesh**



**Paniam Quartzite, South of Orvakallu, Kurnool district, Andhra Pradesh**

## Paniam Quartzite

Owk Shale conformably overlain by the Paniam Quartzite, is named after the 'Panem' village in Kurnool district. It is represented predominantly by arenaceous rocks with upper unit being pinnacled due to erosion and presence of joints. Petrographically this quartzite is mineralogically and texturally mature with >95% quartz. It is well sorted with sub-rounded to rounded grains and tightly packed with presence of silica overgrowth. It is well exposed in Orvakallu-Kalva.

**Pinnacled Paniam Quartzite, Orvakallu, Kurnool district, Andhra Pradesh**



**Paniam Quartzite unconformably overlying the Owk Shale, Orvakallu, Kurnool-Nandyal section, Kurnool district, Andhra Pradesh**



**Paniam Quartzite unconformably overlying the Owk Shale, Orvakallu, Kurnool-Nandyal section, Kurnool district, Andhra Pradesh**



**Trough cross bedding in Paniam Quartzite, Orvakallu, Kurnool-Nandyal section, Kurnool district, Andhra Pradesh**



**Pinnacled Paniam Quartzite, Orvakallu, Kurnool-Nandyal section, Kurnool district, Andhra Pradesh**



**Brecciated Paniam Quartzite, Inuparati Konda, South of Durgi, Guntur district, Andhra Pradesh**



**Mould of Pyrite in Paniam Quartzite, south of Jangamaneshwarapuram, Guntur district, Andhra Pradesh**

## Koilkuntla Limestone

*The thinly laminated Koilkuntla Limestone conformably overlies the Paniam Quartzite and is micritic grey limestone deposited in a shallow marine reducing environment. Stratigraphically it is having a maximum thickness of 50m. This limestone is clay rich compared to Narji Limestone. It is poorly exposed and not many well exposed outcrops are present.*

**Overtuned Koilkuntla Limestone along the western boundary of Nallamalai Fold Belt (Rudravaram Line), Cuddapah district, Andhra Pradesh**



**Koilkuntla Limestone (farther) conformably overlying the Paniam Quartzite (nearer), east of Inuparati Konda, Kakirala reserve forest, Guntur district, Andhra Pradesh**



**Recumbent folds in Koilkuntla Limestone near thrust zone with Nallamalai fold belt, east of Inuparati Konda, Kakirala reserve forest, Guntur district, Andhra Pradesh**



**Overtuned Koilkuntla Limestone, as footwall due to thrusting of Nagari Quartzite, Khajipet-Badvel highway, western boundary of Nallamalai Fold Belt, Cuddapah district, Andhra Pradesh**



**Bedding parallel tension gashes in Koilkuntla Limestone near thrust zone, Khajipet-Badvel highway, Cuddapah district, Andhra Pradesh**



**Thinly laminated Kolikuntla Limestone, Velugodu Dam, Atmakur, Kurnool district, Andhra Pradesh**



**Thinly laminated Kolikuntla Limestone, east of Inuparati Konda, Kakirala reserve forest, Guntur district, Andhra Pradesh**



## **N**andyal Shale

*Nandyal Shale is the top most unit of the Kurnool Group and is characterised by well laminated, fine purple or brown laminae or beds. At places they are calcareous and clay dominated with minor silty beds. The shale is highly weathered and are exposed at few places only. It has a maximum stratigraphic thickness of 100m.*

**Thinly laminated Nandyal Shale Velugodu Dam, Atmakur, Kurnool district, Andhra Pradesh**



**Thinly laminated Nandyal Shale, Velugodu Dam, Atmakur, Kurnool district, Andhra Pradesh**



**Nandyal Shale, exposed along the canal of Velugodu Dam, Atmakur, Kurnool district, Andhra Pradesh**



## Epilogue

Cuddapah Basin is a representative of  $\sim 12.5$  km stratigraphic thickness of sedimentary sequence that hosts combinations of magmatic, volcanic and sedimentary units. The lithological variations and structural heterogeneities in the Cuddapah Basin is always recognised and dealt in relation to regional tectonics. The alternate sequence of arenaceous, carbonate/argillaceous units mark the lower part of the Cuddapah Supergroup while the upper most host two cycles of arenaceous, carbonate and argillaceous units in the Kurnool and the Palnad sub-basins. The Nallamalai Fold Belt has discrete geology, structure and mineralisation milieu compared to rest of the basin. Understanding the evolution of the Cuddapah Basin is a continuous process and a number of mapping, sedimentological, petrological, structural, geochemical and geochronological studies are done. Questions regarding the mechanism of opening and closing of the basin, depth of sedimentary sequence, search for deep economical deposits are some of the recent ongoing works in the basin by various agencies and scientists.

This pictorial atlas is prepared with the hope to cater a bridge in understanding of the basin in visual way for the geoscientific community and young research fellow. Displaying a basin having an extent as those of Cuddapah Basin can never be portrayed in detail and so does this Pictorial Atlas of Cuddapah Basin.





*William King*



## Bibliography

- Anand, M., Gibson, S.A., Subbarao, K.V., Kelley, S.P., Dickin, A.P., 2003. Early Proterozoic Melt Generation Processes beneath the Intra-cratonic Cuddapah basin, Southern India. *Journal of Petrology* 44, 2139–2171.
- Anil Kumar, Padma Kumari, V.M., Dayal, A.M., Murthy, D.S.N., Gopalan, K., 1993. Rb–Sr ages of Proterozoic kimberlites of India: evidence for contemporaneous emplacement. *Precambrian Research* 79, 363–369.
- Basu A and Bickford ME (2015) An alternate perspective on the opening and closing of the intracratonic Purana Basins in Peninsular India, *Journal Geological Society India* 85 (1) 5 – 25.
- Bhaskar Rao, Y.J., Pantulu, G.V.C., Damodar Reddy, V., Gopalan, K., 1995. Time of early sedimentation and volcanism in the Proterozoic Cuddapah basin, South India: evidence from Rb–Sr age of Pulivendla mafic sill. *Geological Society of India Memoirs* 33, 329–338.
- Bickford, M.E., Saha, D., Schieber, J., Kamenov, G., Russell, A. and Basu, A. 2013. New U–Pb Ages of Zircons in the Owk Shale (Kurnool Group) with Reflections on Proterozoic Porcellanites in India, *Journal Geological Society of India*, 82, 207–216.
- Chakraborti, S. and Saha, D., 2009. Tectonic stresses and thin-skinned tectonics in a Proterozoic fold-and-thrust belt read from calcite mylonites in the Cuddapah basin, south India. *Indian Journal of Geology*, 78, 37–54.
- Chakraborti, S., 2006. Analysis of fold-and-thrust structures in parts of Neoproterozoic Palnad Sub-basin, Cuddapah basin, south India. Ph.D. thesis, University of Calcutta.
- Chakrabarti, G., Shome, D., Kumar, S., Armstrong, J.S., Sial, N.A., 2013. Chemostratigraphy of carbonate succession of the Vempalle formation, Cuddapah basin, India: a stratigraphic record of terminal Paleoproterozoic ocean-atmosphere-biosphere system. *Carpathian Jour. of Earth and Environmental Sciences* 8 (1), 71 – 80.
- Chalapati Rao et al., 1996. New Proterozoic K–Ar ages for some kimberlites and lamproites from the Cuddapah Basin and Dharwar Craton, south India: evidence for non-contemporaneous emplacement. *Precambrian Research* 79, 363–369.
- Chalapati Rao et al., 2004. Petrogenesis of Proterozoic lamproites and kimberlites from the Cuddapah Basin and Dharwar Craton, Southern India. *Journal of Petrology* 45, 907–948.
- Chalapati Rao et al., 2010. Petrogenesis of the Mesoproterozoic lamproites from the Krishna valley, eastern Dharwar craton, southern India. *Precambrian Research*, vol. 177 (1), 103–130.
- Chalapati Rao et al., 2014. Petrology and petrogenesis of Mesoproterozoic lamproites from the Ramadugu field, NW margin of the Cuddapah basin, eastern Dharwar craton, southern India *Lithos* 196–197 150–168
- Chalapati Rao et al., 2016. Petrogenesis of Mesoproterozoic lamproite dykes from the Garledinne (Banganapalle) cluster, south-western Cuddapah Basin, southern India *Mineralogy and Petrology* 110 247–268.
- Chalapati Rao, N.V., Fu-Yuan, Wu and Srinivas, M., 2012. Mesoproterozoic emplacement and enriched mantle derivation of the Racherla alkali syenite, Palaeo-Mesoproterozoic Cuddapah Basin, southern India: insights from in situ Sr–Nd isotopic analysis on apatite. *Geological Society, London, Special Publication* 365, 185–195.
- Chandrakala K, Pandey OP, Prasad ASSRS, and Sain K (2015) Seismic imaging across the Eastern Ghats Belt – Cuddapah basin collisional zone, southern Indian Shield and possible geodynamic implications *Precambrian Research*, 271, 56–64
- Chandrakala, K., Pandey, O.P., Mall, D.M., Sarkar, D., 2010. Seismic signatures of a Proterozoic thermal plume below southwestern part of the Cuddapah Basin, Dharwar craton. *Journal of the Geological Society of India* 76 (6), 565–572.
- Chandrakala, K., Mall, D.M., Sarkar, D. and Pandey, O.P. 2013. Seismic imaging of the Proterozoic Cuddapah basin, south India and regional geodynamics, *Precambrian Research*, 231, 277–289.
- Chakrabarti, G., Shome, D., Chandra Sekhar Reddy, L. and Sinha, S. 2016. Provenance and Tectonic Setting of the late Paleoproterozoic Clastic Sedimentary Rocks of the Cuddapah Basin, South India. *Research Journal of Chemical Sciences*, 6(10), 1–7.
- Chakraborty, K., Mukhopadhyay, P.K. and Pankaj, P. 2016. Magmatism in Western Cuddapahs: The Mafic Sills and Lava Flows of Vempalle and Tadpatri Formations, *Journal Geological Society of India*, 87, 631–660.



- Chatterjee and Bhattacharji, 2001. Petrology, Geochemistry and tectonic setting of the mafic dykes and sills associated with the evolution of the Proterozoic Cuddapah Basin, South India. *Indian Academy of Science* vol. 110, pp. 433-453.
- Chetty, T.R.K., 2011. Tectonics of Proterozoic Cuddapah Basin, Southern India: A Conceptual Model. *Journal of the Geological Society of India*, 78, 446-456.
- Collins, A., Patranabis-Deb, S., Alexander, E., Bertram, C.N., Falster, G.M., Gore, R.J., Mackintosh, J., Dhang, P.C., Saha, D., Payne, J.L., Jourdan, F., Backé, G., Halverson, G.P., Wade, B.P., 2014. Detrital mineral age, radiogenic isotopic stratigraphy and tectonic significance of the Cuddapah Basin, India. *Gondwana Research*. In Press, dx.doi.org/10.1016/j.gr.2014.10.013.
- Coulson, L., 1933. The Kalva (Calwa) 'Wall' in the Kurnool district of the Madras Presidency, an example of monoclinial folding, accompanied by faulting, probably along an old line of weakness. *Rec. Geol. Surv. India* 66, 438-449.
- Crawford, A.R., Compston, W., 1973. The age of the Cuddapah and Kurnool systems, Southern India. *Journal of Geological Society of Australia* 19, 453-464.
- Das, S. and Chakraborty, M. (2019) Petrology and geochemistry of mafic dyke and sills in Cumbum Formation, of the Proterozoic Nallamalai fold belt, Rajampet area, Andhra Pradesh, India, *Journal of Earth System Sciences*, 128, article id 116, 22p. DOI 10.1007/s12040-019-1102-0.
- Dasgupta, P.K., Biswas, A., 2006. Rhythms in Proterozoic sedimentation: an example from Peninsular India. *Satish Serial Publishing House, Delhi*, pp. 340.
- Deb, M., Bheemalingeswara, K., 2008. Carbonaceous tuff-stratiform barite association in Mangampeta deposit, Andhra Pradesh, India: Implications on depositional environment and origin. Ore deposits associated with black shales: from their origin to their environmental impacts: 33rd International Geological Congress, Oslo, Norway, Abstract, MRD134071.
- Dobmeier, C., Lütke, S., Hammerschmidt, H., Mezger, K., 2006. Emplacement and deformation of the Vinukonda granite – implications for the geological evolution of peninsular India and for Rodinia reconstructions. *Precambrian Research* 146, 165-178.
- Dutt, N.V.B.S., 1962. Geology of the Kurnool System of rocks in Cuddapah and the southern part of Kurnool district. *Records of the Geological Survey of India* 87, 540-604.
- French, J.E., Heaman, L.M., Chacko, T., Srivastava, R.K., 2008. 1891-1883 Ma Southern Bastar-Cuddapah mafic igneous events, India: a newly recognized large igneous province. *Precambrian Research* 160, 308-322.
- Ganguli SS, Singh S, Das N, Maurya D, Pal SK and Rama Rao JV (2019) Gravity and magnetic survey in southwestern part of Cuddapah Basin, India and its implications for shallow crustal architecture and mineralization. *Journal Geological Society of India*, 93, 419 – 430.
- Geological Survey of India, 1981. Explanatory brochure on Geological and Mineral Map of Cuddapah Basin. 1-21.
- Gopakumar, B. and Waghmare, M. 2016. Nature of Occurrence of Phosphatic Bands in Owk Formation, Neoproterozoic Kurnool Basin, Andhra Pradesh, *Journal Geological Society of India*, 88, 213-221.
- Goswami S, Bhattacharjee P, Bhagat S, Suresh Kumar and Zakaula S. 2015. Petrography of chert nodules in stromatolitic dolostone of Vempalle Formation, along Tummalapalle - Motnupalapalle, Cuddapah Basin, India. *Indian Journal of Geoscience*, 69, 13-24.
- Goswami S, Mukherjee A, Zakaula S and Rai AK. 2016. Stress states, faulting and their effects on the Papaghni Group, Cuddapah Basin, India: a study along Giddankivariapalle - Madyalabodu tract. *Indian Journal of Geoscience*, 70, 1-16.
- Goswami S, Mukherjee A, Bhattacharjee P and Zakaula S. 2017a. Primary sedimentary structures and MISS in Gulcheru quartzite along SW part of Cuddapah Basin. *Journal Geological Society of India*, 89, 511-520.
- Goswami S, Upadhyay PK, Bhagat S, Zakaula S, Bhatt AK, Natarajan V, and Dey S. 2018. An approach of understanding acid volcanics and tuffaceous volcanoclastics from field studies: A case from Tadpatri Formation, Proterozoic Cuddapah basin, Andhra Pradesh, India. *Journal of Earth System Sciences*, 127, 20 doi: 10.1007/s12040-018-0929-0
- Gupta, J.N., Pandey, B.K., Chabria, T., Banerjee, D.C., Jayaram, K.M.V., 1984. Rb-Sr geochronological studies on the granites of Vinukonda and Kanigiri, Prakasam district, Andhra Pradesh, India. *Precambrian Research* 26, 105-109.



- Jeyagopal AV, Rai AK, Parihar PS. 2012. Tectonic setting of Tummalapalle uranium deposit in southern margin of Cuddapah basin, Andhra Pradesh. *Exploration and Research in Atomic Minerals*, 22, 43–54.
- Jokhan Ram 2012. Neoproterozoic successions in Peninsular India and their hydrocarbon prospectivity. *Geological Society London Special Publication*, 366, 59-73 doi: 101144/SP3664
- Joy, S., Jelsma, H.A., Preston, R.F. and Kota, S., 2012. Geology and diamond provenance of the Proterozoic Banganapalle conglomerates, Kurnool Group, India. From: Mazumder, R. & Saha, D. (eds) 2012. *Palaeoproterozoic of India*. Geological Society, London, Special Publications, 365, 197–218.
- Kaila & Tewari 1985. Structural trends in the Cuddapah basin from Deep Seismic Sounding (DSS) and their tectonic implications. *Tectonophysics* vol. 115, pp. 69-86.
- Kaila and Krishna, 1992. Deep Seismic Sounding Studies in India and Major Discoveries: *Current Science*, Vol.62, NOS 1&2, 25, January 1992
- Kaila et al. 1979. Crustal structure along Kavali-Udipi profile in the Indian peninsular shield from deep seismic sounding; *J. Geol. Soc. India* v20, pp. 307-333.
- Kaila et al., 1987. Crustal structure of the northern part of the Proterozoic Cuddapah basin of India from Deep Seismic Sounding and gravity data. *Tectonophysics* vol. 140, pp. 1-12.
- Khan T, Srinivasa Sarma D, Somasekhar V, Ramanaiah S, Ramakrishna Reddy N. 2019. Geochemistry of the Palaeoproterozoic quartzites of Lower Cuddapah Supergroup, South India: implication for the palaeoweathering, provenance and crustal evolution. *Geological Journal*, 25 p doi. 10.1002/gj.3849.
- King, W., 1872. The Cuddapah and Karnul formations in Madras Presidency: *Memoir Geological Survey India* 8 (I), 1-346.
- Krishna Brahmam, N. 1989. Gravity and seismicity of the Cuddapah basin and surrounding places. *Journal Geological Society of India*, 34, 373 – 384.
- Krishna Brahmam N, Sarma JR, Aravamadhu PS and Subbarao DV. 1986. Explanatory brochure on Bouger gravity anomaly map (NGRI/GPH-6) of Cuddapah basin, India with scale 1:250,000 NGRI, Hyderabad 36 p
- Lakshminarayana, G. and Bhattacharjee, S. 2000. Shallow Marine Siliciclastic Sedimentation in the Middle Proterozoic Gandikota Formation, Cuddapah Basin, Andhra Pradesh, *Journal Geological Society of India*, 55, 65-76.
- Lakshminarayana, G., Bhattacharjee, S. Kumar, A. 2000. Palaeocurrents and Depositional Setting in the Banganapalle Formation, Kurnool Sub-basin, Cuddapah Basin, Andhra Pradesh, *Journal Geological Society of India*, 53, 255-259.
- Lakshminarayana, G., Bhattacharjee, S., Ramanaidu, K.V., 2001. Sedimentation and stratigraphic framework in the Cuddapah basin. *Geological Survey of India, Special Publication* 55, 31-58.
- Lakshminarayana G and Vijay Kumar D. 2018. Occurrence of High Level Magma Intrusives and Associated Mineralization near Gani Inlier, Kurnool Sub-Basin, Cuddapah Basin, India. *Journal Geological Society of India*, 91, 431-440.
- Matin, A., 2014. Tectonics in the Cuddapah fold-thrust belt in the Indian shield, Andhra Pradesh, India and its implication on the crustal amalgamation of India and Rayner craton of Antarctica during Neoproterozoic orogenesis. *International Journal of Earth Science*, 103, 7-22.
- Matin, A. and Guha, J., 1996. Structural geometry of the rocks of the southern part of the Nallamalai Fold Belt, Cuddapah Basin, Andhra Pradesh. *Journal Geological Society of India*, 47, 535-545.
- Meijerink, A.M.J., Rao, D.P., and Rupke, J., 1984. Stratigraphic and Structural development of the Precambrian Cuddapah Basin, SE India, *Precambrian Research*, 26, 57-104.
- Mishra et al. 1987. Three dimensional structural model of Cuddapah basin and adjacent eastern part from geophysical studies. In: Radhakrishnan, B. P. (ed.) *Purana Basins of peninsular India*, vol. 06, Geological Society of India, memoir, pp. 311-329.
- Mitra R, Chakrabarti G, and Shome D. 2018. Development of Stromatolites in a mixed siliciclastic carbonate succession: An example from Palaeo-Mesoproterozoic Tadpatri Formation, Cuddapah Basin, India. *Int J Res Anal Rev*, 5380–384.
- Mukherjee, M. K., 2001. Structural pattern and kinematic framework of deformation in the southern Nallamalai fold-fault belt, Cuddapah district, Andhra Pradesh, Southern India. *Journal Asian Earth Sciences*, 19, 1-15.



- Murthy, Y. G. K., Babu Rao, V., Guptasarma, D., Rao, J. M., Rao, M. N. & Bhattacharjee, S. 1987. Tectonic, petrochemical and geophysical studies of mafic dyke swarms around the Proterozoic Cuddapah Basin, South India. Geological Association of Canada Special Paper, 34, 303–316.
- Nagaraja Rao, B.K., Rajurkar, S.T., Ramalingaswamy, G., and Ravindra Babu, B., 1987. Stratigraphy, Structure and Evolution of the Cuddapah Basin. In: Radhakrishna, B.P. (ed.) *Purana Basins of Peninsular India (Middle to Late Proterozoic)*. Geological Society of India, Memoir, 6, 33-86.
- Natarajan, V. and Rajagopalan Nair, S., 1977. Post Kurnool thrust and structural features in the northeast part of the Palnad basin, Krishna district. A.P. J. Geol. Soc. India, 18, 111-116.
- Neelakantam 1987. Geological map of Mangampet barite deposit, Andhra Pradesh.
- Panja M, Chakrabarti G, and Shome D. 2018. Earthquake induced soft sediment deformation structures in the Paleoproterozoic Vempalle Formation (Cuddapah basin, India) Carbonates and Evaporites doi: 10.1007/s13146-017-0412-z (published online).
- Patranabis-Deb S, Saha D and Tripathy V. 2012. Basin stratigraphy, sea-level fluctuations and their global tectonic connections—evidence from the Proterozoic Cuddapah Basin. Geological Journal, 47, 263–283 doi: 10.1002/gj1347).
- Patranabis-Deb S, Majumder T, and Khan S. 2018. Lifestyles of the Palaeoproterozoic stromatolite builders in the Vempalle Sea, Cuddapah Basin, India. Journal of Asian Earth Sciences, 157, 360-370
- Rai AK, Pandey UK, Zakauilla S and Parihar PS. 2015. New 1.9-2.0 Ga, Pb-Pb (PbSL), age of dolomites from Vempalle Formation, Lower Cuddapah Supergroup, Eastern Dharwar craton, India. Journal Geological Society of India, 86 (2), 131-136.
- Rajurkar, S.T., 1972. Geology of Vami Konda ranges and adjoining Palnad area, Cuddapah basin, Andhra Pradesh. Unpublished report, Geological Survey of India.
- Rajurkar ST, and Ramalingaswami, G. 1975. Facies variations within the Upper Cuddapah Strata in the northern part of the Cuddapah Basin. In: Precambrian Geology of the Peninsular Shield, Part 1. Geological Survey of India, Misc. Publ 23, 157-164.
- Ramlinga Swamy, G., 1972. Geology of the Karempudi, Gummanampadu and adjoining areas in Cuddapah basin, Guntur district, Andhra Pradesh. Geological Survey of India, unpublished report.
- Saha, D., 2002. Multi-Stage Deformation in the Nallamalai Fold Belt, Cuddapah Basin, South India - Implications for Mesoproterozoic Tectonism Along Southeastern Margin of India. Gondwana Research, 5, 701-719.
- Saha, D., 2004. Structural asymmetry and Plate tectonic set-up for a Proterozoic Fold and Thrust Belt Nallamalai Fold Belt and Adjoining Terrane, South India, Geological Survey of India, Special Publication, 84, 101-119.
- Saha, D. and Chakraborty, S., 2003. Deformation Pattern in the Kurnool and Nallamalai Groups in the Northeastern Part (Palnad Area) of the Cuddapah Basin, South India and its Implication on Rodinia/Gondwana. Tectonics, Gondwana Research, 6, 573-583.
- Saha, D. and Patranabis-Deb, S., 2014. Proterozoic evolution of Eastern Dharwar and Bastar cratons, India – An overview of the intracratonic basins, craton margins and mobile belts. Journal of Asian Earth Sciences, 91, 230-251.
- Saha, D., Tripathy, V., 2012. Palaeoproterozoic sedimentation in the Cuddapah Basin south India and regional tectonics – a review. In: Mazumder, R., Saha, D. (Eds.), Paleoproterozoic of India, vol. 365. Geological Society of London Special Publication, pp. 159–182.
- Saha, D., Chakraborti, S. and Tripathy, V., 2010. Intracontinental Thrusts and Inclined Transpression along Eastern Margin of the East Dharwar craton, India. Journal of the Geological Society of India, 75, 323-337.
- Saha, D., 1994. Fold-Fault structures of the Nallamalai range, Diguvametta-Nandi Ka Nama Pass, Prakasam district, Andhra Pradesh, South India. Indian Journal of Geology, 66, 203-213.
- Sahoo, D, Pruseth, K.L. Upadhyay, D., Ranjan, S., Pal, D.C., Banerjee, R. and Gupta, S. 2017. New constraints from zircon, monazite and uraninite dating on the commencement of sedimentation in the Cuddapah basin, India, Geological Magazine, 1-17.
- Sharma, M. and Shukla, M. 1998. Microstructure and microfabric of Palaeoproterozoic small digitate stromatolites (ministromatolites) from the Vempalle Formation, Cuddapah Supergroup, India, Journal of the Palaeontological Society of India, 43, 89-100.



- Sharma, M. and Shukla, Y. 2012. Occurrence of helically coiled microfossil *Obruchevella* in the Owk Shale of the Kurnool Group and its significance, *Journal Earth System Sciences*, 121, 755-768.
- Sheppard Stephen, Rasmussen Birger, Zi Jian-Wei, Somashekar, V., Srinivasa Sharma, D., Ram Mohan, M., Bryan Krapez, Simam A. Wide, Neal J. McNaughton, 2017a. Sedimentation and magmatism in the Paleoproterozoic Cuddapah basin, India: Consequences of lithospheric extension. Accepted manuscript *Gondwana Research* 1796.
- Sheppard S, Rasmussen B, Zi, JW Soma Sekhar V, Srinivasa Sarma D, Ram Mohan M and Krapez B. 2017 b. U-Pb dating of metamorphic monazite establishes a Pan-African age for tectonism in the Nallamalai Fold Belt, India. *Journal Geological Society London*, 174 (6), 1062-1069 doi: 101144/jgs2017-051
- Sesha Sai V.V. 2006. Igneous activity in Proterozoic Cuddapah basin. Volume on research papers in DST sponsored field workshop "Cuddapah Basin" conducted by GSITI, Hyderabad. Unpublished Field Workshop volume, p. 53-62.
- Sesha Sai, V.V., 2011, Petrology and Mineral Chemistry of Picrite Sill from Peddakudala-Velpula Area in Southwestern Part of the Proterozoic Cuddapah Basin, Andhra Pradesh, India: in Srivastava, R.K., ed., *Dyke Swarms: Keys for Geodynamic Interpretation*: Springer-Verlag, Berlin Heidelberg, p. 115- 124.
- Sesha Sai, V.V. 2019. Proterozoic Magnesian Feldspathic Magmatism in the Nallamalai Fold Belt, Southern India – Petrogenesis of Vellaturu-Ipuru-Nakerikallu (VIN) Arc Magmatic Granites, Eastern Dharwar Craton, *Journal Geological Society of India*, 93, 409-418.
- Sesha Sai, V.V., 2013. Proterozoic Granite Magmatism along the Terrane Boundary Tectonic Zone to the East of Cuddapah Basin, Andhra Pradesh – Petrotectonic Implications for Precambrian Crustal Growth in Nellore Schist Belt of Eastern Dharwar Craton. *Journal of Geological Society of India* 81, 167–182.
- Sesha Sai, V.V. 2014. Pyroclastic Volcanism in Papaghn Sub-basin, Andhra Pradesh: Significant Paleoproterozoic Tectonomagmatic Event in SW Part of the Cuddapah Basin, Eastern Dharwar Craton, *Journal Geological Society of India*, 83, 355-362.
- Sesha Sai, V.V., Khanna, T.C. and Krishna Reddy, N.R., 2016. Red beds in the Cuddapah Basin, eastern Dharwar craton, India: Implications for the initiation of sedimentation during the Proterozoic Oxygenation event. *Journal of Indian Geophysical Union* 20, 342-350.
- Sesha Sai, V.V., Tripathy, V., Bhattacharjee, S. and Khanna, T.C., 2017. Paleoproterozoic magmatism in the Cuddapah basin, India. *Journal of Indian Geophysical Union* 21, 516-525.
- Sheppard S, Rasmussen B, Zi JW, Sekhar S, Sarma S, Ram Mohan M, Krapež B, Wilde SA, and McNaughton NJ, (2017) Sedimentation and magmatism in the Paleoproterozoic Cuddapah Basin, India: Consequences of lithospheric extension *Gondwana Research*, 48, 153 – 163 doi:101016/jgr201704024.
- Sheppard S, Rasmussen B, Zi, JW Soma Sekhar V, Srinivasa Sarma D, Ram Mohan M and Krapez B (2017 b) U-Pb dating of metamorphic monazite establishes a Pan-African age for tectonism in the Nallamalai Fold Belt, India *J Geol Soc London* 174 (6) 1062-1069 doi: 101144/jgs2017-051.
- Singh D, Manikyamba C, Subramanyam KSV, Ganguly S, Khelen AC, and Reddy R (2018) Mantle heterogeneity, plume-lithosphere interaction at rift controlled ocean-continent transition zone: Evidence from trace-PGE geochemistry of Vempalle flows, Cuddapah Basin, India, *Geoscience Frontiers* 9 1809-1827
- Singh, A.P. and Mishra, D.C. 2002. Tectono sedimentary evolution of Cuddapah basin and eastern ghat mobile belt (India) as Proterozoic collision: gravity, seismic, and geodynamic constraints. *Jour. Geodynamics*, 33, 249-267.
- Sivasubramaniam R, Birua MK, Kumar S, Christopher Arulmani P, Zakaula S, and Rai AK. 2016. Petro-physical characteristic of uraniferous dolostone in Vempalle Formation, Tumallapalle Uranium Deposit, Andhra Pradesh, India. *Expl Res Atomic Min*, 26, 137-142.
- Somayajulu J. G., Singhal, B. B. S., 1968. Petrochemistry of basic rocks from Pulivendla, Cuddapah District, Andhra Pradesh. *Journal Geochemical Society of India* 3,75-84.
- Somasekhar V, Ramanaiah S, Srinivasa Sarma, D. 2018. Geochemical characterisation of the siliciclastic rocks of Chitravati Group, Cuddapah Supergroup: implications for provenance and depositional environments. *Journal Earth System Science*, 127 doi 10.1007/s12040-018-0955-y.
- Srikantia SV, (1984) Kuppalapalle volcanic - a distinct Upper Papaghn volcanic activity in the Cuddapah Basin *Jour Geol Soc India* 25 (12) 775-779.



- Srikantia, S.V., 1984. Kuppalapalle volcanic - a distinct Upper Papaghni volcanic activity in the Cuddapah Basin, *Journal of the Geological Society India* 25 (12), 775-779.
- Tewari HC and Rao VK. 1987. A high velocity intrusive body in the upper crust in the south western part of Cuddapah basin as delineated by Deep Seismic Sounding and gravity modelling In *Purana Basins of Peninsular India* (Ed Radhakrishna BP) Geological Society of India Mem6 349-356.
- Tripathy, V. and Saha, D., 2010. Structure and low grade metamorphism of the east central part of the Proterozoic Nallamalai fold belt, south India—thrust stacking and discontinuous metamorphic gradients along eastern margin of East Dharwar craton. *Indian Journal of Geology*, 80, 1-4, 173-188.
- Tripathy, V. 2011. Brittle Deformation in the Western Cuddapah Basin, South India and Implications for Intra-Continental Tectonics. *Jadavpur University*, p. 264 (Ph.D. thesis).
- Tripathy, V. and Saha, D., 2013. Plate margin paleostress variations and intracontinental deformations in the evolution of Cuddapah basin through the Proterozoic. *Precambrian Research*, 235, 107-130.
- Tripathy, V. and Saha, D., 2015 Inversion of calcite twin data, paleostress reconstruction and multiphase weak deformation in cratonic interior - Evidence from the Proterozoic Cuddapah basin, India. *Journal of Structural Geology*, 77, 62-81.
- Tripathy V, Satyapal, Mitra SK and Sesha Sai VV (2019) Fold-Thrust Belt Architecture and Structural Evolution of the Northern Part of the Nallamalai Fold Belt, Cuddapah Basin, Andhra Pradesh, India In: *Tectonics and Structural Geology: Indian Context* (Ed Mukherjee S) Springer Geology 219-252.
- Vadlamani, R., Hashmi, S., Chatterjee, C., Qiang Ji, W. and Wu, FY. 2014. Initiation of the intra-cratonic Cuddapah basin: Evidence from Paleoproterozoic (1995 Ma) anorogenic porphyritic granite in Eastern Dharwar Craton basement. *Journal of Asian Earth Sciences*, 79, 235-245.
- Vasudeva Rao, M, Nagabhushana JC, Jeyagopal AV. 1989. Uranium mineralisation in the middle Proterozoic carbonate rocks of the Cuddapah Supergroup, southern Peninsular India. *Explor Res Atom Miner*, 2, 29-38
- Verma, R.K. and Satyanarayana, Y. 1990. Gravity field, deep-seismic sounding and crust-mantle structure over the Cuddapah basin and Dharwar Craton of India. *Tectonophysics*, 178, 337-356.
- Venkatakrishnan, R. and Dotiwala, F.E., 1987. The Cuddapah salient: a tectonic model for the Cuddapah basin, India, based on Landsat image interpretation, *Tectonophysics*, 136, 237-253.
- Verma MB, Som A, Latha A, Umamaheswar K, Maithani PB. 2008. Geochemistry of host granitoids of uranium deposit at Chitrial area, Srisailam Sub-basin, Nalgonda district, Andhra Pradesh Geological Society of India Mem, 73, 37-54.
- Verma MB, Gupta S, Singh RV, Latha A, Maithani PB, and Chaki A. 2011. Ore body characterization of Koppunuru uranium deposit in Palnad Sub-basin, Guntur district, Andhra Pradesh. *Indian Minerals*, 45, 51-61.
- Vimal R, Banerjee R, Gupta S, Krishna V, Achar KK, Ramesh Babu PV, Parihar PS, and Maithani, PB. 2012. Geochemistry and Sr and Pb isotope systematics of basement granitoids from north and west of Palnad Sub-basin, Guntur and Nalgonda districts, Andhra Pradesh. *Journal Applied Geochemistry*, 14, 295-315.
- Zachariah, J.K., Bhaskar Rao, Y.J. Srinivasan, R. and Gopalan, K. 1999. Pb, Sr and Nd isotope systematics of uranium mineralised stromatolitic dolomites from the proterozoic Cuddapah Supergroup, south India: constraints on age and provenance, *Chemical Geology*, 162, 49-64.
- Zakulla S, Umamaheshwar K, Tirupathi PV, Sharma UP, Basu H, and Ali MA. 2004. Geological and geochemical appraisal of uranium bearing Gulcheru Formation of Cuddapah Supergroup, Gandhi area, Cuddapah district, Andhra Pradesh. *Journal Geological Society of India*, 64, 719-730.







**Geological Survey of India**

2



**Geological Survey of India**