Study of Micro-Stylolite based on Geometry and Bedding Relationship Pattern in Neo-Proterozoic Narji Limestone from Betamcherla – BanganapalleArea of Kurnool Sub-Basin, Andhra Pradesh, South India

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ABSTRACT *Microstyololites within the Neo-Proterozoic Narji Limestone inBetamcherla–Banganapallearea are very well developed. They commonly occur within fine grained micritic limestone and mostly contain clayey material within them. Different types of microstylolites are recorded and described on the basis of the geometry and the bedding plane relationship. On the basis of the geometry the microstylolites are wavy and simple suture in nature.Whereas based on their bedding plane relationship they are horizontal, inclined as well as vertical in attitude. Their relationship with the host rock clearlyindicates that they are formed from the action of pressure solution process during lithification and diagenesis.*

Keywords: *Kurnool sub-basin,Narji,Pressure solution,microstylolite.*

1. INTRODUCTION

Stylolites have been derived from Greek word means stylos or pillar; and lithos means stone. These are zigzag surfaces within a rock mass at which mineral material within the rock has been removed by pressure dissolution due to diagenesis and/or tectonic features (Kerrich, 1978; Robin, 1978 and others). This results in a process that decreases the total volume of rock. They are recognized from there irregular planes of discontinuity between two rock units in the shape of columns and pyramids. The two rock units appear to be interlocked or mutually interpenetrating. Well-developed macro and micro stylolites are seen within in the carbonate rocks of Kurnool group, Andhra Pradesh. Earlier Vijayam and Reddy (1973), Malur and Nagendra (1988) and Madesh et al (2012) reported microstylolites from Precambrian carbonate rocks. The occurrence of macro and micro stylolite in Kurnool group was reported first by Vijayam and Reddy (1973). Stylolite study from Narji Limestone was carried by Natarajan and Rajagopalan Nair (1977) and Harish (1995). Our present work mainly focuses on the the classification and origin of microstylolites within the Narji Limestone reflecting the probable effect on sedimentological, diagenetic process and tectonic influence or disturbance in the area.

2. LOCATION OF THE STUDY AREA

LithostratigraphicallyCuddapah Basin is subdivided into older CuddapahSupergroup and relatively younger Kurnool Group (Table. 1). The Kurnool Group of rocks is well exposed in two sub basin namely the Kurnool sub basin in the west central part and the Palnad sub basin in the north eastern part of the Cuddapah. The two sub basins are separated by the distance of 75km, with the Srisailam Quartzite covering the gap. The NarjiLimestone within the Kurnool Sub-basin was deposited conformably on top of the clastic rock of the BanganapalleFormation.

Table 1. Stratigraphy of the Cuddapah Basin (after NagarajaRao et al., 1987)

GROUP	FORMATION	LITHOLOGY	AGE
KURNOOL	Nandyal (50-100 m)	Shale/ Limestone	Neoproterozoic
	Koilkuntala (15-50 m)	Limestone with shale	
	Paniam (10-35 m)	Quartzite	
	Owk (10-15 m)	Shale	
	Narji (100-200 m)	Massive Limestone, Flaggy Limestone	
	Banganapalli (10-15 m)	Quartzite with conglomerate	

------Unconformity------				
CUDDAPAH SUPERGROUP		Srisailam (300 m)	Pebbly grit, Quartzite, HeterolithicShales and stone	Mesoproterozoic
	------Unconformity------			
	NALLAMALAI	Cumbum (~ Pullampet Shale) (2000 m)	Shale, Dolomitic limestone, Quartzite	
		Bairenkonda (~ Nagari Quartzite) (5500 m)	Pebbly grit, Quartzite, HeterolithicShales and stone	
	------Unconformity------			
	CHITRAVATI	Gandikota (300 m)	Quartzite, Pebble beds	Mesoproterozoic
		Tadpatri (4600 m)	Shale, Quartzite, Stromatolitic dolomite with mafic flows, Sills and Dykes	
		Pulivendla (1-75 m)	Conglomerate, Quartzite	
	------Unconformity------			
	PAPAGHNI	Vempalle (1900m)	Stromatolitic dolomite, Shale, Basic flows and intrusive	Palaeoproterozoic
		Gulcheru (30-210 m)	Conglomerate, Feldspathic sandstone and quartzite	
------Unconformity------				
DHARWAR CRATON				Archean

The three sections were chosen for investigation. The first sections is along the road cut section (15°18'45.00"N, 78°07'35.76"E) of Patapadu-Yaganti hills located around 11Km from the town of Banaganapalle in Kurnool District. The second section is around Betamcherla hills (15°25'18.49'' N, 78°05'6.20'' E) and the third section is the Kottala hills (15°27'36.68'' N, 78°08'34.30'' E). These sections are located about 20km from the town Banaganapalle in Kurnool District, Andhra Pradesh. The micritedominatedNarji Formation starts with quartzite bearing massive purple limestone followed by siliceous pink and purple laminated limestone with thin lenticular lenses of gritty ferruginous sandstone (Patranabis Deb et al; 2012). These siliceous rich layers are mostly dominated towards the base of the formation (Patranabis Deb et al; 2012).These layers grade into pyrite and chert bearing massive whitish-grey limestone along with alternating laminated limestone layer. Thin and discrete beds of intraformational conglomerate occur within the Narji limestone (Patranabis Deb et al; 2012). The massive and the laminated units show symmetrical distribution throughout the sections till it show a gradational contact with the yellowish Owk shale towards the top. The layers are mostly separated by paleokarstic surfaces.

3. CLASSIFICATION OF MICROSTYLOLITES

Microstylolites occurring in the Narji Limestone are mostly parallel, inclined and vertical with respect to bedding plane. They are identified by their irregular nature. Their penetrative columns contains insoluble residue within them. These residues sometimes vary within their individual crest and trough regions. These structures have varied in

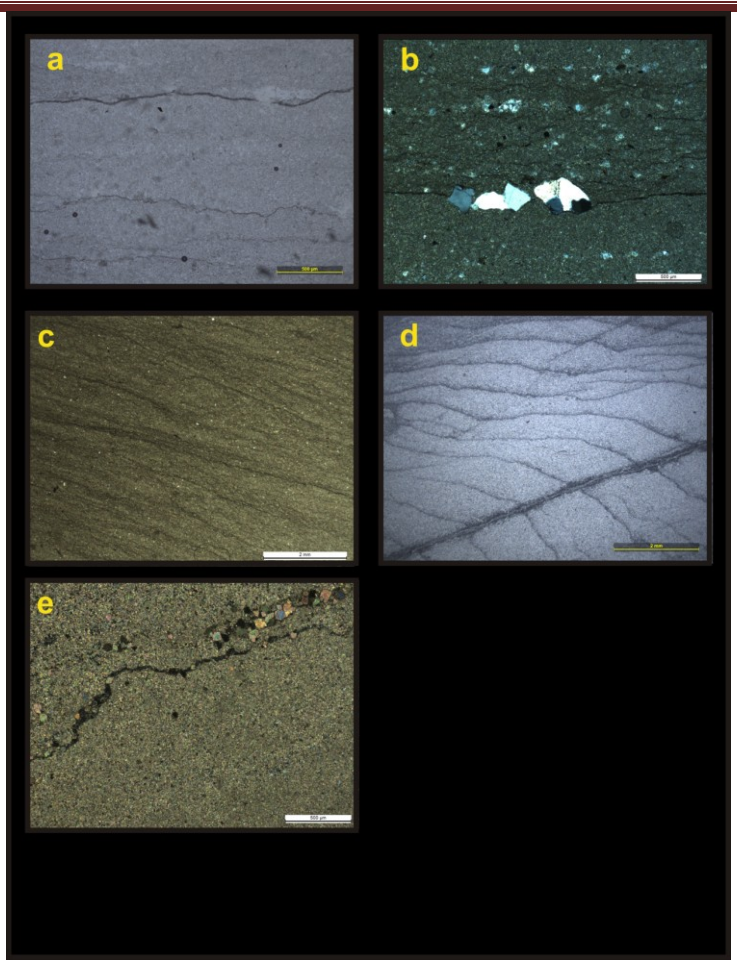

Fig. 1.Geometrical classification of microstylolites;aand**b**: stylolite of simple wavy parallel type-smooth and parallel to the bedding; **c**and**d**: stylolite of simple wavy non- parallel type-non parallel and interconnecting with each other; **e**: stylolite of suture type-simple suture likes projections on both sides.

amplitude, wavelength and shape result in different geometric pattern. Their classification is based on their (a) Geometrical classification and (b) attitude with respect to bedding.

(a) Geometrical classification:

Earlier geometric classification was given by Park and Schot (1968) into six different types. Malur et al., (1988 and 1992) classified microstylolites from Bhima Basin based on the pure geometry and bedding orientation. The microstylolite patterns within the Narji Limestone are mostly wavy while some are simple suture types that are both parallel and non-parallel types (Fig.1). Wavy microstylolites have small and gentle undulation with small amplitude (Malur and Nagendra 1988, Madesh et al 2012). Their crest and trough are mostly smooth, gentle and wavy (Fig.1 a-d). They run parallel or non-parallel to the bedding surface. The non-parallel types are mostly interconnecting and branching types. Mostly found in layered sedimentary rocks like carbonates. The residual clay materials are irregularly distributed within the stylolites (Fig.1 a-d). The simple suture type resemble like ammonoid suture pattern (Fig. 1e). Their anticline and synclinal patter of suture are symmetrically distributed. They are mostly non-parallel and asymmetrically distributed. They have interlocking project ions in either side. They are formed due to differential pressure solution phenomena forming suture of various amplitude (Fig. 1e).They mostly occur in quartz bearing limestone.

(b) Attitude with respect to bedding:

With respect to the bedding plane they are generally horizontal, inclined and vertical in attitude. Horizontal microstylolites (Fig. 2a) are developed parallel to bedding plane and it is common in almost all carbonate rocks. Vertical microstylolites are formed perpendicular to the bedding (Fig. 2b), and generally found along fracture planes. They are formed when the pressure act at right angle to the bedding. Inclined or oblique types have different inclination with respect to bedding. The rocks which they occur may be affected and unaffected by structural activity.

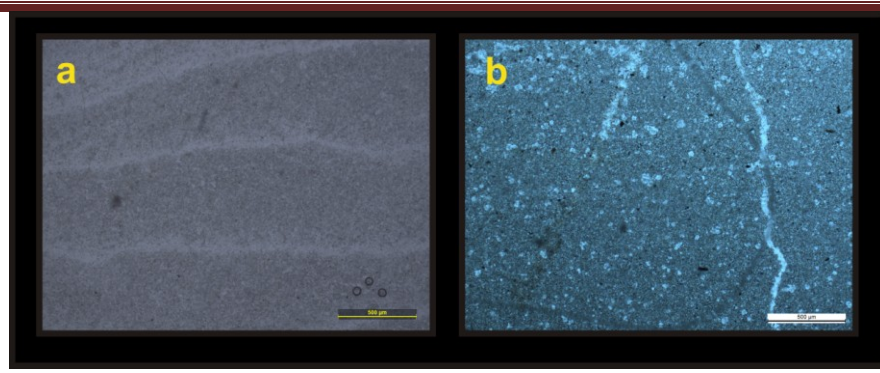

Fig. 2: Attitude with respect to bedding a: horizontal microstylolite parallel to bedding plane; **b**: Vertical microstylolitesareformed perpendicular to the bedding;

4. ORIGIN OF MICROSTYLOLITES

The three different theories based on the origin and formation of stylolite have been proposed by Wagner (1913) and Stockdale (1922) which is based on solution pressure theory, Rothpletz (1900) based on contraction pressure and finally by Rothpletz (1900), Shaub (1939), Marsh (1968), and Prokopovich's (1952) based on subaqueous solution theory.

During our study it is observed that some microstylolites are initially inclined which branches later (Fig.3a). It is caused by action of two successive differential pressure phenomena. It may be due to disturbance acting in different direction forming microstylolite of low amplitude. Some thin sections indicate diagenesis like presence of dolomite grains (Fig.3b) while other indicates micro faulting. These micro faults lack significant continuity within the host rocks (Fig.3c). Along stylolite, symbol of pre-lithification, pressure solution during compaction are identified. All these are well supported by the presence of residual seam having insoluble residual material along stylolite surface. Initially there is deposition of sediment which may be associated with water. The fine grained carbonate sediment mostly occurs with pyrite and clay. Due to dynamic

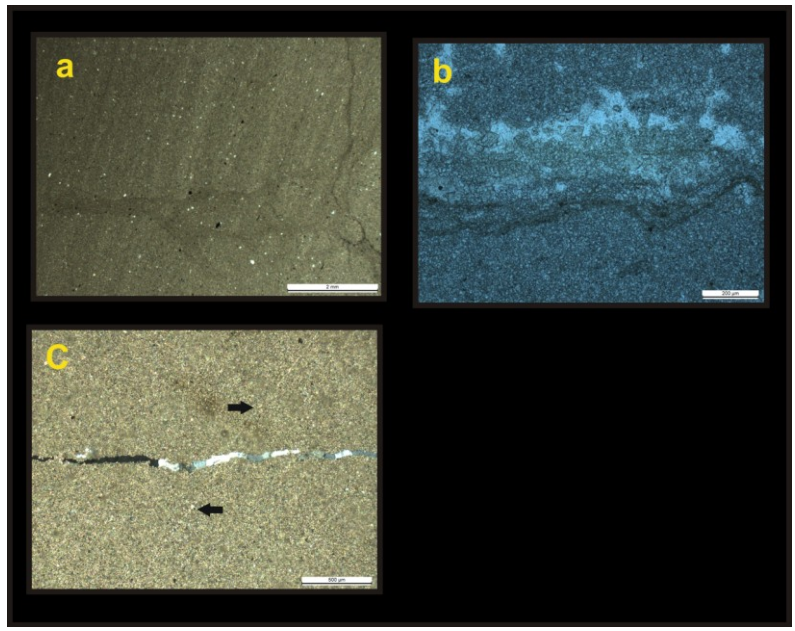

Fig. 3: a: stylolite of interconnecting branching type; **b:** presence of dolomite grains along the stylolite, **c:** micro faultwihin host rock

pressure effect during lithification the stylolite layers becomes mostly parallel or horizontal with respect to bedding plane. The pressure is generated by overlying rocks or due to tectonic influence (Madesh et al; 2012) during compaction and dewatering of sediments. During this process there is volume contraction and differential pressure due to loss of water. The soluble materials are pressed out of the rocks and the insoluble materials at the contacts remain intact as relicts forming stylolite seams.

5. MICROSTYLOLITE AND HOST ROCK RELATIONSHIP

The Narji limestone are mostly fine grained contains both micro and macro stylolites. Other accessory minerals are quartz and pyrite. The quartz grains are mostly subhedral and euhedral. The microstylolites have their distinct geometric forms and structure. Insoluble minerals, like clays, pyrite and calcite, occur within the stylolites and are fairly visible in some samples. The stylolite seams can be easily distinguishable from the material and the composition of the host rock which it contains. Due to cryptocrystalline nature of the carbonate rocks the identification of individual minerals under the petrological microscope is very difficult. The stylolites give evidence of probable disturbance in the area.

6. CONCLUSION

The microstylolites within Narjilimestones help to depict the sedimentological, diagenetic process and tectonic disturbance within the study area. The wavy and simple suture types reveal many features which can be explained by the pressure solution theories. Presence of dolomite grains along the microstylolite indicates diagenesis. The pre lithification process was identified by the presence of residual seam, insoluble material, micro faults and suture type stylolites. The presence of residual clay capping in the stylolite indicate the solution pressure theory or origin .The horizontal, vertical and inclined stylolite evidence from the successive pressure system indicate local disturbance and tectonic activity in this area with varied direction of action of these forces.

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