LITHO FACIES ANALYSIS OF JURASSIC SANDSTONE, GUNTUPALLI, ELURU DISTRICT, ANDHRA PRADESH, INDIA

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Abstract:

The present study focuses on the lithofacies analysis of Jurassic Sandstone from the Kota Formation at Guntupalli near Jeelakarragudem, Andhra Pradesh. Four litho sections, field relationships and geometry of sand bodies and structures were recorded. The summary of investigations in the study area indicates that, a range of lithofacies, including clast-supported conglomerate sandstone (Gm), trough cross-stratified sandstone (St), planar cross-stratified sandstone (Sp), massive sandstone (Sm), and claystone (F). The sedimentary structures and lithofacies suggest that the sediments are indicative of channel and point bar deposits typical of a braided river system.

Key words: Lithofacies analysis, Textural and structural studies, Jurassic Sandstone, Guntupalli Caves.

INTRODUCTION

The study area Guntupalli is located near Kamavarapukota in the Eluru District of Andhra Pradesh and it is 41 km North of Eluru town and 25 km Southwest of Jangareddigudem. It is lies in between latitude 17^0 1' 15.66″ N and 17^0 0' 56.66″ N and longitude 81^0 7' 42.91″ E and 81^0 7' 54.92″ E. The location map and contour map of the study area is given in the Figures 1 & 2 respectively.

Earlier studies on stratigraphy (Lakshminarayana & Murti, 1990, Lakshminarayana et al., 1992, and texture Vani Sailaja et al. 2013, of the Gondwana formations in the Chintalapudi Sub-Basin, whereas lithostratigraphy and tectonics (Rao, 1993; Lakshminarayana, 1995; Ramamohana Rao et al., 1996, 1999; Burhanuddin, 2007) are mainly focused on the Lower Gondwana sandstones.

The objective of the present study is to study lithofacies based on megascopic / visual interpretation of textural and structural characteristics of Upper Gondwana Jurassic sandstone to understand the depositional environment and it conditions.

METHODOLOGY

Systematic field work has been carried out in the study area, particularly at the archaeological site of Guntupalli Caves at Jeelakarragudem. Four distinct lithological sections were recorded to assess vertical and horizontal (lateral) variations, as well as field relations, and to measure the thickness of various lithological units. No samples were collected due to the site is archaeological significance.

GEOLOGY OF THE STUDY AREA

The Gondwana Supergroup consists of a continuous sequence of freshwater sediments, primarily composed of terrigenous material with occasional marine layers. The Geological map of the Chintalapudi sub-basin is given in the Figure 3. The Pranhita-Godavari Basin is an intracratonic rift basin that developed perpendicularly to the evolving curvilinear Eastern Ghat Mobile Belt (Lakshminarayana, 1997). The SE-NW direction is preserved and contains 3000m thick sediments deposited over approximately 200 million years. This Gondwana sequence of the Pranhita-Godavari Valley is divided into four sub-basins: the Godavari, Kottagudem, Chintalapudi, and Krishna-Godavari (Coastal sub-basin) from NW to SE (Raja Rao, 1982). The first three sub-basins contain continental Gondwana sequences and form the NNW-SSE trending linear tract of the Godavari Valley coal field. The Krishna-Godavari (K-G) coastal belt in southeastern Godavari Valley mainly contains Upper Gondwana sediments. Blanford (1872) identified rock units in the Chintalapudi sub-basin as Kamthi sandstone. Geological mapping by Lakshminarayana and Murthi (1990) found Talchir, Barakar, and Kamthi of the Lower Gondwanas and Kota and Gangapur Formations of Upper Gondwanas in the Chintalapudi basin.

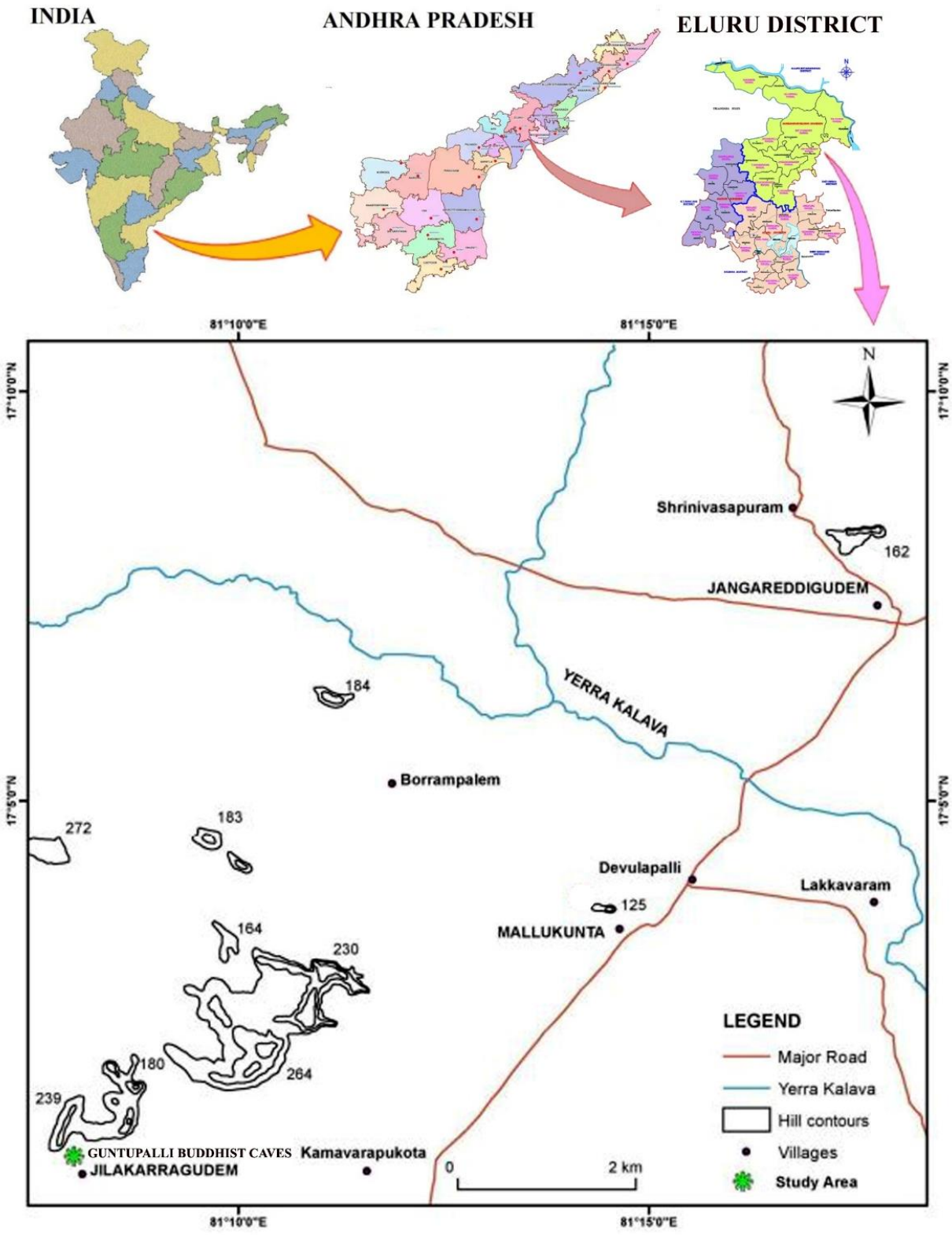

Fig.1. Location map of the study area

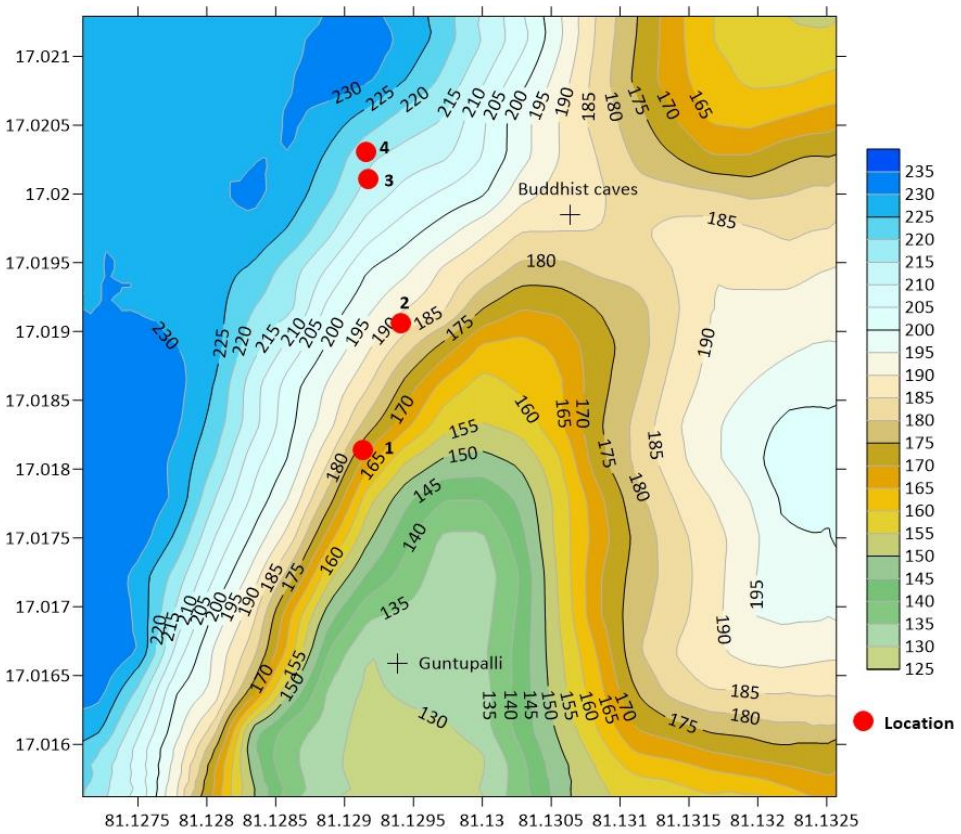

Fig.2. Contour map of study area.

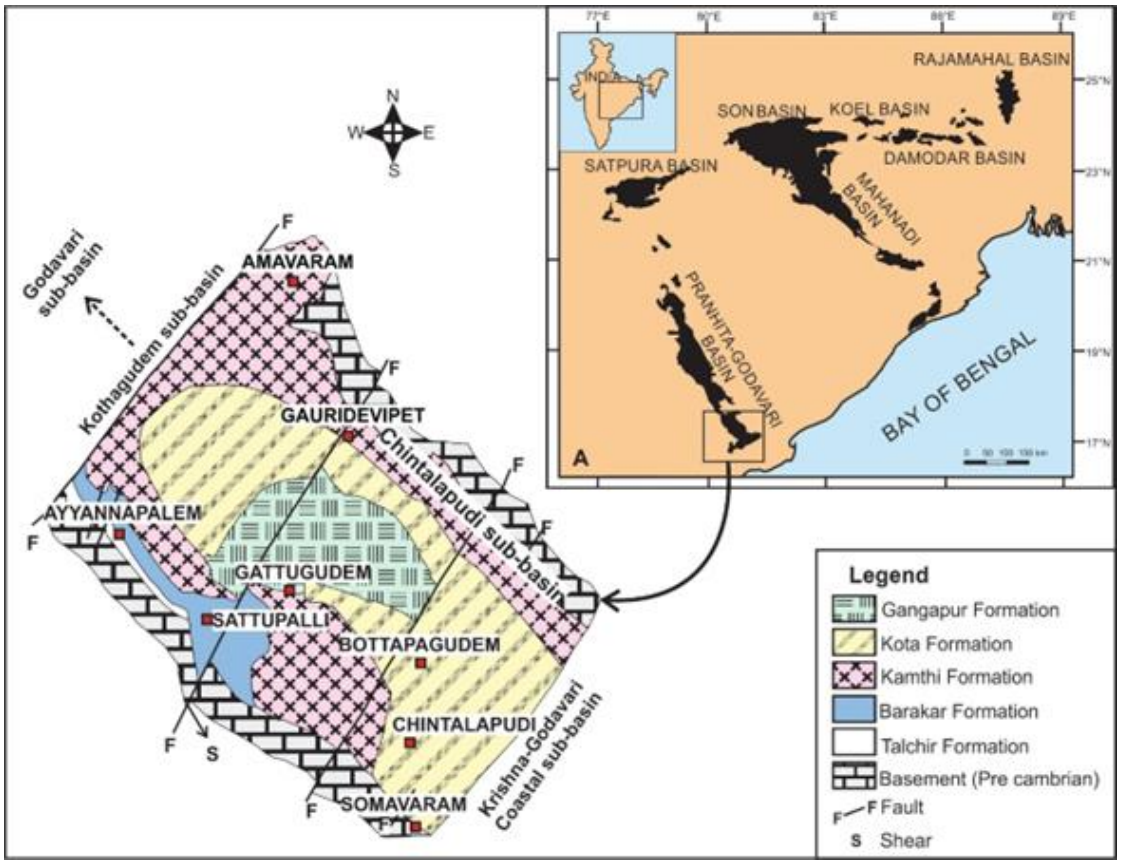

Fig. 3. Geological map of the Chintalapudi sub-basin (after Lakshminarayana, 1996).

The second century AD Buddhist caves are carved out of Jurassic sandstone sheets belonging to the Kota Formation. These sandstone sheets, numbering eight in total, are exposed in the horse-shoe shaped hill ranges near Guntupalli at Jilakarragudem. Each sandstone layer varies in thickness from 8 to 11 meters. A notable 120-meter-long and 2.5-meter-deep concave-up channel scour has formed over the underlying clay bed.

The sandstone features prominent fluvial lithofacies, including clay clast-bearing massive sandstone, cross-bedded sandstone, horizontal stratified sandstone, and claystone. The principal fluvial macroform is the channel, which is characterized at its base by a concave-up channel scour and comprises an interrelated succession of massive clay clast-bearing sandstone facies. Several small cycles of these facies form each channel macroform. The palaeocurrent direction is towards the northwest.

The sand is medium to very coarse-grained, and angular, with large interstitial pores filled with a silty clay matrix. In addition to quartz, feldspars, and lithic fragments, the sand contains opaques. The lithic fragments include vein quartz, quartzite, khondalite, and reworked sandstone.

Table 1. Stratigraphic succession of the Gondwana sediments, Chintalapudi Sub-basin (after Lakshminarayana et al., 1992).

Age	Supergroup/Group	Formation	Lithounits
Quaternary			Soil and Alluvium
		Rajahmundry Formation	Sandstone and Clay stone
		Unconformity	
Upper Cretaceous to early Eocene		Deccan Traps	
		Unconformity	
Late Cretaceous	Upper Gondwana Supergroup	Chikiala Formation	Conglomarate, Conglomaratic Sandstone
Early Cretaceous		Gangapur Formation	White Sandstone, Silt & Clay Stone, Carbonaceous Clay
Jurassic		Kota Formation	Sandstone, Limestone, Conglomeratic Sandstone, troughcross sandstone
Middle-Late Triassic		Maleri Formation	Red clay and Sandstone
		Unconformity	
Late Permain to Early Triassic	Lower Gondwana Supper group	Kamthi Formation	Conglomerate, Conglomerate Sandstone, Siltstone, Gray Shale
Permian		Barren Measures Formation	Sandstone, Siltstone, Shale with thin coal bands
Permian		Barakar Formation	Upper-white feldspethic Sandstone, Shale Carbonaceous Shale & Coal seams, very Coarse grained Sandstone
Late Carboniferous — Early Permian		Talchir Formation	Diamicrite, Rhythmite & ligh green Sands
		Unconformity	
Archean/Proterozoic	Pakhal and Sullvai Group		Khondalites and Charnockites (EGMB) Basement crystallines

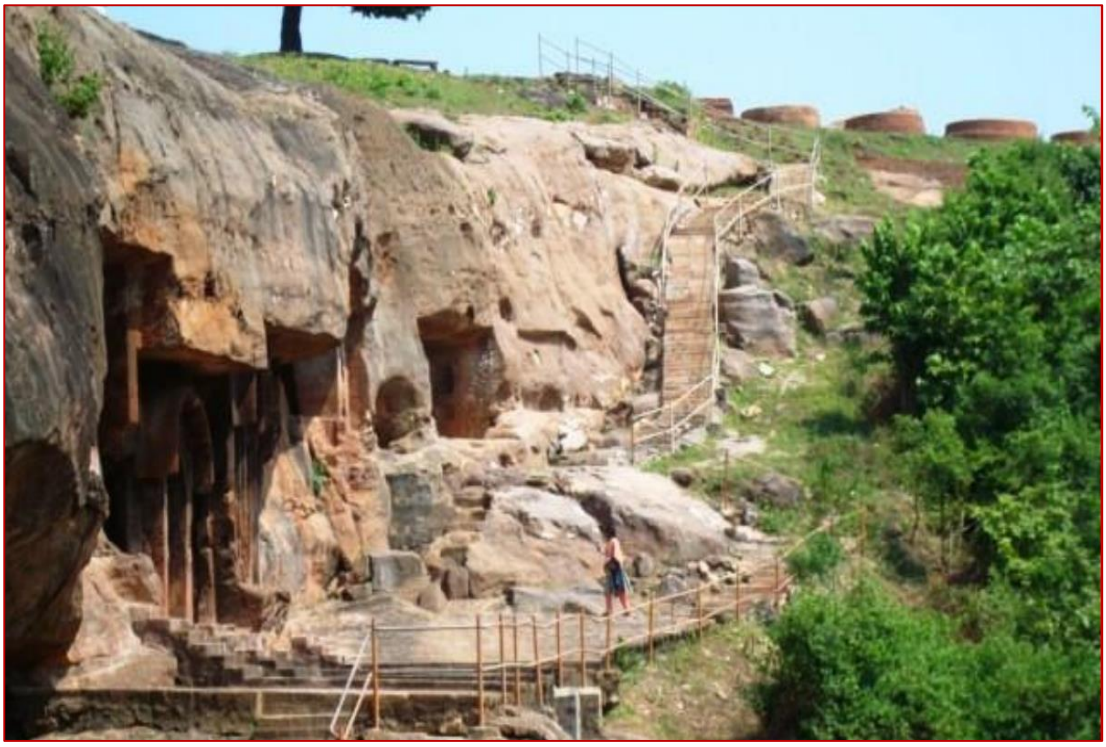

Fig. 4. Caves at Guntupalli – Kota Formation – Jurassic age

DESCRIPTION OF LITHOFACIES

The description of individual litho sections was given below.

Litholog 1.

The litholog has a total thickness of 6.5 meters. The bottom part of the litho section consists of 1.5 meters of massive dark brown sandstone, overlain by 4.5 meters of graded bedded sandstone with pebbles. The pebbles range in size from 1 to 5 centimeters and are rounded to subround in shape (Fig. 5).

Litholog 2.

The total thickness of the litholog is 8.5 m. The lower portion of the litho section consists of a 1.7 m thin planar sandstone in dark brown color, which is overlain by a 1.8 m thick massive sandstone with clay. Next, there is a 1.7 m thin planar cross-bedded sandstone, which is followed by a 3.3 m yellow-colored massive sandstone (Fig.6).

Lithology 3.

The total thickness of the litholog is 10.7 m. The lower portion of the litho section consists of a 2.9 m horizontal bedded (planar) sandstone in dark brown color, which is overlain by a 1.9

m trough cross bedding sandstone and followed by planner bedding. Next, there is a 0.75 m clay bed, which is followed by a horizontal bedded sandstone (Fig.7).

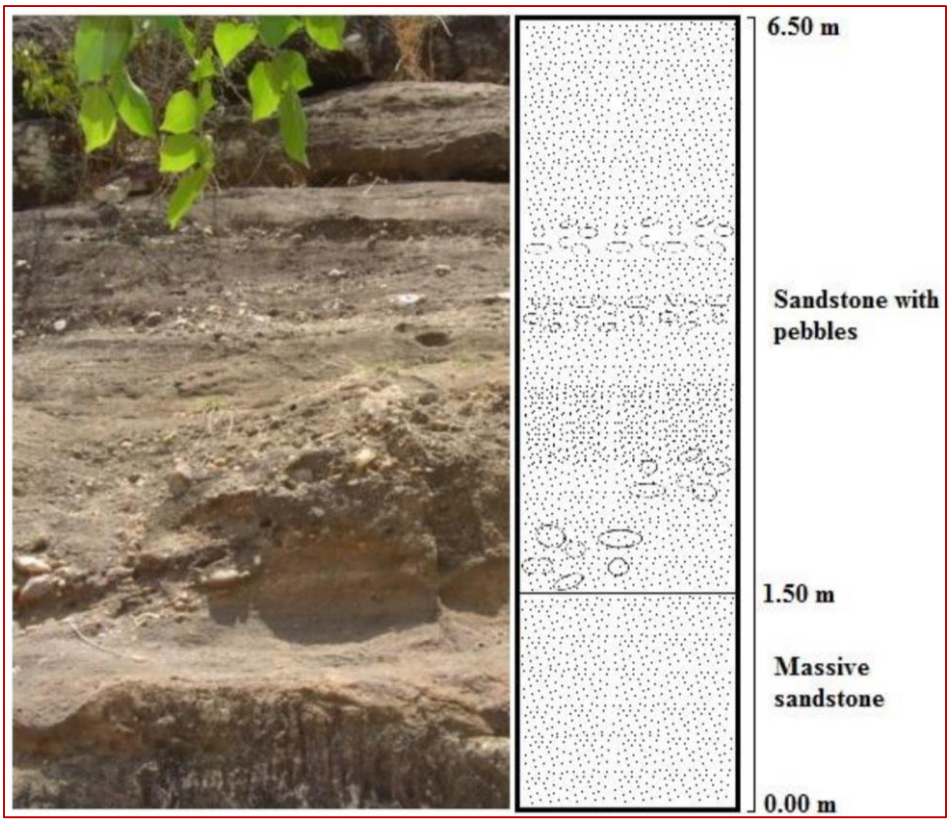

Fig. 5. Litholog-1 at Guntupalli caves

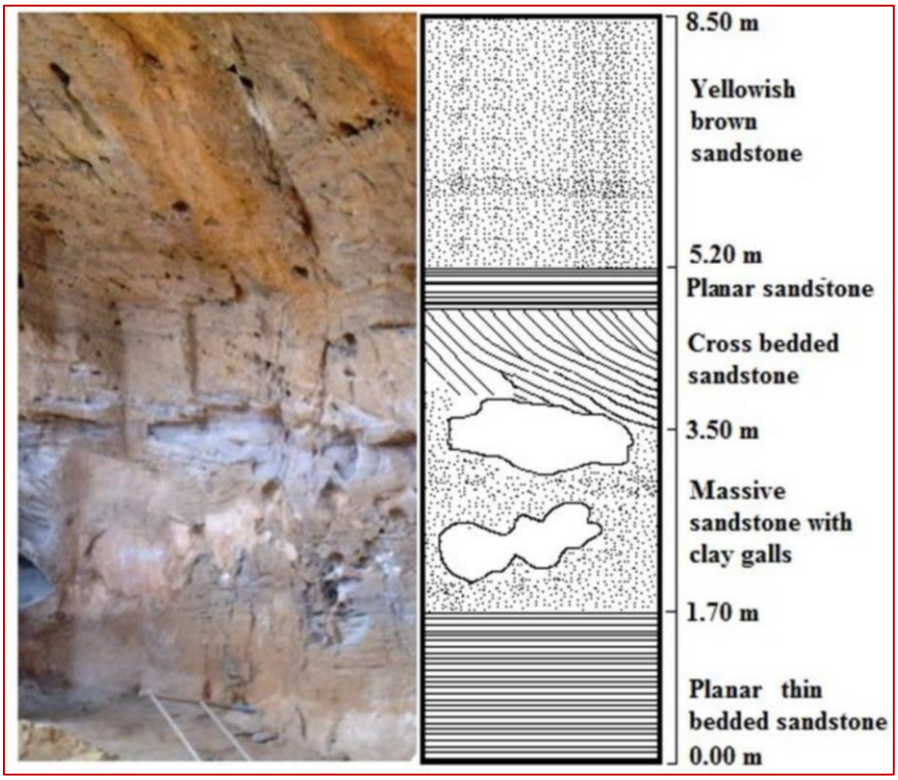

Fig. 6. Litholog-2 at Guntupalli caves

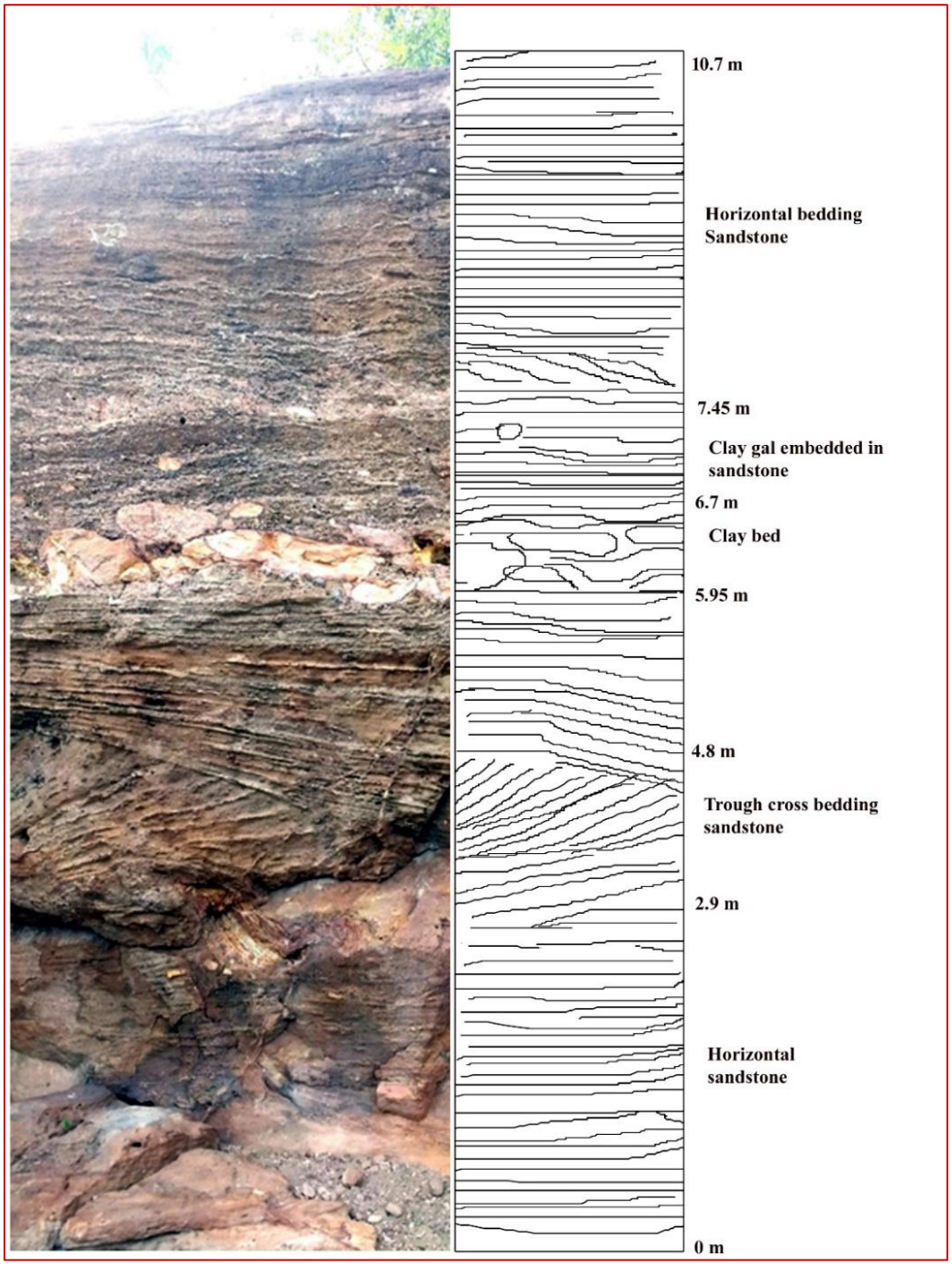

Fig. 7. Litholog-3 at Guntupalli caves

Lithology 4.

The total thickness of the litholog is 11 m. The lower portion of the litho section consists of a 2.2 m cross bedded sandstone in dark brown color, which is overlain by a 0.9 m trough cross bedding sandstone and followed by planner bedding. Next, there is a 0.8 m clay bed, which is followed by a horizontal bedded sandstone (Fig.8).

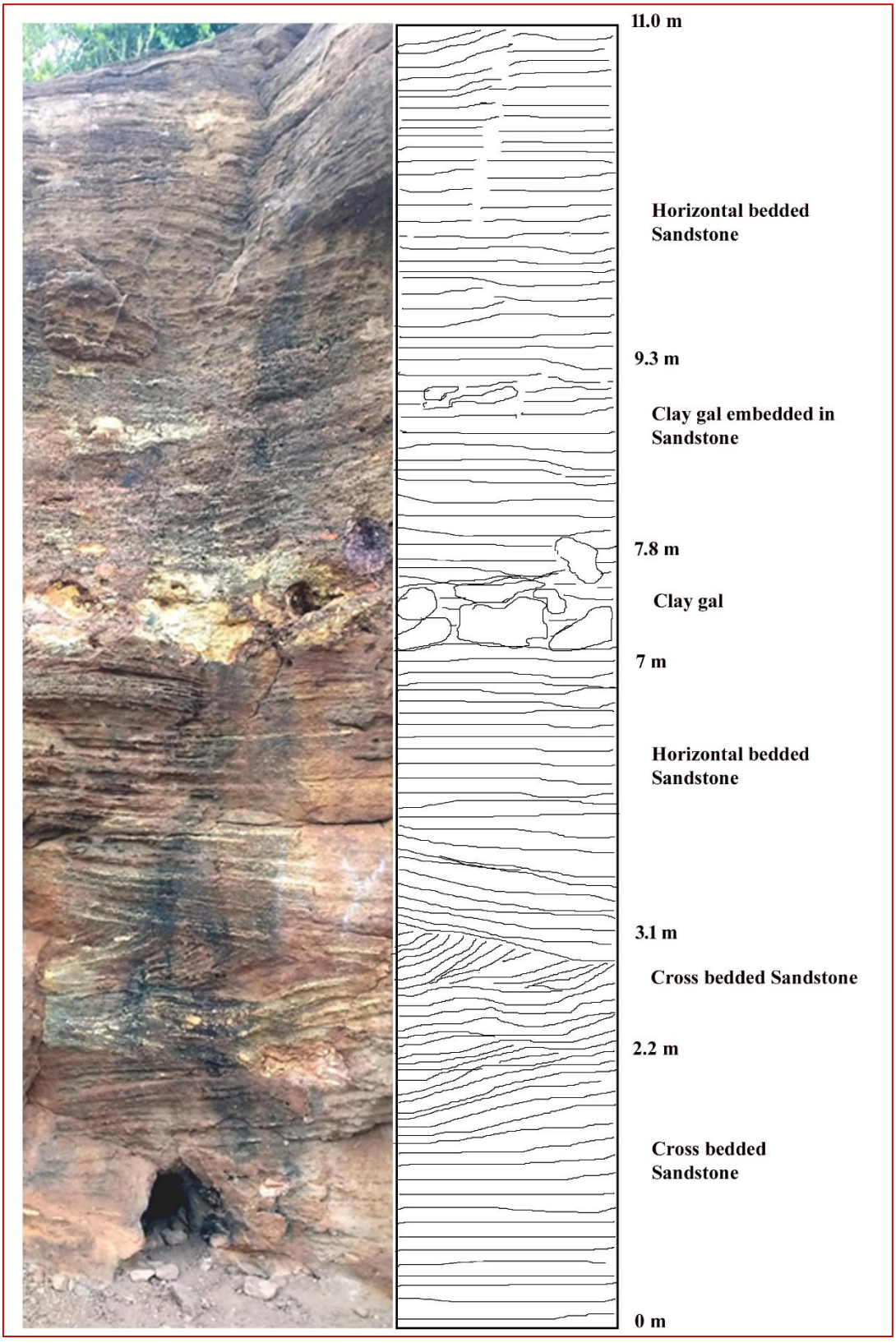

Fig. 8. Litholog-4 at Guntupalli caves.

LITHO FACIES

The characteristics of rocks arise from various physical and chemical processes, including weathering, erosion, transportation, deposition, diagenesis, and lithification. Lithofacies are subdivisions within a sedimentary sequence, distinguished by lithology, grain size, sedimentary structures, and stratification, which directly correspond to depositional processes. Lithofacies and their associations (groups of related lithofacies) are essential for interpreting depositional environments. The summary of lithofacies in the study area is described below based on litho sections

Cross Bedded Sandstone (Sp)

This lithofacies is widespread in various lithologies and environments, and it is predominantly present in the study area. Generally, this facies is overlain by trough cross-bedded sandstone facies or appears individually as sets or cosets at the basal or middle parts of litho sequences within channels. Large-scale bed forms are typically identified by their internal cross-stratification alone. The principal types are classified according to the scale of the feature, which correlates with grain size, velocity, and depositional settings. A cross-stratified bed may comprise a single set of cross-lamination or bedding, or multiple sets, collectively known as a coset. Observations in the current study area indicate that medium-scale bed forms were recognized on the bed surface, consisting of coarse to medium-grained material. Cross-bedded sandstone is located in between horizontal bedded sandstone (Figs. 7 & 8). The size of the cross bedding approximately ranges from 1 to 2 meters. The cross-bedding sandstone and overlain by conglomeratic sandstone in the Fig. 9b.

Horizontal (Planer) Bedded Sandstone

This facies (Figs. 6-8) consists of medium to coarse-grained sandstone, with bed thickness ranging from 0.1 to 3 meters.

Trough Cross Bedded Sandstone (St)

This facies (Fig.7) is characterized by medium to coarse-grained, with a bed thickness of approximately 1 to 2 meters. The trough cross-bedded sandstone contains clay galls and iron staining.

Clay Clast Bearing Sandstones (Ccs)

This facies consists of medium to fine-grained, and whitish pink. Clay clasts in the sandstones range from 2.0 to 4.90 m in size and are sub-angular to rounded (Fig.9f).

Pebbly and graded bedded Sandstone

Graded bedding in sandstones forms during the depositional process. These facies, ranging from 4 to 8 meters, is dark brown and associated with pebbles varying in size from 1 to 5 centimeters, which can be rounded to subrounded (Fig.9 g & h).

a. Sandstone sheet with major channel scour at base

b. Cross bedding of sandstone

c. Angular unconformity and horizontal Bedding of sandstone

d. Chemical weathering of channel scour at Base

e. Horizontal bedding and cross bedding of Sandstone

f. Clay gal embedded in sandstone

g. Pebbly and graded bedded sandstone

h. Pebbly sandstone

Fig. 9. Different lithology of Jurassic Sandstone of Kota Formation at Guntupalli Caves,

DISCUSSION

The study focuses on Guntupalli caves at Jeelakarragudem in the Chintalapudi sub basin, mainly composed of Kota Formation from the Upper Gondwana period. The area is covered with sandstones, conglomeratic sandstone, and minor silt and claystones. The Chintalapudi sub basin is part of the Pranhita-Godavari Valley, stretching 300 km NW-SE and 40 km wide. During the Upper Gondwana period (Upper Triassic to Late Jurassic), sedimentation was primarily fluvial or lacustrine. The Gondwana River, flowing SE-NW, changed its course westward due to the uplift of Mailaram high in the NW. This alluvial-fluvial system deposited sediments in various sub-environments such as alluvial fans, braided rivers, and meandering rivers.

Based on detailed field data, such as lithological variations, sedimentary structures, and megapetrographic characteristics, lithofacies have been classified according to the schemes of Miall (1977, 1978), Rust (1978), and Tirsgaard (1993). The main lithofacies in the study area are matrix-supported conglomerate sandstone (Gms), clay clast-bearing sandstone (Ccs), trough cross-bedded sandstone (St), planar thin-bedded sandstone (Sp), planar cross thin-bedded sandstone (Spc), horizontally thin-bedded sandstone (Sh), and claystone (F).

The sequence of lithofacies assemblage includes: 1) Clast supported conglomerate sandstone (Cms), massive sandstone (Sm), 2) Massive sandstone (Sm), planar thin-bedded sandstone (Sp), clay clast-bearing sandstone (Ccs), and planar cross thin bedded sandstone (Spc), 3 & 4). Horizontally thin bedded sandstone (Sh), clay clast-bearing sandstone (Ccs), claystone (F), planar cross thin-bedded sandstone (Spc) and trough cross bedded sandstone (St). Similar lithofacies have been reported in the upper Gondwana succession of Salbardi area, Madhya Pradesh (Srivastava and Mankar, 2008) and Bairam and Belkaher area, Maharashtra (Srivastava et al. 2004). The vertical sections of lithofacies indicate braided river channel deposits (Selley, 1976).

The study area's sandstones exhibit various bed forms (thick, thin planar, and very thin bedded) and lithofacies assemblages, indicating a fluvial environment with moderate to coarse-grained planar laminations. The unidirectional migration of sand waves in shallow water is shown by cosets of planar and trough cross beds. A vertical reduction in the size of these beds suggests a gradual decline in bed form height, implying stream channel shallowing. Deformed cross beds in the upper part of the channels may indicate loading from overlying sandstone. These features suggest a gradational filling of channel sand bars, typical of sinuosity stream deposits, and variable energy conditions of the river.

The clay clasts, exhibiting variable sizes and sub-angular to sub-rounded shapes, are found in association with sandstones. Additionally, smaller-sized clay clasts are aligned along the bedding planes of the sandstones.

The size of bed forms created by unidirectional water currents is influenced by water flow velocity, grain size, and water depth. Subaqueous currents like sand waves and ripples lead to tabular or trough cross bedding and the migration of large ripples (Harms et al., 1982). Clay clasts in sediments can come from river base erosion or overbank clay erosion during channel shifts. Large clay clasts indicate high stream competency. Field studies at Jilakarragudem show that Gondwana River base's bedrock is siltstone and claystone, suggesting clay clasts resulted from stream avulsion (Lakshminarayana, 1995; Murthi and Lakshminarayana, 1996). Previous studies at Guntupalli, 15 km southwest of Jangareddigudem, identified stream avulsion and thick clay clast-bearing sandstone sequences.

Field observations and litho section interpretations (Figs.9 g & h) show that the lowest unit is a conglomeratic sandstone with rounded pebbles, indicating long-distance transport. The pebbles are primarily khondalite and quartzite, suggesting the sediment's source might be the Eastern Ghat Granulite Belt (EGGB). This same provenance has been identified for the Kota Formation in Kamavarapukota, located further northwest (Lakshminarayana et al., 1992, and Lakshminarayana,1995) of the study area.

The large size of trough cross bedding in the study area indicates a greater depth of the water column in the stream and high-energy eddy currents typically found in braided streams. The coarse-grained nature of the sediment suggests high-energy conditions during deposition. The thin laminated planar structures were developed in calm (low-energy) environments.

The presence of cross-bedded and planar bedded sandstones, along with clay clasts and interbedded clay layers, suggests a braided channel depositional environment. These lithofacies have been proposed by Reineck and Singh (1980), Tewari (1995), and Miall (1996). The cross-bedded sandstone facies, associated with fine clasts, indicate deposition within areas of a fluvial system characterized by significant accumulation of fine clasts, such as overbank levees and floodplains. These formations are interpreted as resulting from channel aggradation and lateral accretion in crevasse channels, respectively, indicating deposits from braided and meandering streams (Tewari, 1998).

CONCLUSIONS

In the study area, sandstones, and clay stones constitute the primary lithological units, exhibiting variable thicknesses with different colors. The sandstones are characterized by thick-bedded pebbly ferrous formations, thin-bedded clay clast-bearing structures, thick trough-cross bedding, thick planar bedding, graded bedding, and thin bedding. The pebbles within these sandstones are sub-rounded to well-rounded, with some oriented along the bedding planes. Additionally, the clay galls vary in size and possess sub-angular to sub-rounded shapes. Smaller clay clasts are also aligned along the bedding planes of the sandstones.

The summary of various litho sections in the study area reveals a range of lithofacies, including clast-supported conglomerate sandstone (Gm), trough cross-stratified sandstone (St), planar cross-stratified sandstone (Sp), and claystone (F) from bottom to top. The lithofacies clast-supported conglomerate sandstone (Cc) features sub-rounded to well-rounded pebbles (up to 5 cm) of khondalites, granitic gneisses, and quartzite. It is overlain by trough cross-bedded sandstone (St), indicating sediment deposition under high-energy fluvial conditions by eddy currents. This is succeeded by clay clast-bearing sandstone, suggesting that stream avulsions caused erosion of bank deposits (levee and floodplain deposits). Planar laminated sandstone is overlain by cross-stratified sandstone (Sr) and claystone (F).

The sedimentary structures and lithofacies suggest that the sediments are indicative of channel and point bar deposits characteristic of a braided river system. The presence of large-scale trough cross-bedding and the coarse-grained nature of the sediment in the study area signify a greater water column depth and high-energy eddy currents. Thin laminated planar structures developed under calm, low-energy conditions. The truncated fining-upward sedimentary sequences indicate that these Kota sediments were deposited within a braided meandering stream environment.

Planar and cross-bedded sandstone, as well as clay clasts and interbedding's, indicate these sandstones come from a braided channel environment. Pebbly ferrous sandstones suggest channel deposits. Lithofacies studies show these sediments originate from point bar and channel deposits in a braided river system.

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