CHAPTER 4

SEDIMENTARY STRUCTURES
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4.0.0. GENERAL:

Sedimentary structures are of immense use in understanding the environment of deposition and analysing any sedimentary basin as a whole. Sedimentary structures are broadly divided into inorganic and organic. The inorganic structures are further divided depending upon the surface on which they occur and the modes and causes of their formation. Many sedimentary structures are yet to be identified and classified. Origin of certain structures is not clearly understood and as such they could not be necessarily indicates of particular depositional environment. The classification of sedimentary structures was best done by Pettijohn (1975) (Table - 4-1). In his classification, the genetic aspect of structure is also described, and the origin of a few interesting structures is discussed.

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### 4.1.0. CLASSIFICATION OF STRUCTURES OF SEDIMENTARY ROCKS

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4. 1. 1. INORGANIC STRUCTURE:

4. 1. 2. Bedding; Internal structure:

4. 1. 2a. Cross / Current Bedding:

The quartzites of Papagni, Chitravati, Nallamalai Groups show current bedding. Nagari Quartzite exhibits maximum current bedding of different magnitudes. Most of it is of the planar type, though trough type of current bedding is also observed. The forest beds are mostly concave and are tangential to the underlying beds. In most of the cases it is 'bc' plane that is exposed. Generally it is 'Mn' and 'Pi' cross stratification (Allen, 1963) that is noticed in these rocks. No particular style or cross bedding is characteristic of any particular agent and / or environment (Pettijohn 1975). Gandikota Quartzite shows herringbone cross bedding (Fig. 4-1).

![Fig. 4-1 “Herringbone” cross-bedding – Gandikota Quartzite](image-url)
4. 1. 2b. Ripple marks:

Ripple marks are difficult to define without illustrations. However, they refer to rhythmic or periodic undulations that occur on bedding planes (Potter & Pettijohn 1963). They are produced as a result of interaction of waves and currents on sediments surface (Reineck & Singh 1973). Ripple marks are one of the constituents of secondary structures both in recent and ancient sediments.

These are seen in almost all the formations in the Cuddapah basin. The quartzites and siliceous shales show more ripples than any other unit. The ripple marks observed are mainly waves or symmetrical ripples with curved crests. Wave ripples are symmetrical or slightly asymmetrical undulations produced by the action of wave on non-cohesive surface (Reineck and Singh 1975). Symmetrical wave ripples are marked by the shapes of their crests, (Fig 4-2).

Besides these, there are interference ripples in which the crest of one set of ripples lie in line with trough of another set. These are resultant of the superimposed ripple patterns (Pettijohn, 1957) and are known as ‘tadpole nests’. These are wave ripples produced by two equally strong wave directions. Symmetrical ripple marks generally occur in aqueous sediments up to a depth of 600 feet (200 m) (Weller, 1960). But these are reported even at greater depths (Pettijohn, 1957). Ripple marks at right angles to each other have been reported by Iron (1943, in Pettijohn, 1957).

All the said types of ripples (Fig. 4-3) are noticed in the Gulcheru, Nagari, Gandikota and Banaganapalle Quartzites. Further a special type of ripple marks is observed in the Gandikota Quartzite (Fig. 4-4).
Fig. 4-2 Symmetrical ripple marks

Fig. 4-3 Current ripple marks in Gulcheru Quartzite
Finning Upward is mostly observed in the conglomerate of Nagari horizon in the area south of Apparajupalli. The lowermost bed is a boulder bed, where in the individual boulders measuring up to 0.50 - 0.75m along the longer axes. In the direction of dip this grades into grit. Finning upward is observed in the Nagari outliers also.

Occasional finning upward (graded bedding) is noticed in quartzites and other sands, both ancient and modern, which are typical because they are not deep water deposits characterized by a complete or partial Bouma cycles (Pettijohn. 1975). Kuneuen and Migliorini (1956) first expressed the view that turbidity currents are the probable cause of most graded bedding. Kuneuen (1953 a) has presented a detailed review of the evidence for the turbidity origin of the graded beds. The finning upward sequence is also observed in the Gandikota Quartzite also.
4.2.0. Bedding Plane markings (on sole) (current marks) Flute casts:

4.2.1. Scour or Current marks:

4.2.1a. Flute Casts:

Crowell (1955) described flute casts as sharp, sub-conical welts, one end of which is rounded or bulbous whereas the other end flares out and merges gradually with the bottom surface of the sandstone layer (Pettijohn, 1975). On a given sole the casts tend to be of the same size and much alike.

Based on the shape of flute several classifications have been suggested. Dzulynski and Walton (1965) distinguished four types, namely, languid form, triangular or conical, elongate symmetrical and bulbous. This is purely descriptive and transitional forms exist. Generally flutes in Cuddapah basin are all symmetrical in shape.

These are noticed on the sole of shales of Nagari Quartzite and Tadpatri Formation. They range in size from a few mm to a few cms. Some are elongate (Fig. 4-5), some are deltoid and some are distorted and overlapping. Flute casts are of the most widespread of sole marks and most useful as a guide to the directions of current flow (Potter & Pettijohn, 1963). Flute casts are noticed even on the soles of sandstone and it would be erroneous to attribute them to deep water facies. Although found most abundantly in flysch sediments, flute marks are seen equally abundant in shallow water marine as well as in non-marine environments.
4.2.2. Tool marks:

4.2.2a. Groove and Striation Cast:

Groove casts were first described by Hall (1843). Groove marks have been dealt in detail by Ten Haaf, (1959), Dzulynski and Sanders (1962), Dzulynski and Walton (1965) and others.

Grooves are produced by tools carried by the current along a soft bottom. Both rolling and dragging objects make grooves on a soft sediments surface but generally it is not possible to distinguish between the two. (Reineck and Singh, 1973). These have been called ‘groove casts’ (Shrock, 1948) drag marks (Kuenen, 1957) and Schleifmarken (Seilacher, 1960).
Grooves are related substratal lineation and most prominent and most abundant in the flysch sequence. They have been attributed to the action of turbidity current. They are known from deposits not presumed to be turbidites. In such cases the grooves are a few, and less complete or continuous.

Grooves are observed on the soles of siliceous shales of Tadpatri Formation (Fig. 4-6) and in the quartzite intercalations of Pullampet Formation. These are generally formed in the underlying shale before it is consolidated and are characterized by straight running nature for greater length and uniformity of height. Groove or striations generally just fade out; only a few end abruptly and in rare cases some small object, such as shale chip (Mc. Bride, 1962; Dzulynski and Radmoski, 1955) lies at the down current end of the groove (Pettijohn, 1957). Groove marks are profusely produced in shallow water sediments. Especially in the areas affected by water level changes i.e. inter-tidal flats etc, Reineck et al (1975).

Fig. 4-6 Groove and striation casts - Tadpatri Formation
4.3.0. Bedding plane markings (on surface (pits and prints))

4.3.1. Pits and Prints:

4.3.1a. Raindrop structures:

These are best observed in the intercalated flaggy quartzites of Koilkuntla Limestone, Kurnool Group they simulate load casts. Shrock, while describing the raindrop structures said the rims of craters rise somewhat above the general surface and there are likely to be features are reported mainly on continental deposits in arid and semi-arid climates.

4.4.0. Deformed Bedding:

4.4.1. Load and founder structure:

4.4.1a. Flame structure:

This was first described by Sorby, (1908) as the structure which is closely related to the load casts, which has curved and pointed tongues which project into the overlying bed. Lamont (1938) designated the term antidunes to it, which was subsequently modified as ‘Flame structure’ by Waltons (1955) and ‘load waves’ by Sullwold (1959, 1960). The flame structure is noticed in the siliceous shales of Tadpatri Formation. This, used with a little caution is helpful in recognizing the top and bottom. Kuneuen and Monard, (1952) ascribed these structure to two factors, (1) drag extended by turbidity currents on the watery clay film of its bed, and (2) local setting and squeezing caused by the rapid accumulation of overburden on the highly mobile foundation. Flame structure is best seen in cross section of rocks in which the sand and shale layers are welded together, as they commonly are, in Precambrian rocks.
(Potter & Pettijohn, 1963). Flame structure is seen in the siliceous units of the Tadpatri Formation (Fig. 4-7).

Fig. 4-7 Flame structure – Tadpatri Formation

4. 4. 2. Synsedimentary folds and breccias:

4. 4. 2a. Convolute Laminations:

Convolute bedding is not only one of the most difficult structure to define but it is also the most difficult to explain (Potter & Pettijohn, 1963). Convolute lamination first designated "convolute bedding" by Kuenen, (1953) is a structure characterized by marked crumpling or intricate folding of the lamination within a well defined undeformed sedimentation unit. It has been termed ‘Curled bedding’ (Fearndies, 1910) ‘Crinkled bedding’ (Migliorini 1950), ‘intra strata contortion’ (Rich, 1950) etc.
The convolutions do not involve the external bedding planes. The convolutions are remarkably continuous; faulting is not associated with them. Generally the convolutions are confused with slump structures. Slump structures are commonly faulted; they general involve more than one sedimentation unit. (Potter & Pettijohn, 1963).

Convolute bedding is observed in the Gulcheru siliceous shale horizon, other siliceous shale horizons of other units. These are best observed in the siliceous shale horizons of Nagari Quartzite. Convolute lamination is believed to occur only in turbidite sequence (Sanders, 1960); Dott and Howard (1962) however believe that it also occurs in non-turbidite sequence and is not therefore an infallible criterion of turbid current action.

4.5.0. Other structures:

4.5.1a. Intra Formational Conglomerate:

These are observed in the Gulcheru Quartzite, Nagari Quartzite, and Pullampet and in the Narji Limestone, when the conglomerate occurs in the Quartzite horizon, the pebbles are also of quartzite and chert, embedded in a siliceous matrix. In Pullampet Formation the pebbles are made up of chert and dolomite and occur in a calcareous matrix. In Narji Limestone both the pebbles and matrix are calcareous (Fig. 4-8). This is formed due to exposure of sedimentation unit above the wave level, and after it gets brecciated and goes down below the wave level, the sedimentation continues. This is indicative of shallow water deposition.
4. 5. 1b. Ring structure due to leaching:

The Gulcheru Quartzite in Gandi area exhibits this feature. Circular patterns were noticed on the surface of the quartzite. The margins are decorated by ferruginous material 'nuclei' like features are also seen. On the weathered surface of the quartzite these are standing out as pebbles. This is a three dimensional feature. It is seen even in the fresh rock.

The possibility is that the ferruginous material gas migrated by solid diffusion. The details of mechanism of migration are not discussed here.

A similar feature but without pebble formation on weathered or fresh surfaces was observed in the Gandikota Quartzite also (Fig. 4-9). Because of leaching of the ferruginous cementing material, these portions have become more friable than the rest of the rock.
4. 6. 0. Chemical (Secondary):

4. 6. 1. Solution Structures:

4. 6. 1a. Stylolites:

These are noticed in the carbonate rocks and quartzites of Pullampet Formation. Based on the geometrical classification of Park & Schot, 1968 these are broadly Classification as sutured type; Sharp peak in Vempalle dolomites (Fig. 4-10), up peak and down peak type in Pullampet quartzite (Fig. 4-11). Stylolites of sutured type are very common in the Kurnool limestones and shales of the Pullampet Formation. Based on the genetic classification these can be classified as horizontal type. Siliceous and argillaceous seam material is usually noticed in the Stylolites. These stylolites could have formed by pressure solution theory of Wagner, (1913) and Stockdale, (1955) who stated that the stylolites originate though differential solution and pressure along a fracture or mechanical plane of the hardening (i.e. after complete cementation) of the carbonate host rock.
Fig. 4-10 Sharp peak type of stylolite in the Vempalle Formation

Fig. 4-11 Up peak type of stylolite in the quartzite of Pullampet Formation
Concretions:

These are very common in the dolomites of Vempalle Formation and in the limestones and shale of Tadpatri Formation. In the dolomites of Vempalle Formation these are mostly siliceous and cherty in nature and stand out to weathering. In the limestones of Tadpatri, these concretions are of different shape and are mostly siliceous with a faint calcareous nature.

These are best observed in the Mallela ghat section (Fig. 4-12). The other concretions in the shales of Tadpatri Formation are mostly disc like in nature (Fig. 4-13). This is a characteristic feature of the shales of the Tadpatri Formation. These may be primary in nature.

Fig. 4-12 Calcareous concretions in the shale of the Tadpatri Formation

Fig. 4-13 Disc nature concretions in the shale of the Tadpatri Formation