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Facies analysis and dynamic depositional modelling of the Upper Permian Chhidru Formation, Salt Range, Upper Indus Basin, Pakistan

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Abstract

In this paper we have used the outcrop data and utilized facies analysis techniques for the dynamic depositional modeling of Chhidru Formation, exposed in the Nammal Gorge and the Chhidru Nala sections in the Salt Range, Upper Indus Basin of Pakistan. Based on the integrated field and petrographic criteria, five different facies types i.e., CHF-1-CHF-5 are recognized. The CHF-1 corresponds to the sandy limestone interbedded with clays facies while CHF-2 is a medium bedded sandy limestone facies. The CHF-3 is represented by the massive sandy limestone facies. The CHF-4 (calcareous sandstone facies) and CHF-5 (thick bedded to massive white sandstone facies) have been identified in the upper part of the two stratigraphic sections. The depositional characteristics of these facies are consistent with the proximal inner shelf to distal middle shelf settings of a siliciclastic-carbonate mixed platform. Based on the integration of the outcrop data, facies information and fusulinid biostratigraphy the dynamic depositional model of the Chhidru Formation is presented. The new data enabled identification of two (02) 3rd order Transgressive-Regressive depositional sequences. The first Transgressive Sequence consists of the Transgressive Systems Tract (TST 1) that further constitutes six parasequences. The second transgressive depositional sequence constitutes the second Transgressive Systems Tract (TST 2) with no significant parasequence. The chronologic calibration fusulnid biostratigraphic age of the Chidru Formation suggest that deposition of the at the base TST 1 started at 252.5 Ma and the topmost beds of TST 2 corresponds to 253.8 Ma, respectively. The global comparison of the relative sea level during 252.5-253.8 Ma shows prominent eustatic signatures, however the flooding surfaces bounding the parasequences are ascribed to the local tectonics.

Keywords: Upper Permian; Shelf; Sequence stratigraphy; Pakistan.

1. Introduction

The Chhidru Formation within the two stratigraphic sections, Nammal Gorge (near Musa Khel) and Chhidru Nala near Chhidru Village (Fig. 1) in the western Salt Range were investigated for the facies analysis to interpret the paleo-environments and dynamic depositional model. The Chhidru Formation (Dunbar, 1933) is well exposed in the study area and constitutes a siliciclastic-mixed carbonate sequence. In earlier stratigraphic investigations (Theobald, 1854; Wynne, 1878, 1880; Waagen, 1887; Noetling, 1900, 1901) Permian age was assigned to the Upper Productus Chhidru Group. Schindewolf (1954) measured the Permian-Triassic beds in the western Chhidru Nala. However, he did not notice the evidence for a major break between Permian and Triassic sequence. Kummel and Teichert (1964, 1966) studied various sections in the Salt Range and Trans Indus Range and described distribution of lithology and fauna of the beds above and below the Permian-Triassic boundary and called this boundary "as a Paraconformity of undetermined magnitude". Furnish and Glenister (1970) described the Permian ammonoid Cyclolobus from the Salt Range. Sweet (1970) studied the uppermost Permian and lower Triassic conodonts of the Salt Range and Trans Indus Range. Sarjeant (1970) explained the acritarchs and Tasmanitids from the Chhidru Formation. Balme (1970) studied palynology of Permian and Triassic strata in the Salt Range and Surghar Range. The Pakistan-Japanese Research Group (1981, 1985) studied the stratigraphy of the Permo-Triassic sequence of Salt Range and Surghar Range. Mertmann (2003) studied the evolution of the marine Permian carbonate platform in the Salt Range and described various systems tracts within the Chhidru Formation. Although, information exists about the stratigraphic and sedimentological aspects of the Chhidru Formation, however, this paper aims to contribute by critically appraising the facies and faunal distribution within the Chhidru Formation for determining the relative and eustatic effects within different identified order of cyclicity in a stratigraphic framework in the western Salt Range.

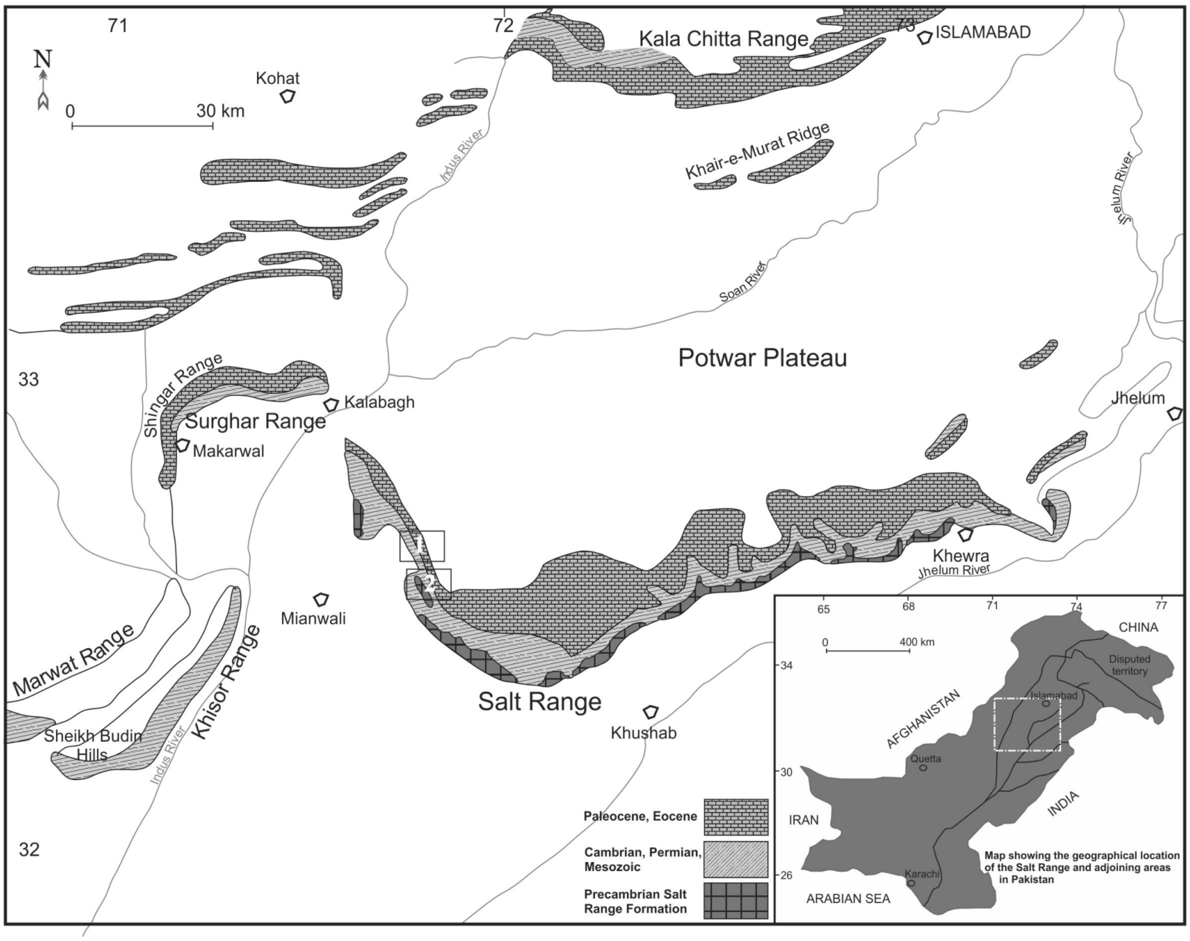


Fig. 1. Location map of the Stratigraphic Section: (1) Nammal Gorge Section, near Musa Khel; (2) Chhidru Nala, near Chhidru Village (after Gee, 1980; 1989).

2. Material and methods

The Chhidru formation was measured, sampled and logged in detailed incorporating the information related to the distribution of various lithofacies, fauna and sedimentary structures (Figs. 2 and 3). A total of 66m thick sequence recorded at the Nammal Gorge Section while it is 24m thick in the Chhidru Village Section. We collected a total of 23 rock samples from the Nammal Gorge and 05 samples from the Chhidru Nala Sections for a detailed facies analysis. The lithofacies description were based on the outcrop investigations, key stratigraphic surfaces were marked (maximum flooding surfaces, flooding surfaces, condense sections and unconformity surfaces. The petrographic classification of the carbonate rocks was based on Dunham (1962), Embry and Klovan's (1972), and sandstones are classified after Pettijohn (1987). The sequence stratigraphic analysis and order of cyclicity were carried out according to Embry and Johannesen (1992), and Duval et al. (1992) respectively. The sea level curve was then compared with global sea level curve of Haq and Schutter (2008), Chen et al. (1998), and Ross (1995).

3. Results

3.1. Facies analysis

3.1.1. Sandy limestone interbedded with clays facies (CHF-1)

In the Nammal Gorge section, CHF-1 facies is represented by grayish color sandy limestone which is hard, fossiliferous and medium grained, The petrographic study of CHF-1 (Appendix 1: In thin sections 1, 2, 4, 5, 8, 11, 13, 15, 16 and 19) show a mudstone depositional texture with a poor preservation of fusulinids, brachiopod, gastropods (Plate 1; Figs. A, B and C) and bryozoans in allomicritic matrix. The quartz, feldspar and muscovite grains are also randomly distributed. The diagenetic fabric of the sandy mudstone facies includes iron leaching (Plate 1; Fig. D), stylolites and calcite filled fractures (Plate 1; Fig. E).

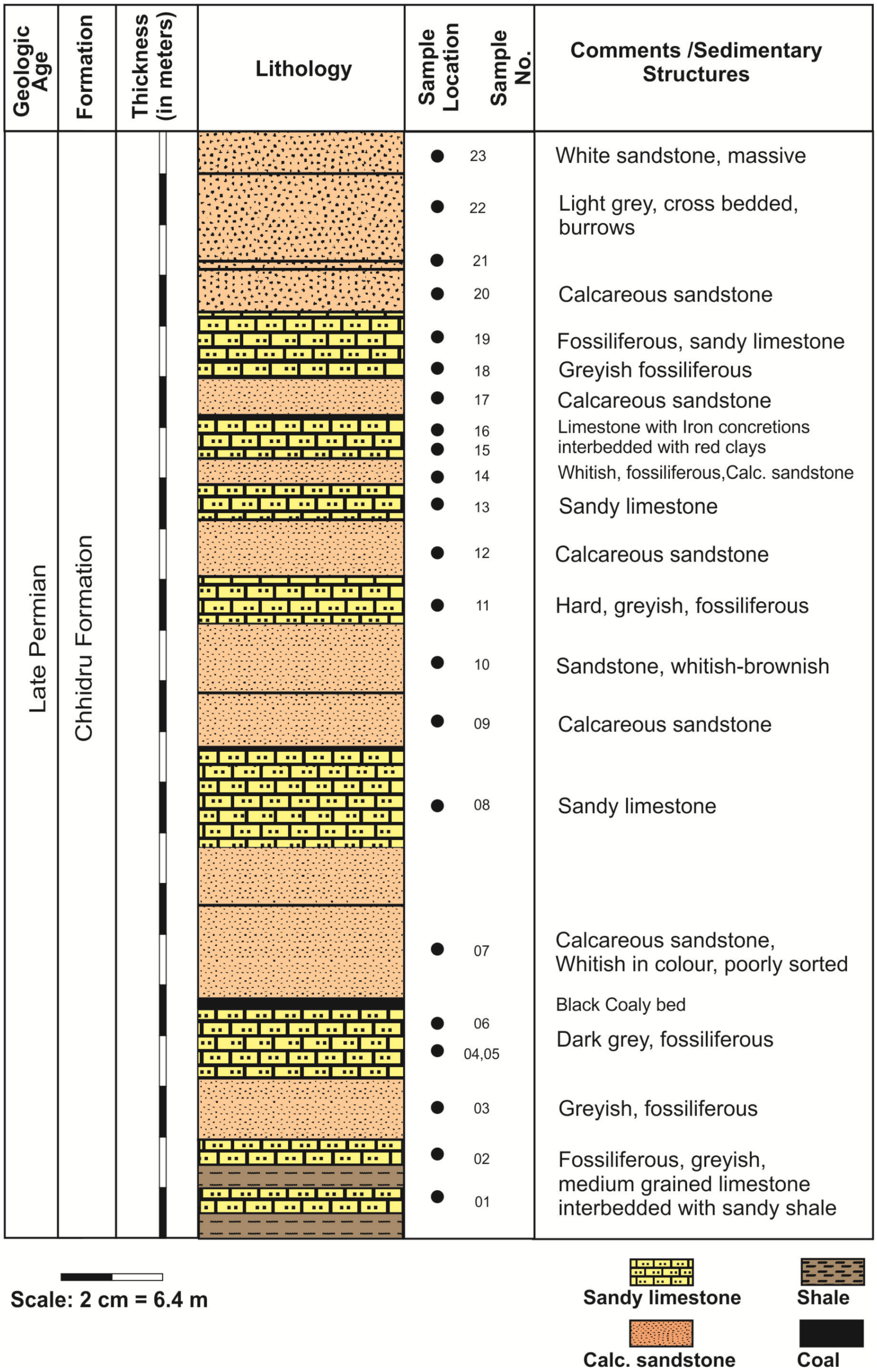


Fig. 2. Stratigraphic log of the Chhidru Formation in Nammal Gorge, western Salt Range.

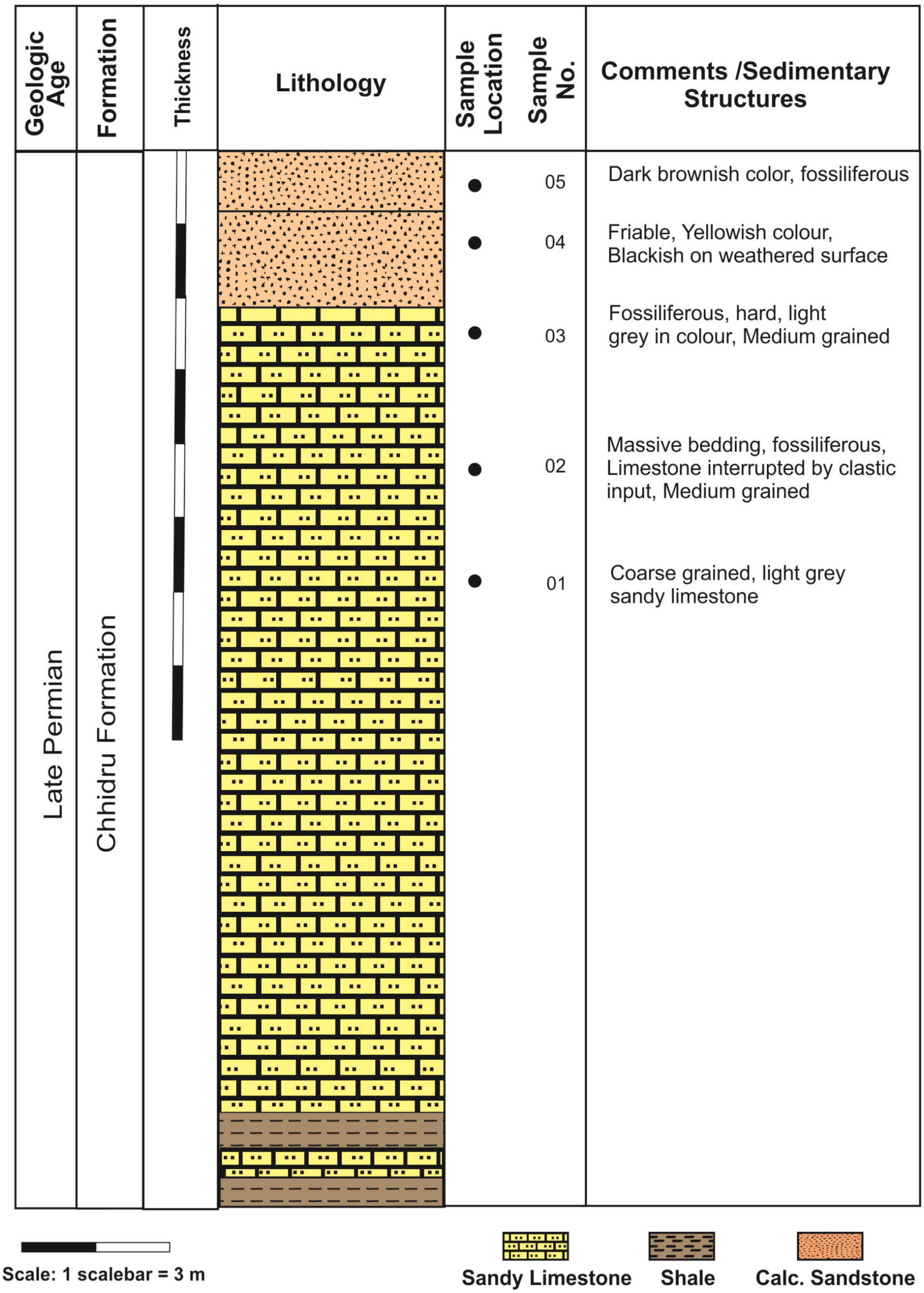


Fig. 3. Stratigraphic log of the Chhidru Formation, in a section close to the Chhidru village, western Salt Range.

Interpretation

Fusulinids foraminifera are believed to live in clear water of the marine environment far from offshore (Moore et al., 1952). Bryozoans live only in normal sea water with a normal salinity (Taylor, 2005). The presence of diverse fauna and micrite matrix indicates subtidal marine conditions. The dominance of lime mud within the depositional fabric is indicative of low energy conditions as agitated water does not allow settling of lime mud. Based on the presence of shallow marine fauna the CHF 1 facies was deposited under low energy below fair weather wave base (FWWB) conditions of a middle shelf setting.

3.1.2. Medium bedded sandy limestone facies (CHF-2)

The CHF-2 facies is represented by medium bedded dark grey fossiliferous sandy limestone in the Nammal Gorge section. In petrographic studies (Appendix 1: In thin section 6), this facies is characterized by mudstone-wackestone depositional texture with moderately preserved bioclasts of brachiopods, fusulinids, and bryozoans (Plate 2; Figs. F and G) along with detrital quartz grains.

Interpretation

Brachiopods are particularly common in Paleozoic and Mesozoic limestone of shallow marine origin. These were largely benthic, sessile organism (Tucker, 2001). All brachiopods are marine organisms, but the group exhibits a significant salinity range into both brackish (hypo saline) and slightly hyper saline settings (Scholle et al., 2003). The poor preservation of the bryozoans and fusulinid foraminifera is attributed to the high continental influx during the deposition of the CHF-2 facies and indicates a proximal middle shelf depositional setting.

3.1.3. Massive sandy limestone facies (CHF-3)

In the Nammal Gorge section, the facies is represented by light to dark grey sandy limestone beds. It is fossiliferous, massive bedded, hard and medium grained (Appendix 1: represented by a thin section 18). In Chhidru village section, this facies is characterized by limestone beds with patches of clastic input. This facies is characterized by wackestone to packestone depositional texture (Appendix 2: represented by thin sections 1, 2, and 3). The allochems are bryozoans (23%), fusulinids (15%) and brachiopods (13%). Sparry cement constitutes 21% while micritic matrix is present with an average abundance of 26%. Un-differentiated bioclasts are also present with an average abundance of 28%. Quartz, feldspar and muscovite are present in minor amounts. The diagenetic fabric of this facies is characterized by calcite filled fractures, microstylolites and micritized bioclasts and recrystallized fossil fragments (Plate 2; Figs. H and I).

Interpretation

Bryozoans are small, colonial marine organisms that are significant suppliers of carbonate sediments (Tucker, 2001). In the past they have contributed to the formation of reef and other limestones, particularly in the Paleozoic (Tucker, 2001). Fusulinids lives in clear water in the marine environment away from offshore (Moore et al., 1952). The presence of sparry cement indicates high energy conditions. Thus, CHF-3 facies represents deposition below the storm wave base in the distal middle shelf setting.

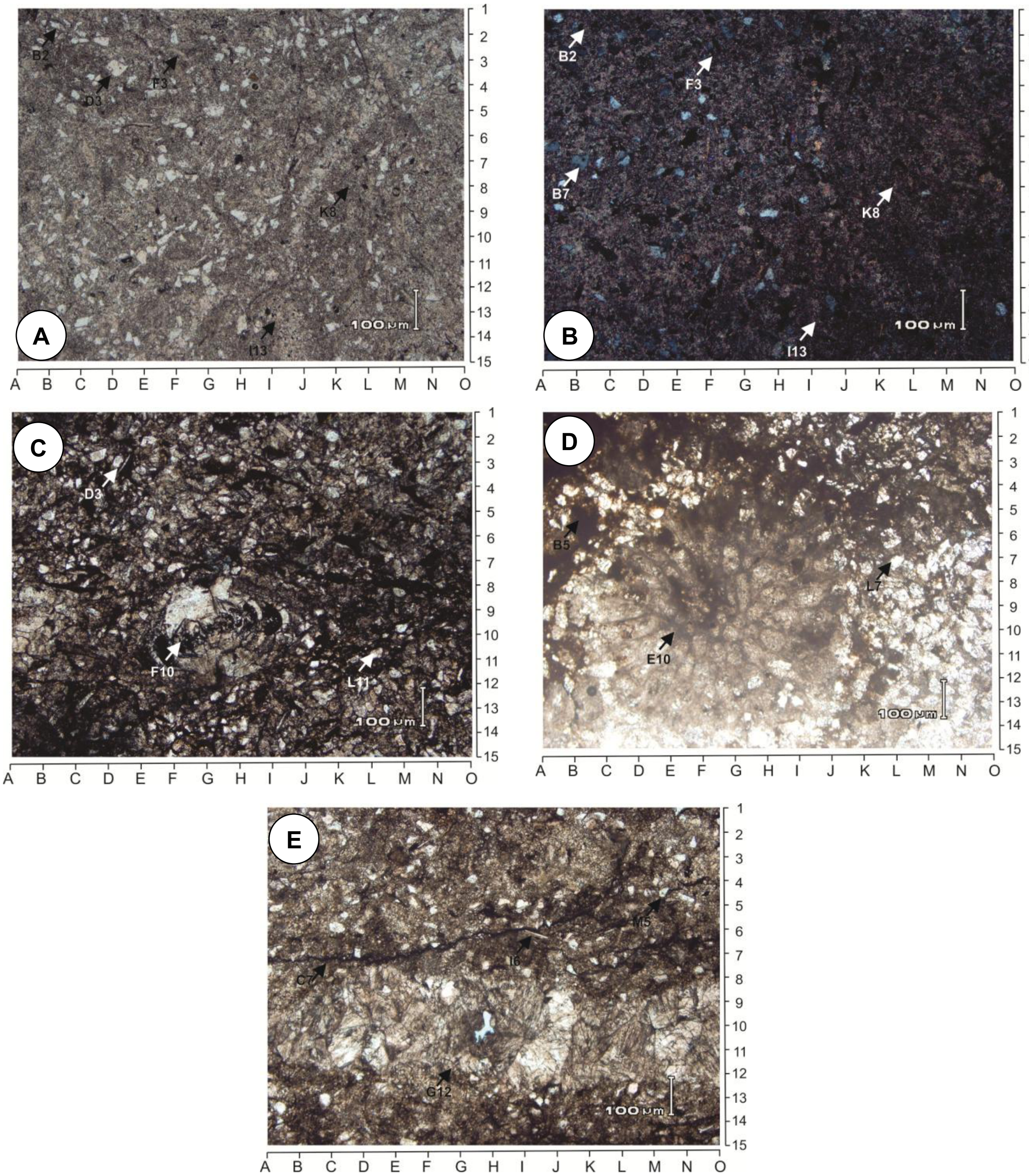
3.1.4. Calcareous sandstone facies (CHF-4)

In Chhidru village section, the facies is represented by calcareous sandstone which is dark brownish, hard and have broken shell fragments of brachiopods (Appendix 4: represented in thin section 5) while at Nammal Gorge section it is grayish, whitish and brownish in colour and is fossiliferous (Appendix 3: represented by thin sections: 3, 7, 9, 10, 12 and 14). This facies consists of quartz, feldspar, rock fragments and accessory minerals and classed as "Feldspathic greywacke" (Pettijohn et al. 1987). The average abundance of quartz is 89.57%. The quartz grains are mostly monocrystalline but <1% polycrystalline grains are also present. The monocrystalline quartz shows uniform extinction. The contact between the grains is mostly pointed otherwise they are floating in the matrix (Plate 3: Figs. J, K, L, M and N). The abundance of feldspar ranges between 3-5%. It is present in the form of plagioclase, orthoclase and microcline. Plagioclase has diagnostic polysynthetic twinning whereas microcline has cross-hatched twinning. Most of the feldspar grains are medium sized.

Interpretation

This microfacies is characterized by marine fossils fragments, sub angular to sub rounded grains, moderate to poor sorting and abundant calcitic and ferroginous matrix. The presence of matrix suggests deposition in low energy

Plate 1



A. Photomicrograph showing fossil fragments (B2, F3, I13), micrite (K8), and detrital quartz (D3) in sandy mudstone facies (CHF-1; PPL).

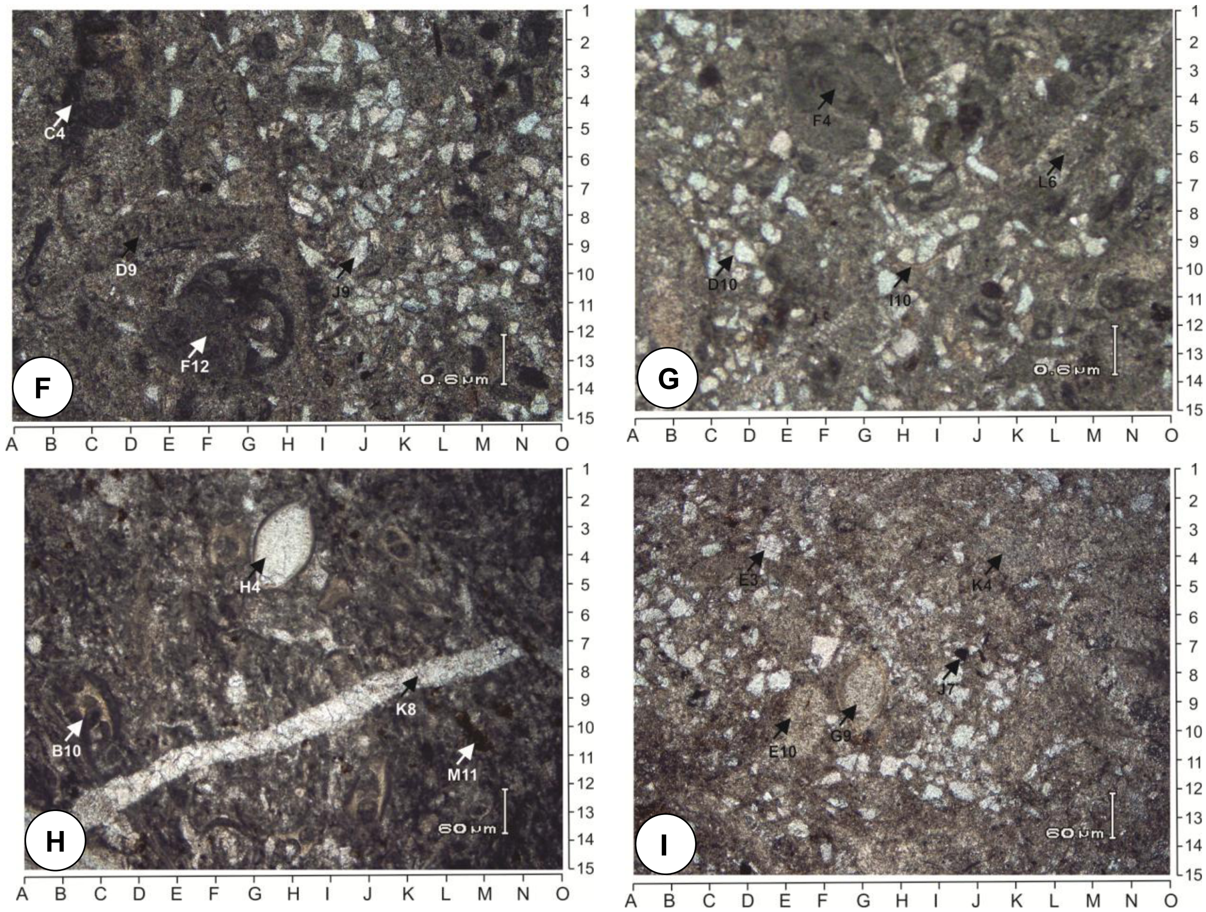
B. Photomicrograph showing fossil fragments (B2, F3, I13), quartz (B7) and micrite (K8) in sandy mudstone facies (CHF-1; XPL).

C. Photomicrograph showing fusulinid (F10), quartz grain (L11) and muscovite grain (D3) in sandy mudstone facies (CHF-1; XPL).

D. Photomicrograph showing bryozoan colony (E10), quartz (L7), and iron leaching (B5) in sandy mudstone facies (CHF-1; PPL).

E. Photomicrograph showing calcite vein (G12), stylolite (C7), quartz (M5) and muscovite grain (I6) in sandy mudstone facies (CHF-1; PPL).

Plate 2



F. Photomicrograph showing micritized fossils (C4, D9, F12) and quartz grain (J9) in medium bedded sandy limestone facies (CHF-2; PPL).

G. Photomicrograph showing fusulinid (F4), undifferentiated bioclast (I10), quartz (D10) and micrite (L6) in medium bedded sandy limestone facies (CHF-2; PPL).

H. Photomicrograph showing calcite filled fusulinid (H4), bryozoan (B10), calcite vein (K8) and iron oxidation (M11) in massive sandy limestone facies (CHF-3; PPL).

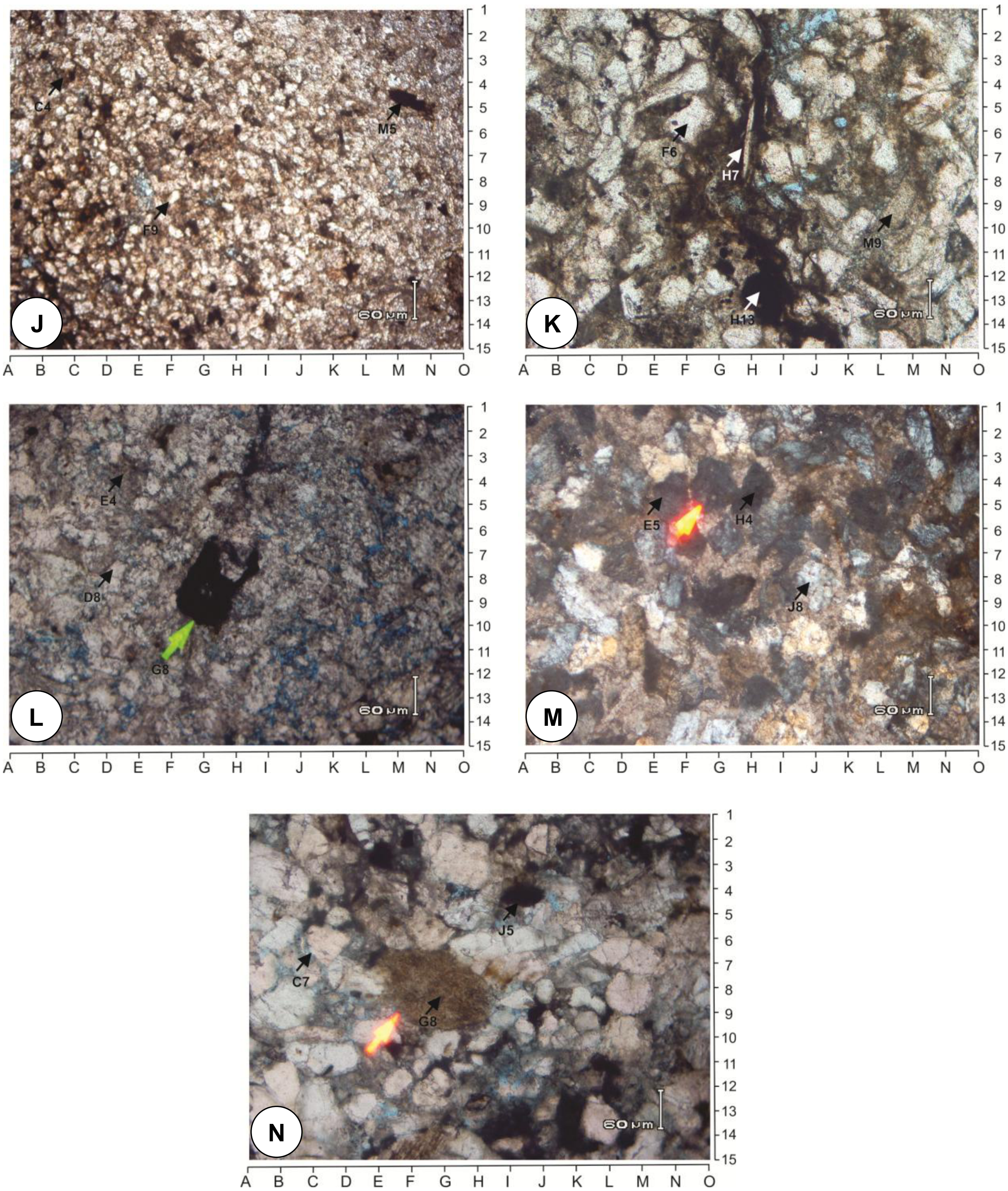
I. Photomicrograph showing micrite filled fusulinid (G9), micritized fossils (E10), ore mineral (J7), matrix (K4) and quartz (E3) in massive sandy limestone facies (CHF-3; PPL).

environment below fair weather wave base. The fossils fragments and texture of the sandstone suggests deposition in proximal part of the inner shelf setting. Similar kind of greywacke have been recognized in polar Siberian Hapschan series and interpreted as deposited on inner shelf (Zlobin et al., 2002).

3.1.5. Thick bedded to massive white sandstone facies (CHF-5)

In Nammal Gorge section, the facies is represented by light to dark grey and whitish colour sandstones. It displays sheet like geometry with pebbly appearance at places and with different sets of cross beds (Appendix 3: represented by a thin sections 17, 20, 21, 22 and 23). This facies at Chhidru village section is yellowish on fresh surface and blackish on weathered surface and is friable (Appendix 4: represented by a thin section 4). Microscopic study of this facies has revealed Quartz wacke texture (Pettijohn et al., 1987) with the dominance of fine to medium grained, inequigranular, monocrystalline quartz (ranges between 43-65%). The grains are rarely in contact and are floating in the matrix (Plate 4: Figs. O, P, Q, R, and S). Most of the feldspar grains are medium sized while coarse and fine grains are not uncommon. Rock fragments are 1.77% in average. The moderate sorting exists between the angular, subangular to sub rounded grains. The CHF-5 facies is mineralogicaly mature but texturally submature.

Plate 3



J. Photomicrograph showing the overall abundance of grains with respect to matrix, iron leaching (M5), matrix (C4) and quartz (F9) in calcareous sandstone facies (CHF-4; PPL).

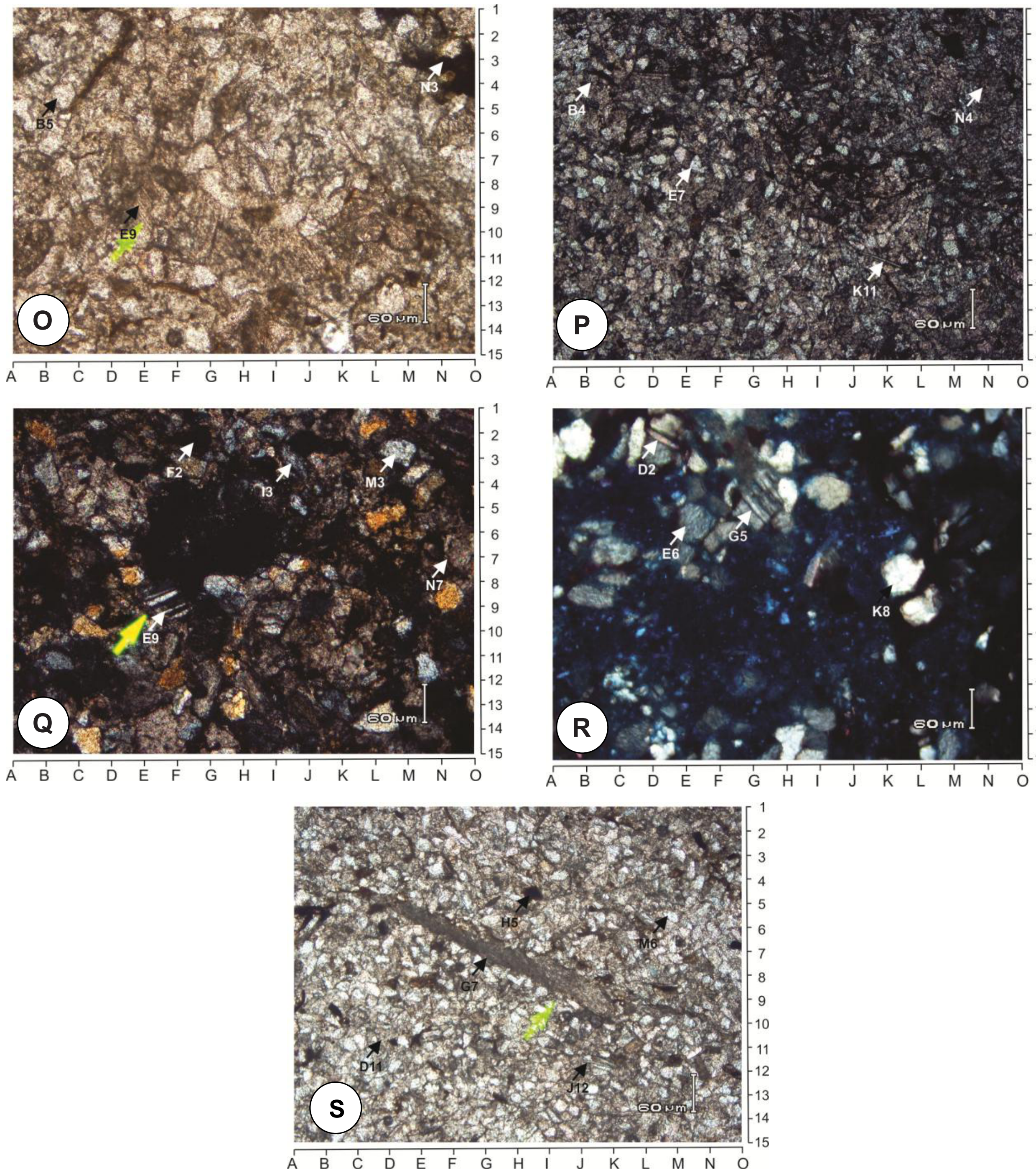
K. Photomicrograph showing muscovite grain (H7), feldspar (M9), quartz (F6) and iron leaching (H13 in calcareous sandstone facies (CHF-4; PPL).

L. Photomicrograph showing ore mineral (G8), quartz (D8) and calcitic matrix (E4) in calcareous sandstone facies (CHF-4; PPL).

M. Photomicrograph showing feldspar (E5, H4) and quartz (J8 in calcareous sandstone facies (CHF-4; XPL).

N. Photomicrograph showing rock fragment (G8), quartz (C7) and iron leaching (J5) in calcareous sandstone facies (CHF-4; XPL).

Plate 4



O. Photomicrograph showing calcite (E9), quartz (B5) and iron leaching (N3) in thick bedded to massive white sandstone facies (CHF-5; PPL).

P. Photomicrograph showing the overall abundance of grains with respect to matrix, and presence of muscovite (K11), quartz (E7) and feldspar (B4) in thick bedded to massive white sandstone facies (CHF-5; XPL).

Q. Photomicrograph showing plagioclase (E9), feldspar (I3), monocrystalline quartz (M3), matrix (N7) and iron oxide (F2) in thick bedded to massive white sandstone facies (CHF-5; XPL).

R. Photomicrograph showing plagioclase (G5), muscovite (D2), monocrystalline quartz (K8) and feldspar (E6) in thick bedded to massive white sandstone facies (CHF-5; XPL).

S. Photomicrograph showing brachiopod fragment (G7), quartz (M6), muscovite (J12), iron leaching (H5) and matrix (D11) in thick bedded to massive white sandstone facies (CHF-5; PPL).

Interpretation

Cross bedding shows a shallow sandy braided river system. Less distinct fining upward successions, sheet-like geometry of sandstone and pebbly sandstone imply a shallower fluvial system. Multiple accumulations of planar cross stratified coarse-grained sandstone beds with a small dispersion in paleocurrent directions are the evidence of the shallow sandy braided river system. Thus the deposition of CHF-5 facies occurred in the braided fluvial system.

4. Dynamic depositional model

The sequence stratigraphic analysis is a valuable tool for the dynamic depositional modelling of regional domain of subsidence characterized by sediment fill in time and space. A Sequence, as defined by Sloss et al. (1949), is a stratigraphic unit bounded by subaerial unconformities. Such a stratigraphic unit proved to be of limited value, because sequences then could be recognized only on margins of a basin where subaerial unconformities were present. Vail et al. (1977 and 1987) expended the utility of sequences for basin analysis when they redefined the term as a unit bounded by unconformities or correlative conformities. The addition of correlative conformities allowed a sequence to be recognized over an entire basin (Embry, 2002). Depositional Sequence is composed of systems tracts which are interpreted to be deposited between eustatic-fall inflection points (Posamentier and Vail, 1988). Later on, this inference was discarded due to the fact that stratal stacking patterns form in response to relative sea level changes (subsidence and eustasy) rather than to just eustasy (Posamentier and Allen, 1999). Embry and Johannesen (1992) defined the T-R sequence. This sequence uses the subaerial unconformity as the unconformable portion of the boundary on the basin margin and the maximum regressive surface (MRS) as the correlative conformity farther seaward. This model offers an alternative way of packaging strata into sequences, to bypass the pitfalls of both the depositional sequence and the genetic stratigraphic sequence. Maximum Flooding surfaces are used to subdivide the T-R sequence into transgressive and regressive system tracts. The amalgamation of different genetic types of deposits into one single unit, i.e., "The regressive systems tracts", provide a simple way of subdividing the rock record into systems tracts and may be the only option in particular case (Embry and Johannesen 1992). In this study we have followed the Transgressive-Regressive (T-R) sequence model of Embry and Johannesen (1992).

4.1. Regressive systems tract

It is bounded by the maximum flooding surface at the base and by the maximum regressive surface at the top and is defined by the progradational stacking patterns in both marine and non-marine strata. In Chhidru Formation, Regressive Systems Tract consists of calcareous sandstones having feldspathic greywacke and quartz wacke fabric. These facies have been interpreted to be deposited in inner shelf environment. Seven regressive systems tracts in Nammal gorge with total thickness of 41m and one in Chhidru village Section with measured thickness of 3.2m have been identified (Figs. 5 and 6).

4.2. Transgressive systems tract

Transgressive systems tract is bounded by the maximum regressive surface at the base and by the maximum flooding surface at the top. This systems tract forms during the portion of base level rise when the rates of rise surpass the sedimentation rates.

In Chhidru Formation, the transgressive systems tract is characterized by sandy limestone, which has been recognized as sandy mudstone, sandy mudstone-wackestone, and sandy wackestone-packestone facies. These facies have been interpreted to be deposited in middle shelf environment. Seven transgressive systems tracts in Nammal gorge with thickness of 28m (Fig. 5) and one in section close to Chhidru village with measured thickness of 8.8m (Fig. 6) have been identified in Chhidru formation.

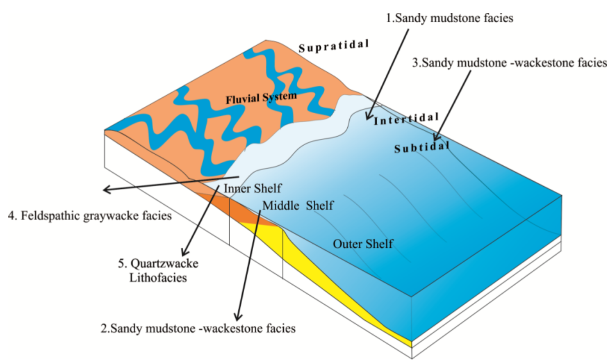


Fig. 4. Depositional model, for various facies of the Chhidru Formation.

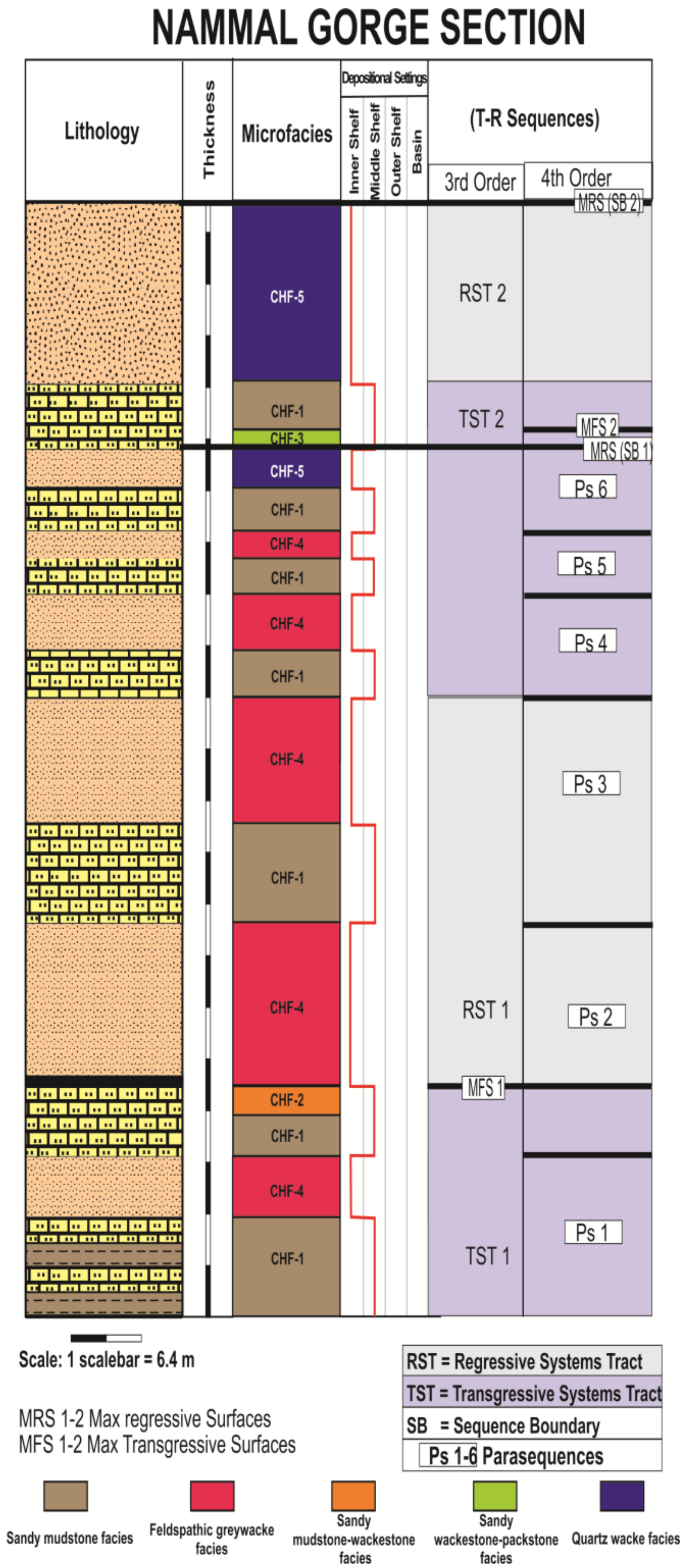


Fig. 5. Vertical distribution of systems tracts of the Upper Permian Chhidru Formation in the Nammal Gorge section.

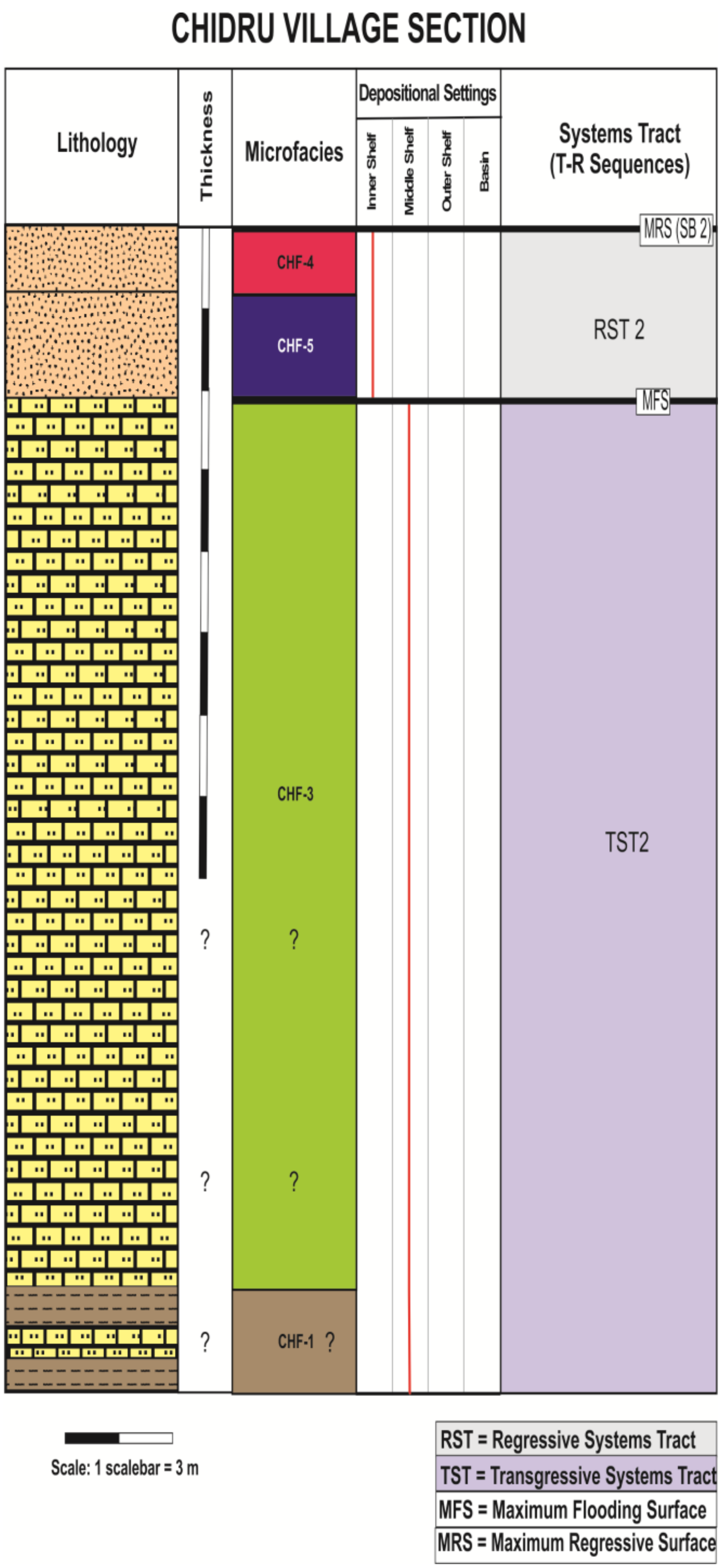


Fig. 6. Vertical distribution of systems tracts of the Upper Permian Chhidru Formation, in section close to Chhidru village.

5. Discussion and conclusions

5.1. Relative age constraints and cyclicity

Previously, the Chhidru Formation has been dated differently, Based on the brachiopods biostratigraphy, Grant (1970) assigned the Guadeloupian age to the Chhidru Formation, however, he argued against the use of brachiopods for correlation. Further, he also assumed that the Upper Permian (Dzulfian) strata is absent from the Salt Range. The fusuliniid foraminiferal biostratigraphic dating (Nakazawa and Dickins, 1985) and Ammonites biostraigraphic dating (Furnish and Glenister, 1970) constraints the Upper Permian (Dzulfian) age (254-252.5 Ma) of the Chhidru Formation.

To study the cyclicity within the Chhidru Formation, we use Upper Permian (Dzulfian) age of the Chhidru Formation (Nakazawa and Dickins, 1985; Furnish and Glenister 1970) for comparison of the deduced relative sea level curve with chronology of eustatic sea level curves of Haq and Schutter (2008), Chen et al. (1998) and Ross and Ross (1995). The relative sea level curve of the Chhidru Formation is constructed from the recognition of various facies types and their inferred depositional settings. The previous biostratigraphic interpretation (Nakazawa and Dickins, 1985; Furnish and Glenister 1970) implies that deposition of the Chhidru Formation took place in two different episodes of a third order cycle with a 1.5 Ma span (Duval et al., 1992). Within these third order cycles, six fourth order cycles with a 0.1-0.4 Ma time span (Duval et al., 1992) are recognized. There are five facies recognized within the Chhidru Formation, which are: the sandy limestone (represented by the CHF-1, CHF-2 and CHF-3 facies) deposited during tectonically stable periods while the fine clastic admixture was supplied from distal sources. The calcareous sandstones (represented by CHF-4 and CHF-5 facies) deposited when the proximal source area was tectonically unstable and immature terrigenous materials were transported into the shelf via various agents, representing two (3rd Order) T-R cycles and six (4th order) parasequence cycles. The deposition in third order cycles are controlled by galcio-eustacy (Vail et al., 1977 and 1987) and tectonic subsidence. Increased glacial ice volume in late Paleozoic could have produced global third order cycle deposits (Emery and Mayers, 1996). The parasequences within the Chhidru Formation may have resulted due to local subsidence that ensues with marine flooding surface bounding different parasequence in a cyclic fashion.

At the base of the CHF-5 a tentative Sequence boundary is marked that shows fluvial depositional signature that may be related to the abrupt vertical juxtaposition of the coarse grained fluvial deposits on marginal marine deposits recording a sequence boundary (Emery and Myers, 1996). We have also compared the relative sea level curve of the Chhidru Formation with the global sea level (Fig. 7) during Upper Permian (Dzulfian). The global sea curve of Haq and Schutter (2008) has two falls of medium range (25-75m) in the Dzulfian time at 253.8 and 252.5 Ma, and can be correlated with the sea level fall at the base and top of the Chhidru Formation respectively. The other five cycles of falls are thus not present globally and are attributed to the local tectonic activities. Comparison with sea level curve of Chen et al. (1998) also shows a fall at 253.8 and correlates well with the fall of 253.8 Ma of global chart (Haq et al., 2008) and also with this study. While 252.5 Ma fall cannot be correlated as curve of Chen et al. (1998) has a maximum flooding surface at that time while in the study area we can speculate that local local tectonics was playing its role. Comparison with the sea level curve of Ross and Ross (1995) suggests that the falls and rises of this study cannot be correlated with it (Fig. 7).

We conclude that deposition of the Chhidru Formation within the study area has effects of both the global sea level as well as local tectonics within the depositional signals.

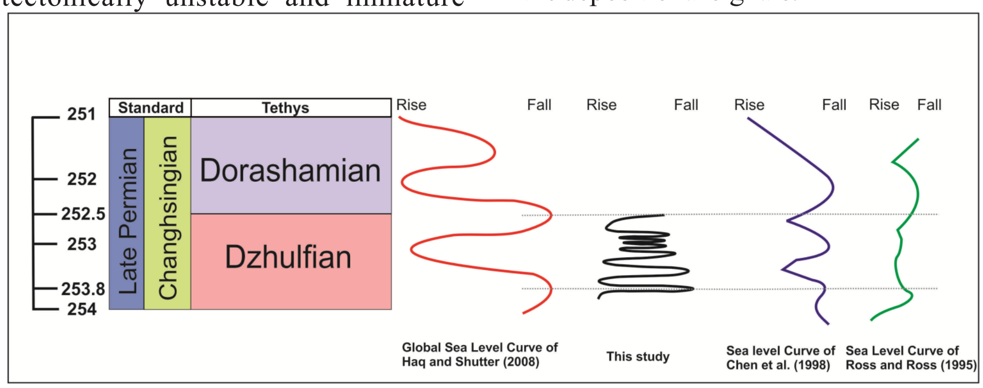


Fig. 7. Comparison of sea level curve of this study with Global sea level curves of Haq and Schutter (2008), Chen et al. (1998) and Ross (1995).

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Appendix 1: Distribution of allochems, sparite, micrite and infered microfacies type in Chhidru Formation in Nammal Gorge section.

Thin Section No	Allochems (%)	Sparite (%)	Micrite (%)	Allochems (in 100%)							Classification (After Dunham, 1962)
				Bryozoans	Fusulinids	Brachiopods	Echinoderms	Gastropods	Undifferentiated Bioclasts	Extraclasts	
1	5	1	94	0	0	11	33	0	0	56	Mudstone
2	10	1	89	9	32	23	0	0	0	36	Mudstone
4	5	0	95	0	25	17	0	0	0	58	Mudstone
5	9	3	88	4	27	20	4	0	0	45	Mudstone
6	20	8	72	9	33	23	0	0	0	35	Mudstone-Wackestone
8	9	2	89	10	12	22	9	0	0	47	Mudstone
11	8	1	91	5	21	41	8	0	0	25	Mudstone
13	7	1	92	5	20	25	0	0	0	50	Mudstone
15	10	0	90	4	48	26	4	0	0	18	Mudstone
16	8	0	92	4	36	24	0	0	0	36	Mudstone
18	28	6	66	8	45	21	0	0	0	26	Wackestone-Packestone
19	6	0	94	6	14	33	0	0	0	47	Mudstone

Appendix 2: Distribution of allochems, sparite, micrite and infered microfacies in Chhidru Formation in section close to Chhidru village.

Thin Section No	Allochems (%)	Sparite (%)	Micrite (%)	Allochems (in 100%)							Classification (After Dunham, 1962)
				Bryozoans	Fusulinids	Brachiopods	Echinoderms	Gastropods	Undifferentiated Bioclasts	Extraclasts	
1	66	33	1	37	2	12	-	-	30	19	Wackestone-Packestone
2	60	30	10	29	5	7	-	-	45	14	Wackestone-Packstone
3	57	15	28	18	6	15	-	-	36	25	Wackestone-Packestone

Appendix 3: Petrographic data of siliciclastic rock thin sections from Nammal Gorge section.

Thin Section No.	Quartz (%)	Feldspar (%)	Rock Fragments (Lithics)(%)	Heavy Minerals (%)	Matrix (%)	Classification (After Pettijohn et al., 1987)
23	65	4	3	1	27	Quartz wacke
22	61	3	1	1	34	Quartz wacke
21	69	4	0	1	26	Quartz wacke
20	52	4	1	1	42	Quartz wacke
17	43	3	1	1	52	Quartz wacke
14	70	5	2	1	22	Feldspathic greywacke
12	63	7	2	1	23	Feldspathic greywacke
10	61	6	3	1	29	Feldspathic greywacke
09	62	7	1	1	29	Feldspathic greywacke
07	77	7	1	0	15	Feldspathic greywacke
03	68	5	3	1	23	Feldspathic greywacke

Appendix 4: Petrographic data of sandstones thin sections from section close to Chhidru village.

Thin Section No.	Quartz (%)	Feldspar (%)	Rock Fragments (Lithics)(%)	Heavy Minerals (%)	Matrix (%)	Classification (After Pettijohn et al., 1987)
05	42	5	0	1	52	Feldspathic greywacke
04	64	3	1	1	31	Quartz wacke