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A review of the Lower – lowermost Upper Jurassic facies and stratigraphy of the Jaisalmer Basin, western Rajasthan, India

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Key words: facies, lithostratigraphy, Jurassic, Jaisalmer Basin, India.

Abstract. The Lower – lowermost Upper Jurassic (up to Oxfordian) sedimentary succession of the Jaisalmer Basin on the Rajasthan Shelf is characterized by gradual lateral and rapid temporal facies variations, the existence of condensed sequences in certain horizons, and rich and highly diverse faunal contents. Lithostratigraphically, these Jurassic rocks of the basin have been grouped into the Lathi and Jaisalmer formations and the lower part of the Baisakhi Formation. The facies consist of (i) cross-bedded medium- to coarse-grained sandstone, (ii) cross-bedded to thinly laminated silt to fine-grained sandstone, (iii) silty marl, (iv) calcareous mud- to grainstone and sandy rudstone, (v) thinly laminated carbonaceous shale and (vi) conglomerate. These represent fluvial, floodplain, lacustrine, protected marginal marine, and shoreface to shelf environments. There are several marker units, which allow the making of intrabasinal lithostratigraphic correlations; however, a lack of knowledge of the detailed stratigraphic successions within individual lithostratigraphic units makes difficult a precise intra-basinal stratigraphic correlation.

The present review provides a summary of the lithostratigraphy established by previous workers on the Lower – lowermost Upper Jurassic (up to Oxfordian) rocks of the Jaisalmer Basin, incorporating additional data, with a detailed stratigraphic succession within each lithostratigraphic unit, and more faunal elements recently.

INTRODUCTION

The Jaisalmer sedimentary basin (Fig. 1) is significant for its fossiliferous Jurassic sedimentary rocks (Blanford, 1877; Oldham, 1886; Das Gupta, 1975; Fürsich *et al*., 1992; Kulkarni *et al*., 2008; Pandey *et al*., 2010), hydrocarbon reserves and building stones. Lately it has been found to be an excellent Jurassic sedimentary basin for the study of depositional history. There have been several gradual changes in the depositional setting from fluvial/lagoonal, delta front, shoreface to offshore depositional environment with fluctuating water energy and salinity (Pandey *et al*., 2006a, b). The Jaisalmer Basin is a pericratonic basin, placed now on the northwestern margin of the Indian peninsular shield (Fig. 1A) and dipping to the northwest. Palaeogeographically, the Jaisalmer Basin was situated about 23° south of the equator and represented the southern Tethyan margin (Fig. 1B). Tectonically, the Rajasthan shelf has been divided into four units, namely: the Jaisalmer Basin, the Bikaner-Nagaur Basin, the Barmer-Sanchor Basin, and the Pokaran-Nachna High (Figs 1C, 2A), but due to changes in geographic settings from the Late Precambrian to the Neogene the extent of these sedimentary basins of the Rajasthan shelf changed from time to time.

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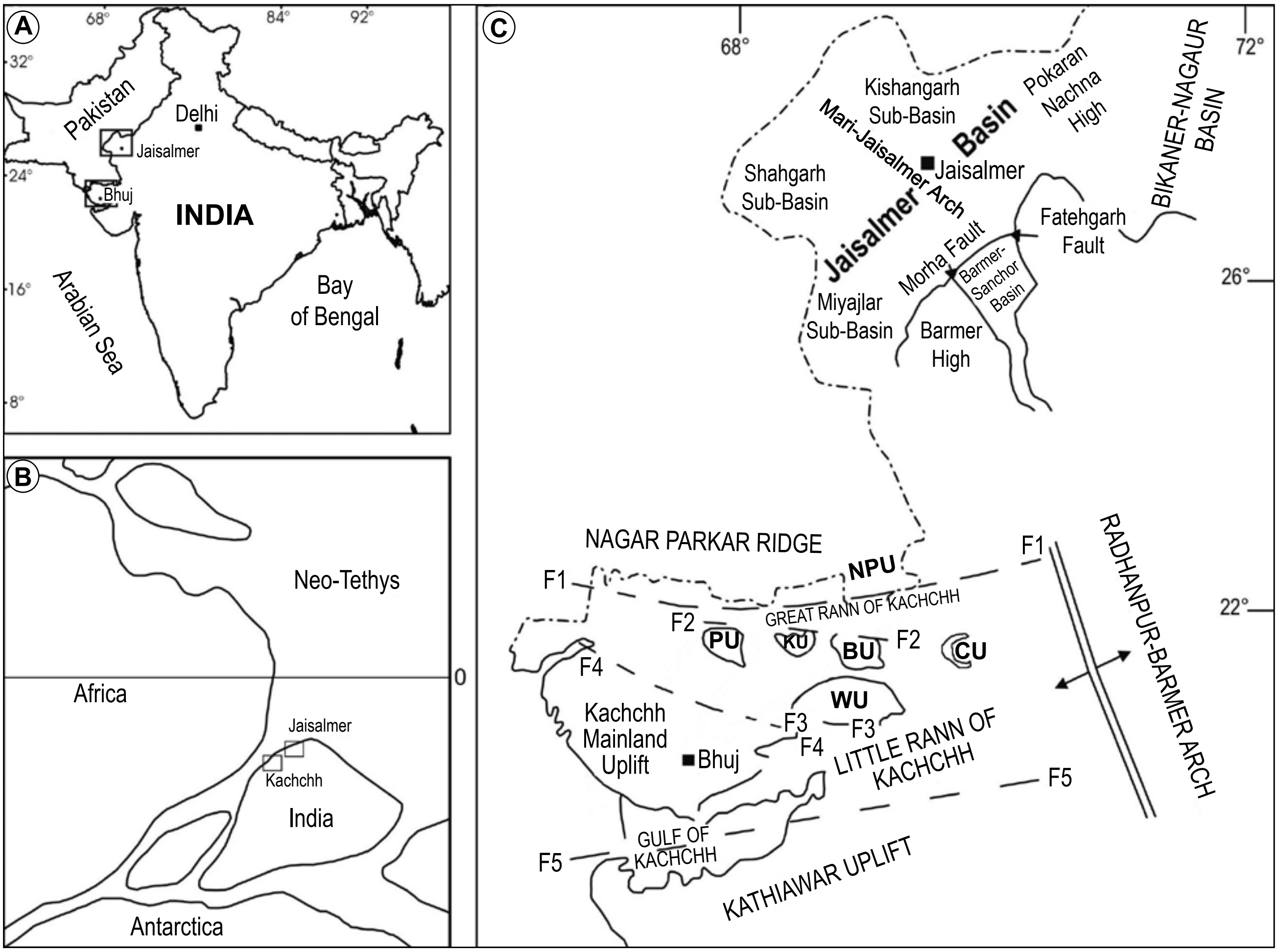


Fig. 1. A. Outline map of India showing location of Jaisalmer and Kachchh basins. B. Palaeogeographic position of Jaisalmer and Kachchh basins during the Jurassic. C. Tectonic outline map of Jaisalmer and Kachchh basins (after Biswas, 1982 and Misra *et al.*, 1993)

WU – Wagad Uplift, PU – Pachham Uplift, KU – Khadir Uplift, BU – Bela Uplift, CU – Chorar Uplift, NPU – Nagar Parkar Uplift, F1 – Nagar Parkar Fault, F2 – Islands Belt Fault, F3 – South Wagad Fault, F4 – Kachchh Mainland Fault, F5 – North Kathiawar Fault

The Jurassic of the Jaisalmer Basin begins with widespread outcrops of fluvial, deltaic, or lacustrine sediments of the lower part of the Lathi Formation on the southeastern part of the basin (Srivastava, 1966; Lukose, 1972; Bonde, 2010), and followed by marginal marine sediments of the upper part of the Lathi Formation and a succession of several non-marine, marginal marine and fully marine sediments, which are grouped in to the Jaisalmer, Baisakhi and Bhadasar formations (Das Gupta, 1975; Pareek, 1984; Mahendra, Banerji, 1989; Fürsich *et al.*, 1992; Pandey *et al.*, 2005, 2006a, b, 2009a, 2010). The outcrops of younger Jurassic formations are confined to the raised Mari-Jaisalmer Arch (Fig. 2B) (Oldham, 1886; Swaminath *et al.*, 1957, 1959) in the Jaisalmer Basin.

The succession is represented by either alternating siltstones/sandstones and limestones, or alternations of poorly cemented and well cemented beds of bioturbated and cross-bedded sediments. Erosional surfaces, lateral changes in lithology and repetition of sedimentary facies are common features, and therefore due to a lack of knowledge of the detailed stratigraphic succession within individual lithostratigraphic units, a precise intra-basinal stratigraphic correlation was limited.

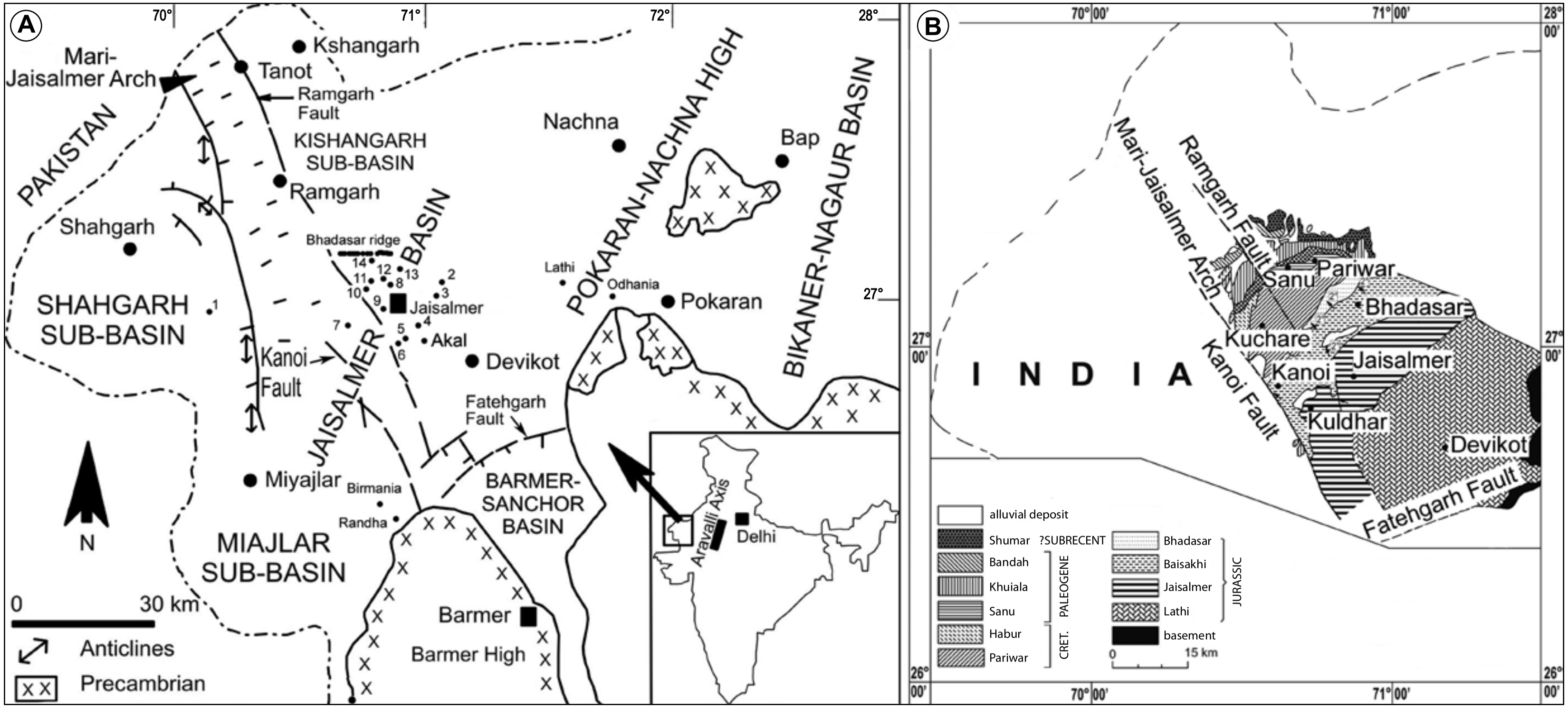


Fig. 2. A. Geostructural units of the Jaisalmer Basin (modified after Misra *et al.*, 1993).
B. Geological map of the Jaisalmer Basin (modified after Das Gupta, 1975) with the names of the formations given

Localities mentioned in the text: 1 – Bhuana, 2 – Hamira, 3 – Thaiyat, 4 – Soran-Ki-Dhani, 5 – Joyan, 6 – Sata-Ki-Dhani, 8 – Badabag, 9 – Amarsagar, 10 – Ludharwa, 11 – Rupsi, 12 – Baisakhi, 13 – Pohar, 14 – Lanela

The aim of the review is to summarize achievements of the several decades of studies carried out by earlier workers on the Lower – lowermost Upper Jurassic (up to Oxfordian) rocks of the Jaisalmer Basin and to focus on the more precise stratigraphic successions within each lithostratigraphic unit and the record of faunal elements.

LITHOSTRATIGRAPHY OF LOWER – LOWERMOST UPPER JURASSIC SEDIMENTS

BASEMENT ROCKS

The Pre-Cambrian igneous (Malani Igneous Suite – rhyolite/granite) and metamorphic rocks (phyllite and schist) constitute the basement for the overlying sedimentary successions in the western Rajasthan basins. The Malani rocks have been dated as ranging from 779–681 Ma (Pareek, 1984; Rathore *et al*., 1999). Among the recent dates of the Malani Igneous Suite, the one giving an U-Pb Zircon age of 770–750 Ma, determined by Thermal Ionization Mass Spectrometry (Torsvik *et al*., 2001) is frequently cited. The depth of the basement in the Jaisalmer Basin is 10,000 m near the Indo-Pakistan border (Rao, 1972). These basement rocks in the Jaisalmer Basin are exposed east of the Devikot and southwest of the Pokaran (Fig. 2A) areas only. The oldest sedimentary units recorded in the basin from a borehole and from surface outcrops near Birmania and Randha village (Fig. 2A) range in age from Late Precambrian to Early Cambrian (Bhandari, 1999).

LATHI FORMATION

The lowermost Early Jurassic stratigraphic unit of the Jaisalmer Basin (Table 1, Fig. 2B) rests on the Permian--Triassic Bhuana Formation (Lukose, Misra, 1980; Misra *et al*., 1996) and extends southward up to the Barmer-Sanchor Basin. Eastward in the Bikaner-Nagaur Basin (Fig. 2A) the Lathi Formation has been correlated with the Triassic–Jurassic Mayakor Formation (Shrivastava, 1971). The name Lathi Formation was designated as Lathi beds by Oldham (1886) after the village Lathi (Fig. 2A) on the Pokaran–Jaisalmer road and was considered as a continental deposit. Swaminath *et al*. (1959) grouped the beds into a formation. The sporadic outcrops of this formation occur in the south, southeast and east of Jaisalmer (Roy, Jakhar, 2002: 287).

The estimated thickness of the Lathi Formation is 330–360 m (Narayanan *et al*., 1961; Narayanan, 1964; Pareek, 1975), however, subsequently a maximum subsurface thickness of 600 m has been recorded (Pareek, 1980: 61; 1984: 32). Earlier workers such as Blanford (1877) and Das Gupta (1975) recorded dicotyledonous wood fragments from this formation (see also Bhatia, 1977; Verma, 1982). Current knowledge suggests that these are gymnosperm wood fossils because angiosperm plants did not appear before Upper Jurassic/Cretaceous (Arnold, 1978: 334; Sharma, Tripathi, 2002).

Lukose (1972) studied pollen grains and spores from subsurface samples of the Lathi Formation. The sporomorph assemblage recorded by him consists of *Cyathidites*, *Gleicheniidites*, *Lophotriletes*, *Osmundacidites*, *Dictyophyllidites*, *Endosporites*, *Matonisporites*, *Araucariacites*, *Inaperturopollenites*, *Laricoidites*, *Spheripollenites*, *Classobollis*, *Gliscopollis*, *Clavatipollenites*, *Cycadopites*, and *Psilospora.* Lukose (1972) discussed the age of these sporomorphs and on the basis of abundant *Spheripollenites*, *Classobollis*, *Gliscopollis*, *Araucariacites*, and *Inaperturopollenites*, and the absence of some significant Upper Triassic and Middle Jurassic forms he concluded the age of Lathi Formation as Early Jurassic. Lately, Sharma and Tripathi (2002) and Bonde (2010) recorded fossil wood belonging to conifer families, *viz*. Podocarpaceae, Cupressaceae and Araucariaceae from the Lathi Formation. The gymnosperm wood fossils are quite common in this formation suggesting existence of luxuriant forest during the Early Jurassic.

On the basis of lithology and depositional environment, Das Gupta (1975) divided the Lathi Formation into two members (Table 1) – a lower Odania Member and an upper Thaiat Member.

Odania Member

The basal part of this member is typically exposed in the Lathi-Odhania area (Fig. 2A; Tables 1, 2). It starts with low- to high-angle cross-bedded, well cemented, poorly sorted ferruginous sandstones with pebbles predominantly of quartzite (seen north and southeast of Odhania) and is followed by a sequence of white to maroon, sandy siltstone, dark ferruginous sandstone and arkosic poorly sorted coarse-grained sandstone (Das Gupta, 1975; Pandey *et al.*, 2006b). The upper part is typically exposed in the area around the Akal National Park (Wood Fossil Park), 17 km east of Jaisalmer around Akal (Fig. 2A). In the upper part the rock units are poorly cemented, poorly sorted, medium- to coarse--grained, mica-bearing, cross-bedded, calcareous to ferruginous sandstones with concretions (occasional), gymnosperm wood fragments and tree trunks. Quartz grains are angular to subangular. Akal National Park is the best locality from where large gymnosperm wood fossils have been recorded. The longest preserved fossil wood is 13.4 × 0.9 m. The widest diameter is 1.20 m.

Table 1

A composite lithostratigraphic classification of Jurassic sediments of the Jaisalmer Basin presented here and the corresponding age (information from Krishna, 1979, 1987; Chatterjee, 1990; Pandey and Krishna, 2002 and personal observations of the present authors have also been incorporated)

[1] Narayanan, 1961 [2] Das Gupta, 1975		Kachhara, Jodhawat, 1981		Garg, Singh, 1983		Pandey, Krishna, 1996		Present study Prasad, 2006		Age
Bhadasar Formation	Mokal Member[2]	Bhadasar Formation		Bhadasar Formation	UNCONFORMITY	Bhadasar Formation	Mokal Member	Bhadasar Formation	Mokal Member	?Early Cretaceous
	Kolar Dunger Member[2]						Bhadasar Member		Kolar Dungar Member	Tithonian
									UNCONFORMITY	
Baisakhi Formation	Rupsi Member[2]	Baisakhi Formation		Formation	Rupsi Shale Member		Rupsi Member (includes Ludharwa Member)	Baisakhi Formation	Lanela Member	Late Kimmeridgian
	Ludharwa Member[2]								Ludharwa Member	Kimmeridgian
	Baisakhi Member[2]				Baisakhi Member				Rupsi Member	Early Kimmeridgian
………… UNCONFORMITY …………										
Jaisalmer Formation	Kuldhar Member[1]	Jaisalmer Formation	Jajiya Member	Jaisalmer	Kuldhar Oolite Member	Jaisalmer Formation	Kuldhar Member (includes carbon-ate succession exposed west of Baisakhi village earlier designated as Baisakhi Member)	Jaisalmer Formation	Jajiya Member	Oxfordian
			Kuldhar Member						Kuldhar Member	Callovian
	Bada Bag Member[1]		Bada Bag Member		Amarsagar Limestone Member				Bada Bag Member	Bathonian
	Fort Member[1]		Fort Member						Fort Member	
	Joyan Member[1]		Joyan Member						Joyan Member	Bajocian
	Hamira Member[2]		Hamira Member						Hamira Member	Early Jurassic to Bajocian
Lathi Forrmation	Thaiat Member[2]	Lathi Forrmation		Lathi Forrmation		Lathi Forrmation		Lathi Forrmation	Thaiat Member	
	Odania Member[2]								Odania Member	

Table 2

Brief description of lithostratigraphic units of Lower – lowermost Upper Jurassic (up to Oxfordian) sediments of the Jaisalmer Basin in the order of superposition

Fm.	Mb.	Age	Author	Type-section	Lithology
Baisakhi	Rupsi	E. Oxford.– E. Kimm.	Das Gupta, 1975	Rupsi-section, north of the Rupsi village	shales; lower part carbonaceous
Jaisalmer	Jajiya	Oxfordian	Kachhara and Jodhawat, 1981	1 km west of Kuldhar nala-section, Jajiya scarp and Jajiya river-section, 11–18 km southwest and west of Jaisalmer city	oolitic, bioturbated and cross-bedded limestones with hardgrounds and sandstone
	Kuldhar	Callovian	Narayanan *et al*., 1961	16 km southwest of Jaisalmer city along Kuldhar nala-section	fossiliferous, oolitic silty marls, shell beds, shales and limestones
	Bada Bag	Late Bathonian	Narayanan *et al*., 1961	6 km north of Jaisalmer city around Badabag cenotaphs and 16 km southwest of Jaisalmer city along basal part of Kuldhar nala-section	siltstones, sandstones, well cemented shelly and sandy limestones with hardgrounds and intraformational conglomerate
	Fort	Early–Mid. Bathonian	Narayanan *et al*., 1961	fort-hill sections, just north of Jaisalmer city	poorly to moderately cemented sand-stones, fossiliferous bioturbated to cross-bedded limestones
	Joyan	Bajocian	Narayanan *et al*., 1961	northeast of Joyan village (26°48'45" N; 71°53'45" E), southeast of Jaisalmer city on the Jaisalmer-Thaiyat, Jaisalmer-Akal and Jaisalmer-Kuri roads	cross-bedded limestones with erosional surfaces and reworked large coral heads, bioturbated limestones and fine-grained sandstones
	Hamira	Early Jurassic–Bajocian	Das Gupta, 1975	east and southeast of the Jaisalmer city, top of Thaiyat scarp-section	cross-bedded calcareous sandstones
Lathi	Thaiat		Das Gupta, 1975	Thaiyat scarp-section (26°56' N; 71°04' E), 16 km east of Jaisalmer city	siltstones and fine-grained sandstones
	Odania		Das Gupta, 1975	sporadic outcrops around Lathi (27°01' N; 71°30' E), Odhania (26°58' N; 71°43' E), Akal and Devikot in the south, southeast and east of Jaisalmer city	cross-bedded, poorly sorted sandstones with pebbles

The sandstones exposed in the Akal Wood Fossil Park are so much diagenetically changed that it is difficult to ascertain whether some of the concretions are biogenic in origin. However, there are impressions of *Thalassinoides*, *Ophiomorpha*, and *Planolites* trace fossils (pers. obs. with Alfred Uchman). The high-angle cross-bedded, well-sorted sandstone exposed in this area could represent aeolian deposits. In general, continental to marginal marine depositional environments have been recognized by previous workers. The authors also interpret the depositional environment as fluvial, flood plain to aeolian with occasional marine influence. The fossil records (mentioned above) suggest the Early Jurassic age of the Odania Member.

Thaiat Member

In contrast to the sandstones of the Odania Member the overlying Thaiat Member consists predominantly of siltstones. Due to limited outcrops the boundary between the two members has not been traced. The Thaiat Member is best exposed along the Thaiyat-ridge scarp to the east and southeast of Thaiyat village 16 km east of Jaisalmer city (Fig. 2A). The section consists of a sequence of red to brown siltstones in the basal part and yellow to grey, poorly cemented, often calcareous fine-grained sandstones and variegated sandy siltstones in the upper part. The upper part is also exposed along the basal part of an outlier, which is a southward extension of the Thaiyat ridge (best approached from the Jaisalmer-Barmer road, 3 km N of the 13 km milestone E of Jaisalmer). The outlier is truncated by a NW-trending fault.

The upper part of the Thaiat Member consists of shell concentrations with nerineid gastropods, heterodont and bakevelliid bivalves, *Trigonia*, *Eomiodon*, and the trace fossils *Teichichnus*, *Gyrochorte*, *Rhizocorallium jenense* Zenker, and *Thalassinoides* (Pandey *et al*., 2006a; and pers. obs. with Alfred Uchman). The nature of the sediments and fossils suggest deposition in a brackish to marine, low energy environment. Das Gupta (1975) mentioned that the Thaiat Member was deposited in a marine littoral environment.

Pandey *et al*. (2006b) distinguished three facies units within the Lathi Formation, *i.e*. Facies unit 1, ferruginous, conglomeratic, cross-bedded sandstone, Facies unit 2, cross-bedded, poorly sorted, fossil-wood bearing sandstone within the Odania Member, and Facies unit 3 (Figs 3, 4), cross-bedded, rarely bioturbated, alternating silt and fine-grained sandstone corresponding to Thaiat Member.

Based on the occurrence of the characteristic Bajocian coral *Isastraea bernardiana* (d'Orbigny) in the lower part of the overlying Jaisalmer Formation (Pandey, Fürsich, 1994; Pandey *et al.*, 2006a), which is coeval to the Late Bajocian ammonite *Leptosphinctes*-yielding horizon in the neighbouring Kachchh Basin (Pandey *et al.*, 2009a), the upper age limit of the Lathi Formation should be Bajocian or Pre-Bajocian, therefore the age of the Thaiat Member ranges from Early Jurassic to Bajocian.

JAISALMER FORMATION

The overlying Jaisalmer Formation (Tables 1, 2; Fig. 2B) consists predominantly of calcareous sediments. The basal part marks an increase in marine influence, which had already started during deposition of the Thaiat Member. This Formation consists of limestones (calcirudite, calcarenite, calcilutite, *etc*.), sandstones (mostly calcareous), siltstones, conglomerates and marls. The beds are both cross-bedded with some exhibiting ripple surfaces and bioturbated. The original name “Jaisalmer Limestone” was given by Oldham (1886). It was redefined as the Jaisalmer Formation by Swaminath *et al*. (1959). Narayanan *et al*. (1961) defined four members in the Jaisalmer Formation (Tables 1, 2). In addition, Das Gupta (1975) recognized the Hamira Member, Kachhara and Jodhawat (1981) added the Jajiya Member. Accordingly, the Jaisalmer Formation is divisible into six members (Tables 1, 2).

The Jaisalmer Formation is exposed around Jaisalmer town (Fig. 2A, 26°55' N; 70°55' E) and forms a major part of the marine Mesozoic succession of Rajasthan. The lower part of the Jaisalmer Formation is exposed to the east and southeast of Jaisalmer city, whereas the middle part is exposed along the ridge north of Jaisalmer city and further north up to Badabag (Fig. 2A). The upper part of the formation is mostly studied to the west of Jaisalmer at Kuldhar nala-section and a scarp near the village Jajiya (Fig. 2A). Ammonoids (Table 3), giant rhynchonellids, terebratulids, bivalves, gastropods, echinoderms, bryozoans, and corals are common fossils (Pandey *et al*., 2009b).

The lower three members of the formation contain few ammonites. Ammonites begin to be common from the Kuldhar Member upwards (Krishna, 1979, 1983, 1987; Pandey *et al*., 2010). The reason could be similar to that of the neighbouring Kachchh Basin, where ammonites are also very limited in number in the Bajocian-Bathonian rocks (Singh *et al*., 1982, 1983; Pandey, Agrawal, 1984; Pandey, Callomon, 1995). The basins must have been protected from open marine conditions, which caused reduced salinity at least for some time-intervals, resulting in the appearance of brackish water faunal elements, such as *Eomiodon*, *Protocardia*, *Cyathophora*, *etc*. in the biotic community (Fürsich *et al*., 1994; Pandey *et al*., 2002, 2006a). The Jaisalmer Formation ranges in age at least from Bajocian to Oxfordian (Pandey, Fürsich, 1994; Prasad, 2006).

The thickness of the formation as mentioned by Poddar (1964) is 170 m in the southern sector and decreases northeastwards to 120 m. Pareek (1984) estimated the thickness of the Jaisalmer Formation on the surface outcrops as 300 m. The subsurface thickness of strata encountered by drilling is 600 m. Accordingly, the total thickness calculated is likely to be more than 600 m (Das Gupta, 1975), possibly even about 1000 m (Pareek, 1984: 37).

As mentioned elsewhere, the formation has attracted both palaeontologists and sedimentologists in the past for studies of the basin and inter-basinal correlation with the adjacent Kachchh Basin (Pandey *et al*., 2009).

Hamira Member

This is the basal member of the Jaisalmer Formation, overlying the Lathi Formation (Das Gupta, 1975: 79; Pareek, 1984: 36). It consists of more than 2 m of greyish, brownish, yellow, low-angle cross-bedded, fine- to medium-grained calcareous sandstone and limestone with scattered bivalves (heterodonts, oysters, *Trigonia*, *etc*.), brachiopods, trace fossils (*Rhizocorallium*, *Chondrites*, *Taenidium*, *Planolites*, *Skolithos*, *etc*.), colonial corals, crinoid fragments, solenoporacean algae and wood fossils (Fig. 3; see also Das Gupta, 1975; Mahendra, Banerji, 1990). Kachhara and Jodhawat (1981: 241) recorded a few isolated occurrences of deposits with common but poorly preserved bivalves, such as nuculids (*Palaeonucula*), oysters, *etc*. and referred to it as the *Nucula*

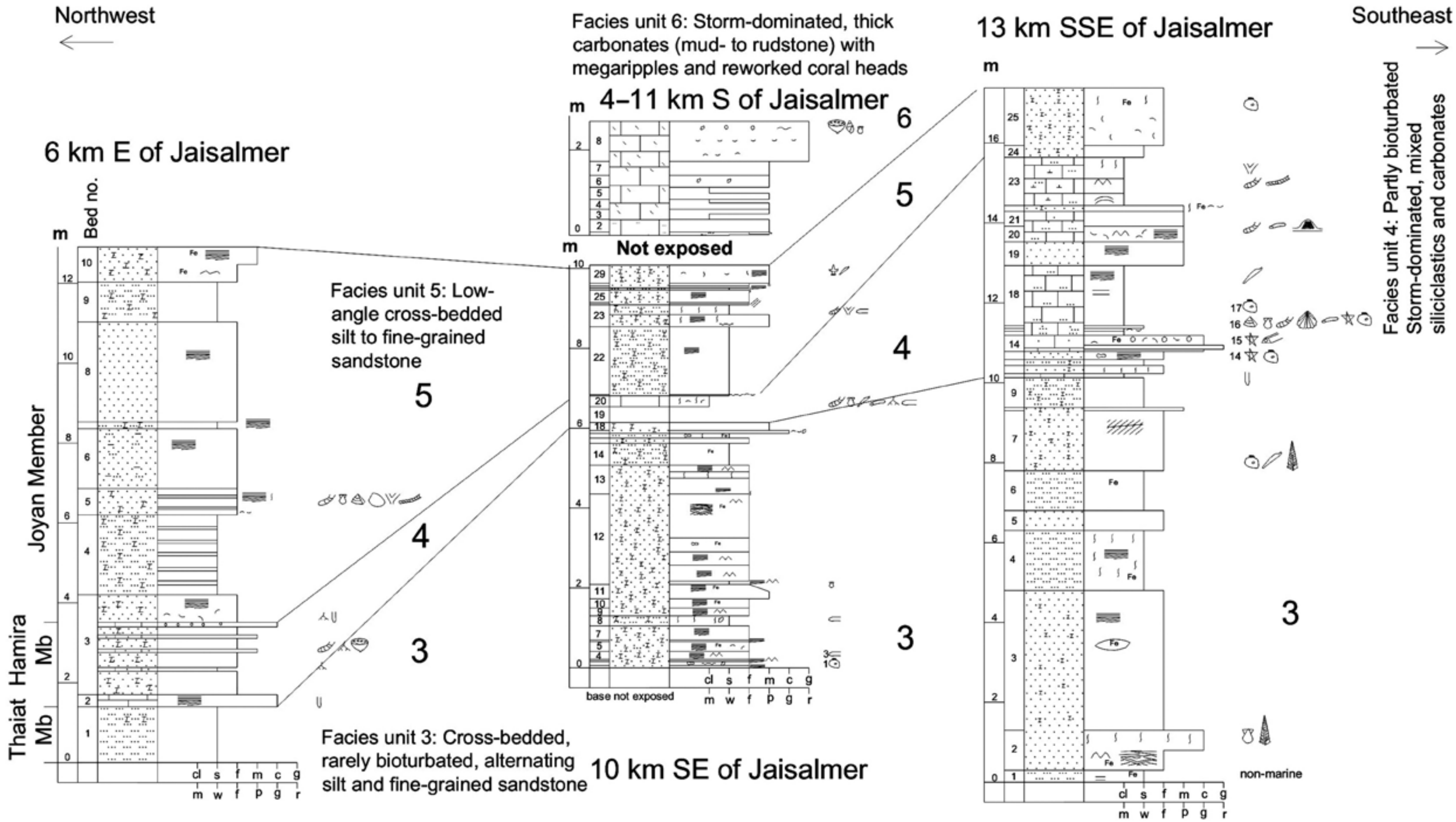
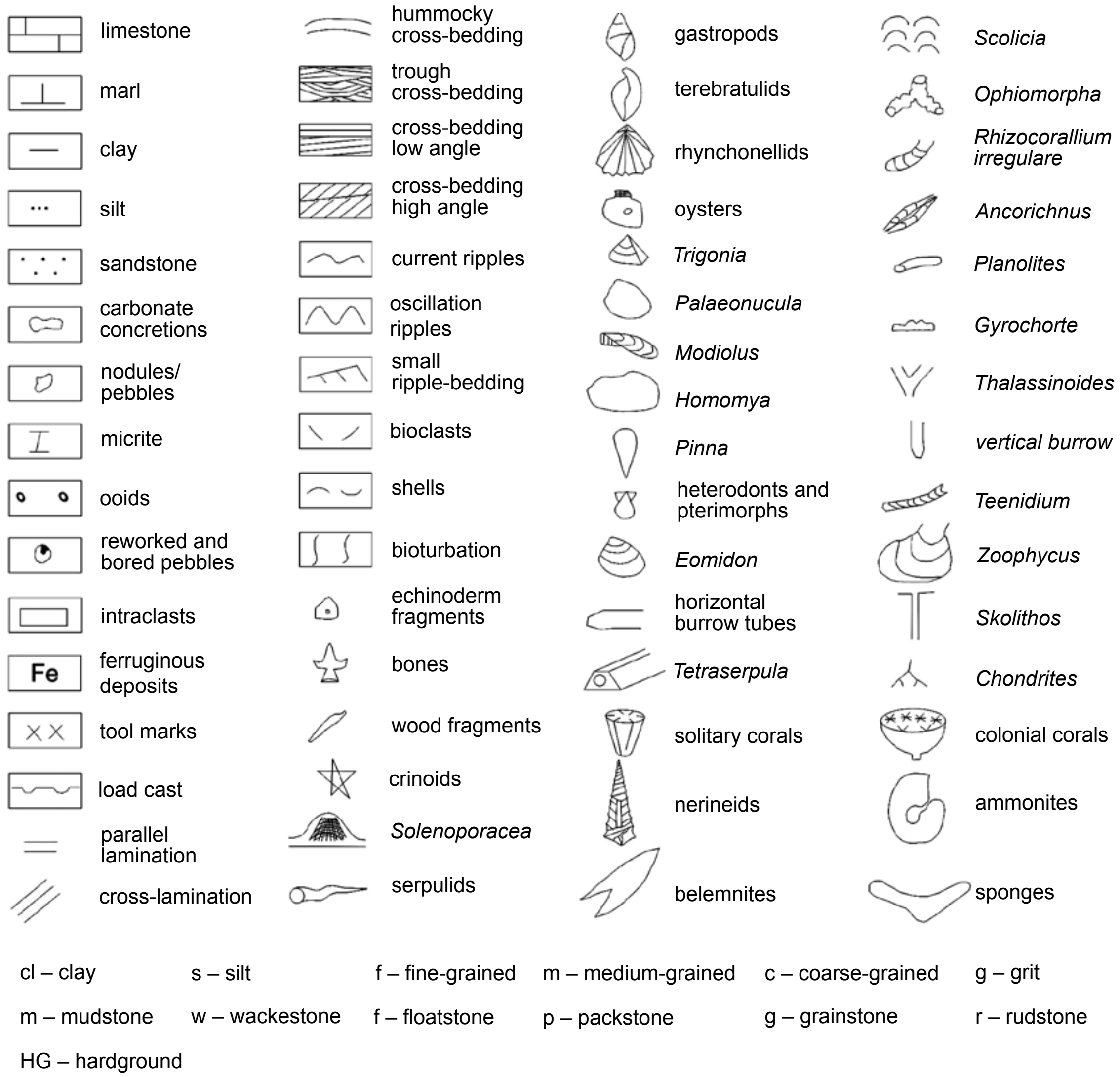


Fig. 3. Stratigraphic position and lateral extension of facies units 3–6 within the Thaiat, Hamira and Joyan members exposed east and southeast of Jaisalmer city (modified after Pandey *et al.*, 2006b)

The numbers at symbols of fossils are the numbers of beds

Key of symbols for Figs 3–6



flags and provisionally compared it with the *Nucula* flags recorded in the Kachchh Basin (Spath, 1924; Cox, 1940). This member is also exposed at the top of the Thaiyat scarp and north of the village Thaiyat along the right-hand side of the road going to a railway crossing near the village of Hamira (Fig. 2A; 27°00' N; 71°05' E). Based on the faunal content, its composition, mode of occurrence and state of preservation, as well as on the nature of the sediment and sedimentary structures, a shallow-marine nearshore depositional environment can be interpreted. The golden calcarenite bed (20 cm thick) with golden yellow-coloured coatings of pyrite on tiny gastropods up to 2 mm exposed in a small outcrop near the village Hameera (Pareek *et al.*, 1977) should not be included in the Hamira Member as its lithology is similar to that of the Fort Member/Kuldhar Member. The stratigraphic continuity of the latter members from the west to east should be traced with great caution. Hitherto, no index fossils has been recorded from this member, however, on the basis of fossil records in the overlying Joyan Member, the Hamira Member can be safely assigned to the interval from Early Jurassic to Bajocian (Table 4).

Table 3

Stratigraphic distribution of ammonites from the Lower–Upper Jurassic (up to Oxfordian) sediments of the Jaisalmer Basin (according to different authors)

Fm	Member	Age		Chatterjee, 1990	Krishna, 1987	Kachhara and Jodhawat, 1981; Jodhawat, 1984	Prasad, 2006; Prasad *et al.*, 2007
Jaisalmer / **Baisakhi**	Jajiya / Rupsi	Oxfordian	Late	*Dhosaites* *Epimayaites* (Rupsi section)		*Mayaites*, *Epimayaites*, *Dhosaites*, *Lissoceratoides*, *Brightia*, *Klematosphinctes*, *Properisphinctes*, *Alligaticeras*	*Dhosaites*, *Epimayaites*, *Dichotomosphinctes* **(Rupsi section)**
Jaisalmer	Jajiya	Oxfordian	Middle		*Mayaites*, *Epimayaites*, *Dhosaites*, *Paryphoceras*		
Jaisalmer	Jajiya	Oxfordian	Early				
Jaisalmer	Kuldhar	Callovian	Late		*Collotia gigantea* ass.		*Properisphinctes*
Jaisalmer	Kuldhar	Callovian	Middle	*Reineckeia* sp.,	*Reineckeia anceps* assemblage (first appearance)	*Sivajiceras*, *Reineckeia*, *Idiocycloceras*, *Subkossmatia*, *Kinkeliniceras*	*Hecticoceras*, *Hubertoceras*, *Obtusicostites*, *Reineckeia*, *Idiocycloceras*, *Subkossmatia*, *Eucycloceras*, *Subgrossouvria*, *Kinkeliniceras*, *Indosphinctes*, *Macrocephalites*
Jaisalmer	Kuldhar	Callovian	Early	*Subgrossouvria aberrans*, *Subkossmatia opis*, *Macrocephalites formosus*, *M. chariensis*, *Sivajiceras congener* (may come from Late Bathonian – after present author)	*Subkossmatia opis* (first appearance) *Macrocephalites transitorius*, *M. chariensis*, *M. semilaevis*		
Jaisalmer	Bada Bag	Bathonian	Late		*Macrocephalites madagascariensis*		
Jaisalmer	Fort	Bathonian	Middle				*Clydoniceras*
Jaisalmer	Fort	Bathonian	Early				
Jaisalmer	Joyan	Bajocian					
Jaisalmer	Hamira	Early Jurassic to Bajocian					
Lathi	Thaiat	Early Jurassic to Bajocian					
Lathi	Odania	Early Jurassic to Bajocian					

Table 4

Biostratigraphic correlation of the Jurassic successions of the Kachchh and Jaisalmer basins (after Kachhara, Jodhawat, 1981; Singh *et al.*, 1982, 1983; Pandey, Agrawal, 1984; Krishna, 1987; Callomon, 1993; Pandey, Callomon, 1995; Prasad, 2006; Jain, 2007; Krishna *et al.*, 2009; Shome, Bardhan, 2009 and pers. obs.)

Age	Jaisalmer Basin: Fm.	Jaisalmer Basin: Member	Index/Guide Fossils (Jaisalmer)	Index/Guide Fossils (Kachchh)	Kachchh Basin: Member	Kachchh Basin: Fm.
Tithonian to Early Cretaceous	**Bhadasar**	Mokal			Umia Plant Bed Pars?	**Umia**
		Kolar Dungar	*Substeueroceras alticostatum*, *Kossmatia*, *Virgatosphinctes*	*Corongoceras*, *Himalayites*, *Durangites*,*Tithopeltoceras*, *Blanfordiceras*, *Pterolytoceras sutile*, *Aulacosphinctes*, *Umiaites* (=*Proniceras*), *Micracanthoceras micracanthus*, *Virgatosphinctes*	Umia Ammonite Bed	
Late Kimmeridgian	**Baisakhi**	Lanela	*Katroliceras*	*Katroliceras katrolensis*	Upper	**Katrol**
Early Kimmeridgian		Ludharva	*Torquatisphinctes*	*Torquatisphinctes bathyplocus*, *T. alterniplicatus*	Lower	
		Rupsi				
Late Oxfordian	**Jaisalmer**	Jajiya	*Dichotomoceras*, *Dichotomosphinctes*, *Dhosaites*, *Mayaites maya*, *Paryphoceras*, *Epimayaites Klematosphinctes*, etc.	*Gregoryceras*, *Dichotomoceras*, *Dichotomosphinctes*, *Dhosaites*, *Mayaites maya*, *Paryphoceras*, *Epimayaites*, etc.	DOM & DCB; Nara Shale	**Chari**; **Washtawa**
Early to Middle Oxfordian						
Early Oxfordian			*Peltoceratoides semirugosus*	*Peltoceratoides semirugosus*	Dhosa Sandst.	
Callovian		Kuldhar	*Collotia gigantea*, *Reineckeia anceps*, *Subkossmatia opis*, *Macrocephalites formosus*, *M. chariensis*, *M. semilaevis*	*Peltoceras athleta*, *Collotia gigantea*, *Reineckeia anceps*, *Subkossmatia opis*, *Subgrossouvria aberrans*, *Macrocephalites* spp.	Gyps. Shale Ridge Sandst. Shelly Shale	
Late Bathonian		Bada Bag	*Macrocephalites madagascariensis*, *M. triangularis*, *Sivajiceras congener*	*Macrocephalites madagascariensis*, *M. triangularis, Sivajiceras congener*	Raimalro Limestone/ Sponge Limestone	**Patcham**
Middle Bathonian		Fort	*Clydoniceras* sp.	*Clydoniceras triangularis*, *Clydoniceras pachchhamensis*, *Micromphalites* sp.	Purple Sandst. /Echnoderm Packstone; Gadaputa Sandstone; JCL; GDYF	**Jhurio**; **Goradongar**
Early Bathonian						**Kaladongar**
Bajocian		Joyan		*Leptosphinctes* sp.	**L-PR**	
Early Jurassic to Bajocian		Hamira			Babia Cliff Sandst.	
	Lathi	Thaiat			Kaladongar Sandst.	
		Odania			Dingi Hill	
Basement rocks						

JCL – Jumara Coral Limestone; GDYF – Goradongar Yellow Flagstone Member; L-PR – *Leptosphinctes*-bearing Pebbly Rudstone; DOM & DCB – Dhosa Oolite Member & Dhosa Conglomerate Bed

Joyan Member

The lower part of the member consists predominantly of siliciclastic sediments (Narayanan *et al.*, 1961; see also Table 2), whereas the upper part is exclusively calcareous. The best outcrops of the member are near Soran-Ki-Dhani (Fig. 2A, locality 4), WSW and NE of the village of Joyan (Fig. 2A, locality 5). Partially, the member is also exposed along the left side of the Jodhpur–Jaisalmer road, between 15 km East of Jaisalmer and Jaisalmer city. The topmost bed of the member is a rudstone (approximately 70 cm-thick) with mega-ripples on the upper surface and with large reworked heads of the coral *Isastraea bernardiana* (d'Orbigny). In addition to coral heads, Kachhara and Jodhawat (1981) and Jodhawat (1984) collected bivalves from the upper part of the member in the area near Joyan Kharin. These include *Isognomon*, *Inoceramus*, *Myoconcha*, *Modiolus*, *Mytilus*, *Trigonia*, *Palaeonucula*, *Gervillia*, *Nanogyra*, *Protocardia* and *Corbula*. According to Mahendra and Banerji (1990) the Joyan Member consists of coquinoidal limestone and gritty sandstone. Trace fossils recorded recently are *Rhizocorallium jenense* Zenker, *Chondrites* isp., and *Rosselia* isp. The shells occasionally occur as pavements (Pandey *et al.*, 2006b). Isolate large-sized turreted gastropod shells (height up to 70 mm) have also been observed (pers. obs.). Kachhara and Jodhawat (1981: 242), based on the evidence of the the bivalve assemblage, mentioned that in all probability the Joyan Member is Bajocian in age; however, all these bivalve taxa have no biostratigraphic importance at stage level. The occurrence of the characteristic Bajocian coral *Isastraea bernardiana* (d'Orbigny) in the topmost bed of the member refines the upper boundary of the Joyan Member as Late Bajocian (Pandey, Fürsich, 1994). The topmost bed of the Joyan Member represents the peak of the first marine transgression of the Jaisalmer Basin, probably contemporaneous with the Late Bajocian one in the neighbouring Kachchh Basin (Pandey *et al.*, 2006b, 2009a; see also Table 4).

Pandey *et al*. (2006b) distinguished three facies units corresponding to the Hamira and Joyan members (Fig. 3; note variation in the thickness of facies): Facies unit 4, partly bioturbated, storm-dominated, mixed siliciclastics and carbonates, Facies unit 5, low-angle cross-bedded silt to fine-grained sandstones, and Facies unit 6, storm-dominated thick carbonates (mud- to rudstone) with megaripples and reworked coral heads. Facies unit 4 is characterized by an intra-formational conglomerate and at least three more storm-induced beds alternating with low-energy events. The facies has been interpreted as a mixed siliciclastic-carbonate protected ramp. Facies unit 5 has been interpreted as a near-shore shallow-water environment above fair-weather wave-base, possibly on a siliciclastic ramp with fluctuating energy level but no storm deposits. The uppermost facies unit 6 has been assigned to a high-energy environment during a major transgression. However, this transgression apparently did not bring any ammonites to the uppermost Joyan Member but many reworked coral heads, large-sized gastropod shells and bioclasts.

Fort Member

This member is best exposed along the Jaisalmer Fort escarpments (Narayanan *et al.*, 1961, see also Table 2, Fig. 4). The member crops out widely in the northern part (*i.e.* north of Jaisalmer), but it pinches out southwards near Sata-Ki-Dhani (Jodhawat, 1984; see also Fig. 2, locality 6). The Fort Member consists of fine- to medium-grained sandstones, oolitic, sandy, bioturbated, fossiliferous limestones, and cross-bedded sandy limestones (Mahendra, Banerji, 1990; Pandey, Dave, 1998; Pandey *et al.*, 2006a). The carbonate-rich part is highly fossiliferous and has yielded several taxa of bivalves, brachiopods, gastropods, echinoids, corals, bryozoans, and foraminifers (Pandey *et al.*, 2006a, 2009a, b). Sahni and Bhatnagar (1958), Dave and Chatterjee (1996: fig. 2), Kachhara and Jodhawat (1981: 242), Garg and Singh (1986), Bhatia and Mannikeri (1976) recorded also some faunal elements, such as the bivalves *Eomiodon* spp., *Corbula* spp. and *Dacryomya lacryma* (Sowerby), and the foraminifers *Sporobulimina rajasthanensis* Bhatia et Mennikeri, *Tewaria* sp. and *Dorothia poddari* Dave et Chatterjee and assigned this member to Bathonian. However, this fauna may also occur in Callovian, and it seems that these bivalves and foraminifers are not age-diagnostic.

Recently, Pandey *et al*. (2006a) and Kulkarni *et al*. (2008) recorded some trace fossils such as *Thalassinoides* isp., *Skolithos* isp., *Arenicolites tenuis* Kulkarni *et al*., ?*Bichordites* isp., *Planolites* isp., *Rhizocorallium irregulare* Mayer, *Rhizocorallium jenense* Zenker, and *Taenidium serpentinum* Heer, in addition to several vertical burrows.

Pandey *et al*. (2006a) distinguished four facies units in the Fort Member (Figs 3, 4; note variation in the thickness of facies), *i.e.* Facies unit 7, well-sorted, fine-grained sandstone; Facies unit 8, mixed siliciclastics-carbonates; Facies unit 9, fossiliferous, bioturbated, mixed carbonates-siliciclastics; Facies unit 10, cross-bedded bio-pack- to grainstone. The non-marine sediments of facies unit 7 change to the brackish water facies of unit 8, which in turn is replaced by facies units 9–10 corresponding to fully marine conditions. The latter record a shallowing of the basin from below to above the fair-weather wave-base, with increasing water energy, occasionally touched by storms and also with a higher rate of influx of sediment. On the basis of the interbasinal correlation of marker-beds (Pandey *et al.*, 2009a), and the stratigraphic position of this member above the Late Bajocian coral bearing

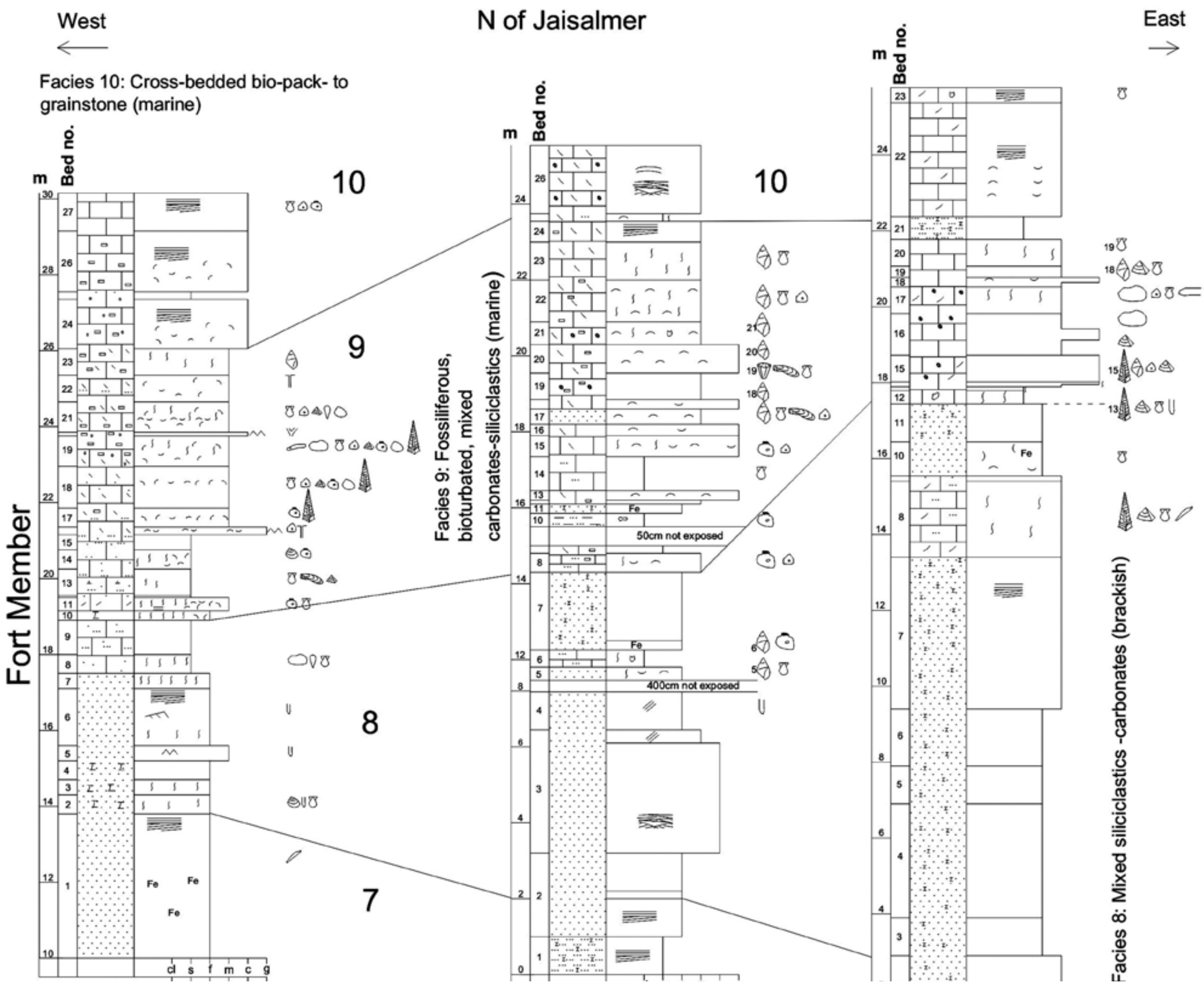


Fig. 4. Stratigraphic position and lateral extension of facies units 7–10 within the Fort Member exposed north of Jaisalmer city (modified after Pandey *et al.*, 2006a)

For explanations see page 69

horizon of the Joyan Member and below the Late Bathonian ammonite-bearing Bada Bag Member, the age of the Fort Member can be safely assigned to the Early Bathonian to Middle Bathonian/?Late Bathonian (Table 4).

Bada Bag Member

This member is best exposed at Badabag (along the scarp east of Cenotaphs), 6 km north of Jaisalmer along the Jaisalmer-Ramgarh road, and 16 km southwest of Jaisalmer along the basal part of the Kuldhar nala-section (Fig. 2A). It consists of ferruginous siltstone, ferruginous cross-bedded calcareous sandstone, dolomitized sandy limestone, hardgrounds and intraformational conglomerate (Mahendra, Banerji, 1990; Pandey, Dave, 1998; Pandey *et al.*, 2006a). The general diversity of body fossils in the lower part of the Bada Bag Member is very low in contrast to that occurring high in the upper part. Bivalves (*Trigonia*, *Dacryomya lacryma* (Sowerby)) and brachiopods (*Globirhynchia amarsagarensis* Singh et Mishra and *G. jaisalmerensis* Singh et Mishra, *Plectoidothyris jaisalmerensis* Sahni et Bhatnagar) are common (Singh, Mishra, 1980; Kachhara, Jodhawat, 1981: 239, 243; Ghosh, 1990; Dave, Chatterjee, 1996;

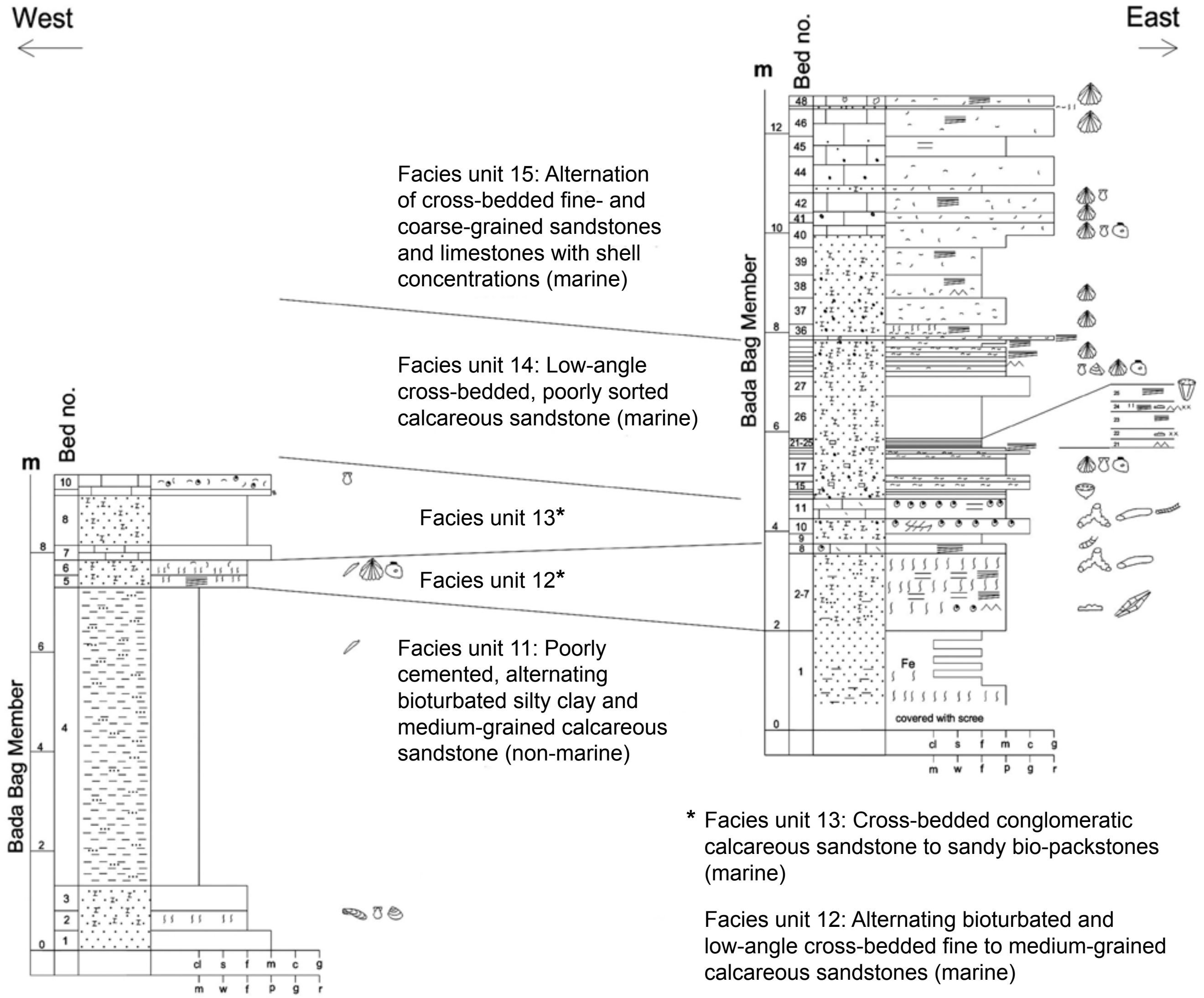


Fig. 5. Stratigraphic position and lateral extension of facies units 11–15 within the Bada Bag Member exposed in the Badabag, 6 km north of Jaisalmer city on the Jaisalmer-Ramgarth road (modified after Pandey *et al.*, 2006a)

For explanations see page 69

Mukherjee, 2010). The Bathonian ammonite *Clydoniceras*, recently recorded by Prasad *et al*. (2007) from the basal part of the Bada Bag Member has to be considered with caution (see reinterpretation of its stratigraphical position in Tables 3 and 4, and lithostratigraphic remarks below). The body fossils recorded from the upper part of the Bada Bag Member are the ammonites (*Macrocephalites madagascariensis* (Lemoine), *M. triangularis* Spath, and *Sivajiceras congener* (Waagen)), brachiopods *Plectoidothyris jaisalmerensis* Sahni and Bhatnagar, *Cryptorhynchia* sp.), corals (*Craterastraea crateriformis* Gregory, C*ollignonastraea meandra* (d'Orbigny), *Periseris* cf. *elegantula* (d'Orbigny)), *etc*. (Jain, 2008; Pandey *et al*., 2009b; Mukherjee, 2010). As far as trace fossils are concerned the Badabag area is the most accessible and richest locality. Among the trace fossils *Gyrochorte* (Kumar, 1979; Fürsich *et al*., 2006), *Ophiomorpha*, *Thalassinoides*, *Planolites*, *Rhizocorallium*, *Asterosoma*, *Taenidium*, *Arenicolites*, *Skolithos* (pers. obs. with Alfred Uchman) and 'pearl-string' *Ctenopholeus kutcheri* Seilacher et Hemblében (Fürsich *et al.*, 2006) commonly occur in the Bada Bag Member suggesting a shallow water depositional environment. The trace fossils are indicative of the *Cruziana* and *Skolithos* ichnofacies.

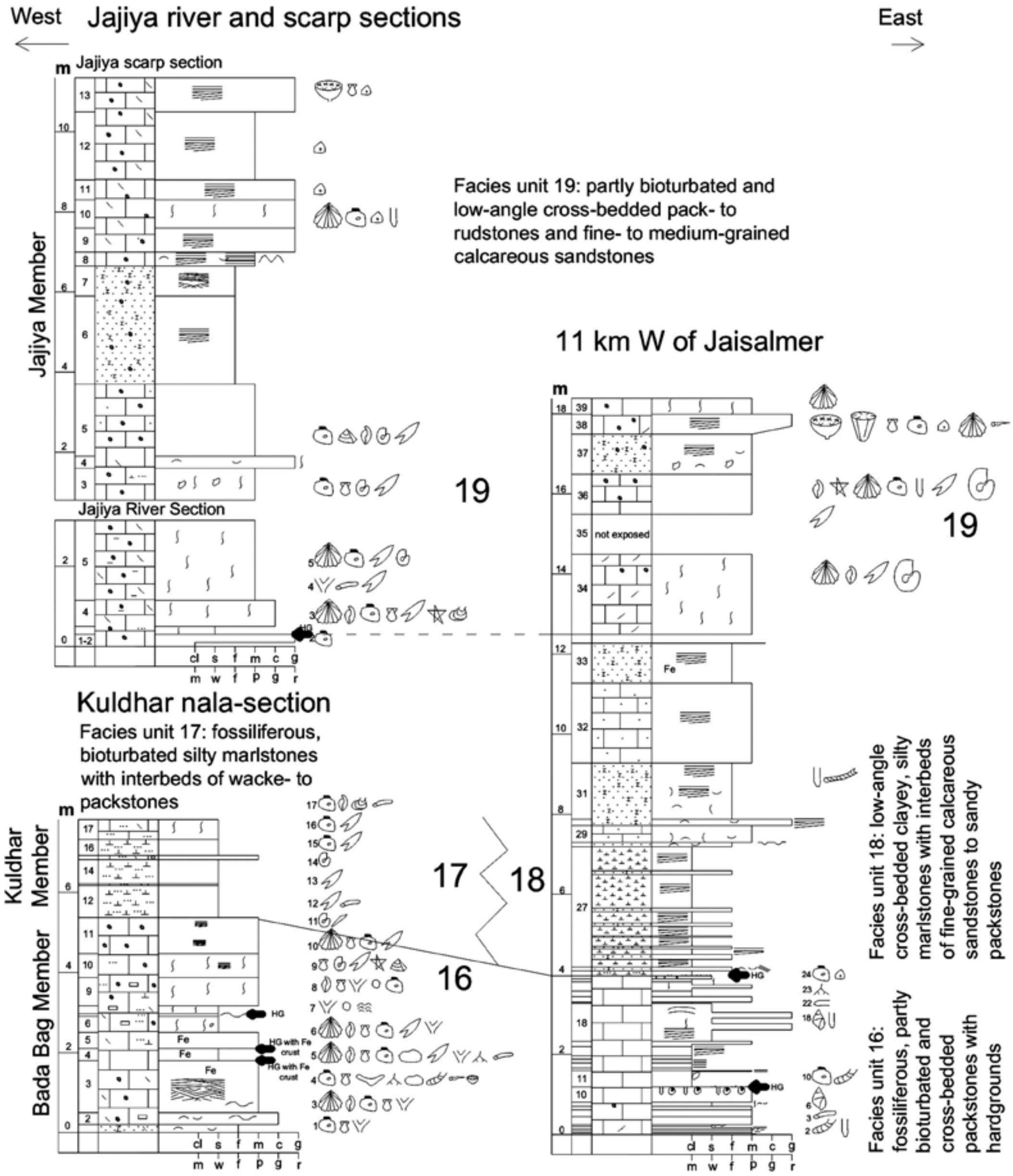


Fig. 6. Stratigraphic position and lateral extension of facies units 16–19 within the Bada Bag, Kuldhar and Jajiya members exposed between 11–18 km west of Jaisalmer city (modified after Pandey *et al*., 2010)

For explanations see page 69

Pandey *et al*. (2006a) distinguished six facies units within the Bada Bag Member (Figs 3, 5, 6): Facies unit 11, poorly cemented, interbedded bioturbated silty clay and medium-grained calcareous sandstone; Facies unit 12, alternating bioturbated and low-angle cross-bedded fine- to medium-grained calcareous sandstone; Facies unit 13, cross-bedded conglomeratic calcareous sandstone to sandy bio-packstones; Facies unit 14, low-angle cross-bedded, poorly sorted calcareous sandstone; Facies unit 15, alternation of cross-bedded fine- and coarse-grained sandstones and limestones with shell concentrations; and Facies unit 16, fossiliferous, partly bioturbated and cross-bedded packstone with hardgrounds.

The basal facies unit of the Bada Bag Member was deposited under non-marine conditions followed by brackish and fully marine conditions with fluctuating water energy until Facies unit 13 was deposited during a transgressive event.

The overlying Facies unit 14 represents a nearshore environment with periodic changes of wave intensity. The topmost facies units 15 and 16 record drastic changes of water energy in a fully marine, nearshore storm-dominated environment. Based on the records of the Late Bathonian ammonites (*Macrocephalites madagascariensis, M. triangularis*, and *Sivajiceras congener*), from the upper part of this Member, and Callovian ammonites (see below) from overlying Kuldhar Member, a Late Bathonian age has been assigned to the Bada Bag Member (Table 5).

Kuldhar Member (= Kuldhar Oolite Member)

Because of the poorly cemented nature of most part of the member, good outcrops are restricted. This member has been intensively studied at its best section along the Kuldhar River south and southwest of the ruined Kuldhar village (Fig. 2B), 16 km SW of Jaisalmer (Narayanan *et al*., 1961). The member is also exposed west of the village of Baisakhi. The member consists of gypsiferous silty marls, ferruginous silty and oolitic limestones, oolitic shales, and sandstones. The gypsum in the member is secondary and may not be used for depositional interpretation. The member is richly fossiliferous. Commonly occurring faunal elements are Callovian ammonites (*Macrocephalites semilaevis* (Waagen), *M. chariensis* (Waagen), *Reineckeia anceps* (Reinecke), *Subkossmatia opis* (Sowerby), and *Collotia gigantea* (Bourquin) (Table 4), nautiloids, belemnite guards, rhynchonellid and terebratulid brachiopods, bivalves, echinoids, and crinoids. In addition, trace fossils have also been observed (Das Gupta, 1975; Garg, Singh, 1983; Krishna, 1987; Pandey *et al*., 2010). Microfossils such as foraminifers and ostracods have also been recorded and described from this member (Subbotina *et al*., 1960; Lubimova *et al*., 1960; Kalia, Chowdhury, 1983; Jain, 2008). Based on the ammonite assemblages, the lower part of the Kuldhar Member has been correlated with the Chari Formation of the neighbouring Kachchh Basin (Krishna, 1987: table 2; Pandey *et al*., 2009a) and has been assigned to the Callovian.

Jajiya Member

This is the topmost member of the Jaisalmer Formation, Kachhara and Jodhawat (1981) placing this member above the Kuldhar Member. The member originally formed part of the Kuldhar Member. It was separated owing to its distinctive lithology and age. It consists of oolitic, bioturbated and cross-bedded limestone with hardgrounds and sandstone. This member is also richly fossiliferous. Bivalves, ammonoids, gastropods, large-sized rhynchonellid and terebratulid brachiopods, and crinoids are common.

Pandey *et al*. (2010) distinguished three facies units within the Kuldhar and Jajiya members (Figs 3, 6). These are Facies unit 17, fossiliferous bioturbated silty marlstones with interbeds of wacke- to packstones; Facies unit 18, low angle cross-bedded clayey, silty marlstones with interbeds of fine-grained calcareous sandstones to sandy packstones; and Facies unit 19, partly bioturbated and low angle cross-bedded pack- to rudstones and fine- to medium-grained calcareous sandstones. These facies units represent the maximum deepening of the basin which resulted in the establishment of fully marine conditions. Intermittent fluctuations of current intensity, energy level, sediment influx, which at some stage resulted in sediment starvation, turbidity and water depth below and above fair-weather wave-base have been recorded.

The ammonoid genera, such as *Lissoceratoides*, *Brightia*, *Distichoceras*, *Dhosaites*, *Mayaites*, *Epimayaites*, *Alligaticeras*, *Properisphinctes*, and *Klematosphinctes* recorded by Kachhara and Jodhawat (1981), suggest the Oxfordian age of the Jajiya Member. Similarly, Krishna (1987) and Prasad (2006) recorded *Peltoceratoides semirugosus* (Waagen), *Mayaites*, *Epimayaites*, *Dhosaites*, *Paryphoceras*, *Dichotomosphinctes* and *Dichotomoceras* from the upper bed/beds of the Kuldhar Member, which in fact should correspond to the Jajiya Member, which indicate the Early to Late Oxfordian age of this member.

The index fossil ammonites, and other faunal elements, such as belemnites, echinoderm spines, a few bivalves and brachiopods together with hardgrounds, a conspicuous condensed horizon and well preserved ferruginous ooids in this member have been correlated with the Dhosa Oolite (Oxfordian) of the neighbouring Kachchh Basin (Table 4; see also Arkell *et al.*, 1957; Kachhara, Jodhawat, 1981; Pandey *et al*., 2009a, 2011).

BAISAKHI FORMATION

The basal part of the Baisakhi Formation has been assigned to the Upper Oxfordian (Tables 3, 4; see also Chatterjee, 1990; Prasad, 2006). The formation has been named after the village Baisakhi (27°02' N; 70°54' E) (Fig. 2A) for shales with buff coloured sandstone exposed around the village (Swaminathan *et al*., 1959). The formation is also exposed north of the villages Rupsi and Ludharwa, up to the Bhadasar ridge (south of the village Lanela and Bhadasar) and towards east along the Kala Dongar up to north of the village Kanod (27°07'56" N; 71°06'8" E). The shales unconformably overlie the Bada Bag, Kuldhar, or Jajiya members of the Jaisalmer Formation (Willm, 1964; ONGC/IFP unpublished report; see also Table 1). Their thickness recorded on surface outcrops ranges from 150–165 m (Narayanan *et al*., 1961; Pandey, Dave, 1998). The Bhadasar Formation, with a sandy to gritty calcareous conglomerate bed at its base, is best exposed near the cliff of the Bhadasar ridge and overlies the Baisakhi Formation. Lithostratigraphically, the Baisakhi Formation has been divided into three members; Rupsi, Ludharwa and Lanela members (Table 1). The Baisakhi Formation ranges in age from Oxfordian to Kimmeridgian. The depositional environment of this formation is marine. The outcrops of the Baisakhi Formation are rich in fossils. The biotic components include ammonites, belemnites, wood fossils, *Sagenopteris* leaf, *etc*. (Das Gupta, 1975; Pareek, 1984: 38; Krishna, 1987; Misra *et al*., 1993; Prasad, 2006). Middle Oxfordian ammonites were recorded only from the basal carbonaceous shales of the Rupsi Member resting with sedimentary continuity on the Jaisalmer Formation, best studied at the Rupsi section north of Rupsi village; these yielded: *Dhosaites*, *Epimayaites* and *Dichotomosphinctes* (Chatterjee, 1990; Prasad, 2006, pers. obs., see also Table 3).

COMPARISON WITH THE NEIGHBOURING KACHCHH BASIN

The Jaisalmer Basin has gained importance for its geographic position very near to the classic Jurassic basin of Kachchh. Kachchh Basin is an E–W oriented graben structure that formed during the Late Triassic as a result of rifting between Africa and India (Biswas, 1982, 1991, 1993), whereas the Jaisalmer Basin is a shelf basin. The Jurassic succession of the Jaisalmer Basin is less complete and less fossiliferous than that of the neighbouring Kachchh Basin (Fürsich *et al*., 2001; Pandey *et al*., 2009a). The reason is that local tectonics exerted a major control on the palaeogeography. However, a few marker-beds useful in the inter-basinal correlation have been demarcated (Pandey *et al*., 2009).

In the Jaisalmer Basin the sediments deposited during transgressive events are generally not very thick (maximum up to 1.0 m) in contrast to thicker (occasionally 10 to 15 m) in the Kachchh Basin (Fürsich *et al*., 2001). These are characterized by either cross-bedded rudstones or calcareous sandstones with erosional surfaces. The sediments deposited between two such events are much thicker (minimum up to 1 m) and characterized by a bioturbated unit followed by either cross-bedded coarsening- upward calcareous sandstones/packstones beds, or alternating bioturbated and cross-bedded beds, either well cemented or poorly to moderately cemented, or storm-produced shell beds within silty marl beds. Several hemi-cycles in the depositional sequence have been observed in both the basins (Fürsich *et al*., 2001; Pandey *et al*., 2010).

REMARKS ON LITHOSTRATIGRAPHY

Garg and Singh (1983), and Krishna (1980, 1983, 1987) proposed an alternative lithostratigraphic subdivision of the Jaisalmer Formation. According to them, the five members of the Jaisalmer Formation (mentioned above) were grouped into only two members; the lower Amarsagar Limestone Member/Jaisalmer Member and the upper Kuldhar Member (Table 1, 5). However, the members of the Jaisalmer Formation listed in the present work have been well characterized showing either distinctive microfacies and faunal elements or else distinctive lithological successions beginning with

Table 5

Alternate lithostratigraphic scheme proposed for the Jaisalmer Formation by Garg and Singh (1983) and Krishna (1987)

Garg and Singh, 1983			Krishna, 1987		
Stage	Member	Lithology with thickness	Stage	Member	Lithology
Kimmeridgian	Baisakhi Member		Kimmeridgian	Baisakhi Member	
UNCONFORMITY			Bajocian to Oxfordian	Kuldhar Limestone	yellow, compact, fossiliferous limestones and marls with several golden and brown oolithic horizons, and rich in ammonoids
Callovian (Lower–Middle)	Kuldhar Oolite Member	profusely fossiliferous sequence of interbedded oolitic limestone, marl and shale; abundance of marine macro- and microfauna (10–15 m)			
Bathonian (Middle–Upper)	Amarsagar Limestone Member	argillacerous to aranaceous limestone and marl, sparsely oolithic, with subordinate sandy shale and sandstone; scarcely fossiliferous in the lower sandy-shaly part, profusely fossiliferous in the upper calcareous part (100 m)		Jaisalmer Limestone	yellow, well cemented, fossiliferous sandy limestones with interbeds of thick sandstones near the base, clay, and marl intercalations common, rich in bivalve and brachiopods. mostly transgressive shallow marine intertidal to inner neritic shelf

non-marine (*e.g*. Fort and Bada Bag members) or marginal marine siliciclastic sediments (*e.g*. Joyan Member) and ending with fully marine predominantly calcareous sediments.

Similarly, Prasad (2006) did not distinguish the Jajiya Member (Table 2) and merged the corresponding sediments with the Kuldhar Member. As mentioned in the Table 2, Kuldhar Member (Callovian), best exposed in the Kuldhar nala-section, is characterized by silty marl with shell-beds, shale and limestone beds, whereas Jajiya Member (Oxfordian), exposed between 1 km west of Kuldhar nala-section to Jaijiya river-section further west, consists of bioturbated and cross-bedded limestone with hardgrounds. Further, with the help of detailed study of the stratigraphic succession, in the Kuldhar nala-section, the Kuldhar Member with exclusively Callovian ammonites, such as *Macrocephalites formosus* (Sowerby), *M. chariensis* (Waagen), *Indosphinctes* peregrines, *Subkossmatia opis* (Sowerby), *Reineckeia anceps* (Reinecke), *Subgrossouvria aberrans*, *etc*. may also be distinguished from the underlain Bada Bag Member, which only yields Late Bathonian ammonites, such as *Silvajiceras congener* (Waagen), *Macrocephalites madagascariensis* (Lemoine) and *M. triangularis* Spath (Agrawal, Pandey, 1985; Krishna, 1987; Callomon, 1993; Jain, 2008; Pandey *et al*., 2009a).

It may be also also suspect the two specimens of *Clydoniceras* recorded by Prasad *et al.* (2007) from the Bada Bag Member in fact come from the Fort Member. As mentioned above the basal part of the Bada Bag Member has been deposited under non-marine condition followed by brackish and fully marine conditions with very low diversity of body fossils. Secondly, Facies unit 9 of the Fort Member and Facies unit 12 of the Bada Bag Member are quite similar and may be confused if not examined carefully with respect to their stratigraphic positions. The correlation of inter-basinal marker beds (Pandey *et al.*, 2009a) also suggests that *Clydoniceras* should come from Facies unit 9 of the Fort Member (Table 4). Prasad *et al*. (2007: 55), while recording the genus *Clydoniceras* from the Jaisalmer Basin, also mention in their stratigraphic discussion that the remains of the matrix on the specimen is similar to that of the underlying bed. From the matrix one may understand reworking, but the level of reworking from a particular underlying bed is not easy to localize until some index/guide fossils common to both the beds have been recorded.

Yet another example of misleading stratigraphic correlation is the rock succession of Gharoi river-section, west of the village Baisakhi. The Gharoi river-section exhibiting well preserved 'pearlstring' trace fossils *Ctenopholeus kutcheri* Seilacher et Hembleben along with *Gyrochorte*, *Taenidium*, *Thalassinoides* (Fürsich *et al*., 2006), *Ophiomorpha*, *Helminthoidichnites*, *Planolites*, *Protovirgularia*, *etc*. (pers. obs. with Alfred Uchman) on thin-bedded sandy biopackstones with oscillation ripples, was considered previously to be the top of the Jajiya Member of the Jaisalmer Formation. However, based on further detailed stratigraphic correlation, and records of Middle Callovian ammonites from the overlying, poorly cemented, ferruginous silty sandstone bed of the Kuldhar Member, the Gharoi river-section succession has now been assigned to the top of the Bada Bag Member.

REMARKS ON BIOSTRATIGRAPHY

The temporal distribution of ammonites recorded from the Early to Late (up to Oxfordian) Jurassic sediments of the Jaisalmer Basin by earlier workers (Jodhawat, 1984; Krishna, 1987; Chatterjee, 1990; Prasad, 2006; Prasad *et al*., 2007) has been summarized in Table 3 and has been compared broadly with that of the neighbouring Kachchh Basin (Table 4). Recent studies of Krishna *et al*. (2009a), Alberti *et al*. (2011b) and Pandey *et al*. (2012) have revealed that a good number of ammonites zones, such as the Cordatum, Plicatilis, Transversarium, Bifurcatus, Bimammatum zones, occur in the Oxfordian succession of the Kachchh Basin. In contrast, from the Jaisalmer Basin many of the ammonite zones cannot be determined due to lack of finds of ammonites. Some of the index ammonite taxa, such as *Gregoryceras* sp., *Perisphinctes* (*Dichotomoceras*) *stenocycloides* Siemiradzki, *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz, *etc*., which occur in the Kachchh Basin, have so far not been recorded from the Jaisalmer Basin. The Oxfordian ammonite genera recorded from Jajiya Member of the Jaisalmer Basin are *Peltoceratoides*, *Mayaites*, *Epimayaites*, *Dhosaites*, *Paryphoceras*, *Klematosphinctes*, and *Dichotomoceras* (Kachhara, Jodhawat, 1981; Prasad, 2006; Krishna, 1987). Krishna (1987: 144) also traced the *Mayaites maya* assemblage zone consisting of *Mayaites*, *Epimayaites*, *Dhosaites*, and *Paryphoceras*. Prasad (2006: 78) recognized three faunal horizons; *Peltoceratoides*, *Mayaites*, and *Dichotomoceras* corresponding to Early, Middle and Late Oxfordian, respectively. The Jajiya Member has been broadly correlated with Oxfordian Dhosa Oolite Member and Dhosa Conglomerate Bed (Table 4) of the Kachchh Basin (Krishna *et al*., 1996, 2009b, c; Pandey *et al*., 2009a; Alberti *et al*., 2011a, b).

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