The Intrabasinal Correlations in the Middle Jurassic Callovian Stage of Kachchh (Gujarat) and Ammonoid-Foraminifer Integration

Jai Krishna and Jai Ram Ojha

Department of Geology, B.H.U., Varanasi-221 005

Krishna J & Ojha J R 2000. The intrabasinal correlation in the Middle Jurassic Collovian Stage of Kachchh (Gujarat) and Ammonoid-foraminifer integration. *Geophytology* **28** (1&2) : 101-120.

The high resolution (ca 200,000 years per horizon) Callovian ammonoid chronologic scheme developed recently (Ojha 1996; Krishna & Ojha 1996) in the ammonoid rich Keera section (ca 210 m thick with 390 beds/ bands and over 150 ammonoid levels) into 7 zones, 15 subzones and 25 horizons, is applied to strengthen intrabasinal correlations and ammonoid-foraminifer integration of Lakhapur (Jara), Jumara, Jhura, Habo, Ler and Patcham sections in Kachchh.

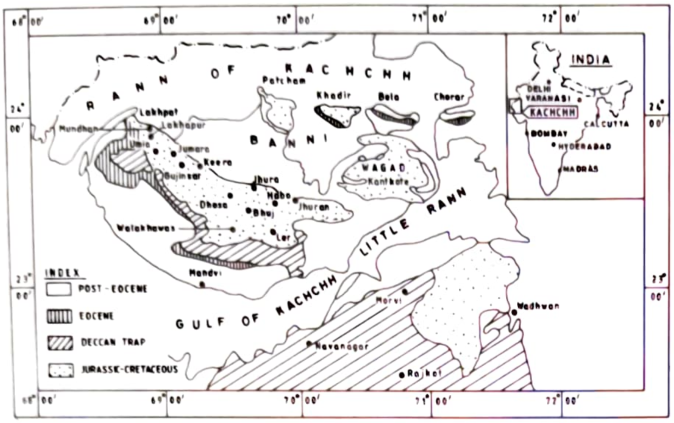
The Callovian sedimentary succession is nearly continuous and complete in the sections considered except in Ler (late Early Callovian to Late Callovian part present) and Patcham (mostly Early Callovian part present). In general the Early Callovian succession is found thicker than Middle or Late Callovian. The Bathonian/Callovian transition is displayed in the Patcham, Jumara and Jhura sections between the greyish white limestone and the overlying grey shales (Triangularis Zone/Madagascariensis Zone). The golden oolitic limestones are developed in the mid. Early Callovian (Chrysoolithicus Zone) only at Keera while similar looking limestones of Jhura and Patcham are found distinctly much older of late Middle to early Late Bathonian age. The earliest Early Callovian beds in Keera are non-oolitic below the golden oolitic limestones. The Early Callovian in other sections is mostly represented in the shale dominant facies with several thin, transgressive, nodular/concretionary levels of the 4th to 6th order para/mini/hemi depositional sequences (*sensu* Vail) rich in marine body fossils, mostly bivalves and ammonoids. Significant sand influxes are observed in the Patcham, Ler, Habo and Jhura sections in the relatively shallower and more proximal part of the basin in the north and east with precise beginning in the late Early Callovian Semilaevis Zone in contradiction to the late Middle Callovian or younger age suggested on the basis of benthic forams. Another significant younger sand inteval present widely in the Mainland Kachchh is present in the Middle Callovian (Paramorphum Subzone of the Anceps Zone). Yet, another much thinner lithological marker bed in the Mainland Kachchh is ammonoid age constrained in the early Late Callovian (Athleta Zone), while the youngest Callovian marker interval in many sections (at least two levels) is made up of red marls with pyritised nuclei of ammonoids placed in the latest Late Callovian to doubtful earliest Early Oxfordian.

The ammonoid-foraminifer stratigraphic integration demonstrates major disagreement of ages, stage boundaries and correlations. In this context, the relatively much highly resolved, more reliable and stable ammonoid based results are favoured. Accordingly, the foraminifer based *L. discipiens* Zone is assigned to late Late Bathonian instead of basal Callovian, *T. kutchensis* Partial Range Zone is assigned to early and middle part of the Early Callovian corresponding to the Madagascariensis Zone-Chrysoolithicus Zone interval, and the Diffugiformis - Anceps Zone is dated as Middle Callovian. The succession passes up into the Late Callovian without any unconformity, atleast not a major one, and the overlying Majungaensis Zone mostly corresponds to the late Middle to Late Callovian instead of its foraminifer based assignment to the Oxfordian. The 'Charian'/ 'Dhosaian' boundary instead of corresponding to the international Callovian/Oxfordian boundary is considered intra-Callovian almost one substage below the international boundary. The creation of local stages 'Badian', 'Charian', Dhosaian' etc. is found violative of fundamental norms of chronostratigraphy.

Key-words–Correlation, Callovian, Ammonoids, Foraminifers, Sea-level cyclicity.

INTRODUCTION

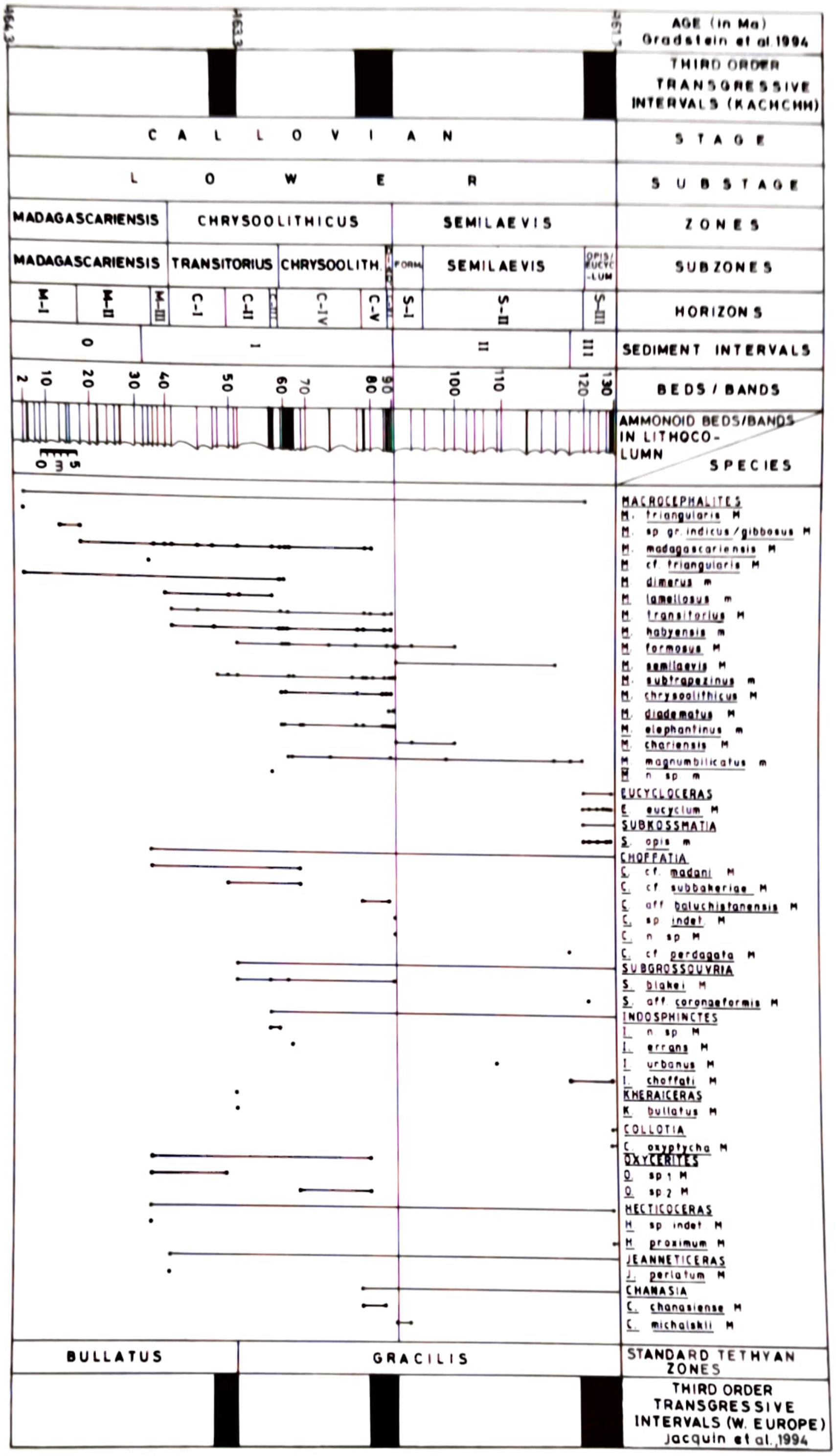
THE Kachchh basin is well known for its classic invertebrate fossil rich Mesozoic sedimentary succession (Text-fig.1). The Mainland Kachchh exposes a thick and highly fossiliferous sedimentary succession, classified into Patcham Formation, Chari Formation, Katrol Formation and Umia Formation in ascending order (Stoliczka, in Waagen 1873-75) ranging in age from Bajocian to at least Albian (Krishna *et al.* 1983). The present endeavour is restricted to the Callovian part of the Chari Formation of Callovian to Middle Oxfordian age. The Chari Formation consists mainly of thinly laminated claystone/shale/packstone/flagstone/ siltstone intercalated with hard, ferruginous,



Text-fig. 1

concretionary, marly/pebbly/calcareous sandstone, sandy limestone and oolitic limestone beds/bands. The top of the formation in Mainland Kachchh is a marker bed - the Dhosa Oolite Member. It is a prominent, transgressive, starved, slow sedimented, yellowish-brown, nodular, oolitic limestone widely distributed nearly throughout the Mainland Kachchh ranging in age from the late Early to early Middle Oxfordian (Krishna *et al.* 1983). It may be noted that the Chari Formation in Wagad - the most proximal part of the basin (Text-fig.1) extends in age upward until late Middle Oxfordian (Jhadasa Member, Krishna *et al.* 1998). The important Callovian stratigraphic sections of the Mainland Kachchh in consideration here are at Lakhapur (Jara), Jumara, Keera, Jhura, Habo, Walakhwas and Ler (Text-fig.1). The other partially or fully exposed Callovian sections are located in the 'Island' belt at Patcham, Khadir, Bela and Chorar (Text-fig.1). Among these, a few sections, particularly, the Jumara and Jhura in the Mainland and Patcham in 'Island' belt also display the Bathonian/Callovian transition. On the basis of stratigraphically significant ammonoids, the Bathonian/Callovian boundary in the Jumara and Jhura sections is best placed between the greyish white limestones and the overlying gray shales (Krishna 1984; Krishna & Westermann 1985, 1987; Krishna & Cariou 1990, 1993; Callomon 1993; Fürsich & Oschmann 1993). The Callovian/Oxfordian boundary is so far determined only in the Mainland Kachchh. It is best placed within 1 to 2 m of the non-gypsiferous marls/shales lying immediately below the base of the Dhosa Oolite proper (*sensu* Krishna 1983; Singh 1989). It has somewhat similar stratigraphic position, lithology and pyritized ammonoid nucleii fauna as that of the classic Renggeri Marls of Central and South Europe on the North Tethyan margin. Unlike the differentiation of the Callovian/Oxfordian boundary based on ammonoids as above, Pandey and Dave (1993) have included about 50 m of shales immediately underlying the Dhosa Oolite in the Oxfordian on the basis of benthic foraminifer studies, which, however, does not agree with ammonoid data (Krishna *et al.* 1998).

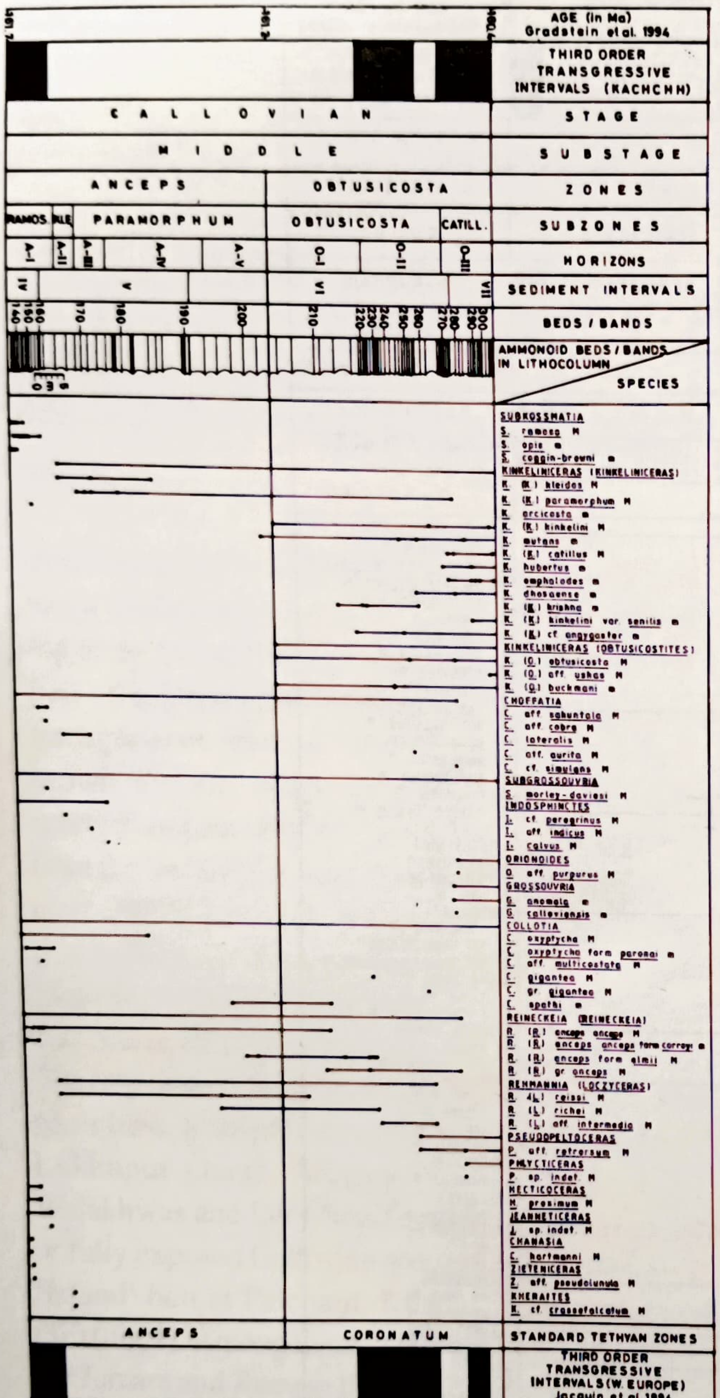
The Callovian Stage, in particular, is known to be the most prolifically fossiliferous of the entire Jurassic-Cretaceous interval developed in the Mainland Kachchh, and hence this interval indicates being part of the phase of increase in basinal depth. In view of the richness in diverse marine megainvertebrates and microfossils, it has attracted several paleontologic and stratigraphic studies over the last one and half century. Among the megainvertebrates studied, the stratigraphically significant ammonoids have been known through the early works of Waagen (1871, 1873-75) and Spath (1924, 1927-33). Thereafter, a number of attempts have been made towards stratigraphic refinement, inter/intrabasinal and interregional correlations from time to time by different workers (Rajnath 1932, 1942, 1952; Agrawal 1956, 1957, 1982; Biswas 1971, 1977, 1991; Kanjilal 1974, 1978, 1984; Agrawal & Kachhara 1977, 1979; Agrawal & Kacker 1978; Prasad 1988, 1993; Singh *et al* 1979). These works invariably lacked detailed lithostratigraphic record of the sections, bed by bed collection of ammonoids alongwith precise stratigraphic ranges of the subfamilies/genera/species recorded and studied details. Even the relatively recent works of Agrawal and Kacker (1980), Mitra *et al.* (1979), Bardhan and Dutta (1987), Bhaumik *et al.* (1993), Pandey and Fürsich (1998) and Prasad (1998) failed to address the above essential prerequisites. Publications of Krishna and co-workers (Krishna 1983, 1984, 1987 a,b; Krishna & Westermann 1985, 1987; Krishna & Cariou 1986, 1990, 1993; Cariou & Krishna 1988; Krishna *et al.* 1988; Cariou *et al.* 1990) could also make only limited progress towards stratigraphic refinement and cor-



Text-fig. 2

relations, that too confined to the Early Callovian interval. However, the first ever detailed ammonoid zonation scheme in the Kachchh Callovian interval has been developed very recently (Ojha, 1996; Krishna & Ojha, 1996) in the Keera section into 7 zones, 15 subzones and 25 horizons based on extremely detailed lithostratigraphic column of 390 beds/bands and over 150 ammonoid levels (Text-figs 2-4).

Besides ammonoids the benthic foraminifers have also attracted substantive attention (Subbotina *et al.* 1960; Agrawal & Singh 1961; Singh 1977a,b, 1979; Bhalla 1977; Bhalla & Abbas 1976; Bhall & Talib 1978, 1985; Mandwal & Singh 1989, 1994; Pandey & Dave 1993).

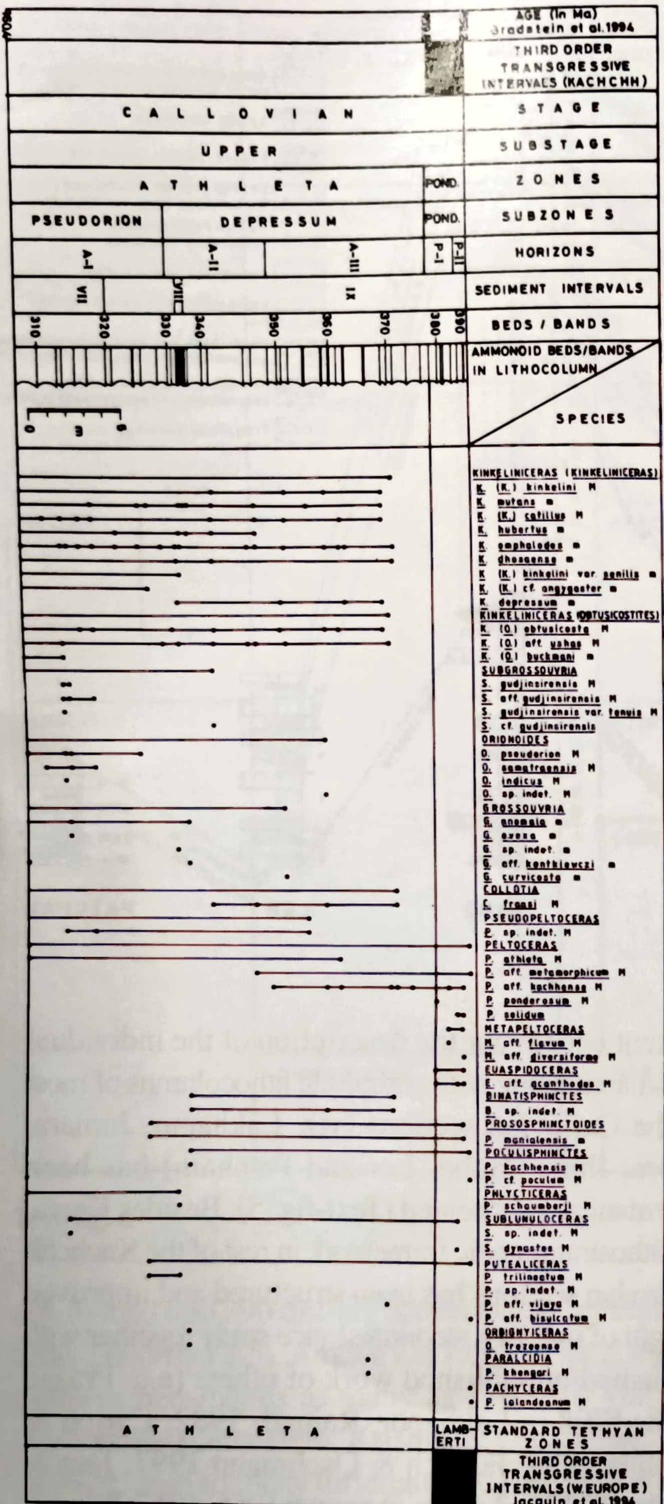


Text-fig. 3

The prime objective of the present paper is to strengthen the intrabasinal correlation and ammonoid-foraminifer integration during the Callovian interval in Kachchh. The stratigraphic sections here considered for intrabasinal correlations are (Lakhapur) Jara, Jumara, Jhura, Habo, Ler and Patcham lying respectively in the west, east and northeast of the Keera section (Text-figs 1,5). The detailed foraminifer stratigraphic zonation (Pandey & Dave 1993) has been taken into account for the purpose of evaluation, correlation and ammonoid-foraminifer integration (Text-fig.6).

AMMONOID AND FORAMINIFER ZONES

Salient Features—The Kachchh Callovian ammonoid succession has been considered well developed with inherent potential for an independent regional standard zonation since its very early study (Waagen 1873-75; Spath 1924, 1927,33). However, the first comprehension in this direction could be made only recently with the proposition of a high resolution biochronologic scheme of 7 ammonoid zones, 15 subzones and 25 horizons in the Keera section (Ojha 1996; Krishna & Ojha 1996). The proposed ammonoid zonal/subzonal/horizonal scheme is by and large based on the evolutionary succession and species ranges of the geographically restricted Indo-East-African subfamilies, e.g. Macrocephalitinae in the early and middle Early Callovian, Eucycloceratinae in the late Early and early Middle Callovian and Kinkeliniceratinae (Ojha 1996; Krishna & Ojha 1996) in most of the Middle and Late Callovian together with the other subordinate elements common to both North and South Tethyan margins (viz. Phlycticeratinae, Oppeliinae, Distichoceratinae, Hecticoceratinae, Tulitidae, Pseudoperisphinctinae, Reineckeiinae, Peltoceratinae, Aspidoceratinae, Pachyceratidae etc.) (Text-figs 2-4). The first appearance datum of a particular species has been invariably applied for the differentiation of the individual zones/subzones/horizons which are otherwise strengthened on their characteristic assemblages. The ammonoid zones worked out in Keera have been recognised and confirmed in other Callovian sections of Kachchh (Text-fig. 5). Long distance correlation between the two (North and South) margins of the Tethys has been strengthened and precised on the basis of same genera/species and/or morphologically close species common to both the margins (Krishna & Ojha 1996). The scheme developed (as mentioned above) provides the highest biochronologic resolution of about 200,000 years per horizon ever achieved in the Indian Phanerozoic (Text-figs 2-4) . It is also comparable to the global best developed in recent years in Europe (Cariou & Hantzpergue 1997). At the same time, it scores 3 fold

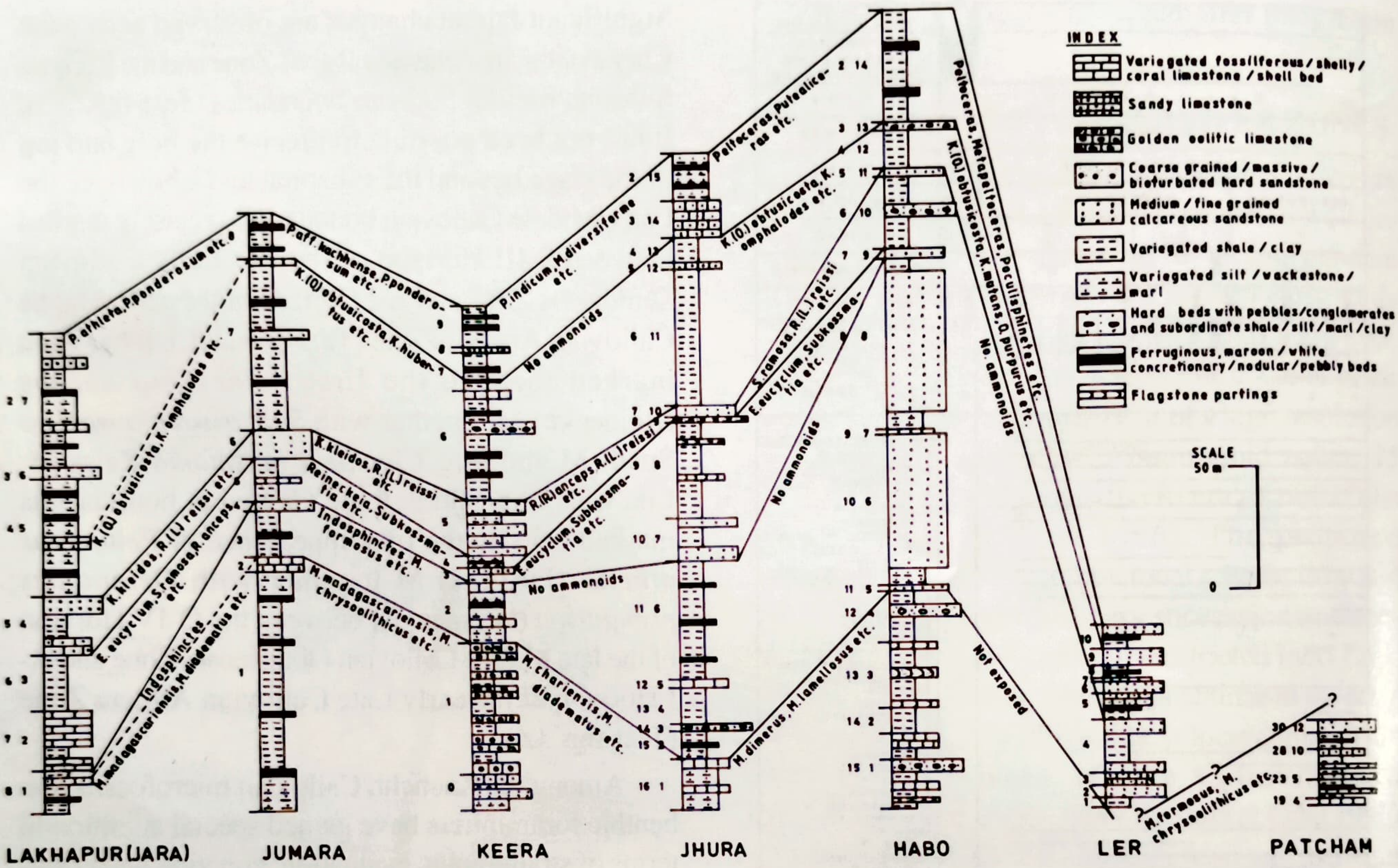


Text-fig. 4

improvement over the earlier 8 imprecise ammonoid assemblages of Spath (1927-33) in the Callovian of Kachchh.

The Kachchh Callovian ammonoid study at Keera (Ojha, 1996; Krishna & Ojha, 1996) has realised precise ranges of the Callovian ammonoid genera and species for the first time in the last 150 years in India. Significant faunal changes are observed across the Chrysoolithicus Zone/Semilaevis Zone and the Ramosa Subzone/Kleidos Subzone boundaries (Text-figs. 2,3). It has not been possible to precise the base and top of the stage beyond the subzonal level, however, the Early/Middle Callovian boundary is precisely marked between S-III Horizon of the late Early Callovian Semilaevis Zone and A-I Horizon of the early Middle Callovian Anceps Zone (Text-figs.2,3,). It has been marked through the first *Reineckeia anceps* (Reinecke) M together with *Subkossmatia ramosa* Spath M and rare *Chanasia hartmanni* Zeiss M. Likewise, the Middle/Late Callovian boundary is marked here by the first appearance of *Peltoceras athelta* (Phillips) M together with *Orionoides pseudorion* (Waagen) M between the O-IV Horizon of the late Middle Callovian Obtusicosta Zone and A-I Horizon of the early Late Callovian Athleta Zone (Text-figs.3,4).

Among the Kachchh Callovian microfossils, the benthic foraminifers have gained special attention in terms of stratigraphic evaluation, zonation and correlation. Emphasis on the limited applicability of the benthic foraminifers beyond suprastage resolution has been made repeatedly by most of the workers (Singh 1977a,b, 1979; Bhalla 1977; Bhalla & Abbas 1976; Bhalla & Talib 1978, 1985; Mandwal & Singh 1989, 1994 and others) . The most detailed recent work on benthic foraminifers in Kachchh is of Pandey and Dave (1993). They have, however, attempted intrastage zonal differentiation and have worked out 3 successive foraminifer zones within the Callovian (their 'Charian') interval of Kachchh (Text-fig. 6). These foraminifer zones are based mainly on the total or partial ranges of the nominal species in the studied Jumara section irrespective of their different ranges elsewhere in the world. The complete ranges of the nominal species even in other Kachchh Callovian sections are still elusive and remain to be precised. The boundary demarcation as well as the age assignments of the different individual foraminifer zones have been indicated either on the basis of the long ranging foraminifer species mostly created and restricted in Kachchh or on the strength of the imprecise, insufficient, incorrect, old and outdated ammonoid data.



Text-fig. 5

Nevertheless, the benthic foraminifer data presented by them (Pandey & Dave 1993) is of immense value, specially so in context of subsurface studies. The integration of such data in the ammonoid based biostratigraphic framework (Ojha 1996; Krishna & Ojha 1996), it is hoped, should increase its creditability and resolution as envisaged in the present endeavour.

Brief Remarks On The Individual Kachchh Callovian Sections, Ammonoid Stratigraphic Evaluation And Intrabasinal Correlations— The lithostratigraphic succession belonging to the Callovian Stage in Kachchh includes major part of the Chari Formation. It includes by and large cyclic alternations of thin, hard, transgressive, ammonoid rich, pebbly / nodular / concretionary / bioturbated/ shelly calcareous sandstone, sandy limestone or oolitic limestone beds/ bands of variegated colours with somewhat softer, thicker, mostly gypseous shale-cum-siltstone beds/bands. Thick sandstone beds, have found significant expression in the proximally located sections e.g. Jhura, Habo, Ler and Patcham. However, in the present endeavour the description of the individual beds/bands along with composite lithocolumns of most of the Callovian sections (viz. Lakhapur, Jumara, Keera, Jhura, Habo, Ler and Patcham) has been schematically presented (Text-fig. 5). Besides Keera, the lithostratigraphic framework in rest of the Kachchh Callovian sections has been structured and improved in light of our own reconnaissance study together with published/unpublished work of others (e.g. Prasad 1988, 1998 in Lakhapur, Rajnath 1932; Cariou & Krishna 1988; Fürsich & Oschmann 1993; Jain & Pandey 1997 in Jumara, Agrawal 1956, 1957; Fürsich *et al.* 1992; Fürsich & Oschmann 1993 in Jhura, Kanjilal 1974, 1978 in Habo, Pandey 1992 unpublished; Agrawal & Kachhara 1977, 1979; Fürsich *et al.* 1991 in Ler, Pandey 1983; Fürsich *et al.* 1994; Pandey & Fürsich 1998 in Patcham and also many others).

The ca 210 m thick Callovian sedimentary column at Keera has been organised into 10 major sediment intervals from 0 to 9 which have been further

TETHYAN STANDARD ZONES	FORAMINIFERA ZONES (PANDEY & DAVE 1993)	STAGE	SUBSTAGE	KACHCHH ZONES, SUBZONES & HORIZONS (KRISHNA & OJHA 1996)			FORAMINIFERA ZONES (PANDEY & DAVE 1993) AGES REVISED HERE
LAMBERTI	P. DIFFUSIFORMIS	CALLOVIAN	UPPER	PONDEROSUM		P-II	E. MAJUNGAENSIS
						P-I	
ATHLETA				ATHLETA	DEPRESSUM	A-III	
						A-II	
					PSEUDORION	A-I	
CORONATUM	T. KUTCHENSIS		MIDDLE	OBTUSICOSTA	CATILLUS	O-III	
					OBTUSICOSTA	O-II	P. DIFFUSIFORMIS
						O-I	
ANCEPS				ANCEPS	PARAMORPHUM	A-V	
						A-IV	T. KUTCHENSIS
						A-III	
					KLEIDOS	A-II	
					RAMOSA	A-I	
GRACILIS			LOWER	SEMILAEVIS	EUCYCLUM / OPIS	S-III	
					SEMILAEVIS	S-II	
					FORMOSUS	S-I	
BULLATUS				CHRYSOOLITHICUS	DIADEMATUS	C-VI	
					CHRYSOOLITHICUS	C-V	
						C-IV	
					TRANSITORIUS	C-III	
						C-II	
						C-I	
	L. DISCIPIENSE			MADAGASCARIENSIS		M-III	
						M-II	
						M-I	

Text-fig. 6

subdivided into 390 distinct beds/bands in ascending order (Text-figs 2-5). Among the 195 thin, hard, transgressive beds/bands as many as 150 have yielded ammonoids (Ojha 1996; Krishna & Ojha 1996). Incidently, with so many differentiated beds/bands and over 150 ammonoid levels, the Callovian section at Keera perhaps records the highest number of ammonoid levels in the Callovian anywhere in the world.

The intrabasinal correlation (Text-fig.5) is attempted here in context of the precisely resolved ammonoid biostratigraphic framework in the Keera section (Ojha 1996; Krishna & Ojha 1996) in conjunction with the limited ammonoid stratigraphic data available in other Callovian sections of Kachchh (viz. Waagen 1871, 1873-75; Spath 1927-33; Agrawal 1956, 1957,1982; Kanjilal 1974, 1978; Agrawal & Kachhara 1977, 1979; Agrawal & Kacker 1978, 1980; Pandey 1983; Prasad 1988, 1998; Mitra *et al.* 1979; Bardhan & Dutta 1987; Bhaumik *et al.* 1993; Krishna & co-workers 1983 onwards; Pandey & Fursich 1998). This is not only in context of the improvement/strengthening of the correlations but also demonstration of the applicability of the scheme across the basin. In comparison to the ammonoid chronology based on the most precise collection of ammonoids in the Callovian section of Keera (Ojha 1996; Krishna & Ojha 1996), the successions of ammonoid fauna realised by other workers (as above) in different Kachchh Callovian sections (particularly, in Keera, Lakhapur, Jumara, Jhura, Habo, Ler and Patcham) include only a few broad assemblages / associations/ biozones. These faunal assemblages / associations/ biozones belong mostly to broad and thick sediment intervals of few tens of meters. Within these relatively thicker intervals, information, particularly about the position of the stratigraphically significant ammonoids in the columns is generally found imprecised. In this situation, the intrabasinal correlation realised (Text-fig. 5) is mostly of zonal level. However, the meagre and imprecise data from other section amply proves the presence of evolutionary succession of the principal lineages used in the zonation in the same manner.

Lakhapur (Jara)

It is the most distal exposed Callovian section situated in the extreme northwestern part of the Kachchh Mainland. The ca 200 m thick sedimentary succession (Text-fig.5) comprises chiefly shales with thin limestones. The sandstone development in comparison to other Callovian sections is found relatively poor. 7 distinct succesive sediment intervals from 1 to 7 in ascending order have been distinguished which correspond to beds 2 to 8 of Prasad (1988, 1998) in descending order.

The common first appearances of several macrocephalitin species, such as *M. madagascariensis* Lemoine, *M. dimerus* (Waagen), *M. lamellosus* (Sowerby), *M. gibbosus* (Spath), *M. formosus* (Sowerby), *M. transitorius* (Spath), *M. diadematus* (Waagen), *M. semilaevis* (Waagen) etc. together with the first *Indosphinctes* (*I.* cf. *urbanus* Spath) in sediment interval 1 (bed 8 of Prasad, 1988, 1998) of Jara and in sediment intervals 0 to 2 of Keera suggest good correlation. Hence, sediment interval 1 (bed 8 of Prasad 1988, 1998) of Jara is found to include the Madagascariensis Zone, Chrysoolithicus Zone as also the Formosus Subzone and the Semilaevis Subzone of the Semilaevis Zone of Early Callovian age (Ojha 1996; Krishna & Ojha 1996). However, on the basis of similar lithology (gypsiferous shales with sandy limestones/ marls/ironstones) in Jumara and Habo sections the ca 15 m basal part of sediment interval 1 (bed 8 of Prasad 1988, 1998) of Jara is found tentatively correlatable to sediment intervals 0 to 1 of Keera representing the Madagascariensis Zone-Chrysoolithicus Zone interval. If that be so, further up the rest of the sediment interval 1 (bed 8 of Prasad 1988, 1998) of Jara also with almost similar lithology (Text-fig.5) suggests correlation to sediment interval 2 of Keera spanning Formosus Subzone -Semilaevis Subzone interval. In terms of thickness, the Early Callovian is found thicker, better developed and richer in ammonoids at Keera than in Jara. The golden oolitic limestone interval localised at Keera is found time equivalent of much thinner shales/marls/ironstones alternations of Jara (Text-fig 5). The sediment intervals 2 and 3 (beds 7 and 6 of Prasad 1988, 1998) of Jara correlate well to sediment intevals 3 and 4 of Keera on the strength of the common occurrences of *Eucycloceras eucyclum* (Waagen), *Subkossmatia coggin-browni* Spath, *Subkossmatia ramosa* Spath, *Choffatia* aff. *sakuntala* Spath, *Subgrossouvria morley-daviesi* Spath, *Reineckeia (Reineckeia) anceps* (Reinecke) and *Reineckeia (Reineckeia) anceps* form *corroyi* (Zeiss). Therefore, sediment intervals 2 and 3 (beds 7 and 6 of Prasad 1988, 1998) of Jara are assigned to the latest Early Callovian Eucyclum/Opis Subzone of the Semilaevis Zone and the earliest Middle Callovian Ramosa Subzone of the Anceps Zone (Ojha 1996; Krishna & Ojha 1996). It also displays the Early/Middle Callovian substage boundary. The Eucyclum Subzone is included here as the youngest Early Callovian in view of the occurrence in it of Early Callovian Tethyan marker *Collotia oxyptycha* (Neumayr).

The most striking and marker calcareous sandstone/sandy limestone development present in almost all the Mainland Callovian sections of Kachchh of the Middle Callovian (Text-fig.5) age is represented by the sediment interval 4 (bed 5 of Prasad 1988, 1998) at Lakhapur. It has been correlated to sediment interval 5 of Keera not only on lithological ground but also on the basis of the common presence of *Kinkeliniceras (Kinkeliniceras) kleidos* (Spath), *K. (K.) paramorphum* (Waagen), *Rehmannia (Loczyceras) reissi* (Steinmann) and also the common first appearance of the genus *Kheraites*. In this way, sediment interval 4 (bed 5 of Prasad 1988, 1998) of Jara represents mostly the Kleidos Subzone and the Paramorphum Subzone of the Anceps Zone (Ojha 1996; Krishna & Ojha 1996). It is very surprising to note that the sediment interval 5 (bed 4 of Prasad 1988, 1998) of Jara includes the first *Kinkeliniceras (Obtusicostites) obtusicosta* (Waagen), *Peltoceras athleta* (Phillips) and also *Peltoceras ponderosum* (Waagen). These significant species have been used as zonal indices of the late Middle Callovian Obtusicosta Zone, early Late Callovian Athleta Zone as also mid. to late Late Callovian Ponderosum Zone with their first apearances respectively in the late Middle Callovian, early Late Callovian and mid./late Late Callovian intervals (Ojha 1996; Krishna & Ojha, 1996). Such discrepancy has occurred on account of highly broad and imprecise stratigraphic placement of the ammonoids by Prasad (1988, 1998) in his bed 4 of Jara. The simultaneous presence of above three zones in sediment interval 5 (bed 4 of Prasad 1988, 1998) has been further strengthened by the first occurrences also of *Kinkeliniceras (Hubertoceras) omphalodes* (Waagen), *K. (H.) hubertus* (Spath) (of the Obtusicosta Zone) and *Peltoceras solidum* Spath (of the Ponderosum Zone). Moreover, the Middle/Late Callovian substage boundary in the Jara section happens to fall, yet higher up in this bed (bed 4 of Prasad) (Text-fig.5). Based on the ranges upwards of the same common taxa (as enumerated above), part of the sediment interval 5 (bed 4 of Prasad 1988, 1998) of Jara can safely be correlated to sediment interval 6 together with ca 5 m basal part of sediment interval 7 of Keera representing mostly the Obtusicosta Zone. The remaining upper part of sediment interval 5 (bed 4 of Prasad 1988, 1998) as also sediment intervals 6 and 7 (beds 2 and 3 of Prasad 1988, 1998) of Jara are found correlatable to ca 11 m uppermost part of sediment interval 7 together with sediment intervals 8 and 9 of the Keera section on the strength of the common first occurrences of the decidedly Late Callovian ammonoid species, *P. athleta* (Phillips), *P. ponderosum* (Waagen), *P. solidum* Spath, *P.* aff. *kachhense* Spath, *Phlycticeras schaumberji* (Waagen), *Sublunuloceras dynastes* (Waagen), *Pachyceras lalandeanum* (d'Orbigny) etc. and also on the basis of the ammonoid genera *Metapeltoceras* and *Unipeltoceras*. Hence, part of sediment interval 5 as also sediment intervals 6 and 7 of Jara can be assigned here to the Athleta Zone-Ponderosum Zone interval (Ojha 1996; Krishna & Ojha 1996).

The ammonoid biozonation of the Middle-Late Jurassic sediments with special reference to Keera and Jara domes by Prasad (1998) is critically evaluated here in context of our recent ammonoid stratigraphic framework (Ojha 1996; Krishna & Ojha 1996). Besides numerous minor discrepancies, the major objections to Prasad's zonation are:

(i) *Inadequate Lithostratigraphic Differentiation* : The prime and foremost requisite for biostratigraphic refinement is the precise positioning of ammonoids in the lithostratigraphic column. This in turn, is possible only in a detailed differentiation of beds. Unfortunately, Prasad (1998) has the Keera column differentiated only in 11 beds compared to the 390 beds/bands of Krishna and Ojha (1996). The latter can only allow precise ranges, correlation and determination of precise timing of expansion and migration of ammonoid taxa.

(ii) *Lack of Precision in Collection of Ammonoids* : Another significant factor is the number of ammonoid bearing beds/bands which has to be always less than the total number of beds/bands, since all the beds/bands are not found ammonoid bearing. Unfortunately, Prasad (1998, p. 28) has collected ammonoids only from 11 beds in Keera and 7 beds in Jara. Moreover, these beds are very broad sediment intervals of often few tens of meters thick. In contrast, we (Ojha 1996; Krishna & Ojha 1996) have collected ammonoids from over 150 ammonoid levels in the Callovian section at Keera. In our opinion, what Prasad (1998) has achieved is only the assignment of the sedimentary columns at Keera and Jara broadly into Early, Middle and Late Callovian.

(iii) *Lack of Precise Ranges and Timing of the First / Last Appearances of the Various Species :* The zonation proposed by Prasad (1998) in absence of properly detailed lithostratigraphically differentiated columns and precise position of ammonoids in the columns is not based on ammonoid stratigraphic range-chart of different ammonoid subfamilies/genera/species.

In want of taxon range-chart, precise identification of time boundaries (stage/substage/zonal/subzonal/horizonal) is simply impossible. This is the fundamental requirement of any biostratigraphic zonation, nothing to speak of intrabasinal and inter-regional/intercontinental correlations worth the name.

(iv) *Duplication of the Nominal Zonal/Subzonal Indices* : Most of the nominal Zonal/subzonal indices used by Prasad (1998) (e.g. Triangularis Zone, Formosus Zone, Madagascariensis Subzone, Diadematus Subazone, Semilaevis Subzone, Anceps Zone, Eucyclum Subzone, Athleta Zone, etc.) have already been used and defined by other workers earlier (Oppel 1856-58; Spath 1927-33; Krishna 1984; Krishna & Westermann 1985, 1987; Krishna & Cariou 1986, 1990; Krishna *et al*. 1988; Krishna & Ojha 1996; Ojha 1996). Later workers, like Prasad can at the most effect only minor revision, yet can not use the same indices for different ranges. Any way, the units made by the original authors carry their names for all time as per the code of stratigraphic nomenclature. The use of the same unit names by Prasad (1998) in his scheme is fundamentally violation of the fundamentals of bio- and chronostratigraphy.

(v) *Anomalous Occurrences / Ranges of E. eucyclum* (Waagen) and *R. (R.) anceps* (Reinecke) : According to our (Ojha 1996; Krishna & Ojha 1996) detailed bed by bed collection of ammonoids *vis-a-vis* imprecise collection from very broad sediment intervals of Keera and Jara sections by Prasad (1988, 1998), *E. eucyclum* (Waagen), the first species of the Eucycloceratinae lineage, occurs decidedly earlier to first *R. (R.) anceps* (Reinecke) (Text-figs 2,3). Prasad (1998) has not indicated precise position either of the first *E. eucyclum* (Waagen) or the first *R.(R.) anceps* (Reinecke). Although, he vaguely implies the occurrence of *R. (R.) anceps* (Reinecke) at the base of sediment interval 3 (bed 6 of Prasad, 1998, p. 28, fig. 3). It is found contradictory to our detailed observations and precise collections. In this context, Bardhan and Dutta (1987) have indicated the simultaneous first occurrence of *E. eucyclum* (Waagen) and *R. (R.) anceps* (Reinecke) in their bed 4 (p. 123, tab.1) of the Keera section. The discrepancy and imprecision in the first occurrence of *E. eucyclum* (Waagen) and *R. (R.) anceps* (Reinecke) becomes more evident in context of discussion on the correlation of Keera and Jara domes by Prasad (1998). Prasad (1998, p. 30, para 4) has himself stated that 'faunal differentiation at Jara is not very clear and as such, subzonation of Middle Callovian is not possible'. All the lower three marker species (*anceps, eucyclum* and *singulare*) with *Subkossmatia opis* occur together at one stratigraphic level in Jara (bed 7, Kanjilal & Prasad 1992).

Jumara

The Jumara dome is the most widely studied Callovian section of the Kachchh Jurassic. It displays beautifully the Bathonian/ Callovian transition as well. Rajnath (1932, 1942) indicated a total thickness of about 300 m of the Chari Formation and differentiated 26 beds in descending order inclusive of the Patcham Formation. However, the thickness approximations are found to differ from worker to worker (Biswas 1977; Cariou & Krishna 1988; Bhaumik *et al*. 1993; Fürsich & Oschmann, 1993; Pandey & Dave 1993; Jain & Pandey 1997).

The ca 250 m thick monotonous Callovian sediments of the Jumara section (Text-fig.5) are mainly composed of olive-grey, fossiliferous, laminated shales/siltstones/marls with thin, hard, maroon, ferruginous, concretionary (usually reworked concretions), pebbly, nodular, occasionally bioturbated beds/bands. Alternations of variegated/shelly limestone beds/bands and occasional yellowish-grey, ridge-like, hard, massive sandstone beds with ripple-marks and crossbeddings are also found. Lithologically, Jain and Pandey (1997) have classified the beds 21 to 9 of Rajnath (1932, 1942) into 45 beds from B1 to B45 in ascending order. However, at present the entire Callovian sedimentary succession at Jumara (beds 21 to 1 (in part) in descending order of Rajnath, 1932) has been organised into 8 major sediment intervals from 1 to 8 in ascending order (Text-fig.5).

There is observed presence of several macrocephalitin species; *M. madagascariensis* Lemoine, *M. dimerus* (Waagen), *M. habyensis* (Spath), *M. chariensis* (Waagen), M. *chrysoolithicus*

(Waagen) etc. in sediment intervals 1 and 2 (beds 17 to 21 of Rajnath 1932 1942; beds B1 to B15 of Jain & Pandey 1997) of Jumara. These species are also known to occur in sediment intervals 0 and 1 of Keera (Ojha 1996; Krishna & Ojha, 1996). Hence, sediment intervals 1 and 2 (beds 17 to 21 of Rajnath 1932 1942; beds B1 to B15 of Jain & Pandey 1997) of Jumara are correlated to sediment intervals 0 and 1 of Keera and are assigned to the Madagascariensis Zone-Chrysoolithicus Zone interval. The shale/silt dominated sediment intervals 3 and 4 (beds 10 to 16 of Rajnath 1932, 1942; beds B 16 to B 43 of Jain & Pandey 1997) of Jumara are correlated to sediment interval 2 of Keera (Text-fig.5). This is based on the common first occurrences of *M. semilaevis* (Waagen) and also the genus *Indosphinctes* in association of *M. chariensis* (Waagen), *M. formosus* (Sowerby) and *M. magnumbilicatus* (Waagen). Therefore, sediment intervals 3 and 4 (beds 10 to 16 of Rajnath 1932, 1942; beds B 16 to B 43 of Jain & Pandey 1997) of Jumara are assigned to the Semilaevis Subzone of the Semilaevis Zone. The genera, *Subkossmatia, Kinkeliniceras* and *Reineckeia* mark their first appearances in sediment interval 5 (beds 6 to 9 of Rajnath 1932, 1942) of Jumara and also in sediment intervals 3 and 4 of Keera which bring out their correlation. In view of this correlation, sediment interval 5 (beds 6 to 9 of Rajnath 1932, 1942) of Jumara represents the latest Early Callovian Eucyclum/Opis Subzone of the Semilaevis Zone to the Ramosa Subzone of the Anceps Zone of the earliest Middle Callovian age. Thus, the Early/Middle Callovian substage boundary evidently falls within sediment interval 5 of the Jumara section (Text-fig.5). The significant marker sandy limestone/calcareous sandstone sediment interval 6 (bed 5 of Rajnath 1932, 1942) of Jumara is correlated to the sediment interval 5 of Keera with almost similar lithology. This correlation is based on the common as well as restricted occurrence of *K. (K.) kleidos* (Spath), *Indosphinctes calvus* (Sowerby) and *Rehmannia (Loczyceras) reissi* (Steinmann) in the said sediment intervals of Jumara and Keera. So, the sediment interval 6 (bed 5 of Rajnath 1932, 1942) of Jumara is found ammonoid age constrained between the Kleidos Subzone to the A-IV Horizon of the Paramorphum Subzone of the Anceps Zone (Ojha 1996; Krishna & Ojha 1996). Sediment interval 7 (bed 4 of Rajnath 1932, 1942) of Jumara is correlated to sediment interval 6 plus ca 5 m basal part of sediment interval 7 of the Keera section. The basis of this correlation is the common first occurrence of *K. (H.) mutans* (Waagen), *K. (H.) hubertus* (Spath), *Kinkeliniceras (Obtusicostites) obtusicosta* (Waagen) and *Collotia gigantea* (Bourquin) in the above mentioned sediment intervals of Jumara (Spath 1927-33; Cariou & Krishna 1988) and Keera (Ojha 1996; Krishna & Ojha 1996). Hence, sediment interval 7 (bed 4 of Rajnath 1932, 1942) of Jumara represents mostly the A-V Horizon of the Paramorphum Subzone of the Anceps Zone and the entire Obtusicosta Zone. The common first occurrences of *P.* aff. *kachhense* Spath, *P. ponderosum* (Waagen) *P. metamorphicum* Spath, *Orionoides indicus* Spath and *Metapeltoceras* aff. *diversiforme* (Waagen) suggest good correlation between sediment interval 8 (beds 1 (partly) to 3 of Rajnath 1932, 1942) of Jumara and sediment intervals 7 (ca 11 m uppermost part) to 9 of Keera. Therefore, sediment interval 8 of Jumara is assigned to the Athleta Zone-Ponbderosum Zone interval. This correlation also indicates the demarcation of the Middle/Late Callovian substage boundary in between sediment intervals 7 (bed 4 of Rajnath 1932, 1942) and 8 (bed 3 of Rajnath 1932, 1942) of the Jumara section (Text-fig.5).

Jhura

The Jhura dome (also known as 'Jhurio hill') is another widely investigated (Agrawal 1957; Mitra & Ghosh 1964; Biswas 1977; Pandey & Dave 1993; Fürsich & Oschmann 1993; Mandwal & Singh 1994) Callovian section in the Kachchh Mainland. It exposes not only the well developed Chari Formation but also good development of the Patcham Formation below. The ca 273 m thick Callovian sedimentary succession has been modified after Agrawal (1957) and has been organised into 15 distinct sediment intervals from 1 to 15 in ascending order which correspond respectively to beds 2 to 16 of Agrawal (1957) in descending order (Text-fig.5). At Jhura, the Chari Formation in general, although resembling to that at Jumara, is characterised by an increasing content of coarse siliciclastics in the clay and silt range which are replaced upsection by largely bioturbated marly or argillaceous silt with intercalations of thin shell beds and concretionary calcareous siltstone levels (Fürsich &Oschmann 1993).

In spite of the significant progress made in the lithostratigraphic record (Fürsich & Oschmann 1993), and ammonoid stratigraphic data (Agrawal 1956, 1957) of the Callovian sedimentary succession at Jhura is similarly not updated. Nevertheless, the common first occurrence of *M. chariensis* (Waagen), *M. habyensis* (Spath) and *M. diadematus* (Waagen) suggests correlation of sediment interval 1 (bed 16 of Agrawal 1956, 1957) of Jhura to sediment intervals 0 to 1 of Keera. In view of this, sediment interval 1 (bed 16 of Agrawal 1956, 1957) of Jhura falls within the Madagascariensis Zone-Chrysoolithicus Zone interval (Text-fig. 5). The sediment intervals 2 to 6 (beds 11 to 15 of Agrawal 1956, 1957) of Jhura are without any ammonoids (see Agrawal 1956, 1957). However, *Eucycloceras eucyclum* (Waagen) is found to occur commonly in sediment interval 7 (bed 10 of Agrawal 1956, 1957) of Jhura and also in sediment interval 3 of Keera. Hence, based on the similar overlying as well as underlying ammonoid taxa (as above) sediment intervals 2 to 6 (beds 11 to 15 of Agrawal 1956, 1957) of Jhura are indirectly correlated to sediment interval 2 of Keera. Therefore, sediment intervals 2 to 6 of Jhura are assigned safely to the Formosus Subzone to the Semilaevis Subzone interval of the Semilaevis Zone. The sediment intervals 7 to 9 (beds 8 to 10 of Agrawal 1956, 1957) of Jhura are correlated to sediment interval 3 of Keera on the strength of first common occurrence of *Eucycloceras* and *Subkossmatia*. These sediment intervals (beds 8 to 10 of Agrawal 1956, 1957) of Jhura are found assignable to the latest Early Callovian Eucyclum/Opis Subzone of the Semilaevis Zone. The sediment interval 10 (bed 7 of Agrawal 1956, 1957) of Jhura and sediment intervals 4 and 5 of Keera mark the common first appearance of *R. (R.) anceps anceps* (Reinecke), *R. (L.) reissi* (Steinmann), *Collotia oxyptycha* (Neumayr) together with several kinkeliniceratins. This brings out the correlation between sediment interval 10 (bed 7 of Agrawal 1956, 1957) of Jhura and sediment intervals 4 and 5 of Keera. Hence, sediment interval 10 (bed 7 of Agrawal 1956, 1957) of Jhura falls within the earliest Middle Callovian Anceps Zone. This in turn, also reveals the Early/Middle Callovian substage boundary between the sediment intervals 9 and 10 (beds 7 and 9 of Agrawal 1956, 1957) in the Jhura section (Text-fig.5). Again, the sediment intervals 11 to 13 (beds 4 to 6 of Agrawal 1956, 1957) of Jhura are without any ammonoids (Agrawal 1956, 1957). This in turn, poses difficulty in precise correlation. However, the sediment intervals 14 and 15 (beds 3 and 2 of Agrawal 1956, 1957) of Jhura as also sediment intervals 7 (ca 11m uppermost part) to 9 of Keera reveal the common first occurrence of the undoubted Late Callovian *Subbonarellia discipiens* Spath, *Pachyceras indicum* Spath and *Metapeltoceras diversiforme* (Waagen). Thus, sediment intervals 14 and 15 (beds 3 and 2 of Agrawal 1956, 1957) correlate well with sediment intervals 7 (ca 11m uppermost part only) to 9 of Keera and are assigned to the Late Callovian Athleta Zone-Ponderosum Zone interval (Ojha 1996; Krishna & Ojha 1996). On the basis of the similar common overlying and underlying ammonoid species (as enumerated above), sediment intervals 11 to 13 (beds 4 to 6 of Agrawal 1956, 1957) of Jhura are indirectly correlated to sediment interval 6 as also ca 5m basal part of sediment interval 7 of the Keera section. This correlation also displays the Middle/Late Callovian substage boundary between sediment intervals 13 and 14 (beds 3 and 4 of Agrawal 1956, 1957) in the Jhura section (Text-fig.5).

Habo

The Habo dome is situated at about 25 km northeast of Bhuj (Text-fig.1), after the village Habo (alias Habae, Habye or Hubbo), which lies at about 3 km to 5 km on the south-southeast flank of the dome. The Jurassic sedimentary rocks are exposed in an elliptical outcrop which is about 16 km from east to west and 6 km from north to south. Kanjilal (1978) mapped the area and proposed a detailed local lithostratigraphic scheme. The ca 330 m Callovian sedimentary succession at Habo has been modified after Kanjilal (1978) and has been organised into 14 distinct sediment intervals from 1 to 14 in ascending order which on the other hand, correspond to beds 2 to 15 of Kanjilal (1978) in descending order. The composite lithocolumn of the Callovian Habo section has been shown in (Text-fig.5).

The sediment intervals 1 to 4 (beds 12 to 15 of Kanjilal 1974, 1978) of Habo correlate well with sediment intervals 0 to 1 of Keera (Text-fig.5). The reason behind this correlation is the common first appearance of *M. lamellosus* (Sowerby), *M. formosus* (Sowerby), *M. chariensis* (Waagen), *M. dimerus* (Waagen), *M. transitorius* (Spath), *M. chrysoolithicus* (Waagen), *M. diadematus* (Waagen) and *M. magnumbilicatus* (Waagen) in these sediment intervals of Habo and Keera. Thus, sediment intervals 1 to 4 (beds 12 to 15 of Kanjilal 1974, 1978) of Habo collectively represent the Madagascariensis Zone-Chrysoolithicus Zone interval of the Early Callovian age. The calcareous sandstone / sandy limestone dominated sediment intervals 5 to 8 (beds 8 to 11 of Kanjilal 1974, 1978) of Habo are devoid of any ammonoids (Kanjilal 1974, 1978). This interval has considerable thickness of ca 130 m in the lithocolumn (Text-fig.5). This poses difficulty in direct correlation. However, the successively overlying sediment interval 9 (bed 7 of Kanjilal 1974, 1978) of Habo correlates well with sediment interval 3 of Keera on the strength of common first occurrence of *Eucycloceras* and *Subkossmatia*. This is why the sediment interval 9 (bed 7 of Kanjilal 1974, 1978) of Habo is assigned to the latest Early Callovian Eucyclum/Opis Subzone of the Semilaevis Zone. Now, it becomes easy to correlate the sediment intervals 5 to 8 (beds 8 to 11 of Kanjilal, 1974, 1978) of Habo indirectly to sediment interval 2 of Keera on the basis of similar overlying and underlying ammonoid species. Thus, sediment intervals 5 to 8 (beds 8 to 11 of Kanjilal 1974, 1978) of Habo fall within the Formosus Subzone-Semilaevis Subzone interval of the Semilaevis Zone. The sediment interval 10 (bed 6 of Kanjilal 1974, 1978) of Habo is well correlated to sediment interval 4 of Keera. The basis of this correlation is the common first appearance of *Subkossmatia ramosa* Spath together with significant common presence of *Subkossmatia opis* (Sowerby) and *Subkossmatia coggin-browni* Spath. Hence, the sediment interval 10 (bed 6 of Kanjilal 1974, 1978) of Habo is assigned to the earliest Middle Callovian Ramosa Subzone of the Anceps Zone. In view of this, the Early/Middle Callovian substage boundary happens to fall between the sediment intervals 9 and 10 (beds 7 and 6 of Kanjilal 1974, 1978) in the Habo section (Text-fig.5). The common first appearance of *R. (L.) reissi* (Steinmann) supports the correlation of sediment interval 11 (bed 5 of Kanjilal 1974, 1978) of Habo to the sediment interval 5 of Keera. Therefore, the sediment interval 11 (bed 5 of Kanjilal 1974, 1978) of Habo is found ammonoid age constrained between the Kleidos Subzone and Paramorphum Subzone of the Anceps Zone.

The sediment intervals 12 and 13 (beds 4 and 3 of Kanjilal 1974, 1978) of Habo are found correlative to the sediment interval 6 plus ca 5 m basal part of sediment interval 7 of Keera. This is because of the common first occurrence of *K. (H.) mutans* (Waagen), *K. (H.) omphalodes* (Waagen), *K. (H.) hubertus* (Spath), *K. (O.) obtusicosta* (Waagen), *K. (O.) buckmanni* and *K. (O.) ushas* (Spath). Additionally, the common first appearance of *Orionoides* and *Grossouvria* within these sediment intervals gives extra strength to this correlation. So, the sediment intervals 12 to 13 (beds 3 to 4 of Kanjilal 1974, 1978) represent the Obtusicosta Zone interval in the Habo section. Now, the topmost Callovian sediment interval 14 (bed 2 of Kanjilal 1974, 1978) of the Habo section is correlated to the sediment intervals 7 (ca 11 m uppermost part only) to 9 of Keera. The strength of this correlation is in the common first occurrence of *Peltoceras, Sublunuloceras* and *Putealiceras*. This correlation also depicts the assignment of the sediment interval 14 (bed 2 of Kanjilal 1974, 1978) of Habo to the Late Callovian Athleta Zone-Ponderosum Zone interval. Hence, in Habo section the Middle/Late Callovian substage boundary can be demarcated between sediment intervals 13 and 14 (beds 3 and 2 of Kanjilal 1974, 1978) (Text-fig. 5).

Ler

The exposed Jurassic rocks near the Ler village are part of the Central hill range of the Kachchh Mainland. The village Ler is situated at about 12 km south of Bhuj (Text-fig.1). The Chari Formation (in part) is exposed to the southeast and southwest of Ler and is overlain by Katrol Formation. The Dhosa Oolite serves as a marker horizon in between the Chari Formation and Katrol Formation.

The outcrops of the Chari Formation at Ler have been investigated repeatedly (Smith 1914; Agrawal & Pandya 1966; Agrawal & Kachhara 1977, 1979; Fürsich *et al.* 1991). Agrawal and Pandya (1966) and Agrawal and Kachhara (1977, 1979) have given a detailed lithostratigraphic account and studied the rich fossil molluscs of the Chari Formation, southeast of Ler.

The Callovian sedimentary succession exposed southeast of Ler village has been investigated in detail. Lithologically, it is found dominated by silty clay, argillaceous silt, fine sandy silt and thinly laminated maroon, hard, ferruginous, marly/pebbly/concretionary/ conglomeratic beds/bands. About 75 m thick sedimentary succession (of late Early to Late Callovian age) has been organised here into 10 sediment intervals from 1 to 10 in ascending order (Text-fig. 5).

The previous ammonoid stratigraphic data from the Callovian sedimentary succession at Ler available so far is very scanty. It lacks bed-by-bed precise collection of ammonoids. This in turn, poses trouble in precise correlation. Nevertheless, an attempt has been made in this direction (Text-fig.5). It is difficult to date precisely the lowermost sediment intervals 1 to 4 (beds 11 to 17 of Agrawal & Kachhara 1979) of Ler in want of reliable evidence of ammonoids. Only single fragment of *Grossouvria* sp. has been reported so far from these sediment intervals (see Agrawal & Kachhara 1979). However, higher up in the present succession the sediment intervals 5 to 9 (beds 10 to 3 of Agrawal & Kachhara 1979) of Ler have yielded one or more of the ammonoid species, such as *K. (O.) obtusicosta* (Waagen), K. (H.) *mutans* (Waagen), *K. (H.) hubertus* (Spath), *K. (H.) dhosaense* (Waagen), *K. (H.) omphalodes* (Waagen), *Orionoides* cf. *purpurus* Spath, *Reineckeia* (Reineckeia) sp. indet. and *Collotia* sp. Thus, on the basis of the common first occurrence of the nominal zonal index, *K. (O.) obtusicosta* (Waagen) in association of others (as above), sediment intervals 5 to 9 (beds 10 to 3 of Agrawal & Kachhara 1979) of Ler correlate well with sediment interval 6 and ca 5 m basal part of sediment interval 7 of Keera. Hence, sediment intervals 5 to 9 (beds 10 to 3 of Agrawal & Kachhara 1979) of Ler correlate well with sediment interval 6 and ca 5 m basal part of sediment interval 7 of Keera. Hence, sediment intervals 5 to 9 (beds 3 to 10 of Agrawal & Kachhara 1979) of Ler can safely be assigned to the Middle Callovian Obtusicosta Zone (Ojha 1996; Krishna & Ojha 1996).

In light of the above, sediment intervals 1 to 4 (beds 11 to 17 of Agrawal & Kachhara 1979) of Ler can broadly be assigned to late Early Callovian, Semilaevis Subzone of the Semilaevis Zone to the earliest Middle Callovian Anceps Zone. This is also due to the marked presence of sandstone bodies in this very interval not only in Ler but also in other Kachchh Callovian sections (Text-fig.5). Further more, the sediment interval 10 (bed 2 of Agrawal & Kachhara 1979) of the Ler section is correlated here to the sediment intervals 7 (ca 11 m uppermost part only) to 9 of Keera. This is due to the common first occurrence of *P. athleta* (Phillips), *P. ponderosum* (Waagen), P. aff. *vijaya* Spath, *Putealiceras trilineatum* (Waagen) and *Sublunuloceras dynastes* (Waagen). Hence, sediment interval 10 (bed 2 of Agrawal & Kachhara 1979) is found to represent the Late Callovian Athleta Zone-Ponderosum Zone interval in the Ler section. Therefore, the Middle/Late Callovian substage boundary in Ler can be marked between the sediment intervals 9 and 10 (beds 3 and 2 of Agrawal & Kachhara 1979) (Text-fig.5).

Patcham

There have been number of litho- and biostratigraphic descriptions of the Jurassic rocks exposed at Patcham 'island' (Biswas 1977, 1981; Pandey 1983; Pandey & Agrawal 1984; Pandey *et al.* 1984; Singh *et al.* 1982, 1983; Agrawal & Pandey. 1985; Pandey & Fürsich 1993; Fürsich *et al.* 1994; Pandey & Fürsich 1998). The Jurassic outcrops in Patcham 'island' (Text-fig.1) are exposed in two parallel, fault-bounded ranges of hills : Kala Dongar (Black Hills) in the north, and Gora Dongar (White

Hills) in the south. A good part of the succession is found common to both the hills. However, the Callovian part of the succession is found better exposed in the Gora Dongar.

About 35 m thick Callovian sedimentary column (Text-fig.5) is organised here into 12 distinct sediment intervals in ascending order which correspond to the beds 19 to 30 of Pandey (1983). These beds/bands fall within the 'Kakkar Member' of the 'Khavda Formation' of Pandey (1983). Lithologically, the broadly argillaceous and calcareous facies dominate over the arenaceous facies.

Besides the general information of rocks (Wynne 1872; Biswas, 1980 and others), the ammonoid stratigraphic accounts from Patcham have also been presented during the last decade (Pandey 1983; Pandey & Singh 1982; Pandey & Agrawal 1984; Pandey *et al.* 1984; Singh *et al.* 1982, 1983; Agrawal & Pandey 1985; Fürsich *et al.* 1994 and others). Recently, Pandey and Fürsich (1998) have studied the Jurassic sedimentary succession exposed in Gora Dongar at Patcham. Their studies include not only the litho/biostratigraphy but also the distribution and depositional environment of the exposed rocks. They have recognized three different ammonoid levels in their *Macrocephalites* Range Zone. This differentiation is based on the stratigraphic distribution of *Macrocephalites*. The oldest ammonoid level has been characterized by *M. madagascariensis* Lemoine. This level has been corresponded to the Triangularis Association of Krishna and Westermann (1987) and also to the Triangularis Zone of Spath (1927-33). In view of this it has been assigned the age of latest Late Bathonian (Pandey & Fürsich 1998). The remaining two yonger levels of Pandey and Fürsich (1998) occur within their Lower Shale Member of the Chari Formation. These ammonoid levels have been characterized by the significant presence of various species of *Macrocephalites*. These levels are corresponded to the Madagascariensis and Dimerus/Formosus associations of Krishna and Westermann (1987) as also the Dimerus Zone of Spath (1927-33). Furthermore, Pandey and Fürsich (1998) have assigned these two ammonoid levels an Early Callovian age.

In light of the above, sediment intervals 1 to 12 (beds 19 to 30 of Pandey, 1983 and beds 5 to 18 of Pandey & Fürsich, 1998) of Patcham are correlated at most to the sediment intervals 0 to 1 of Keera (Text-fig. 5). This is because of the common presence of *M. triangularis* Spath, *M. formosus* (Sowerby), *M. transitorius* (Spath), *M. chrysoolithicus* (Waagen), *M. diadematus* (Waagen), *M. chariensis* (Waagen), *M. dimerus* (Waagen), *M. lamellosus* (Sowerby) and *M. magnumbilicatus* (Waagen) in the above mentioned sediment intervals of both the sections, Patcham and Keera (see Pandey 1983; Pandey & Agrawal 1984; Agrawal & Pandey 1985; Pandey & Fürsich 1998; Ojha 1996; Krishna & Ojha 1996). Hence, the sediment intervals 1 to 12 (beds 19 to 30 of Pandey, 1983 and beds 5 to 18 of Pandey & Fürsich 1998) of Patcham island represent mostly the Madagascariensis Zone-Chrysoolithicus Zone interval and therefore can be assigned an early to middle Early Callovian age. Thus, the two younger ammonid levels of Pandey and Fürsich (1998) as above are found to fall within the Madagascariensis Zone - Chrysoolithicus Zone interval.

SEQUENCE STRATIGRAPHIC FORMULATION

In sequence stratigraphic context, the presence of alternating intervals of ammonoid-rich and ammonoid-poor sediment intervals have been noted here. The ammonoid-poor sediment intervals in particular, are found lacking in cosmopolitan Tethyan elements (Text-figs 2-4). These are invariably also found to correspond to the significant silt/sand dominating sediment intervals in the relatively proximally located sections. By way of example among such intervals there can be mentioned sediment intervals 5 to 9 (ca 140 m thick) at Habo as also sediment intervals 2 to 10 (ca 150 m thick) at Jhura (Text-fig.5). In contrast, in the relatively distal Keera, Jumara and Jara (Lakhapur) sections, the sand/silt dominating thicknesses are relatively much less. These alternating intervals are found eustatically influenced, thereby attesting the eustatically influenced depositional/sea level cyclicity. The ammonoid-rich sediment intervals are suggested to correspond to the eustatically strengthened increase in basinal depth, while the ammonoid-poor sediment intervals to phases of relatively decreased basinal depth. In the backdrop of ammonoid time framework, these silt/sand dominating sediment intervals (Text-fig.5) of Habo and Jhura are much longer ranging than in Keera, Jumara, Jara (Lakhapur) and Ler (Semilaevis Zone to Anceps Zone). However, unlike Habo, Ler and Jhura the silt/sand dominating sediment intervals of Keera, Jumara and Jara (Lakhapur) are found exclusively of Anceps Zone age (Text-fig.5). It is further revealed that most of the silt/sand dominating thickness (sediment intervals 5 to 8, ca 135 m) of Habo is of Semilaevis Zone age while at Jhura (sediment intervals 7 to 10, ca 65 m) is found exclusively of Anceps Zone age. The Semilaevis Zone and the Anceps Zone instead of belonging to the same depositional sequence, come from successive 3rd order depositional sequences LZA 3 (Text-figs 2,3). This stands in contrast to the model developed by Fursich and Oschmann (1993, fig. 13, p. 183) in which such silts/sands are interpreted to indicate the High Stand System Tract of a single 3rd order depositional sequence of Middle Callovian age. They have failed to differentiate the sand build-up of Semilaevis Zone from that of Anceps Zone. The Callovian sediment intervals rich in cosmopolitan Tethyan elements clearly suggest better communication under eustatic maxima (Text-figs. 2-4) of successive 3rd and finer order depositional cycles.

THE AMMONOID-FORAMINIFER ZONAL INTEGRATION IN THE CALLOVIAN OF KACHCHH

The foraminifer based 'Charian' has been held coeval to the standard Callovian Stage (Pandey & Dave 1993), without substantiation. Yet the three foraminifer zones of 'Charian' have been integrated here (Text-fig.6) to the recently developed Callovian ammonoid zonal scheme in Kachchh (Ojha 1996; Krishna & Ojha 1996). Such integration demonstrates major disagreement of ages, stage/substage boundaries and correlations. The first foraminifer based *Lenticulina discipiens* Zone marks the base of 'Charian'. It is also claimed (Pandey & Dave 1993) to correspond to the early part of the Early Callovian. However, on the basis of the significant presence of *M. triangularis* Spath in this zonal interval, it has been here revised as of Late Bathonian age instead of early Early Callovian.

The *Tewaria kutchensis* Partial Range Zone (the second foraminifer zone of the 'Charian') in the same table (p.67-68, Pandey & Dave 1993) has been corresponded at one place to the European Macrocephalus Zone to the Coronatum Zone interval, while at another place indicated equivalent to the Kachchh Dimerus Zone-Anceps Zone interval (Fig. 11, p. 67-68, Pandey & Dave 1993). This foraminifer zone is claimed (Pandey & Dave 1993) also to correspond to beds 21 to 2 of Rajnath (1932, 1942) in the Jumara section. In this context, it is noteworthy here that the Anceps Zone (= Jason Zone) is internationally known to correspond only to the early part of the Middle Callovian, which is overlain by the late Middle Callovian Coronatum Zone. Here, the *T. kutchensis* Partial Range Zone is found ammonoid age constrained between the early Early Callovian Madagascariensis Zone to the early Middle Callovian Ramosa Subzone of the Anceps Zone (Text-fig.6). Its extension through the entire Middle Callovian (Pandey & Dave, 1993) is unsubstantiated. Moreover, the *T. kutchensis* Partial Range Zone, on ammonoid evidence, corresponds only to beds 21 to 6 of Rajnath (1932, 1942) instead of beds 21 to 2 in the Jumara section.

The youngest and the third foraminifer zone of the 'Charian' is the *P. diffugiformis* Zone. It has been corresponded to the Late Callovian Athleta Zone interval (Pandey & Dave 1993). It is significant to note here that the Late Callovian Athleta Zone is represented and identified by the essential presence of *Peltoceras* all over the world including Kachchh. Unfortunately, the *P. diffugiformis* zonal interval is found devoid of any peltoceratins. Instead, it shows significant presence of the undoubted and undisputed Middle Callovian reineckeiins. On the basis of our ammonoid evidences (Ojha 1996; Krishna & Ojha 1996), the *P. diffugiformis* Zone is age constrained in the early Middle Callovian Kleidos Subzone to the Paramorphum Subzone of the Anceps Zone (Text-fig.6).

The foraminifer based 'Charian' (Pandey & Dave

1993) in the Jumara section includes also 18.3 m limestone succession of the Patcham Formation of Stoliczka (in Waagen 1871, 1873-75) at the base (underlying the 'Jumara Formation' stratotype of Biswas 1977). Moreover, it is also said to include the overlying beds 1 to 5 and the lower 16 m of bed 6 of the 'Jumara Formation' (Biswas 1977). Pandey and Dave (1993) consider the 'Badian'/'Charian' contact conformable and have corresponded it to the Bathonian/Callovian boundary. The overlying 'Dhosaian' (including the well known Dhosa Oolite plus ca 45 m of the underlying shales) is claimed (Pandey & Dave 1993) isochronous to the standard Oxfordian Stage. However, the major part of the 45 m thick shales underlying Dhosa Oolite shows marked presence of bituberculate reineckeiins and peltoceratins together with other ammonoids of distinctly late Middle and Late Callovian age (Text- figs 3,4). Furthermore, according to Pandey and Dave (1993) the 'Charian'/'Dhosaian' boundary is unconformable near the close of the Late Callovian and also it corresponds to the Callovian/Oxfordian boundary. However, in view of the undisputed ammonoid evidence (as above) the 'Charian'/'Dhosaian' boundary instead of corresponding to the Callovian/Oxfordian boundary is found to fall within the Middle Callovian without involvement of any major break. Similarly, the 'Dhosaian' *E.majungaensis* Zone on ammonoid evidence is found mostly of the late Middle and Late Callovian age (Text-fig.6). In contrast, this zonal interval has been foraminiferally dated (Pandey & Dave 1993) as of Oxfordian age.

The above account and discussion unambiguously brings out that the creation of 'Badian', 'Charian' and 'Dhosaian' stages is illconceived on account of either incorrect or vague age assignments, lack of correlatibility across the basin and grossly faulty correspondence to the international Bathonian, Callovian and Oxfordian stages of the Jurassic. Further, in view of their definition in unknown stratigraphic gaps through undatable bases, such creation is held violative of fundamental norms of the chronostratigraphy.

CONCLUSIONS

(i) The intrabasinal correlation in the Callovian interval of Kachchh established here is mostly suprazonal. At places, subzonal and even horizonal correlations are also suggested.

(ii) Substage and some of the zonal time boundaries in different Kachchh Callovian sections (viz. Jara, Jumara, Jhura, Habo, Ler and Patcham) are suggested.

(iii) The Callovian ammonoid chronologic scheme developed in Keera is extended in other Kachchh sections.

(iv) The spatial as well as temporal migration of significant lithofacies is observed. The marker sediment intervals (e.g. golden oolitic limestones/ calcareous sandstones/sandy limestones/major sand influxes etc.) are identified and dated under high resolution ammonoid chronologic framework in different Kachchh Callovian sections.

(v) Third order and smaller depositional sequences are identified in terms of relative sea-level cyclicity. Seven third order transgressive intervals are observed in the Kachchh Callovian Keera section which are found coeval to the global ones.

(vi) The creditability and resolution of Kachchh Callovian benthic foraminifer zones are integrated in the highly resolved ammonoid chronologic framework. The zonal boundaries and age assignments of different foraminifer zones are revised.

ACKNOWLEDGEMENTS

The Laboratory facility rendered by the Department of Geology, Banaras Hindu University is thankfully acknowledged. We would also like to thank the Council of Scientific and Industrial Research for financial support to one of us (J.R.O.) in the form of Research Associateship.

REFERENCES

Agrawal., SK 1956. Contribution a letude stratigraphique et paleontologique due Jurassique due Kutch (Inde). *Ann. Centre Et. Doc. Paleont., Paris* **19** : 1-188.

Agrawal, SK 1957. Kutch Mesozoic : a study of the Jurassic of Kutch with special reference to the Jhura dome. *J. paleont. Soc. India* **2** ; 119-130.

Agrawal, SK 1982. The Kachchh Mesozoic : some problems and recent contributions. *Rec. Res. Geol.* **88** : 397-415.

Agrawal, SK & Kachhara, RP 1977. Habo beds near Ler, Kutch : Pt. 2. succession and fossil molluscs of the beds on the east of Ler. *Rec. Res. Geol., Delhi* **3** : 495-503.

Agrawal, SK & Kachhara, RP 1979. Habo beds near Ler, Kutch : Pt. 3. biostratigraphy of the beds on the east of Ler. *Proc. Ind. nat. Sci. Acad.* **45** (2) : 129-146.

Agrawal, SK & Kacker, AK 1978. Succession and fossil molluscs of the Jurassic rocks near Mouana, Eastern Bela 'Island', District Kutch, Gujarat. *Rec. Res. Geol.* **4** : 482-497.

Agrawal, SK & Kacker, AK 1980. Biostratigraphy of Bathonian-Callovian beds of Mouana dome, Eastern Bela 'Island', Kutch (Gujarat). *Rec. Res. Geol.* **61**: 631-649.

Agrawal, SK & Pandey, DK 1985. Biostratigraphy of the Bathonian=Callovian beds of Gora Dongar in Pachcham 'Island', District Kachchh (Gujarat). *Proc. Ind. nat. Sci. Acad.* **51** : 887-903.

Agrawal, SK & Pandya, MK 1966. Habo beds near Ler (Cutch) : Pt. 1, succession in the central dome. Univ. Rajasthan : 62-68.

Agrawal, SK & Singh, CSP 1961. Kutch Mesozoic : on the occurrence of foraminifers in the Jurassic of Kutch (Gujarat, W. India). *Jour. Sci. Res.* **11** (20): 313-316.

Bardhan, S & Dutta, K 1987. Biostratigraphy of Jurassic Chari Formation : a study in Keera dome, Kutch, Gujarat. *J. geol. Soc. India* **30** : 121-131.

Bhalla, S.N. 1977. Stratigraphic nomenclature of the Jurassic sequences of Kutch. *Bull. India Geol. Assoc.* **10**(2) :71-72.

Bhalla, SN & Abbas, SM 1976. The age and paleogeographical significance of Jurassic foraminifera from Kutch, India. *Meritime sediments*, spl. publ. 1b : 537-544.

Bhalla, SN & Talib, A 1978. A preliminary note on Jurassic foraminifera from Chari 'Series', Badi, Kutch. *Bull. India Geol. Assoc.* **11** (1) : 85-86.

Bhalla, SN & Talib, A 1985. On the occurrence of foraminifera in the Jurassic rocks of Jhurio hill,Central Kutch. *J. paleont. Soc. India* **24** (1) : 54-56.

Bhaumik, D, Jana, SK, Dutta, K & Bardhan, S 1993. Taxonomy and intraspecific variation of *Macrocephalites formosus* (Sowerby) from the Jurassic Chari Formation, Kutch, Western India. *J. geol. Soc. India* **42** : 163-179.

Biswas, SK 1971. Note on the geology of Kutch. *Q. Jl. geol. Min. metall. Soc. India* **43** (4) : 223-236.

Biswas, SK 1977. Mesozoic rock stratigraphy of Kutch. *Q Jl. geol. Min. metall. Soc. India.* **49** (3 & 4) : 1-52.

Biswas, SK 1980. Structure of Kutch-Kathiawar region. *Proc. 3rd Ind. Geol. Congr.* : 225-272.

Biswas, SK 1981. Basin framework, paleoenvironment and depositional history of the Mesozoic sediments of Kutch basin, Western India. *Q. Jl. geol. Min. metall. Soc. India* **53** (22) : 56-85.

Biswas, SK 1991. Stratigraphy and sedimentary evolution of the Mesozoic basin of Kachchh, Western India. *In* : Tondon S. K., Pant C.C. & Cashyap S.M. (eds) - *Sedimentary basins of India - Tectonic Context*, Gyanodaya Prakashan, Nainital : 74-103.

Callomon, JH 1993. On *Perisphinctes congener* Waagen 1875 and the age of the Patcham Limestone in the Middle Jurassic of Jumara, Kutch, India. *Geol. Bl. No-Bayern* **43** (1-3) : 227-246, Erlangen.

Cariou, E & Hantzpergue, P 1997. Biostratigraphie du Jurassique Ouest european et mediterranean : zonations paralleles et distribution de inverebres et microfossiles. *Bull. Centre Rech. Elf. Explor. Prod. Mem.* **7** : 1-440.

Cariou, E & Krishna, J 1988. The Tethyan Reineckeiinae of Kachchh and Jaisalmer (West India) : systematic, biostratigraphic and biogeographic implications. *Paleontographica A.* **203**: 149-170.

Cariou, E, Krishna, J & Enay, R 1990. Dynamicque biogeographique des ammonites tethysiennes an Callovien inferior et correlations stratigraphiques entrales marges indienne et europeene. *CR. Acad. Sci.* **311** (12) : 373-379, Paris.

Fürsich, F T & Oschmann, W 1993. Shell beds as tools in basin analysis : the Jurassic of Kachchh, Western India. *J. geol. Soc., London* **150** : 169-185.

Fürsich, FT, Oschmann, W, Jaitly, AK & Singh, IB 1991. Faunal response to transgressive-regressive cycles : example from the Jurassic of western India. *Palaeography Palaeoclomatology Palaeoecology* **85** : 149-159, Amsterdam.

Fürsich, FT, Oschmann, W, Singh, IB, Jaitly, AK 1992. Hardgrounds, reworked concretion levels and condensed horizons in the Jurassic of western India : their significance for basin analysis. *J. geol. Soc. London,* **149** : 313-331.

Fürsich, FT, Pandey, DK, Callomon, JH, Oschmann, W & Jaitly, AK 1994. Contributions to the Jurassic of Kachchh, Western India. II. Bathonian stratigraphy and depositional environment of the Sadhara Dome, Pachchham Island. *Beringeria* **12** : 95-125, Wurzburg.

Gradstein, FM, Agterberg, FP, Ogg, JG, Hardenbol, J, Van Veen, P, Thierry, J & Hyang, Z 1994. A Mesozoic Time Scale. *J. Geoph. Res.* **99** (B12) : 24051-24074.

Jacquion, T, Graciansky, P Ch de & Vail, PR 1994. Jurassic sequence cycles chart for Western European basins. Project-Mesozoic-Cenozoic sequence stratigraphy of European basins.

Jain, S & Pandey, DK 1997. Revision of the age of heteromorph ammonite *Parapatoceras* from Kachchh, Western India. *J. palaeont. Soc. India.* **42** : 133-139.

Kanjilal, S 1974. *A study of the fauna and stratigraphy of Jurassic rocks of Habo hill, district Kutch (Gujarat), W. India.* Unpublished Ph. D. thesis, B.H.U., Varanasi.

Kanjilal, S 1978. Geology and stratigraphy of the Jurassic rocks of Habo hill, district Kutch (Gujarat). *Proc. Ind. nat. Sci. Acad.* **44** (1) : 1-15.

Kanjilal, S 1984. On some Callovian (Jurassic) proplanulitin ammonoids from the Habo hill, district Kutch, Gujarat. *Q. Jl. geol. Min. metall. Soc., India* : 56-70.

Kanjilal, S & Prasad, S 1992. Geology and stratigraphy of Callovian-Oxfordian (Jurassic) rocks of Jara dome, district Kachchh, Gujarat, W. India. *Jour. Ind. Acad. Geosci.* **35** (1) : 1-18, Hyderabad.

Krishna, J 1983. Callovian-Albian ammonoid biogeography in the Indian subcontinent with special reference to the Tethys Himalaya. *Him. Geol.* **11** : 42-71.

Krishna, J 1984. Current status of Jurassic stratigraphy of Kachchh, Western India. *Internat. Symp. Jur. Strat.* **3** : 731-742, Erlangen.

Krishna, J 1987a. An overview of the Mesoszoic stratigraphy of Kachchh and Jaisalmer. *J. palaeont. Soc. India* **32** : 136-152.

Krishna, J 1987b. The Jurassic-Cretaceous ammonoid geography in the Indian subcontinent *vis-a-vis* marine seaways and plate tectonics in the Indian Ocean region. *Geol. Surv. India.* Spl. Publ. **11** (1) : 453-482.

Krishna, J & Cariou, E 1986. The Callovian of Western India : new data on the biostratigraphy, biogeography of the ammonites and correlations with Western Tethys. *Newsl. Strat.* **17**(1): 1-8.

Krishna, J & Cariou, E 1990. Ammonoid faunal exchange during Lower Callovian between the Indo-East-African and Submediterranean provinces : implications for the long distance east-west correlations. *Newsl. Strat.* **23** (2) : 109-122.

Krishna, J & Cariou, E 1993. The Tethyan Macrocephalitinae : evolutionary, environmental and dispersal strategies. *Geobios* **15** : 218-227.

Krishna, J & Ojha, JR 1996. The Callovian ammonoid chronology in Kachchh (India). *Geo Research Forum* **1-2**: 151-164, Switzerland.

Krishna, J & Westermann, GEG 1985. Frogress report on the Middle Jurassic ammonoid zones of Kachchh, Western India. *Newsl. Strat.* **14** (1) : 1-11.

Krishna, J & Westermann, GEG 1987. Faunal associations of the Middle Jurassic ammonite genus *Macrocephalites* in Kachchh, Western India. *Can. Jour. Earth Sci.* **24** : 1570-1582.

Krishna J, Cariou, E & Enay, R 1988. Succession of Macrocephalitinae assemblages as revealed at Keera dome in Kachchh, Western India. *2nd Internat. Symp. Jur. Strat. Lisboa* : 383-394.

Krishna, J, Pathak, DB & Pandey, B 1998. Development of Oxfordian (early Upper Jurassic) in the most proximally exposed part of the Kachchh basin at Wagad outside the Kachchh Mainland. *J. geol. Soc. India* **52**: 513-522.

Krishna, J, Singh, IB, Howard, JD & Jafar, SA 1983. Implication of new data on Mesozoic rocks of Kachchh, Western India. *Nature* **305** : 790-792.

Mandwal, N & Singh, SK 1989. Bathonian age for the sediments of Jhurio hill, Kachchh : foraminiferal evidence. *J. palaeont. Soc. India* **34** : 41-54.

Mandwal, N & Singh, SK 1994. The Jurassic foraminifer from the Patcham-Chari Formations of Jhurio hill (Jhura dome), Kachchh, Western India. *J. geol. Soc. India* **44** (6) : 675-680.

Mitra, KC & Ghosh, DN 1964. A note on the Chari Series around Jhura dome, Kutch. *Sci. Cult.* **30** : 192-194.

Mitra, KC, Bardhan, S & Bhattacharya, D 1979. A study of Mesozoic stratigraphy of Kachchh, Gujarat with special reference to rock stratigraphy and biostratigraphy of Keera dome. *Bull. Indian Geol. Assoc.* : 129-143.

Ojha, JR, 1996. The Callovian at Keera, Kachchh, India : ammonoid systematics, chronology and geography. *Jour. Sci. Res.* **46** : 233-244.

Pandey, DK 1983. *Biostratigraphical and palaeoecological studies of the Bathonian - Callovian rocks of Khavda-Sadhara area, Pachchham 'Island', (Kachchh, Gujarat).* Unpublished Ph. D. thesis, B.H.U., Varanasi.

Pandey, DK & Agrawal, SK 1984. Bathonian-Callovian molluscs of Gora Dongar, Pachchham 'Island' (District Kachchh, Gujarat). *Q. Jl. geol. Min. metall. Soc. India* **56** : 176-196.

Pandey, DK & Fürsich, FT 1998. Distribution and succession of Jurassic rocks in Gora Dongar, Pachchham 'Island', Kachchh, India. *J. geol. Soc. India* **51** : 331-344.

Pandey, DK & Singh, CSP 1982. On a new species of *Macrocephalites* Zittel from Jurassic of Kachchh (Gujarat). *J. geol. Soc. India.* **23** : 621-623.

Pandey, DK & Singh, CSP & Agrawal, SK 1984. A note on new fossil finds from Gora Dongar, Pachchham 'Island', District Kachchh (Gujarat). *Jour. Sci. Res.* **34** : 299-310.

Pandey, J & Dave, A 1993. Studies in Mesozoic foraminifera and chronostratigraphy of Western Kachchh, Gujarat. *Palaeontographica Indica* **1** : 1-221.

Prasad, S 1988. *Ammonite biostratigraphy of the Callovian-Oxfordian (Jurassic) rocks of Jara dome, district Kachchh, Gujarat.* Unpublished Ph. D. thesis, B.H.U., Varanasi.

Prasad, S 1993. A note on the Middle Jurassic stratigraphic succession of Keera dome, Kachchh district, Gujarat. *J. geol. Soc. India* **41** (2) : 156-161.

Prasad, S 1998. Ammonite biozonation of the Middle-Late Jurassic sediments with special reference to Keera and Jara domes, Kachchh district, Gujarat. *J. geol. Soc. India* **52** : 25-40.

Rajnath 1932. A contribution to the stratigraphy of Cutch. *Q. Jl. geol. Min. metall. Soc. India.* **4** : 161-174.

Rajnath 1942. The Jurassic rocks of Kutch, their bearing on some problems of Indian geology. Pres. Addr. *Proc. 29th Ind. Sci. Congr.* : 93-106.

Rajnath 1952. On the upper age limit of the Gondwana System. *Palaeobotanist* **1** : 382-385.

Singh, IB 1989. Dhosa Oolite - a transgressive condensation horizon of Oxfordian age in Kachchh, Western India. *J. geol. Soc. India.* **34** : 152-160.

Singh, P 1977a. Late Jurassic *Epistomina* from the subsurface of Banni deep well-2, Kutch. *Proc. 4th Indian Colloq. Micropalaeont. Strat.* : 30-35.

Singh, P 1977b. The Jurassic nannoplankton from the Jurassic sequences of the Rann, Kutch. *J. palaeont. Soc. India.* **20** : 331-332.

Singh, P 1979. Biostratigraphic zonation of the Jurassic sequences in the subsurface of Banni, Rann, Kutch. *Bull. Indian Geol. Assoc.* **12** (1) : 111-128.

Singh, CSP, Agrawal, SK & Kacker, AK 1979. Callovian cephalopods from the Mouana dome, Eastern Bela 'Island', District Kutch (Gujarat). *Bull. Indian Geol. Assoc.* **12** (2) : 173-189.

Singh, CSP, Jaitly, AK & Pandey, DK 1982. First report of some Bajocian-Bathonian (Middle Jurassic ammonoids) and the age of oldest sediments from Kachchh, India. *Newsl. Strat.* **11** : 37-40.

Singh, CSP, Pandey, DK & Jaitly, AK 1983. Discovery of *Clydoniceras* Blake and *Gracilisphinctes* Buckman (Bathonian-Middle Jurassic ammonites) in Kachchh, W. India. *J. Palaeont.* **57** : 821-824.

Smith, JH 1914. Notes on the Cutch Ammonites : East of Ler. *Bombay Nat. Hist. Soc.* **23** : 176-179.

Spath, LF 1924. On the Blake collection of ammonites from Kachh, India. *Mem. Palaeont. Indica* **9** (1) : 1-29.

Spath, LF 1927-33. Revision of the Jurassic Cephalopod fauna of Kachh. *Mem. Palaeont. Indica* **9**(2) : 1-945.

Subbotina, NN, Dutta. AK & Srivastava, BN 1960. Foraminifera from the Upper Jurassic deposits of Rajasthan (Jaisalmer) and Kutch, India. *Bull. geol. Min. metall. Soc. India* **23** : 1-48.

Waagen, W 1871. Abstract of result of examination of the ammonite fauna of Cutch with remarks on their distribution among the beds and probable age. *Rec. geol. Surv. India* **4** (4) : 89-101.

Waagen, W 1873-75. Jurassic fauna of Kutch : The Cephalopoda. *Palaeont. Indica* **9**(1) : 1-247.

Wynne, AB 1872. Memoir on the geology of Kutch, to accompany the map compiled by A. B. Wynne and F. Fedden, during the seasons of 1867-68 and 1868-69. *Mem. geol. Surv. India* **9** (1): 1-283.

(Received 19.07.1999; Accepted 29.11.1999)