

Chapter - 10

CHAPTER-X

LITHOSTRATIGRAPHIC, BIOSTRATIGRAPHIC AND
MAGNETOSTRATIGRAPHIC CONSIDERATIONS

*Most of this has
already been done in
earlier chapters.*

An attempt has been made in this chapter to bring out the possible lithostratigraphic units and biostratigraphic zones in different Intertrappean beds especially at Anjar, Dayapar, Matanomadh, Ukra etc., sections. The description is given in the descending order, starting from the top i.e. beginning with the 5th intertrappean bed and then following upto the bottommost bed.

X.1. V INTERTRAPPEAN BED:

Section (cm)	Lithology	Main Fossils	Biozones		
Flow F7 72.8	Basalt	-			
	Sandy Limestone & Calcareous sandstone	Invertebrates, Plants, gastropod, bryozoans, and forams	1		
56.0				2	
	Stratified Limestone Laminated Limestone	Microgastropods & Plant fragments	?		3
42.5					
	Massive chert	Oncolitic growth & finer plant matter siliceous oncolites	?	?	?
30.0					
	Banded chert	Mainly algal	?	?	?
	Chert				
0.0					
Flow F6	Basalt				

Biozones:

1. Forams and Bryozoans Zone
2. Invertebrata Zone
3. Angiosperm Plant Zone

X.1. FIFTH INTERTRAPPEAN BED:

The fifth Intertrappean bed contains richly fossiliferous lensoidal bodies of sandy limestone with fossil blue green algal elements, prolific invertebrates bryozoan (?) and fossil plant fragments in section. Identification of individual fossils can not be done on the basis of microsections.

X.2. FOURTH INTERTRAPPEAN:

The reddish sandy clays and sandstone have not yielded fossils.

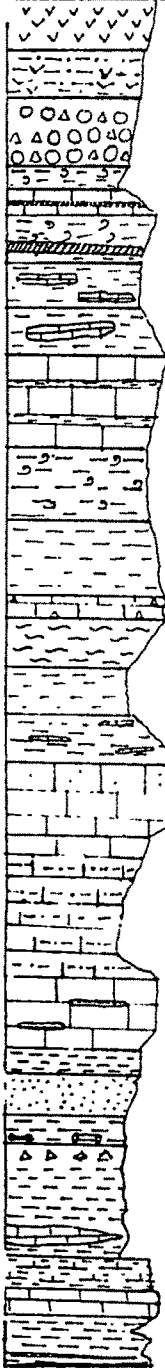
X.3. THIRD INTERTRAPPEAN BED:

This is very important horizon and shows many lithological variations alongwith fossil zonations which can briefly be summarised as :

Third Intertrappean bed

Section cm	Lithology	Important Fossils	Zones
664 54-	Olivine basalt (F4)		
646 36-	Black soil with weathered basalt fragments	Algae, Oncolites, (Angiosperm) spores/pollens	
617 27-	Kankar (concretions) with sandy & basalt clasts. Concretions - calcareous and gypseous clay	Algae, Chara, Mammalian bones	
609 09-	Grey fossiliferous shale	Fossil plants	
600 00-	Cherty limestone with gypseous layers	Girvanella, Oncolites	
589 09-	Brown and grey fossiliferous shale with gypsum	Charophytes, fossil plants (wood)	
570 90-	Alternating sequence of fossiliferous shale & lensoidal limestone	Lamellibranchs & gastropods (mainly <i>Physa</i>)	
558 18-	Brown chocolate coloured shale with lensoid bodies of limestone	Egg shell - avian, <i>Physa</i>	
546 36-	Thickly bedded limestone with thin intercalations of shale	Egg shell- avian & crocodilian, <i>Physa</i> , Rhizome, charophyta	
526 36-	Brown chocolate coloured fossiliferous shale with prolific fossils	<i>Physa</i> , Geckoid egg shells, bivalves	
454 54-	Intercalated sequence of grey shale with lensoid bodies of brown shale & lenses of algal limestone	<i>Physa</i> , lamellibranchs, Charophytes geckoid & avian egg shells, <i>Girvanella</i> , oncolites	
402 73-	Black clay/ muddy soil with boulders of trap	<i>Physa</i> charophytes	
371 82-	Grayish white fossiliferous shale	Egg shell fragments	
338 18-	Black fossiliferous shale with lenses of (White) mottled clay	Charophytes	
313 63-	White mottled limestone with black nodules	Profuse <i>Physa</i> & other invertebrates, oncolites, <i>Girvanella</i> , chara & wood	
287 27-	Blackish white mottled compact marl with ferruginous encrustation	Egg shells (crocodilian affinity), affinity), oncolites, algal mats, invertebrate shell debris	
188 18-	Sequence of blackish mottled kankary clay & marl bands. The clay contains concretions & pebbles / boulders	<i>Physa</i>	
159 09-	Cherty white chalky limestone with lenses of chert	Mainly small invertebrate shell debris, algal growth & oncolites	
153 63-	Fine laminated ash	Vertical and inclined burrows	
140 07-	Reddish limonitic layer with very high Ir/Os values	(?) Planktonic foraminifera, abundant gastropods & bivalves shell debris, algal bands, spores & wood	
123 63-	Greyish chocolate shale		
90 90	Basaltic debris and black fossiliferous shale with lenses of limestone/marl	Dinosaur bones & burrows	
49 10-		Avian egg shells, Chara, tiny shells and fossil wood of various types- dicot and monocot, dinosaurian teeth	
47 30	Fragmental marl and limestone	Dinoflagellates, cysts & pollen spores (Palmae)	
0 00-	Dirty white limestone	Mostly with charophytes and oncolites	
	Black fossiliferous shale with few chert layers in the basal part	Charophytes and oncolites	
		Prolific vegetal carbon wood, invertebrate debris, charophytes and fish scales	

IIIrd Intertrappean bed

Section	Lithology	Important Fossils	Zones
	Olivine basalt (F4) Black soil with weathered basalt fragments Kankar (concretions) with sandy & basalt clasts. Concretions - calcareous and gypseous clay Grey fossiliferous shale Cherty limestone with gypseous layers Brown and grey fossiliferous shale with gypsum Alternating sequence of fossiliferous shale & lensoidal limestone Brown chocolate coloured shale with lensoid bodies of limestone Thickly bedded limestone with thin intercalations of shale Brown chocolate coloured fossiliferous shale with prolific fossils Intercalated sequence of grey shale with lensoid bodies of brown shale & lenses of algal limestone Cherty limestone with trap boulders Black clay/ muddy soil with boulders of trap Grayish white fossiliferous shale Black fossiliferous shale with lenses of (White) mottled clay White mottled limestone with black nodules Blackish white mottled compact marl with ferruginous encrustation Sequence of blackish mottled kankary clay & marl bands. The clay contains concretions & pebbles / boulders Cherty white chalky limestone with lenses of chert Finely laminated ash Reddish limonitic layer with very high Ir/Os values Greyish chocolate shale Basaltic debris and black fossiliferous shale with lenses of limestone/marl Fragmental marl and limestone Dirty white limestone Black fossiliferous shale with few chert layers in the basal part	Algae, Oncolites, (Angiosperm) spores/pollens Algae, Chara, Mammalian bones Fossil plants Girvanella, Oncolites Charophytes, fossil plants (wood) Lamellibranchs & gastropods (mainly Physa) Egg shell - avian, Physa Egg shell- avian & crocodilian, Physa Rhisome, charophyta Physa Geckoid egg shells, bivalves Physa lamellibranchs, Charophytes geckoid & avian egg shells, Girvanella oncolites Physa charophytes Egg shell fragments Charophytes Profuse Physa & other invertebrates, oncolites, Girvanella chara & wood Charophytes, Oncolites Egg shells (crocodilian affinity), affinity), oncolites, algal mats, invertebrate shell debris Physa Mainly small invertebrate shell debris, algal growth & oncolites Vertical and inclined burrows (?) Planktonic foraminifera, abundant gastropods & bivalves shell debris, algal bands, spores & wood Dinosaur bones & burrows Avian egg shells, Chara, tiny shells and fossil wood of various types - dicot and monocot, dinosaurian teeth. Dinoflagellates, cysts & pollen spores (Palmae) Mostly with charophytes and oncolites Charophytes and oncolites Prolific vegetal carbon. wood, invertebrate debris, charophytes and fish scales	

Biozones:

1. Dinosaurian Fossil Zone
2. Dinosaurian / Avian / Geckoid Eggs Zone
- 2A. Crocodilian / Avian Eggs Zone
3. Gymnosperms - Ferns and other plants Zone
- 3A. Ferns - Gymnosperms Zone
4. Planktonic Forams Zone
5. Angiosperms - spore / pollens Zone
6. Fish Scale Zone
7. Charophytes / Oncolites / *Girvanella* zone
8. *Physa* Zone

X.4. SECOND INTERTRAPPEAN BED:

This horizon is mainly composed of yellowish sandy clays, bentonitic clays, dirty white calcareous sandstone, porcellanite ash and greenish black fossiliferous shales and contains dinosaurian bone fossils; fossil wood; invertebrate fossil shells, dinosaurian egg shells and algal remains.

II nd Intertrappean Bed

Section	Lithology	Main Fossils	Zones
	Olivine bearing basalt flow		
	Yellow concretionary calcareous sandstone & ferruginous sandstone.	Dinosaurian bones, Ophiomorpha burrows and fossil wood	
	Bole in the lower part		
	Greyish green volcanoclastic bed with pyroclastic material with feldspar clasts, lapilli and lava droplets. Contains conc. structures & Ophiomorpha	Contains concentric Ophiomorpha burrows common in base and top	
	Thin lenses of limestone with invertebrate fossils	Invertebrates, stromatolitic growth, charophyte and blue-green algae	
	Laminated shale and ash with porcellanites, banded chert with basal sandy clays and bentonitic clays	Dinosaurian bones, eggs and fossil wood (dicot and monocot) Prolific small gastropods	
	Basal Flow - 2		

Biozones:

- 1 Charophytes and blue green algae.
2. Dinosaur fossils - bones and eggs
- 3 Invertebrates - gastropods and bivalves (in upper)
4. fossil wood (Angiospermous)

X.5. BASAL INTERTRAPPEAN BEDS:

The basal intertrappean bed comprises white feldspathic, indurated volcanoclastic sandstone and variegated sticky sandy and bentonitic clays, ash and volcanoclastic material. No major fauna or flora have been found from them. The biozonations are summarised in the table given below:

Basal Intertrappean Beds:

Section	Lithology	Important Fossils	Zones
	Greenish grey coarse porphyritic basalt with basal chilled altered zone		
	Alternating red and yellow layers in the basal part		
	Dominantly sandstone burrowed.		
	Green glauconitic and reddish sandy clay with rhizomes in marly layers		
	Greyish and reddish sticky burrowed clay in alternation with green loose friable sands		
	Marly layer - pinkish chocolate coloured sticky clay.	Dinosaurian and other reptilian bones.	
	Marly layer about 1 - 2 cm (marly layer)		
	Chocolate coloured (upper 10-12cm)		
	Greenish grey mottled (lower 20cm)		
	Burrowed sandy clay		
	Purple coloured ocherous layers with mottling (ML)		
	Green grey marly horizon with ostracodes, charophytes, physa, bivalves, crinoid stems		
	Green and pink coloured sandy burrowed clay with yellow marly layers containing physa and bivalves		
	Reddish burrowed sandy clay		
	Yellowish green glauconitic sandy clays red sand is marly intercalations.		
	Oncolites common, gymnosperms plants.		
	Unconformity		
	Mesozoic Bhuj Formation		

In the Dayapar section the flow I, II and intertrappeans 1 and 2 are exposed near Kora and Khannot but better sections of intertrappean 2 (above section) is exposed near Dayapar due to overlapping relationship with upper Member sandstone; hence this section was sampled. The horizons above the glauconitic sandstone of Mesozoic rests with distinct unconformity exposed in form of erosional contact - and hard ground expressed with extensive burrowing and cavernous nature of the contact. The sequence above this burrowed sandstone contain abundant ostracodes, charophytes, Crinoid stems and physa and other invertebrates zonation within different units as shown above. The dinosaurian bone bearing horizon is confined above these zones. The physa zonation shows some overlapping with

ostracode, charophyte, caytonials and dinosaurian bone beds, but after that it is not found. Only annelid burrows are confined to clays, sandy and marly zones. This may be due to comparatively higher rate of sedimentation in the upper part of the section where marly sand and sandstone with intervening clays have developed.

X.6. STRATIGRAPHY:

The stratigraphy of Events in Anjar area, based on the lithostratigraphy, biostratigraphy, magnetostratigraphy and geochemical and geochronological studies are given below :

X.6.1. Lithostratigraphy:

The major lithostratigraphic units are already described under geological studies (Chapter-V). Major lithostratigraphic units as already dealt are summarised below :

Age	Formation		Lithounits		Important Fossil
Recent	Subrecent		Alluvium, Sand-silt		
Quaternary	Miliolitic Limestone		Stratified and bedded calcarenite, Boulder bed		Miliolida
Pliocene	Antarjal		Calcareous sand stone, silt stone, Lateritised reworked bed.		Avian eggs, Invertebrates Pelecypods, Vertebrate bones
Miocene	Mandaviya		Clay, shales and silt stone		Plant fossils, logs Vertebrates
Eocene to Palaeocene	Matanamadh		Laterite, bauxite, kaolinitic clay, bentonite, lithomarge		
Uppermost Palaeocene	Anjar Formation	Kutch Traps	Upper flows	Compound F1 Lava flows with inter-trappeans F5	Foraminifers, Plantdebries, Algae
K.T.B	Anjar		Basal	Lava flows F4	Avian eggs, Physa,
Maestrichtian	volcanics		Volcano sediments	and associated sediments-F1	Angisperms dinosaurs, fish
Maestrichtian	Bhuj	Upper Member	Sandstones, shales, clay, ironstones conglomerate		Dinosaurs, Upper Gonwana plants
Middle to Lower Cretaceous		Lower Member	Sandstone, shales ironstones, ochreous bed, burrowed sandstones		Dinosaur foot tracks Upper Gondwana Plants
Lower Cretaceous to Up. Jurassic	Kat-rol	Up. Member	Calc. sandstones, siltstones, shale ochreous beds		Upper Gondwana plants dinosaur tracks, bivalves

The lithostratigraphic description of units has already been dealt at length under chapter on geological setting of the area.

X.6.2. Biostratigraphy, Magenatostratigraphy and Geochrono- stratigraphy:

The detail biozonations of different units are dealt in detail under sub-chapter on biostratigraphy of intertrappean beds. The overall biozonation identified are summarized below. The biochronological appearances and range of forms/groups are given in a Table given below vis-a-vis the comprehensive stratigraphies including magnetostratigraphy, geochronostratigraphy and geochemical events. The important biozonations identified are as follows :

Sl. No	No.	Biozone	Important Forms /Group of Fossils
9	9	Crocodylian/ Avian egg zone	Crocodylian, avian eggs and dinosaurian eggs(interogation of avian characters).
8	8	Foraminifera zone	Globigerina, G.eugubina, Trochomania, Palaeotaxtularia, Virgulinella, angiosperm spores, gymnosperm spores, Azola primaeva, Mancicarpus sp.
7	7A	Dinoflagellate	Lycopodium scariosum
	7	Angiosperm pollen	Angiosperm pollen seeds zone, wood, fruits
6	6	Fern-Gymnosperm	Spores of gymnosperm effinity, Azolla, Caytonia, Mancicarpus
5	5	Physa	Physa bullinus, and other forms
4	4	Charophytes/Oncolites Girvinella	Charophytes of different types ostracods, girvinella
3	3	Fish scale zone	Fish scales and otoliths
2	2A	Avian egg zone	Different types of egg shells
	2	Dinosaurian/Avian (2A) Geekoid eggs	Different types of egg shells
1	1	Dinosaur fossil zone	Different type of dinosaur fossil and skeletal parts.

The magnetostratigraphy, geochronostratigraphy and geochemical aspects are dealt under each one separately, elsewhere.

BIOSTRATIGRAPHIC ZONATIONS OF SECTIONS IN KUTCH
ANJAR SECTION - INTERTRAPPEAN BED NO. III

Sl No	Probable age	Biozone	Main	Elements	Subordinate	Corresponding lithozonations	Probable Environments	Remarks/Explanation to abbreviations & symbols
		WEATHERED	BASALT	FLOW-3	F-3			
1		Angiosperm Zone-I	Spore Pollens SP (Angio)	Algae (Al) oncolites (OS)		Black and reddish clay Black clay and laminated chert	Very shallow drying lacustrine under temperate tropical to sub-tropical climate with subaerial exposures	FS = Fish scale P = Physa C = Charophyte D.B = Dinosaur bone D.E = Dinosaur egg A.E = Avian egg Cd.E = Crocodilian eggs G.E = Gecko egg M.B = Mammalian bone Pt = Plants P.M. = Plants monocotyledons P.D. = Plant dicotyledons Al = Algae OS = Oncolite CO = Coccolith Pt.A = Plants angiosperm Pt.Gy. = Plants Gynnosperms Al.Ge = Algae Gervinella D.C. = Dinoflagellate cyst Cy = Cycades F = Forams P.Cy = Plants Caytonia
2	P A L A E	Angiosperm Zone-II	Spore pollens SP (Angio)	Algae (A), Chara (C), Mammalian bones (MB)		Burrowed black clay marl and limestone laminated (algal) chert with white limestone and gypsaceous black mud	shallow brackish lagoons in temperate semi-arid conditions with drying algal mats (Semi arid temperate)	
3	O C E N	Physa & Charophyte zone	Physa (P), Chara (C), Fish Scale(FS)	Avian egg (A.E) Bivalves (B.V), A. Os.		Alternations of greyish to dirty white fossiliferous limestone and black mud/shales with gypsaceous partings Highly fossiliferous shales	-do- (with algal mats) extensive calcritisation and subaerial exposure	
4		Charophyte Zone	Charophytes(C) Caytonia (P.Cy-Gyn)	Invertebrate shells, plants(Pt)		Black shale with lense of chocolate coloured lacustrine shales, black & grey laminated and banded chert lenses, ash and ocherous indium containing nodules marl and cherty limestone	Shallow lacustrine (seasonal) Temperate seasonal to brackish water with frequent sub-aerial exposures and calcritisation	
5		Angiosperm Zone-III	Mega plants- Angio (PT.A) PD, PM. Gynnosperm (Pt.Gy), Araucarie Cycades (Cy) Algae-Gervinella Ostracodes (O)	Algae invertebrate shells (I.S), forams (F), Dino Egg (D.E.), Avian egg(AE), Cd.E Os Coccoliths (Co)				

6	C M	Dinosaurian	B.R. 3-----	Iridium Layer - 3-----	B.R. 3-----	=	P.A	Plants Araucarites
	R a	Dinosaurian bones (D.B.) D.E.	Plants Pt. Gy. P.Cy.	Brown and black shale	Shallow seasonal lacustrine		F.Sk.	Fern spikes
	E c	Bone Bed	P.A.Cy.	Ash and tuffaceous layer			Al oz	Algae azolla
	T s						O	Ostracodes
	A t	Zone	B.R. 2-----	Iridium layer - 2-----	-B.R. 2-----		M.T	Micromammal teeth
	C r		Dinosaurian eggs (D.E.)	Chara (C)	Black shale, grey shale alternating with each other		B.N.	Annelid burrows
	E i		Invertebrate shale (I.S.)				C.M.s	Caytonia and Megasporophylls
	O c		Fern spikes (F.Sk).				C.V.	Chelonian
	U h						C	Carapace
	7	O t		B.R. 1-----	Iridium layer - 1-----		B.R. 1-----	B.V.
S i		Charophyte/	C.F.S., A.E., G.E.	Micromammals (MT)	Nodular lensoid marls and limestone banded chert	A.B.	Avian bones	
a		Gymnosperm II	Algae (Azolla)	Al. Os. Co. Al oz.	weathered altered basalt fragments	T	Teeth (Dinosaur/fish)	
n		Plant Bed (Palmae)	Os. Co. Pd. DM. (PD)	F.S. Wood fragments		C.arb.	Carbonaceous	
		(PM)	C.I.S. D.Ct. Dino.			Pt	Plant	
		Chara			Black fossiliferous shales with lensoid chert bands. fragments of basalt			
					Shallow seasonal lacustrine			
WEATHERED BASALT			FLOW-3	F-3				

NOTE. The charophytes, Fern spikes layer, the angiosperm pollen spores, dinoflagellate cysts, Azolla algae and ferns are considered as basal most Palaeocene/uppermost Maestrichtian elements and accordingly K/T boundary is tentatively placed at a level slightly above the basal Iridium (BR-1) layer.

BIOSTRATIGRAPHIC ZONATIONS OF SECTIONS IN KUTCH BIOSTRATIGRAPHIC ZONATION OF DAYAPAR

Probable age	Biozone	Main	Elements	Subordinate	Corresponding lithozonations	Probable Environments
I n t T P E A R L A A I E A O R C Y E N E a n	Burrow Zone	Annelid Burrow(BN)	Rhisomes Annelids		Sandstones, sandy with green glauconitic sandy layers, with marly intercalations at top and base	Seasonal stream channels over bank clays
	Dinosaurian Bone Bed	Burrows (BN) D.B Chelonian vertebrae, carapace (C), Boidean vertebrae (B.V) and avian bones(AB)	Dino Teeth(T) and Shell (DE), fragments, PTL, BN, T		Chocolate coloured mottled sticky clays	Channel / pool deposits and over bank clays-shallow lagoon
V M o U a l P e c s M P s a e E E t n d S R r o i O i m Z C c e O R h n I E t C T i a A a r C n y E	Ostracode	Ostracode (O)	Caytonia		Basal Greenish grey mottled, marly layers and burrowed sandy clays at top.	Lacustrine
	Charophyte	Charophyte(C)	megasporephyll (C.M S) P, IS, T			
	Zone	Oncolites(Os)				
N.B.	Physa	Physa (P)	Palludina, lymnea-		Pink coloured marly bands with minor short dry spells, burrowed sandy clays	Lacustrine, interchannel and over bank clays - intermitant channel deposit
	Annelid	BN	Cyprea, (I S.)			
	Burrows	Charophytes(C)	charophytes(C); Burrows			

Stratigraphic Unit	Approx. Age (Ma)	Approx. Depth (m)	Approx. Thickness (m)	Approx. Lithology	Approx. Fossil Content	Approx. Facies
O.U.S.	2.5	0	10	Green glauconite sandy clay with maroon coloured sandy burrow		Bar deposits,
J	2.0	10	10	Yellowish marly horizons		
F	1.5	20	10	-Alternating maroon and green glauconitic sands, silt and sandy clays, ocherous nodular bed at base with channel filled structures		Flat and bar deposit
O	1.0	30	10			
R	0.5	40	10			
M	0.2	50	10			Channel fill
A	0.1	60	10			
T	0.0	70	10			
I	0.0	80	10			
O	0.0	90	10			
N	0.0	100	10			
Disconformity						
Burrow B.N	0.0	110	10	Ocherous nodular band with yellowish nodules in two layers		
Plants	0.0	120	10			
Gymnosperm Plants	0.0	130	10			
Burrows(BN)	0.0	140	10	Alternating sequence sandstone sandy clays, black carb shales, with Plant fossils		