CHAPTER - 3
STRATIGRAPHY OF THE STUDY AREA

3.1 INTRODUCTION

Kachchh basin preserved an excellent geologic record of the Mesozoic, from Middle Jurassic to Early Cretaceous in the form of stratified rocks. The unique stratified rock unit, body fossils and trace fossils serve as an important tool to decode past geological events. This Mesozoic successions are well developed and exposed in disconnected high grounds which include Kachchh Mainland, Patcham Island, Khadir Island, Bela Island, Chorar Island and Wagad Highland. Based on the uniqueness of the rock types, patchy outcrops and its lithological discontinuities led to difficulty in correlation from one sub-basin to another sub-basin. Hence a separate lithostratigraphic unit names are proposed by Biswas (1971, 1977, 2016).

The northern part of the Kachchh basin exposes the oldest sequence from Aalenian? Bajocian to Oxfordian in the northern and easternmost Islands viz. – Patcham, Khadir, Bela and Chorar, collectively referred to as the 'Island Belt Zone'. The study areas which include Khadir, Bela and Chorar Islands are broadly classified into two formations namely Khadir and Gadhada formations. Coralline limestone at the top of the Khadir Formation is prominent in all the islands and serves as the marker bed for stratigraphic correlation. Revised classification of the eastern Kachchh is also proposed by Fürsich et al. (2001) which was later modified by Biswas (2016) incorporating the acceptable modification in accordance with the stratigraphic norms. This latest lithostratigraphic classification proposed by Biswas (2016) is used in the present study.

The detailed description of the newly adopted members and formations is lacking hence an attempt is also made to describe the detailed lithostratigraphic units following Biswas (2016) lithostratigraphic classification scheme. A mixed siliciclastic-carbonate classification proposed by Mount (1985) and carbonate classification proposed by Dunham (1962) is adopted to access the lithology.

The Khadir Island is characterized by ~692 m Middle Jurassic succession comprising of clastic, non-clastic and mixed siliciclastic-carbonate components and are exposed in Cheriya Bet in the north, Khadir Island and the Kakinda Bet in the south. Both the formations, Khadir and

Gadhada are well exposed across the Khadir Island from Cheriya Bet in the north and Kakinda Bet in the south. The Mesozoic succession of Bela Island comprises ~216 m clastic, non-clastic and mixed siliciclastic-carbonate sediments belonging to Khadir and Gadhada formations of Bathonian and Callovian ages respectively. The succession shows wide vertical and lateral lithological variation and the limestone with the conglomeratic limestone at the top of the Hadibhadang sandstone Member serves as a marker bed for correlating the lithology. The Middle Jurassic succession of the Chorar Island is exposed in discontinuous and isolated patches and comprises a ~109 m thick succession of Hadibhadang Shale and Hadibhadang Sandstone members of Khadir Formation and Ratanpur Sandstone Member of Gadhada Formation (Patel et al. 2018). The thickly bedded coralline limestone at the top of the Khadir Formation serves as the marker bed for stratigraphic correlation. The oldest Cheriya bet conglomerates and the lower part of Hadibhadang shales members of Khadir Formation and the upper part of Ratanpur Sandstone and Bambhanka members are not exposed in the Bela and Chorar Islands.

3.2 REVIEW OF MESOZOIC STRATIGRAPHY

The continuous Mesozoic record in the form of rock strata, abundant body fossils, and trace fossils along with its interesting basin dynamics of the Kachchh basin attracted many geologists across the globe. The report on ‘Geology of Kachchh’ by Grant (1840) may lay the foundation of future geological research, however, the stratigraphic study of the basin was initiated by Stoliczka’s field diary of 1867 which was later published by Waagen (1871) where he divided the exposed Mesozoic succession into Pachham, Chari, Katrol and Umia. Waagen (1875) formalized Stoliczka’s classification based on ammonite fossils assemblage and correlate it with the European zones for chronology. Thus, this led to the development of chronostratigraphy. In Waagen’s classification, the Pachham, Chari, Katrol and lower part of Umia corresponded with the “Lower Series” and the upper part of the Umia with the “Upper Series” of Wynne (1872) who divided the Mesozoic succession into ‘lower’ (marine) and ‘upper series’ (non-Marine) deposits. His classification does not include non-ammonite bearing horizons, Island Belt Zone and Wagad Highland. It also lacked proper use of stratigraphic ranks, (Biswas, 2016).

Rajnath (1932) modified Wagen’s classification by retaining the Pachham, Chari, Katrol, Umia (in a restricted sense) and introduced the ‘Bhuj Series’ based on detailed stratigraphic and

paleontological studies. He restricted ‘Umia’ to only ‘Lower Umia’ of Waagen and considered the upper non-marine beds with plant fossils as the Bhuj series. His classification lacks the use of suffixes except for the ‘Bhuj series’. Subsequently, Pascoe (1959) and Krishna (1968) formalized the classification by replacing the suffix ‘Group’ of Waagen by ‘series’. Agrawal (1957) attempted modification of the stratigraphic nomenclature by giving importance to the type section thereby replacing Chari by Habo Series and Dhosa oolites by Mebha Oolites. However, his studies were based on localized studies and do not reflect the basin as a whole (Biswas, 2016).

Poddar (1964) modified Rajnath’s (1932) chronostratigraphic classification by replacing the suffix ‘series’ with ‘formation’ without any redefinition of the stratigraphic unit while upgrading the Ukra beds to formation. Krishna (1987) modified Rajnath’s (1932) and Poddar’s (1964) classifications by reinstating the four-fold classification and retaining the age of Arkell (1956) which was published in his book ‘Jurassic Geology of the World’. The four-fold classification however lacks proper mapping, the definition of stratigraphic units, unit boundaries, stratigraphic units based on ammonite assemblage rather than lithology and little to no attention was paid to sediment deposited in the sub-basins like the Island Belt and Wagad Highland (Biswas, 2016). Hence the four-fold classification remained informal with respect to the International Code of Stratigraphic Nomenclature (Hedberg, 1972, 1976) until a detailed mapping of the Kachchh basin on a 1"=1mile scale was undertaken by a team of geologists from ONGC for hydrocarbon exploration.

Biswas (1971, 1977) formally presented *sensu stricto* lithostratigraphic classification of the entire Kutch Basin for the first time based on the detailed mapping, surface and subsurface studies. He proposed a separate classification for Kachchh Mainland, Patcham Island, and Eastern Kachchh citing the high variation in the lithologic characters and difficulty in direct correlation. The detail of the Mesozoic stratigraphy is tabulated and described in Chapter 2. Meanwhile, Krishna. (1987), Krishna et al. (2009) strongly argued for the retention of the old nomenclature by replacing the suffix ‘series’ with ‘formation’ but lacks a designated stratotype and is supported by the formal description of the litho-unit. Pandey and Dave (1998) proposed a chronostratigraphic classification based on foraminiferal biostratigraphy. Fürsich (2001, 2014) reconstructed the stratigraphic classification by adopting the basic framework of Biswas (1971, 1977) while retaining the old nomenclature (Waagen,1875; Rajnath, 1932). He correlated the whole basin by identifying marker beds, identifying new members and elevating

Gadhada Member to the formation. This classification is supported by detailed paleontological and ichnological data. Biswas (2016) updated his classification by incorporating the subsequence changes which are in accordance with the International Code of Stratigraphic Nomenclature which will be followed in this work.

3.3 KHADIR FORMATION

Khadir Formation comprises ~307 m thick clastic, non-clastic and mixed siliciclastic carbonate succession ranging in age from Aalenian/Bajocian to early Oxfordian. The Khadir Formation is subdivided into Cheriya Bet Conglomerate, Hadibhadang Shale and Hadibhadang Sandstone members. Khadir Island and the neighboring islets viz Kakinda Bet and Cheriya Bet serve as the type section for the Khadir and Gadhada formations. The oldest member, Cheriya Bet Conglomerate exposed in a small islet called the Cheriya Bet; Hadibhadang Shale and Hadibhadang Sandstone members are well exposed in the northern scarp; Ratanpur sandstone Member is well exposed in the southern slope of the Khadir Island and Bambhanka Member is well exposed in the southernmost part of the Island, a small islet called Kakinda bet.

3.3.1 Cheriya Bet Conglomerate Member

The name Cheriya Bet is derived from the small islet (type section) in the north of Khadir Island where polymictic conglomerate is mono dominantly rock type is exposed all along the Islet. Cheriya bet succession is 42 m thick characterized by abundant reworked materials of the basement, cross-bedded, poorly sorted conglomeratic to fine grain with fining upward sequence (Plate 3.1a). The clast mainly consists of pink, brown to black pebbles and cobbles of granites and syenites (Plate 3.1d and e). The pebbles and cobbles are angular and faceted suggesting to have been dumped together after a very short distance of transport. This member is characterized by very coarse grain, pebbles, cobbles and occasional boulders of granite, syenites and basic rocks forming polymictic conglomerate with a decrease in grain size toward the top of the member where it is replaced by micritic sandstone which shows crude stratification (Plate 3.1 b and c) and planar lamination. The conglomerate occurs as pockets or lenses in a poorly stratified cross-bedded sandstone and the occurrence of clay materials is also observed. This member is not exposed in Bela and Chorar Island.

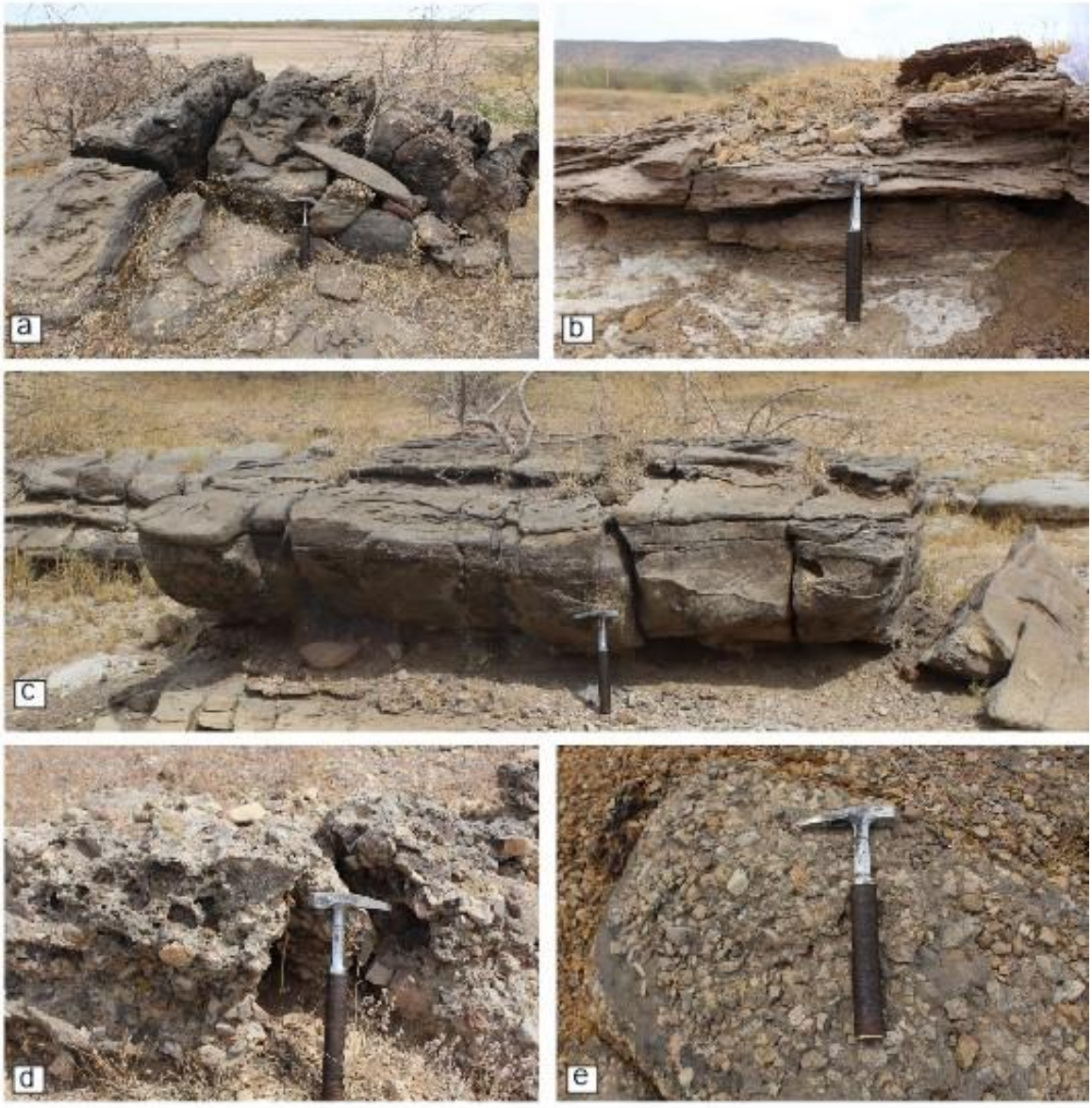


Plate 3.1 Field photographs of the Cheriya Bet Conglomerate Member of Khadir Formation. A. Steeply inclined sandstone showing fining upward sequence with conglomerate at the base. (b) thinly laminated ferruginous sandstone (c) Conglomeratic sandstone showing with planar and cross-stratification (d) and (e) lumps of a polymictic clast-dominated conglomerate.

3.3.2 Hadibhadang Shale Member

In Khadir Island, Hadibhadang Shale Member is observed at the foothills of the north-facing scarp of the Khadir Island and comprises of ~180 m thick shale dominated succession intercalated with thickly cross-bedded micritic sandstone (Plate 3.2a, b and c) with thin bands of bioclastic packstone/grainstone and sandy allochemic limestone belonging to Bajocian age. This member shows wide lateral facies variation where it is more argillaceous in the east intercalated with thickly bedded micritic sandstone while it tends to be more arenaceous

towards the west. Shale and sandstone interfinger with one another marking the lateral facies variation. The thickness of the micritic sandstone increases at the western tip of the island with prominent cross-bedding and contains large wood fossils with palaeo-channel (Plate 3.2d). The sandstones are generally greyish in colour, friable, and very fine to coarse with abundant polycrystalline quartz grains. It often contains pockets or lenses of intraformational conglomerates which are the reworked sediments from the older member. The shales are siliceous and frequently gypseous in nature and the colour varies from grey to brownish red. The shale beds contain thin bands of bioclastic packstone/grainstone with abundant *Turritella* body fossils towards the top of the member. This member witnessed wide lateral facies variation with interfingering of micritic sandstone and shales as well as an increase in argillaceous content from west to east within the Island. The western part of the island is dominated by thickly bedded, friable, cross-bedding micritic sandstone containing the huge log of wood fossils while the eastern part of the Island is dominated by shale intercalated with bedded micritic sandstone. The top of the member is marked by a facies transition from argillaceous shale to thick micritic sandstone.

In Bela Island, Hadibhadang Shale Member is exposed at the base of the north-facing scarp. It is shale dominated succession and comprises 46 m thick, with intercalations of packstone and micritic sandstone (Plate 3.2e). In the Muwana dome, the shale succession is greyish to purple in colour and is exposed at the core where it is intruded by igneous.

In Chorar Island, the base of this member is not exposed but upper contact with the overlying Hadibhadang Sandstone Member is conformable and easily distinguishable by the contrasting lithology of dirty yellow to brownish coloured sandy allochemic limestone. The Hadibhadang Shale Member is exposed in arcuate shape scarp facing towards the village Avaal (Plate 3.2f) and well developed on the northern side where it attained a maximum thickness of about 23 m and mainly comprises of intercalated yellowish to greyish coloured gypseous, laminated shale with buff-coloured cross-bedded micritic sandstone. The shale is very thick, loose, fissile, structurally disturbed and followed by intense weathering; many laminations of shales grades into millimetres thick siltstone layers which are calcareous in nature. Micritic sandstone is brown and grey coloured, hard, compact in the lower part and pink to brownish, thick massive and cross-, current bedded in the upper part. The whole unit is poorly fossiliferous in nature and hard micritic sandstone comprises various types of biogenic sedimentary structures.

Plate 3.2 Hadibhadang Shale Member of Khadir Formation. (a) Ferruginous Shale is exposed at the foothills of the north-facing scarp of Khadir Island. (b) Cross-bedded micritic Sandstone at the base of the north-facing scarp of Khadir Island. (c) Close up view of the micritic sandstone showing cross-bedding and liquefaction structure. (d) Micritic sandstone with palaeo-channel in the western tip of Khadir Island (e) Hadibhadang Shale Member exposed at the northern tip of Bela Island. (f) Hadibhadang Shale Member exposed at the core of an elliptical dome near Aaval village in Chorar Island.

	Age	Formation	Member	Khadir	Bela	Chorar
Jurassic Period	Oxfordian (161-156 m.y.)	Gadhada Formation	Bambhanka	195 m	Not Exposed	Not Exposed
	Callovian (155-161 m.y.)		Ratanpur Sandstone	190 m	138 m	55 m
	Aalenian-Bathonian (176-165 m.y.)	Khadir Formation	Hadibhadang Sandstone	85 m	79 m	31 m
			Hadibhadang Shale	180 m	46 m	23 m
			Cheriya Bet Conglomerate	42 m	Not Exposed	Not Exposed
			Basement	Not Exposed		

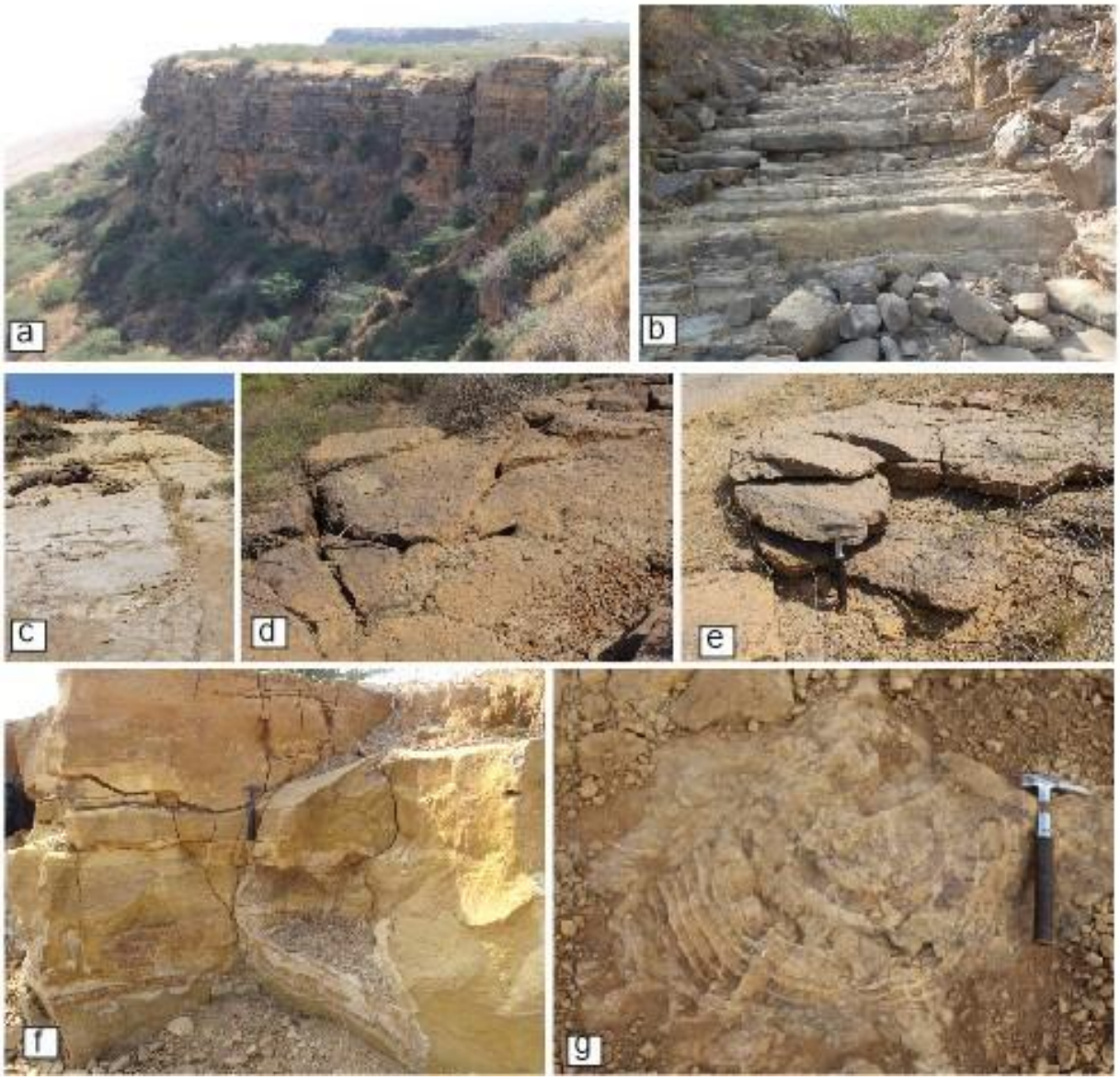
Table 3.1 Stratigraphy of the Khadir, Bela and Chorar Islands with the corresponding thickness of each member.

3.3.3 Hadibhadang Sandstone Member

The Hadibhadang Sandstone Member is coeval to Gadaputa Sandstone and Raimalro Limestone members of Goradongar formation of Patcham Island and Member 'F' and 'G' of Jhurio Formation of Mainland Kachchh and belongs to Bathonian in age (Biswas, 2016). The Hadibhadang Sandstone Member of the Khadir Island forms north-facing vertical cliff where maximum thickness is exposed along the Hadibhadang Pir which is the type section of the member. It comprises ~85 m clastic and non-clastic deposits belonging to the Bathonian age.

Thick grey friable micritic sandstone showing gradation from shales to sandstone marks the base of the member overlain by thick yellowish micritic sandstone. This micritic sandstone is cross-bedded, fine to coarse grain in nature with pockets/lenses of the polymictic conglomerate. The carbonate component increases towards the top and grades in bioclastic/pelloidal packstone. The top of the member is marked by thinly bedded pelloidal packstone with cherty noodles which is a facies variant of the Raimalro Limestone Member of Patcham Formation (Fürsich et al. 2001) or Goradongar Formation (Biswas 2016). The argillaceous component

within this member is negligible in the west till the Hadibhadang Pir which is the type section while it increases towards the east. The carbonate content also decreases towards the western tip of the island and increases in the siliceous content.



Plates 3.3 Hadibhadang Sandstone Member of Khadir Formation. (a) Panoramic view of the north-facing scarp of Hadibhadang Sandstone Member of Khadir Formation in Khadir Island. Micritic sandstone at the base of Hadibhadang Sandstone Member in Khadir Island. (c) Thickly bedded micritic sandstone is exposed on the banks of the north-flowing Lelagar river in Bela Island. (d and e) Hard limestone at the top of micritic sandstone marked the top of the Hadibhadang Sandstone Member in Bela Island. (f) Sandy allochemic limestone with well developed (e) corals at the top of the member in Chorar Island.

The Hadibhadang Sandstone Member of the Bela Island is characterized by 79 m thick arenaceous succession of Bathonian age. It is dominated by thickly bedded micritic sandstone (Plate 3.3c) with the negligible argillaceous unit and capped by thinly bedded packstone with conglomerate containing granite and metamorphic pebbles (Biswas, 1993). This member, like the Khadir type section forms the upper part of the escarpment with hard limestone at top of the micritic sandstones (Plate 3.3d and e). The micritic sandstone is Characterized by greyish to pale yellow, thickly bedded and friable in nature with sedimentary structures such as cross-stratification and planar lamination. The succession is rarely bioturbated baring the base where few burrows of *Skolithos* are observed.

In Muwana Hill, the limestones are thickly bedded, yellowish, fossiliferous, and interbedded with calcareous sandstones. Cuesta slopes are formed by hard rocks in a sequence of shales, friable sandstones and limestones. This particular member is of the Bathonian age. This member is mainly comprised of micritic sandstone with packstone-nodular limestone and contains structures such as ripple marks, cross-bedding as well as trace fossils and bivalves as abundant body fossils. This member constitutes a thickness of about 78 m. Micritic sandstone which is the dominant lithotype shows bright yellow to dark brown colour and is friable, fine to coarse-grained, flaggy in nature, cross-bedded and planar lamination often truncated by sandstone dyke. The friable micritic sandstone is generally devoid of body fossils with few *Skolithos* burrows. Nodular limestone occurs at the top of the micritic sandstone. This rock is of pale-yellow colour, shows planar lamination and is of varying thickness. Petrographically, it is packstone dominated by allochems which are often dolomitized and cemented by micrite. In Chorar Island, Hadibhadang Sandstone Member of Callovian age is well preserved and best exposed amongst the other units within the island, exposed in an elliptical dome near Avaal village. It attained a maximum thickness of about 31 m and consists of recurring thinly to thickly bedded sandy allochemic limestone, sandy micrite and micritic sandstone intercalated with thin yellow calcareous shale and capped coralline limestone. The sandy allochemic limestone in this member is characterized by yellow to reddish, greyish to pale, bright yellow, dark brown to blackish colour, hard and massive rock. It is well developed in the upper part of the member where it attains 4-5 m thick (Plate 3.3f), hard compact, massive unit, while at the lower part it is intercalated with calcareous shales. A sandy allochemic limestone is highly fossiliferous in nature and contains abundant bivalves (*Trigonia, Gervilla*), brachiopods, algae, foraminifera and echinoid spines. Micritic sandstone appears as bright yellow and dirty yellow to dark brown in coloured, fine to medium-grained, hard, thickly bedded rock. It is fossiliferous

and consists of bivalves and gastropods with echinoid spines. It shows cross-bedding and various sizes and types of ripples at the top. Sandy micrite is hard, compact, massive, and devoid of physical and biogenic structure as well as body fossils. The thin layer of sandy micrite often contains alternating cross-bedding and planar lamination. Coralline limestone which is a facies variation of Raimalro limestone of Patcham Island (Biswas, 2003) marks the upper boundary of this member. It is 2.7 m thick, very fine-grained, dirty yellow, hard and bedded limestone (Plate 3.3f). It is highly fossiliferous and contains abundant, the large size of corals and a few fragments of bivalve shells. The intensity of the corals (Plate 3.3g) decreases laterally towards the northern part of the dome.

3.4 GADHADA FORMATION

Gadhada Formation comprises of 385 m thick succession which is subdivided into Ratanpur Sandstone and Bambhanka members belonging to Callovian-Oxfordian in age. This formation is sandstone dominated at the base and shows a gradual increase in the argillaceous content towards the top. Gadhada Formation was regarded as a part of Khadir Formation (Biswas, 1993), and later upgraded to the formation by Fürsich et al. (2001) with Gadhada and Bambhanka as the constituent members. However, Biswas, (2016) argues that the name of the formation and its constituent members could not be the same as per stratigraphic code. He, therefore, renamed Gadhada Member as Ratanpur Sandstone Member where the sandstone dominated succession is best exposed near Ratanpur village is considered as a stratotype. The renaming and assigning of the stratotype of Ratanpur Sandstone Member by Biswas (2016) lack a formal description of the member, hence a detailed description of the constituent members of the Gadhada Formation is given below.

3.4.1 Ratanpur Sandstone Member

Ratanpur Sandstone Member is equivalent to Modar Hill Formation of Patcham Island, Shelly Shale Member, and Ridge Sandstone Member of Jumara Formation of Mainland Kachchh (Biswas, 2016) and Chari Formation (Fürsich et al. 2001, 2013). This member shows great variation in lithology within the three islands viz. Khadir, Bela and Chorar. The Ratanpur succession in Khadir Island is characterized by 190 m thick clastic, nonclastic and mixed siliciclastic carbonate rocks. It was formerly described as Gadhada Sandstone Member (Fürsich et al. 2001) and redefined as Ratanpur Sandstone Member by Biswas (2016) forms the back slope to the southern part of Khadir Island (Plate 3.4a and b). It is best exposed in and around

Ratanpar village near Gadhada where the stratotype is assigned. This member extends from the eastern tip to the western tip of the Khadir Island and shows an increase in the argillaceous content from west to east. The Ratanpur Sandstone Member is arenaceous at the base mainly consisting of micritic sandstone which covers most of the back slope of the Island with few bands of sandy allochemic limestone. It is bioturbated at varying intensities and consists of a number of trace fossils genera, including *Imbrichnus, Laevicyclus, Ophiomorpha, Palaeophycus, Planolites, Protovirgularia, Rhizocorallium, Taenidium, Chondrites, Curvolithus, Lockeia,* and *Thalassinoides*. The micritic sandstone is yellowish to brown in colour with occasional cross-bedding and contains pockets/lenses of the polymictic intraformational conglomerate. The thickness of the bed decreases and becomes flaggy at times and intercalated with fossiliferous limestone bands. The upper part of the Ratanpur Sandstone Member is dominated by shales that are intercalated with thin bands of micritic sandstone, bioclastic packstone/grainstone, bioclastic grainstone, and peloidal wackestone/packstone along with sandy allochemic limestone. The shale dominated succession is mostly observed in the southern part of the island.

In Bela Island, the Ratanpur Sandstone Member constitutes a of thickness about 138 m and is the youngest Mesozoic succession exposed. It is characterized by shale dominated succession (Plate 3.4d) intercalated with micritic sandstone, mudstone (limestone), sandy allochemic limestone and allochemic sandstone. The micritic sandstones of this member are fine to coarse-grained, yellow to dark brown in colour, friable nature at places and flaggy at others. Sedimentary structures such as trough cross-stratification, cross-bedded, and thinly laminated are observed at places (Plate 3.4c). Its thickness varies from place to place. The allochemic sandstone is pale yellow to bright yellow in colour and occurs as is thickly bedded to thinly laminated and often intercalated with the shales and micritic sandstones. The sandy allochemic limestone band is also observed in few places and is thinly bedded, yellowish in colour and ferruginous at places due to the secondary alteration process. It also shows different types of ripple marks. It contains abundant trace fossils such as *Arenicolites, Didymaulichnus, Diplocraterion, Helicolithus, Hillichnus, Lockeia, Monocraterion, Ophiomorpha, Palaeophycus, Planolites, Phycodes, Protovirgularia, Rhizocorallium* and *Skolithos*. Bivalve is the only body fossil present in a few places. Mudstone is of greyish white to yellowish-white in colour and of varying thickness and and often intercalated with Shales. Ratanpur Sandstone Member in Muwana Dome comprises of ~70 m thick succession characterized by thick friable micritic sandstone underlain by shale at the base. The thickness of the exposed section greatly

varies from east to west where maximum exposure is observed in the eastern part of the dome. Corals are also observed in sandy allochemic limestone in the western part of Muwana Dome.

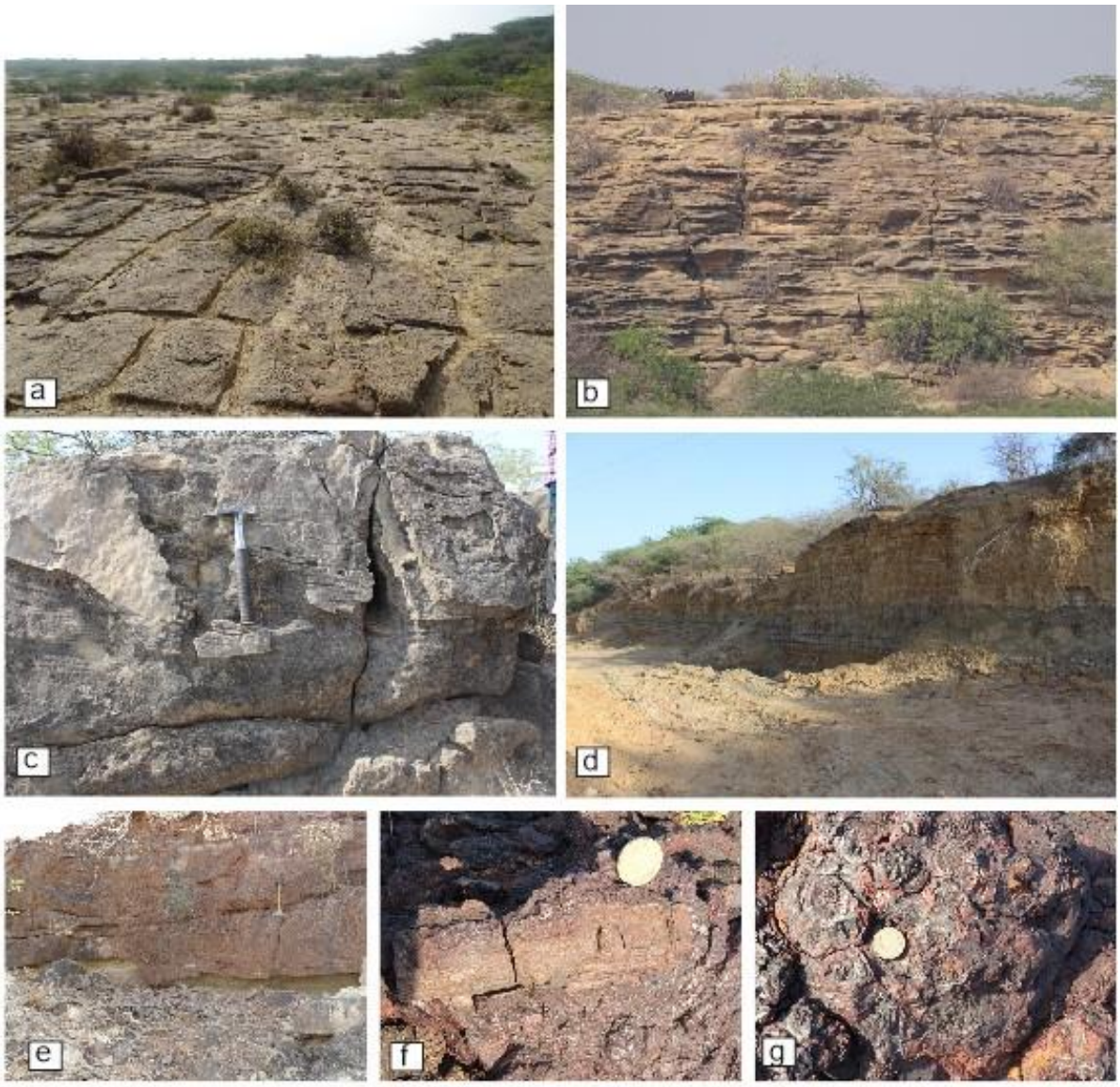


Plate 3.4 Ratanpur Sandstone Member of the Gadhada Formation. (a) Micritic sandstone forms the back slope of Khadir Island. (b) Vertical cliff section formed by fluvial erosion on the back slope of Khadir Island. (c) Thickly bedded, friable micritic sandstone with trough cross-stratification in Bela Island. (d) Thick shale succession of Ratanpur Sandstone Member exposed near Dhabda village. (e) Thickly bedded friable sandstone of Ratanpur Sandstone Member in Chorar Island. Ferruginous sandstone containing (f) fossils wood and (g) iron concretion in Ratanpur Sandstone Member of Chorar.

In the Chorar Island, Ratanpur Sandstone Member is the youngest member well exposed along the periphery of an elliptical dome near Aaval. It is about 55 m thick and mainly comprises shales, limestone (mudstone), allochemic sandstone, cross-bedded white sandstone and ferruginous sandstone. The base of this member is marked by intercalated shale and mudstone succession that overlain the coralline limestone of the Hadibhadang Sandstone Member. The shale is highly fissile, grey to dirty yellow coloured and grades to mudstone in the lower part which are a thin, hard, yellow in colour and contains bivalve shells while the upper part is intercalated with thinly bedded dirty yellow to brown colour allochemic sandstone. This sequence is overlain by thickly bedded, white coloured cross-bedded sandstone which is highly friable (Plate 3.4e) and devoid of body fossils. The succession is finally capped by 25 m thick rusty brown to black and reddish coloured ferruginous sandstone (Plate 3.4f and g) well exposed on south and southwest of the village Aaluvas (southern part of the Island). It consists of one to three bands of ferruginous sandstone which merge together from east to southern periphery of the island. The ferruginous sandstone is fossiliferous in nature and consists of gastropods, wood fossils and vertical and horizontal burrows.

3.4.2 Bambhanka Member

Bambhanka Member comprises of 195 m thick succession exposed only in a small islet called Kakinda Bet, south of Khadir Island and the southern tip of Khadir Island (Plate 3.5a). The islet is intensely faulted and is preserved as a half dome with beds dipping generally towards the west. This member is characterized by greyish gypseous shale at the base with thin bands of highly fossiliferous limestone. The gypseous shale is overlain by bedded, highly fossiliferous limestone containing ammonite, *Alectronia*, belemnites etc. with micritic sandstone which is bioturbated at varying intensities and consists of ichnogenera, including *Curvolithus, Didymaulichnus, Gyrochorte, Laevicyclus, Monocratereon, Ophiomorpha, Palaeophycus, Phycodes, Planolites, Protovirgularia, Rhizocorallium,* and *Skolithos*. The micritic sandstone becomes highly ferruginous (Plate 3.5b) at times with a conchoidal structure while at times very friable with abundant *Rhizocorallium*. The thickly bedded friable micritic sandstone is overlain by thick shale intercalated with thin bands of micritic sandstone often containing belemnites. The whole succession is characterized by 6-7 hard bands forming parallel ridges dipping towards the west.

Plate 3.5 Bambhanka Member of Gadhada Formation exposed only at the southern tip of Khadir Island and Kakinda Bet. (a) Sandy allochemic limestone at the southern tip of Khadir Island (b) Ferruginous sandstone containing abundant trace fossils. (c) Panoramic view of the hard bands forming ridges.