CHAPTER-II

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2.1 GENERAL GEOLOGY, STRATIGRAPHY, SEDIMENTATION HISTORY AND TECTONICS OF THE CAMBAY BASIN WITH SPECIAL REFERENCE TO BROACH DEPRESSION

The Cambay basin has been under continuous geological investigation by the Oil and Natural Gas Corporation, India since late fifties. The work commenced in 1957-58 when T.K.Roy and others mapped the areas east of Broach and recognised a number of stratigraphic units having potentials for the petroleum reservoirs. With this background, the first well drilled in the Cambay basin in 1958 proved great success and thereby accelerated the tempo of invetigations in surrounding localities. Eversince, information as gathered on the various aspects of the geology of Broach depression has been regularly stacked in the published and unpublished reports of the ONGC and in some leading Journals. This work thus accomplished on the Cambay Basin has immensely contributed to the understanding of the Regional Geotectonic and structural framework of the basinal development.

The geological, geophysical, litho- biostratigraphical studies undertaken clearly indicate that the sedimentation history of the Cambay basin is intimately associated with its tectonic framework. A brief review of all such overlaping aspects is,therefore dealt by the author in the following paragraphs.

As well known, the Cambay basin is a narrow elongated rift graben, running approximately in NNW-SSE direction. In the south of Son Narmada lineament, it takes a swing and aligns in NNE-SSW direction and finally merges into the Gulf of Cambay (Fig.1). On the northeast, it is flanked by the Aravalli swell, and on the west by the Saurashtra Craton. The Deccan Craton, having extrusive basaltic flows, lie to its east and south east. Early studies have postulated that this basin came into existance during

Late Jurrassic as evidenced by the presence of 700 m thick Dharangadhara sandstone (U.Jurassic) on the western margin (Mathur, et al, 1980). To date a few exploratory wells drilled by the UNGC within the basin have penetrated Mesozoic section leading support to this surmise. During Mesozoic period, the Cambay basin was genetically related to Kutch and Saurashtra towards the west. It is claimed that the son Narmada geofracture which was getting periodically rejuvenated has a substantial role to control the marine Mesozoic sedimentation especially in the vicinity of the down thrown side to the south of Geostructure. Structurally the entire Cambay Basin is divisible into five tectonic blocks based on the transverse fault system (Mathur et al, 1968). From south to north, they are :

1. Narmada Block.
2. Jambusar-Broach Block.
3. Cambay-Tarapur Block.
4. Ahmedabad-Mehsana Block and
5. Patan-Tharad-Sanchor Block.

NARMADA BLOCK

This block extends from Billimora (to the south of Tapti river to Narmada River in the north). The northern limit is the major transverse fault (Narmada geofracture) with down-throw towards north. The broad structural trend is parallel to the Narmada fault system (ENE-WSW)(Fig.1.3,2.2).

JAMBUSAR-BROACH BLOCK

This tectonic block is bounded by the Narmada River in the south, with its associated transverse fault system with down-throw towards north, and Mahi river to the north with another deep seated fault system with down

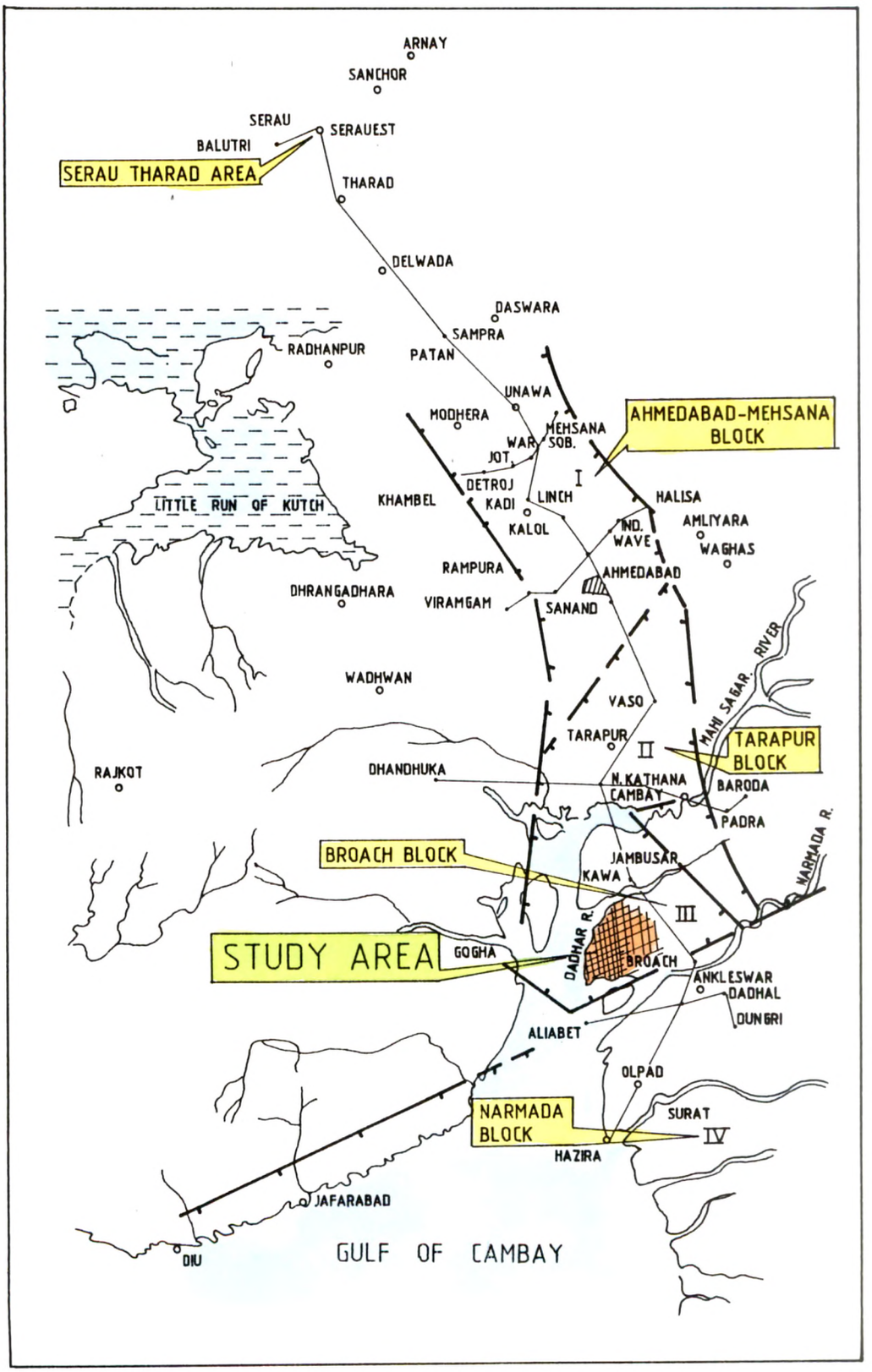

FIG.1·3 TECTONIC MAP OF CAMBAY BASIN SHOWING FOUR BLOCKS

(MODIFIED AFTER MATHUR et.al 1968)

throw towards south. This block had a maximum subsidence history and thus contains huge thickness of Tertiary sediments to a tune of 7000 m. The regional dip of the block is towards south with the deepest part lying to the south east of Pakhajan. The structural trends in the block are mainly aligned in Northwest-southeast direction and at places intercepted by North North East-South South West trend (around Gandhar).

CAMBAY-TARAPUR BLOCK

This block is situated immediately to the north of Jambusar-Broach block with its northern boundary coinciding with Vatrak river. Along the course of Vatrak river a deep seated fault with down throw to south can be inferred from the subsurface data. To date only two moderately large structures, Cambay and Kathana have been delineated by the UNGC which are aligned approximately in Northeast-Southwest direction.

AHMEDABAD-MEHSANA BLOCK

This block extends from Vatrak river in the south to probably Banas river (to the north of Patan) in the north.

The regional dip of this block is towards SSE.Majority of the structures are aligned in the NNW-SSE trend.

PATAN-THARAD-SANCHOR BLOCK

This block is limited in the south by Banas river. The northern limit could be a few kilometres north of Sanchor town area. The general alignment of the block is in the north-south dirction. The block is characterised by the presence of three major depressions separated from one another by narrow transverse ridges. The Sanchor depression is generally believed to be separate from Cambay basin in view of its different evolutionary history.

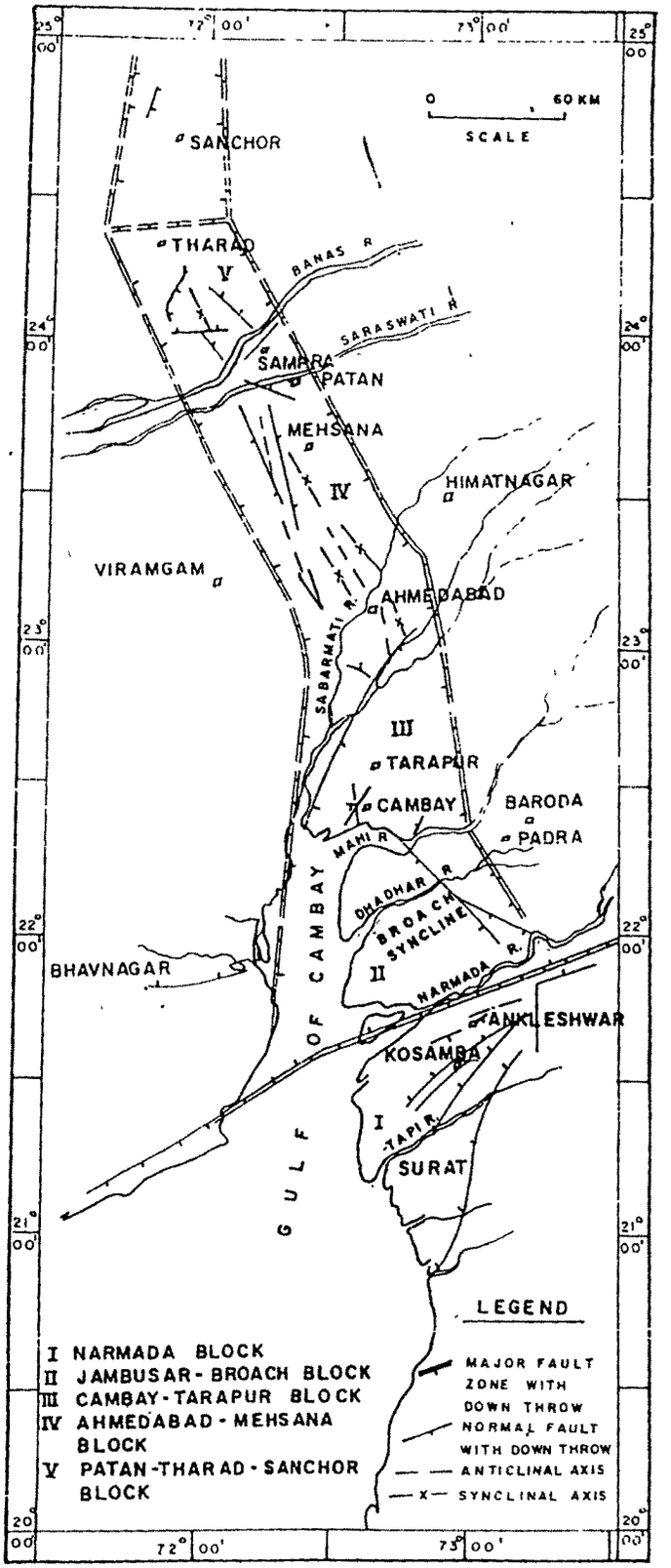

FIG 2.1 TECTONIC MAP OF CAMBAY BASIN
(MODIFIED AFTER MATHUR et al 1968)

2.1.1. MESOZOIC SEDIMENTATION HISTORY AND TECTONICS

The sedimentation history in Cambay basin which dates from Middle Jurassic to Recent is worked out in detail by Valmiki et al., 1990 . As postulated by this author during Late Jurassic to Early cretaceous, the sediments came mainly from Delhi-Aravalli system. These sediments were deposited in a fluviodeltaic environment in the northern part of the basin. The presence of Wadhwan and Dhrangadhra sandstones over the western flanks and Himmatnagar sandstones in the eastern flank of the basin lends support to such a probability. The presence of Lameta, Bagh and Nimar beds along the Narmada graben suggests fluviodeltaic environment over the flanks of the graben and marine influence in the deeper parts of the graben to the south-west. There are evidences for sea level fluctuations during Cretaceous over the deeper parts of Narmada graben. The conditions were conducive for the development of limestones during Cretaceous.

The structural trends of the exposed Mesozoic sediments (Dharangdhara and Wadhwan formations) in the north-eastern part of Saurashtra suggest that there was a continuous progradation of sediments towards west and south-west.

The close of Mesozoic era is marked by a major volcanic eruption during Late Cretaceous which resulted in the deposition of thick basaltic flows over major parts of Cambay basin and Saurashtra and over parts of Kutch mainland. In Cambay basin, the Trap is found to be thicker towards south and gradually thins northwards. This is substantiated by the well data of Ankleshwar super deep-1 that the huge thickness of trap is formed by a series of intermittant flows.

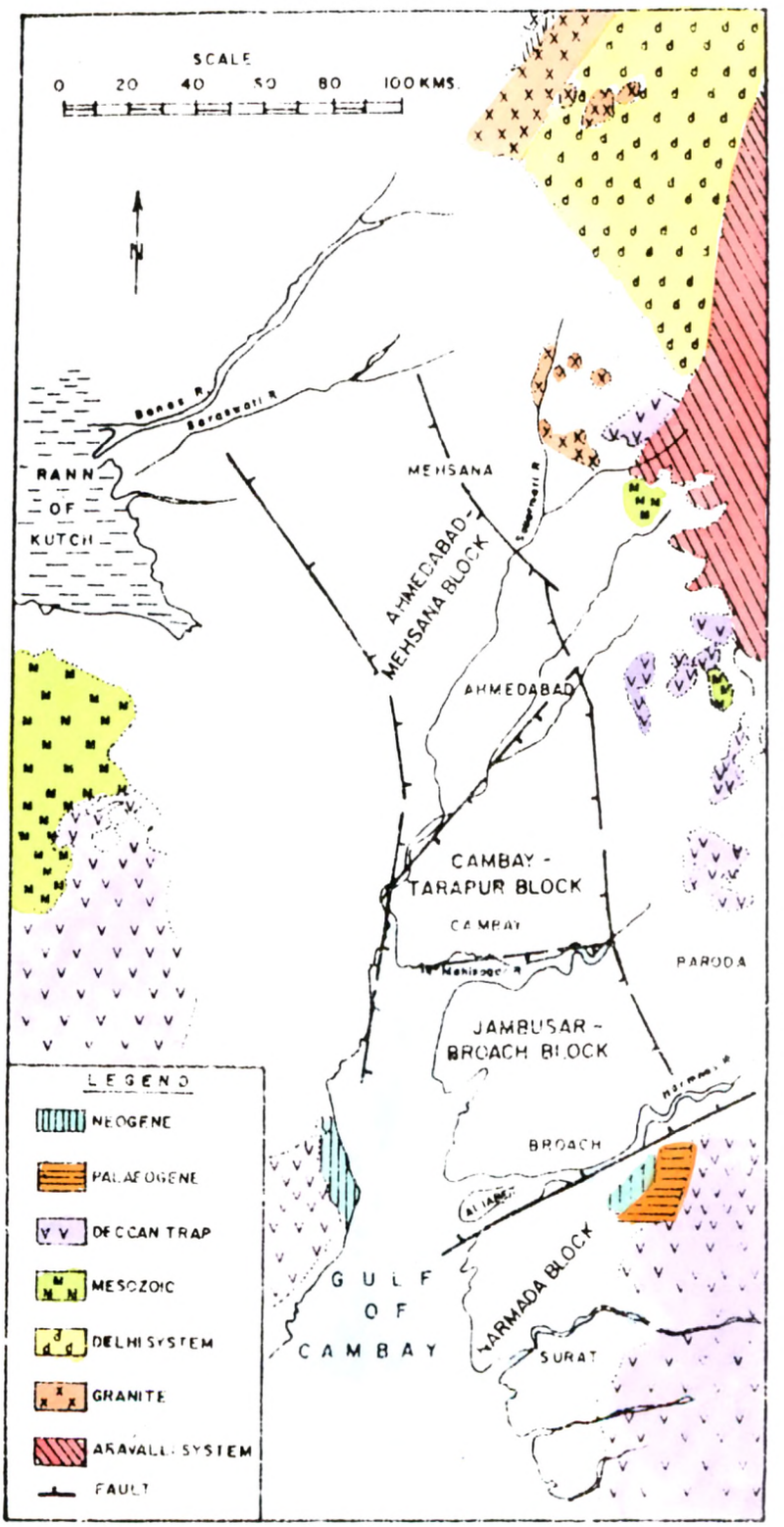

Fig.22 MAP SHOWING TECTONIC BLOCKS OF CAMBAY BASIN

(MODIFIED AFTER CHANDRA AND CHOUDHAR 1969)

2.1.2. CENOZOIC SEDIMENTATION HISTORY AND TECTONICS

The beginning of Cenezoic era witnessed several interesting tectonic changes over the entire western part of India. During this time, the Saurashtra craton was under fluvio-deltaic regime where 400-1000 m thick sediments are inferred to have deposited as indicated from the recent DTEM surveys. Subsequently, it remained a positive area during a major part of Tertiary period.

Information exists to indicate (Valmiki et al., 1990) that the pre-existing longitudinal lineaments flanking the Cambay basin were rejuvenated after the Mesozoic resulting in the gradual development of rift graben, known as Cambay Basin. This naturally became the depocentre for the subsequent Tertiary sediments. On the western flank, the prominent marginal fault continued towards southwest and later along the western coast of Cambay Gulf and finally met the transverse Narmada fault zone. The throw of this fault system is maximum to the west of the Tarapur depression and gradually decreases towards north as well as south. The eastern flank of Cambay basin rises gradually interspersed with a number of longitudinal faults. These faults are seen to be enechelon and at places discontinuous. The marginal faults flanking the basin are mainly alligned in the Dharwarian trend to the north of Narmada Geofractrure with occasional superimposition of Arawalli trend, while to the south of the geofracture they follow the Satpura trend. These longitudinal fault systems are thought to be responsible for the creation of Cambay rift graben.

Subsequent to the basaltic flows, the weak planes within the Precambrian basement were rejuvenated resulting in the formation of the Cambay rift graben. During Paleocene the sedimentation was mainly confined to the Paleoflows where poorly sorted trap derivatives were deposited over

the undulating surface in fluvial to swampy regime and at places marine (Uneli well). The term Olpad/Vagadkhol formation has been designated to represent the sedimentary units (Chandra et al.,1969). The maximum thickness of the Olpad Formation established so far is around 2000 m at Jambusar-P although it could be much more in the western part of Broach. In general, it is thinning towards the flanks the basin and also to the north.

During Late paleocene-Lower Eocene, there was a major transgression of sea from the south in Cambay basin covering all paleohighs upto Sanchor with the exception of the areas flanking the northern most tectonic block. This has resulted in depositing thick black fissile, pyritiferous shales under euxinic conditions. However, there were some minor sea level fluctuations as revealed by the presence of deltaic sands of Unawa and Linch in the northern part. The southern part of Cambay basin remain submerged all through the Lower Eocene. The shales deposited in this environment are known as Older Cambay Shales" and in general, they are thinning from Narmada geofracture to north and also towards the flanks of the basin. Subsequent to the deposition of the Older Cambay shale, there was an uplift to the west of Mehsana Horst which remaining a positive area till the Late Eocene-Oligocene transgression. This was followed by a minor fall of sea level; its impact being more on the flanks of the basin and in part of Narmada Block. Because of this situation some silts were brought in over the flanks and sands in south Cambay basin were deposited. This was followed by a marginal sea level rise allowing the deposition of "Younger Cambay Shale." During this period there was a continuous supply of coarser clastics leading to the deposition of "Kadi deltaic sands". These sands were covered by a transgressive shale, locally termed as Upper Tongue" (Aldesan Shale).

During the Middle Eocene, a major regression is suggested for the Cambay basin. This has resulted in the deposition of relatively thick deltaic sediments over major parts of the basin. Two main deltas which contain the major accumulation are the Kalol in the north and Hazad in the south. These two deltas are separated by the Mahi embayment.

The Kalol had a clastic input from the north and northeast (Raju et al; 1985). It is divided into twelve major Arenaceous units separated by two thick argillaceous units. Nandasan shale separates the lower most Kalol sands XII from the upper coal sand and silt units of Kalol VI to XI. These are overlain by Kansari Shale. Kalol I to V units overlie this shale unit and known as Wavel sands.

The facies and the thicknesses of these individual units vary laterally as revealed by the subsurface data (Mehrotra et al, 1980).

In south Cambay basin, the Kalol equivalents are Hazad member of Ankleshwar Foramtion with the clastic input from east and north east, mainly fed by Proto-Narmada and Proto-Dadhar. This has been divided into five Arenaceous units, designated as S_1 through S_5 upwards, separated by thin transgressive shales. In the area around Gandhar, however, the Hazad member has been divided into twelve sand units designated as GS-1 through GS-12 upwards (Madan Mohan et al, 1987).

Although Kalol and Hazad were mainly deposited under deltaic regime, differential subsidence of the different tectonic blocks resulted in the deposition of considerable amount of coals towards north within Kalol. The Hazad delta had relatively uniform sedimentation pattern with exceptions like Ankleshwar High (Rao, 1969).

Hazad member is overlain by Kanwa shale in the entire south Cambay.

Subsequently, there was a regression and the Ardoldetaic sediments were deposited with relatively more progradation than the underlying Hazad sediments.

In Tarapur Block, the Kalol equivalents are known as Vaso Formation containing two sand units named EP IV and DP III. North of Patan, the two major units Kadi and Kalol, merge into one unit, dominantly represented by thick sands.

The beginning of Late Eocene is marked by a major transgression which covered all the paleohighs including Mehsana Horst. The shales deposited during this period in north Cambay are known as Tarapur Shale Formation. The presence of silts in the middle part of the Tarapur Shale formation suggests minor pulse of regression. Its equivalent south of Mahi river are Telwa Shales. These Telwa Shales are overlain by thick deltaic sands, known as Dadhar Formation. It was during this period there was a major progradation into the present day gulf.

The Mio-Pliocene being marked by a low stand and followed by a high stand and resulted in deposition of sands and clays throughout the basin. The Lower Miocene known as Babaguru Formation, witnessed deltaic sedimentation prograding into gulf. The Middle Miocene, which is marked by a sea level rise resulted in deposition of grey clay and claystones even over the flanks of the basin. Middle to Late Miocene is represneted by white grey calcareous and Micaceous sandstones known as Jhagadia Foramtion. During the Pliocene the entire basin was covered by brown to reddish brown claystones and sandstones (Broach formation).

During Pleistocene-Recent period, the sedimentation was mainly of fluvial regime, where coarse, sands, gravel clays and kankar were deposited (Jambusar Formation).