

## Research paper

## Cenozoic sequence stratigraphy of the Kachchh Basin, India

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## ABSTRACT

The Kachchh sedimentary basin in the western continental margin of India is a peri-cratonic rift basin which preserves a nearly complete rock record from Middle Jurassic to Recent, punctuated by several stratigraphic breaks. The Cenozoic sediments exposed in the western part of the Kachchh mainland extend offshore into the present-day continental shelf. The unique feature of the outcropping area is a nearly complete, richly fossiliferous and easily accessible Cenozoic succession. Detailed field mapping and litho-biostratigraphic studies have made it possible to identify the chronostratigraphic units, map them in the field and extend the correlation into the offshore, aided by the development of continuously recognizable key biostratigraphic horizons and time boundaries. Detailed field mapping of key sections integrated with the litho-biostratigraphic information has helped in working out a sequence stratigraphic framework for the Cenozoic succession in the basin. The succession comprises a first-order passive margin sequence. Excellent biostratigraphic control has enabled identification of unconformities of various magnitudes which in turn have helped in mapping 5 second-order and four third-order sequences. Each sequence is discussed with respect to its extent, nature of sequence boundaries, sedimentary fill, key sequence stratigraphic surfaces and depositional setup, to understand the Cenozoic sequence stratigraphic architecture of the basin.

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## 1. Introduction

The Kachchh sedimentary basin extending from the Great Rann in the north to Kathiawar (Saurashtra) peninsula in the south, is a typical peri-cratonic embayed basin occupying a rifted graben (Fig. 1). The basin preserves almost a complete record of sedimentary succession from Mesozoic to Recent punctuated by several stratigraphic breaks (Fig. 2). In the outcrops (Fig. 3), the Mesozoic (Middle Jurassic to Cretaceous) sedimentary rocks crop out extensively in highland areas, whereas the Cenozoic strata are exposed only in the bordering plains. In the central part of the mainland, extensive development of Deccan Trap basalts is seen over the highest Mesozoic (Early Cretaceous) clastics (Bhuj Formation). Stratigraphically, the northern limit of Kachchh outcrops continue north beyond Indo-Pakistan border. In the offshore Kachchh and further south, the basin is contiguous with the Mumbai Offshore basin. The infra-trappean sequence ranges in age from Middle Jurassic to Cretaceous in the offshore at the depths penetrated by

wells.

Rifting and consequent subsidence of the block between the Nagar Parkar hills and the Saurashtra Peninsula in the Late Triassic, as evidenced by continental Rhaetic sediments in oil wells drilled by the Oil and Natural Gas Corporation (ONGC) in the onland Kachchh (Koshal, 1984), initiated the development of the Kachchh Basin. The first occurrence of marine sediments of Bathonian age indicates that the basin became fully marine during the Middle Jurassic. The basin formed the site for a westerly deepening epicontinental sea, probably an extension of the Tethys, in which a thick pile of sediments, ranging in age from Middle Jurassic to Early Cretaceous, was deposited in shallow marine to deltaic environments. The sediments were deposited in two major stages - a Middle Jurassic transgressive stage and a Late Jurassic-Early Cretaceous regressive stage (Biswas, 1983). During the transgressive stage mainly carbonates and shales were deposited, whereas deltaic clastics constitute the regressive deposits. In the Early Cretaceous, the sea began to recede in response to thermo-tectonic up-arching of the western continental margin, and a thick pile of fluvial clastics (Bhuj Formation) was deposited. The Mesozoic sediments were intruded and covered by Deccan Trap basaltic flows in Late Cretaceous-Early-Paleocene time. The onland

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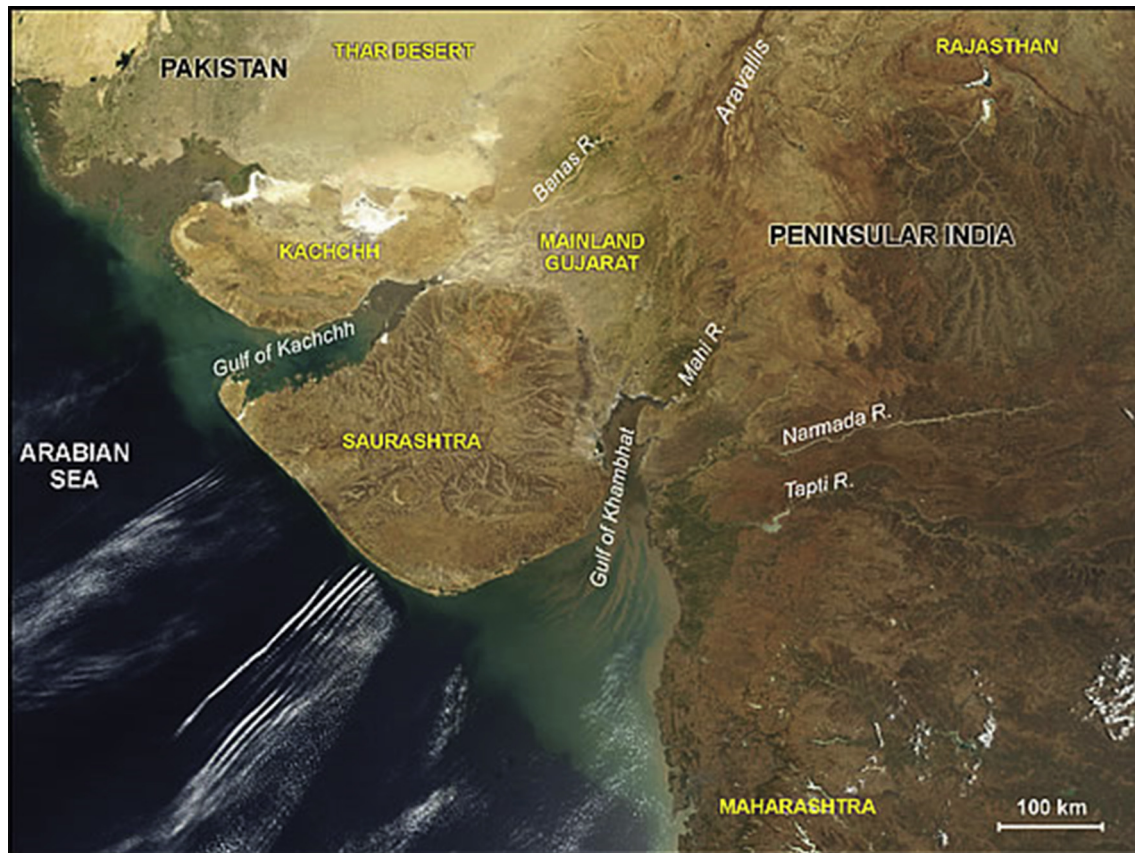


Fig. 1. Location map showing the position of the Kachchh Basin in a regional context.

part of the basin experienced a period of nondeposition during the Late Cretaceous. The occurrence of thick carbonates and clastics of Late Cretaceous age in several offshore wells indicates that shallow marine conditions continued to prevail in the offshore part of the basin during this time, and withdrawal of the sea from the offshore part of the basin was of very short duration, represented probably by the period of Deccan Trap activity and the development of the Early Paleocene continental clastics. The continental Early-Middle Cretaceous clastics, below the datable marine Late Cretaceous sediments are recorded in offshore wells. These unfossiliferous fluvial clastics may represent extensions of the outcropping Early Cretaceous Bhuj Formation in the subsurface. Coniacian to Maastrichtian (Late Cretaceous) carbonates and clastics, representing a Late Cretaceous marine transgression, are recorded in several offshore wells below the Deccan Trap.

The Cenozoic sedimentation began in Kachchh in a stable shelf environment. Thus, the strata have remarkable lateral continuity from onland to offshore. These sediments have been dated based on their faunal assemblages and several unconformities have been recorded which continue to the offshore area over the continental shelf. The Early Paleocene sediments (variegated lithologies of the Matanomadh Formation) exposed in the onland are not encountered in the subsurface of the Kachchh offshore. The Late Paleocene represents the onset of first marine transgression of the Cenozoic. Early Eocene transgression extended over the entire western margin of India, marking the beginning of post-rift history of development of the western continental margin of India. Sedimentary sequences of the subsequent time represent deposition contemporaneous with passive subsidence of the continental margin during drift of the Indian plate away from the spreading

centre.

The environmental framework of the Kachchh and Saurashtra basins and those of the other southern basins was differentiated into shelf, slope and basin floor. The horst-graben complex, including the lowlands of the onland part of the Kachchh Basin (Fig. 4), form the site for development of shelf depositional systems, which include deltas, clastic and carbonate tidal flats, strandplains, and extensive carbonate ramps. The Mesozoic highlands, in the onland part of the Kachchh Basin (Fig. 4), behaved as stable horst blocks throughout the Cenozoic restricting Tertiary deposition in peripheral lows bordering them. To the south and southwest, the slope-basin regions formed the site for development of submarine fans and hemipelagic and pelagic deposits. Carbonate build-ups (pinnacle reefs) have also been observed in areas of favourable paleobathymetry.

Several breaks in sedimentation are recorded in the Cenozoic sedimentary history of the basin. The significant ones are Paleocene/Early Eocene unconformity, Early/Middle Eocene unconformity, Eocene/Oligocene unconformity, Early/Late Oligocene unconformity, and minor hiatuses at the Oligo-Miocene and Early/Middle Miocene boundaries. Clastic sediment influx, drowning of carbonate platform and deepening of the basin characterizes the Post-Middle Miocene history of the basin, when the western margin as a whole experienced heavy influx of clastics manifested in basinward rapid shift of the shelf edge over a considerably long distance to its present position. A condensed section of the Cenozoic is exposed in the western part of the onland near the Matanomadh village (Fig. 5) and is discussed in detail below. In the region of the Kachchh Basin, the structural differentiation between the shelfal horst-graben complex, the Kori-Comorin depression and

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