2 GEOGRAPHY, GEOMORPHOLOGY AND GEOLOGY OF THE EARTHQUAKE AREA

2.1 Geography

Kutch, or Katchchh region has a population of 1,252,507 according to 1991 census in Gujarat state of West India, bounded on the North by Pakistan. It is largely barren except for a fertile band along the Gulf of Kachchh in the Arabian Sea. Mandvi, Bhuj, and Kandla, a new port, are the chief towns (Figure 2.1).

The state of Gujarat is the heartland of Indian industries like petroleum, power and steel. It is largely barren except for a fertile band along the Gulf of Kachchh in the Arabian Sea. It was the scene of major border disputes between India and Pakistan in 1965 and1971. Kachchh or Kutch is an erstwhile princely state of India. It is the largest district of the state of Gujarat and the second largest district in India covering an area of 45,612Sq Kms. The land is virtually an 'island' resembling a tortoise "Katchua or Kachbo", surrounded by sea water. Kutch was also known as the kutchdweep or Kutchbet." The Great Rann of Kutch" which dominates a major portion of the district. The Great Rann of Kutch and the Little Rann of Kutch respectively-uninhabitable deserts which during the monsoon season (June to October) is often completely submerged by floods.

Figure 2.1 Satellite view of Kutch region

According to the provisional results of 1991 census, the population of Gujarat is 4.12 million, forming 4.88% of the countries population and is predominantly rural (65.6% rural and 34.4% urban). The state ranks fourth in urbanization amongst the states of India. Its density of population is 210 persons per sq.km. as against 267 persons per sq.km.for the country.

2.2 Geomorphology

Geomorphologically, Kutch (Kachchh) is categorized into four major E-W trending zones (Fig. 2.2):

1.Coastal Zone - demarcating the southern fringe

2.Kachchh Mainland - divided into the central portion comprising rocky upland, northern hill range and coastal plains,

3) Banni Plains (less than 5m MSL)-marked by raised fluviomarine sediments, mud flats and salt pans and

4) the two Ranns Great Rann (~ 2m MSL) in the north and Little Rann in the east comprising vast saline wasteland. The boundaries of these main geomorphic zones are bounded by the major E-W trending faults.

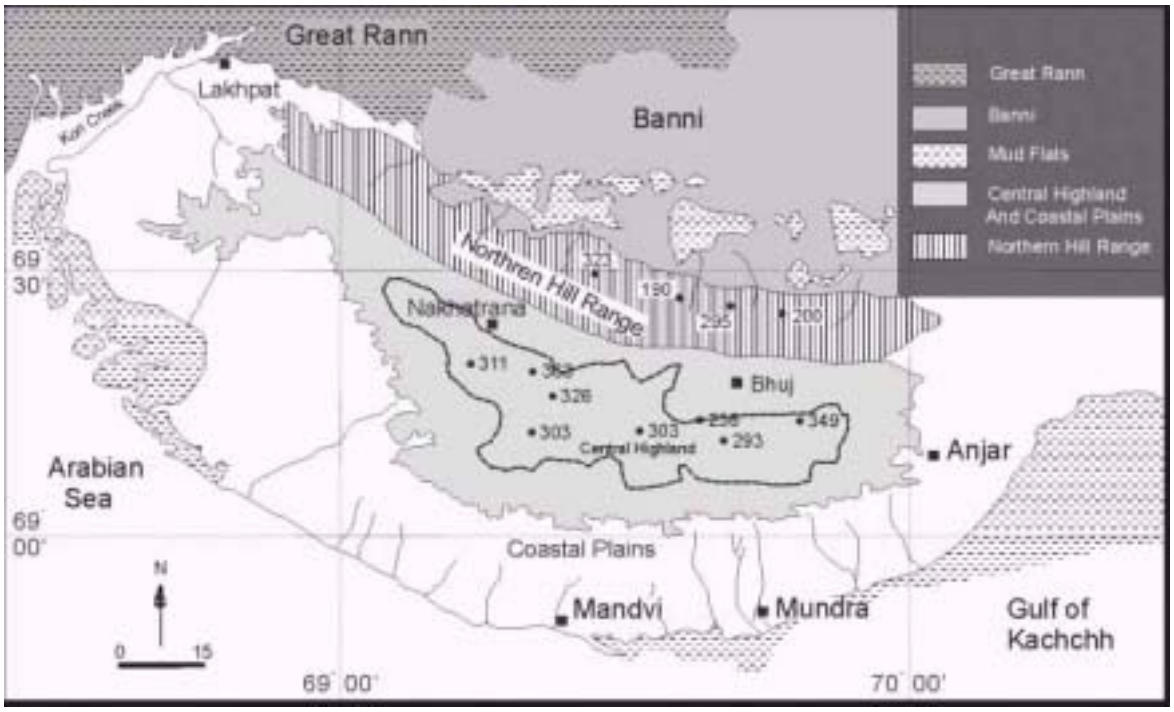

Figure 2.2 Geomorphic Map of Kutch (Kachchh)

The Kutch landscape comprises an array of tectonogenic geomorphic elements in the form of uplifts and residual depressions. Elevated landforms are occupied by Mesozoic and Tertiary rocks, whereas the residual depressions or low-lying regions between the uplifts consist of Quaternary sediment successions marked alluvial river terraces in the rocky

mainland and the mud-flats and salt pans in the Great and Little Ranns and Banni Plains. The general forms of the uplifts are marked by domes and asymmetric anticlines. All major uplifts are bounded, at least on one side, by a fault or a sharp monoclinal flexure, and on the other side by gently dipping peripheral plains, the strata (Tertiary) in which dip gently into the surrounding residual depression (Biswas, 1980).

2.3 Geology of Kutch (Katchchh) and Ahmedabad Basin

Sedimentary rocks ranging in age from Jurassic to Eocene age cover Kutch region. These sediments have a zone of Deccan trap volcanics sandwiched between Jurassic rocks of the northern part and Eocene sedimentaries in the south towards the coast. Limestones, shales and sandstones are the most common rocks (Krishnan, 1982) (Figure 2.3).

The Jurassic rocks have an estimated thickness of 1950 m and crop out in three anticlinal ridges trending E-W. Owing to an E-W fault the whole sequence is repeated. The northern range is about 160 km long and broken in to four islands (Pachham, Karir, Bela and Chorar) in the Rann of Kutch.

The middle ridge is 190 km long trending ESE from Lakhpat on the west. The southern ridge, south of Bhuj, is 65 km long and forms the Charwar and Katrol hills. The Jurassic rocks are repeated in these two ridges. The main outcrop, of which they form parts, is cut by an E-W strike fault.

An isolated but large outcrop, on which Wagur and Kantkote stand, is about 80 km long, in NE Kutch. These anticlines show transverse undulations so that the domes like parts have been separated from each other by denudation. (Krishnan 1982).

Both Eocene and Jurassic rocks are fossiliferous. The Eocene rocks are exposed along the southern fringe of the Kutch peninsula as a thin band bounded by Deccan traps on the north.

The northern part of the Kutch peninsula is covered by Recent marine deposits on which Jurassic rocks form outcrops. The coastal areas have thick alluvial and marine sediments of Recent origin. This area seems to be undergoing some marine recession. A major paleo-rift valley lies along the east west direction passing through the Kutch region.

Sedimentary rocks of this region are generally well indurated and behave like hard rocks. The pore spaces are mostly cemented with calcium carbonate and therefore are mostly impervious. The Deccan Traps are exposed along the southern part of the Kutch peninsula.

Both limestones and sandstones are used as building materials in this region. Many quarries

exist in this region for mining good quality limestone for making slabs for flooring and covering walls. Several cement factories mine limestones in this region. Bauxite is also being mined in this region.
Mesozoic rocks of Kutch region are exposed in three chains of east-west trending ridges. The 2000 m thick succession of marine sedimentary rocks represent a phase of transgression of sea along the west coast during Jurassic-Early Cretaceous times. The succession has been intruded by various sills and dikes and overlain by Deccan Traps of same age. Mesozoic rocks of Kutch region are grouped into several formations as follows.

Patcham Formation marks the beginning of Jurassic marine transgression in Kutch. It consists of 300 m thick succession of limestone, marl and shale and has yielded pelecypods, corals and ammonites.

Chari Formation consists of 400 m thick succession of limestone, marl and shale. It contains fossil remains of ammonites and gastropods.

Katrol Formation is a 750 m thick succession of shale, limestone and sandstone deposited during Late Jurassic.The Katrol Formation has yielded fossils.

Umia Formation is about 550 m thick succession of sandstone, sandy shale and marl. This formation is characterized by presence of ammonite fossils like.

Bhuj Formation comprises of sandstone and shale and is characterized by presence of plant fossils.

The state of Maharashtra is almost entirely covered by the basaltic lava flows of the Deccan Trap. The Traps have a thickness of about 2000 m near the western edge and thin out towards east. The lava flows extend into neighbouring Madhya Pradesh, Gujarat and Karnataka. The eastern edge has been eroded with some remnants occuring as far as Jabalpur. They were emplaced between Cretaceous to Paleocene period. Within the basaltic lava flows, numerous sedimentary beds (the Intertrappeans) of carbonates & cherts occur in the east and Gujarat. Usually the middle part of Trap is devoid of these intertrappean beds. It is believed that the Deccan Trap is the result of sub-aerial volcanic activity associated with continental divergence in this part of the earth during Mesozoic. Most magma-carrying fissures trend parallel to the western coast, Narmada lineament and the Cambay basin.

Gujarat Kutch and Cambay Basin contains an existing gas discovery and several untested gas-bearing reservoirs.

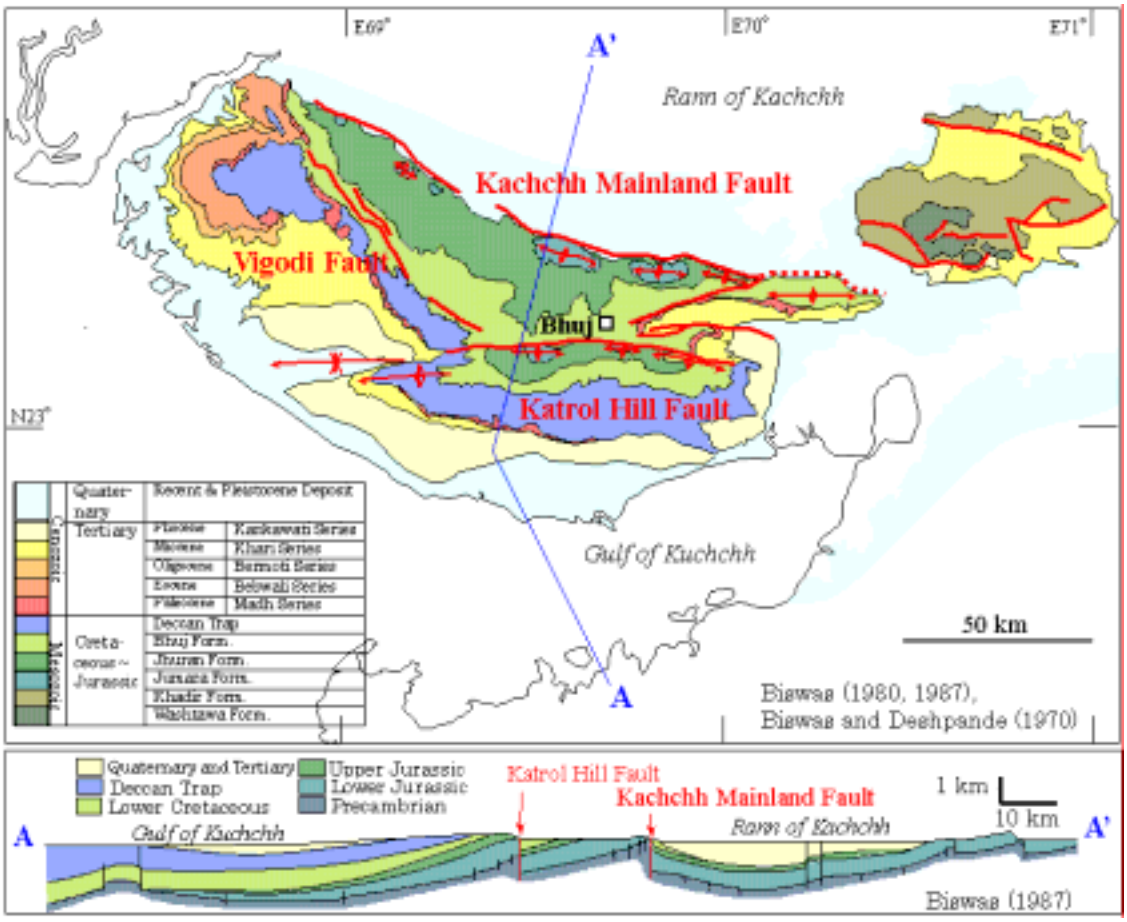

Figure 2.3 Geology of Kutch(Katchchh) region (after Biswas 1970,1980,1987)

The RC buildings in Ahmedabad city, which is about 300 km far away from the epicenter, suffered damages of different degree and the maximum ground acceleration was 0.11g. Therefore, the geology of the basin in the vicinity of the Ahmedabad city is briefly outlined according to a recent publication by Banarjee et al. (2000). Figure 2.5 shows the geology map of Cambay basin and its close vicinity. The Cambay Basin, a rift sag Tertiary basin, in the western onshore part of India includes Mehsana, Ahmeda-bad, Tarapur, Broach, and Narmada blocks, separated by faults aligned transverse to the general north–south axis of the rift. The area consists of Deccan trap, Cretaceous and Pre-Cambrian rocks. Deccan trap rocks are mainly extrusive rocks described previously. Cretaceous rocks consist of shale, sandstone, coal, siltstone, limestone and conglomerate. Figure 2.6 show a geological cross section along the east-west direction of the Cambay basin shown in Figure 2.5. At the top Neogenic sediments consisting of sand, silt, clay and alluvium layers exist and its maximum thickness is about 2250m at the centre of the basin and its thickness diminishes towards the east and west boundary faults of the basin.

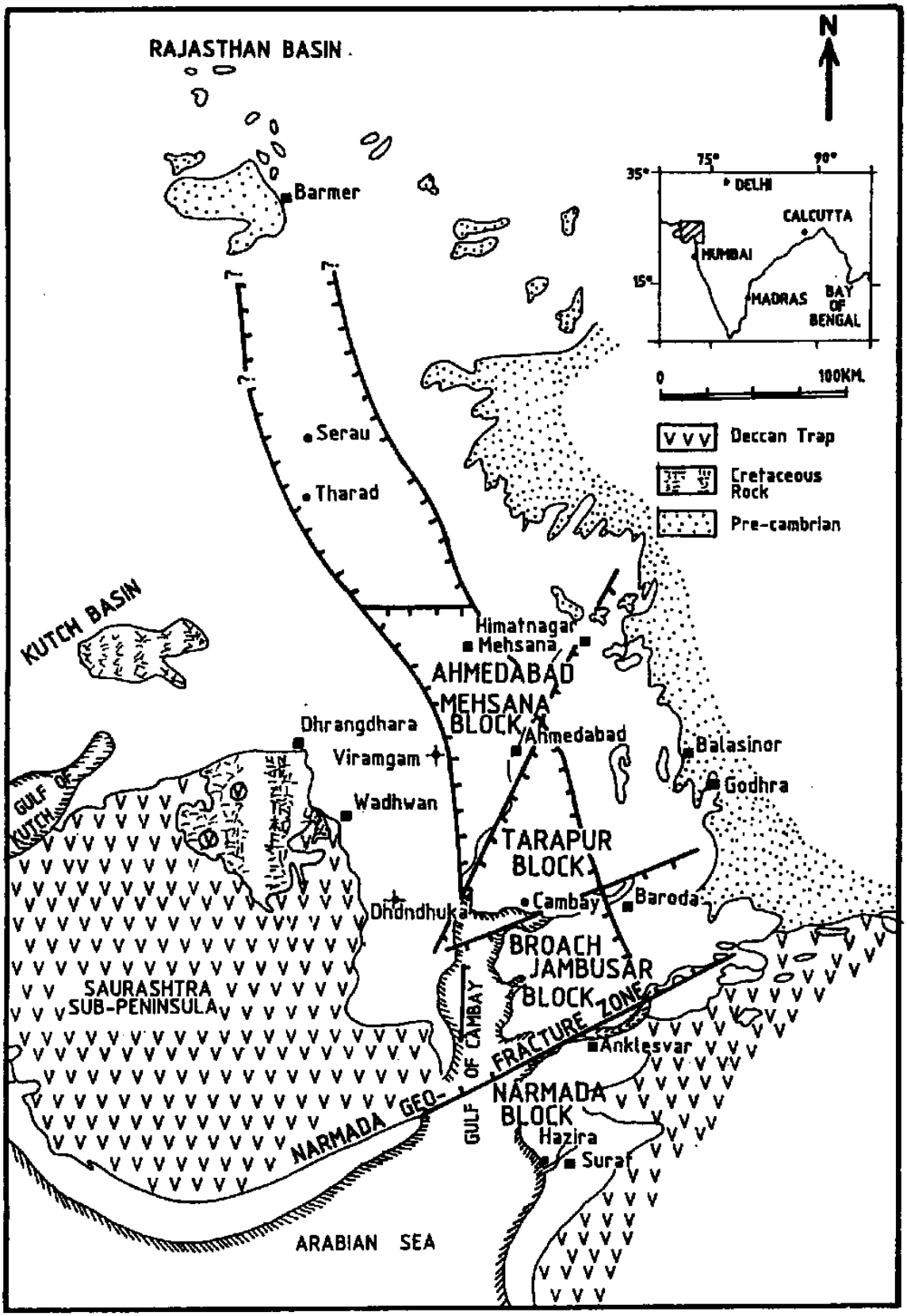

Figure 2.4 Geology of Cambay Basin and its close vicinity (after Banerjee et al. 2000)

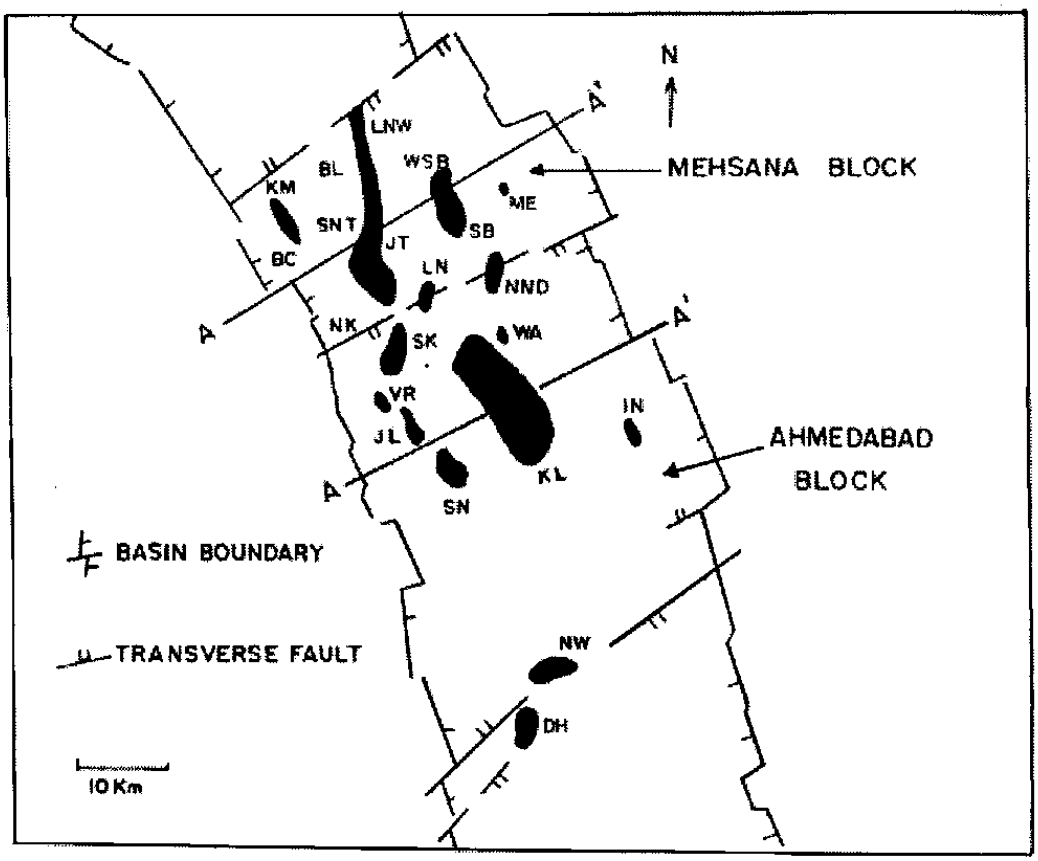

Figure 2.5 Oil fields and structural geology of Cambay Basin near Ahmedabad

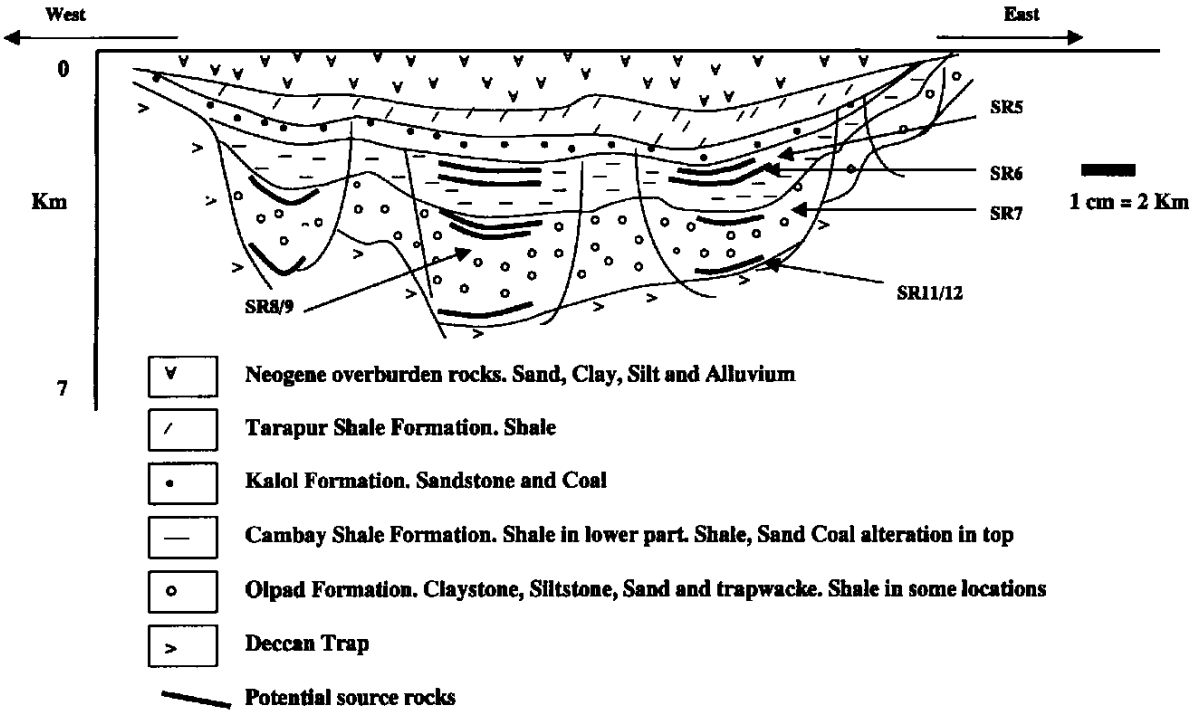

Figure 2.6 Geologic cross-section of Cambay Basin near Ahmedabad