CHAPTER VI

NEOTECTONISM

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GENERAL INFORMATION

The charm irresistable but hostile landscape of Thar desert owes its present day configuration to episodic geo-climatic perturbations initiated since Neogene period. The Aravalli Mountain Range and its associated tectonism played a significant role in shaping the Thar desert and its neighbouring environs.

It has already been alluded in the preceding chapters on that the pre-existing basement linears and their subsequent reactivation were responsible for imparting modifications in landform features and drainage fabric.

The study pertaining to the neotectonic aspects of the Thar desert dates back to almost hundred years. La Touche (1902) in his classic work on the Geology of Western Rajasthan has postulated the Quaternary tectonism as a causative factor of drainage disruption. However, the last two decades have witnessed maximum attention from the earth scientists on neotectonism. Voluminous literature is now available. Nevertheless, the neotectonic history of the Thar desert is still full of embroilment, perhaps due to the paucity of continual features, superimposition and/or overlapping surficial processes and landforms, thereby leading to an obliteration of numerous features.

PREVIOUS WORK

In order to synthesise an overall neotectonic picture of the study area, the author has carefully scrutinised the available information. A critical appraisal of important works on neotectonic aspects is highlighted in ensuing paragraphs.

Ahmad and Ahmad (1980) postulated the upliftment of the Aravalli range during the Quaternary period as a horst between the Sardarshahr fault in the west and the Great Boundary Fault in the east. According to these workers, this faulting has caused changes in the course of important rivers like Saraswati, Sutlej, Beas and Indus. The drainage disruption has led to the extinction of the once flourishing Harappan and Mohenjo-Daro river valley civilisations.

Sen and Sen (1983) have recorded a series of morphological features in the central Aravallis including fault scarps, rapids and waterfalls, straight river courses, terraces and presence of knick-points at a constant distance from the mountain range all in the west-flowing rivers. According to them, these features were produced due to the reactivation of pre-existing faults as well as the later vertical movements along these faults.

Sinha-Roy (1986) has attributed the implication of Neotectonics in the northeastern parts of Rajasthan to the Himalayan collision and indentation of Aravalli orogen by the Bundelkhand wedge. He has further identified three regional geomorphic surfaces attributed to neotectonic activities. These neotectonic features, according to him, were due to the collision of the Indian and Tibetan plates and manifested as strike-slip faults, normal faults, thrust faults and graben structures; responsible for causing drainage disorganisation, changes in the river courses, creation of fault scarps, knick-points, pull-apart basins and lakes.

Dassarma (1986) summarised the evidences of neotectonic movements in northeastern Rajasthan as structural, geomorphological, pedological and stratigraphic features. The structural evidences include truncated hill fronts with faceted fault scarps, troughs and stepped grabens, slicken-sided gossans and silcretes in alluvium and post-orogenic bending, shattering and dragging of ridges with rotational effects to form transverse wind gaps. The pedological features, *viz.*, relict silcrete and calcrete layers on topographic highs and anomalous depths of oxidation in adjacent blocks on opposite sides of the NE-SW trending faults. Presence of a number of hanging valleys, network of palaeochannels, lineament controlled river captures, river diversions, creation of sag-ponds and salt lakes across disorganized channels, inversion of slopes and consequent inversion in drainage direction and anomolous terracing in adjacent rivers are the important geomorphological features providing ample evidences on neotectonism. The stratigraphical evidences include differential accumulation of sediments in adjacent blocks with local 'drowned' Quaternary topography. Dassarma has further emphasised that the Neogene and Quaternary tectonism rejuvenated the older Precambrian basement faults. These faults are the sites of upliftment of segmented blocks of the crust that formed the Aravalli Mountain Range.

Kar (1988b & c), while providing evidences for neotectonism from the Indian Desert, suggested that the neotectonic movements in the desert plains of Rajasthan are related to the neotectonic movements in the Aravallis. He identified two episodes of tectonic movements in the Luni-Jawai plains during the Quaternary period resulting in drainage disorganisation.

Bakliwal and Ramasamy (1987) and Bakliwal and Grover (1988) studied the lineament fabric and have further opined that the migration of the Saraswati river in the Thar desert is attributed to neotectonic movements. Ghosh *et al.* (1991) examined the tectonically active Mendha river basin in northeastern Rajasthan and carried out neotectonic analysis of the basin using LANDSAT TM data. These workers have analysed the Riedel and Antithetal Riedel shears within the basin and opined that the basement faults of the area are mostly strike-slip in nature and the overall neotectonic pattern in the area is suggestive of the crustal movements under brittle conditions. The presence of faulted blocks resulted in the topographic irregularities. The reactivations of the basement faults during the Neogene-Quaternary period played a major role in the development of numerous landform types typical of the present-day Thar desert.

PRESENT STUDIES

The study area displays ample evidences of neotectonism, imprinted over the terrain as numerous landform features. Based on the studies on the lineament configuration, geomorphology and satellite imagery interpretations, and also the available literature, the author has synthesised the neotectonic map of the study area (Fig. 6.1). Detailed neotectonic features of the Luni block and the Kantli-Sambhar blocks are given in the respective neotectonic maps (Figs. 6.2 and 6.3).

In the fore-running account, the author has solely emphasised on the location specific neotectonic features vis-à-vis an overall effect on various terrain attributes.

NEOTECTONIC EVIDENCES

It has already been stated that the characteristic neotectonic features in the study area are the products of the rejuvenation of the older Precambrian basement faults and the subsequent development of new fault/fracture systems sympathetic to basement fractures which must have been developed during the Neogene and Quaternary tectonic episodes. These neotectonic activities had created immediate as well as progressive impacts on the landscape, thereby the evolution of the terrain. The NE-SW trending Luni-Sukri rift system faults, NNW-SSE and E-W trending uplifted blocks, stepped faults (horst and graben structures) in the Sambhar lake-Mendha basin area and surroundings, development of ravine lands in Kantli-Sabi watersheds, anomolous terrace systems in some of the rivers, presence of nearly 3 km wide defunct trunk streams (palaeochannels) in the midst of alluvial plains, disorganised drainage systems and changed river courses, uplifted gravelly ridges around Jayal and structurally controlled saline depressions/ playas, etc., are some of the manifestations of Quaternary tectonism.

Strike Faults

(i) The Luni-Sukri left lateral strike slip faults form a part of the NE-SW trending Luni-Sukri rift valley system. It extends from the south of Jodhpur up to the Sambhar lake for about 250.km and is traceable further northeastward as the Nawan-Alwar left lateral strike slip fault up to the

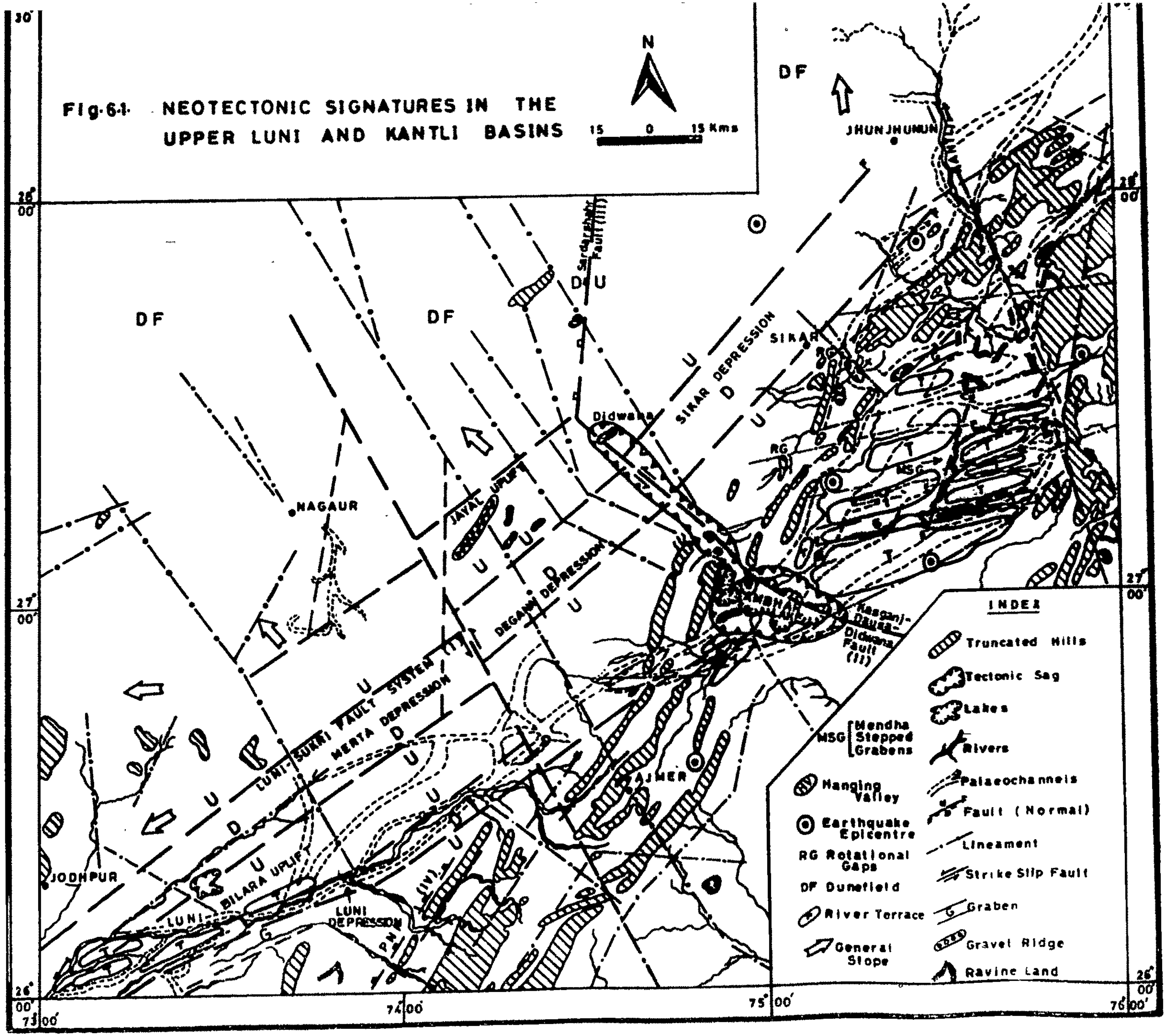


Fig.6.1. NEOTECTONIC SIGNATURES IN THE UPPER LUNI AND KANTLI BASINS

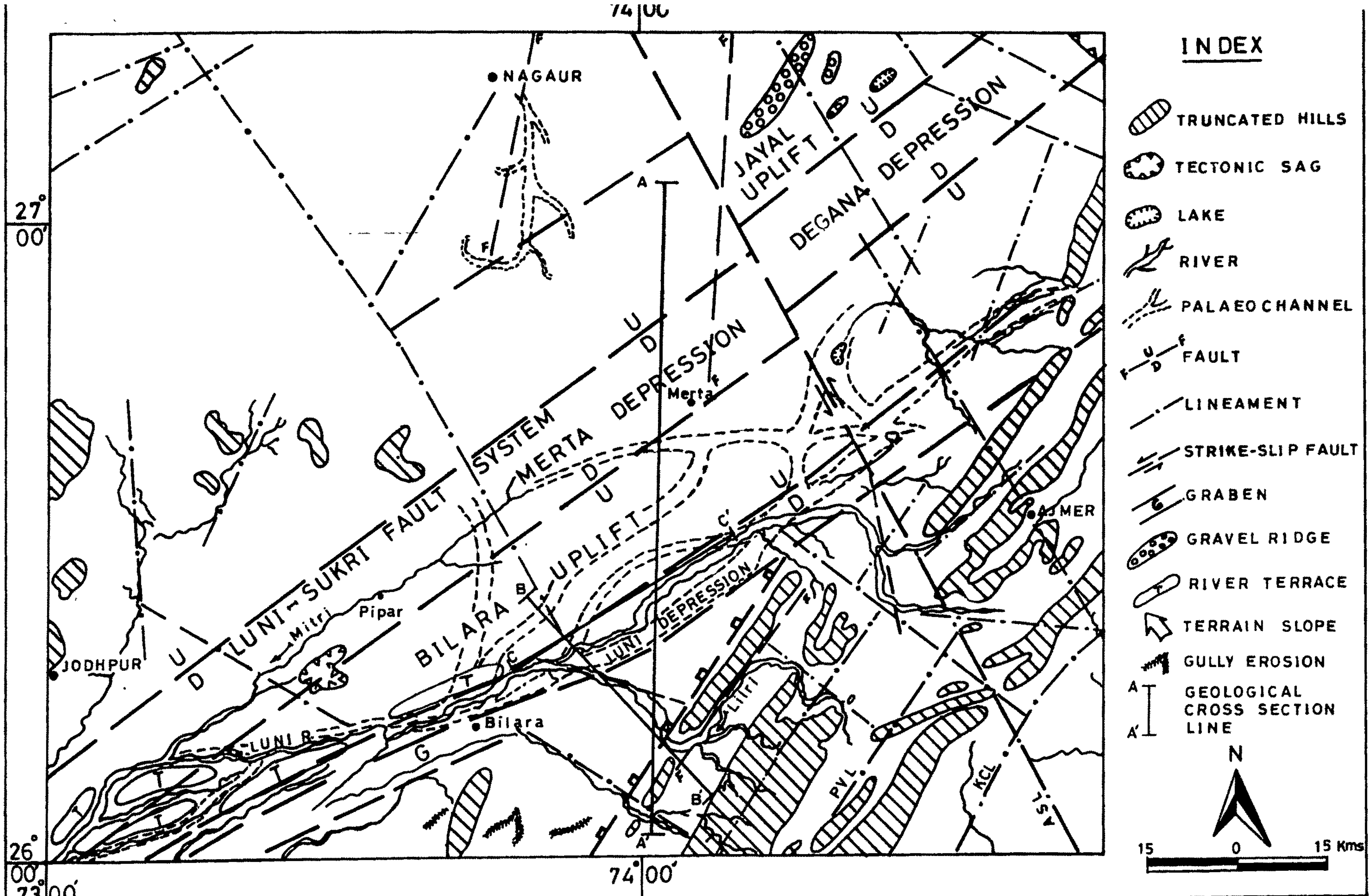


Fig. 6.2. NEOTECTONIC SIGNATURES IN THE UPPER LUNI BLOCK

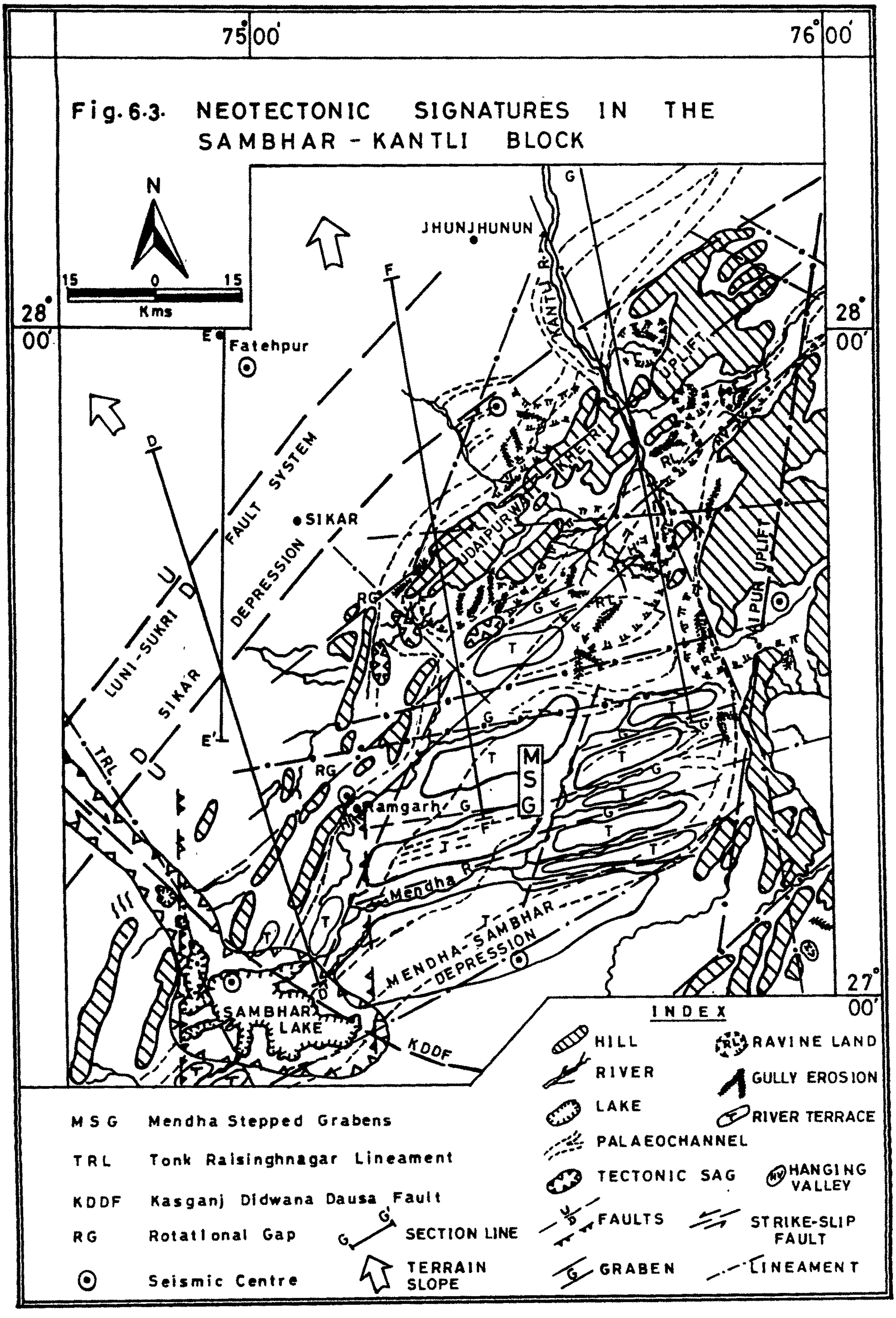


Fig. 6.3. NEOTECTONIC SIGNATURES IN THE SAMBHAR - KANTLI BLOCK

Siwalik foothills. The Luni-Sukri fault system comprises a set of NE-SW trending two parallel faults which have given rise to a graben structure (Ramasamy *et al.*, 1991). This fault system largely controls the course of the Luni river and is also probably responsible for the NE-SW oriented dune free wind gap in the study area (Plate VI.1), passing through Luni-Merta-Degana-Sikar. The author's studies on the present day dunal activity in the study area has led to an interesting and significant conclusion. It has been observed that the dunal activity ceases in the vicinity of this regional tectonic feature. All along its northern block margin, i.e. the Degana-Sikar depression, the dunes display steep facets. Continual slipping of aeolian sands further provide a clue regarding the activeness of these lineaments. Within these lineament pairs, one side has imparted horst-graben configuration along NE-SW axis, and in the other side the obstruction created by the uplifted basement block has grossly modified the wind regime, distributing the aeolian load. The area south of these identified depressions is more or less devoid of any dunal activity, which is obvious, as now the area forms a part of shadow zone. Only restricted aeolian activity can be seen in the form of obstacle dunes, which are developed all along the foot slopes of the Aravalli Mountain Range.

Further, the central uplifted block in parts of present day Kantli watershed seems to be responsible for drastic modification of drainage. The overall mechanism of drainage evolution, vis-à-vis neotectonism is discussed separately.

The distribution of stream terraces of the Luni river and its tributaries in the uplifted blocks of Luni-Sukri Rift system, formation of Allah Bund in the Kachchh region during the 1819 earthquake, etc., point to the reactivation of the Luni-Sukri lineaments in the Recent past.

(ii) The Kasganj-Dausa-Didwana regional fault is a curvilinear right lateral strike-slip fault extending for more than 500 km in a roughly E-W direction from Kasganj in the east to Didwana in the WNW. The combined effect of the Kasganj-Didwana and the Luni-Sukri fault systems was responsible for the creation of the saline lakes of Sambhar, Didwana and Kuchaman. The Kasganj-Didwana fault chronologically appears to be of younger age than the Luni-Sukri rift system since this fault at places has caused northwestward lateral shifts. The

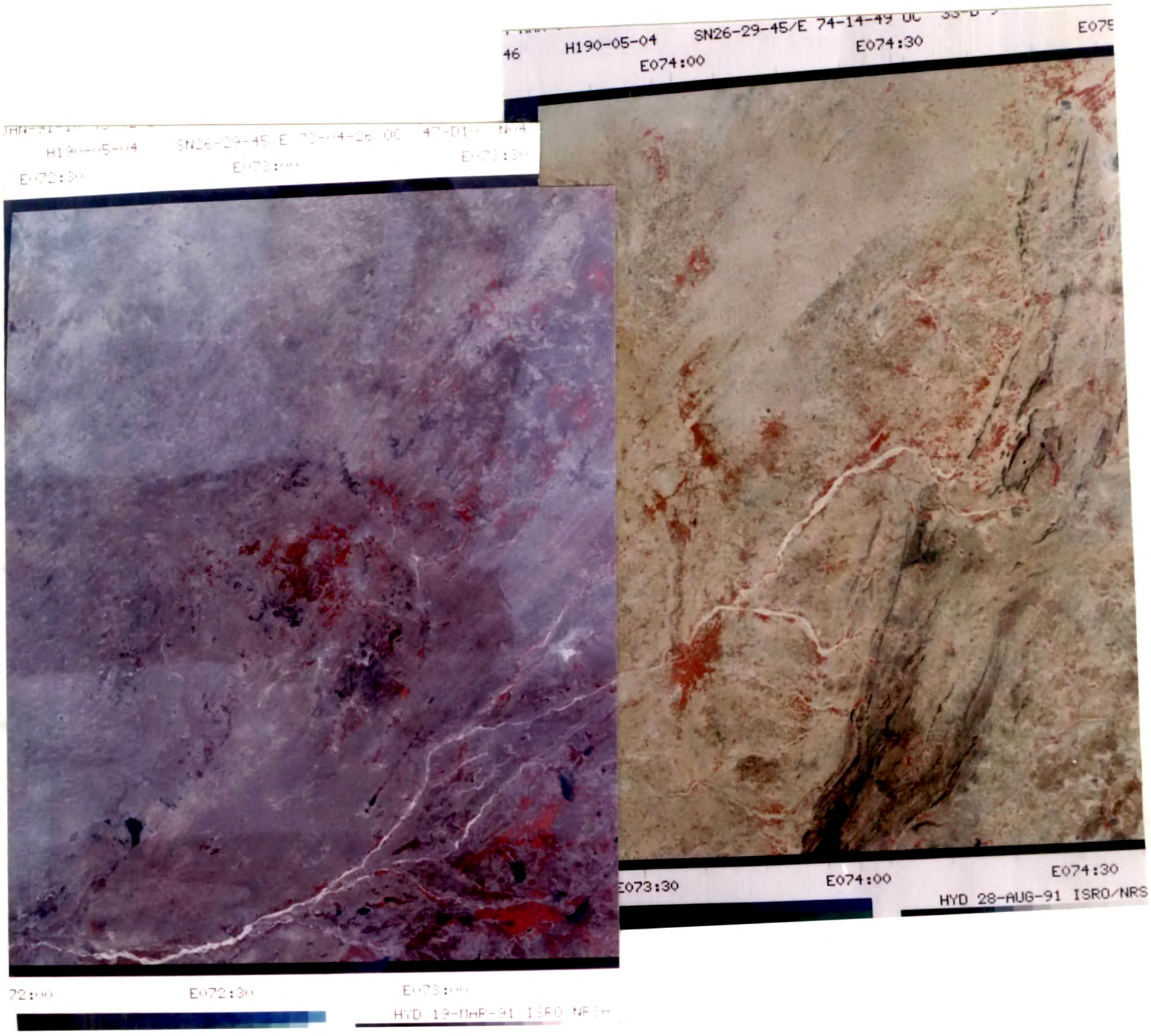


Plate VI.1 IRS (LISS - I) view showing the NE-SW oriented dune free wind gap in the upper Luni block: a manifestation of the Luni-Sukri fault system.

signatures of such displacements are discernible in the continuity and disposition pattern of the Aravalli Mountain Range around Sambhar lake.

In order to check the neotectonic imprints of Dausa-Didwana (a segment of the Kasganj-Dausa-Didwana) fault and the Tonk-Raisinghnagar lineament, a NW-SE sub-surface geological profile has been drawn (Fig. 6.4). It could be seen from the section that the combined effect of these major tectonic linears and minor sympathetic fault/fracture systems has given rise to horst and graben configuration. The maximum uplift is seen at Nawa, demarcated as Nawa horst. The adjacent blocks of Nawa horst, i.e. (i) the Sambhar graben on right, (ii) Luni-Sukri graben on left, depict step faultings. The presence of imbricated lenses of Quaternary sediments and their relative displacement seen in the profile, point to their reactivation during Quaternary times.

Normal Faults

(i) The N-S trending Sardarshahar fault with more than 250 m throw towards the west (Ahmad and Ahmad, 1980) is a significant fault within the study area. The presence of thick pile of Quaternary sediments in the down thrown block is attributed to this faulting.

(ii) The Pindwara-Nimaj fault (PNF) is prominent normal fault located along the western flanks of the Delhi fold belt and extends as a series of normal faults in a NNE-SSW direction for about 350 km (Sinha-Roy, 1986). Breaks in the river profile gradient of almost all westerly flowing rivers of the area have been observed along this significant knick-point lineament (Sen and Sen, 1983). The down thrown block for this normal fault lies to the west and the Delhi fold belt has been uplifted along it in the east during the Neogene and post-Neogene times.

Thrust Faults

The Great Boundary Fault (GBF) running for about 400 km in a NE-SW direction is a major dislocation in the Rajasthan region. Structural evidences point to a thrust fault nature in the southwestern part, but in the northeast the fault changes into a right lateral strike-slip fault (Sinha-Roy, 1986). Further north, the major strike-slip faults of the region meet the Great

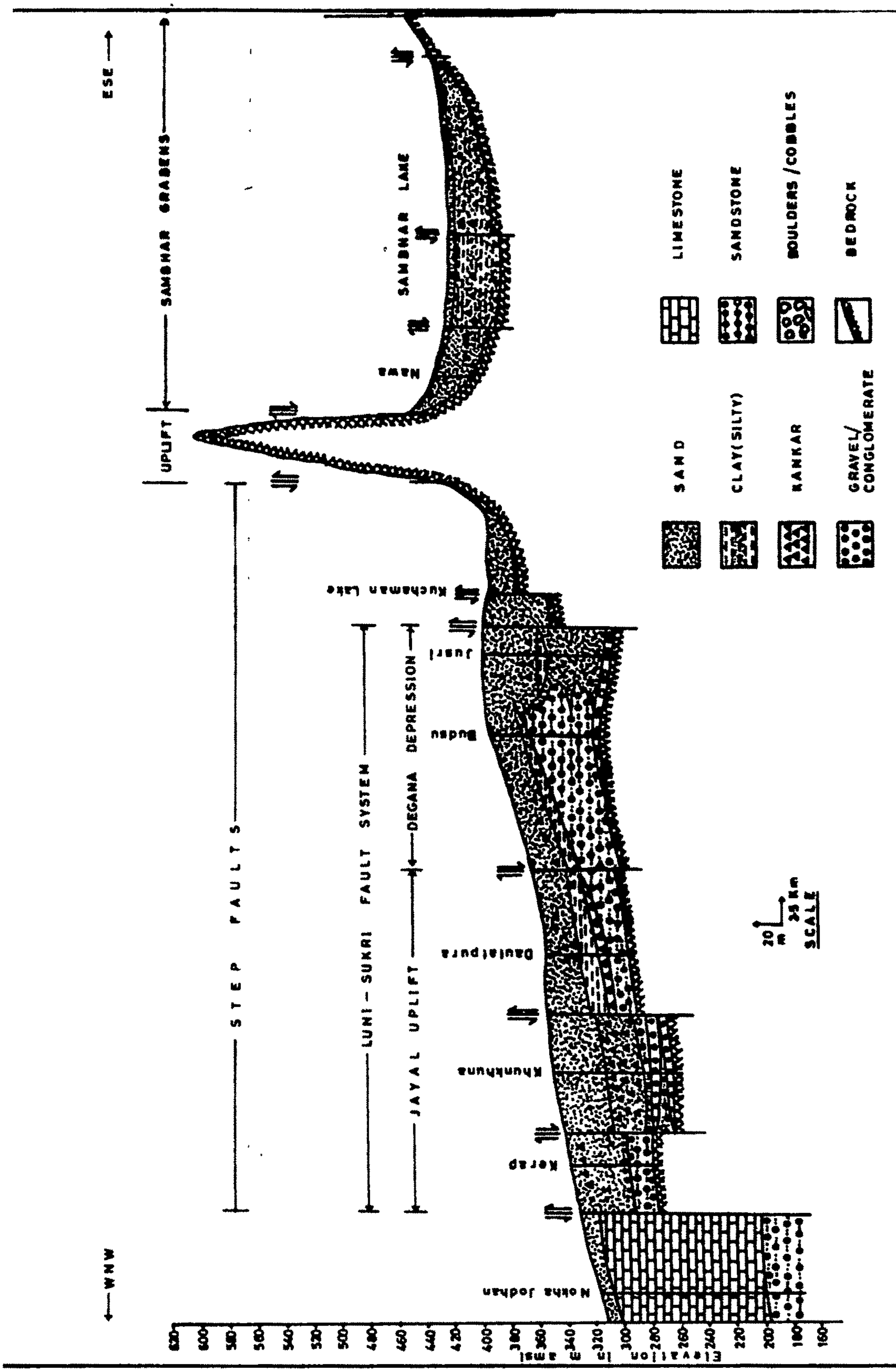


Fig. 6.4 GEOLOGICAL CROSS SECTION ALONG NOKHA JODHAN - DAULATPURA - NAWA (Based on CGWB bore hole data)

Boundary Fault. This major fault was primarily responsible for the upliftment of the Aravalli Mountain Range and also partly controlled the course of few rivers *viz.*, Berach, Banas, etc. In association with other faults, this thrust fault may also have played a role in the rotational tilting of the northwestern block and drainage migrations.

Step-Faults and Graben Structures

Stepped faults, horst and graben structures and stepped grabens are characteristic neotectonic features that have greatly controlled the Quaternary sedimentation in the area as well as vastly modified the terrain attributes. The study area is riddled with innumerable step-fault and garben structure systems defined by structural depressions, disorganised and increased drainage density, terraces, etc. These tectonic structures with a general E-W to ENE-WSW trend were produced by the reactivation of northerly trending master strike-slip faults.

The frequency of occurrence of the stepped faults and stepped grabens are especially high in the western, southwestern and northeastern parts of the study area. The surficial manifestations of these step-faults and stepped grabens are a general northwesterly slope in the central and northern parts of the study area and a southwesterly slope in the Luni watershed. In the area between Merta and Bilara, Dassarma (1986) has identified a southeastward migration of the Luni river channel for over a distance of 50 km in a series of steps parallel to its NE-SW trend, leaving behind, in the process, parallel linear valleys which are now covered by vast sand sheets.

The grabens (pull-apart basins) and horsts (push-up swells) are prominent morphotectonic features around Sambhar lake, Mendha and Rupangarh rivers and further northeast in the Kantli watershed comprising the Chandrawati river, Sabi and Sukh Nadis. These are clearly demarkated in the satellite imageries as linear features (Plate VI.2). Large scale regional disruption of the prior drainage in the region was due to the differential movements of the tectonic blocks resulting in tilting and generation of sag-ponds across their courses. The courses of the Mendha and Rupangarh rivers and other ephemeral drainage systems of the Sambhar and Didwana lakes are controlled by these linear horst and graben structures of the region. The Mendha river and the Sukh-Sabi nadis originate in the highlands typical of a tectonically uplifted area (the

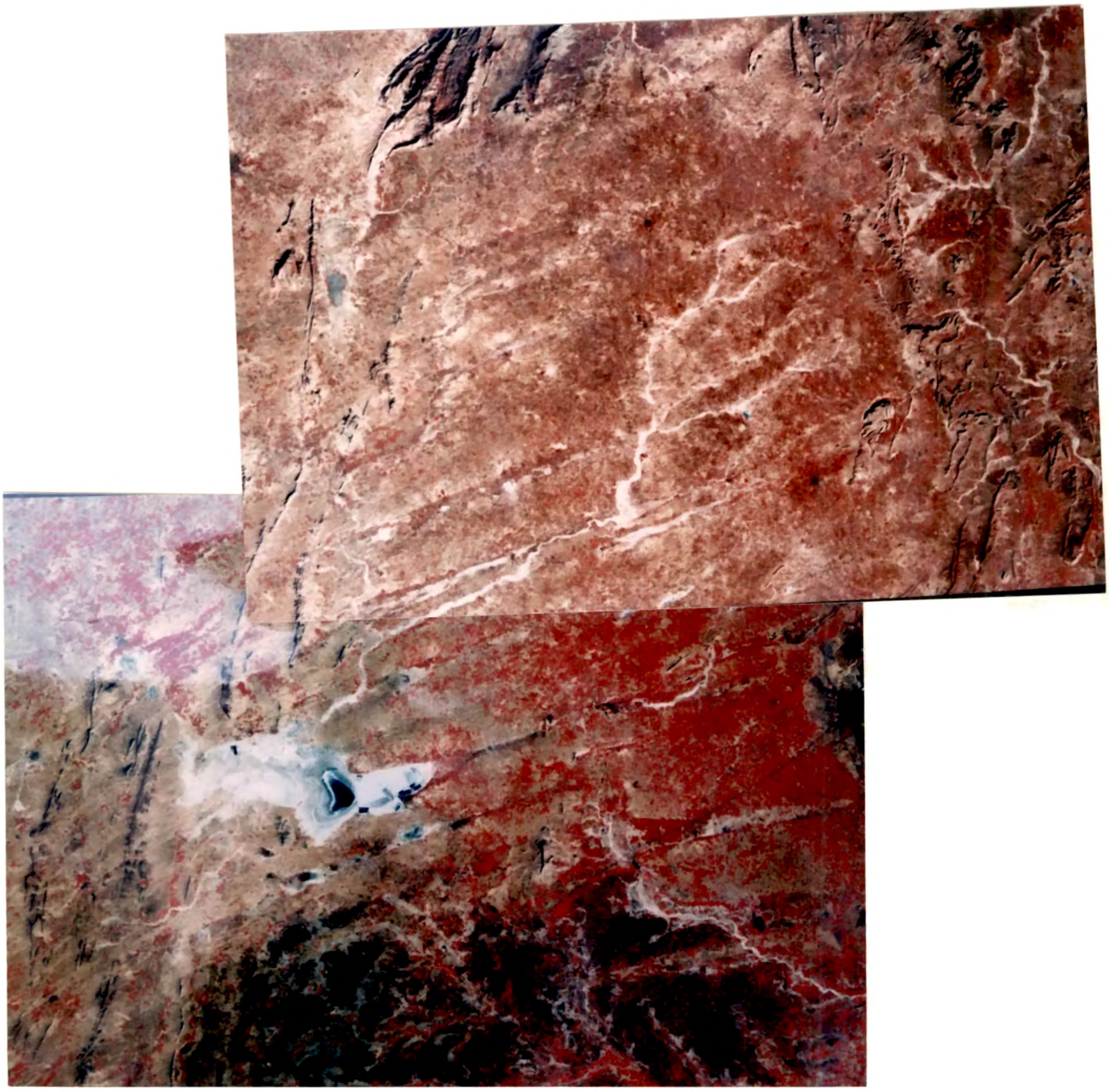


Plate VI.2 IRS (LISS - I) view of Sambhar lake and its environs. The linear ENE-WSW features in the Mendha watershed signify the horst and graben structure, ravine land and palaeochannel courses.

Jaipur-Neem ka Thana uplift), from where the Mendha flows in a southwesterly direction and the Sukh and Sabi Nadis have a northeasterly flow. Detailed neotectonic map of the Kantli-Sambhar block (Fig. 6.3) clearly shows these significant features. The sedimentation in the different stepped grabens in the Luni and Mendha valleys was a later phenemenon.

Rotational Movements

The continued uplift of the Aravalli Mountain Range during the Neogene and Quaternary periods, was accompanied by a general rotational tilting of the entire northwestern crustal block of Indian peninsula, along the Aravalli orographic axis. This rotational movement with an anti-clockwise component was hinged in the northeastern parts where the Aravalli Mountain Range plunges beneath the Indo-Gangetic alluvium. The uplift was not uniform along the length of the range as well as transverse to it, and was concentrated in the central and southwestern parts, resulting in a higher relief in these parts and a general decrease in altitude towards northeast. Sen and Sen (1983) have identified a fall in the summit surface of the Aravalli Mountain Range, as exhibited by the ridge and valley province, and a decline in the average land elevation both to the south and north, but at a rate more rapid to the south. The longitudinal outline of the Aravalli Mountain Range thus provides an assymmetric convex upward curve with gentle northerly arms and steep southerly arms. The average elevation of the plateaus also falls gradually northwards and more rapidly to the south.

Formation of the windgaps transverse to the Aravalli orographic axis, between the Sambhar lake and Kantli river, where a series of NE-SW, NW-SE and N-S faults intersect each other, has been attributed to these rotational movements. The relative anti-clockwise rotation of the crustal block has imparted a gentler slope to the eastern flanks of the Aravalli Mountain Range, whereas the western flanks have steeper slopes. The drainage migrations *viz.*, Chambal (southeast) and Luni and ancient river courses (northwest) perhaps could be attributed to such rotational movements.

Badlands and Badland Gullies

Badlands or ravine lands, intricately dissected by rills and gullies are clearcut evidences of neotectonic uplift. High rates of erosion are characteristic of the ravine lands. As already discussed in the chapter on Geomorphology, the badlands mostly occur in the northeastern and eastern parts of the study area in the Kantli watershed around Nim ka Thana, Amarsar, Chirawa, Fatehpura, Shri Madhopur, Bishangarh, etc. (Plate VI.3 & 4). These ravine lands and associated tributary gullies are seen to be aligned in line with the numerous NE-SW, NW-SE, E-W and N-S trending lineaments.

The rills and gullies usually develop in three topographic or litho-structural settings *viz.*, gullies in alluvial fill deposits in preformed valleys, gullies cut in bedrock on slopes or valley sides, and gullies developing as headward extensions of a drainage system on undissected upland surfaces (Campbell, 1989). In the study area, rills and gullies are seen to form in the alluvial fill deposits and also develop as headward erosions by the ephemeral rivers and streams on upland terrains.

The ravine lands in the study area mostly comprise of unconsolidated sand and silt, forming the palaeo-alluvial plains. Initial stages of calcrete development in the form of nodules and thin layers are observed in these unconsolidated materials. The ephemeral drainage pattern in these areas is mostly of the trellis to sub-trellis type.

The headward extension of gully systems into the flat to gently undulating terrain and upland regions in northeast Rajasthan around Kantli watershed provides excellent examples of various gully activating processes and their relationship to the neotectonic activities in the area. These gully systems are directly related to the scouring and incision action of the numerous ephemeral streams in the area especially the Dohan, Dongar, Sota Nadi, Sabi Nadi, Madhobini Nadi, the Kantli and its tributaries. They are the typical cases of the adjustments of the ephemeral streams in tune with the past as well as present crustal adjustments made by the movement of tectonic blocks.

Plate VI.3 A view of incised (ravine) topography characterized by intense rill/gully erosion, an indicator of neotectonic activities. Location: Mandoli

Plate VI.4 A view of undulatory badland terrain around Nim Ka Thana.

NEOTECTONISM AS EVIDENCED THROUGH SUBSURFACE PROFILES

It has already been discussed in the preceding chapter that the study area displays a variety of landform features that are attributed to fluvial, aeolian, mechanical and tectonic processes. The complex and episodic changes in process dynamics coupled with climatic perturbations have resulted in the superposition as well as burial of neotectonic signatures, particularly the palaeo-drainage, palaeo-fringe lines of pluvial lakes and playas, terraces, fault/fracture systems, etc.

In order to unearth such concealed neotectonic signatures, the author has constructed a number of subsurface profiles by referring numerous borehole records, which are described on the basis of blockwise neotectonic maps, *viz.* the Luni block and the Kantli-Sambhar block (Figs. 6.2 and 6.3).

LUNI BLOCK

(i) **Kasnau-Merta-Barr section** (A-A'), (Fig. 6.2.1).

The subsurface profile depicts the differential movements along the identified faults at Nimaj, Luni channel, Kekind, Rajod and Badauli, which were responsible for encountering basement rocks and Marwar Supergroup of rocks at variable depths. The structurally controlled depressions account for thick accumulations of Quaternary sediments.The Merta depression, the Bilara horst and the Luni depression are the manifestations of the different fault/fracture systems.

(ii) **Ransigaon-Thakurwas-Bar section** (B-B'), (Fig. 6.2.2).

The occurrence of reactivated basement faults are seen to occur at Ransigaon, Nimbol, Malpuriya, Agewa and Nimbaj. The Bilara uplift is the result of the faults passing through Ransigaon and Nimbol, whereas the Luni depression is due to the faults passing through Nimbol and Malpuriya. Towards the southeastern parts of this section around Barr, the basement rocks are exposed very near to the surface. The fault controlled intermontane depression (i.e., the

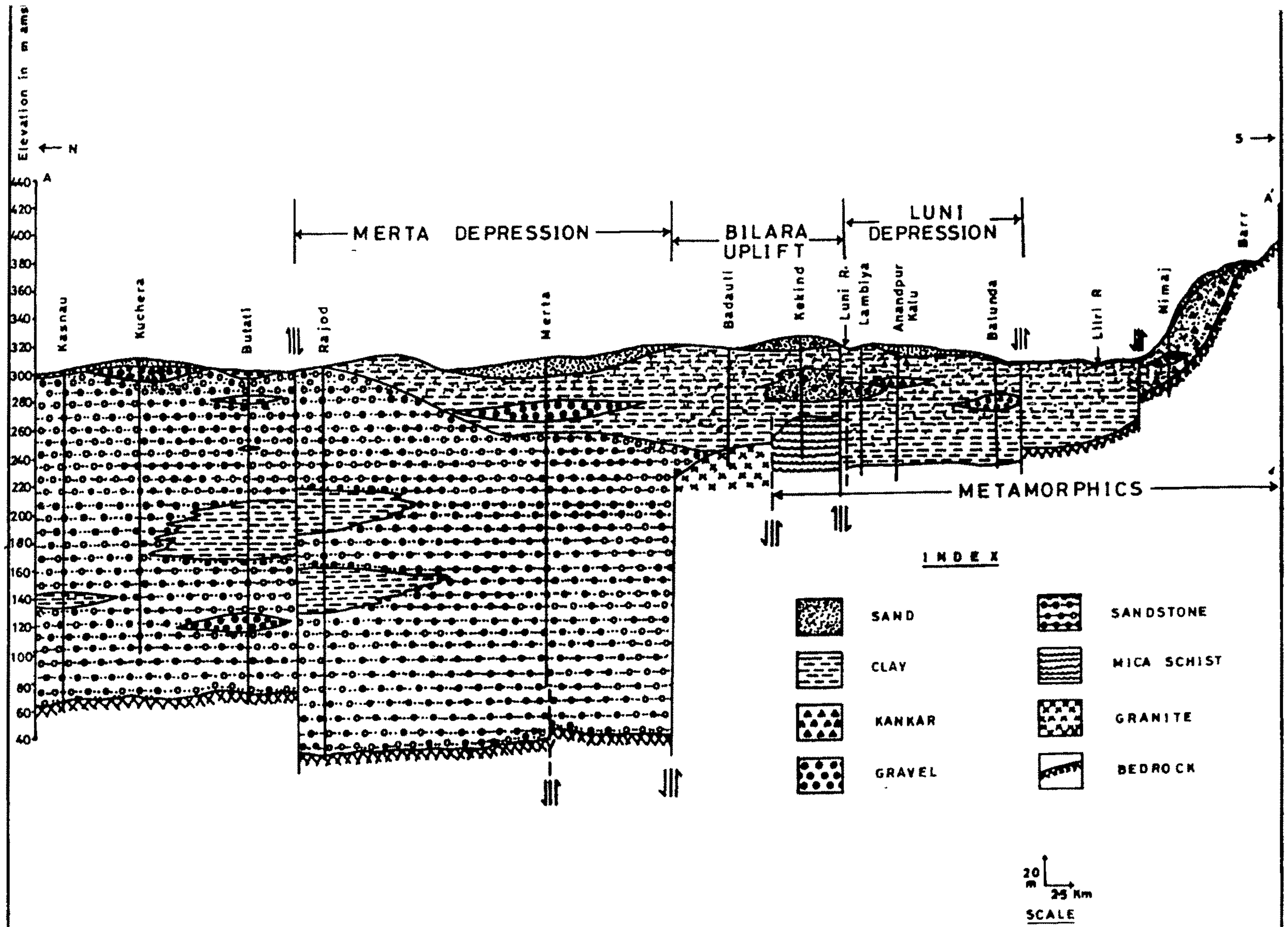


Fig. 6.2.1. GEOLOGICAL SECTION ALONG KASNAU - MERTA - BARR
(Based on CGWB bore hole data)

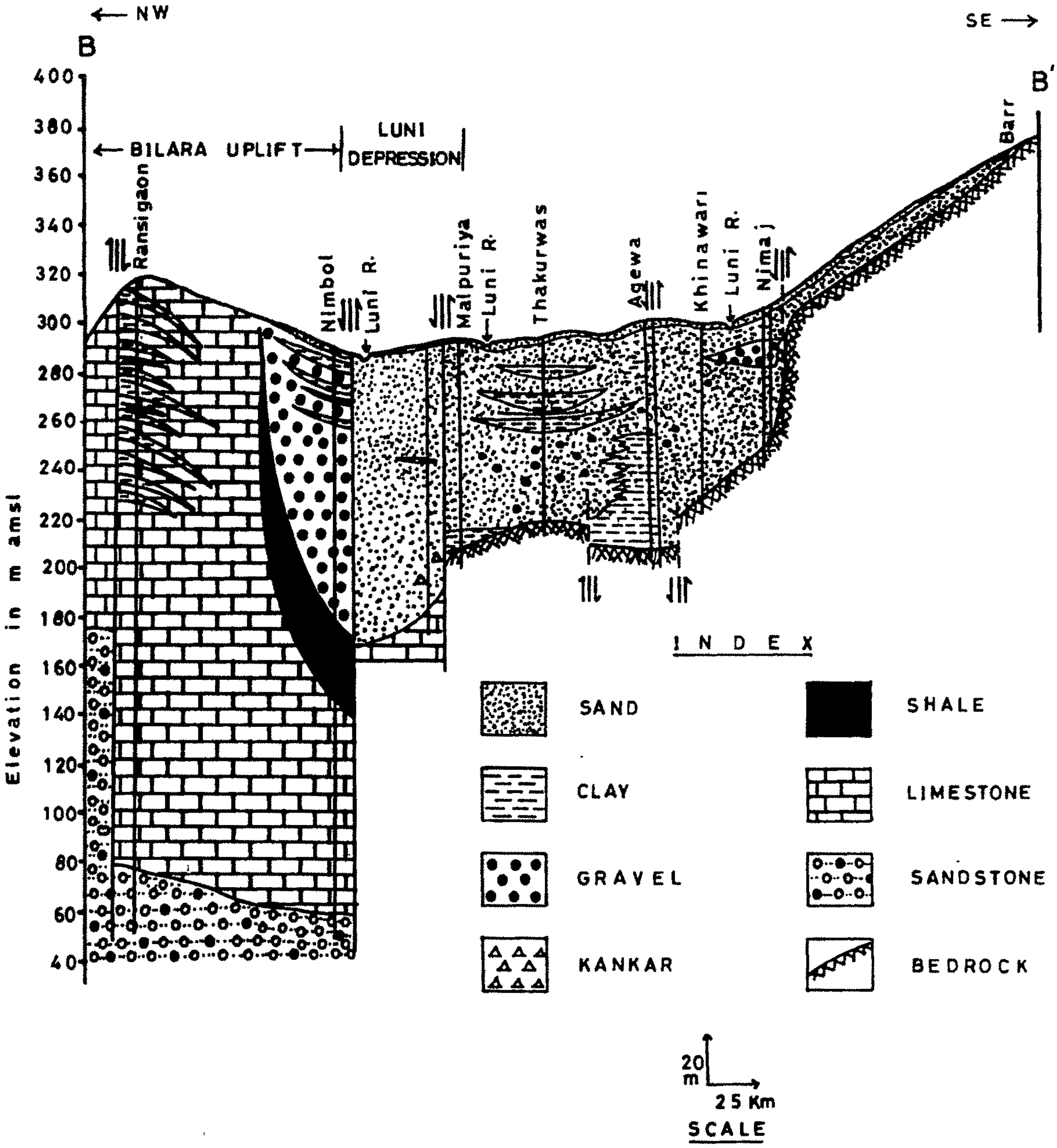


Fig. 6.2.2. GEOLOGICAL SECTION ACROSS LUNI RIVER ALONG RANSIGAON - THAKURWAS - BARR (Based on CGWB bore hole data)

Bilara - Bar uplifted blocks) account for more than 100 m thick pile of Quaternary sediments and also the confinement of the Luni channel.

(iii) **Jhak-Kalu-Badauli section** (C-C'), (Fig. 6.2.3).

This section depicts the occurrence of fault at Nimbol, that has relatively uplifted the Palaeozoic group of rocks. Palaeozoic gravels and cobbles are seen to occur in the subsurface horizons at Nimbol and Jhak. Towards ENE part of this section gravels and cobbles of recent deposits (20-40 m thick) are seen to occur in the subsurface horizons at Kaulia Kalan, Kekind, Badauli, etc. The bedrock comprising of mica schists occur nearer to the surface at Kekind, Badauli, etc.

KANTLI BLOCK

(i) **Talai ki Dhani-Losal-Nawa section** (D-D'), (Fig. 6.3.1).

This NNW-SSE section reveals the occurrence of basement fault controlled Sikar depression between Patoda and Losal, which forms a graben configuration. Further south upto the Aravalli Mountain Range, the stepped faults are characteristic. To the southeastern side, the stepped faults/grabens have produced the Sambhar lake depression, the effects of the Kasganj-Dausa-Didwana fault and the Luni-Sukri fault clearly recognisable in this section. The evidences of reactivations of these regional fault/fracture systems are well percieved in the Quaternary sediments.

(ii) **Fatehpur-Patoda-Losal section** (E-E'), (Fig. 6.3.2).

This section depicts a general decline in the slope of the terrain towards north, with the basement rocks having gone down by 20 - 30 m due to the effect of step-faults. This has resulted in the gradual thickening of Quaternary sediment pile. The Luni-Sukri fault system has created the Sikar depression as revealed in the section between Dhod and Patoda.

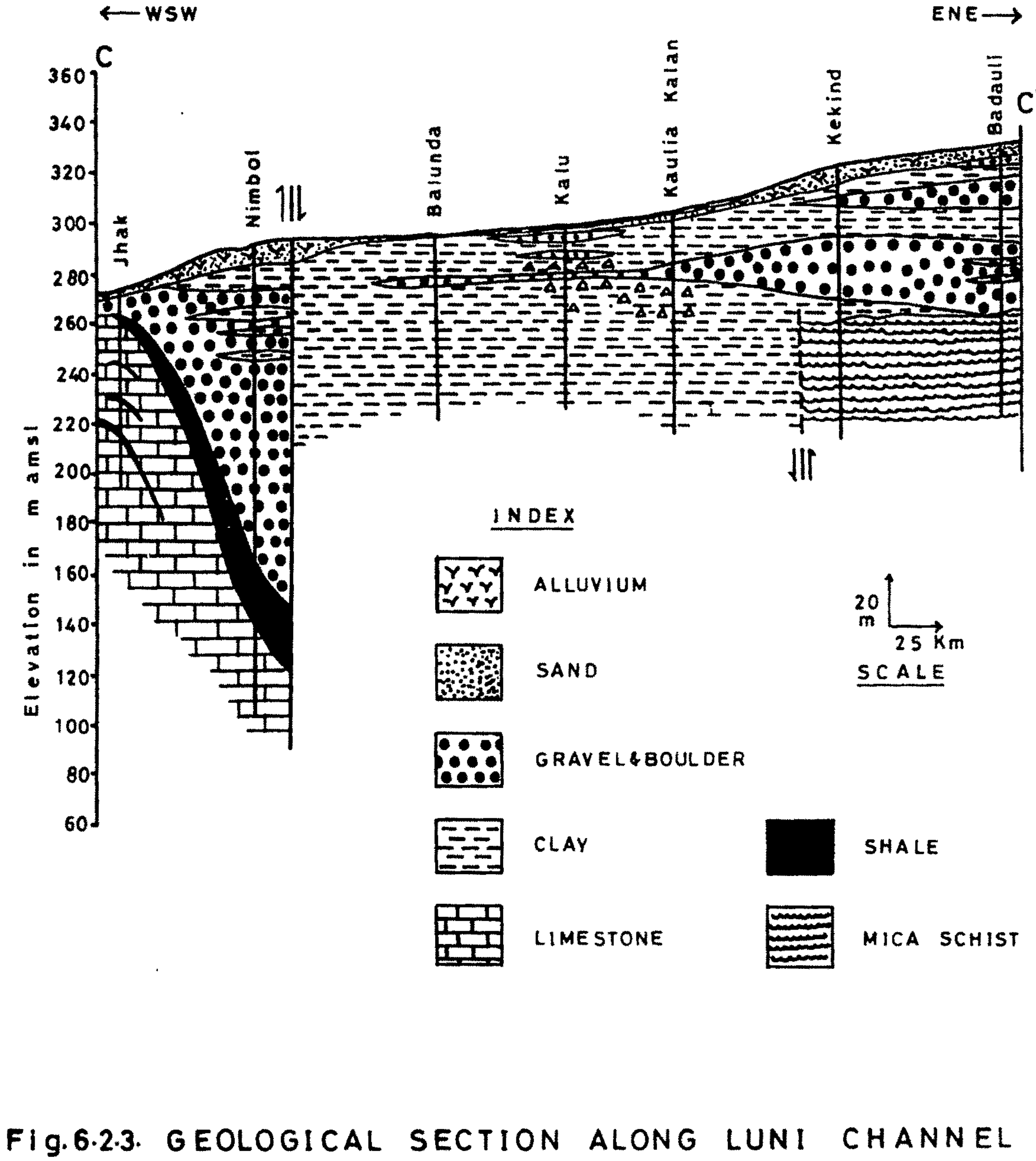
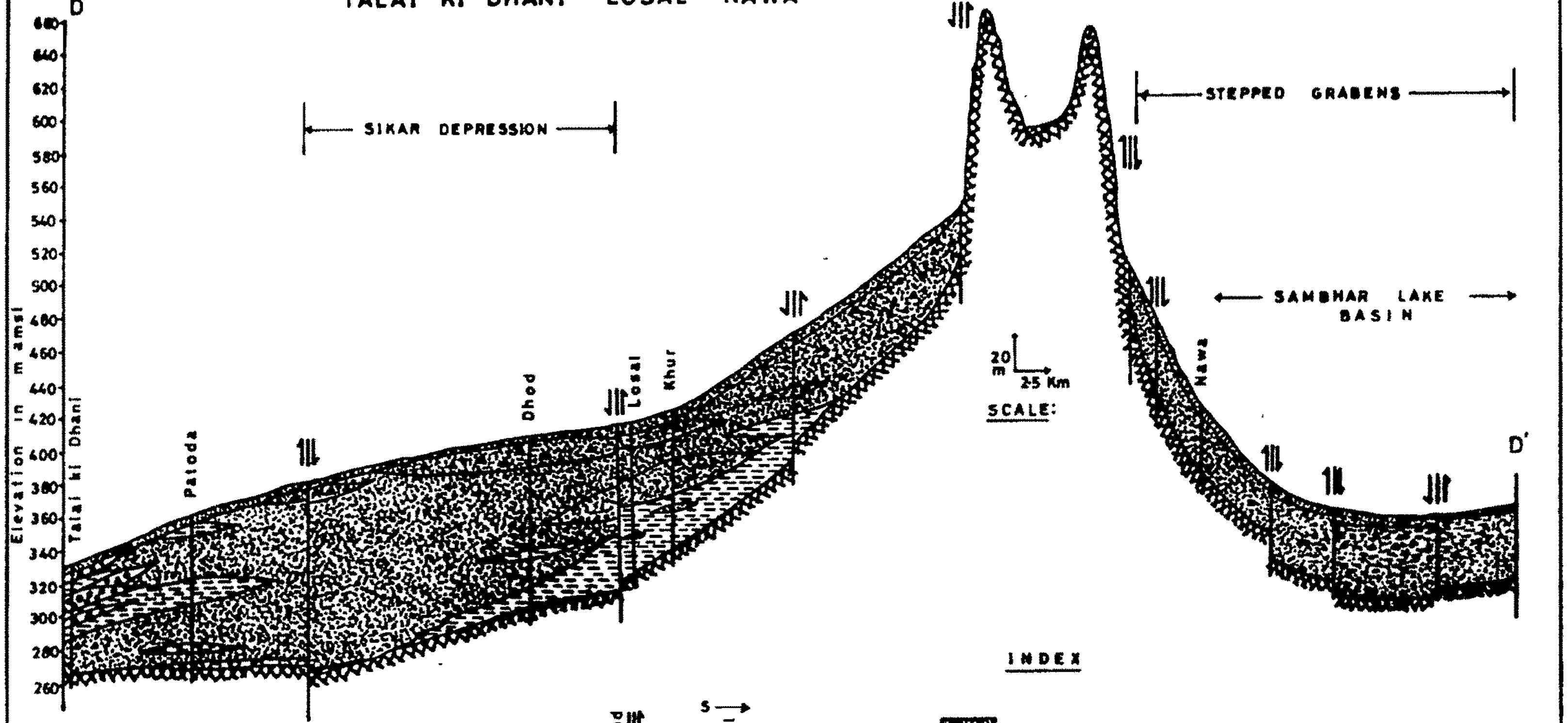


Fig. 6·2·3· GEOLOGICAL SECTION ALONG LUNI CHANNEL
(JHAK - KALU - BADAULI)
(Based on CGWB borehole data)

Fig. 6.3.1. GEOLOGICAL CROSS SECTION ALONG TALAI KI DHANI - LOSAL - NAWA



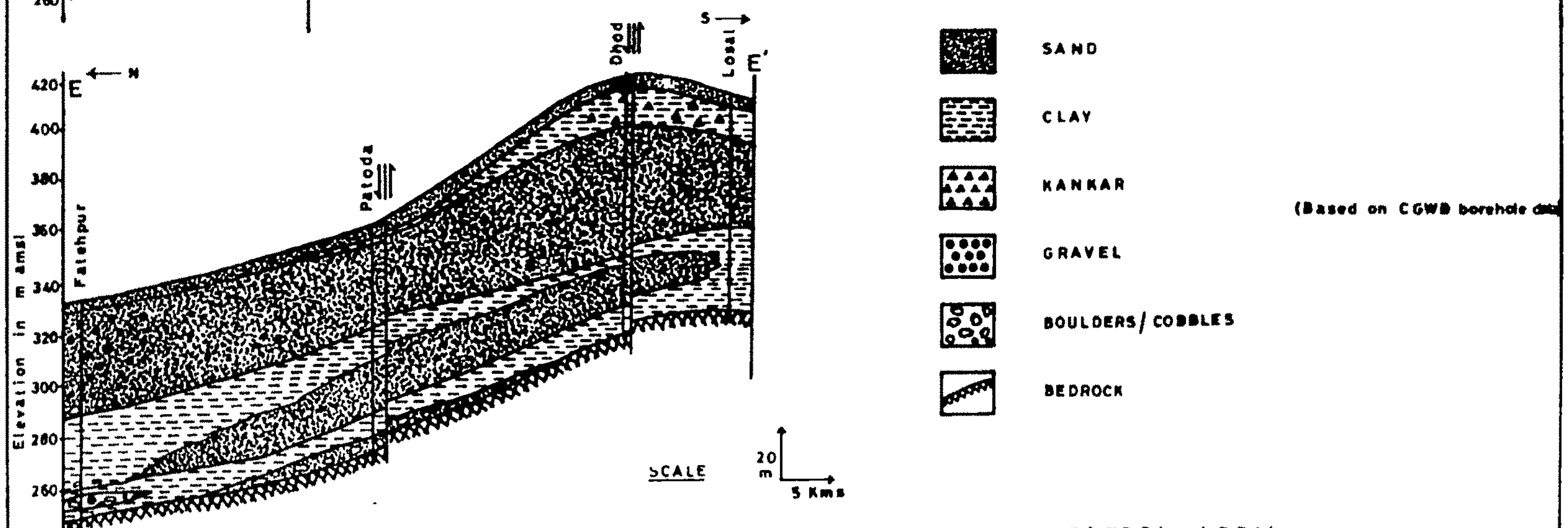


Fig. 6.3.2. GEOLOGICAL CROSS SECTION ALONG FATEHPUR - PATODA - LOSAL

(iii) **Dighal-Gungara-Palsana-Bai section** (F-F'), (Fig. 6.3.3).

The NNW segment of this section reveals the occurrence of Sikar depression between Dighal and Parasrampura, created by the basement reactivated Luni-Sukri fault system. The Udaipurwati-Khetri uplift forms a part of the Aravalli Mountain system. Towards the SSE segment of this section, basement fault systems are seen to occur between Ranoli, Palsana, Gauti and Bai, creating horst and graben configuration with relative down throw towards SSE, where the Mendha stepped grabens occur. Here also the evidences of reactivation are well percieved within the Quaternary sediments.

(iv) **Chirawa-Jodhpura-Trilokpura section** (G-G'), (Fig. 6.3.4).

The major basement fault is the Luni-Sukri fault (LSF) occurring between Chirawa and Chaonra. The Udaipurwati-Khetri uplift is depicted as various basement step-faults at Chaonra, Jodhpura and between Guhala and Shilpura. The continued reactivations of the basement faults between Guhala and Shiplura, at Thoi, between Rampura and Trilokpura, etc., have produced ravine land topography towards the SSE segment of this section.

(v) **Danta Ramgarh-Gauti-Ghuwala section** (H-H'), (Fig. 6.3.5).

This SW-NE section depicts the occurrence of basinal depressions created by the faults at Bai and Palsana and the basement uplift at Gauti.

In the light of above discussed subsurface profiles it can be concluded that the study area constitutes an important part of morpho-tectonic block of Trans-Aravalli continent with ample evidences of neotectonic movements.

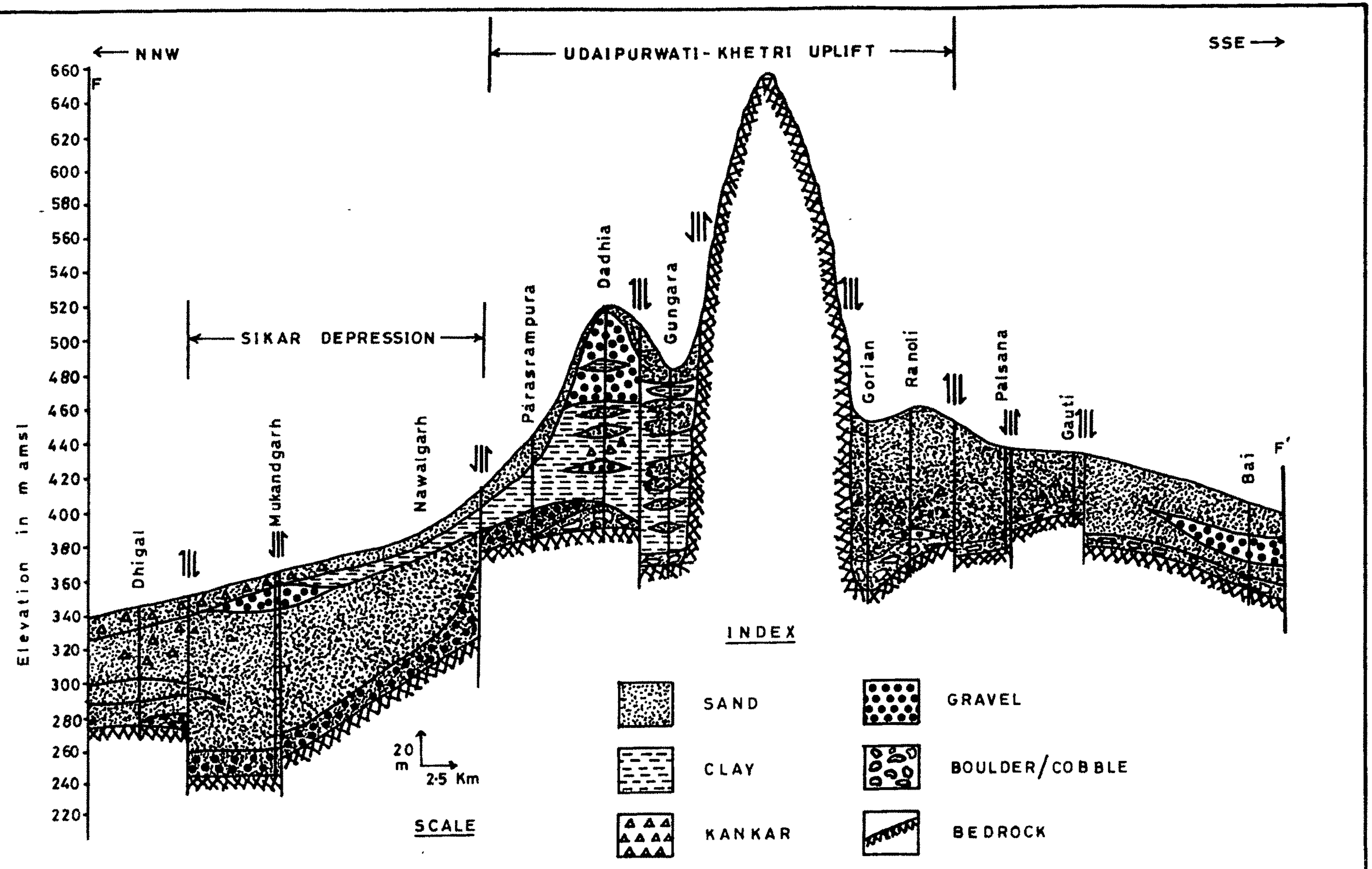


Fig. 6·3·3. GEOLOGICAL CROSS SECTION ALONG DIGHAL - GUNGARA - PALSANA - BAI
(Based on CGWB bore hole data)

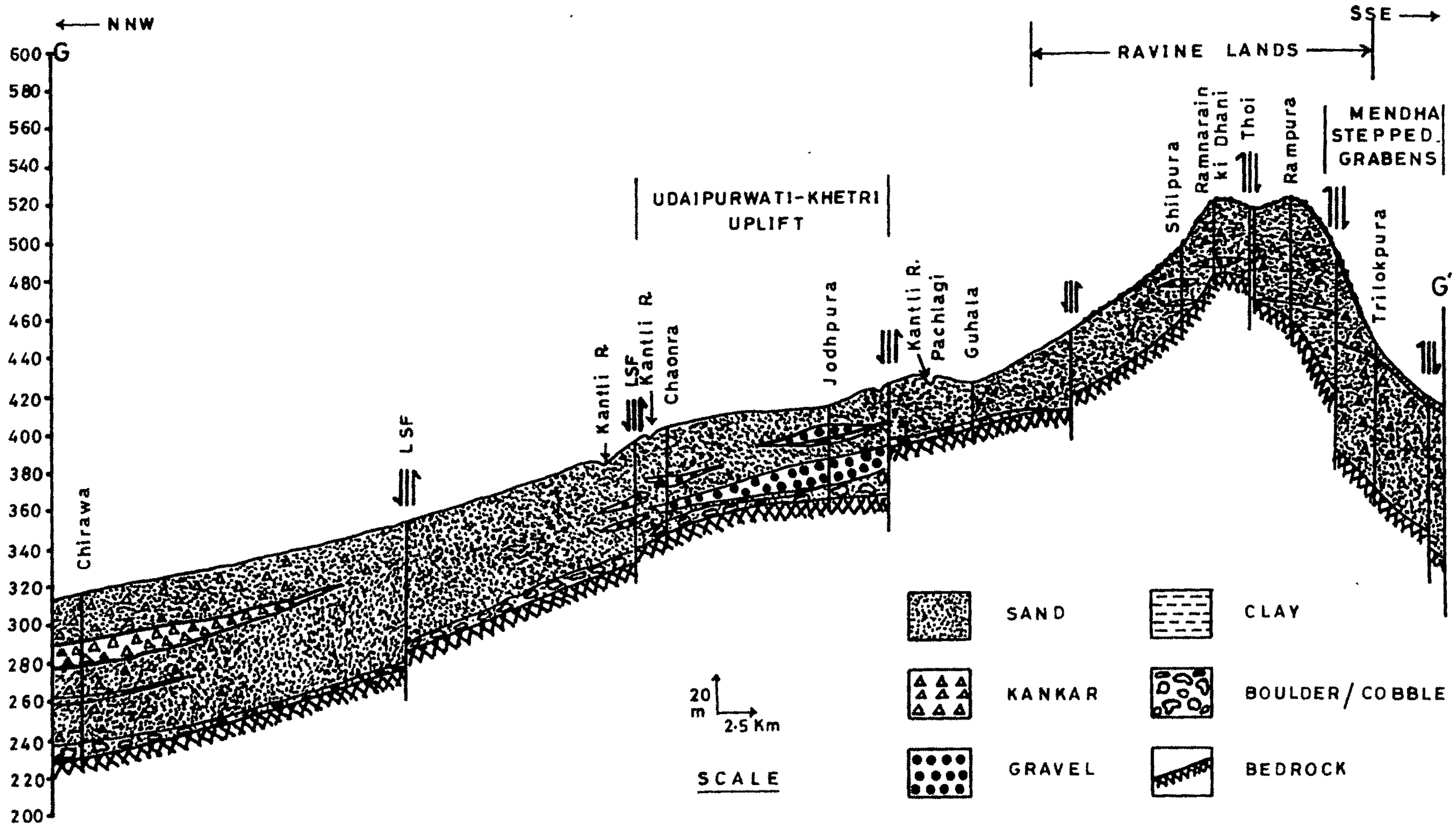


Fig. 6.34. GEOLOGICAL CROSS SECTION ALONG CHIRAWA - JODHPURA - TRILOKPURA
(Based on CGWB bore hole data)

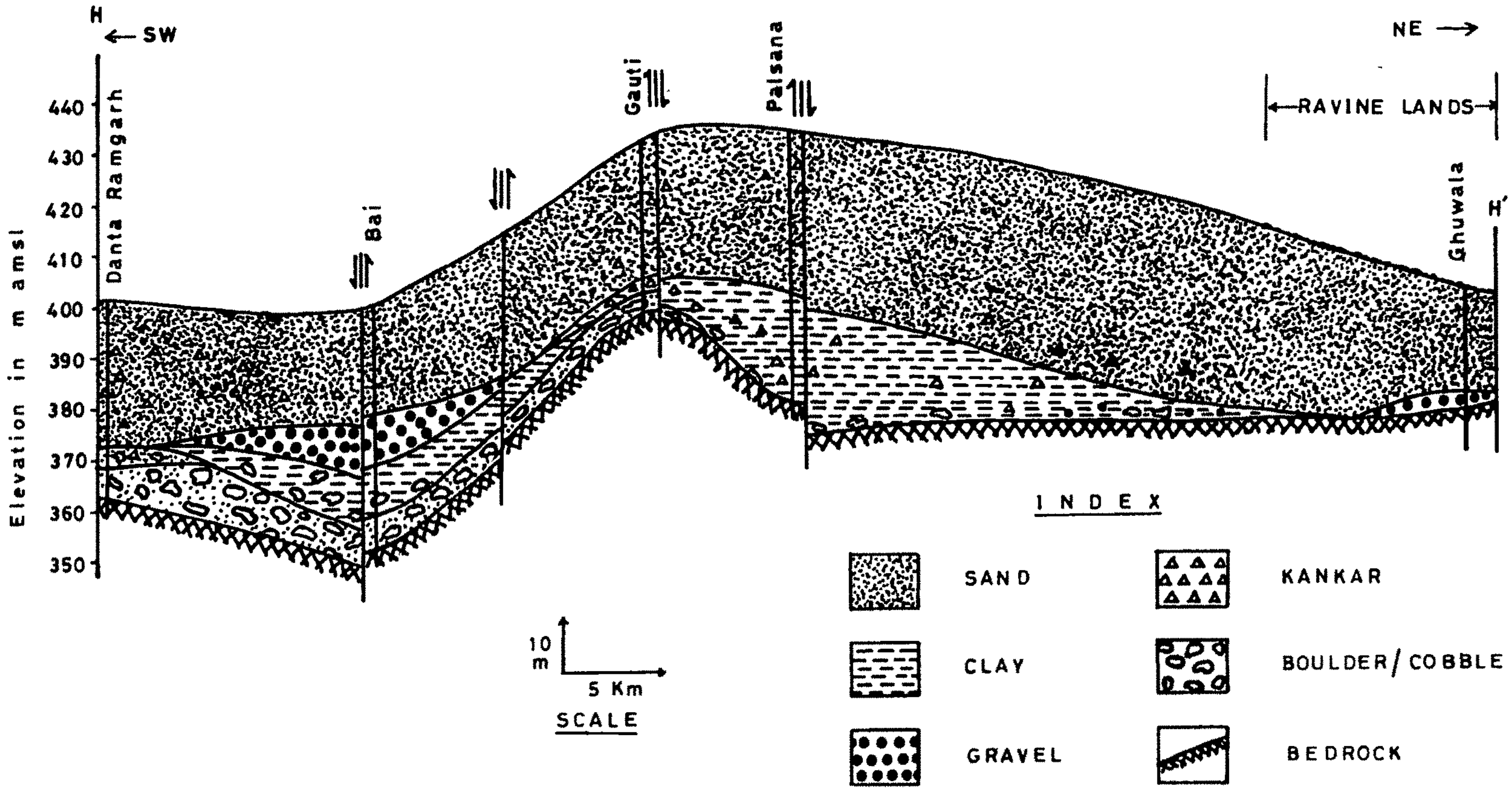


Fig. 6.3.5. GEOLOGICAL CROSS SECTION ALONG DANTA RAMGARH - GAUTI - GHUWALA
(Based on CGWB bore hole data)