CHAPTER VII

NEOTECTONIC AND QUATERNARY

MOVEMENTS IN THE AREA
NEOTECTONIC AND QUATERNARY MOVEMENTS IN THE AREA

7.1 Introduction

As a result of plate motions and resulting distensional tectonics within a plate, recent or present day displacements, as well as those which have occurred during the past 100,000 years are now being studied with much greater stress than before. These neotectonic studies carried out within the past two decades have assumed a new dimension and are generally related to the present day movements of lithospheric plates. The studies help to throw light on the kinematics of plate motions and are shown in many regions to be intimately related to the seismicity of the region and focal mechanism solutions. Further, it has also been found that these disturbances are definitely related to the elastic strains or residual stresses built up within the rocks at deeper crustal levels and occur in sudden "jumps" or bursts that create earthquakes of small magnitude. On the other hand, elastic strains may be actually released very gradually almost imperceptibly over a thousand years or more, that express themselves in the disruption and displacement of the recent deposits on the earth's surface. The plates move at infinitesimally small rates as substantiated by the movements along some of the thrusts measured by using geophysical devices.
The role of pre-existing structures in controlling the geometry of structures formed in the younger rocks at a later geological period is now well known. For example, the Alpine belt has the same trend as the Hercynian pre-triassic crystalline basement it overlies. It is well known that the Atlantic ocean began opening about 220 Ma along the pre-existing weak zones in the basement formed as a result of Caledonian, Appalachian and Moroccean orogenic belts. However, the structures transverse to the present day orogens are formed along the grain of pre-existing widely spaced structures within the basement. For example, the locations of fold structures in the Jura mountains of Alps is controlled by the structures within the older Rhine graben as are the transverse structures in Himalayas which are located along the continuation of the Aravalli belt, the extension of the Cambay graben, the extension of the Great Boundary Fault (GBF) which continues as Datagunj-Tilhar fault underneath the Indo-Gangetic alluvium (Sastry et al. 1971) or the extension of Bundelkhand granitic massif as Faizabad ridge (Valdiya 1973) etc.

Usually the present day movements are located along the weak basement zones since these are the avenues for release of residual stresses. The release of stored elastic strains through pre-existing zones is a least work configuration or occurs with the expenditure of least work.
7.2 The Major Tectonic set up in the Area

The area under investigation falls close to the major boundary between the large Indo-Australian plate and the small Iranian or Persian plate, which can be considered as an independent entity within or binding the still larger Arabian plate. The principal boundary between the two plates occurs in Pakistan in the form of an intracontinental transform fault, the Chaman transform fault. This fault has an overall dextral sense of movement and is continuous with the very ancient Owen fracture zone along which the split between India and Madagascar occurred about 100 Ma. It falls in the category of other intracontinental transform faults like the famous San Andreas transform fault (which is the transcurrent fault affecting the North America subduction zone), the Alpine fault of New Zealand (which is a transcurrent fault that displaces the Kamdulc subduction zone), the Anatolian transform fault (which displaces the mid Atlantic ridge in the Atlantic Ocean at Azores Island and runs along the southern boundary of the Turkish Aegean plate). The chaman transform fault displaces the principal Himalayan range to the south on the western side (a closer look of Fig 76 would reveal that the actual sense is dextral), in the form of a large number of thrusts in Iran, south of the Zagros mountains. The Murray ridge is a displaced segment of the Aden rift, and the large number of earthquakes in this region are because of the renewed movements along this fault and
the Murray ridge. Incidentally, the Great Boundary Fault of Rajasthan has the western continuation along the northern coastline of Saurashtra in the Gulf of Kutch and apparently, is continuous with the Murray ridge. This is the general plate tectonic set up of the region in which the present area lies. Some outstanding work in the desert region to the west has been done in recent years (Yashpal et al. 1980).

7.3 **Applicability of Remote Sensing in Neotectonic Movement Study**

The remote sensing data is providing insights into the neotectonic activity, basically because it offers a regional tectonic set up into a larger frame. It helps to identify the tectonic lineaments by straight courses of drainage, tonal contrasts etc., and by their very rectilinearity which is more or less uniform over a region. These features normally take years to be mapped on the surface by a geologist and sometimes even pass unnoticed. In this context, therefore, the remotely sensed data has become all-the-more important. The data may be obtained from the computerized images based on reflected quanta through the diachroic prism of a satellite for a given pixel (picture element of given dimension). More important however is the analysis based on the various computer enhancing techniques of these images. A classic work in the Rajasthan desert has been, the delineation of the exact course of the giant
Saraswati river which was mightier than the Ganges, Jamuna, Brahmputra or Indus rivers at the time the ancient Hindu Scriptures (the Vedas and Upanishadas) were written by the Aryans whose origin is traced to Siberia. The course of the ancient lost Saraswati river (Yashpal et al. 1980), is now represented only by a small stream called Ghaggar in Haryana and Hakra in Rajasthan. For details on this aspect the reader is referred to Yashpal et al. (1980). However, this study puts a constraint on the development of desert belt of western India - Arabia, as a relatively more recent phenomenon (because Vedas were written about 3000 BC) which the geological data does not suggest, with salt, Gypsum unhydrites of Eocen age, found in Rajasthan and Cambrian salt range now in Pakistan. However, this is another aspect, and a criticism of the plate tectonic theory with desert conditions prevailing in the belt since Cambrian (500Ma). It makes us accept the theory of Global expansion, first postulated by Carey (1958) on the basis that the gravitational constant of the earth has been decreasing with time.

7.4 Neotectonism - Its Relationship with Major Lineaments

In the area under study, the neotectonic activity is prominent but is of a lesser magnitude than to the south, substantiated by two rather recent earthquakes of moderate intensity (Table 7.1) at mount Abu. Lesser seismic activity
Table 7.1. Seismic record

<table>
<thead>
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<th>Year</th>
<th>Lat</th>
<th>Long</th>
<th>Place</th>
<th>Intensity</th>
</tr>
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<tr>
<td>1668 May</td>
<td>25.8</td>
<td>68.0</td>
<td>Samaji Delta of Indus</td>
<td>X old</td>
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<tr>
<td>1819 June</td>
<td>23.6</td>
<td>69.6</td>
<td>Kutch</td>
<td>XI</td>
</tr>
<tr>
<td>1820 Jan</td>
<td>23.2</td>
<td>69.9</td>
<td>Bhuj</td>
<td>V</td>
</tr>
<tr>
<td>1820 Nov</td>
<td>23.2</td>
<td>69.9</td>
<td>Bhuj</td>
<td>IV</td>
</tr>
<tr>
<td>1828 July</td>
<td>23.2</td>
<td>69.9</td>
<td>Bhuj</td>
<td>VI</td>
</tr>
<tr>
<td>1942 Jan</td>
<td>26.0</td>
<td>63.0</td>
<td>NW provinces</td>
<td>VI</td>
</tr>
<tr>
<td>1942 Oct</td>
<td>22.3</td>
<td>73.2</td>
<td>Baroda</td>
<td>V</td>
</tr>
<tr>
<td>1843 Feb</td>
<td>23.0</td>
<td>72.7</td>
<td>Ahmedabad</td>
<td>V</td>
</tr>
<tr>
<td>1945 Apr</td>
<td>23.8</td>
<td>68.9</td>
<td>Lakhpat</td>
<td>VIII</td>
</tr>
<tr>
<td>1845 June</td>
<td>23.8</td>
<td>68.9</td>
<td>Delta of Indus</td>
<td>VII</td>
</tr>
<tr>
<td>1848 Apr</td>
<td>24.4</td>
<td>72.7</td>
<td>Mt. Abu</td>
<td>VII</td>
</tr>
<tr>
<td>1864 Apr</td>
<td>22.3</td>
<td>72.8</td>
<td>Ahmedabad</td>
<td>VII</td>
</tr>
<tr>
<td>1906 Aug</td>
<td>24.4</td>
<td>72.7</td>
<td>Mt. Abu</td>
<td>V</td>
</tr>
<tr>
<td>1907 July</td>
<td>26.0</td>
<td>72.0</td>
<td>Malani</td>
<td>VI</td>
</tr>
<tr>
<td>1919 Apr</td>
<td>22.0</td>
<td>72.0</td>
<td>Bhavnagar and vicinity</td>
<td>VIII</td>
</tr>
<tr>
<td>1922 Mar</td>
<td>22.0</td>
<td>71.0</td>
<td>Patoi, Rajkot and Jhalawar</td>
<td>V</td>
</tr>
<tr>
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<td>27.5</td>
<td>68.5</td>
<td>Larkana</td>
<td>5.6</td>
</tr>
<tr>
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<td>Larkana</td>
<td>6.5</td>
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<tr>
<td>1940 Oct</td>
<td>22.5</td>
<td>70.4</td>
<td>Dwarka and Vicinity</td>
<td>VI</td>
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Table 7.1 (Contd.)

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<th>Intensity</th>
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<td>71.2</td>
<td>Bhuj</td>
<td>V</td>
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<tr>
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<td>Anjar</td>
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<td>24.1</td>
<td>70.9</td>
<td>Rann of Kutch</td>
<td>-</td>
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<td>73.0</td>
<td>North Gujarat</td>
<td>5.6</td>
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<td>1963 July,13</td>
<td>24.9</td>
<td>70.3</td>
<td>Thar Parkar</td>
<td>5.6</td>
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<tr>
<td>1964 Oct.,4</td>
<td>27.9</td>
<td>69.2</td>
<td>Sukkur</td>
<td>4.8</td>
</tr>
<tr>
<td>1965 Mar.,24</td>
<td>25.2</td>
<td>67.7</td>
<td>East of Karachi</td>
<td>4.8</td>
</tr>
<tr>
<td>1965 Mar.,26</td>
<td>24.4</td>
<td>70.0</td>
<td>North of Kutch</td>
<td>5.3</td>
</tr>
<tr>
<td>1966 Nov.,20</td>
<td>27.6</td>
<td>67.7</td>
<td>Larkana</td>
<td>4.9</td>
</tr>
<tr>
<td>1967 Mar.,26</td>
<td>27.3</td>
<td>67.5</td>
<td>Mehar</td>
<td>4.9</td>
</tr>
<tr>
<td>1967 May,11</td>
<td>27.0</td>
<td>75.2</td>
<td>Jaipur</td>
<td>5.0</td>
</tr>
<tr>
<td>1969 Aug.,20</td>
<td>27.0</td>
<td>75.8</td>
<td>Near Sambhar lake</td>
<td>4.5</td>
</tr>
<tr>
<td>1969 Oct.,24</td>
<td>24.8</td>
<td>72.4</td>
<td>Mt. Abu</td>
<td>5.3</td>
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<td>1970 Mar.,23</td>
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<td>72.7</td>
<td>Broach</td>
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<td>21.6</td>
<td>72.7</td>
<td>Broach</td>
<td>3.5</td>
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<td>21.7</td>
<td>73.0</td>
<td>Broach</td>
<td>4.0</td>
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<tr>
<td>1973 June,26</td>
<td>27.0</td>
<td>75.2</td>
<td>Jaipur</td>
<td>4.0</td>
</tr>
</tbody>
</table>
has also been recorded at Jaipur, twice in recent years, and assume significance, Jaipur being the capital of Rajasthan. The LANDSAT TM frames were studied first and prominent lineaments were marked in the region (Fig. 7.1A, 7.1B). The work on the area concerned in this thesis, was then mapped on 1:25000 scale aerial photographs. Fig. 7.2 shows the map compiled from the aerial photographs on this scale.

As far as the lineaments of tectonic significance are concerned, these generally fall into two prominent and a third less distinct group. The most prominent are the faults that parallel the orogen and have the trend of the Aravalli range. There are a large number of fractures which have the same trend. Besides the lithologic units have boundaries that parallel these fractures and faults. A large number of streams and nalahs, only some of which are perennial and rest are seasonal, follow the pelitic schists, that follow the strike of the orogen and the weak zone. The second prominent trend is of the ENE lineaments, mostly fractures and faults that are synorogenic, that generally bring antiforms into juxtaposition with synforms. These fractures perfectly adduce that the Aravalli orogen or Delhi orogen are a typical collisional tectonic zone with side push, as was found by Dubey (1980) by model analogue experiments.

The third set, less distinct, of fractures and faults that
NEOTECTONIC ACTIVITY IN THE
AREA UNDER INVESTIGATION
have an ESE trend subperpendicular to the orogen. These fractures could either be typical tensile fractures, possibly developed in the direction of maximum principal compressive stress $\sigma_3$. But some of these lineaments are faults that show sinistral shift or sense of displacement on the horizontal plane and hence it is possible that they could be complementary shears of the ENE trending dextral ones. Fig. 7.2 shows the lineament map of the area covered for investigation. The most interesting point to note, in case of most of the drainages is that, while for a long distance, they cover the trend of the orogen, but later suddenly take right angle bends to ESE to SE at places, cut across deep gorges and then again begin to flow along the axis of the range. However, the streams, once getting out of the range along ESE to SE trending fractures, in the Marwar plain to the west of the range, then meander considerably but again follow the lineaments of the three directions or trends in certain sections.

Fig. 7.3 shows the density contours of the lineaments in the area mapped on the air-photo mosaic. The area was divided into 1 km $\times$ 1 km sectors and the number of lineaments were counted in each of the squares of 1 km$^2$ area. They were then contoured for the percentage as shown by the values of contours in Fig. 7.3. It will be noticed that some best fit lines through the maxima are drawn and these lines also suggest three directions or trends that are described above.
Fig. 7.4 shows the cumulative length contour map for the entire area. The procedure was the same as above except that instead of the number, the total length of all the lineaments in a given square of 1 km² area was considered. The percentage of the total length in the entire area was then computed for each square and the values contoured. The maxima and the disposition of various contours clearly suggest that the three trends as described are most prevalent.

Based on the above lineament data, two rose diagrams (orientation frequency diagram) were also prepared, one for the percentage frequency of the lineaments of a given trend at 20° interval, and other for the cumulative length for each group. These (Fig. 7.5A and 7.5B) also suggest that the three trends are predominant.

It may be pointed out that most of the faults in the Aravalli Range are vertical or subvertical or steeply dipping. This is principally because the faults though developed initially as tectonic slides at moderate angles, were rotated into steeper position at the end of the orogenic cycle. It is due to the fact that the maximum principal compressive stress σ³ did not change its orientation through time and remained more or less in the same direction and presumably plunging at the same angle.

Out of the three principal groups of predominant trends, it is found that the neotectonic activity is generally
LINEAMENT FREQUENCY

LINEAMENT DENSITY
Interval $20^\circ$

FIG 7.5
associated with the ENE trending faults and fractures and little at all along those of the other trends. The ENE trending fractures which are synorogenic are dextral shears, but most of the real displacements found along them are of sinistral sense. The reason for this is given later in this chapter. The reversal of the sense is most certainly related to the later tectonic regime and orientations of the principal stresses, which have been operating within this part of the Indian plate during quaternary times to the present day. The principal compression is generally to the NNE and NE and N, rather in an anticlockwise kind of motion of the Indian plate about a node placed at the Mt Girnar, the gabbroic and alkaline rocks complex of a horst structure as revealed by DSS profile (Kaila et al. 1981), in an area consisting entirely of Deccan basalts.

The ENE trending lineaments are also seen in the desert plain of Marwar in form of buried channels etc. and it seems that they are continuous upto the Kutch and Rann of Kutch areas, a centre of much seismic activity known in the past 200 years (Chandra 1977).

7.5 Evidences of Neotectonic Activity in the Area

The neotectonic activity is confirmed on the land and is seen very well on the aerial photographs, even on as small a scale as 1:25000. The disruption of the flood plain deposits is seen in the river Liri to the west of Giri, where the flood
plain deposited is displaced by almost a ferlong along a NW-SE trending fault. The total displacement is only about 100 meters. As shown later, this fracture/fault may be a synthetic element of a second order fault, related to the Chaman transform zone. It may also be noticed on the lineament map (Fig. 7.2) that the principal course of the river Liri which cuts a gorge north of Giri village, has segments that trend ENE, NW-SE or ESE-WNW and then parallel to the axis of the range. So is the case with the major river Sukri which flows across the range, north of Biranthia. To the WNW of Biranthia, this river braids and a large island is produced which is displaced sinistrally by 200 meters, along an ENE-WSW trending fault. The river though initially braided and produced an island, however, now flows from the northern side only so that the island is now part of the southern bank of the river. South of Barr, again another principal stream has an island that is dextrally displaced along an EW trending fault. Similar feature is again seen further south along a fault of the same trend, but the displacement being sinistral. When this stream finally enters the Marwar plain, it braids giving rise to a large island about 1 km\(^2\) in dimensions. At this place, also, that is SSW of Barr, the river bank is sinistrally shifted along an ENE trending fault. Such small magnitude displacements are by far, very common for most of the benches, alluvial fans and
islands, and flood plain deposits. But, the displacements are predominantly strike-slip along the subvertical planes. Since, a single lithology of the same colour is involved, it is difficult to take photograph in the field and reproduce for the thesis. However, these have been observed in the field and with the exception of one, all have been nearly along EW or ENE trending faults of minor scale. These displacements are manifest of the recent tectonic activity, still continuing, on a much smaller scale in the region, under a differently oriented stress field, along the pre-existing faults that were perhaps generated more than a million years ago.

7.6 Seismicity of the Region

The Aravalli region has been generally seismically passive but for some data on the two Mount Abu earthquakes (see Table 7.1) and two earthquakes at Jaipur. Mt. Abu falls on the western flank of the Delhi orogen and is about 100 kms southwest of the present area. But the evidence is presented in the following sections that the neotectonic activity is principally related to the seismicity, occurring in the area to the west and also in pakistan, along the Indus river, Larkana, the Chaman fault and Murray ridge.

Fig. 7.6 shows the map of a part of the middle east, the boundary between the Indian plate and the Iranian plate. The epicentres of the earthquakes, which occurred during the
FIG 7.6
last 200 years are plotted, only for the relevant part of
the plate and those on the NNE ward extension of the Chaman
fault and the Himalayan range are excluded from this map.
This is only to highlight the importance of the present area
in relation to seismicity where neotectonic activity has been
observed. The earthquakes whose epicentres are plotted are
given in Table 1, with latitude, longitude, locality and
the intensity on the Richter scale. For some of the old
earthquakes, the data is less well known regarding focal
mechanism solutions but from the extent of the region disturbed
an approximate area limits can be drawn. This elliptical area
has a long axis that indicates the trend of the fault plane
along which the seismicity may have occurred. Some of the
earthquakes merit detailed mention since they are of direct
relevance to the area under investigation.

On April, 26, 1848, a seismic shock of intensity VII
on Richter scale was felt at Mt. Abu, about a hundred kms on
the southwestward extensions of the present area. The earth-
quake was preceded by a heavy rumbling noise. From the
earthquake effects of shocks felt at certain regions like
Bhopal on one side and Cambay, and Ahmedabad on the second,
Pelanpur and Daosa on the third, the major axis of the
affected area trending approximately ESE-WNW, can be traced
to the activity in the Rann of Kutch area. Cracks were found
developed on the buildings and the famous marble temples
carved in the Delwara on Mt Abu. The shock was also felt at Sehore, west of Bhopal and Mandaleshwar on the Narmada river bank. According to Tandon, however, the principal fault was of ENE orientation (Tandon 1956) and sinistral. A second earthquake at Mount Abu on August 15, 1906, is said to have occurred in the same direction with a lesser intensity of V on the Richter scale. The palyad earthquake of 1938 with intensity VII also, believed to have occurred along ENE trending fault with the same sense, i.e. sinistral.

An earthquake described as having occurred in NW provinces belongs to the Hindukush range on west of the syntactical bend, this may have had a direct relevance to the activity along the west coast faulted margin of India or the Cambay graben.

In the Malani area of Rajasthan nearly at the eastern margin of the desert of Thar, an earthquake occurred on July 12, 1907, a year after the second earthquake of Mount Abu in 1906. The intensity was VI and direction of displacement is unknown.

A more recent earthquake on July 13, 1963, of 5.6 intensity occurred at Thar Parkar and its direction lay into that of Sambhar Lake region, that is in the ENE to NE direction.

A third shock at Mt Abu was felt on 24 October, 1969.
with an intensity of 5.3. The two earthquakes at Jaipur occurred in 1967 and 1973 of 5 and 4 intensities respectively.

Another earthquakes, whose epicentre was near Sambhar lake, occurred on August 20, 1969. Since Sambhar lake itself has an elongated outline in ENE direction, and LANDSAT frames clearly show that the zigzag boundary of the lake is due to numerous ENE trending fractures, it can be concluded that the fault plane for this earthquake was also oriented ENE.

It is interesting to note that the seismicity in western Rajasthan is intimately related to the activity along the Murray ridge and Chaman fault. The ENE trending lineaments presumably act as antithetic elements of the major Chaman fault. A large number of earthquakes in Kutch, Rann of Kutch and Indus river delta region suggest the correlation between the two. Most of the devastating earthquakes in Kutch, Rann of Kutch and Saurashtra peninsula and other parts of Gujarat have fault plane solutions of ENE trend with sinistral sense, while the earthquake in Lakhpat, near Indus delta, Larkana etc. in Pakistan give fault plane solutions parallel to the Chaman transform fault. It appears that the compression applied was resolved into two directions, one along the NNE to NS trending Chaman transform fault and the less amount of shear stress also transmitted along the ENE trending weak zones. The picture is therefore one of
constantly northeastward acting force causing dextral displacement along chaman fault and sinistral along the ENE trending fractures and fault zones.

The earthquakes at Dwarka and its vicinity (1940) with intensity VI was clearly along the ENE trending north Saurashtra coastilne fault. As many as four earthquake records are available from Bhuj, the southern Kutch region in India.

The Kutch earthquake of 1819 had a strong intensity of XI and was felt over a large part of northern India, at places as far as Calcutta "About 2000 people were killed in Bhuj and the loss of property was heavy in Kutch, Bhuj and as far south as Ahmedabad. The river Indus changed its course at the western extremity of Kutch and flowed through the low ground at Lakhpat". The formation of Allah Bund (wall of God), a long ridge or swell, 24 kms wide and 80 kms long trending EW was a significant manifestation of a large scale crustal deformation caused by the earthquake. "The land to the north of the Bund was elevated to a maximum of 3 to 5 meters. In the Rann of Kutch, numerous jets of blackish muddy water gushed out from the fissures and cones of sands, 2 to 3 m high were ejected" (Chandra 1977).

The Anjan earthquake of July, 1956, having an intensity IX caused much damage at Anjan in the central Kutch with loss of life and property. More than hundred
people were killed, several hundred injured and over a thousand houses were completely destroyed in the village of Anjan alone and another 2000 in the neighbourhood suffered much damage. The area of damage was the central Kutch region. The radius in which the earthquake was felt was over 300 kms elongated in the NE-SW direction, parallel to the Chaman fault and the Aravalli ranges (Tandon 1956).

Thus the earthquake in the Rann of Kutch and Kutch regions are intimately related to those in the western Rajasthan. In Gujarat too, the Broach earthquake of March 23, 1970, gave fault plane solutions parallel to the Narmada fault as also the most devastating earthquake of Amreli in southern Saurashtra.

To sum up, one may conclude that the intensity of earthquakes in Rajasthan though less on the Richter scale then those in the area of Kutch and Saurashtra to the west, is intimately related in the plate tectonic set up described earlier. All earthquakes in Saurashtra and Gujarat are long ENE trending zones parallel either to the Narmada fault or to the westward extension of the great Boundary fault. The earthquakes to the north in Kutch have different kinds of fault plane solutions, ENE-WSW sinistral or NNE-SSW dextral or NNW-SSE, parallel to the Cambay graben axis and the west coast fault.

Fig. 7.7 shows rose diagram of fault plane solution for some earthquakes and other inferred from the longest axis
NUMBER OF EARTHQUAKES 33 - INTERVAL 20°
DATA FROM FAULT PLANE SOLUTION 13
DATA FROM HYPOTHETICAL ELLIPITICITY OF ISOSEISMS BASED ON DAMAGE CAUSED - 20

A- EARTHQUAKES ALONG SYNTHETIC OR II ORDER ANTITHETIC ELEMENTS OF CHAPAII FAULT OR CAUJAY GRAIN: OR NORTH COAST FAULT

B- EARTHQUAKES ALONG CHAPAII FAULT OR PARALLEL TO BOUNDARY FAULTS OF ARAVALLI DELHI GORGES

C- EARTHQUAKES RELATED TO SINISTRAL ANTITHETIC ELEMENTS OF CHAPAII FAULT OR ENE GRAIN OF GREAT BOUNDARY FAULT (MURRAY RIDGE) OR NAGPALA FAULT

FIG 7.7
of the maximally damaged area of the earthquake for the region in southern Pakistan and western India. It will be noticed that the principal trends are ENE, NNE and NNW. Some of the NNW trending solutions may be along the synthetic elements of the Chaman fault which is presently active. Table 7.1 gives complete record of earthquakes during the past 150 years.

7.7 Principal Conclusions

From the above study, the following principal conclusions may be drawn.

(i) The neotectonic activity found in the present area is principally restricted to the ENE trending lineaments with a sinistral sense of displacement on the horizontal plane. The changing of river courses, displacement of benches, banks, flood plain deposits and islands enclosed by braided streams display this phenomena. With the exception of the displacement in the NW-SE direction west of Giri, all displacements observed are in the ENE or easterly directions.

(ii) The lineament study points to presence of three distinct groups - (a) trending ENE, presumably original synorogenic dextral transcurrent faults; (b) faults of NNE to NE trending parallel to the axis of the orogen which could be original moderately dipping faults rotated into steep or subvertical position,
possibly those along which the uplift of the Aravalli mountain range as a horst may have occurred during the post orogenic time, and (c) finally the third group of ESE to SE trending lineaments which could be related to the synorogenic sinistral shears or be the extensional faults subperpendicular to the axis of the Aravalli range. This is substantiated by the lineament map, the density contour map and also the cumulative length percentage contour map, further the rose diagram based on the orientations of lineaments confirms the presence of these faults.

(iii) The seismic activity in the region can be closely tied with the activity going on at the Iranian - Indian plate boundary in the Middle East region.

(iv) The ENE trending lineaments probably act as avenues of shear stresses acting in a sinistral direction during the present day seismicity related to the sudden release of residual stresses. It is suggested here that these ENE trending lineaments presumably acted as antithetic elements of the principal Chaman fault, and therefore had the sinistral sense of displacement as recorded by the neotectonic studies.

(v) The seismicity of the region can be closely tied with the neotectonic activity since the fault plane solutions for the earthquakes and the orientations of
faults along which recent displacements are observed, are closely matching.

(vi) As a result of northeasterly push to the Indian plate albeit, a little anticlockwise, the principal compression activity in this direction was resolved into two systems of weak zone – one along the NNE to NS trending, causing dextral displacements and the other ENE to E causing sinistral displacements. The NW trending fault solutions obtained for some of the earthquakes may be the synthetic elements of the Chaman fault, that is having the same sense of displacement as the Chaman fault. However, sinistral displacement along some such faults as far instance, west of Giri may be due to a second order systems of faults.

(vii) The ENE trending neotectonic activity along Mahi and Sabarmati river (Gadekar et al. 1981) in the southern part, is certainly related to the GBF and Narmada faults. This supports the contention that overall activity, seismic and neotectonic in this region is related to the tectonically weaker zone which trend ENE-WSW.
ADDENDUM:

After this thesis was bound, there occurred an earthquake on 20th October, 1991 with epicentre near Uttarkashi in Almora District of U.P. (6.1 on Richter Scale). Five days later on 25th October, 1991 Friday, a second mild tremor shook this region. A third shock was felt on 7th November, 1991. However, the effects of this later shock were more severely felt in Jodhpur, Pali and other districts in the Marwar plain. In the principal focus on the Uttarkashi region, this tremor in Marwar plane did not get as much coverage through various media, even though a large number of huts were destroyed. This suggests that the collision in the Himalayan zone is related to the plate boundary interaction along the Western margin as well, more or less contemporaneously with the activity that occurs in the collision zone, though on less intense scale.