# CHAPTER - 3

# *GEOLOGY AND REGIONAL TECTONICS*

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## GEOLOGY OF THE AREA

### GENERAL

From the stratigraphy point of view, the coastal terrain under study does not provide much diversity, and comprises only formations of Cretaceo-Eocene and Quaternary periods. constituting fairly vast alluvial plains and coastal deposits of Pleistocene and Holocene epochs, resting directly over a trappean basement, the study area, however, compensates in providing lithologic and geomorphic varieties, which in turn, reveal an interesting sequence of geological events of the Quaternary times.

The present author, described the rocks belonging to the Deccan Trap volcanism, and unconsolidated sediments subsequently deposited over the traps by a prolonged sequence of depositional and erosional processes during Pleistocene and Holocene. In a general way, the Quaternary sediments belong to categories formed by subaerial agencies, river action and shoreline marine processes.

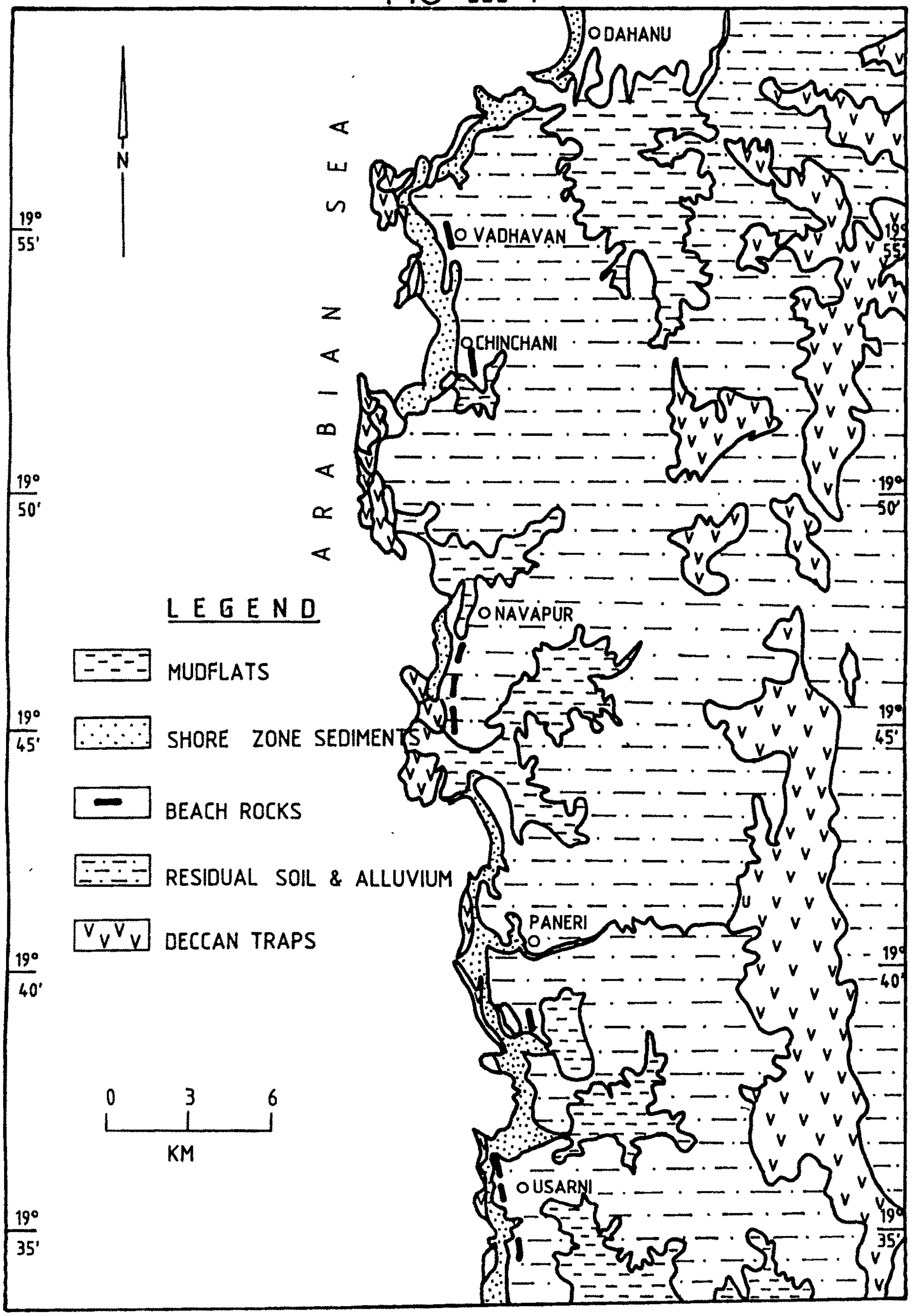
Jootun (1982) has worked out the following stratigraphic sequence in the area north of Dahanu.

| | | |
|---|---|---|
| Shoreline Deposits : Beaches, barriers ridge complex coastal dunes, Palaeobars and beach rock. | | HOLOCENE |
| Fluvio-Marine Deposits : River mouth bars and mudflats | | |
| Fluvial Deposits : Recent alluvium, point bars, channel shoals and backswamps | | |
| Residual Deposits : Colluvium and residual soils | | |
| River Alluvium (Older), Coastal gravel beds | | Late Pleistocene |
| Unconformity | | |
| Basaltic and doleritic dykes | DECCAN TRAP | UPPER CRETACEOUS TO LOWER EOCENE |
| Basaltic lava flows | | |

Sukhtankar, et al (1988) have classified the geology of are between Agashi bay to Bassein creek (south of present area) in to four important lithological units viz (i) Alluvium (ii) Mudflats, (iii) Quarternary Sediments and Basalts.

The author has mapped five important lithological units found in the study area (Fig. III.1) viz (i) Deccan trap, (ii)

FIG. III·1




MAP SHOWING LITHOLOGICAL UNIT OF DAHANU - KORA COAST

Residual Soil and alluvium, (iii) Beach rocks (bio calcarenite to bioclastic arenite), (iv) Shore zone sediments and (v) mudflats.

## 1. DECCAN TRAP

### Occurrence and Field Characters

The lavas of Deccan Trap form the oldest rocks of the succession. They form north-south hill ranges in the eastern part. They are also exposed as rocky platform in the intertidal areas of Vadhavan, Tarapur, Muramba, Mahim and Usarni. It shows intensive erosion due to wave action (Plate III.1)

They are mostly basalts, but a variety of acidic differentiates is also encountered. Owing to their highly weathered nature the rocks show grey, dark grey, greensih grey, brown, reddish brown colours in the field. All these rocks are highly jointed showing several sets, mainly in N-S; E-W, and NW-SE directions. The fracture pattern in the trap shows a distinct relationship with the various major lineaments, which have controlled the formation of the northern part of the West Coast. The more jointed trappean rocks have quite often given rise to spheroidal exfoliation resulting in the formation of large rounded boulders on the outcrops (plate III.2); good examples of these are seen in the areas near the villages Tarapur, Muramba, and Mahim.

PLATE : III.1 Basalt showing intensive erosion due to wave action at Vadhavan coast.

PLATE : III.2 Spheroidal weathering in basalt in the shorezone of Tarapur.

The basalts are traversed by numerous dykes and significantly they show well defined trends in conformity with the joint pattern. Both vertical and as well as inclined dykes are encountered and in the field they are easily recognised as prominent ridges rising well above the surrounding basaltic pediplain.

The trap rocks are made up of different flows, and the thickness of individual flow varies from a few centimeters to more than ten meters. Field studies show that the Deccan trap basalt flows can be divided into two major groups i.e. compact and amygdaloidal

**Compact Basalts**

All compact basalt flows (Plate III.3) occur as thick extensive flows, their thickness, though always considerable, varies greatly and may be up to 115M. THe constituent rocks are both aphanitic basalts and porphyritic contain phenocrysts of plagioclase up to 1 cm long, or giant phenocryst basalts with phenocrysts up to 5 cm long. Mostly the compact basaltic flow upward exhibits coarser texture and gradually merges into thce subophitic texture.

**Amygdaloidal Basalts**

Amygdaloidal basalts show much variation in field characters and are characterised by much smaller size and irregular form than compact basalts. Amygdules are spheroidal or ellipsoidal bodies representing vesicles that have been partially or completely filled by minerals deposited from aqueous fluids. Among those most widely encountered are the following : cryptocrystalline quartz (chalcedony) in some cases macroscopically colour banded (agate); clear isotropic opal (with very low refractive index); yellowish, greenish, or brown chloritic minerals, zeloites, carbonates, notably calcite (Plate III.4), aragonite and spherulitic siderite. Deccan Traps of the study area shows an abundance of amygdaloidal basalts over the compact variety.

## Types of Eruptions

It is obvious from the differences in the field characters of the basaltic flows that they must have been formed by eruptions of different kinds. Following three types of eruption have been visualized as shown below :

Type - I : The classical fissure eruption characterized by out pouring of large quantities of fluid lava through extensive fissures giving rise to thick extensive compact basalt flows, and occasionally amygdaloidal basalt flows.

Type - 2 : Eruption of smaller quantities of less fluid lava than in Type I through a fissure giving rise to tabular amygdaloidal basalt flows.

PLATE : III.3 Compact basalt flows near Vadhavan.

PLATE : III.4 Calcite filled vesicles in amygdaloidal basalt at Kora coast.

Type - 3 : Euption of small quantities of viscous lava at a time through a large number of small cracks occurring over extensive areas.

**Petrography**

The trappean rocks of the area have been divided in to (i) Basaltic lava flows and (ii) dolerite dukes. The lavaflows constitute the earlier phase of the Deccan volcanism, while the dolerite dykes that cut them represent the latter phase.

Under the microscope, the different varieties of basalt typically show a hemicrystalline texture. The compact variety is seen to form a fine grained microlitic groundmass in which are seen embedded phenocrysts of plagiclase (Labrodorite) and augite imparting an overall porphytitic texture. The vesicular and amydaloidal, varieties show usually a fine grained porphyritic texture. Large crystals present due to slow cooling at depth. When rate of cooling increase, glassy matrix between the earlier form larger crystals forming porphyritic textures.

Changes in cooling rate during crystallization produce inequigranular texture (crystals of different sizes) rather than an even-sized granular texture.

The intergranular texture is seen to grade in to the sabophitic and ophitic textures when the pyroxene minerals (augite) enclose feldspar laths (Labradorite) either partially or completely.

Occasional phenocrystic plagioclase and pyroxene (augite) are commonly observed. Though the plagioclase may not generally show any preferred orientation, some times they exhibit such an alignment due to flow, typically characterising apilotaxitic texture. Quite often, in some of the samples a cluster of plagioclase and olivine phenocrysts forming glomerophorphyritic texture.

The top and bottom portions of a flow, some times reveal considerable effect of chilling, and exhibit a very fine grained texture. The process of crystallization being inhibited, the texture, which is typical of basalt is intersertal with tiny laths of plagioclase embedded in a glassy or fine granular ground mass. Occasionally glassy matter occupies the minute spaces left between the microlite of feldspars giving a hyalopilitic texture.

Mineralogically, the main constituents of the basalt are predominantly pyroxene and plagioclase.

The pyroxene is dominantly augite and occurs either as granules in the ground mass or as phenocrysts. It is an-~~un~~isotropic and extenstion angle varies in different grains from 36 to 42. Plagioclase laths occur as ground mass or as phenocrysts. Generally, the phenocrysts are Ab50 An50 to Ab30 An70 (labradorite) whereas the plagioclase occurring in ground mass is Ab70 An30 to Ab50 An50 (Andesine) in a few thin sections Ab30 An70 to Ab10 An90 (bytownite) and Ab100 An0 to Ab90 An10 (albite) varieties an also encountered.

The common accessary minerals are magnetite and hematite. The magnatite occurs as balck opaque minerals while hematite is characterised by its cherry red colour.

## 2. RESIDUAL SOILS AND ALLUVIUM

Residual soil are the weathered products of the basaltic rocks that have not undegone tansportation. In vertical section, they grade into bed rock basalt with depth. At the foot of the eastern hills in the area, gravity induced heterogencous colluvial materials are accumulated giving an extensive deposits. On the hilltops and on the rocky surface weathered product of basaltic rocky with large percentage of finer fractions are seen to overlie a semi decomposed sub soil layer that in turn rests over the bed-rocks.

Alluvium consists mainly of silt sized particles with some amount of sand and clay. Mineralogical studies has revealed a provenance of Deccan Trap rocks. The composition of this alluvium is remarkably constant all over the study area. These thin covers of alluvium essentially represent the ancient flood plains and form a major part of the Quarternary deposits.

## 3. BEACH ROCKS

Numerous occurrences of beachrocks related to the ancient high strandline are recorded all along the coastline right from north of Bombay (Maharashtra) up to Umargaon in Gujarat. These beachrocks are reported in the area at Dahanu, Vadhavan, Chinchani, Navapur, ALevadi, Muramba, Panarvi, Danda and Usarni. These rocks, appear to have been deposited when sea level was raised during the Holocene transgression. A combination of wave action and long shore drift brought about redistribution and redeposition of material generated along the shelf as well as added by the rivers from landward side or brought from the Gulf of Cambay by tidal currents. These normally consists of well bedded rudaceous rocks with bioclastic intercalations of varying size. The layers contain the pebbles and cobbles of mostly trappean rocks embedded in clastic material derived from the inland areas. The bioclasts consist of numerous mega-fossils (mostly mulluscan) and microfossils (foraminifers, bryzoans, echinoderms etc.).

The beachrocks occurs as thin beds and lenses diping seaward (5 to 10) and few meters (2 to 8) above the mean sea level. Their distribution, mode of occurrence and their depositional environment is discuss in detail in chapter six.

## 4. SHORE ZONE SEDIMENTS

Recent sediments occurring in various sedimentary environments, especially as beach and dunes are included in this group. Beach sediments are made up of basaltic rock fragments, quartz and shell fragments. The backshore is narrow and its material is seen to consist dominantly of pebbles and coarse sands with a subordinate content of fine sediments. Overlying the paleo-ridge are coastal dunes. The dune sands are fine grained, rounded are comprise rock fragments, shell fragments and quartz grains.

## 5. MUDFLATS

The area to the south of Dahanu is covered by extensive estuarine mudflats; bordering these mudflats (low marshes) and the raised mudflats (high marshes). In the study area, the mudflats are seen resting over basaltic rocks. The extensive mudflats are observed at Dahanu, Navapur, Tarapur, Muramba, Danda and Kora coast. The material of the mudflats mainly comprises calcareous clay and silt and it typically shows a fine lamination. These mudflats are mostly a recent foreshore deposits associated with river mouths, lagoon and creeks etc. These are mainly formed due to deposition of silt, sand and organic sediments by tidal waters.

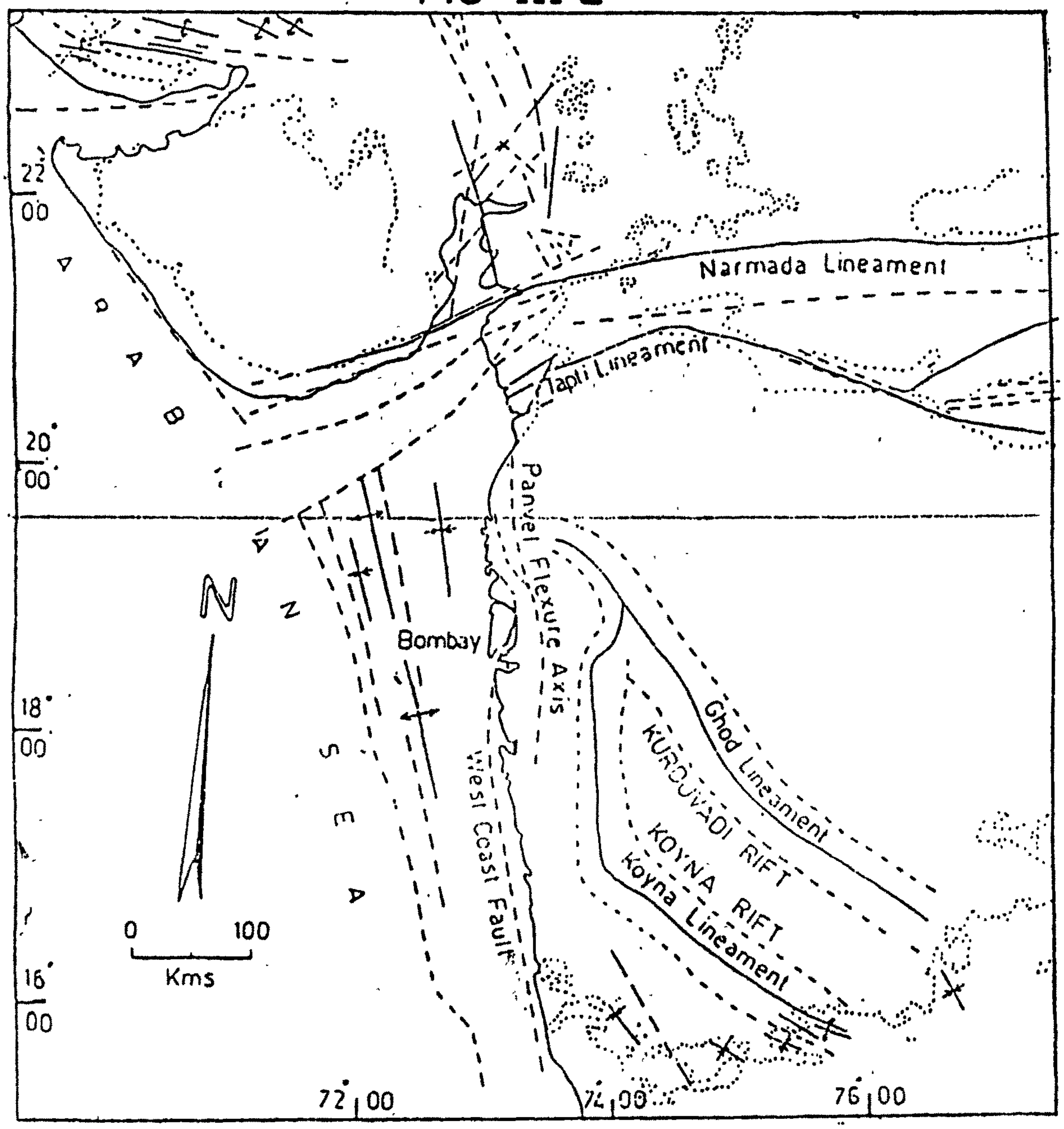
## REGIONAL TECTONIC FRAMEWORK

The West coast of India, especially its tectonic framework (Fig. III.2) and geomorphic features, have posed numerous problems to the geologists, and its evolutionary history is still not fully understood. The straightness of the coastline, trends and nature of Narmada and Tapti valley lineaments, Panvel flexure with associated rifts and lineaments of Koyna, Kurduvadi and Ghod (Powar 1981) alignment of hot springs parallel to the Panvel flexure and the overall fracture pattern, all these have intrigued previous workers. The West Coast Fault, and the trends of basaltic dykes that riddle the Deccan trap along the coast, revealing the numerous fissures during Cretaceo-Eocene times.

The evolution and morphology of the West Coast, have been essentially controlled by movements along a few major crustal fractures, and the coastline as well as its hinterland provide numerous evidences of the tectonic effects of these geofractures. The fracture patterns in the trappean rocks, orientations of the dykes as well as the behaviour of numerous rivers draining the area, ideally reflect manifestations of regional structures.

The trend of the West Coast of India, of which the study area forms a part, has essentially been controlled by a zone of almost N-S faults, commonly referred to as West coast fault zone. With the breaking of the Gondwanaland, during the close of Cretaceous period, the Indian Plate started moving in a north east direction, and this process of drifiting, appears to have

FIG ·III·2




Tectonic framework of the western part of Deccan Volcanic Province.
( After Powar, 1981 )

manifested itself into a zone of N-S (on-echelon) faults. These West Coast faults have been correlated with the Makran fault that runs from Iraq to the Rann of Kutch.

The coastal segment under study shows the presence of a number of prominent structural features, the most prominent being the Panvel flexture axis, the West Coast Fault and the Great Escarpment of the Western Ghats.

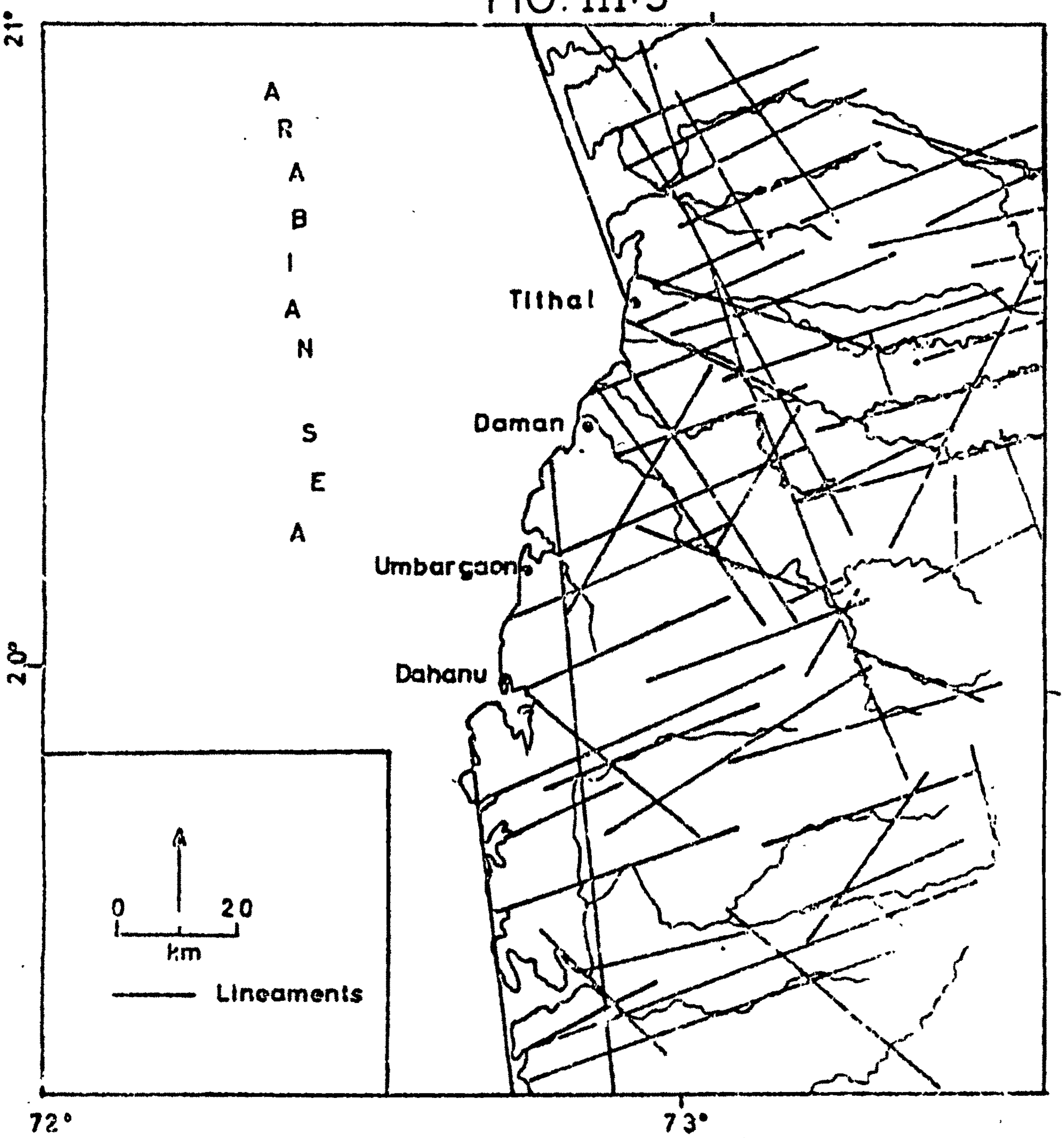
The axis of the Panvel flexture (Blanford, 1867 and Auden, 1949) has been shown to extend further southwards by Das and Ray (1977) along the `line of hot springs', from Vajreshwari in the Thane district to Rajpur in the Ratnagiri district of Maharashtra, Powar et.al (1978, 1979 a) have shown that the flexure dies out in the Raigad (formerly Kolaba) district and does not extend south of the Savitri river. This flexure according to Powar, et.al.(1978) trends almost N-S and has its axis splayed into two, one continues its northerly direction while the other trends NNW and extends to and is marked by the Vaitarna River courses. On account of this flexure the lava flows show a seaward dip. The axis probably corresponds to deep seated crustal fault (Kailasam, et.al 1972). To the west of the flexure axis, the flows show moderate to high dips (upto 60 at Virar) due W or WSW, while on its eastern side the dips are very gentle ($10^\circ$ to $12^\circ$) near Bombay, which further east become $2^\circ$ to $3^\circ$ near Murad (Powar et.al, 1978).

There has been much specualtion about the West Coast fault. It is presumed that the west coast of India represents a fault scarp of probable Miocene age (Krishnan, 1953, p. 54). The exact position of the fault has been the matter of great contoversy for last few decades. Gubin (1969) believes that the West Coast fault is about 1300 km in length and extends parallel to the coast line. However, in another publication (1974, b) the same authors have shown the fault running exactly parallel to the coast and cutting the promontories. Auden (1975) has placed the fault at about 10 km to the west of the coastline. Powar et.al (1978) have recorded evidences of faulting at Sasaune on the west coast of Maharashtra. When this fault is extended northwards, it can be traced in the region of Bombay Harbour. Its southern extension corresponds well with the 'non-proven' fault shown by Auden (1975). This fault is parallel to the 'chasmic fault' along the margin of the continental shelf, Ollier and Powar (1985).

Lineament analysis reveals two major geofracture trends, one N-S and the other almost E-W, besides other minor sets of joints (Fig. III.3). The N-S and E-W fracturing and jointing appear to be related to plate tectonic while the other minor sets have been considered as tensional joints related to the shrinkage of the basalt.

To conclude, the present author would like to mention the most relevant findings of Wensink (1973). According to this author the initiation of the extensive West Coast faulting, could

FIG. III·3




LINEAMENT MAP ( BASED ON THE SATALLITE IMAGERIES ) be partly due to tensional system of forces associated with the translational as well as rotational movements of the Indian plate. The rate of the drift during the Lower Eocene was much higher than the present rate of the movement; such an accelerated movement would naturally result in tensional stresses within the plate. These tensional stresses caused the extensive faulting. With the decrease in such stresses, the tensional fracture and movement along them progressively decreased.