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Report on the Gravity, Magnetic, Seismo-stratigraphic and Structural Characteristics of the Northeastern Bengal Basin

(January, 1995 - June 1996)

By

Md. Noor Alam
Principal Scientific Officer(Geophysics)

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Abstract

The seismo-stratigraphic and structural characteristics of the northeastern Bengal basin have been illustrated in this report based mainly on the interpreted seismic sections, TWT contour and areal extent maps of eight prominent seismo-stratigraphic horizons. Each prominent seismic horizons represented by continuous, high amplitude reflections that extend over a fairly large distance was identified, traced, and mapped to obtain a detail picture on the stratigraphic evolution of the basin.

The findings reveal that the Barind Tract and the Madhupur Tract do not belong to the same seismo-stratigraphic horizon. The TWT sequence of the Barind Tract seems to correlate with the older seismic horizons than the Madhupur Tract. The exposure of the Madhupur Tract coincides with the crestal part of a low amplitude, broad anticlinal fold with it's NW-SE trending axis stretching along Sariakandi in Bogra District to Bhuapur in Tangail District and further to the southeast. This broad anticlinal feature separates spatial distribution of some of the Pleistocene and younger sedimentary horizons of the Surma basin from that of the Faridpur Trough as well as south of the Barind Tract.

The areal extent map of the seven youngest seismo-stratigraphic horizons of the Surma basin have been prepared. The composite map and the sections of the seismo-stratigraphic horizons display the areal extent of Quaternary sediments in the northern and northeastern parts of the Bengal basin. The areal extent of these horizons gradually decrease with time and dip towards their common depocenter near Tangua-Raular Bils north of Madhyanagar Thana in Sunamganj District. The Tangua-Raular Bils coincides with the axis of a broad synclinal fold between the Madhupur Tract and the Chhatak anticline and has undergone a continuous subsidance of about 2 km during post-Pleistocene time. These sediments were probably deposited in a fluvio-lacusterne environment.

The Quaternary sediments have excellent developements in this area and therefore can be considered as type locality for the Quaternary deposits in the Bengal basin.

It is evident from the composite seismo-stratigraphic areal extent map that the northwestern margin of the Bengal Basin shifted with time. During Early Eocene the northwestern boundary was demarcated by the southern margin of the Crest of the Rangpur Saddle (Rangpur Platform). In the later part of the Eocene, the sediments probably transgressed northward beyond Gaibandha across the Rangpur Saddle, but in Oligocene the margin regressed rapidly into the inner-shelf region and transgressed again in late Tertiary.

The Paleocene, late-Eocene and Oligocene formations pinchout in the mid-shelf to slope zone near the Madhupur Tract area. The presence of broad anticlinal structure around Madhupur Tract and the pinchout of the Tertiary formations together should provide a suitable trap for accumulation of hydrocarbon in this area. The Miocene formations over the crestal area seems very prospective in this respect. There are seismic amplitude anomalies on line PK-8402, PK-M-12, PK-7, BK-10 seismic lines and also there is indication of an anticlinal structure in the southwest of Chattak Structure that deserves further study in view of hydrocarbon potential.

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Report on the
Gravity, magnetic, seismo-stratigraphic and structural characteristics of the northeastern Bengal basin.

1. Introduction

This research project was approved in the Steering Committee Meeting held on 18th January, 1995 at the Bangladesh Petroleum Institute (BPI), Dhaka in the presence of representatives from Ministry of Energy and Mineral Resources (MOEMR), Norwegian Petroleum Directorate (NPD), Royal Norwegian Embassy, Dhaka, and Bangladesh Petroleum Institute. The aim of the project was to study the gross sedimentary distribution, stratigraphy, structure and tectonic evolution of the northeastern Bengal Basin on the basis of available data.

This report records the results of the research study carried-out during January, 1995 to June, 1996 on the northern and northeastern parts of Bangladesh covering Bangladesh part of the Himalayan Foredeep, Rangpur Saddle, Bogra Shelf, Surma Basin, northern parts of Bengal Geosyncline and adjoining areas. It's outline is based mainly on the seismo-stratigraphic and structural interpretation of 2500 LKM of regional seismic sections and associated well data covering an area about 75,000 sq. km., preparation of time contour maps of eight horizons and a composite areal extent map of those horizons under consideration. Further continuation of this research study will include preparation of time contour maps of remaining deeper horizons, depth contour map for each of those sixteen horizons, interpreted time sections of other important regional lines, gravity and magnetic analyses along regional seismic lines. The subsurface geological maps (subcrop) by backstripping technique will be done phasewise in the future.

Much of the information has been derived from indirect evidence, chiefly from regional seismic reflection Common Depth Point (CDP) profiles over northern part of Bangladesh. The seismic data on which this study is based were collected by various agencies under contract with OGDC, BOGMC, and Petrobangla during 1971-1988. Continuous seismic reflection profiles constitute a major source of information for this study besides Bouguer gravity, Aeromagnetic and drill hole data.

While interpreting the seismic data, an attempt has been made to relate the seismic records to the geology and tectonics of the surrounding land area. Regarding the gravity and magnetic studies of the basin, some qualitative analyses of the data from the Bouguer Anomaly Map of Bangladesh, and the Aeromagnetic Anomaly Map of Bangladesh, published by the Geological Survey of Bangladesh, were made.

Tectonic subdivisions of northeastern Bengal basin is shown in figure 1 and the location of the seismic profiles discussed in this report are shown in Plate 1 (Plates are given at the back of the report). The Geological Map of Bangladesh is shown in Plate 2. Geological interpretation of this area is interesting and important, not just for the regional and geological understanding of this area but also for basic problems in geology. The geological setting summerised in this paper relates only to the distribution of sedimentary horizons constituting the northern and northwestern part of the newly-formed Bengal basin including the Surma Basin, part of the Faridpur Trough, Bogra Shelf, Rangpur Saddle, Bangladesh part of the Himalayan Foredeep (Dinajpur Slope) area.

All available seismic reflection records have been thoroughly analyzed but only a few selected seismic sections are presented in the text. Different sedimentary or lithologic horizons act as reflectors. These seismic reflecting horizons have been correlated with each other from line to line and were described and designated by alphabets from A through P. Attempts were made to correlate the seismic horizons to the lithologic horizons in the deep boreholes where available. The time units applied in this report are adopted from previous studies by different organizations and authors and are generally well accepted. The results finally were compiled in a set of geological-geophysical cross sections. Structural data were presented in a series of cross sections and time contour maps. Some are based entirely on seismic reflection data, while others are in part interpreted from the published geological literature. Interpretation of much of the data will be incorporated, but because of limitations of space and time, not much of the basic data were presented. Sixteen prominent seismo-stratigraphic horizons have been identified but only upper eight horizons have been mapped. Remaining eight horizons will be included in mapping during detail studies in future. The present paper discusses the general features of the subsurface geology and structural pattern of Bangladesh as seen in several (figure 2 through figare 13) cross sections, and attempts a synthesis of the stratigraphic distribution the basin.

The report has been written and prepared in its entirety in BPI assisted by BPI staff with all figures and plates draughted by BPI drawing office staff. The work was carried out only with the

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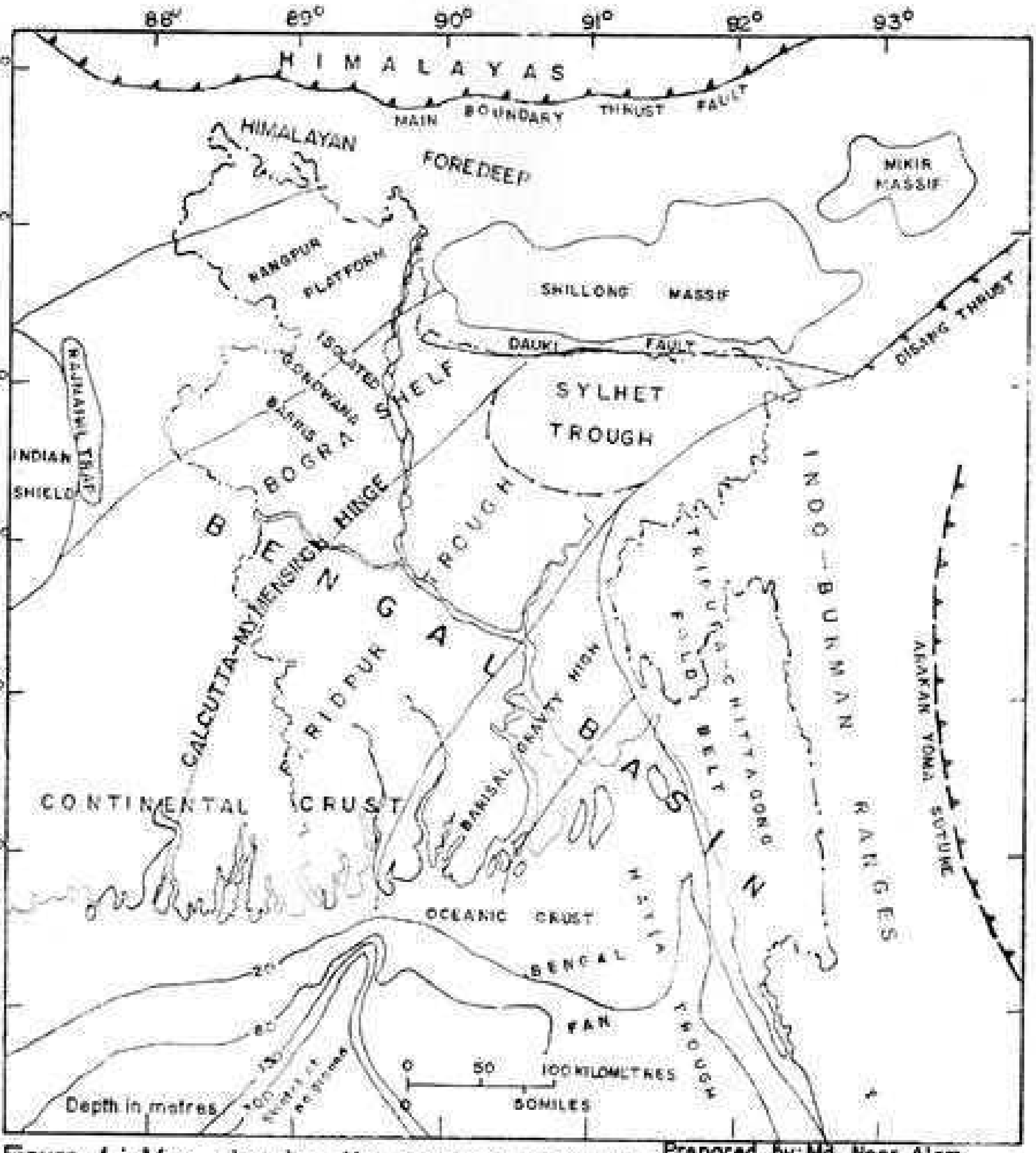

Prepared by: Md Noor Alam

Figure 1: Map showing the generalized tectonic divisions of northeastern Bengal basin from Alam, M.K., et al., 1990.

available geological, geophysical and well data existing at BPI library.

2. Geology of the northeastern Bengal basin area

The Bengal basin covers most of the West Bengal (An Indian state) and Bangladesh. The basin is bordered on the western side by the peninsular shield of India and on the eastern side by the Naga-Lushai orogenic belt.

Bangladesh occupies major part of the Bengal basin. The Bengal basin, a Mesozoic-Cenozoic structural basin (Bengal Geosyncline) is bounded by the Indian Shield on the west, by the Arakan-Yoma, Naga geanticlinorium in the east, by the Shillong Plateau and Rangpur Platform on the north. The geologic history of the Bengal basin started with the intracontinental rifting of eastern Gondwanaland, formation and evolution of rifted young passive continental margins, sea floor spreading of the northeastern Indian ocean and closing of the Tethys sea, collision of India with Asia, uplift of the Himalayas, erosion, transport and deposition of the sediment filling the newly formed Bengal geosyncline (the Bengal basin, Bay of Bengal, and adjacent areas), orogeny of some of this sediment wedge at the subduction plate wedge on the eastern margin of the Bengal Geosyncline and the formation of successive basins on the continental crust south of the Himalayas and on oceanic crust(Curray, J.R., et al., 1982, Sengupta, S., 1966, Mukhapadhya, M. and Dasgupta, S., 1988).

The most important feature of the Bengal basin is its sedimentary fill, with the largest subaerial delta in the world of the confluent Ganges and Brahmaputra rivers filling the Bengal basin(Curray, J.R., 1982). Recent Studies (Lindsay J.F. et al., 1991) revealed three staged evolution of the Ganges-Brahmaputra delta: 1) The proto Ganges delta developed immediately after the breakup of Gondwanaland at approximately 126 Ma, when early delta consisting of relatively small-scale, prograding sedimentation due to smaller catchment area. 2) The transitional delta developed following a major eustatic sea level low at 49.5 Ma, initially sedimentation was relatively restricted but at about 40 Ma, the flux of water and clastic sediments dramatically increased and the delta grew rapidly with the developement of major prograding clastic depositional sequences. The abrupt change in the morphology of the delta appears to be a direct response to the collision of the Indian plate with the Eurasian plate, and the rise of the Himalayas. 3) The modern delta began to appear in its present form following a major eustatic sea level low and erosion at 10.5 Ma. By this time the delta had become tidally dominated and had prograded over a long distance towards south in to deeply embayed Bay of Bengal.

Relatively recent folding and uplift of some of the Brahmaputra derived sediments close to the interplate boundary redirected the course of the Brahmaputra to its present position on the north side of the Shillong massif. The delta has thus evolved in a complex, constantly changing setting through a long time interval. Folding of the Brahmaputra derived sedimentary strata in the east in the late Pliocene to Holocene, in response to eastward directed subduction and strike slip interplate movement beneath the western Indo-Myanmar (Burma) ranges, resulted in the formation of the elongate north-south assymetrical anticlinal structures of eastern Bangladesh and adjacent territories (Curray, J.R. et al., 1982, Lindsay J.F. et al., 1991).

The area of study is the northern and northeastern parts of the Bengal basin, surrounded by the Shillong Plateau on the north, Tripura (Naga-Lushai) folded belt to the east, Rajmahal Hills and peninsular Indian Shield to the west. The geology of the Bengal basin is charactreised by extentional tectonic features, a result of the splitting apart of an older super-continent Gondwanaland in to the Indian, Australian, African, and Antarctica continents during the Mesozoic Era. In general, extentional margins are structurally simple in relation to their post rift sedimentary sequences(Sengupta, S., 1966, Curray, J.R. et al., 1982).

Some of the prominent geologic features of the Bengal basin have been described by Sengupta(1966), Morgan and McIntire(1959), Curray et al.,(1982) and Mukhapadhya and Dasgupta(1988) and may be summerised as follows:

1. Breakup of basement into horsts and graben structures during initial phases of rifting, probably during Pre-Permo-Carboniferous period of time.

2. Deposition in grabens of nonmarine (fluvio-lacustrine) Gondwana sediments. Borehole samples reveals they are of Permian age at least on the continental shelf area.

3. Great subsidance of basement rocks to depths of 3 to 10 km since Triassic or Early Jurassic time. The subsidance is belived to be the result of cooling and an associated increase in density of the deep crustal rocks.

4. Wide-spread distribution of carbonate rocks in the Eocene.

5. Thick sedimentary accumulation of Tertiary through Recent.

6. A series of buried basement ridges, marking the western margin of the Bengal basin presumably kept the Gondwana continental basins isolated from the main Bengal basin through most of Tertiary time. Locally, during the late Tertiary, the sea transgressed over these basement ridges and onlapped parts of the Indian Shield.

3. Data

3.1. Multichannel seismic reflection data

On the onshore Bangladesh approximately 8000 LKM of multichannel seismic reflection profiles were acquired by various agencies under contract with OGDC, BOGMC, and Petrobangla during 1971 and 1988. Although most of the multichennel seismic-reflection profiles acquired and processed by contract geophysical companies, some of the lines were obtained and processed by Petrobangla also. In Bangladesh most of the lines were acquired with dynamite sources fired on 50m shot intervals; data received on 48 to 96 channels with geophone groups distributed over 2450m to 2805m in spread length. The data were recorded from 5 to 10 seconds with analog or digital recorders. Seismic processing included true amplitude recovery, Common-Depth-Point (CDP) gather, prestack deconvolution, velocity analysis, normal moveout correction (NMO), CDP stack (6, 12, 24, and 48 fold), time variable filtering. Some of the lines were migrated too. The location of multichannel seismic reflection profiles used in this report are shown in Plate 1.

3.1.1. Seismic data interpretation

3.1.1.1. Delineation of basinwide seismo-stratigraphic horizons

The seismic horizons described below were distinguished manually on the basis of continuity of their reflectors, intensity (amplitude) of the reflectors, bredth of the reflector, and the geometry (shape) of the horizons. The prominent acoustic horizons A through P, have been traced across the shelf and slope in order to determine their areal extent, estimate thickness and the environment of deposition, so that a thorough idea of the potential reservoirs, direction of migration and accumulation of hydrocarbon can be inferred to locate hydrocarbon potential areas.

High continuity of reflectors indicate a contrast in depositional energy conditions operating over a wide area. These conditions are mostly to be expected on a broad shelf having both high and low energy states that result in the deposition of interbedded sandstone, limestone, or shale. Agents of active sediment transport would probably be waves and currents on the shelf. High continuity of reflectors also characterise deposits of broad swampy coastal plain areas in which fluvial sands are bedded with widespread coal and marsh clays. Conversely, low continuity of reflectors indicates the presence of lithologic units of limited areal extent, such as discontinuous channel sands bedded with flood plain clays in an alluvial plain. To recognize this type of an environment, both the seismic amplitude and the continuity of reflectors are needed.

Seismic amplitudes provide a quantitative guide to the density contrast of the adjacent reflectors. Coupled with low reflector continuity, variable amplitude is used to infer that sequences commonly contain small channel sands that contrast strongly in density with adjacent clays so that high amplitude reflections can result. Thus, nonmarine sequences tend to be characterised by reflectors having low continuity and variable amplitude. Low amplitude reflections or the absence of reflection suggests sedimentary rocks of a uniform lithology-commonly sandstone or shale. To choose between the two lithofacies is difficult unless the relationships to adjacent facies can be discerned.

Attempts have been made to correlate key reflectors with unconformities and use the reflectors to build an acoustic stratigraphy. On the basis of their analysis of seismic reflection profiles in areas where drill-hole is present, it was found that seismic reflections are returned primarily from (1) stratal surfaces and (2) unconformities characterized by sufficient velocity and density contrasts to cause coherent return of acoustic energy. The stratal surfaces are time-synchronous bedding surfaces; at one time, they were surfaces of deposition that existed over a wide area. Unconformities can be used to bound groups of reflectors which are correlated with depositional sequences. About 2800 LKM of seismic sections have been correlated with distinctive reflecting horizons and to give them chronostratigraphic significance (same age throughout area in which observed). Horizon C (Lower Eocene), in the deep ocean basins e.g., is one of the first of the reflectors to be so correlated. Other reflectors (A,B,D,E,F,G,H,I, J,K,L,M,N,O,P, and X) have been used to correlate reflectors across wide areas of the Surma basin, and ultimately to the Faridpur Trough area (figures 2 and 3).

On the continental margin (shelf area), similar attempts have been made to correlate distinctive reflectors, but the results are within the upper one to two seconds of the record because of shallow basement and thinning of the sedimentary section (figure-4). Similar strong reflectors, such as Horizon C, are present just above acoustic basement on the shelf where they were drilled (Bogra-XI, Kuchma-XI, and Singra-1).

In the northwestern Bangladesh the environment that prevailed are mainly shelf or coastal-plain types. However, two shelf slope types, one in the south of Bogra-1X (e.g., KHR-88) and the other in the south of Hinge Zone (e.g., PK-1, PK-8427, PK-M-14) are present in the area along with other seismic facies. The main feature to typify most of these seismic facies is a general parallelism of reflectors. They may diverge in some areas because of differing rates of subsidance (KHR-88, PK-8427, PK-M-14) off the Hinge Zone, and they may become discontinuous because of a presumed change in the types of sediments within the horizon.

In the northern part of Bangladesh, near Chhatak area, acoustic reflectors (geologic time units) have been tied to drill-hole (Chhatak-1) stratigraphy with a high degree of certainty but the correlations were made with the reflectors to key lithologic horizons rather than to unconformities. It has been observed that the horizons H,I, and J corresponds to the Bhuban, UMS + Tipam, and Dupi Tila formations respectively (figure 3).

The time significance of an unconformity is that all the rocks below the unconformity are older than the rocks above it. More importantly, the depositional sequences between major unconformities can be analyzed for coastal onlap, downlap, and toplap to define geochronologic cycles of relative sea-level change. Some of the major unconformities appear to correlate over wide areas and may have formed at the same time worldwide. Thus they indicate a major amount of relative sea-level drop. Major shifts in sea level took place worldwide in the late Miocene, middle to late Oligocene, early-middle Eocene, middle Paleocene, Late Cretaceous, Early Cretaceous, and Early Jurassic. Lesser sea-level shifts also took place and would have caused the unconformities that bound smaller cyclic sequences. The major cyclic sequences would be bounded by the major unconformities formed during the times listed above.

In the Surma Basin area seismic profiles reveal several major unconformities, particularly in the upper part of the section; for example, part of the seismic profile along line PK-SU-6 and PK-SU-19 shown in figures 2 and 3 assume that some of the unconformities regional (e.g., between horizons H and I, J and K) and that some are local (i.e., between horizons K and L, east of Sylhet (on line PK-SU-3). Figure 2 and 3, and line PK-8404 etc., also indicate that major hiatuses exist in the Faridpur Trough area in the late Miocene (between horizons F and G), middle to late Oligocene (between horizons E and F), middle Paleocene (between horizons B and C), Late-Cretaceous (between horizons A and B). The horizons delineated by these hiatuses are lettered C through K and are shown in figures 2 and 3.

A composite section based on line PK-SU-6, PK-SU-19, PK-M-12, PK-15 (figure 3) reveals local unconformities in the upper part of the Cretaceous and major unconformities, one in the Oligocene (between units E and F) one near the base of Tertiary (betewen hoizons A and B).

The sedimentary section of Bangal Basin, Surma basin in particular, have been divided into sixteen horizons, A,B,C,D,E,F,G, H,I,J,K,L,M,N,O, and P. This report is concerned with upper eight horizons which are not all the same as those identified by Petrobangla and other agencies worked on the Bengal basin. Several of these sequences may later have to be subdivided, particularly in the eastern Surma Basin, but the time and available data do not permit this at the present time.

The eight horizons under consideration do not occur over the whole of Bangladesh. For example, the sequence including horizons J,K,L,M,N,O, and P are not represented in the northwest due to erosion or non-deposition, whilst the five deepest sequences are not visible in the Surma Basin because they are below the top of the geopressured zone in the north-east, and in the south, they are below the collected seismic record.

Each of these horizons are stratigraphic units composed of a relatively conformable seccession of related strata. The horizons are not necessarily bounded at their bases and tops by unconformities or their correlative conformities but by the prominent reflections caused by acoustic impedence contrasts between the successive layers.

The seismic horizons having been picked, the depositional environment and lithofacies within the sequences are interpreted from the geophysical and geological data. This analysis includes a description of the seismic reflection parameters like configuration, continuity, amplitude, interval velocity and frequrncy content of the data, and how these parameters indicate the depositional environment and lithofacies.

Most of the prominent reflecting seismic horizons have been traced throughout the Basin area and have been designated by letters A through P and X (Lower through Upper horizons).

Basement: The position of the basement is not always clear on the seismic sections, depending on the sediments immediately overlying it. Where Gondwana sediments occur, it is often very difficult to determine which reflection represents the contact with basement rocks (e.g., line KHR-88, BOG-4, PK-4,5,6,etc.). By contrast the basement is well defined where the Gondwana and Rajmahal Traps are absent (figures 2 and 4).

Horizon X is discernible in the composite section I and lies below Horizon-B (figure-2). This horizon is represented by feeble to reflection free zone between strong amplitude acoustic basement representing the crystalline rocks. This Horizon-X probably belongs to Gondwana sediments within the intracratonic grabens.

The pre-Breakup sequence consists of Gondwana sediments, possibly Permian-Jurassic sediments. The Lower Gondwana coaly section is recognized by its moderate to high amplitude, low frequency events on the seismic section (figures 2 and 4 and lines PK-4,5,6,8, 8404, and KHR-88). These events are generated by low velocity shales and coals within the sedimentary sequence. The events are fairly continuous, but are offset by many small faults of 50 msec or less. The upper Gondwana sandy section is seismically transperent due to the monotonous nature of the sands.

Overall, the Gondwana and Rajmahal are parallel bedded. Even though the event continuity of the reflecting horizons is generally high, the existence of the Rajmahal cannot be reliably predicted without nearby well information because the interval is so thin. By analogy with Gondwana sediments found in nearby basins (Kuchma-1), like the depositional system for the pre-breakups sediments is interpreted as fluvial, and that the coals of the Gondwana developed in the fluvio-lacustrine environment.

This pre-breakup sedimentary wedge section appears to be upto 500 msec (TWT) "thick" at a depth from 0.8 to 1.3 sec on line KHR-88, and 2.0 to 2.5 sec., at the south of Kuchma-1 well (figure 2), and occurs at a depth of 4.0 sec to deeper than 5.0 secs on line PK-SU-19 (figure 3) is of high amplitude events above a reflection free zone. The high amplitude events appear as if they are from broken surfaces. Within these bands of high amplitude events a non parallelism indicates an unconformity within the wedge-possibly the top of Gondwana coals (figure 4, line KHR-88). The high amplitude events occuring at the base of this section look similar to the events at the base of Gondwana.

The structurally deepest events becomes increasely difficult to follow as it deeps below the younger strata of the wedge, fading away at depth on many of the seismic sections (figure 3). The strength of the reflections within the wedge diminishes near the Madhupur High, but the wedge can be jump correlated across the surface. An angular unconformity at the top of the wedge indicates that a great deal of erosion occured before the next sequence was deposited (refer to figure 3 and line PK-SU-19).

The unconformity at the base of the sediments is called the Breakup Unconformity, according to the terminology of Falvey (1974). This unconformity marks a period of erosion associated with thermal and tectonic uplift during the rifting stage and continued after the onset of true sea-floor spreading in the Early Jurassic. Rapid subsidance caused by thermal cooling of the lithosphere and sediment loading (Watts and Stecker, 1979) resulted in a thick wedge of Lower Jurassic through Cretaceous sediments being deposited (figure 2).

^^^^^^^^^^^^^^^^^^^^^^^^Breakup unconformity^^^^^^^^^^^^^^^^^^^^^^^^

In the lower part of the section (figure 3), the boundary at the top Horizon A (Lower Cretaceous to Paleocene) was inferred to be present at the top of the conspicuous group of reflectors 4 to 5 seconds below sea level in the deepest part of the basin; these reflectors can be traced widely over the Surma basin and the Faridpur Trough.

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The oldest traceable acoustic horizon A is assumed to include strata deposited during Cretaceous. The strata unconformably overlie an irregular basement probably consisting of block-faulted continental crust rifted during the last opening of the Indian ocean. On most cross-shelf profiles, acoustic basement is easily discernible under the inner part of the continental shelf where it deepens rapidly to more than 6 km.

As can be seen from figure 3, horizon A pinches out west of line PK-SU-19, where basement rocks are probably 6 km below sea-level. In some areas like northern Surma basin, Line PK-SU-6, the pinchout is irregular because the horizon is continued within fault troughs.

Both non-marine and restricted-marine conditions appear to have prevailed during deposition of horizon A. Strong continuous reflectors (those having high interval velocities) are above discontinuous reflectors of variable amplitude and bredth. No strata this old have been drilled in the shelf or in the basin area (figure 3, line PK-SU-6).

^^^^^^^^^^^^^^^^^^^^^^^^^^^^Unconformity^^^^^^^^^^^^^^^^^^^^^^^^^^^^

Horizon B is thought to include both Cretaceous and the Paleocene sediments. It seems to be wide spread and pinches out against outer shelf area (as seen on line PK-15).

The upper limit of acoustic horizon C is taken as a group of high-amplitude continuous reflectors assumed to represent carbonate beds. Interval velocities below this boundary is about 4 km/sec and those above the boundary is less than 3.00 km/sec. The reflecting horizon C can be correlated with the top of the Sylhet Limestone and is continuous throughout all of the Bengal Shelf, Slope, and partly in the Geosynclinal area and seems to be terminated against the southern margin of the Rangpur Saddle in the north. Northern end of line KHR-88 (figure 4) indicates the termination against Pre-cambrian basement near SP-400 (KHR-88). This is the most well defined reflector of the whole of Bengal basin.

Horizon D, possibly correspond to the Eocene Kopili shale, overlies the Eocene Limestone and extends further north of Eocene limestone margin. The surface separates the Horizons D and E is believed to be an unconformity. The northwestern margin of this horizon extends north of Gaibandha (GDH-31) over the eastern flank of the Rangpur Saddle (figure 5, line Shell-2500), represents a transgression of the late Eocene Bengal basin margin that croses over the Rangpur Saddle structure up to the southern flank of the Sub-Himalayan Foredeep area (Dinajpur Slope).

Horizon E, probably belongs to the Oligocene sediments. This unit has a considerable thickness in the slope and rise area and rapidly thins out on the shelf (see line PK-M-14, 13 and figure 2 and 3). This represents a rapid regression of the paleo-Bengal basin from north of GDH-31 and down to the outer shelf region between Bogra-XI and Hazipur-1 well locations.

The next higher horizon of the shelf zone is identified by the parallel oblique clinoforms (line PK-M-14, 13, PK-8427, etc.,) found under the southeast 20 to 30 kms of the Eocene shelf. To the northwest, the top and the base of this sequence becomes conformable; the horizons thins and the internal reflection geometry becomes concordent with the top and base of the sequence. To the southeast, the sequence boundaries become time lines (non-diachronous) and thin to a single cycle of continental rise sediments.

Horizon F, (figures 2 and 3) probably belongs to the early Miocene sediments and exists all over the Surma basin and the Faridpur Trough and in part of the Bogra shelf. This horizon becomes very thick eastward in the Surma basin. Northward beyond north-east of Rangpur Saddle (north of GDH-31 well) this horizon represents the maximum northward transgression of the Bengal basin sediments and probably demarcates the northern extermity of the Bengal basin margin (plate 14).

Horizon G (figure-3), probably belongs to the late Miocene sediments is represented by continuous to semi-continuous reflections in the Bengal Basin but feebly continuous of variable amplitude reflections in the Dinajpur Slope area (horizon G', figure 5). In a few areas, extremely low angle truncation of the older horizon G against the crystalline basement, is evident but where the truncation is missing, the younger horizon H, still projects through on the basis of its acoustic character.

^^^^^^^^^^^^^^^^^^^^^^^^^^^^Unconformity^^^^^^^^^^^^^^^^^^^^^^^^^^^^

Horizon H (figures 3 and 5), exists almost all over Bangladesh excepting in the northwestern part of greater Dinajpur, and Rangpur Districts. It has maximum northward extension (northern flank of Rangpur Saddle) and probably demarcates the northern margin of the Bengal Basin sediments. Not all acoustic horizons are marked by an obvious unconformity. The acoustic Horizon H (post-upper Miocene) is mainly strong, even reflectors above a presumably older unit that lacks strong, high amplitude, continuous reflectors (figures 2 and 3).

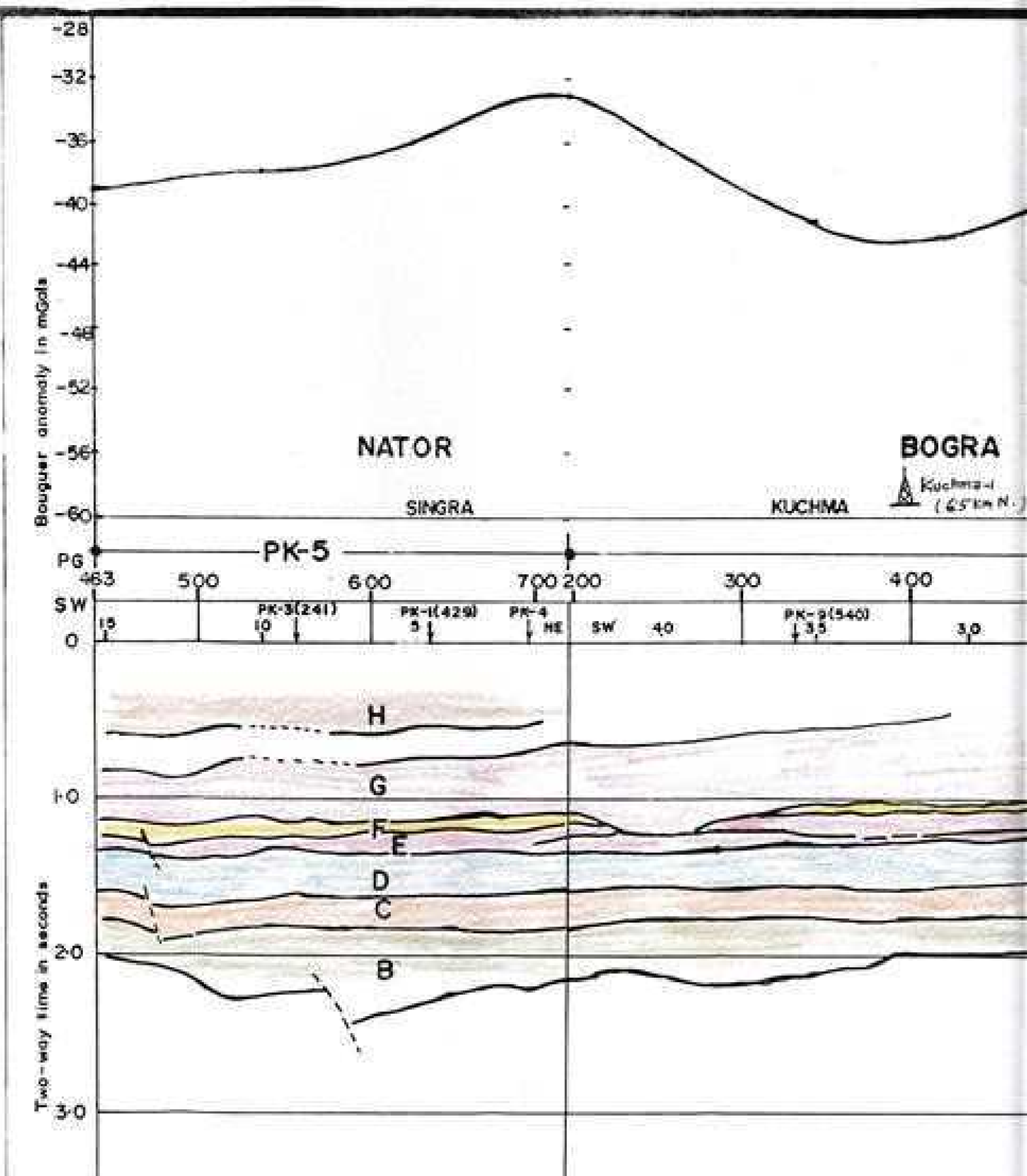
Horizon I (figure 3), probably demarcates the beginning of the Pliocene sequence. This sequence includes acoustic horizons I,J and K. Horizon J (line PK-SU-6 and 19), is represented by high continuity and high amplitude of the seismic events probably the Upper Marine Shale (UMS). The late Miocene or early Pliocene UMS was deposited during a highstand of sea-level, probably at about 5.1 ma on the Vail et al., (1977) Scheme. Depending on the pick of the base of the UMS; gas reservoir sands may occur within the UMS interval. Such is the case for this report at Kailastila, and Rashidpur. It follows then that additional Direct Hydricarbon Indicators (DHI's) should be looked for above the base of the UMS (Well Drill, 1988). The top of the UMS is recognized by the charecter of its reflection in the Surma basin. However, since the lithofacies and depositional environments are time transgressive, the character of the reflection outside the Surma basin changes. This not only makes the event difficult to follow but channelling of the sedimentary section to the west and southwest of the Surma basin causes the time equivalent of this event to be lost (figure-3, near PG-150, line PK-SU-19, horizon I).

In central Bangladesh, deltaic and pro-deltaic facies occur both below and above the UMS, time equivalent deposits. In western Bangladesh, the channel-fill facies occurs both above and below the time equivalent deposits of the UMS (figure 3, western part of composite section II).

Horizon K, this horizon occurs on both sides of Madhupur Tract (PK-M 12, PG-150 and PG-450, Figure-3) and also extends east of Chhatak structure along the Bangladesh-India Border south of the Dauki Fault.

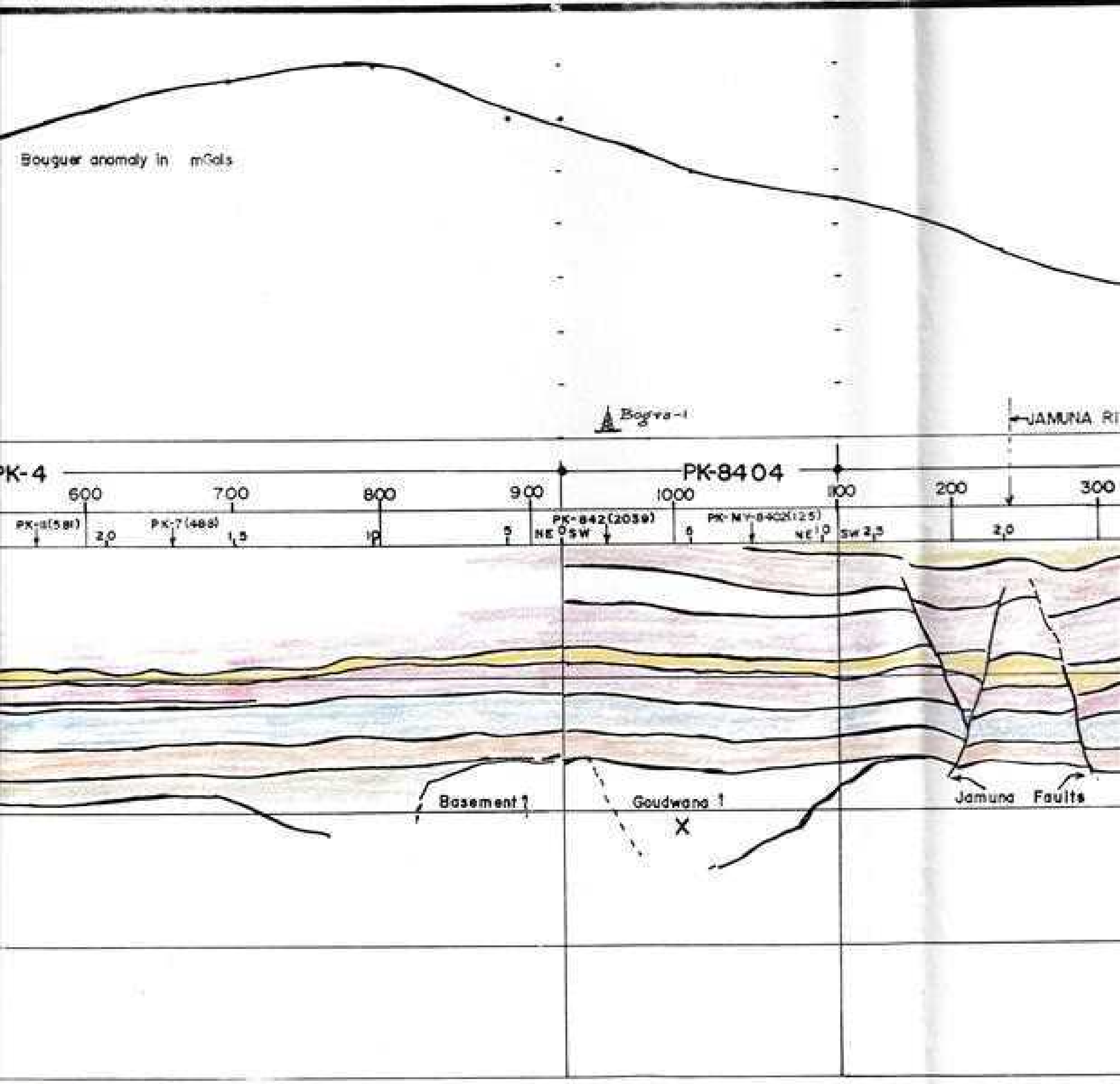
Horizon L, probably demarcates the beginning of the Holocene sequence. This sequence includes horizons L,M,N,O,P and are restricted only to the Surma Basin. Horizons M, N, O,and P are traceable on lines PK-SU-19,PK-SU-6, PK-MY-8403, SU-2, etc., and are represented by continuous, moderate to high amplitude reflections. The most prominent deposition of the horizons L through P exists between PG-9914 and PG-11550 on line PK-SU-6 and between PG-113 and PG-1594 on line Pk-SU-19 and has TWT thickness (2.05 sec.) equivalent to 2000 m. The upper boundary is not traceable due to muting of seismic traces (sections) to remove near surface noise. The depocenter of this sequence (L through P) coincides with the Tangua-Raular bils as seen on line PK-SU-6 (PG-800 to PG-900).

In the northeastern flank of the Rangpur Saddle a set of horizons presumably time equivalent of K,L,M, and N, are designated by K', L', M', and N', as they could not directly be correlated due to lack of seismic data in the region between Gaibandha and Sherpur across the river Jamuna (Plates 1, 4, 5, 6, 10 and 14). This part of the horizons are represented by low continuity and variable amplitude reflections.

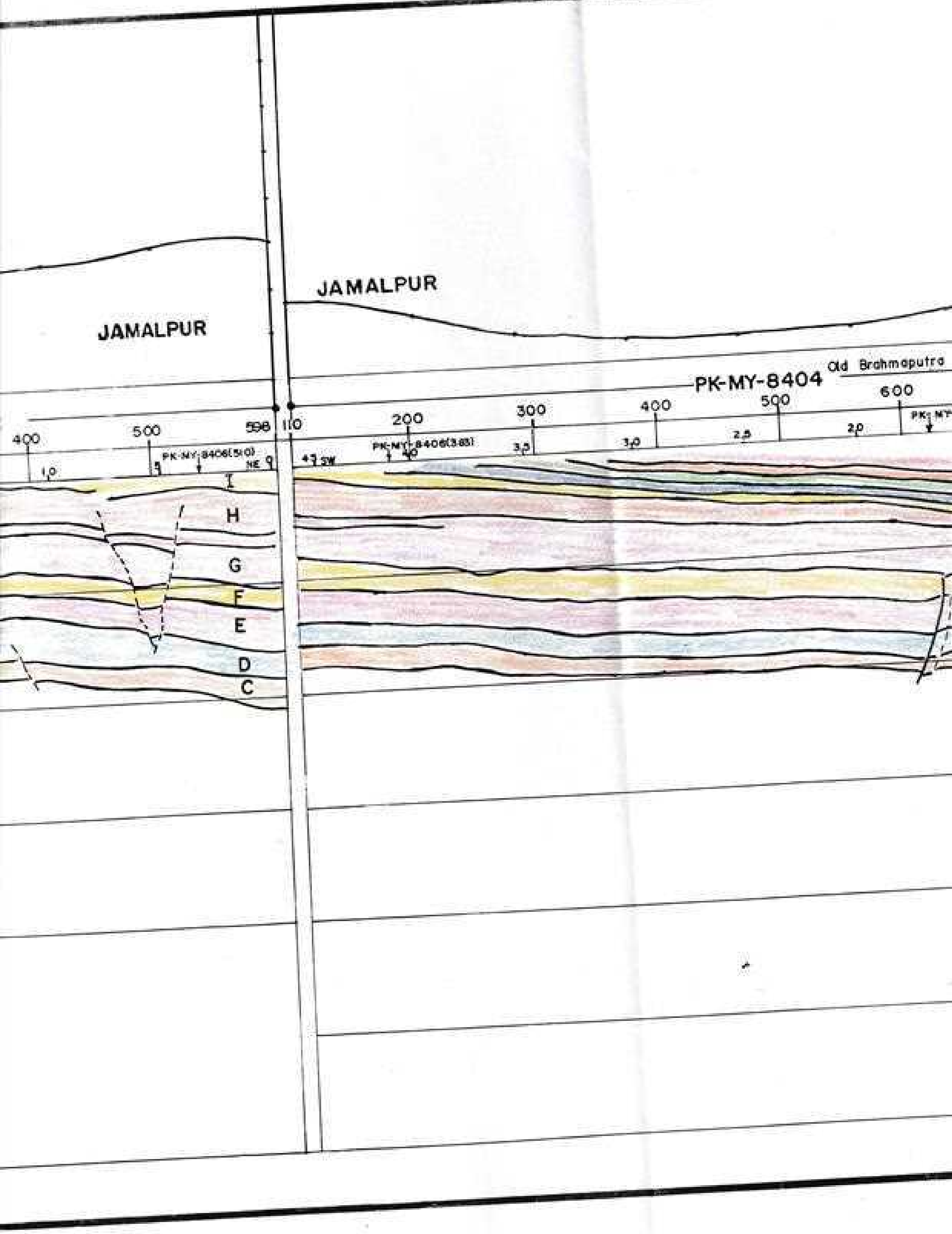


INDEX

A	Horizon A L·Cretaceous to Paleocene	E	Horizon E (E. Miocene)
B	Horizon B Cretaceous/Paleocene	F	Horizon F Surma group (unc
C	Horizon C Sylhet limestone (E·Eocene)	G	Horizon G Surma group (unc
D	Horizon D Kopili shale (L.Eocene)	H	Horizon H U· Bhuban (Mioc

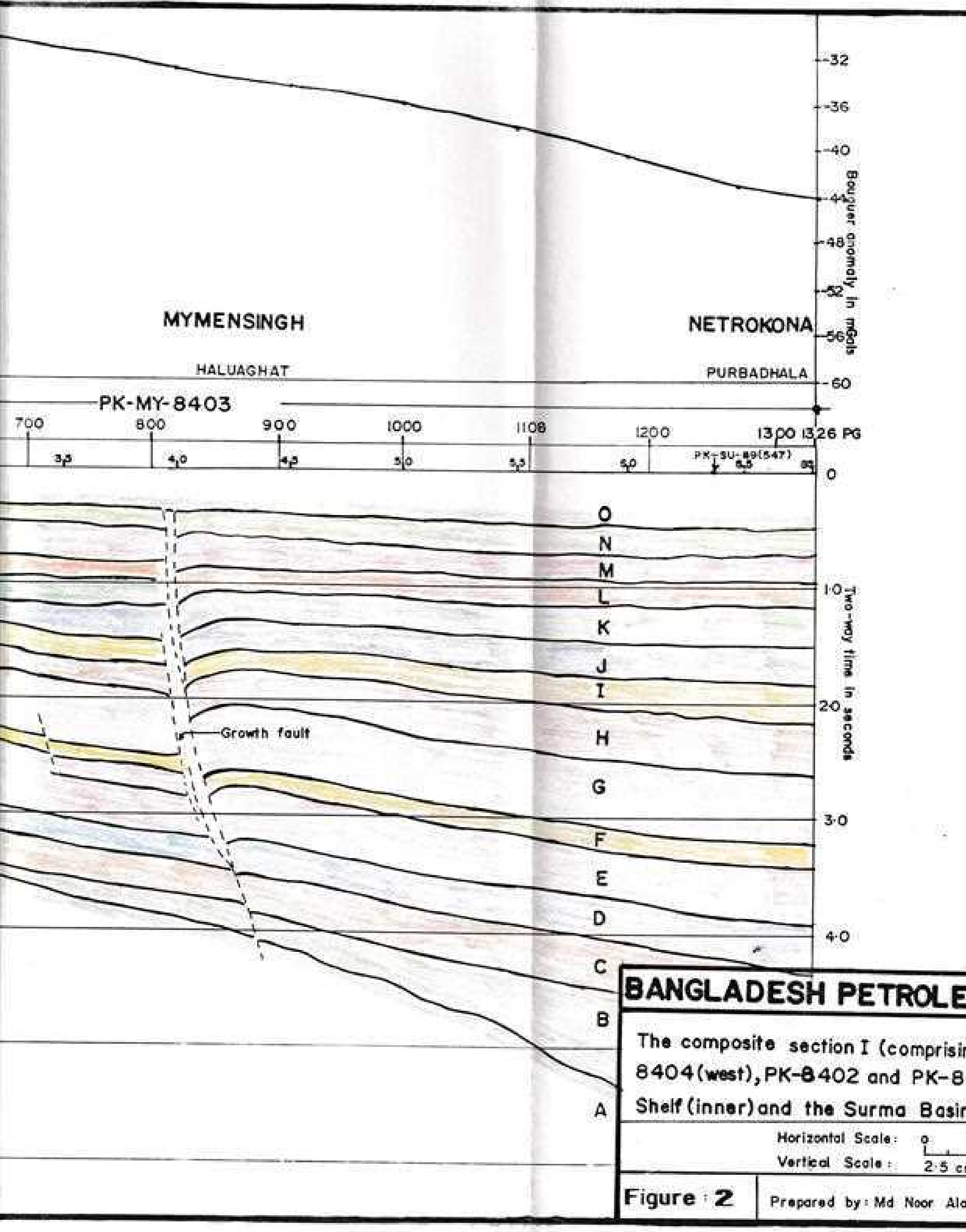


I	Horizon I UMS + Tipam (Neogene)
J	Horizon J Dupi Tila (Pleistocene and Pliocene)
K	Horizon K Dihing (Pleistocene and Pliocene)
L-P	Horizon L through P Pleistocene and Recent

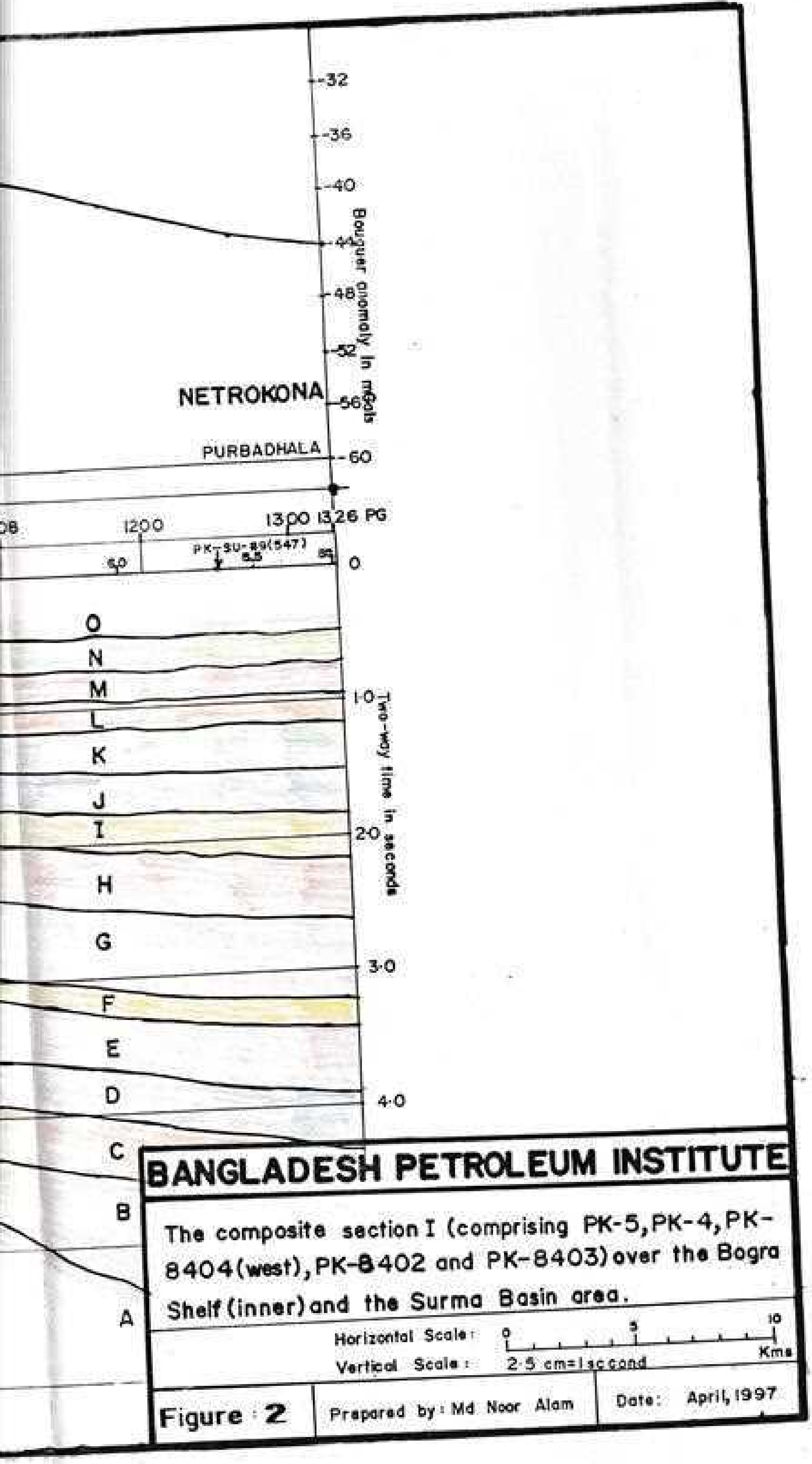


JAMALPUR
JAMALPUR
PK-MY-8404
Old Brahmaputra
400
500
598
110
200
300
400
500
600
1.0
3.5
3.0
2.5
2.0
PK-MY-8406(5.10)
PK-MY-8406(3.85)
NE
SW
I
H
G
F
E
D
C

Bouguer anomaly in mGals
SHERPUR
SHERPUR
SRIBARDI
NALITABARI
800
900
924
100
200
300
400
500
600
PK-MY-8403(128)
NE
PK-MY-8404(890)
N
M
L
K
J
I
H
G
F
E
D
C



-32
-36
-40
-44
-48
-52
-56
-60
Bouguer anomaly in mGals
MYMENSINGH
NETROKONA
HALUAGHAT
PURBADHALA
PK-MY-8403
700
800
900
1000
1108
1200
1300 1326 PG
PK-SU-89(547)
0
1.0
2.0
3.0
4.0
Two-way time in seconds
O
N
M
L
K
J
I
H
G
F
E
D
C
B
A
Growth fault
BANGLADESH PETROLE
The composite section I (comprisi
8404(west), PK-8402 and PK-8
Shelf (inner) and the Surma Basi
Horizontal Scale:
Vertical Scale:
2.5 c
Figure 2
Prepared by: Md Noor Ala



BANGLADESH PETROLEUM INSTITUTE

The composite section I (comprising PK-5, PK-4, PK-8404(west), PK-8402 and PK-8403) over the Bogra Shelf (inner) and the Surma Basin area.

Horizontal Scale: 0 5 10 Kms

Vertical Scale: 2·5 cm=1 second

Figure : 2 | Prepared by: Md Noor Alam | Date: April, 1997

3.1.1.2. Seismic sections of Bogra Shelf, Hinge Zone, Faridpur Trough and Surma basin area.

Some of the seismic sections under study Plate 1 show clear evidance of folding, uplifting and probable faulting of the sedimentary section of the Bengal Basin.

3.1.1.2.1. The composite sections of the shelf and the Surma basin area.

3.1.1.2.2. Section 1: Composite section I

The composite section I (figure 2) comprising seismic lines PK-5, PK-4, PK-8404 (west), PK-8402 extends from near Kuchma-1 well eastward across river Jamuna and PK-MY-8403 towards southeast show clear evidance of normal faulting and one growth faulting (on line PK-8403).

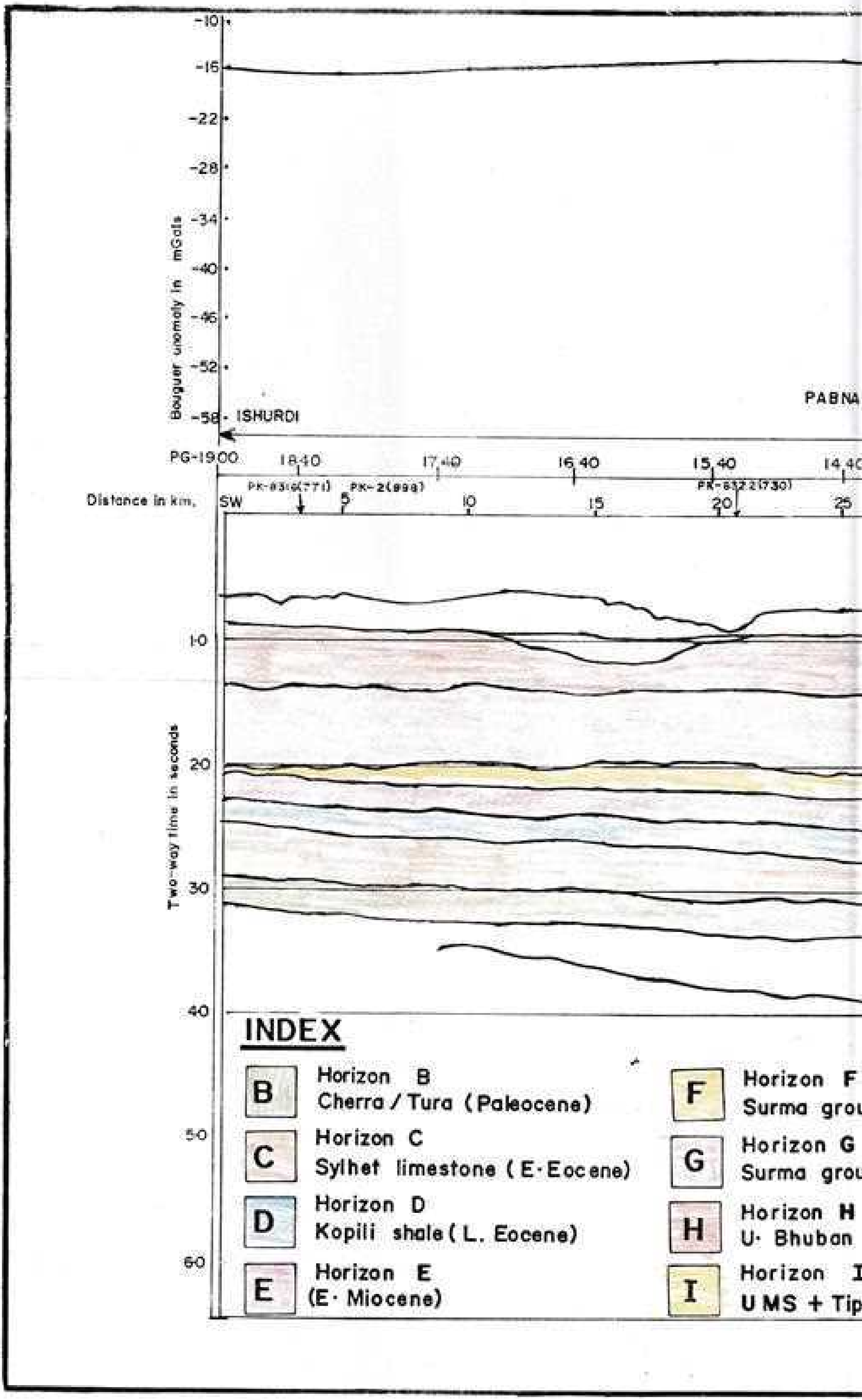
It is apparent from figure 2 that 3 (three) normal faults affects the sedimentary section comprising horizons C,D,E,F,G, and H on line PK-8402 (western part). These normal faults are between PG-150 and PG-300 on line PK-8402 and may bear relation with the Jamuna river. There seems to be a cluster of faults on the northwestern end of line PK-8403 between PG-200 and PG-300. The fault on this line between PG-800 and PG-900 seems to be a growth fault as the throw seems to be veriable across the fault plane. Offset across the fault decreases from 500m at the inferred top of the Horizon F to about 250m near the inferred top of the Horizon L.

There appears to be a double crested anticlinal structure with one crest between PG-450 and PG-1050 on line PK-4, PK-8404 and the other between PG-300 and PG-598 on line PK-8402 (figure 2).

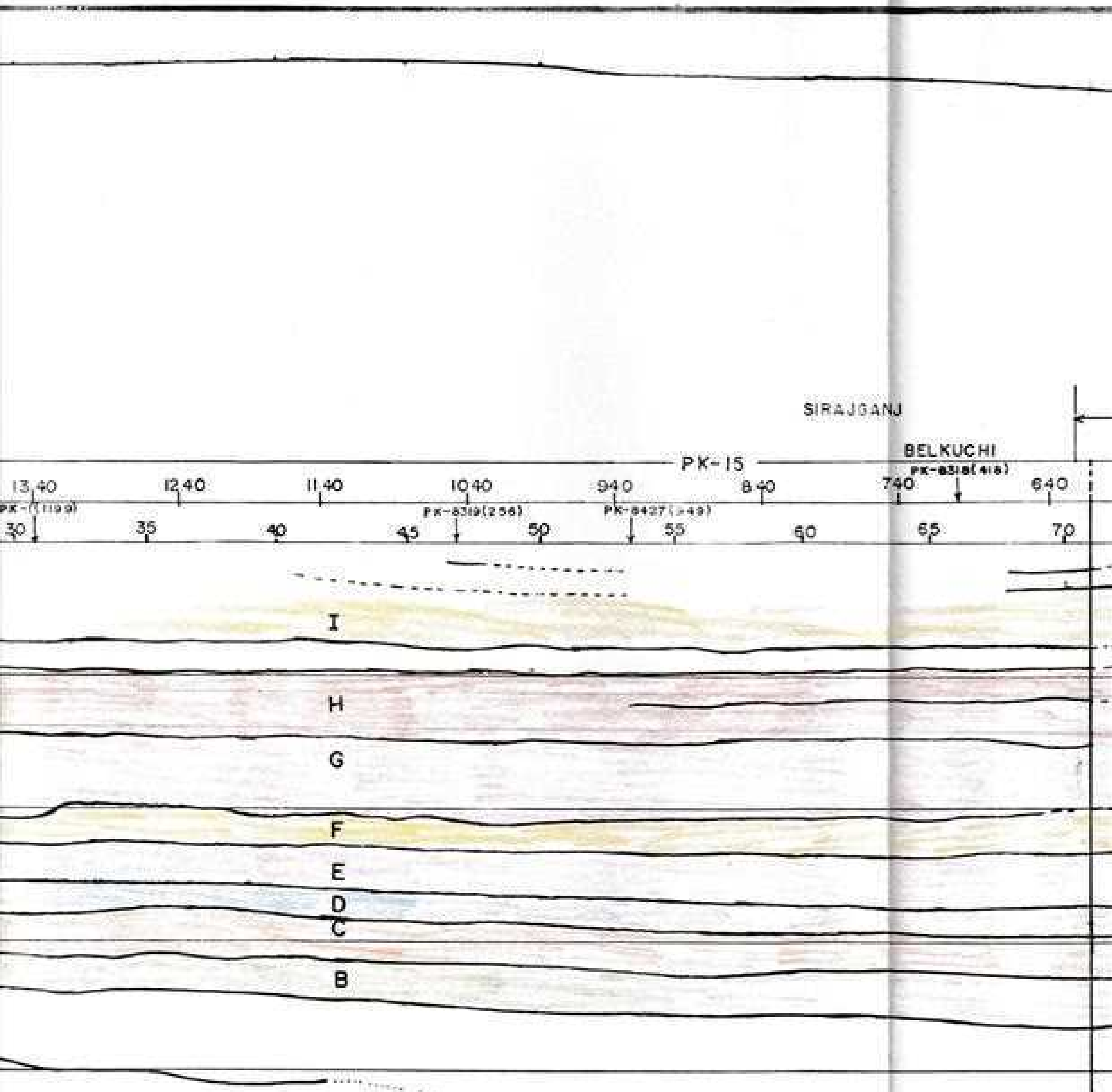
3.1.1.2.3. Section 2: The composite section II

The Composite section II (figure 3) comprising seismic lines PK-15, PK-15 (east), PK-M-12, PK-SU-19, and PK-SU-6 extends from approximately northeastward across river Jamuna and the Madhupur Tract and towards east along Meghalaya foothills along the Bangladesh-India Border.

The upper surface of Horizon H and I' between PG-1450 and 1900 are highly eroded and buried river channel below PG-1540 and PG-1850 are apparent. The upper surface of Horizon F is also affected by erosion between PG-1340 and PG-1450.



Bouguer anomaly in mGals
-10
-16
-22
-28
-34
-40
-46
-52
-58
ISHURDI
PABNA
PG-1900
1840
17,40
16,40
15,40
14,40
PK-8316(771)
PK-2(998)
PK-8322(730)
Distance in km.
SW
5
10
15
20
25
Two-way time in seconds
1·0
2·0
3·0
4·0
5·0
6·0
INDEX
B
Horizon B
Cherra / Tura (Paleocene)
C
Horizon C
Sylhet limestone (E·Eocene)
D
Horizon D
Kopili shale (L. Eocene)
E
Horizon E
(E· Miocene)
F
Horizon F
Surma grou
G
Horizon G
Surma grou
H
Horizon H
U· Bhuban
I
Horizon I
UMS + Tip

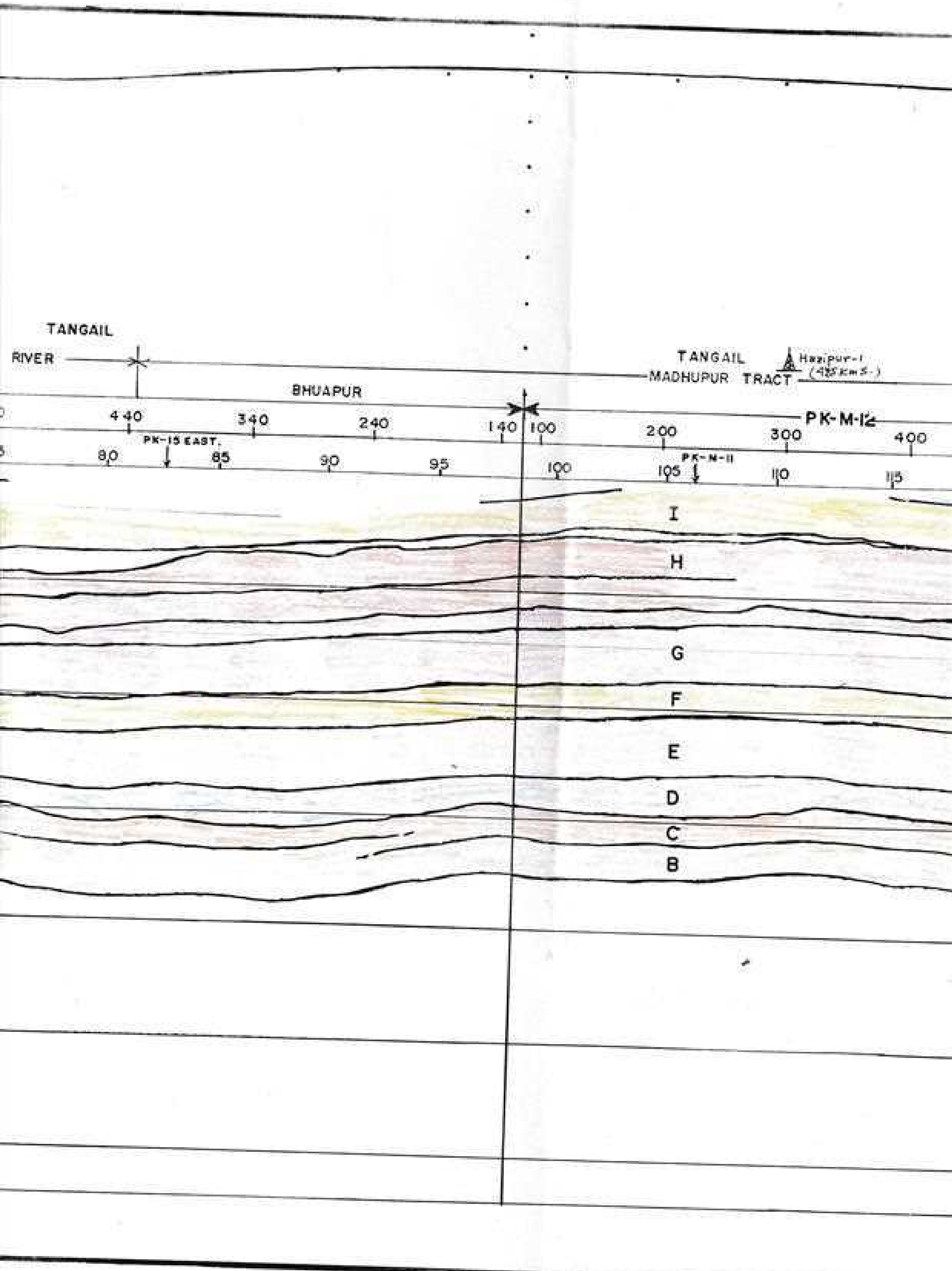


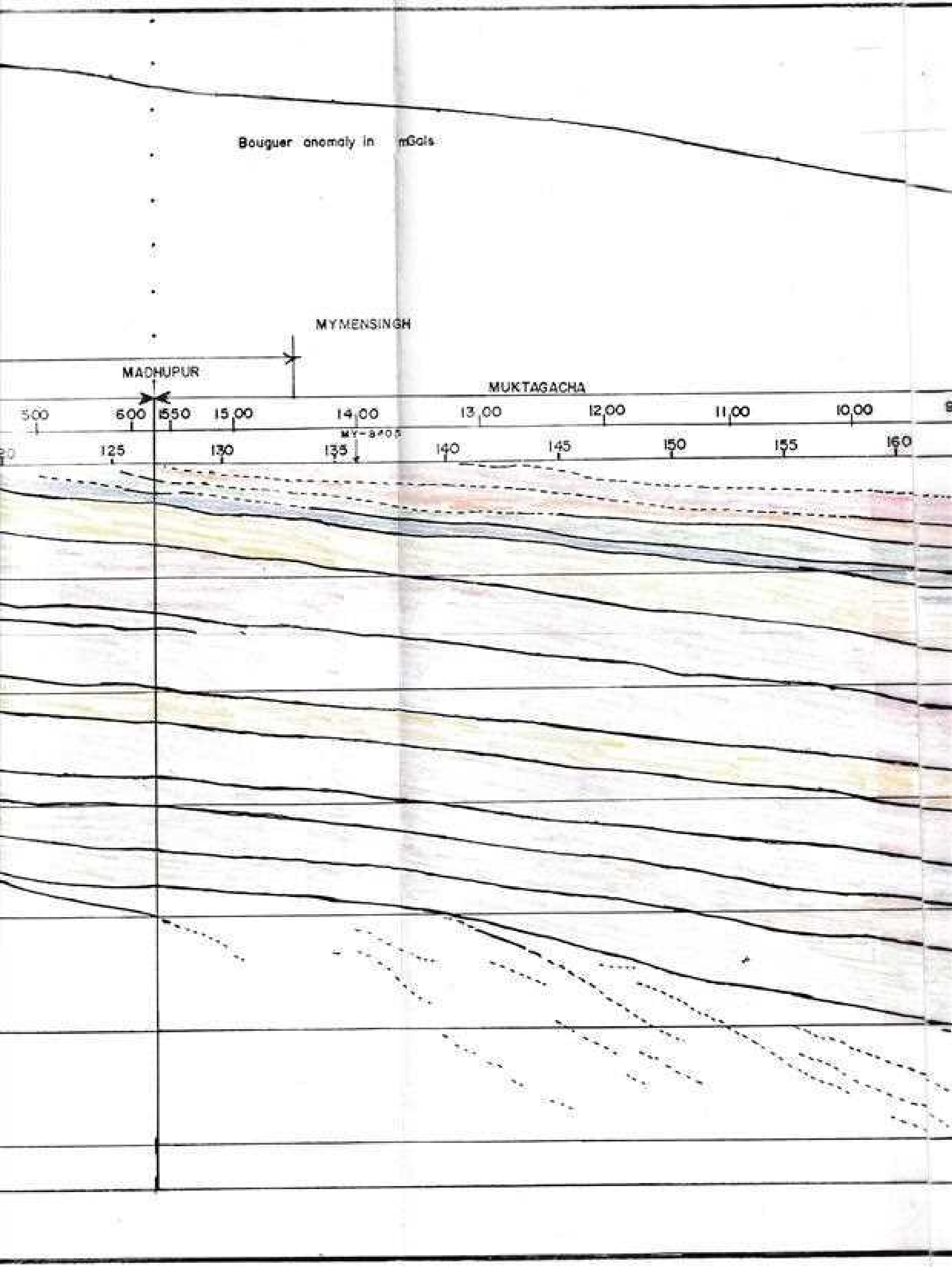
ff.) | J | Horizon J
Dupi Tila (Pleistocene and Pliocene)

f.) | K | Horizon K
Dihing (Pleistocene and Pliocene)

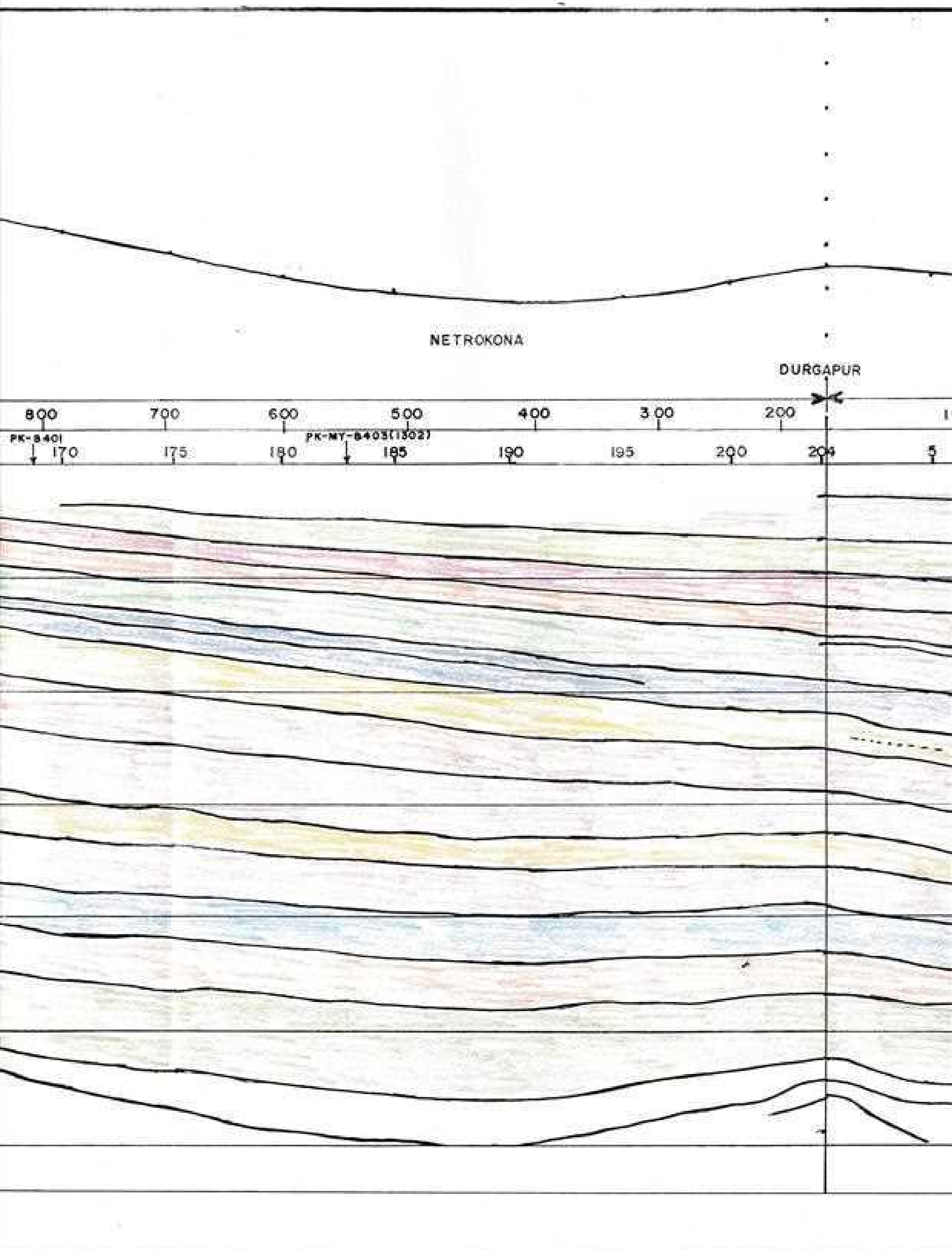
e) | L-P | Horizon L through P Pleistocene and Recent

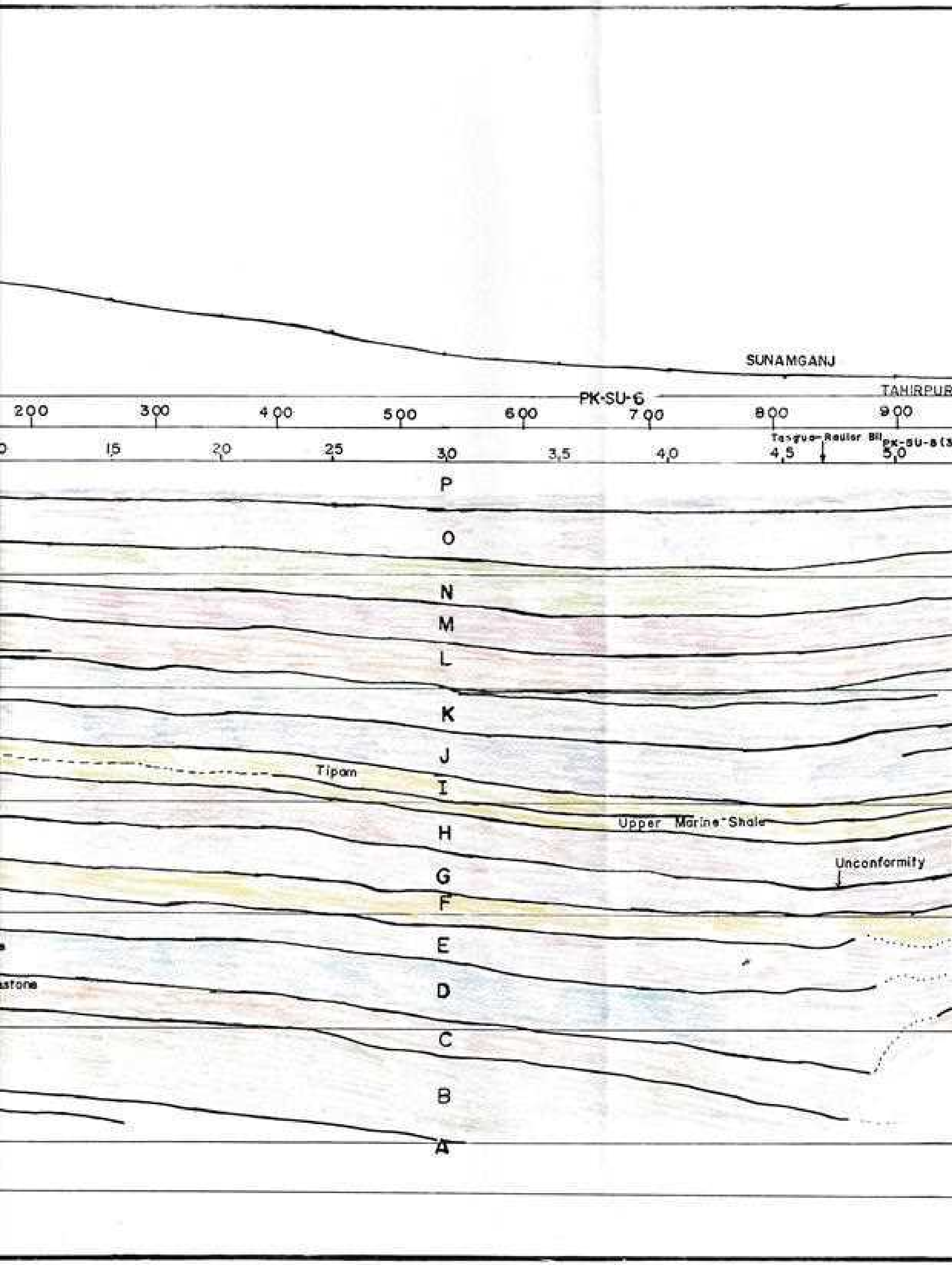
ogene)


TANGAIL
RIVER
BHUAPUR
TANGAIL
MADHUPUR TRACT
Hazipur-1
PK-M-12
440
340
240
140
100
200
300
400
PK-15 EAST.
80
85
90
95
100
105
PK-N-11
110
115
I
H
G
F
E
D
C
B

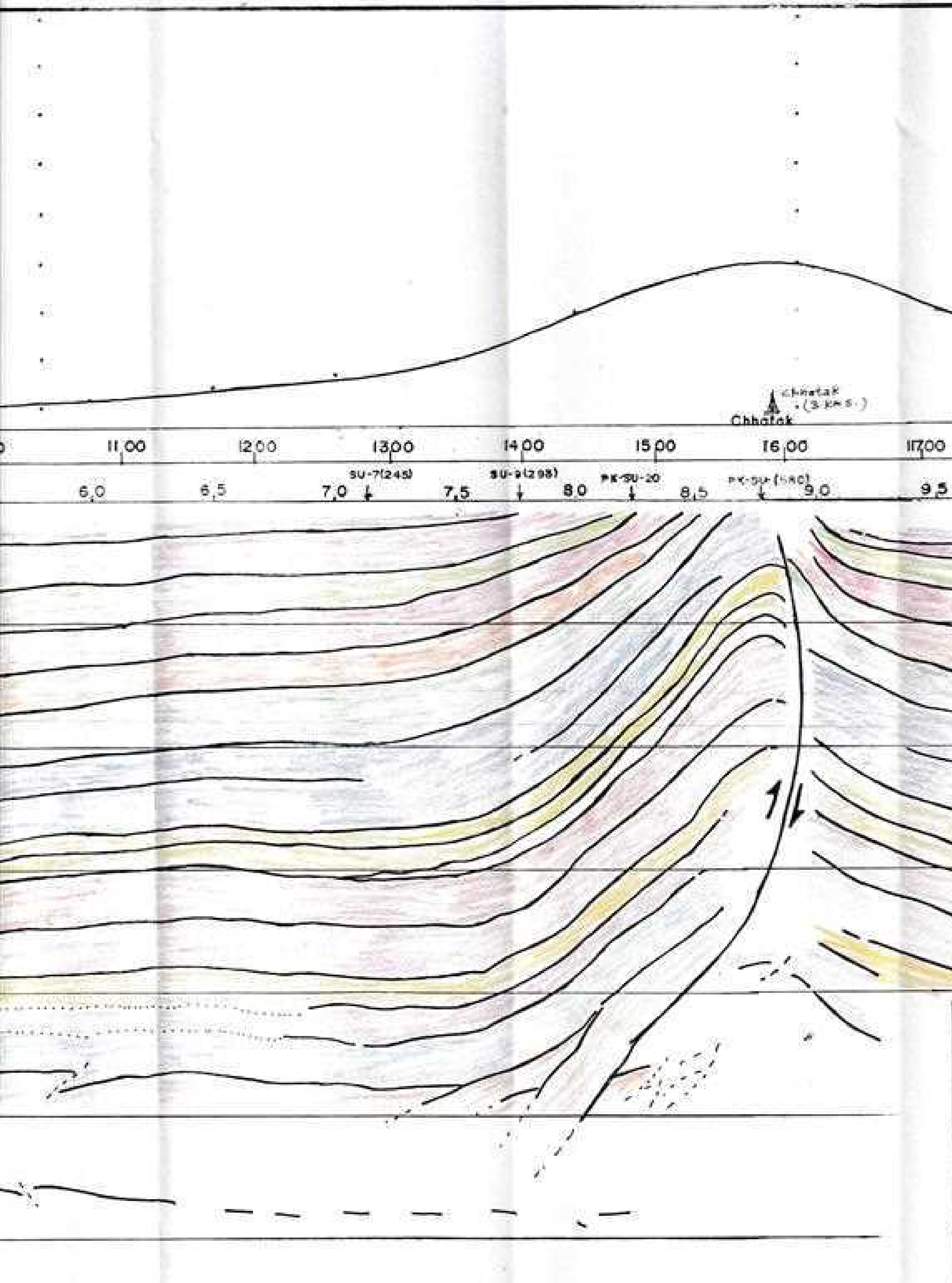


Bouguer anomaly in mGals
MYMENSINGH
MADHUPUR
MUKTAGACHA
500
600
1550
15,00
14,00
13,00
12,00
11,00
10,00
MY-9405
125
130
135
140
145
150
155
160


NETROKONA
DURGAPUR
800
700
600
500
400
300
200
PK-8401
170
175
180
PK-MY-8403(1302)
185
190
195
200
204
5



SUNAMGANJ
PK-SU-6
TAHIRPUR
200
300
400
500
600
700
800
900
15
20
25
3,0
3,5
4,0
4,5
5,0
Tasgua-Raulor Bil
P
O
N
M
L
K
J
Tipam
I
H
Upper Marine Shale
Unconformity
G
F
E
D
C
B
A



BANG

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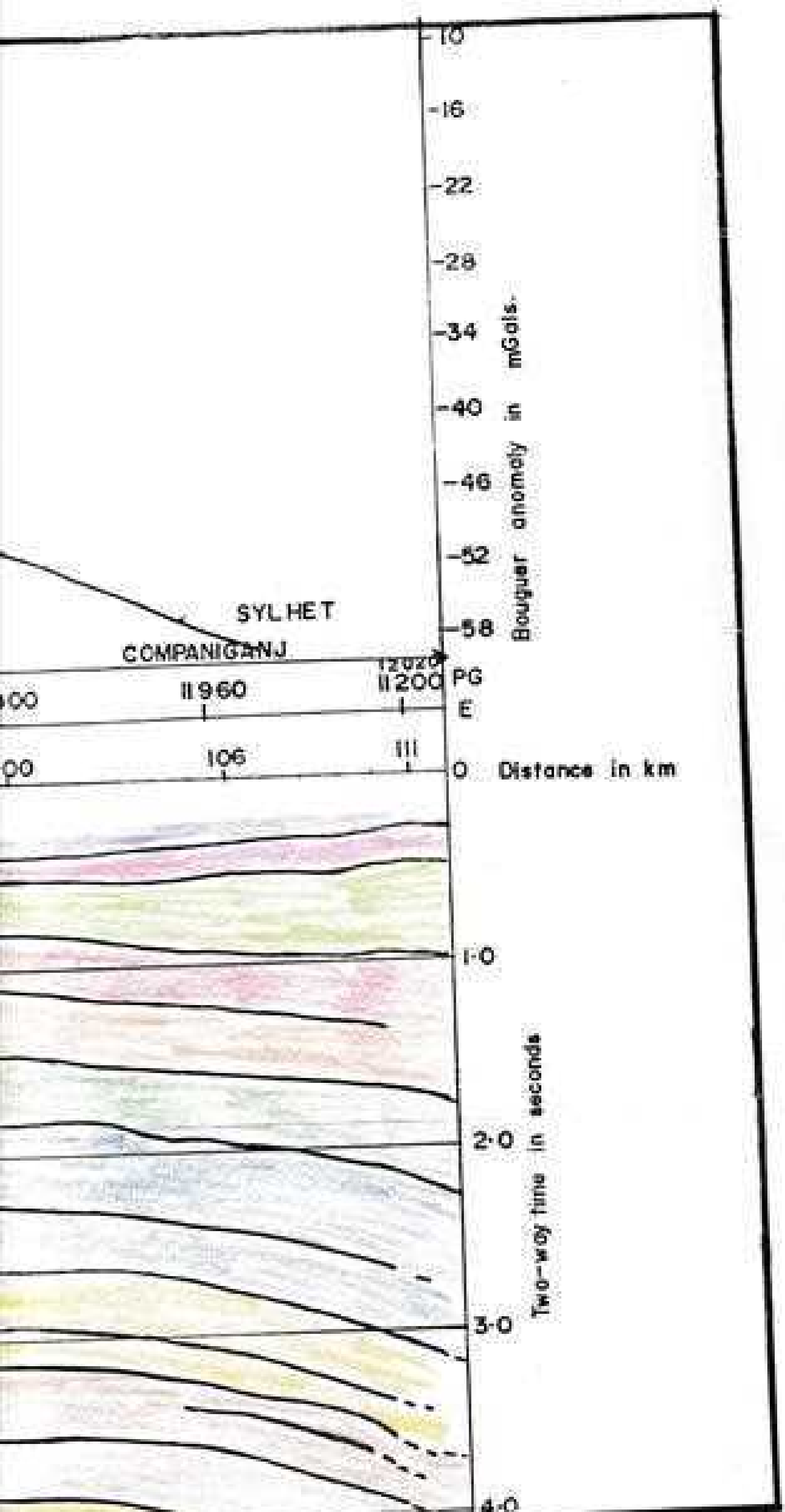
(wes
the
Surm

Figur



GLADESH PETROLEUM INSTITUTE

composite section II (comprising PK-15, PK-15
), PK-M-12, PK-SU-19, and PK-SU-6) over
Bogra Shelf (outer), Hinge zone, and the
a Basin area.

Horizontal Scale 0 5 10 Kms
Vertical Scale : 2·5 cm = 1 second.

re: 3	Prepared by: Md Noor Alam	Date: April, 1997

It is very interesting to note that along this 300 km long composite section, there is apparently no faulting excepting a thrust fault east of Chhatak structure. This fault is probably a thrust fault affecting the entire sedimentary column from Eocene limestone to the surface. The throw across the fault appears to be over 1300 msec, which is equivalent to about 1000m. The Horizon A seems to pinchout westward and therefore the bottom surface of Horizon B may be an unconformity.

It is interesting to note that the Horizons L,M,N,O,P are only confined to the northeastern part of the Madhupur Tract. The time thickness is 2.05 sec TWT (approximately 2 kms).

The deepest part lies below Tangua-Raular Bils (lake) near PG-800 and 900 on line PK-SU-6 in the Surma Basin. It is also interesting to note that just below this bil the Eocene limestone bed appears to underthrust a segmented pile of some formations (figure 3). This segmented pile of formation probably comprises the segmented Eocene limestone and the older Paleocene Tura sandstone detached from from the further east and south east. This buildup may have caused due to crustal shortening related to the subduction to the east.

It is also interesting to note that the trend of Eocene limestone, though follow a gently deeping trend as seen in the western part of line PK-SU-6, it seems to be broken (dotted line) between the Raular Bil and the Chhatak structure (anticline). This condition may be the result of the contact between Eocene limestone to limestone i.e, no impedence contrast no reflection and limestone to Tura sandstones i.e., there is impedence contrast and so there is reflection.

It may also be assumed that the Eocene limestone from the west of line PK-SU-6 is underthrusting the Eocene limestone bed from the east and the process is still continueing as the sedimentation and subsidance at Raular Bil is still active in this area.

It is also apparent that sedimentary section including Horizons B,C,D,E,F,G,H, and I, i.e., the entire Tertiary section shows a very gentle, broad and low amplitude anticlinal fold or a drape feature over the section constituting lines PK-15, PK-M-12, PK-SU-19 (composite section 2). The crest of this anticlinal feature lies between PG-200 to 400 over line PK-M-12 (figures 2 and 3). It is clear from plates 1 and 3 that the crest of the anticlinal structure coincides with the Madhupur Tract, a feature well known to be the exposed part of the Pleistocene formation in the area.

The oldest horizons A and B are probably marine sediments are probably of Early Cretaceous and Paleocene in age, including Tura (Horizon B). These sediments overlie Permian Gondwana continental sediments (horizon X, figures 2 and 3) is regarded as to be of fluvio-lacustrine origin.

Some of the Cretaceous sedimentary section passes seaward down the continental slope and beneath the onlapping western edge of Paleocene marine sediment (Tura?, line PK-M-14, PK-8427 etc.,). Overlying this continental crust, in most places with evidence for a second layer, is a thick section of Tertiary. This thick layer can be correlated in most of the seismic line throughout the Bengal basin and can be clearly be demonstrated to be well stratified in some places. This is interpreted as a sedimentary part of the section of early Tertiary (line PK-1, PK-8427, PK-M-14, 13).

Lines KHR-88, PK-1, and PK-8427 revealed two major sedimentary troughs; one beneath the shelf contains at least 3 km of sedimentary rocks, and a second is beneath the upper continental rise where the sedimentary rocks are at least 10 or 12 km thick. The shelf and rise sediment troughs are separated by an acoustically opaque feature interpreted to be a ridge whose top ranges from 3 to 6 km below sea level.

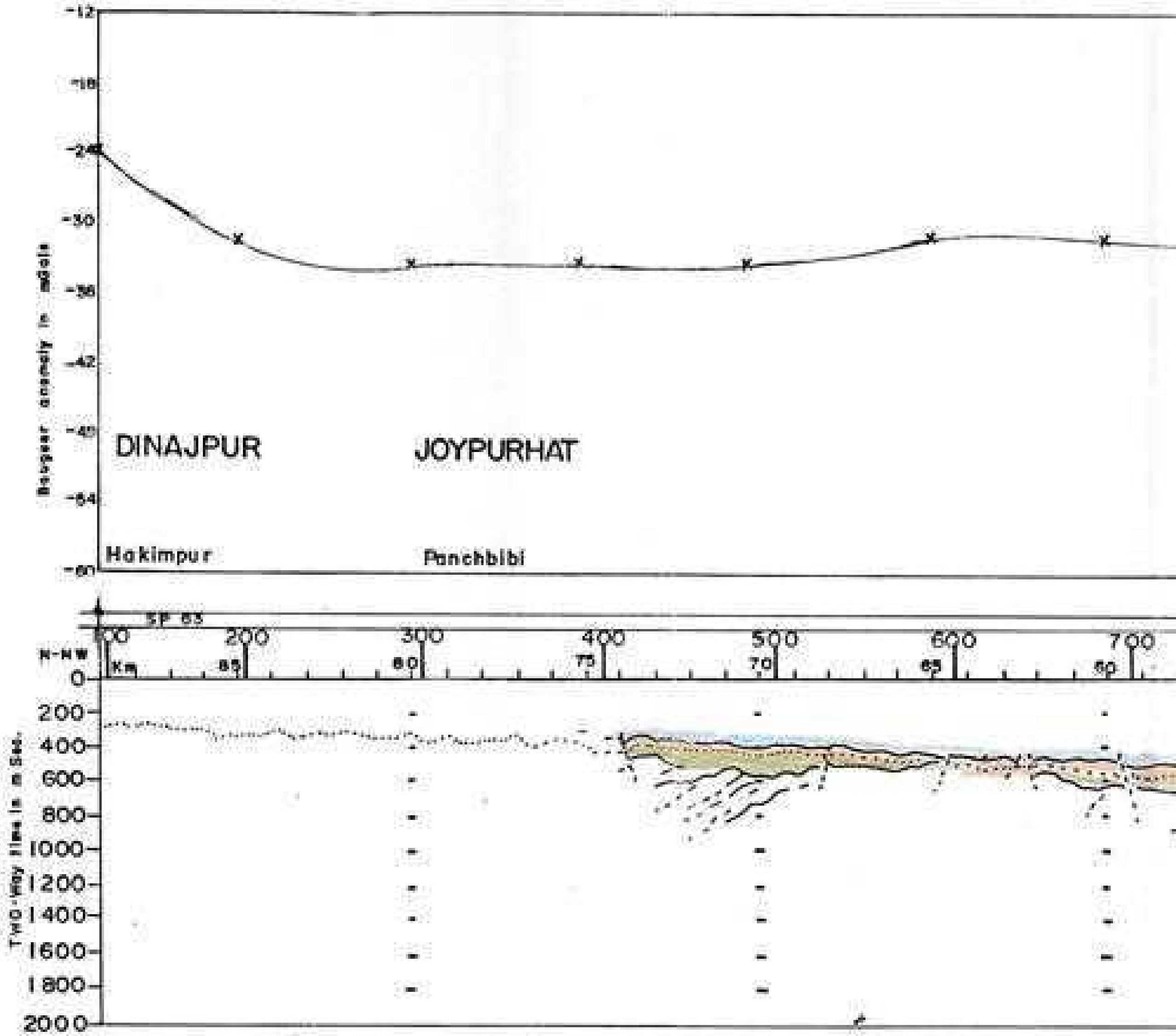
Close examination of the part of seismic profile No. PK-1, PK-MY-13, 14, PK-MY-8416, 8418, 8419, 8421, 8422, 8423, 8427 (location of these lines are shown in plate 1) reveals at least two conspicuous unconformities in the upper part of the record which are recognizable by onlap/toplap of an oblique progradational unit and by onlap of the overlying unit. It is assumed that these two horizons to be F and G (figures 2 and 3) of early Paleocene and of early Miocene age, respectively. The breaks are apparent where the layers were obviously onlapped and truncated. Less obvious are disconformities where reflectors approach the break at an extremely low angle or where the hiatus is evident by the low undulating relief of reflectors adjacent to it. The onlap relation are most obvious on cross shelf (dip sections, line PK-M-14 and PK-SU-19) oriented at right angles to the strike of sedimentary unit where the section thins in a short distance; profiles oriented parallel to the shelf also can show onlap and downlap relations, but the thinning is spread over a longer distance.

Across a depositional basin, the normal progression of environments is from an alluvial plain-coastal marsh, through a sandy littoral zone across a marine shelf, into deeper parts of the basin. In the deeper parts of the basin, conditions are more uniform(less amplitude variation), and the energy of depositional processes can be low (lack of reflector continuity). Obviously in mapping these facies on a grid of seismic reflection profiles, the interpreter must establish the paleogeography; then, potentially confusing facies (and associated lithology) can be sorted out. A uniformly thick sequence of sandstone deposited in a littoral environment can be expected to grade seaward to marine shelf deposits (high continuity and high amplitude or moderate continuity and low to moderate amplitude) and to grade shoreward to nonmarine deposits (low continuity and variable amplitude). A uniform shale deposited in a shelf basin offshore could be expected to grade laterally into normal marine shelf sandstones and shale toward the basin edge and, possibly, into prograded slope deposits (chaotic fill; mounded onlapping fill, fan complex) in a basinward direction.

The grouping of seismic reflections exhibiting common parameters, including reflection configuration, reflection continuity, reflection amplitude, and frequency, within a sequence allows the interpreter to judge what the depositional environment and lithofacies might be. These groups of reflections are called seismic facies. The most important parameter of a seismic facies is the reflection configuration. Reflection configuration is the parallilism or divergence of the reflections and whether or not they are of a progradational, clinoform nature. From this, in combination with the external geometry of the seismic facies, interpretation may be possible of the depositional setting of the facies units, and the lateral relationships of adjacent facies units.

The internal arrangement of reflectorsis also an important guide to distinguishing environment of deposition. Most units associated with the shelf or subaerial coastal plain have a parallel to low angle divergent arrangement of reflectors. But, where the sediments are deposited at the shelf edge or as a delta, then a sigmoid pattern of reflectors (perpendicular to depositional strike) is possible. If high energy conditions have affacted a part of the delta, the shallow-water part of it may be eroded so that an oblique progradational can result because of the truncation of the fondoform beds. Parallel to the depositional strike, the delta can show a mounded arrangement of reflectors (line PK-15 etc.,).

The broad progradational arrangement of reflectors is also present in shelf-edge deposits (line PK-SU-6, PK-M-13 and 14). Normal to the depositional strike, the reflectors can also show the same sigmoid or oblique progradational arrangement found in deltas, depending on emerging conditions at the shelf-edge (as in PK-M 14); obviously a major sea-level drop could strongly affect energy conditions at the shelf-edge and thereby erode the undaform beds to create an oblique progradational pattern of reflectors (PK-MY-6, PK-M-13 and 14). Laterally along the shelf edge, these deposits could be expected to grade into other shelf or upper-slope deposits. Shoreward from the shelf edge, they could grade into normal marine-shelf deposits (parallel; high continuity; high amplitude to low amplitude); in a seaward direction, they could grade into hemipelagic or mass movement deposits of the continental slope.



INDEX

A — Horizon **A**
L· Cretaceous to Paleocene

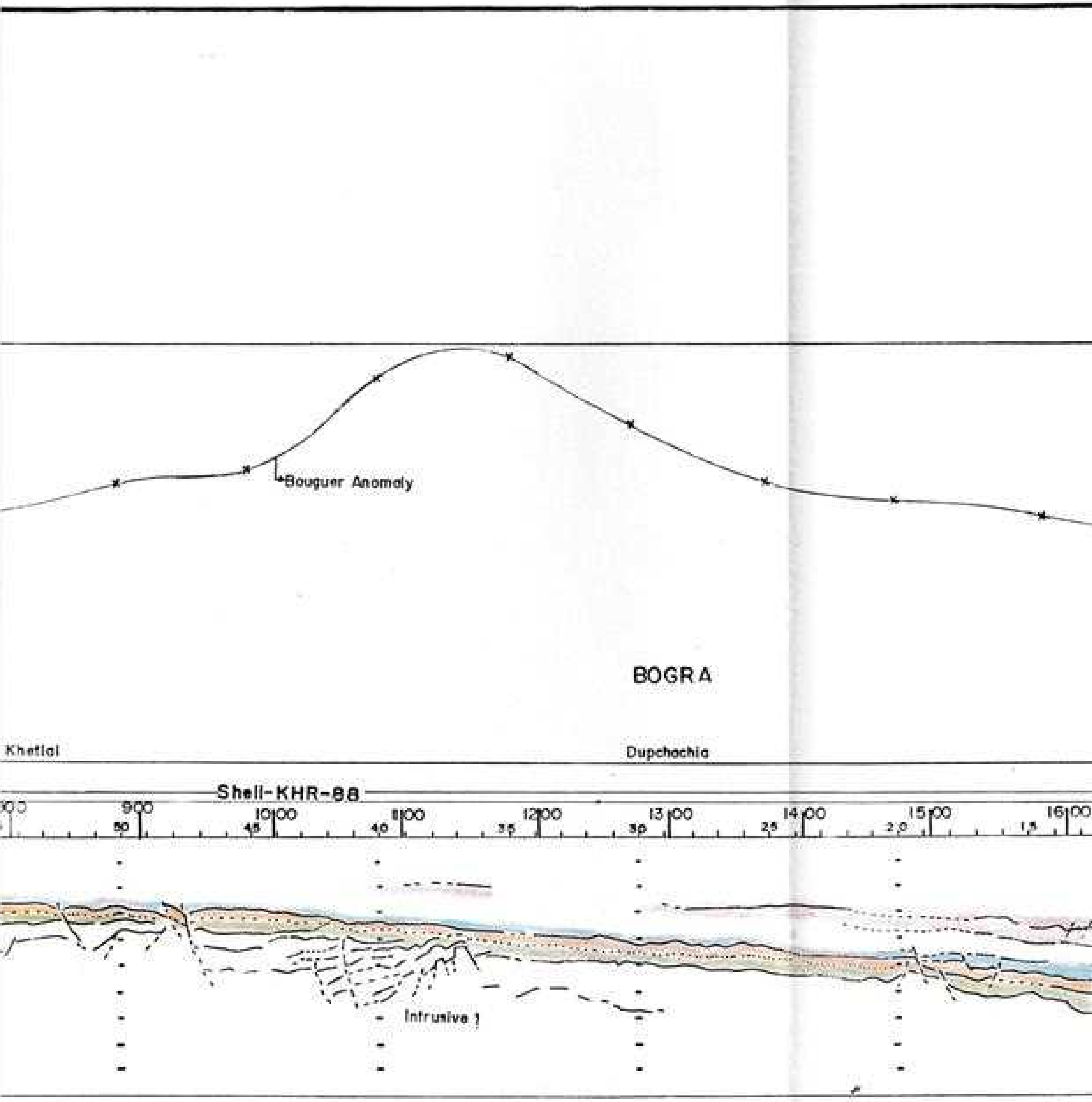
B — Horizon **B**
Cherra/ Tura (Paleocene)

C — Horizon **C**
Sylhet limestone (E·Eocene)

D — Horizon **D**
Kopili shale (L·Eocen

E — Horizon **E**
(E· Miocene)

F — Horizon **F**
Surma group (Undiff.)



G

Horizon G
Surma group (Undiff.)

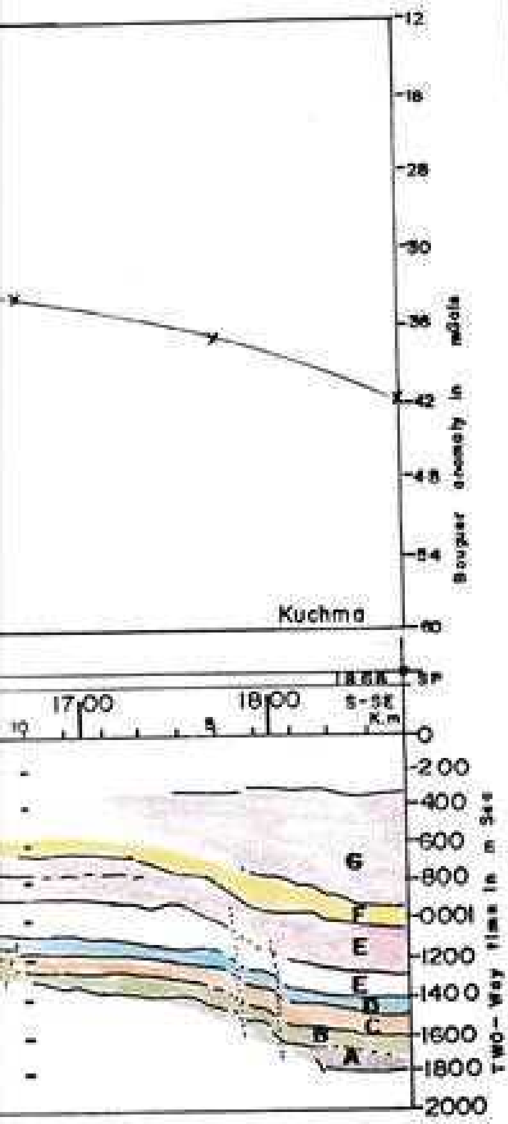
BANGLADESH

The interpreted TWT
KHR-88 across the
Dinajpur to Kuchma–

Horizontal scale
Vertical scale : 2

Figure : 4

Prepared b



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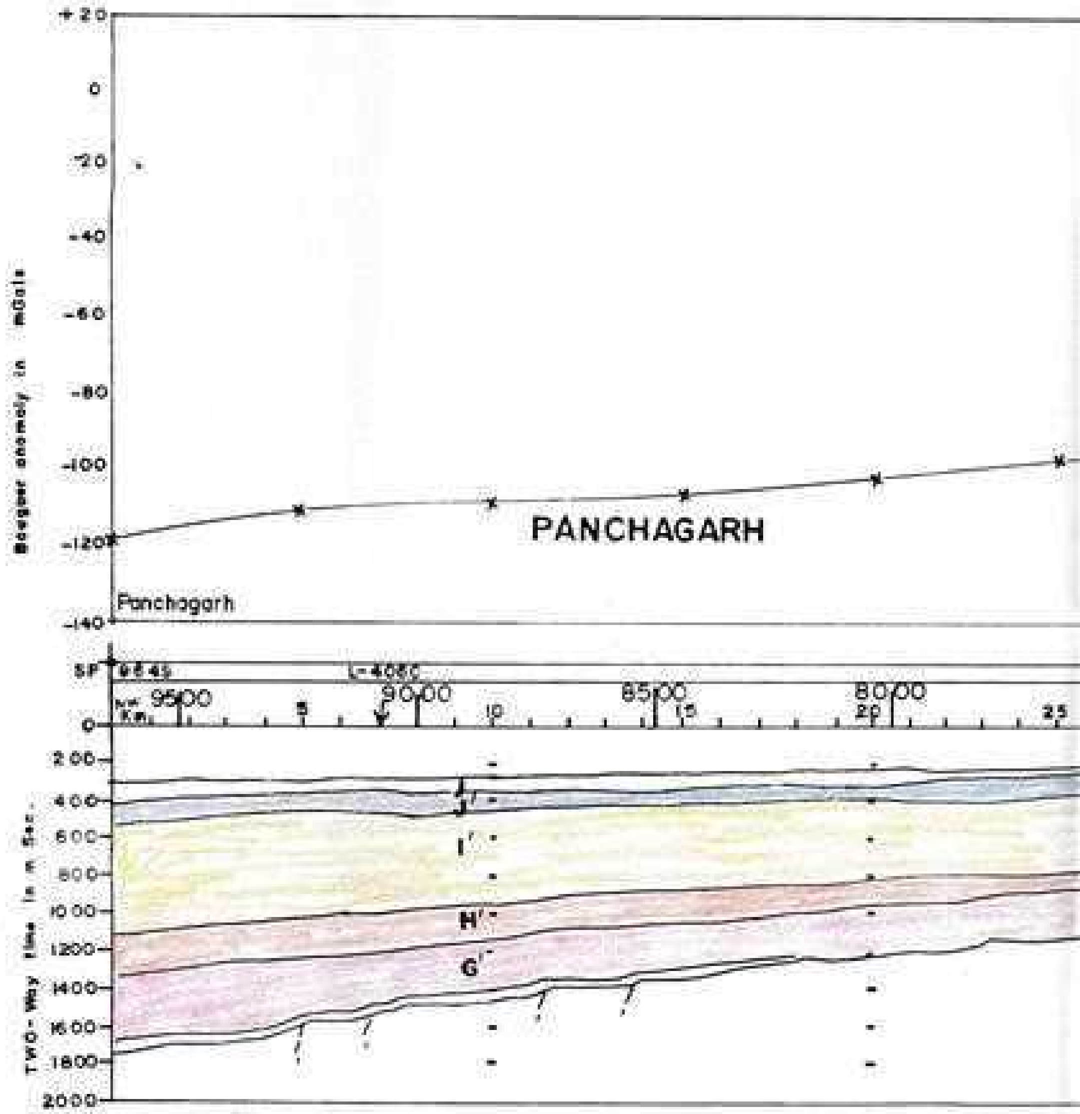
tion of the seismic profile
gra shelf from Hilli in
well in Bogra.

5 10
kms

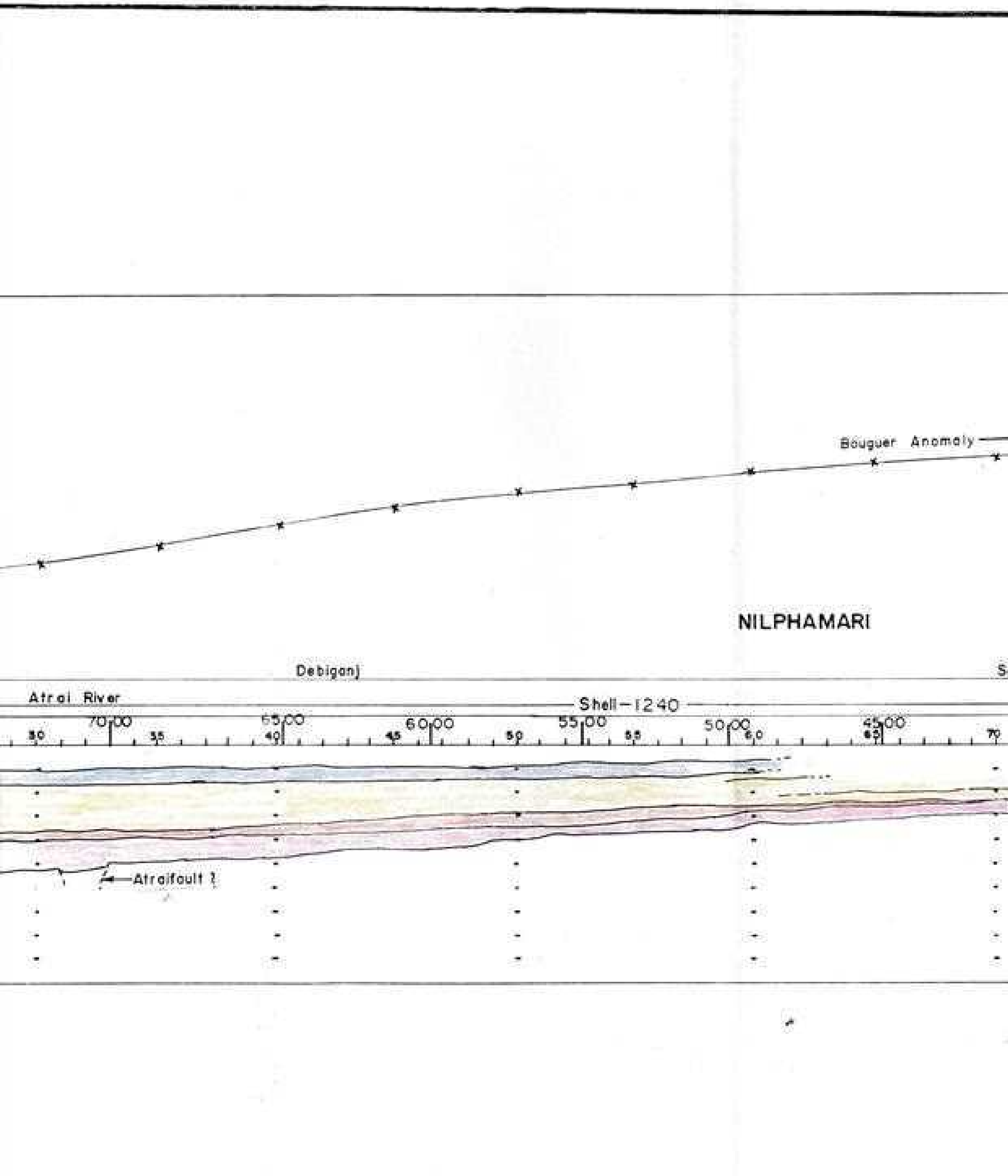
m= I second

d Noor Alam | Date : April, 1997

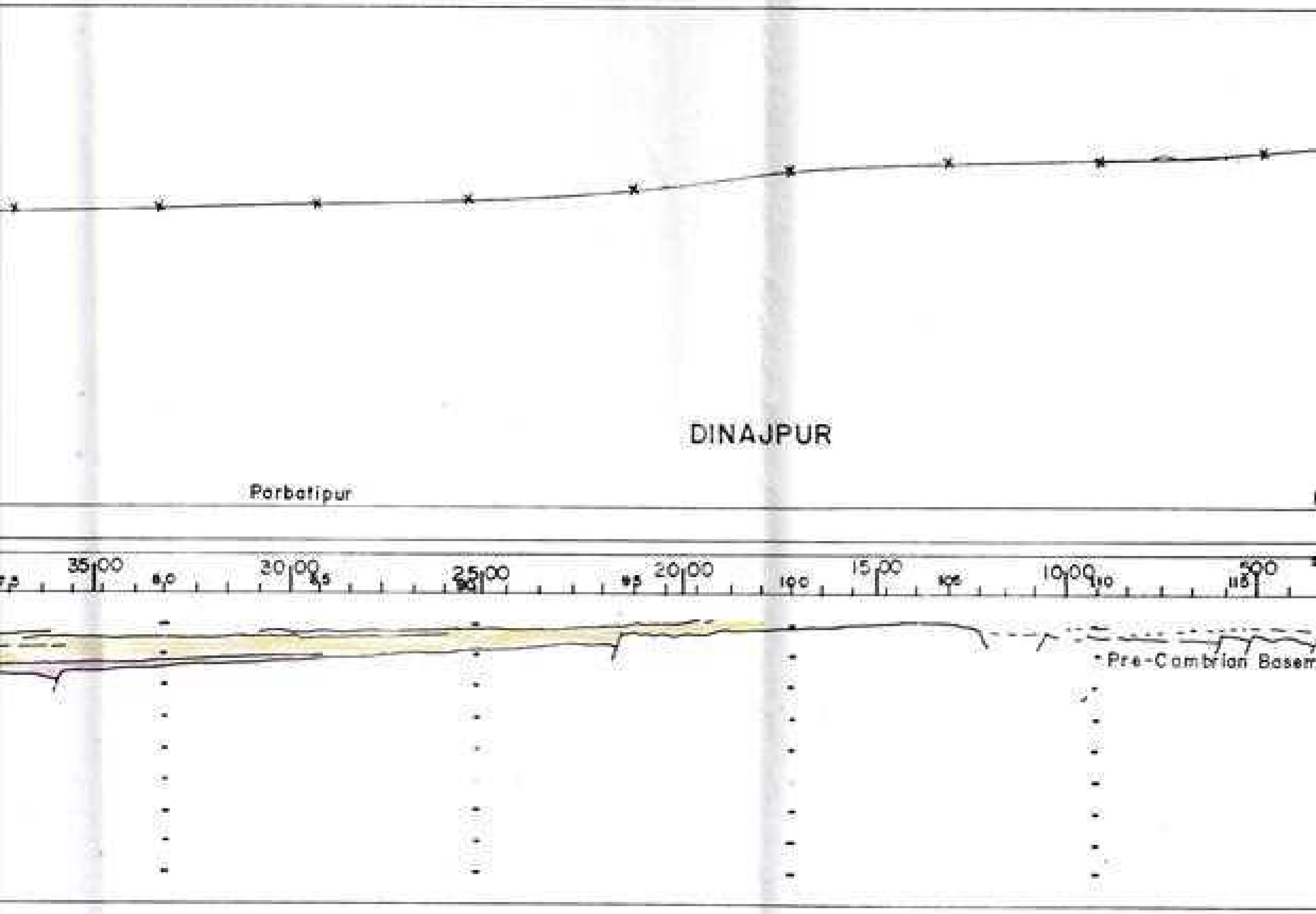


INDEX

G'	Horizon G' Surma (undiff)
H'	Horizon H' U. Bhuban Equivalent } (Miocene)
I'	Horizon I' Tipam Equivalent } (Neogene)
J'	Horizon J' Dupi Tila Equivalent (Pleistocene and Pliocene)



Bouguer Anomaly
NILPHAMARI
Debiganj
Atrai River
Shell-1240
70,00
65,00
60,00
55,00
50,00
45,00
30
35
40
45
50
55
60
65
70
Atraifault ?



BANGLADESH PETROLE

Interpreted TWT section of the s
on 1 cm=2 km and 1 sec=2.50
structures and arrangements of c
stratigraphic horizons.

Horizontal scale:
Vertical scale: 2·5 cm= 1 secon

Figure: 5

Prepared by: Md Noo

EUM INSTITUTE

seismic profile shell-1240
cm scale showing the
different seismo-

5 10 Kms
ond

oor Alam | Date: April, 1997

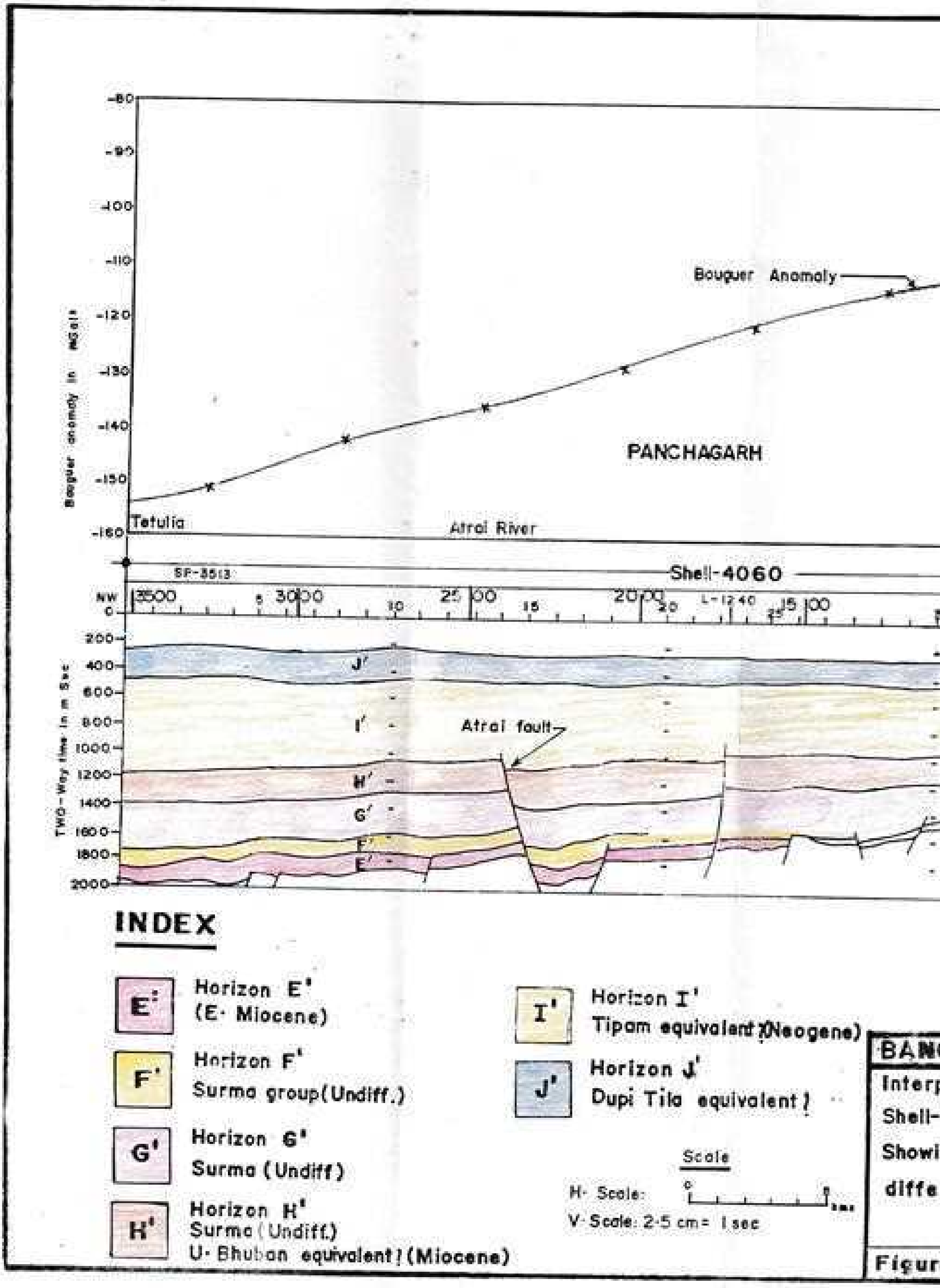
3.1.1.3. Section 3: Seismic line KHR-88

An interpreted section on a reduced scale is shown in figure 4. The location of this line is shown in plate 1. It extends along SSE-NNW direction from Kuchma to Hilli and is about 89 km long. The sedimentary section includes a complete Tertiary sequence at the southern end of the line (Horizons X,C,D,E,F,G, and youngers are not clearly traceable) but includes only a thin sequence of early and late Tertiary at the northern end. Towards north beyond SP-1750, G and younger horizons are not traceable and north of SP-1300, the horizons E and F are also not treaceable. There are step faults between SP-1800 and 1825, where sedimentary thickness suddenly increases just across the fault. The Kuchma-1 well is near SP-11810. There are faults near SP-1655. There are basement faults near SP-1150 and SP-1120. There are Gondwana sediments between SP-1040 and SP-1140 in a graben. There is another graben between SP-410 and SP-500, probably contain Gondwana sediments. The Eocene limestone pinchesout near SP-410. The upper part of the section is very poor to trace the horizons beyond north of SP-750 upto end of line SP-63.

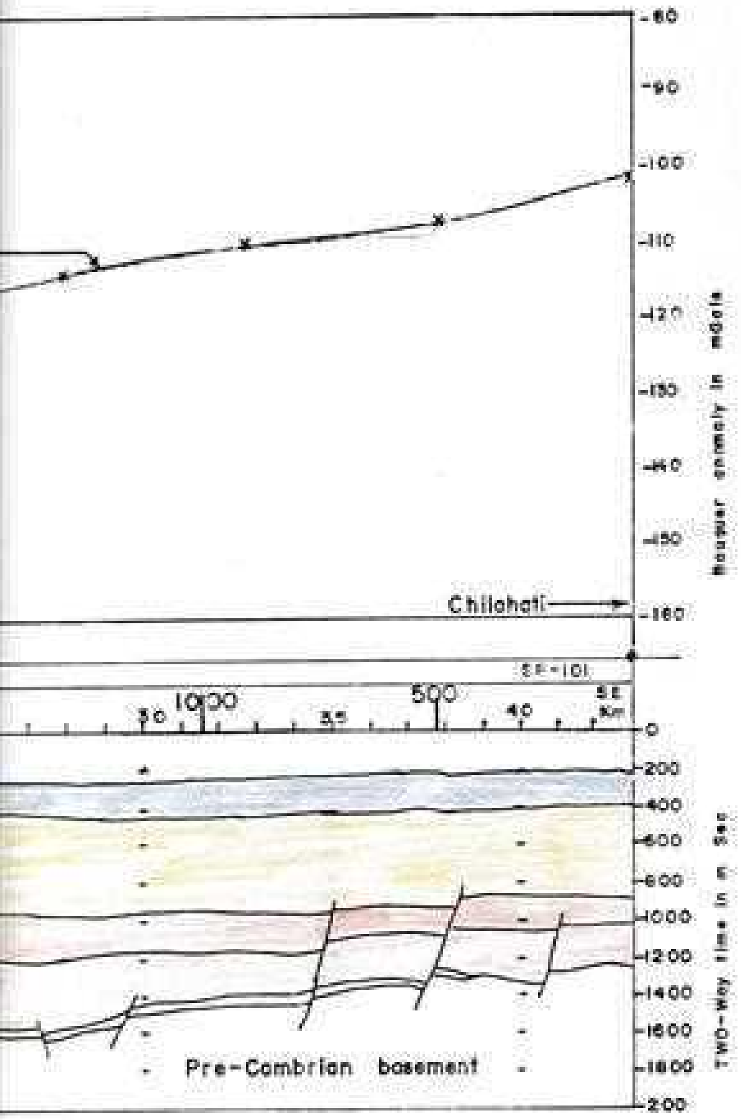
3.1.2. Seismic sections of Dinajpur-Rangpur area (Dinajpur Slope, Himalayan Fore deep area).

During 1987-88 period the Shell has collected a large number of 48 fold, 5 second reflection seismic lines under contract with Petrobangla in the greater Rangpur-Dinajpur Districts area. Some of the regional lines have been interpreted for the purpose of this report and are summerised below. Location of these lines are shown in plate 1.

The seismic reflection horizons have been traced, correlated from line to line across the basin and also have been correlated with subsurface stratigraphic sequences met in wells. Location of seismic line and wells are shown in plate 1. Figures are presented on a reduced scale having vertical time scale: 1 sec.= 2.5 cm, and horizontal distance scale: 1 cm = 2 kms.



-80
-90
-100
-110
-120
-130
-140
-150
-160
Bouguer anomaly in mGals
Bouguer Anomaly
PANCHAGARH
Tetulia
Atrai River
SF-3513
Shell-4060
NW
3500
3000
2500
2000
1500
L-1240
0
200
400
600
800
1000
1200
1400
1600
1800
2000
TWO-Way time in m Sec
J'
I'
H'
G'
F'
E'
Atrai fault
INDEX
E' Horizon E' (E- Miocene)
F' Horizon F' Surma group (Undiff.)
G' Horizon G' Surma (Undiff)
H' Horizon H' Surma (Undiff.) U-Bhuban equivalent ! (Miocene)
I' Horizon I' Tipam equivalent ? (Neogene)
J' Horizon J' Dupi Tila equivalent !
Scale
H- Scale:
V- Scale: 2-5 cm = 1 sec
BANG
Interp
Shell-
Showi
diffe
Figur



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Interpreted TWT section of the seismic Profile Shell-4060 on 1cm=2km and 1sec=2·50cm scale Showing the structures and arrangements of different seismo-stratigraphic horizons.

Figure: 6	Prepared by: Md Noor Alam	Date: April, 1997

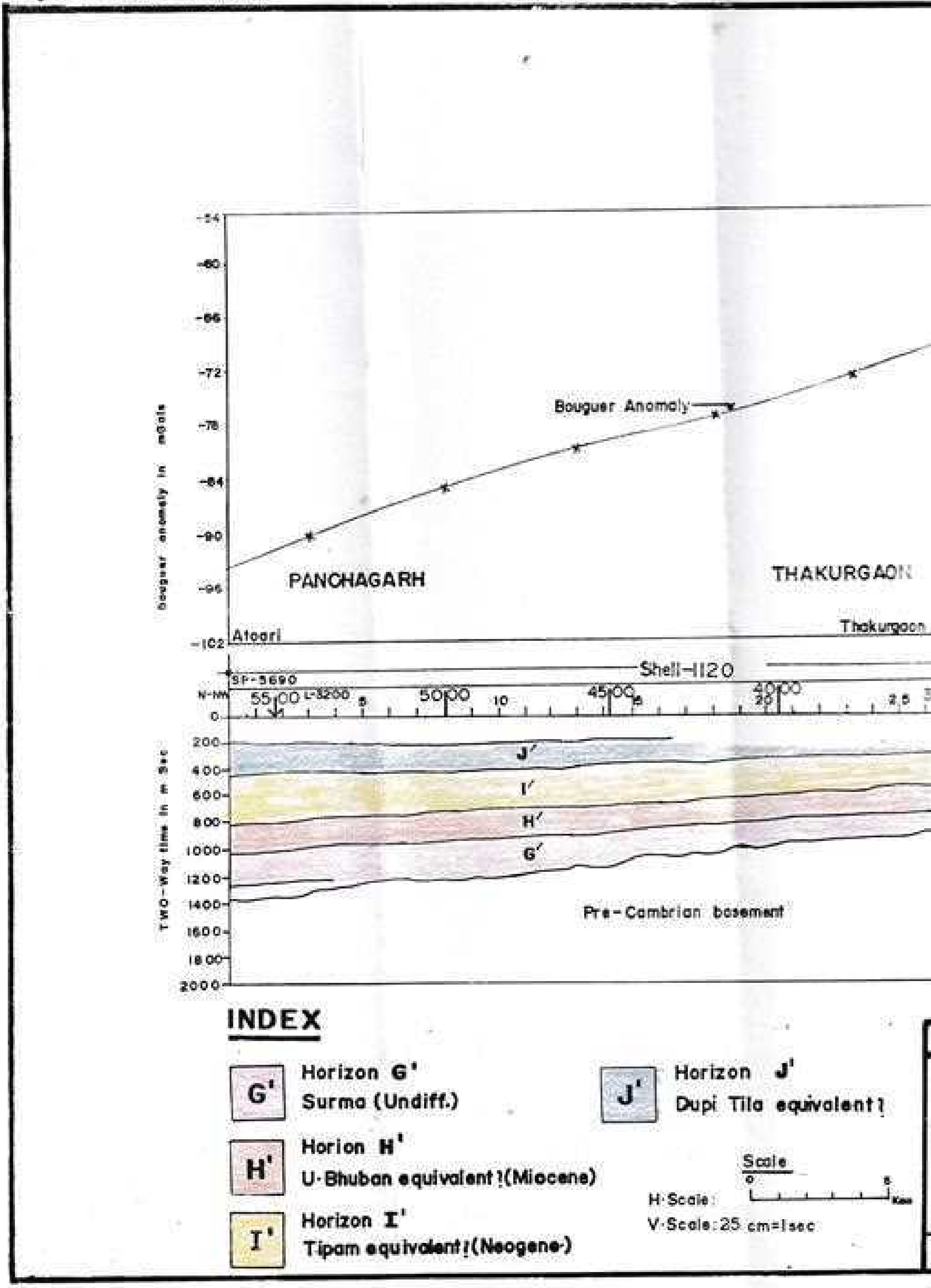
3.1.2.1. Section 4: Seismic line Shell-1240, Dinajpur-Rangpur.

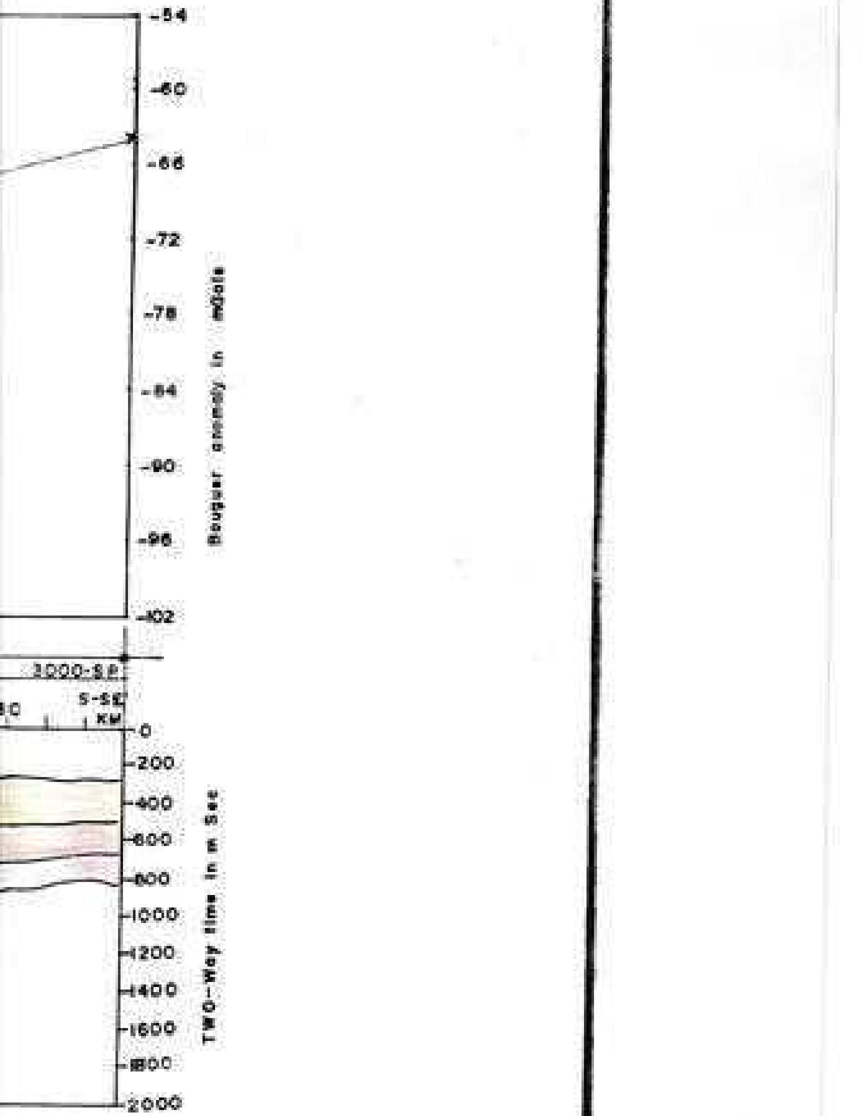
Seismic line Shell-1240 extends NNW-SSE direction and is about 119 km long. An interpreted section of this line is shown in figure 5. The location of this line is shown in plate 1. The section includes acoustic Horizons E, F, and G of the Bengal Basin (NNW end) and H',I', and J' of the Dinajpur Slope area (SSE end). Sediment thickness is minimum between SP-1280 and SP-1440, which is about 200 msec (horizons E and F). Sediment thicknesss increases northwestward and is about 200 msec at the SE end to about 1750 msec at the NW end of the section (horizons G',H',I',and J'). This section do not show the presence of any major fault affecting the overlying sediments of the Himalayan Foredeep area. However, a number of minor basement faults do occur near SP-111080, 1280, 2160,3610, 4020, 7020, 7180, 8530, 8740, 9100 and 9230.

The Bengal Basin sediments pinchesout at the southeastern end of this line where the crystalline basement rock is faulted and forms a graben and some semi-grabens. These grabens probably contain coal bearing gondwana sediments. Sediments on the western flank dips toward NW and some of the horizons disappear near the central part of the section.

3.1.2.2. Section 5: Seismic line Shell-4060

Figure 6 shows an interpreted time section of the line Shell-4060. This line is in the Himalayan Foredeep area (northwestern corner of Bangladesh) along NW-SE and is about 43 km long and is shown in plate 1. The section includes acoustic horizons E',F',G',H',I', and J' and thins towards SE, and in the southeastern end it includes horizons G', H', I', and J' only. The sediment thickness increases from SE to the N-west. Basement rock is faulted and forms some grabens and semi-grabens. Some of the faults affects the overlying sediments (horizons E',F',G', and H'). The most prominent faults are at SP-280, 520, 760, 1780, 2140, and 2340. The most prominent graben is located between SP-2140 and SP-2350 and shows about 100 msec throw. The Shalbonhat-1 well is located on this line near SP-3050. The well is 2500m deep and did touch the basement rock. Near Tetulia area on line Shell-4060, the basement appears to be faulted down towards foothills. At present the throw of this fault appears to be of the order of 50 msec across horizon H' and is about 180 msec across horizon E', and F', probably a growth fault. The fault at SP-2340 on the northern flank appears to extend deep within the crystalline basement rock.


Bouguer anomaly in mGals
Bouguer Anomaly
PANCHAGARH
THAKURGAON
Atoari
Thakurgaon
Shell-1120
SP-5690
L-3200
5500
5000
4500
4000
TWO-Way time in m Sec
J'
I'
H'
G'
Pre-Cambrian basement
INDEX
Horizon G'
Surma (Undiff.)
Horion H'
U-Bhuban equivalent ?(Miocene)
Horizon I'
Tipam equivalent ?(Neogene)
Horizon J'
Dupi Tila equivalent ?
Scale
H-Scale:
V-Scale: 25 cm=1sec



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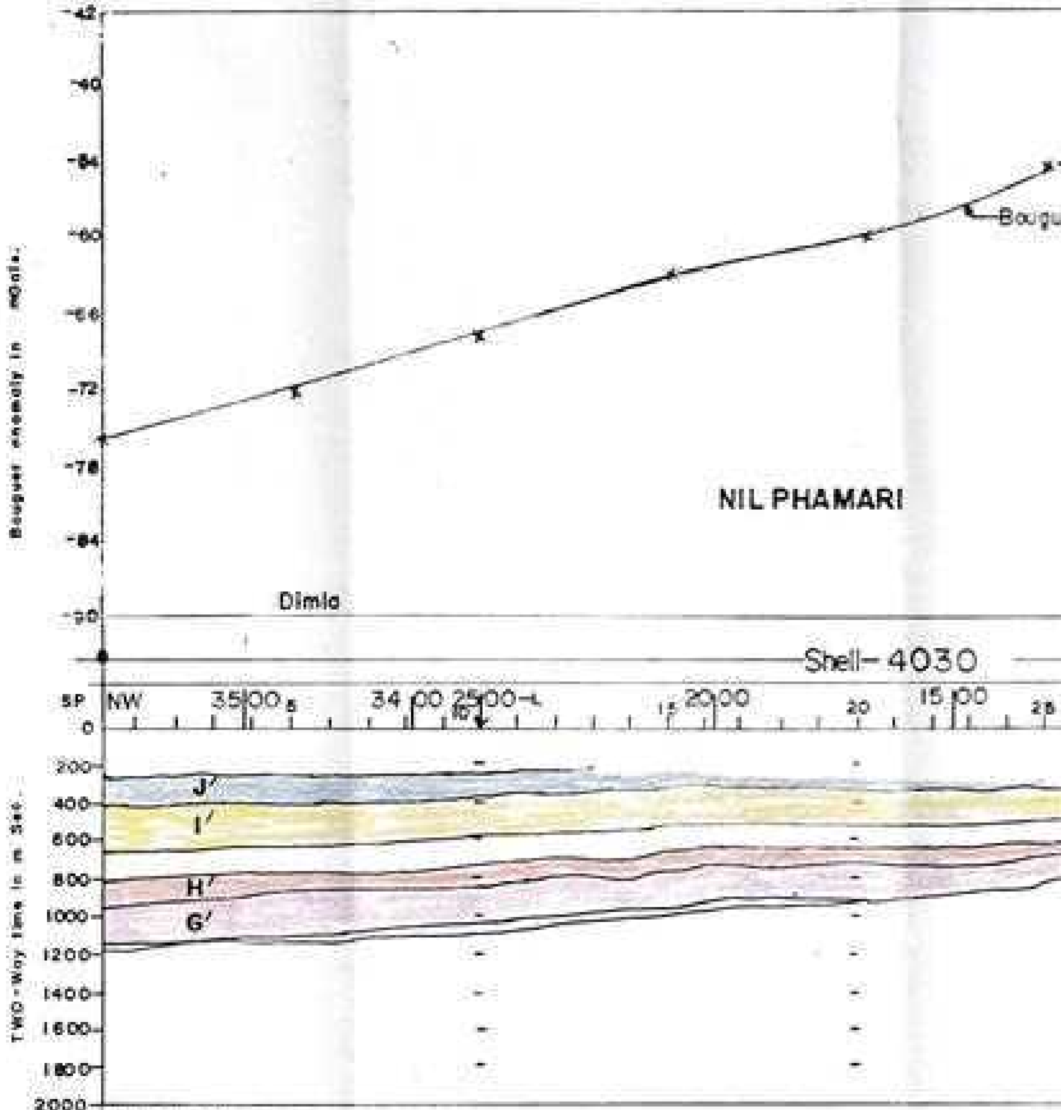
ted TWT section of the seismic
Shell-1120 on 1cm=2 km and 1 sec=
n scale showing the structures and
nents of different seismo-stratigraphic
.

7	Prepared by: Md Noor Alam	Date: April, 1997



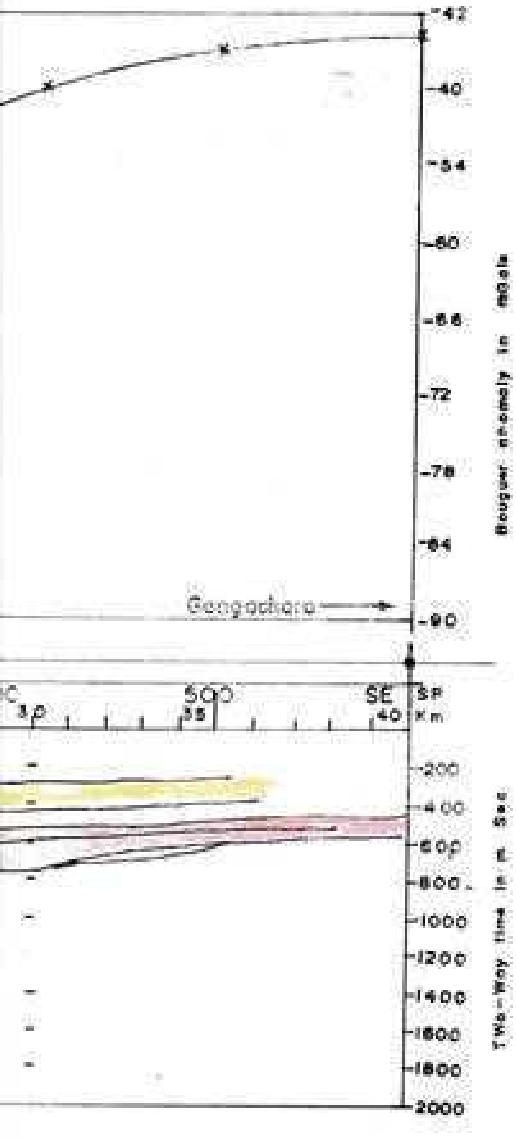
INDEX

G'	Horizon G' Surma (Undiff.)
H'	Horizon H' U-Bhuban equivalent ? (Miocene)
I'	Horizon I' Tipam equivalent ? (Neogene)
J'	Horizon J' Dupi Tila equivalent (Pleistocene and Pliocene)

Scale

H-Scale: 0

V-Scale 2·5 cm= 1sec.



ANGLADESH PETROLEUM INSTITUTE

terpreted TWT section of the seismic Profile hell-4030 on 1cm= 2 km and 1 sec= 2·50 cm cale showing the structures and arrangements f different seismo-stratigraphic horizons.

gure: 8	Prepared by: Md Noor Alam	Date: April,1997

3.1.2.3. Section 6: Seismic line Shell-1120

The interpreted section of the line Shell-1120 is shown on a reduced scale is shown in figure 7. The line extends along N-NW to S-SE direction and the location of this line is shown in plate 1. The sedimentary section includes seismo-stratigraphic horizons viz., G',H',I', and J' at the S-SE end. Towards N-NE end the Horizons are G',H', and I', and the Horizon J' is not traceable. It is evident that the sediment thickness increases southwestward. The crystalline basement rock apparently do not show any faulting.

3.1.2.4. Section 7: Seismic line Shell-4030

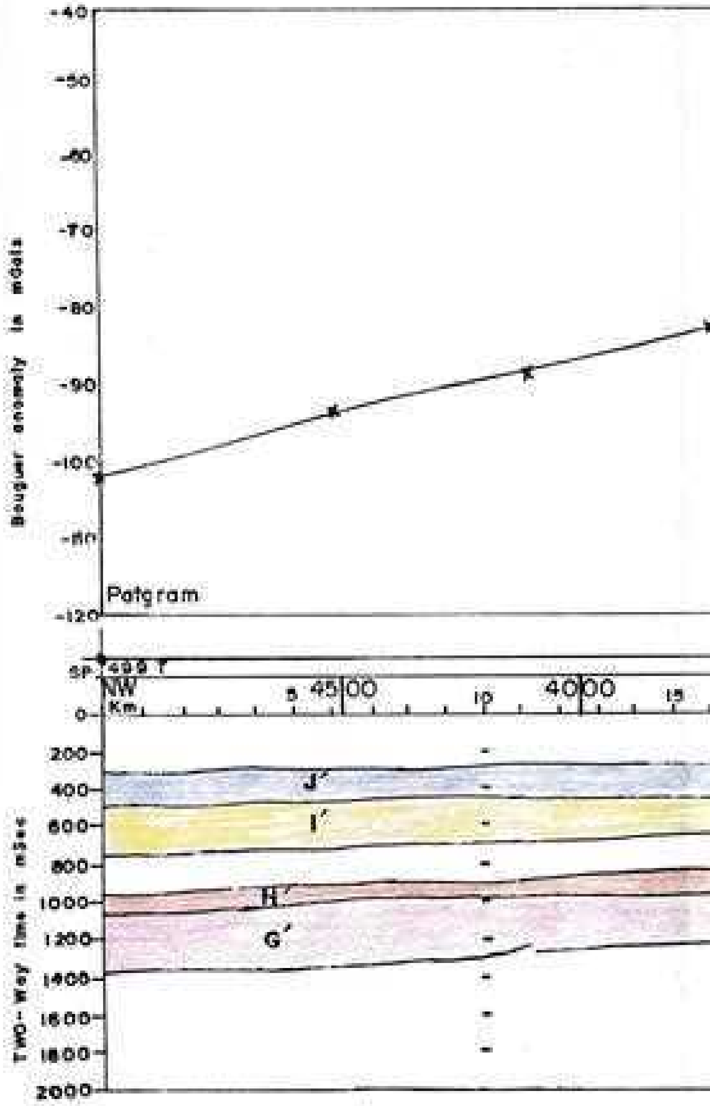
Figure 8 shows an interpreted time section of the line Shell-4030 and the location of this line is shown in plate 1. The section includes acoustic horizons G',H',I', and J' and the horizons thins out towards southeast. The sediments dip toward north and the thickness also increases northward. No fault is evident. But, there may be an intrabasement reflector (fault?) between SP-1080 and 1300. Isolated patches of sediments lie directly over the crystalline basement.

3.1.2.5. Section 8: Seismic line Shell-4020

Figure 9 shows an interpreted time section of the line Shell 4020 and the location of the line is shown in plate 1. The sedimentary sections include acoustic horizons G',H', I', and J' at the northwestern end and thins towards southern end where horizons G',I', and J' are present. The Horizon H' pinchesout in the middle of the line. It is apparent that the sediment thickness increases northward. No fault is apparent. Seismic horizons (horizons G and H) that belong to the Bengal Basin disappear at the central part of the line.

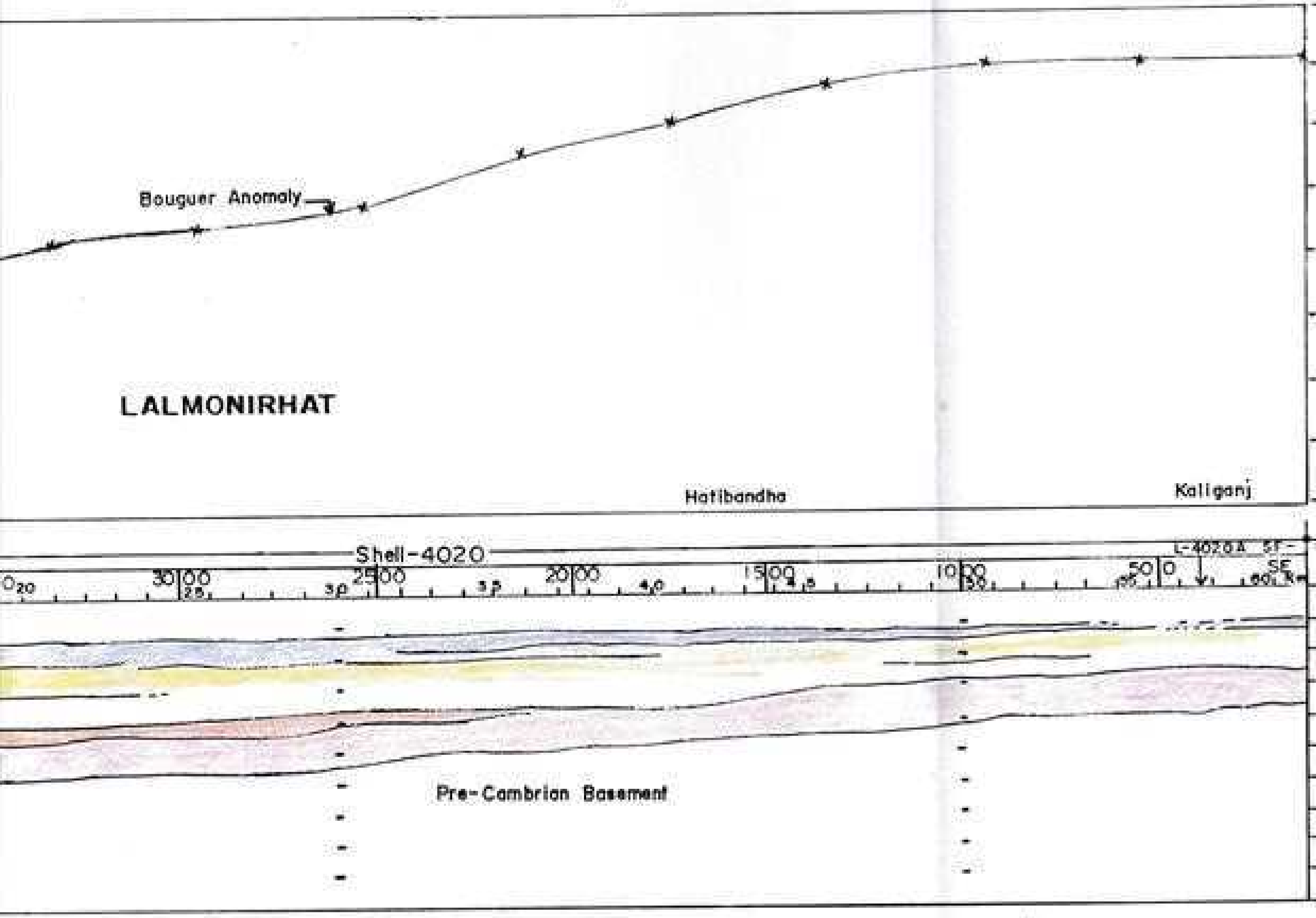
3.1.2.6. Section 9: Seismic line Shell-4020A

Figure 10 shows an interpreted time section of the line Shell-4020A and location of the line is shown in plate 1. The section includes acoustic horizons G', H', and I', however horizons G' and H' are difficult to differentiate towards northwest. Towards south-southeast acoustic horizons include E',F',G', and H', however younger horizons are not prominent. The Bengal Basin sediment thins-out and pinchesout almost near the central part of the line



INDEX

G'	Horizon G' Surma (Undiff)
H'	Horizon H' U· Bhuban Equivalent ? (Mioce
I'	Horizon I' Tipam Equivalent ? (Neogane



J'

Horizon J'
Dupi Tila Equivalent (Pleistocene and Pliocene)

BANGLADESH PE

Interpreted TWT section
on 1cm=2km and 1sec=2
structures and arrangeme
horizons.

Horizontal scale;
Vertical scale: 2·5

Figure : 9

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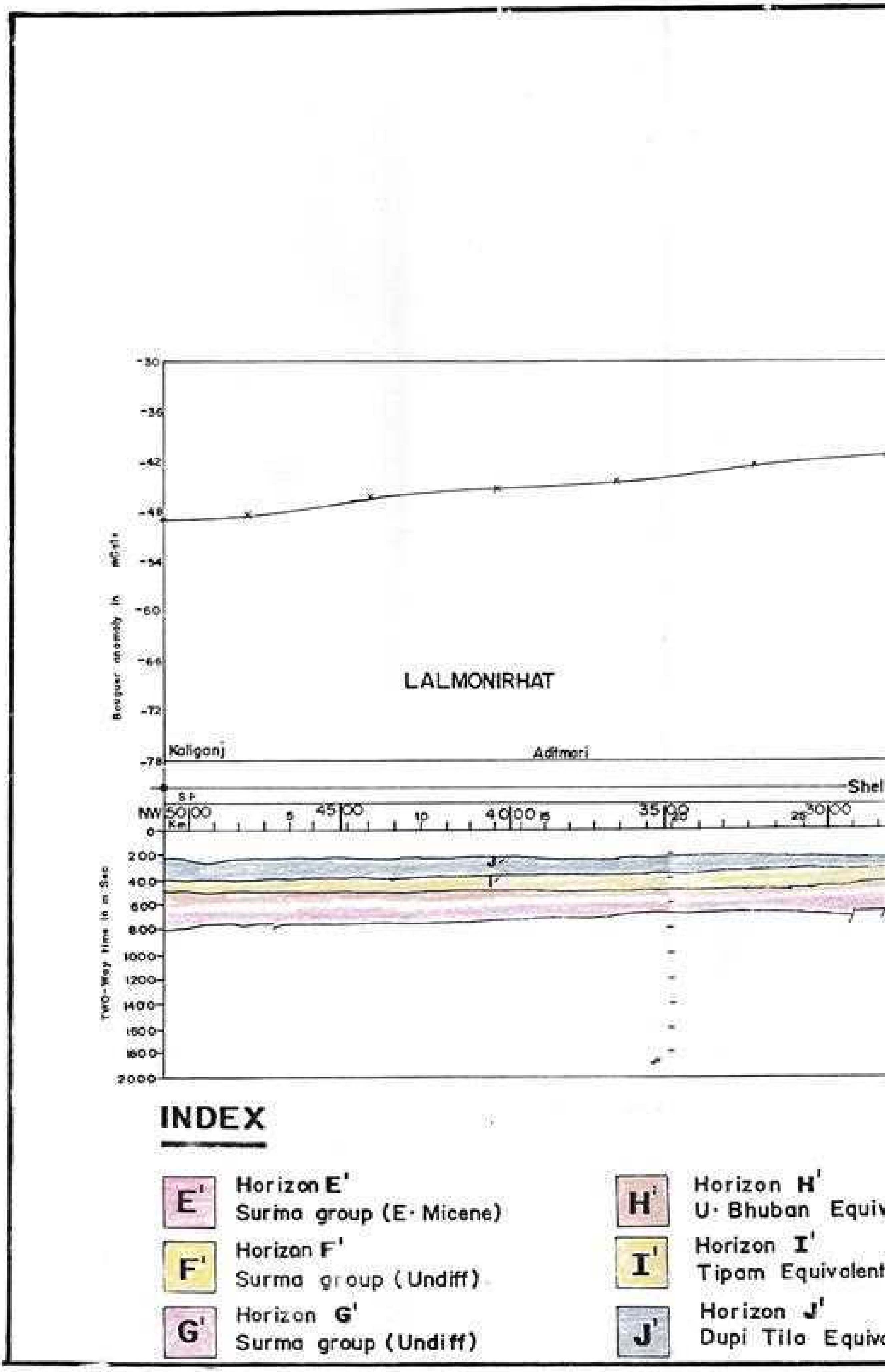
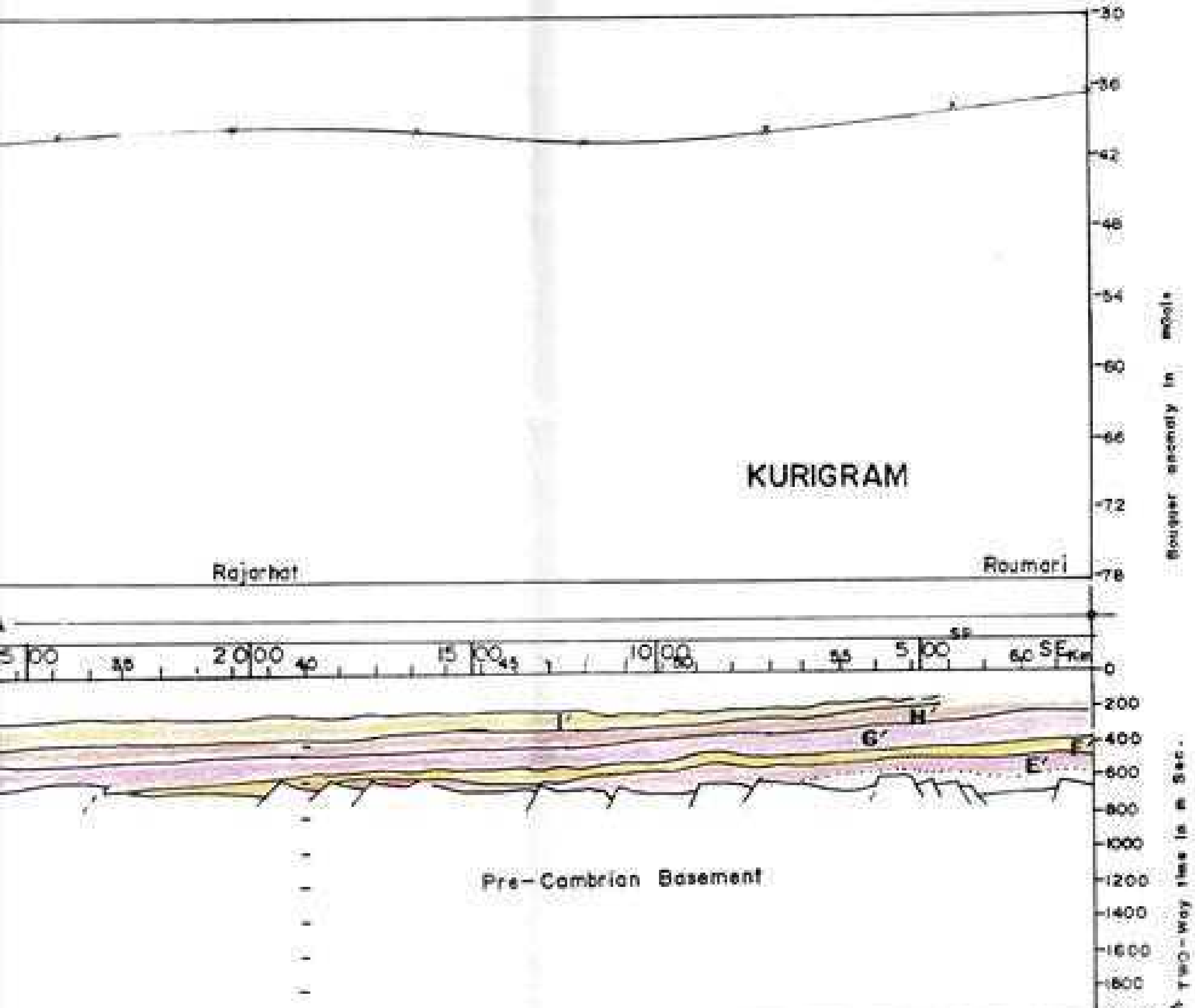
the seismic profile shell=4020
cm scale showing the
of different seismo-stratigraphic

5 10
kms
second

Noor Alam | Date: April, 1997



-30
-36
-42
-48
-54
-60
-66
-72
-78
Bouguer anomaly in mGals
LALMONIRHAT
Kaliganj
Aditmari
Shel
SP
NW
Km
5000
4500
4000
3500
3000
5
10
15
20
J'
I'
TWO-Way Time in m Sec
0
200
400
600
800
1000
1200
1400
1600
1800
2000
INDEX
E'
Horizon E'
Surma group (E· Micene)
F'
Horizon F'
Surma group (Undiff)
G'
Horizon G'
Surma group (Undiff)
H'
Horizon H'
U· Bhuban Equiv
I'
Horizon I'
Tipam Equivalent
J'
Horizon J'
Dupi Tila Equiva



(Miocene)

gane)

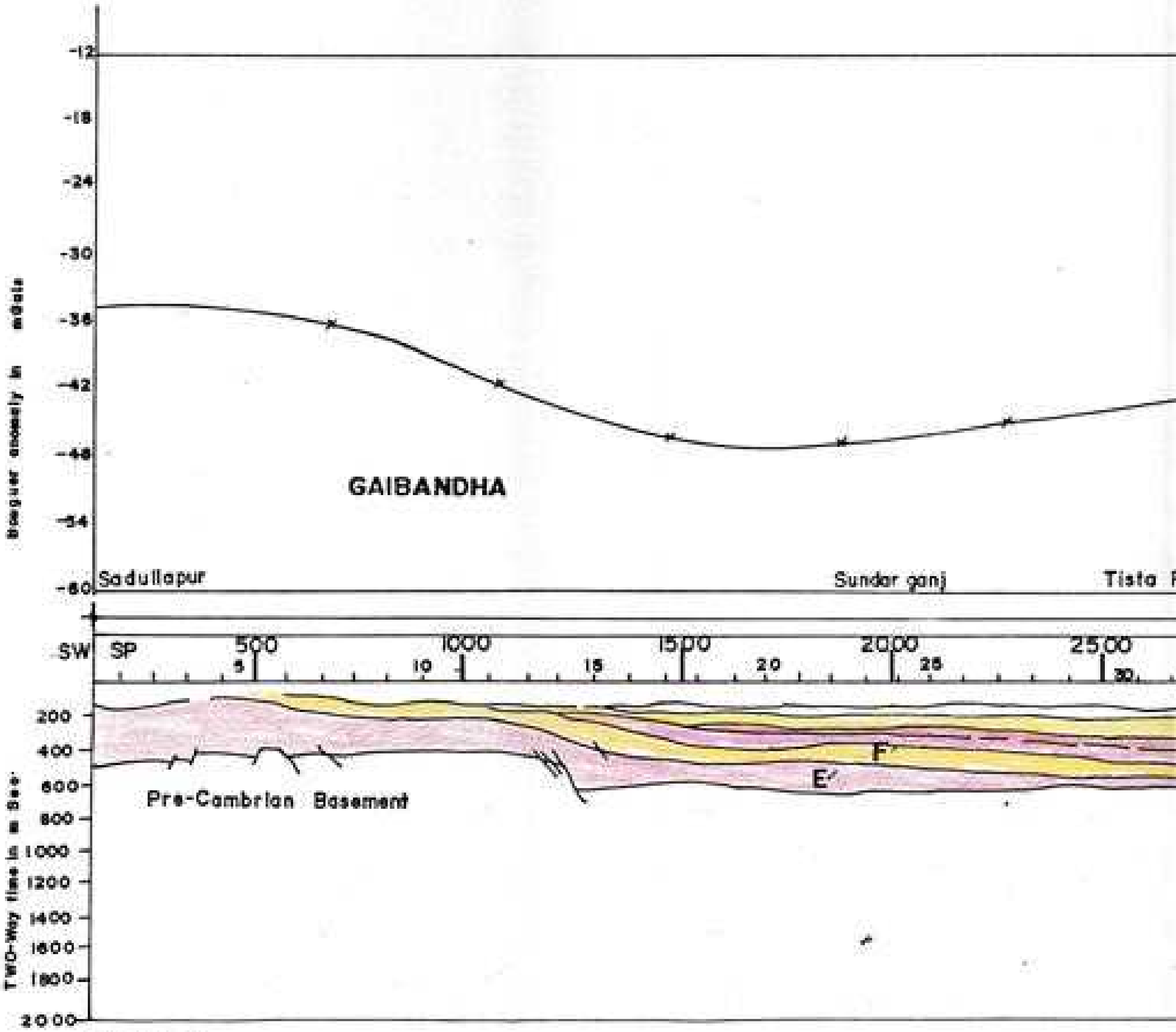
leistocene and Pliocene)

BANGLADESH PETROLEUM INSTITUT

Interpreted TWT section of the seismic profile shell=4
A on 1cm=2km and 1sec=2·50cm scale showing the structures and arrangements of different seismo-stratigra horizons.

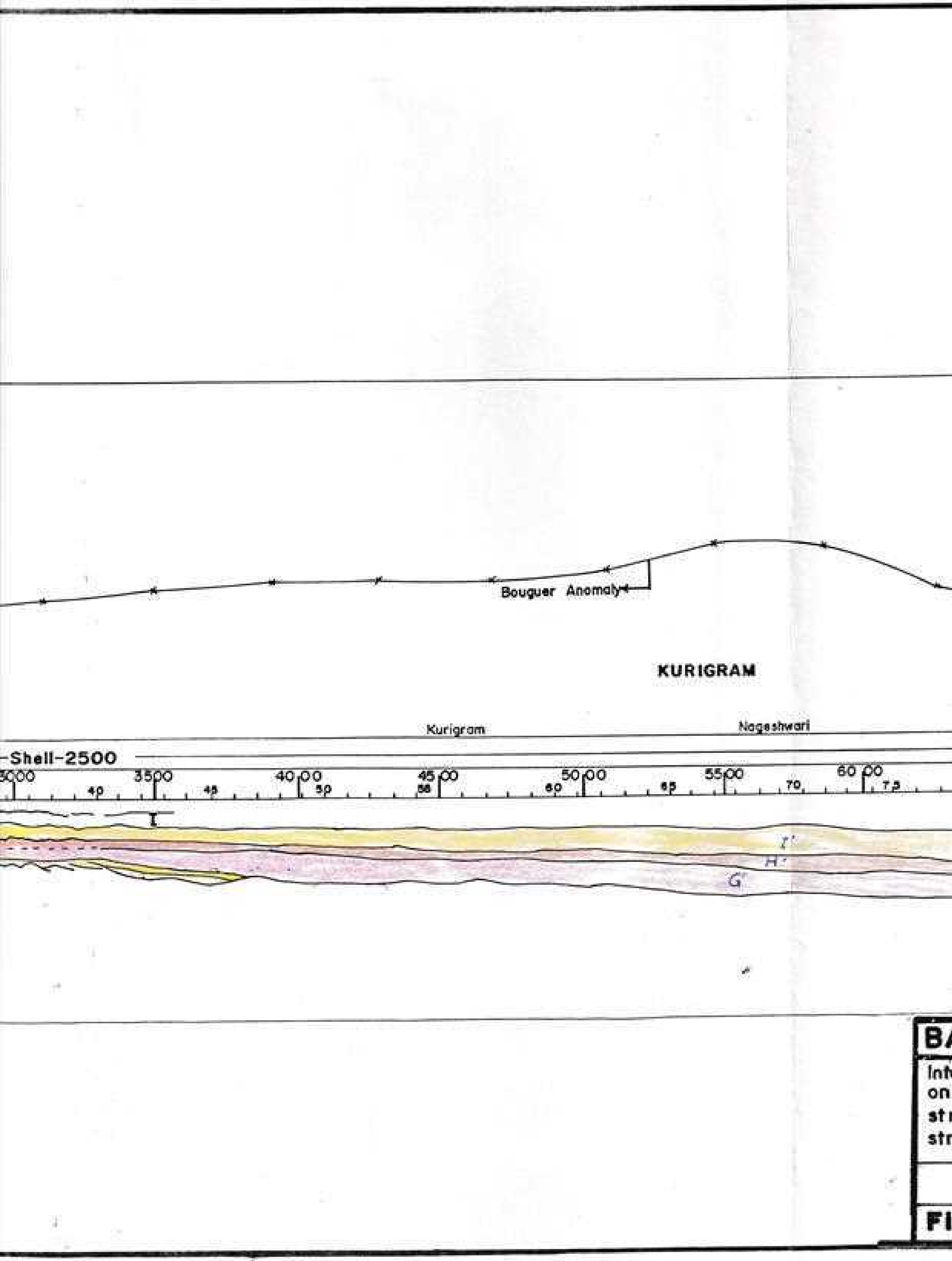
Horizontal scale: 0 5 10 Kms
Vertical scale: 2·5 cm = 1 second

Figure :10 | Prepared by: Md Noor Alam | Date: April, 1997

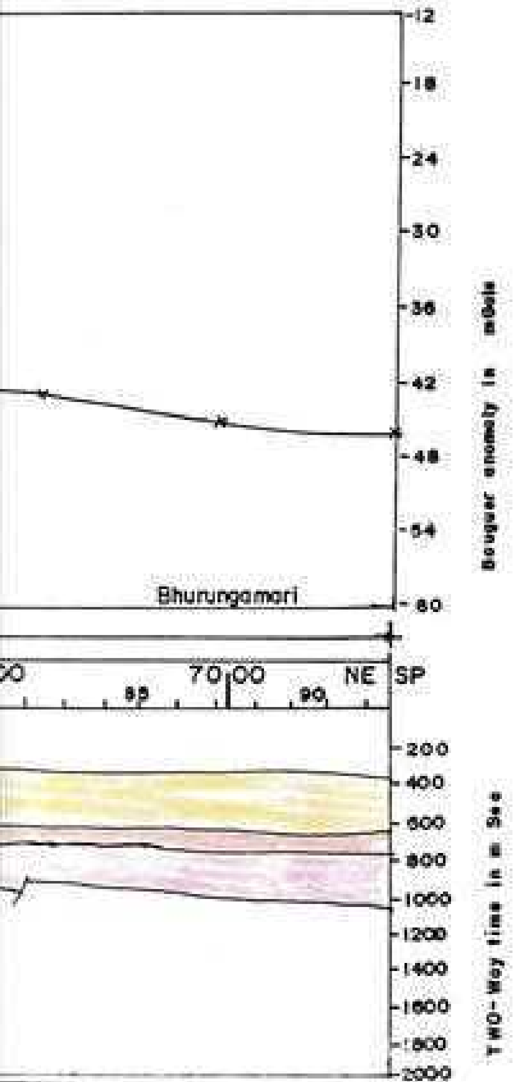


INDEX

E'	Horizon E' Surma group (E· Micene)
F'	Horizon F' Surma group (Undiff·)
G'	Horizon G' Surma group (Undiff)
H'	Horizon H' U· Bhuban Equivalent ? (Mioce
I'	Horizon I' Tipam Equivalent ? (Neogane)



Bouguer Anomaly
KURIGRAM
Kurigram
Nageshwari
-Shell-2500
3000
3500
40 00
45 00
50 00
55 00
60 00
I
I'
H'
G'
BA
Int
on
st
str
FI



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TWT section of the seismic profile shell-2500
n and 1sec=2·50cm scale showing the
and arrangements of different seismo-
: horizons.

rizontal scale: 0 5 10 kms
rtical scale: 2·5cm=1 second

11 | Prepared by: Md Noor Alam | Date: April, 1997

near SP-2300 and SP-2400. In the section the sediments show a general dip N-westward. A large number of basement faults occur near SP-200, 400, 420, 460, 510, 600, 880, 1000, 1200, 1360, 1580, 1750, 1840, 1940, 2320, 2820, and 2940. One set of faults dips northwestward while another set dips southeastward. These faults form some small semi-graben and a graben at the SE end of the line Shell-4020A.

3.1.2.7. Section 10: Seismic line-Shell-2500, Rangpur-Kurigram-Gaibandha.

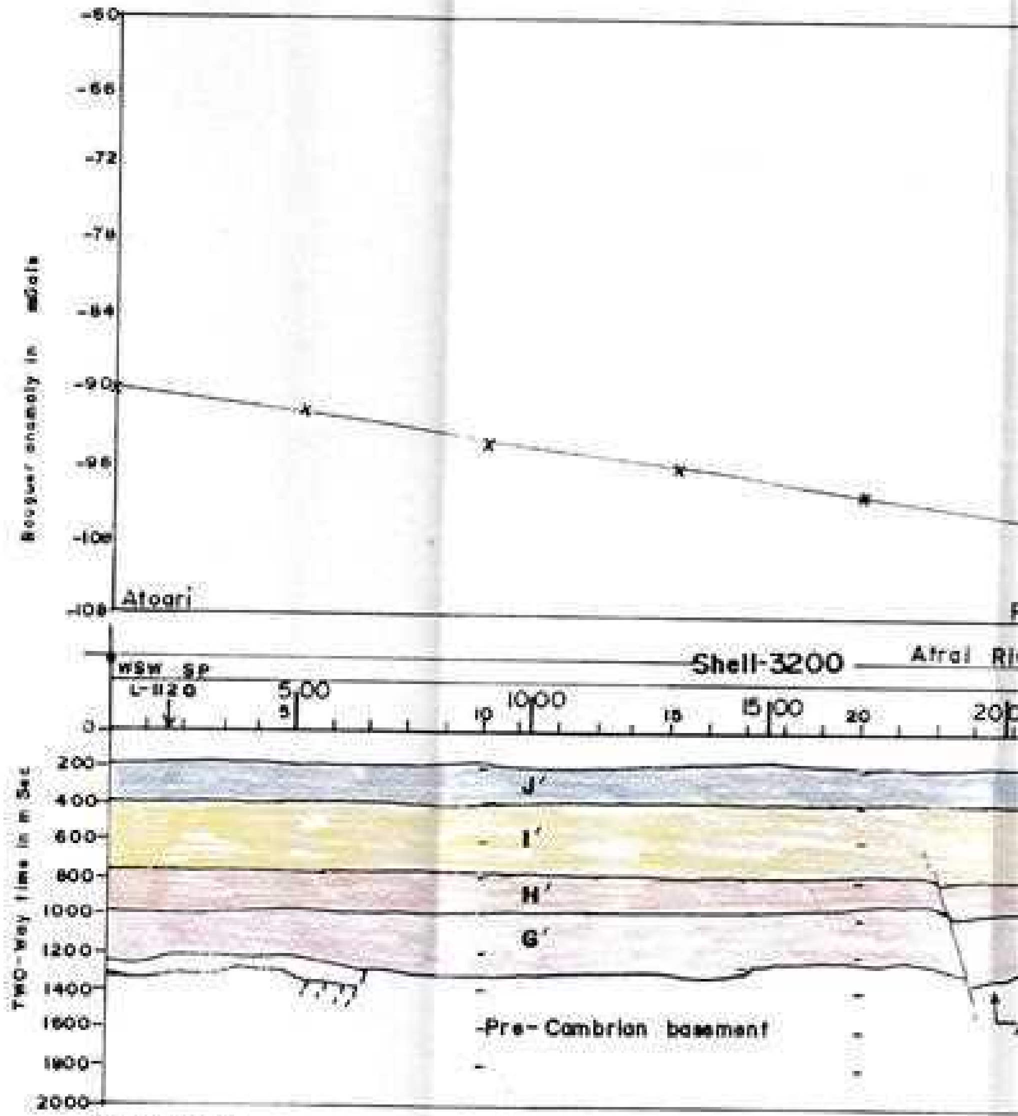
Figure 11 shows an interpreted time section of line-2500 extends about 91 km N-E ward from Pirganj to Bhurungamari in the Himalayan Foredeep area, NW-Bangladesh. The sedimentary section includes seismo-stratigraphic horizons E' and F' at the SW end and G',H',I',and J' on the NE end. In the north of Pirganj fault horizons E',F',G',H',I' and J' are present. However horizons E' and F' pinches out near SP-3900. Sedimentary horizons dip towards NE and also the thickness of the sediments increases towards NE from 1.1km near Pirganj to about 3km near Bhurungamari. A number of minor basement fault occur on the line which might have controlled the deposition of sediments over the Crystalline Basement. The faults occur near SP-280. 340, 450, 480, 580, 680, 1180, 1200, 1230, and 6580. The seismic data also suggests that the Bengal Basin sediments exists upto SP-3860 and pinchesout against basement (between SP-1180 and SP-1240) demarketing the northern margin of the Bengal Basin. However, in absence of any control from refraction seismic or well data nothing can be said conclusively about the stratigraphy of the deeper section.

3.1.2.8. Section 11: Seismic line Shell-3200

In interpreted time section of this line Shell-3200 is shown in figure 13. The location of this line is shown in plate 1. The line extends along W-SW to E-NE direction and is about 33 km long. The is probably a strike line and the section includes acoustic horizons F',G', H', I', and J'. The crystalline basement rocks show three basement faults near SP-660, 1900, ans 2390. The fault near SP-1900 affected the overlying sediments up to horizons G' and H'.

3.1.2.9. Section 12: Seismic line Shell-3400

Figure 13 shows an interpreted time section of the line Shell-3400 and the location of the line is shown in plate 1.



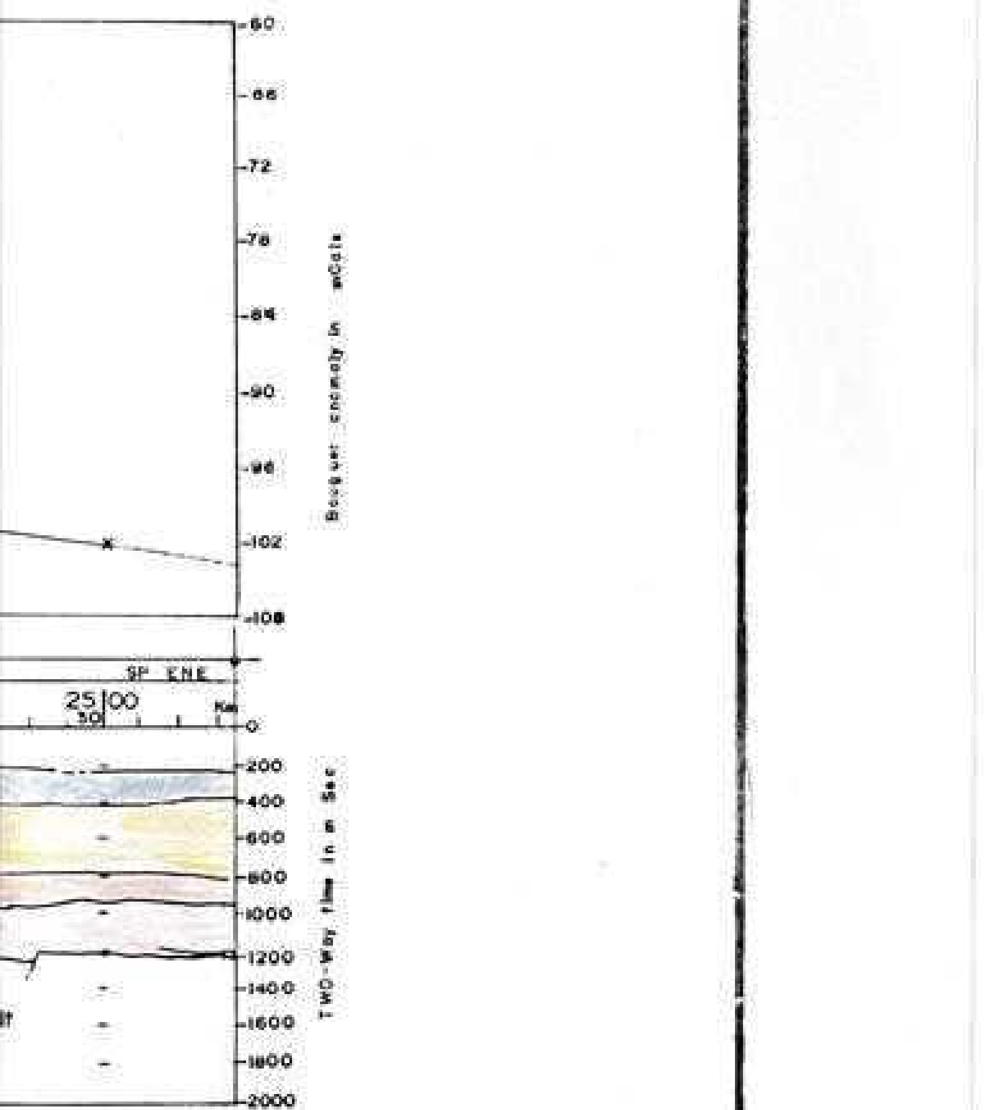
INDEX

G'	Horizon G' Surma (Undiff.)
H'	Horizon H' U· Bhuban equivalent ?(Miocene)
I'	Horizon I' Tipam equivalent ?(Neogene)
J'	Horizon J' Dupi Tila equiv (Pleistocene a Pliocene)

Scale

H·Scale: 0

V·Scale: 2·5 cm=1 sec.



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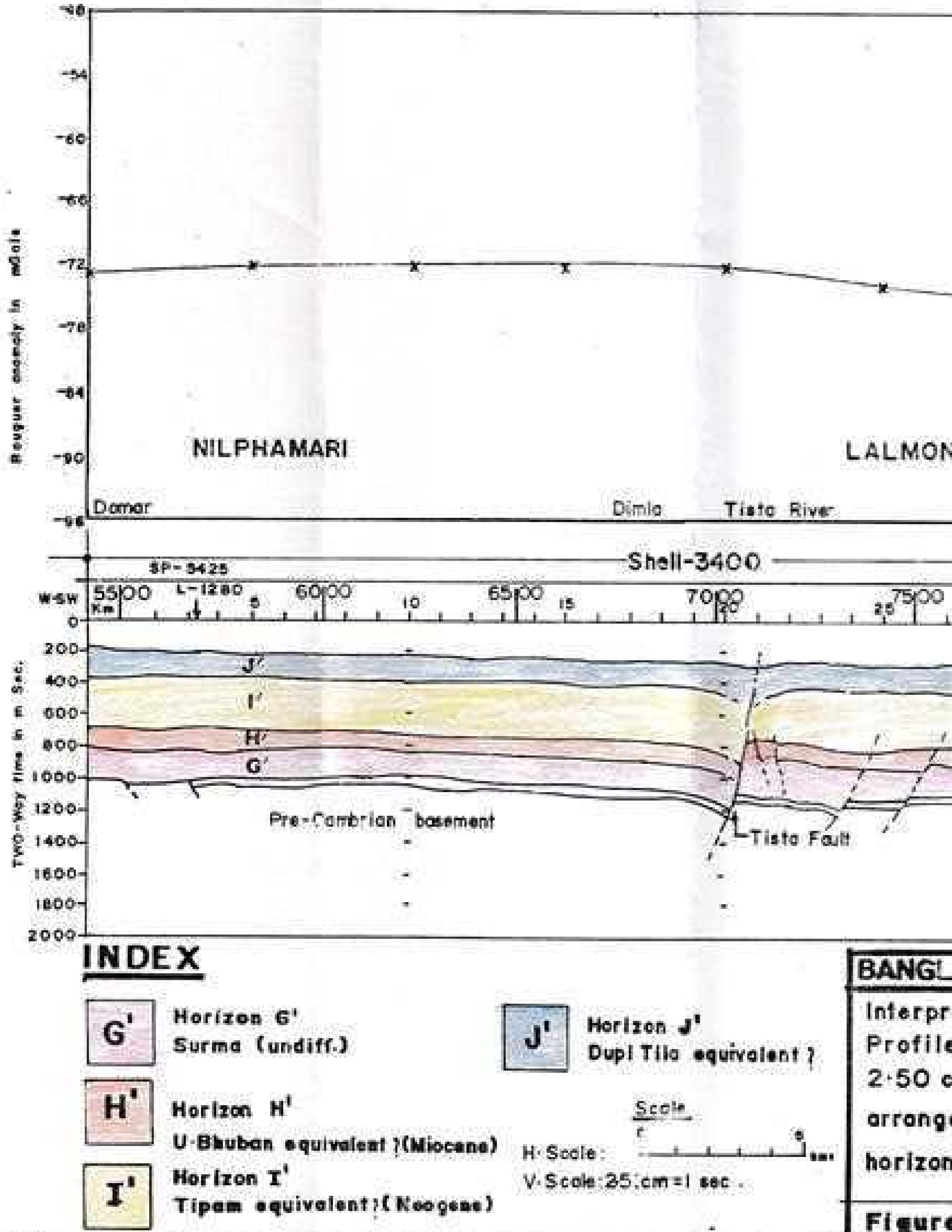
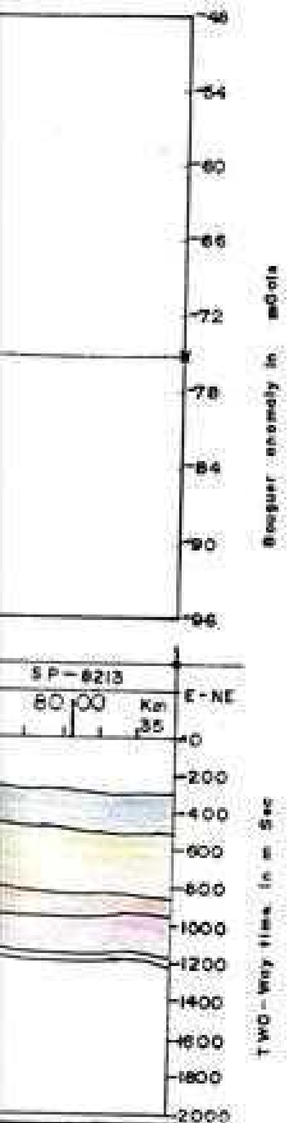
Interpreted TWT section of the seismic Profile Shell-3200 on 1cm = 2 km and 1 sec = 2·50cm scale showing the structures and arrangements of different seismo-stratigraphic horizons.		
Figure : 12	Prepared by: **Md Noor Alam**	**Date:April,19**



Bouguer anomaly in mGals
-48
-54
-60
-66
-72
-78
-84
-90
-96
NILPHAMARI
LALMON
Domar
Dimla
Tista River
Shell-3400
SP-5425
L-1280
W-SW
Km
5500
6000
6500
7000
7500
5
10
15
20
25
TWO-Way time in m Sec.
0
200
400
600
800
1000
1200
1400
1600
1800
2000
J'
I'
H'
G'
Pre-Cambrian basement
Tista Fault
INDEX
G' Horizon G' Surma (undiff.)
H' Horizon H' U-Bhuban equivalent ?(Miocene)
I' Horizon I' Tipam equivalent ?(Neogene)
J' Horizon J' Dupi Tila equivalent ?
Scale
H-Scale:
V-Scale: 2.5 cm=1 sec.
BANGL
Interpr
Profile
2·50 c
arrang
horizon
Figure



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'T section of the seismic
3400 on lcm=2km and 1 sec=
showing the structures and
f different seismo-stratigraphic

Prepared by: Md Noor Alam | Date: April,1997

This is probably a strike line and the section includes acoustic horizons G',H',I', and J'. In the central part of the line there are faults near SP-5510, 5680, 7060, 7340, and 7500. The normal faults related to the basement affected the overlying younger sediments and display a displacement of 100 msec (thick) at SP-7060. This fault seems to be active to date and may be the well known Tista Fault.

3.1.3. Mapping of basinwide seismo-stratigraphic horizons

Seismic facies, given an adequate grid of seismic profiles, are mappable in three dimensions. In this ideal situation, the overall geological setting, including sediment source direction and gross depositional environment, may be interpreted. In any case, the initial analysis begins on the two-dimensional seismic section and is later corroborated by the whole of the three-dimensional grid, where available.

Ideally, each horizon boundary should be mapped, noting the occurrence of downlap and onlaps. In addition, individual seismic facies of each horizon ought to be mapped where a regular grid of seismic data is available such as in Jessore-Kushtia area (HZ lines) data.

(i) Several other continuous and semi-continuous reflector have been mapped over wide areas of Bangladesh including shelf, Rangpur Saddle and Faridpur Trough areas. They correspond to the Horizons I, J and K respectively.

The projected subcrop of the UMS time equivalent deposits to the recent Alluvium was determined by phantoming upwards (figure 3, line PK-SU-19).

(ii) In the eastern and northeastern parts of Bengal Basin i.e., in the greater Mymensingh and Sylhet districts five reflecting horizons have been mapped (horizons J through P). The regional reflectors mapped in this areas are shown in plates 3 to 10). The scale of presentation is 1: 1,000,000, with time contour interval of 250 msec.

Two-way Time (TWT) contour maps on horizons J,K, L,M,N,O, and P have been prepared with 250 msec contour interval and are shown in plates 3 to 10. The time contours, where shown in broken lines represents lack of sufficient data control. Out of these horizons L,M,N,O, and P are confined within the Surma Basin on the northeastern side of Madhupur Tract while I,J, and J are spread on both sides of the Madhupur Tract. These time contour maps are shown in plates 4 to 10. It is apparent that part of the horizons H,I,J, and K are exposed to the surface forms parts of the Madhupur and Barind Tracts (Plate 1 and figure 4).

The TWT contours show undulations on the southwestern side of the Maadhupur Tract. These undulations may be related to erosional features of the horizons or may be related to folding. On the southern side of Madhupur Tract time contours show small closures. On the northeastern corner over greater Sylhet District, the time contours show undulations with closures. These dome shaped closures are known to have direct bearing with the gas fields. The time contours show undulations and there are closures over the anticlinal or synclinal structures. Most of the anticlinal structures are known to have gas reserves. The other closures however have not been tested yet and deserves further investigation. Besides these known gas fields there are closures in the south of Sunamganj and Kishorganj Districts that deserves further investigation in relation to hydrocarbon potential.

The horizons L,M,N,O,P spread over approximately, 17000, 12000, 8000, 5000, and 2000 sq. km. area respectively. TWT contours dips towards their common depocenter near Tangua-Raular Bils (please refer to plates 3 to 10).

3.1.4. The composite areal extent map of the horizons of the northeastern Bengal Basin.

The composite areal extent map is prepared by superposing the areal extent of TWT contour maps prepared on different horizons. The composite areal extent map is shown in plate 10. It may be noticed that the areal extent of the horizons L,M,N,O,P gradually decreased with time i.e., 17000 sq km for L to 2000 sq km for the P horizon. The areal extent of the horizons L,M,N,O, and P are 17000, 12000, 8000, 5000, and 2000 sq km respectively.

The Pleistocene deposits of the Madhupur Tract, the Barind Tract, and the Lalmai Hill areas are exposed to the surface. Eight prominent seismo-stratigraphic horizons have been delineated from multifold seismic data, that revealed regional structure, arrangement and distribution of the Quaternary sediments in the northern and northeastern parts of the Bengal basin. The exposure of the Madhupur Tract appears to coincide with the crestal part of a low amplitude, broad anticlinal fold with it's NW-SE trending axis stretching along Sariakandi in Bogra District to Bhuapur in Tangail District and further to the southeast. This broad anticlinal fold apparently separates spatial distribution of some of those Pleistocene and younger sedimentary horizons of the Surma basin area from that of the Faridpur Trough and south of the Barind

Tract area. Five out of those eight horizons extend upto 2.05 sec., in the Two-way-time section and seems to have been confined within the Surma basin northeast of the Madhupur Tract, and are unique in the sedimentary sequence of the Bengal basin. It is apparent that the areal extent of those five horizons have gradually decreased with time and dips towards their common depocenter near Tangua-Raular Bils (lake) north of Madhyanagar Thana in Sunamganj Disterct. The Quaternary sediments have excellent developements in this area which may be considered as type locality for the Quaternary deposits in the Bengal basin. Present position of these bils coincides with the axis of a broad synclinal fold between the Madhupur Tract and the Chhatak anticline, thereby indicating a continuous subsidance in this area since the Pleistocene time. The total thickness of this sequence is around 2 kms (2.05 sec., two-way-time) in the northcentral part just below the Tangua-Raular Bils and therefore it is presumable that Pleistocene sediments have undergone a subsidance of 2 kms in the area during post-Pleistocene time, probably maximum in the Surma basin area. The Quaternary sediments of this area are well stratified, gently folded and are sparsely faulted. The Quaternary sedimentary sequence under consideration is conformable with the Pliocene beds and cover almost the entire area of study. The arrangement and character of the seismic events suggest that they have probably been deposited in a fluvio-lacusterne environment and the subsidance was concurrent to the deposition. It is very likely that these Holocene sediments have been deposited by the mighty river Brahmaputra and other small rivers from the eastern Indian states surrounding this subsiding area. The most important finding is that the Barind Tract and the Madhupur Tract do not belong to the same seismo-stratigraphis horizon identified on the sequence, rather the Barind Tract seems to correlate with the older horizons than the Madhupur Tract.

On the other hand, it is apparent from the variable, discontinuous arrangement and variable amplitude character of the seismic events (line Pk-15 etc.,) that the Quaternary sediments on the west and southwest of the Madhupur Tract and that south of the Barind Tract were deposited in a rather active deltaic environment and were severely affected by river erosion (figure 3, horizons D,E,F, etc.,). These sediments most probably have been brought in by the river Ganges and its tributaries and distributaries and the delta prograded rapidly towards the Bay of Bengal to the south.

The Quaternary sediments on the north of the Rangpur Saddle belongs to the Upper-Middle Siwalik Himalayan Foredeep sediments and dips towards northwest. Tilting and subsidance of this area seems to have started following the deposition of the Pliocene sediments as both the Miocene and the Pliocene deposits lie unconformably upon the Precambrian basement and are affected by the same faulting. Although no relation so far have been established

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between the Quaternery sediments of this area with that of the Surma basin, it is apparent that they may have common provenance and may be time equivalent at least at the lower part of the sequence, lack od seismic data across the river Brahmaputra area between Sundarganj Thana in Gaibandha and Bakshiganj Thana in Jamalpur has prevented any correlation attempt between them.
At present the common depocenter of all these units coincides with the Tangua-Raular Bils. It is therefore presumeble that the subsidance is still continueing in this area.

3.1.5. Margin of the northwestern Bengal Basin

The Bengal basin margin as interpreted from the available seismic sections is shown in plate 14. The formation represented by Horizon G have the maximum northward transgression beyond the crest of the Rangpur Saddle probably forms the northern extremity of the Benbal Basin sediments i.e., the northern margin of the Bengal Basin.

It is also apparent that the northwestern margin of the Bengal Basin shifted with time in the later part of the Tertiary. During Early Eocene the northwestern boundary was bounded by the southern margin of the Crest of the Rangpur Saddle (Plate 14), Sylhet Limestone margin). In the later part of the Eocene Kopili has transgressed northward beyond Gaibandha, but in Oligocene the margin regressed rapidly in to the inner-shelf region and transgressed again in late Tertiary as demarketed by the Horizon G.

Northeast - Shillong Plateau in India.

West- Rajmahal Hills and Peninsular Shield of India.

Northwest- Northern flank of the Rangpur Saddle.

It may also be observed thet Bengal basin margin transgressed over time period and being regressed again during the Recent.

3.1.6. Limitations of interpretation due to absence of data.

(i) The seismic stratigraphic analysis of Bangladesh has been hindered by gaps in the profile data (Plate 1). There are no seismic lines in the area between Gaibandha and Sherpur districts across the river Jamuna to correlate the younger Surma Basin sediments with that of the Dinajpur Slope area or the Rangpur Platform areas. There are also lack of seismic data in the northwestern parts of Rajshahi and Nawabganj Districts.

(ii) In the deeper parts of the basin some of the seismic data recorded not deeply enough to understand the structural and depositional history of the sediments in Bangladesh, data are required from depths much greater than can be reached by the drill-hole.

(iii) During data processing by different organizations, few hundred milliseconds (from 100 to 800 msec equivalent to 75 to 750 m) of seismic data from the upper part of the sections, particularly on the PK lines have been muted for a better appearence of the section. However, this has cused great difficulty in tracing the horizons in the shelf area where the sediments gradually thins out to a few hundred milliseconds only. Therefore the projected subcrop of the K,L,M,N,O, and P time equivalent horizons to the Recent Alluvium was determined by phantoming upwards (figures 2, 3, 4, and plate 10).

(iv) Lack of drill hole data, particularly stratgraphic wells in the northwestern Surma Basin (Sherpur-Jamalpur area) and in the Jessore-Kushtia area.

(v) Some of the important regional seismic lines and most of the well data are not available in the BPI library to correlate the profile data from line to line and finally from the well to well.

3.2. Bouguer gravity data

During the period from 1955 to 1994 several organizations viz., the then Geological Survey of Pakistan (GSP, 1955-1968), then Oil and Gas Developement Corporation (OGDC, 1955-56), then Pakistan Petroleum Limited (PPL, 1955-56), then Standard Vacuum Oil Company (SVOC, 1955-56) have conducted regional gravity surveys at different parts of northwestern Bangladesh. With these data referenced to Sylhet gravity base a compiled Bouguer gravity anomaly map having 2 mGal contour interval has been published in the Record Series Reports of GSB (Vol. 1, part -3, 1978). This map to a certain extent cover the crestal part of the Rangpur Platform. The BOGMC have conducted regional gravity survey all over Bangladesh (1963-80) and in 1981 prepared a compiled Bouguer anomaly map of Bangladesh (Mir Khamidov and Mannan, 1981). The GSB during 1976-94, systematically conducted regional gravity survey over the crest of the Platform and detailed gravity survey over selected areas for mineral exploration. Observations were made at 1.6 km square grid points for the regional survey and 50m to 200m square grid for the detailed survey using Worden Gravity Meter. The data were referenced to the Sylhet gravity base station and after necessary corrections Bouguer gravity anomaly map with 1 mGal contour interval was prepared.

In 1990 the GSB has published a compiled Bouguer anomaly map of Bangladesh (Rahman et al., 1990) as shown in plate 11 with 2 mGal contour intarval on 1:1,000,000 scale with reference to IGSN-71, on the basis of the Bouguer gravity anomaly map prepared by BOGMC in 1981.

The author edited the Bouguer Gravity anomaly map published by GSB in 1978 with reference to IGSN-71 and then incorporated it into the Bouguer anomaly map of Bangladesh (1990). In this map shallower features over the crest of the Platform along with deep seated over the basin area are really recognizable. This edited Bouguer anomaly map is presented in figure 14. A residual anomaly map has also been prepared for the crestal part of the Rangpur Saddle area after removing the regional effect and is presented in figure 15.

On the basis of characteristic gravity anomaly wavelengths, levels and trends, the Bouguer anomaly map of Bangladesh can be divided in to gravity anomaly "domains". It has been observed that these domains correspond with the tectonic provinces or sub-provinces. These provinces and the sub-provinces as shown in figure 1 and plate 11 are: 1) Himalayan Foredeep, 2) Indian Shield (Rangpur Platform), 3) Bogra Shelf, 4) Bengal Foredeep, 5) The Sylhet Trough, and 6) the Tripura-Chittagong Fold-Belt domains.

3.2.1 Gravity Data Interpretation

A qualitative interpretation of the Bouguer anomaly map (figure 14 and some quantitative interpretation of the residual anomaly map (figure 15 have been discussed in the following. It may be observed from plate 11 and figure 14 that total Bouguer anomaly relief across Rangpur PLatform is 180 mGal, with maximum negative value -169 mGal in the extreme northwest corner in the Himalayan Foredeep region and the maximum positive value +11 mGal near Porsa area, Rajshahi (Plate 11 and figure 14). The Himalayan Fore Deep region is characterized by nearly east-west trending anomaly contours with northward negative gradient. A combined effect of a gradual thickening of the sedimentary wedge and a northward deeping denser substrate in the area is reflected by the anomaly contour patterns.

The Platform region is characterized by variable trends and variable relief of the anomaly contours. Over the crest of Platform relatively short wavelength anomalies having intensities from -10 mGal to -38 mgal are displayed (Plate 11 and figure 14). Intensities over the southern flank of platform varies from +11 mGal near Porsa in Rajshahi District to -58 mGal near Sherpur area in Jamalpur District. The Platform area is underlain by Archean Crystalline rocks forming a broad arch whose crest in Bangladesh rises to within 130m (near Madhyapara) of the surface (Zaher and

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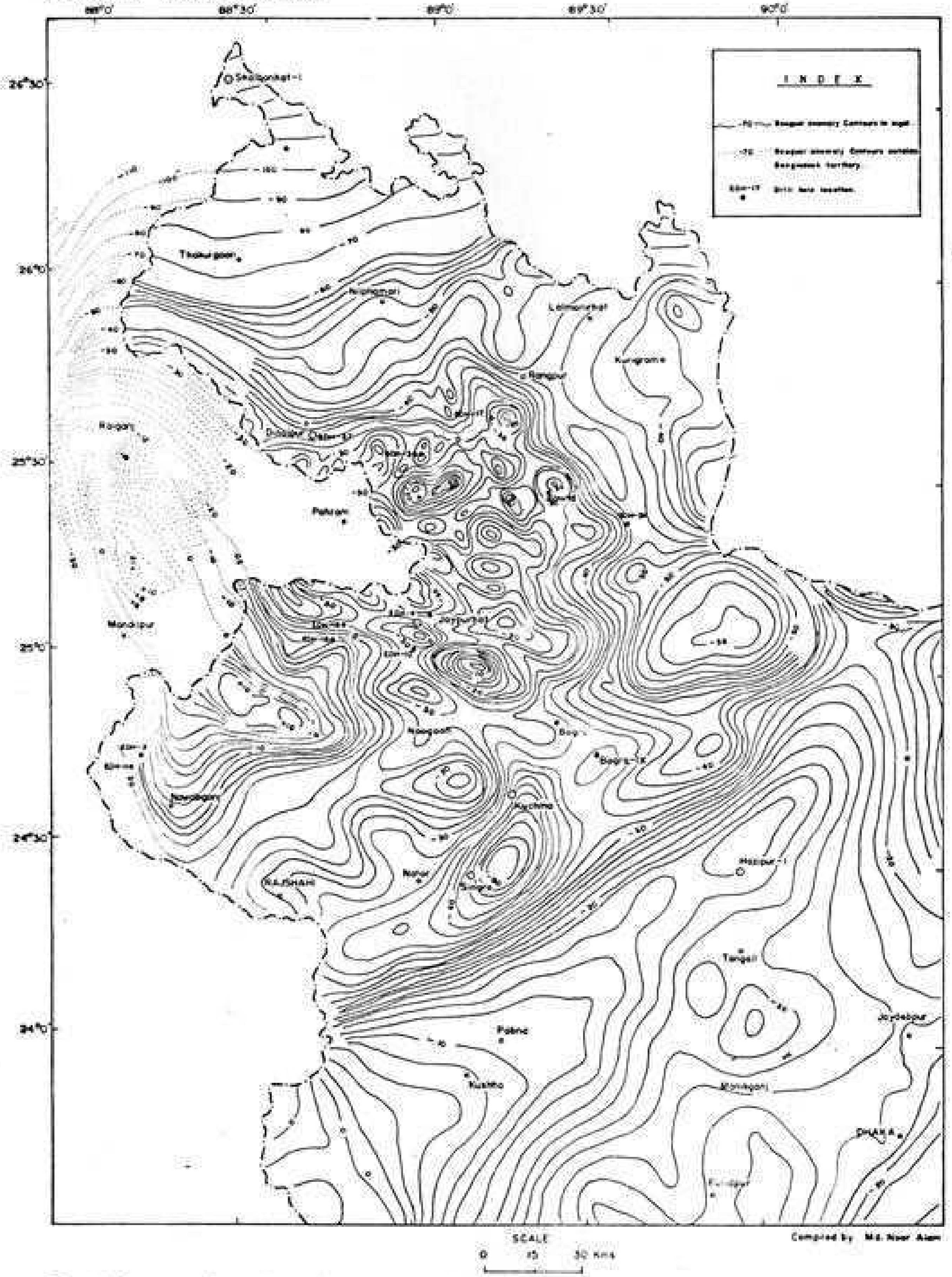

Compiled by Md. Noor Alam

Figure 14: Bouguer gravity anomaly map of the northwestern Bangladesh compiled from the gravity data collected by the Geological Survey of Bangladesh, Bouguer gravity Anomaly Map of Bangladesh (G.S.B 1990), and Gravity map of Purnea-Kishanganj area, Bihar, India (M.B.R. Rao, 1973). Contour interval 2 milligals.

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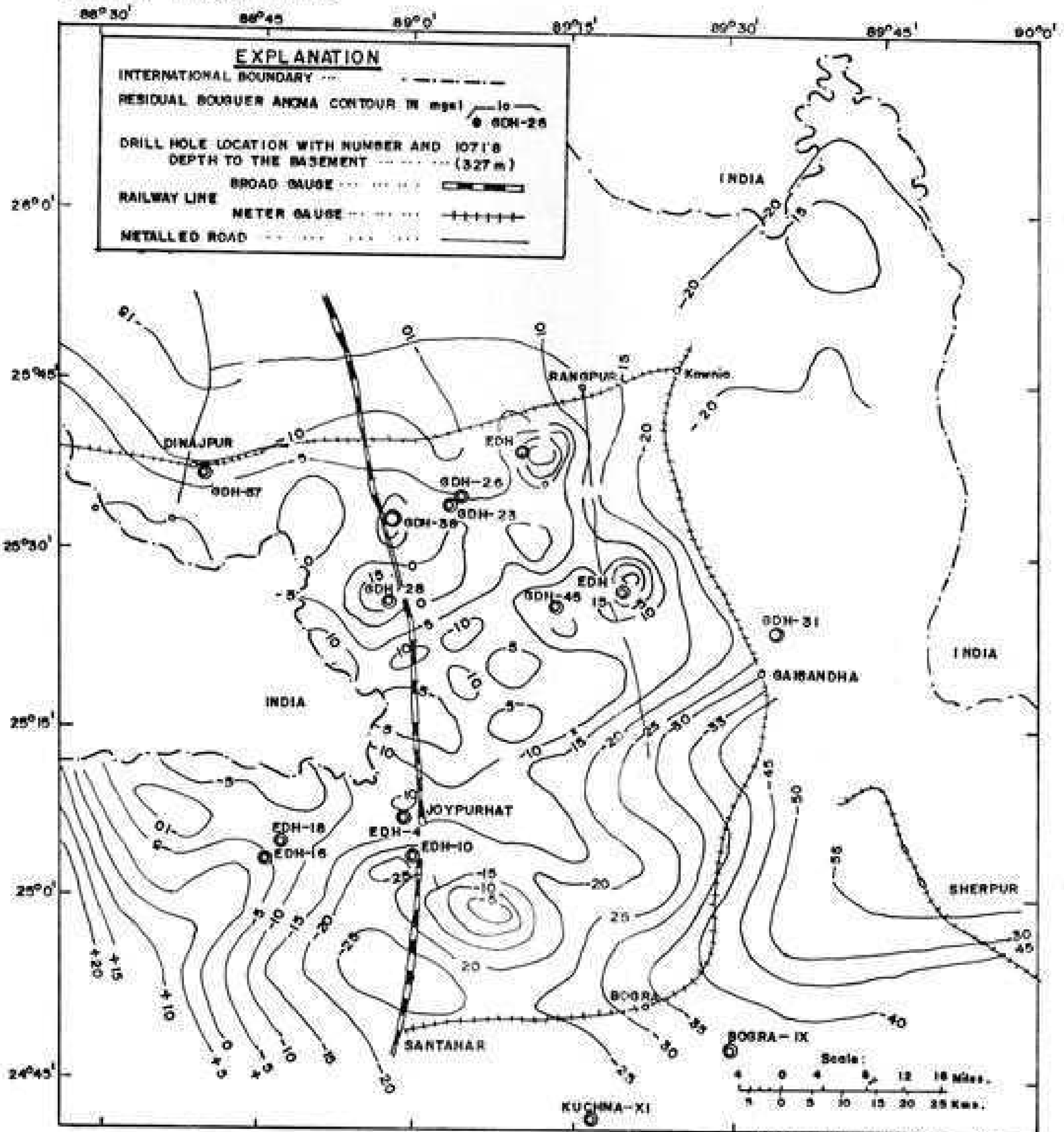

Prepared by: Md Noor Alam.

Figure 15: RESIDUAL BOUGUER ANOMALY MAP OF RANGPUR SADDLE AREA, PREPARED AFTER REMOVING THE EFFECT OF THE REGIONAL GRAVITY FIELD.

Rahman, 1980). Short wavelength gravity highs on the Platform generally correspond to local basement highs and those having very steep gradients correspond to the basic intrusions within the Archean basement rocks as observed in the GDH-17 (Mithapukur) and GDH-15 (Pirganj) area and is shown in figures 17 and 18.

The broad, and long wavelength positive Bouguer gravity values observed over Porsa (figure 44) seems to correspond to the thick Rajmahal Trap basalts overlying the Gondwana and the crystalline basement rocks.

The short wavelength gravity lows flanked by short wavelength gravity highs over the Platform area due to fault controlled grabens within the Archean basement that contains Gondwana sediments(figures 17 and 18) in which potentially exploitable coal seams occur(Zaher and Rahman, 1980; Islam, M., et al., 1985; Miah and Alam, 1986; Alam, M.n., 1990; Islam, N., et al., 1989; Rahman, A., et al., 1992).

A prominent NW-SE trending gravity low (Tista gravity low) east of Rangpur and Gaibandha area (Plate 11 and figures 14, 15 and 17) is probably due to a faulted and subsided block of Archean basement between the Pirganj (figure 17) and the well known Dhubri Fault, west of Garo Hills of Meghalaya in India. Southern edge of this trough extends upto a broad depression corresponding to -58 mGal Bouguer anomaly near Sherpur area (Plate 11), where the seismic data reveals the top of Eocene Limestone to occur at a depth of 5 km from the surface (A. Hossain, 1989) as seen in figure 2 (composite section I).

Bouguer anomaly lows having longer wavelength and greater amplitudes occur on the southern flank of the basement arch in the Bogra Shelf region. They form a NE-SW trending anomaly trough that correspond to a string of deep Gondwana basins referred to as the "Bogra Depression" (Burgess, 1959; Rahman, M.A., et al., 1991). At its northeast end, the Bogra Depression apparently joins with the southern edge of the trough delineated by the Tista gravity low (Plate 11 and figure 15).

A broad gravity low, having a general E-W ternd probably represents a trough faulted basin in the Dandapara-Daudpur area (figure 15). East of Daudpur this is connected to the Khalaspir basin (figure 17, profile AA', where Gondwana coal has been discovered in GDH-45. A relatively large fault controlled basin in the Desma area, west of GDH-28, near Bangladesh-India border and a narrow graben in the northwest of Phulbari (figure 17) and Alam, M.N., 1990. 1991).

Dighipara gravity low is closed on three sides, viz., east, west, amnd south, with opening in the north to ther Daudpur trough.

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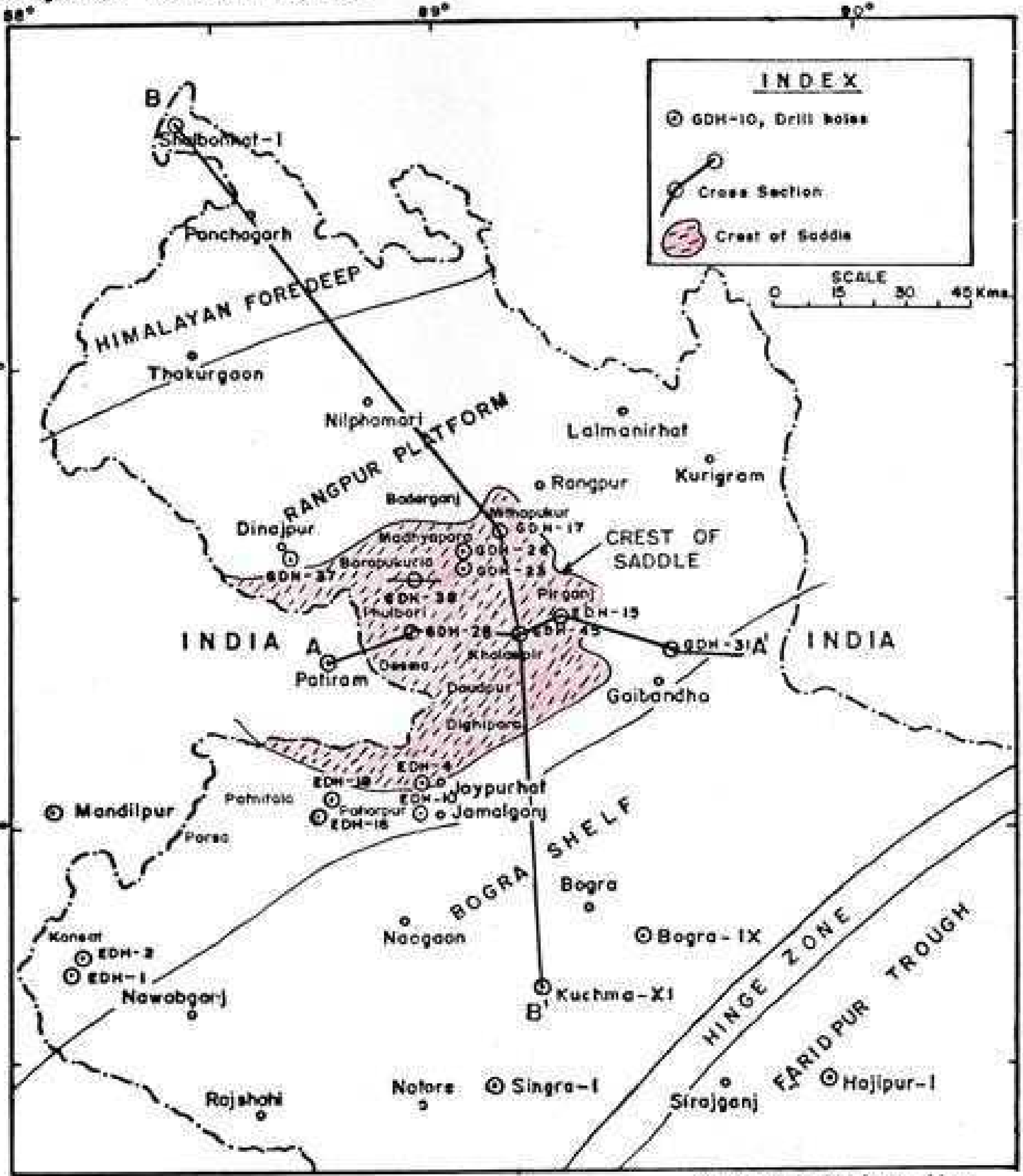

Prepared by: Md Noor Alam

Figure 16 :Index map of northwestern Bangladesh showing area under consideration and tectonic divisions therein.

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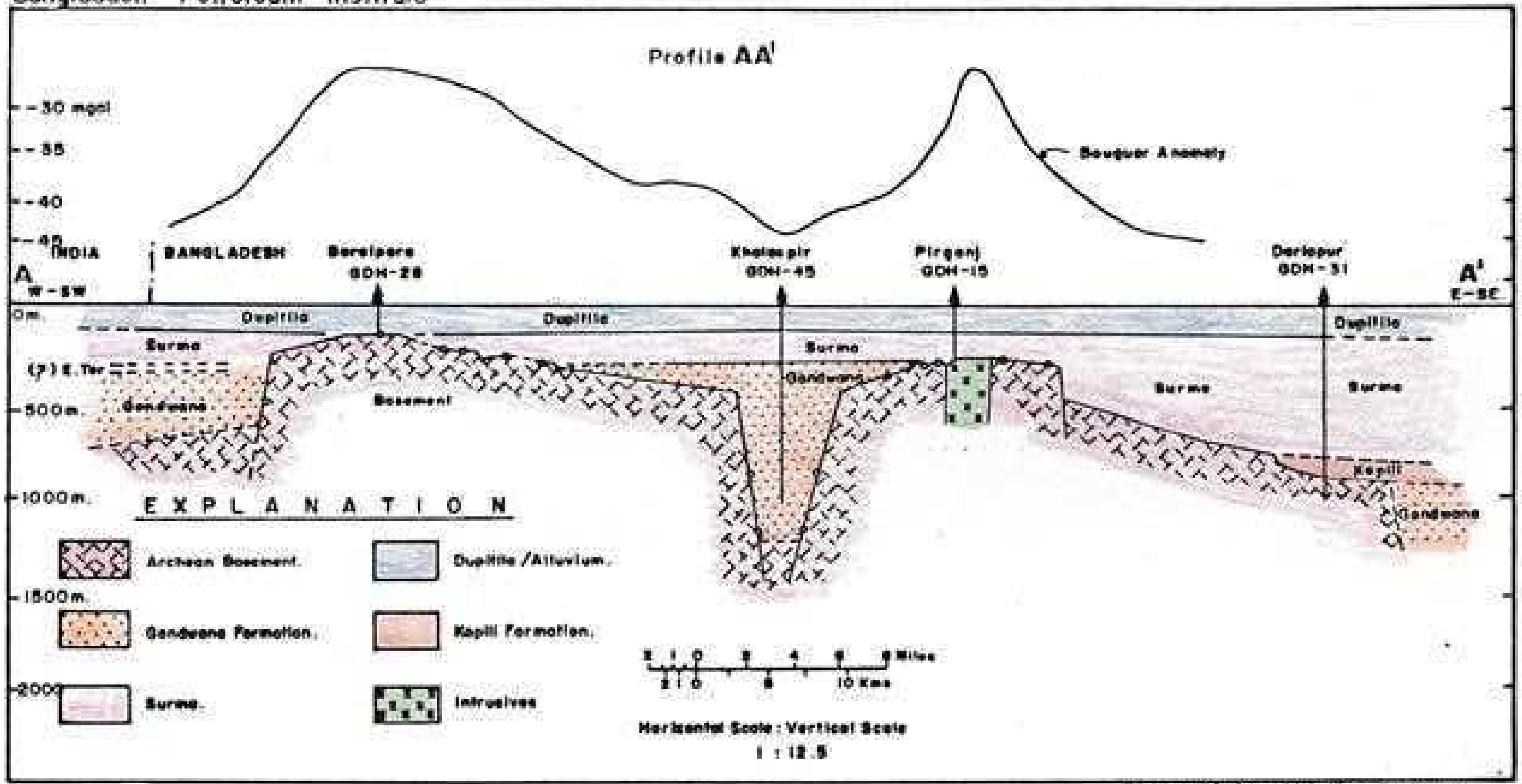

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Figure 17:A Geologic Cross-Section Along Baraipara-Khalaspir-Pirganj-Darlapur Area on the basis of gravity and drill hole data.

This is a small basin whose eastern and western margins are bounded by steep deeping basement faults (Alam, 1990,'91).

Two geologic cross sections (location shown in figure 16), one running almost E-W over the crest of the Platform (figure 17) and the other running NW-SE across the Platform starting from the Shalbonhat-1 well in the Himalayan Fore Deep to the Kuchma X1 well in the Bogra Shelf region (figure 18) have been prepared by estimating depths to the Pre-cambrian basement rocks from the gravity and drill hole data (Rahman, M.A., et al, 1985; Alam, M.N., 1990; Khan, F.H., 1991). The cross-sections have been simplified and do not represent finar stratigraphic variations and structures due to limitations in the scale of plotting. However the features may be observed in the seismic sections of the area e.g., Shell-1240, 2500 lines (figures 5 and 11). It is evident from these figures that the Gondwana sediments fill the Graben like structures within the pre-Cambrian basement, which later on has been covered by the Tertiaty to Recent sediments. It may be noticed that sharp gravity high anomalies bear relation to the igneous intrusions as seen near Pirganj (EDH-15) and broad, strong gravity high anomalies seem to have relation to the late-Createeous basalt flow (Rajmahal Trap). Later observations is better defined in another east-west cross setion near the southern flank of the Platform (figure 18). Location of the drill holes are shown in plate 13, the panel diagram of northwestern Bangladesh prepared on the basis of available drill hole data.

The NW-SE ternding cross-section (figure 17) represents a general distribution of the sedimentary formations across the Paltform. The thickness of Tertiary to Recent fromations increases from the crest of the Platform to both towards north and south. Over the southern flank of the Platform older Tertiary formations represents cleanly a marine environment by the presence of fossiliferous Sylhet Limestone and Kopili Shale and are restricted northward by the crest of Platform. Marine Tertiary formations are thinned out or terminated against the southern flank of the Platform, therby forming the northwestern boundary of the Bengal basin. Across immediate north of the crest of Platform, shallow marine environment may have persisted for a very short period of time as the Limestone and Shale are well developed (Shell, 1988).

Over the southern flank of the Platform and in Bogra Shelf region, Gondwana formations appear to be continuous at least at the upper part. In contrast to this, they are restricted within grabens over the crestal part of the Platform (figure 18). A relatively greater period of erosion and nondeposition for the crestal area than those over the southern flank may be an explanation for this kind of difference. The Upper Jurassic-Cretaceous basalt flows (Rajmahal Traps) overlie the Gondwana formations as a sheet covering a large area in the Bogra Shelf region (figure 18).

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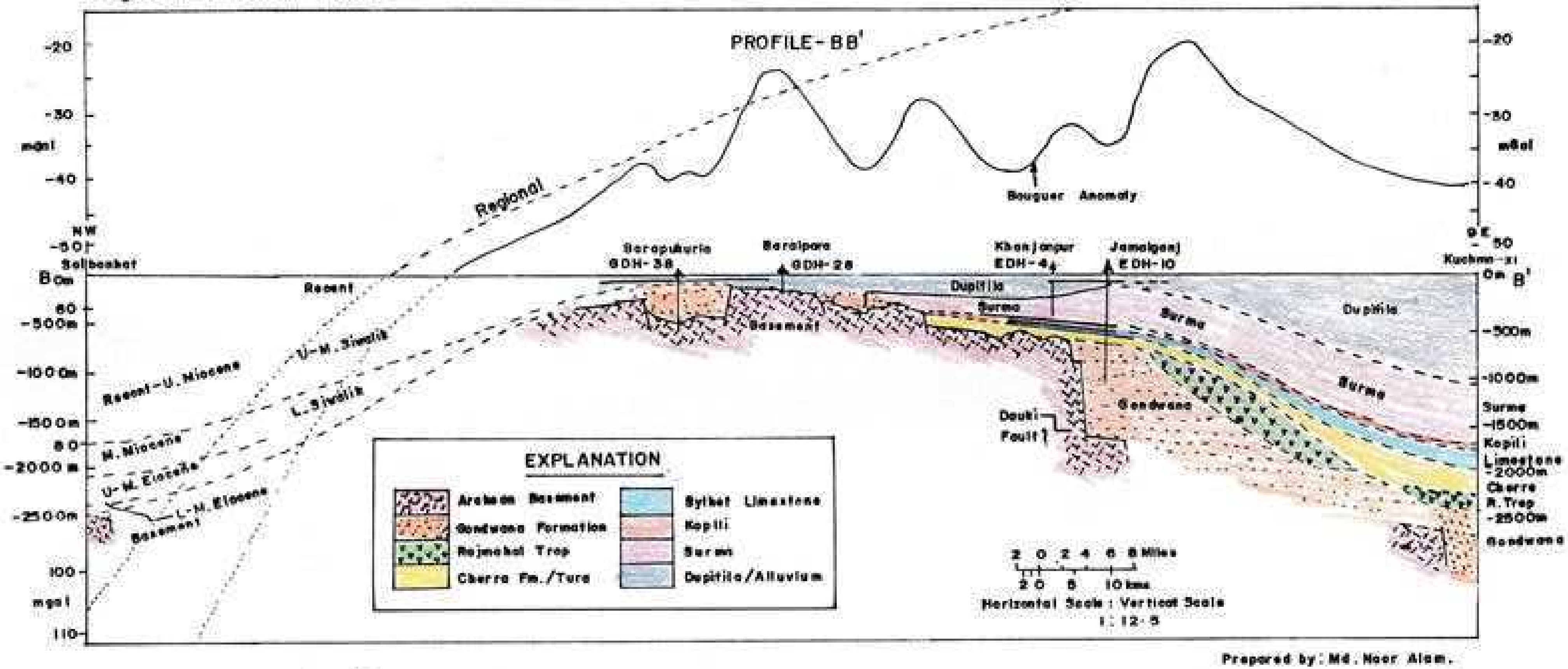

Figure 18: Geologic cross-section along Salbonhat– Barapukuria– Baraipara– Khanjanpur — Jamalganj – Kuchma area prepared on the basis of gravity and drill hole data.

The discovery of Gondwana formations at Kuchma-X1, Singra-1, Jamalganj (EDH-10), Patnitala (EDH-16), Madhyapara (GDH-26), Barapukuria (GDH-38), Khalaspir (GDH-45), Dighipara (GDH-50) and Phulbari (BHP well) area correlates directly to the Bouguer gravity lows and interpreted grabens and semi-graben type of structures within Pre-Cambrian basement. It is therefore seems most likely that other interpreted graben and semi-graben type of structures contain coal bearing Gondwana sediments.

It may also be noticed that over the crest of the platform, north of 24° 15'N, the graben and semi-graben type of structures and their associated faults generally show a NW-SE trend.

3.3 Aeromagnetic data

The Aeromagnetic Anomaly Map of Bangladesh(Rahman, M.A., 1990), is published by the Geological Survey of Bangladesh(GSB) in 1990 (Plate 12). The aeromagnetic survey was done in 1979-80 by the Hunting Geology and Geophysics Ltd. of UK for the Government of Bangladesh. The survey equipment was Proton Magnetometer (Geometrics G-803), with flight lines N 45° W at 3 and 1 km spacing, tie lines N 45° E at 5 km spacing, flight altitude 500 ft above ground level, sampling interval 2 seconds with resolution 0.05 nT. Geomagnetic field with inclination 28° 30'-38° 30', and Declination 13'W- 37'W respectively.

Most of Bangladesh is covered by unconsolidated alluvium and deltaic deposit of Quaternary age except some hilly area in the northeastern and southeastern part of Bangladesh. Northwestern part of Bangladesh shows relatively short wavelength, stronger magnetic anomalies with typical polarity developement (negative in the north) of the northern hemisphere than the southeastern part, where the anomalies are of longer wave length and weaker. The Hinge zone clearly demarcates these two regions. Most significant polarity developements may be seen near Pirganj, north of Bogra, southeast of Jamalganj, Porsha in Rajshahi, east of Hilli and Mohonpur in Dinajpur. These magnetic anomalies occur where there is variation or contrast in the magnetic susceptibility of adjacent rock units. Therefore, the most likely source of magnetic anomalies within Bangladesh (Hunting Geology and Geophysics, 1981) are:

i) granitic intrusions within the basement.

ii) basic and ultrabasic intrusions within the basement.

iii) Extrusive and intrusive rocks within the Gondwana Group.

iv) Ironstones within the Gondwana Group and Bengal sediments.

The Archean basement of Bangladesh is considered to be largely composed of gneisses. These are generally not very magnetic rocks and are not capable of producing the strong anomalies, such as 3000nT at Pirganj, 1100nT northwest of Bogra and 960nT near Dinajpur mapped over Bangladesh. The granitic, basic, and ultrabasic intrusions within the basement could provide the main sources of magnetic anomalies. These magnetic anomalies may be considerably affected by shallow horizons of Rajmahal and Sylhet Traps(lavas).

It is unlikely that sideritic ironstones and pyrite bearing horizons, which occur widely within the Gondwana Group, and to a limited extent in the stratigraphical units of the Bengal Basin will have sufficient magnetic contrast with the associated shales and sandstones to register as magnetic anomalies.

The basic-intermediate lavas of the Rajmahal and Sylhet Traps should give appreciable anomalies at shallow depths. Since, the much less extensive thin sills and dykes, as seen in Damodor vally coalfields will have a weak to negligible magnetic expression. It is therefore possible that large pipe like feeders to the trap lavas may be encountered. Existence of intrusive features have already been reported in Pirganj and Lalpukur areas(Rahman, H.,1975, Rahman, A., 1975). These would occur as basic magnetic plugs of great extent. Strong anomalies northwest of Bogra and that of Porsha area of Rajshahi area may be due to such features. The southeastern part of Bangladesh is however devoid of any well defined anomalies, representing a great depth of burial of the basement rocks.

The Crest of Rangpur Saddle display short wavelength magnetic anomalies characteristic of shallow magnetic horizons. The bore holes EDH-15, 17, 23 to 27, and 28 have intersected Pre-Cambrian granites and gneisses at depthes ranging from 130m to 260m(Khan, F.H., 1991). This would suggest that the magnetic anomalies of this area related to magnetic susceptibility contrasts within shallow basement rocks.

In Rajshahi area the archean basement rocks are at a greater depth than that over the Rangpur Saddle area. It is possible that the short wavelength aeromagnetic anomalies are probably due to the Rajmahal Trap rocks lying over the Archean basement and the coal bearing Gondwana sediments deposited filling the grabens within the Archean basement rocks.

In northwestern corner of Bangladesh the magnetic field character is broadly of longer wavelengths and consequently the existence of relatively deeper basement rocks than the Saddle area (figure 5 and 18). The east-west magnetic trends is strongly expressed throughout this area compared to other directions. This area, with exception of the southeast, is a regional magnetic low. Most of the short strike length anomalies have a peak to peak magnitude of less than 10 nT with wavelengths less than four kilometers. The strong negative anomalies have magnitudes up to 400 nT. The weaker anomalies are most likely due

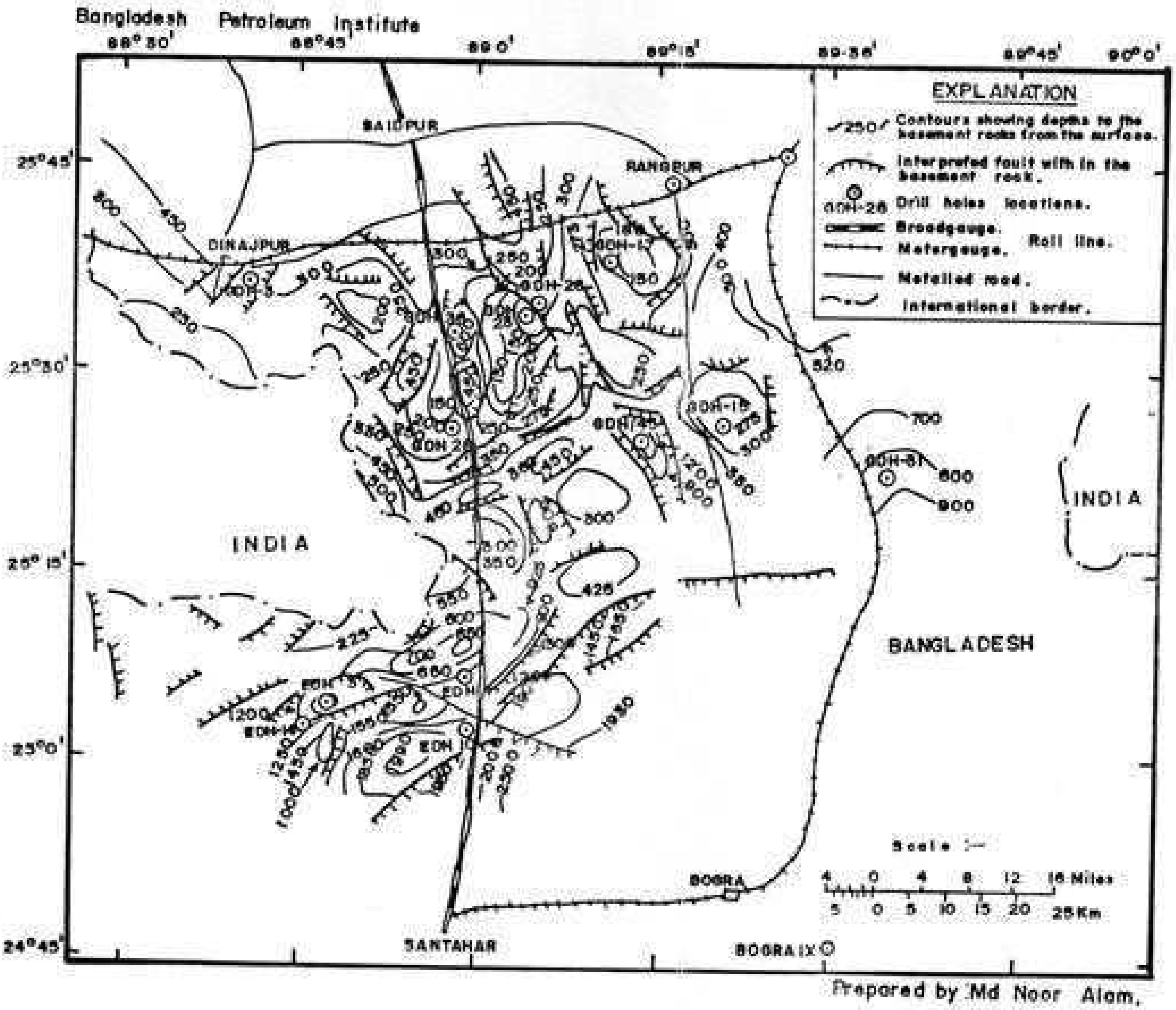

FIGURE 19 : BASEMENT CONFIGURATION MAP OF THE RANGPUR SADDLF ARER (NORTH-WESTERN BANGLADESH) CONTOURS SHOW PROBABLE DEPTHS IN METERS.

to minor changes in the magnetic properties of the basement rocks. The strong negative anomalies in the central part of this area are related to contrasts in the basement rock type such as exists between basic intrusives and granites or lava and granites.

3.4 Faulting in the Precambrian basement of the northwestern part of Bangladesh.

Pre-Cambrian basement related faults as inferred from the geological, geophysical, and drill-hole data have been plotted in figure 19. It is evident from the figure that Gondwana basin marginal faults north of 24 15' in general display NW-SE trend forming several linear belts of depression arranged in a more or less en-echelon fashion. In some cases boundary fault zone is wide comprising a number of parallel down to the basin step faults.

The overal tectonism in the process of growth and evolution of the Gondwana basins is a classic combination of "resurgent tectonism", in which ancient, dormant structural weak planes are reactivated in a newly imposed stress regime and attain mobility (Bondopadhya, S.K., 1977). A kind of resurgent tectonism along weak planes of the southern margin of the crest of the Platform may be observed in figure 19. This fault zone controls the northern margin of the Jamalganj-Patnitala Gondwana basin and it's extension both on the east and west (figure 20). A huge throw across this fault zone and a gradual deepening of the southern downthrown block towards east probably is the manifestation of tectonic resurgence of the Indian Shield.

Northeastern end of this fault zone seems to join the western end of the Dauki fault at the southwestern corner of the Meghalaya state of India. From an analysis of the major characteristics of these two faults, it may be assumed that this fault zone is the westward extension of the dauki Fault lying underneath the sdimentaries of the northwestern Bangladesh. It may also be assumed that the Dauki Fault has originated as a result of old Gondwana tectonism within within Indian Shield and reactivated later on to attain at the current stage of developement.

3.5 The Permo-Carboniferous formations in the northwestern Part of Bangladesh.

Resting directly upon the Archean basement are rocks of the Gondwana Group. These are Early-Middle Permian to Middle Cretaceous in age. Rocks of Gondwana Group occurs within the tectonic troughs

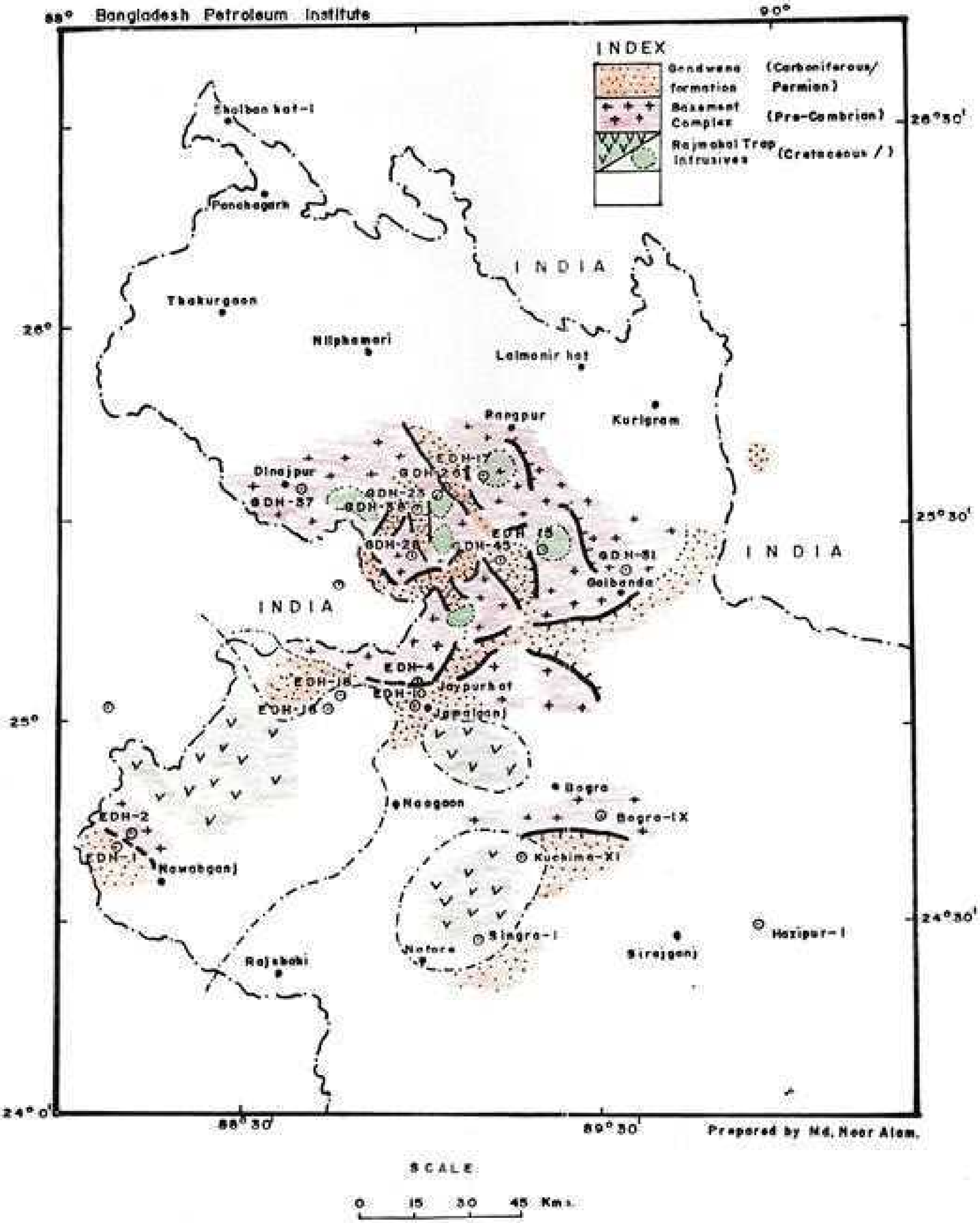

Figure 20: Pobable Subsurface Distribution of Permo-Carboniferous (Gondwana) Formations in the North Western Bangladesh.

and are represented by a fluvio-lacustrine sequence containing bituminous coal. On the southwestern corner of the crest of Platform, basement is overlain by sediments of the Lower Gondwana Group. The discovery of the Gondwana Formations in the drill holes at Madhyapara (GDH-26), Barapukuria(GDH-38), Khalaspir(GDH-45), Jamalganj(EDH-10), Kuchma-X1, Bogra-1X suggest that the Gondwana sediments fill the graben and semi-graben type of structures within the Pre-Cambrian basement of northwestern Bangladesh. All the above mentioned areas correlate directly to the Bouguer gravity lows and therefore the postulation made by the author in an earlier report (Alam, m.N., 1990), that "Every gravity low in the Rangpur Platform is a Gondwana basin", came out to be true. Over the crest of the Rangpur Platform these basins are elongated graben, semi-graben type, whereas, they are much wider in areal extent in the south of 24° 15'N as may be seen in figure 20. It is evident from the figures 19 and 20 that the grabens over the crest of Rangpur Saddle so far not drilled should also contain coal bearing Gondwana sediments.

4. Hydrocarbon prospect in the northwestern Bangladesh.

1) It appears from the study that there exists a broad, low amplitude anticlinal fold with a NW-SE trending axis stretching from Shariakandi (Bogra) to Bhuapur (Tangail) and further to the south-east, most probably includes Madhupur Tract. It has been observed in some of the seismic sections (MY-8405, 8406, 8407) of The Madhupur area that the Paleocene, late-Eocene and Oligocene formations pinchout in the mid-shelf to slope zone. A combination of these two essential factors may provide a suitable trap for accumulation of hydrocarbon in this area. Several noncommercial hydrocarbon (both oil and gas) shows have already been reported around this area e.g., Kuchma-1, Bogra-X1, and Hazipur-1 wells. The Miocene sequence within the crestal part of the this anticlinal structure deserves special attention in the context of hydrocarbon.

2) A number of seismic amplitude anomalies e.g., on line PK-8402, PK-M-12, PK-7, BK-10, have preliminarily been identified for further study in relation to their hydrocarbon association (Plate 15).

3) There are indications of an anticlinal structure in the southwest of Chattak Structure as observed on line PK-SU-8,9,etc., Since all the anticlinal structures in the Surma basin are gas prone this area deserves further study.

5. Conclusions and recommendations

1) Besides known structural traps of eastern Bangladesh, there exists a broad, low amplitude anticlinal fold with a NW-SE trending axis stretching from Shariakandi (Bogra) to Bhuapur (Tangail) and further to the south-east, most probably includes Madhupur Tract. The updip pinchout of some of the Paleocene, late-Eocene and Oligocene formations in the mid-shelf to slope zone associated with seismic amplitude anomalies indicate possibilities for stratigraphic traps. A combination of these two essential factors generally offer suitable trap for accumulation of hydrocarbon. The area around Sariakandi and Bhuapur therefore deserves further detail seismic survey and a deep drill hole to locate any such accumulation.

A zone parallel to the Hinge Zone in the outer Bogra shelf and paleo-slope offers possibility of other types of potential traps that may include unconformities, updip pinchouts, and fault related traps. Extension of the Growth fault observed on line PK-8403 may be studied further on this point of view.

2) The seismic amplitude anomalies identified on line PK-8402, PK-M-12, PK-7, BK-10 etc., may bear relation with hydrocarbons and therefore deserves further study.

3) Significant lateral variations in porosity and permeability could likewise exist, such as in marine carbonate rocks of Eocene age. Gas shows in the Eocene Sylhet limestone and Oil shows in Tura Formation in the Bogra-IX well indicates this possibily.

4) It is evident that the Eocene limestone from the west of line PK-SU-6 is underthrusting the Eocene limestone bed from the east and the process is still continueing as the sedimentation and subsidance at Raular Bil is still active in this area.

5) The crest of the Madhupur anticline lies between PG-200 to 400 on line PK-M-12 (figures 2 and 3). It is clear from Plate 1 and 3 that the crest of the anticlinal structure coincides with the Madhupur Tract, a feature well known to be the exposed part of the Pleistocene formation in the area.

On the north near Shariakandi in Bogra the crest of this structure appears to be a doubly crested anticlinal structure with one crest between PG-450 and PG-1050 on line PK-4, PK-8404 and the other between PG-300 and PG-598 on line PK-8402 (figure 2).

6) The northwestern margin of the Bengal basin shifted with time in the later part of the Tertiary. During Early Eocene the northwestern boundary was bounded by the southern margin of the Crest of the Rangpur Saddle (Plate 14, Sylhet Limestone margin). In the later part of the Eocene Kopili has transgressed northward beyond Gaibandha, but in Oligocene the margin regressed rapidly in to the inner-shelf region and transgressed again in late Tertiary as demarketed by the Horizon G.

7) The Quaternary sediments have excellent developements in the Sunamganj-Kishorganj area which may be considered as type locality for the Quaternary deposits in the Bengal basin. Present position of these bils coincides with the axis of a broad synclinal fold between the Madhupur Tract and the Chhatak anticline, thereby indicating a continuous subsidance in this area since the Pleistocene time. The total thickness of this sequence is around 2 kms in the northcentral part just below the Tangua-Raular Bils and therefore it is presumed that Pleistocene sediments have undergone a subsidance of 2 kms in the area during post-Pleistocene time, probably maximum in the Surma basin area. The Quaternary sediments of this area are well stratified, gently folded and are sparsely faulted. The Quaternary sedimentary sequence under consideration is conformable with the Pliocene beds and cover almost the entire area of study. These sediments have probably been deposited in a fluvio-lacusterne environment and the subsidance was concurrent to the deposition.

At present the common depocenter of all these units coincides with the Tangua-Raular Bils. It is therefore presumeble that the subsidance is still continueing in this area.

On the otherhand, it is apparent from the variable, discontinuous arrangement and variable amplitude character of the seismic events (line Pk-15 etc.,) that the Quaternary sediments on the west and southwest of the Madhupur Tract and that south of the Barind Tract were deposited in a rather active deltaic environment and were severely affected by river erosion (figure 3, horizons D,E,F, etc.,). These sediments most probably have been brought in by the river Ganges and its tributaries and distributaries and the delta prograded rapidly towards the Bay of Bengal to the south.

8) One of the most important finding is that the Barind Tract and the Madhupur Tract do not belong to the same seismo-stratigraphis horizon identified on the sequence, rather the Barind Tract seems to correlate with the older horizons than the Madhupur Tract.

9) The Quaternary sediments on the north of the Rangpur Saddle belongs to the Upper-Middle Siwalik Himalayan Foredeep sediments and dips towards northwest. Tilting and subsidance of this area seems to have started following the deposition of the Pliocene sediments as both the Miocene and the Pliocene deposits lie

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unconformably upon the Precambrian basement and are affected by the common faulting. Although no relation so far have been established between the Quaternery sediments of this area with that of the Surma basin, it is apparent that they may have common provenance and may be time equivalent at least at the lower part of the sequence, lack of seismic data across the river Brahmaputra area between Sundarganj Thana in Gaibandha and Bakshiganj Thana in Jamalpur has prevented any correlation attempt between them.

10) All the graben and semi-graben structures within the Precambrian basement rocks of northwestern Bangladesh bears potential for bituminuous Gondwana coal. Rest of the Graben and semi-graben structures of the Rangpur Platform not drilled so far should be drilled to confirm the presence of Bituminous Gondwana coal at shallow depths.

6. Acknowledgement

The author greatfully acknowledge the kind approval of the Fifth Steering Committee for BPI held in January 18 , 1995 to carry out this research project.

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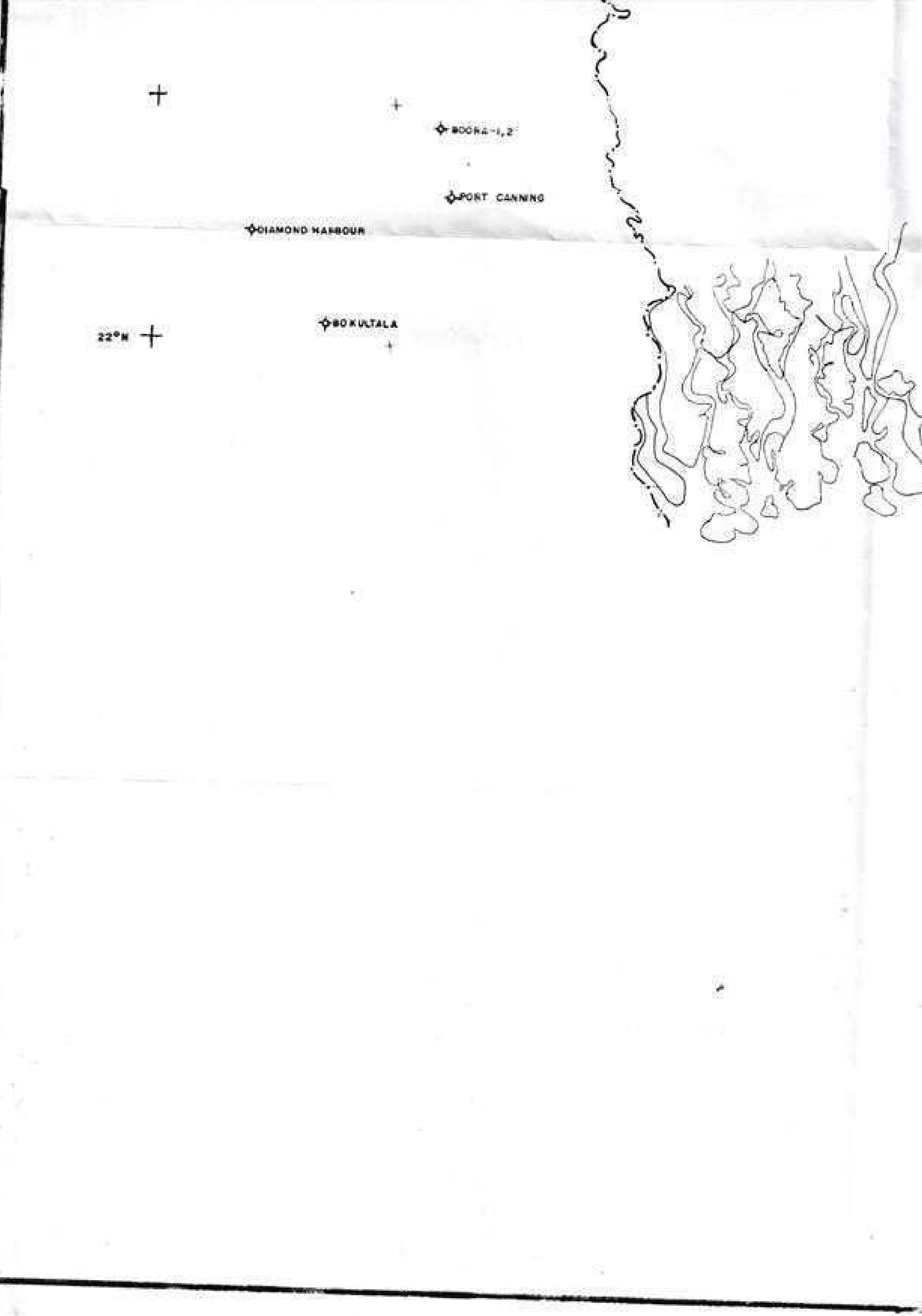
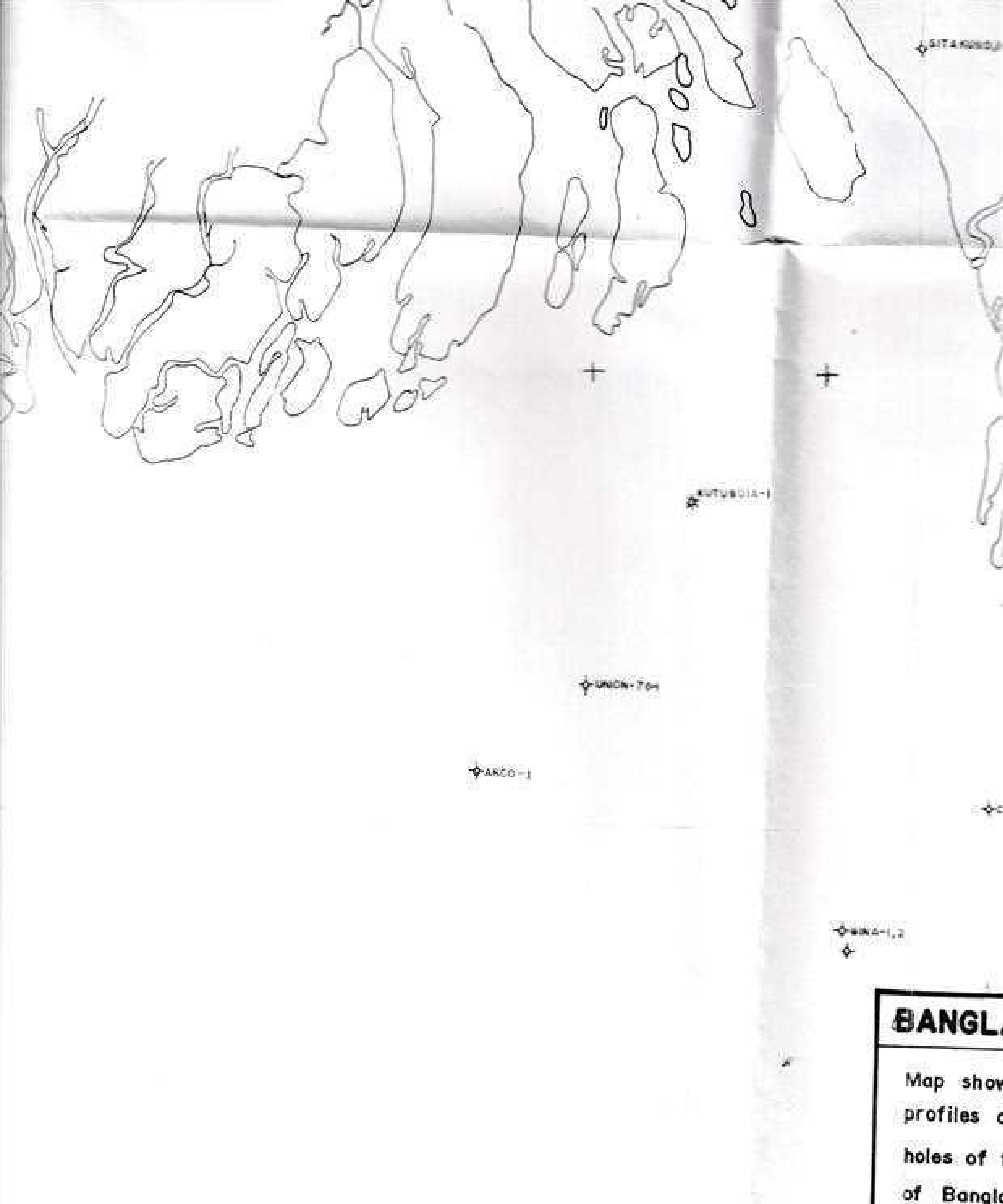

PORT CANNING
DIAMOND HARBOUR
22°N
GOKULTALA

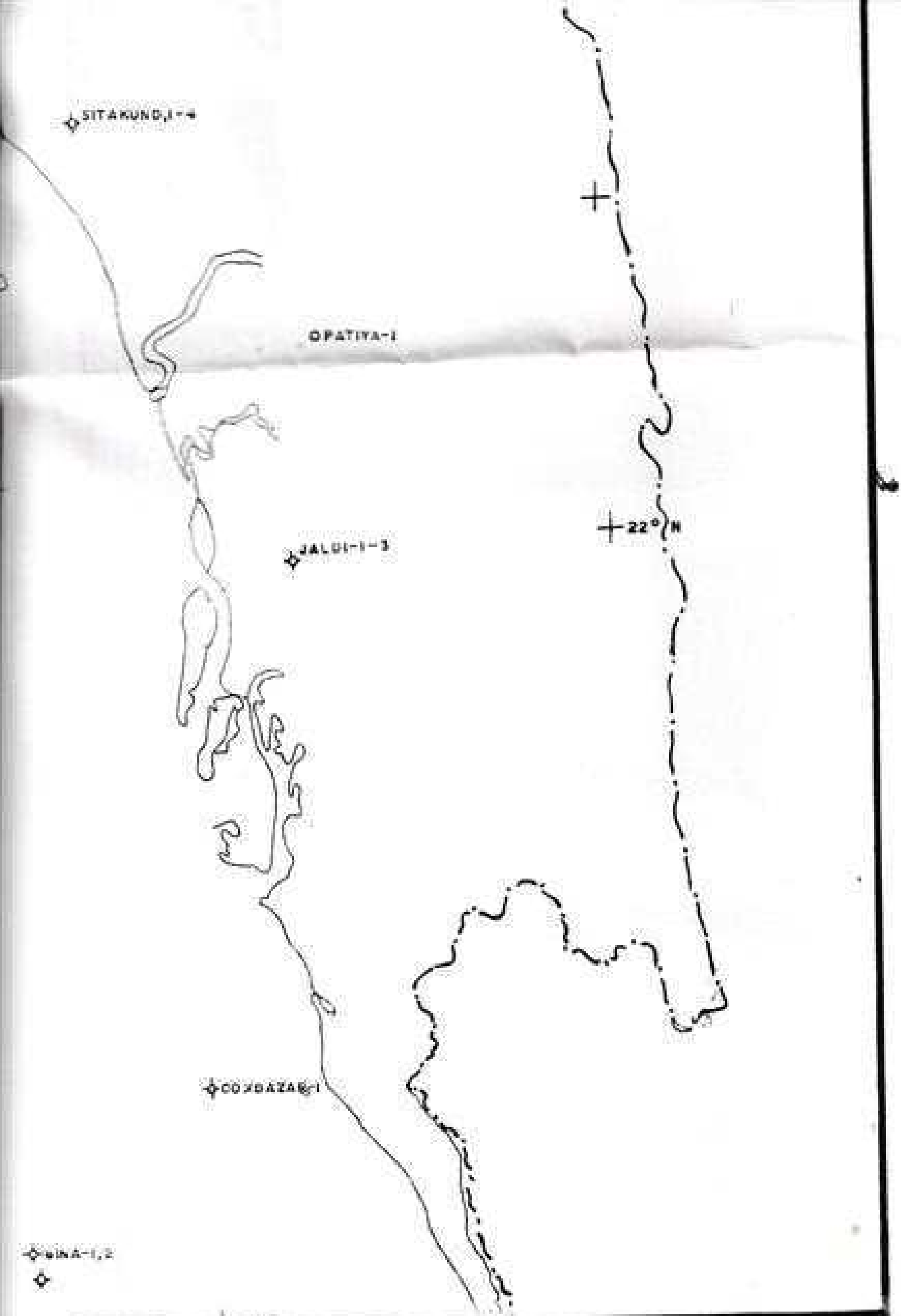


BANGL

Map show
profiles o
holes of t
of Bangla

SCALE: 1:1,00

PLATE NO



BANGLADESH PETROLEUM INSTITUTE

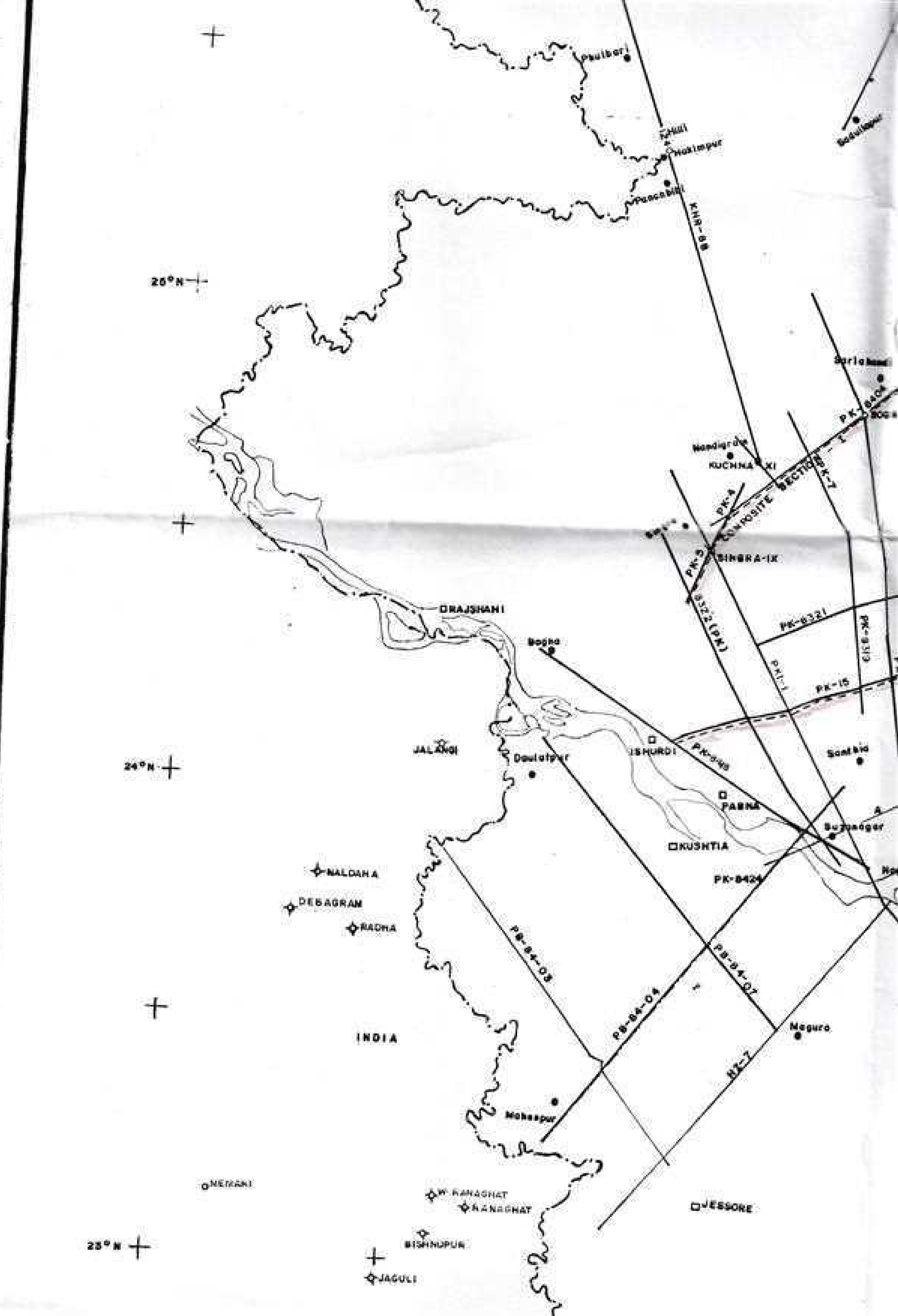
Map showing the location of seismic reflection profiles discussed in the text, location of drill holes of the northern and northeastern parts of Bangladesh.

SCALE: 1:1,000,000

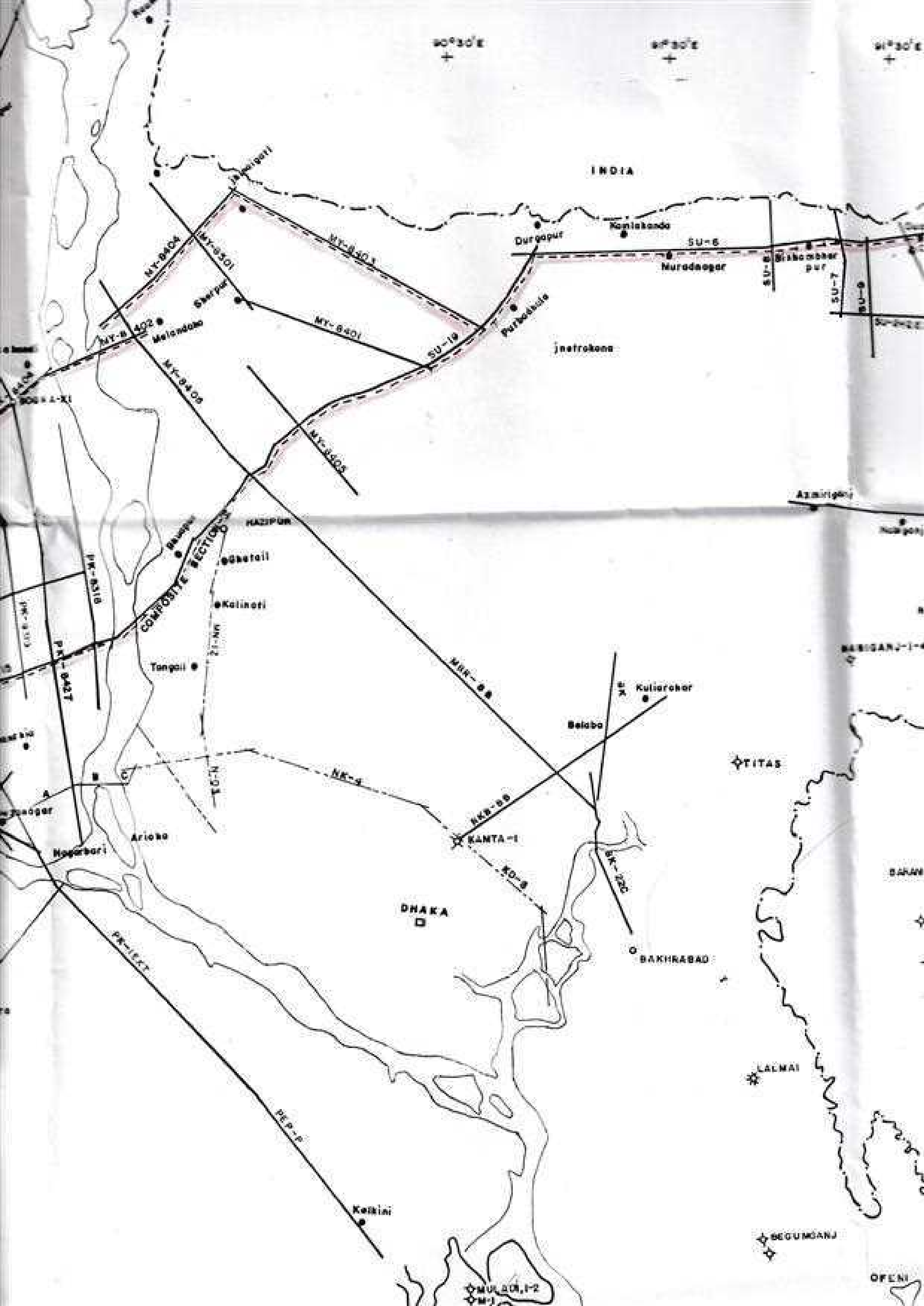
1 Cm = 10 Kms: 0 1 2 3 4 5 6 7

1 inch = 10 miles: 0 1 2

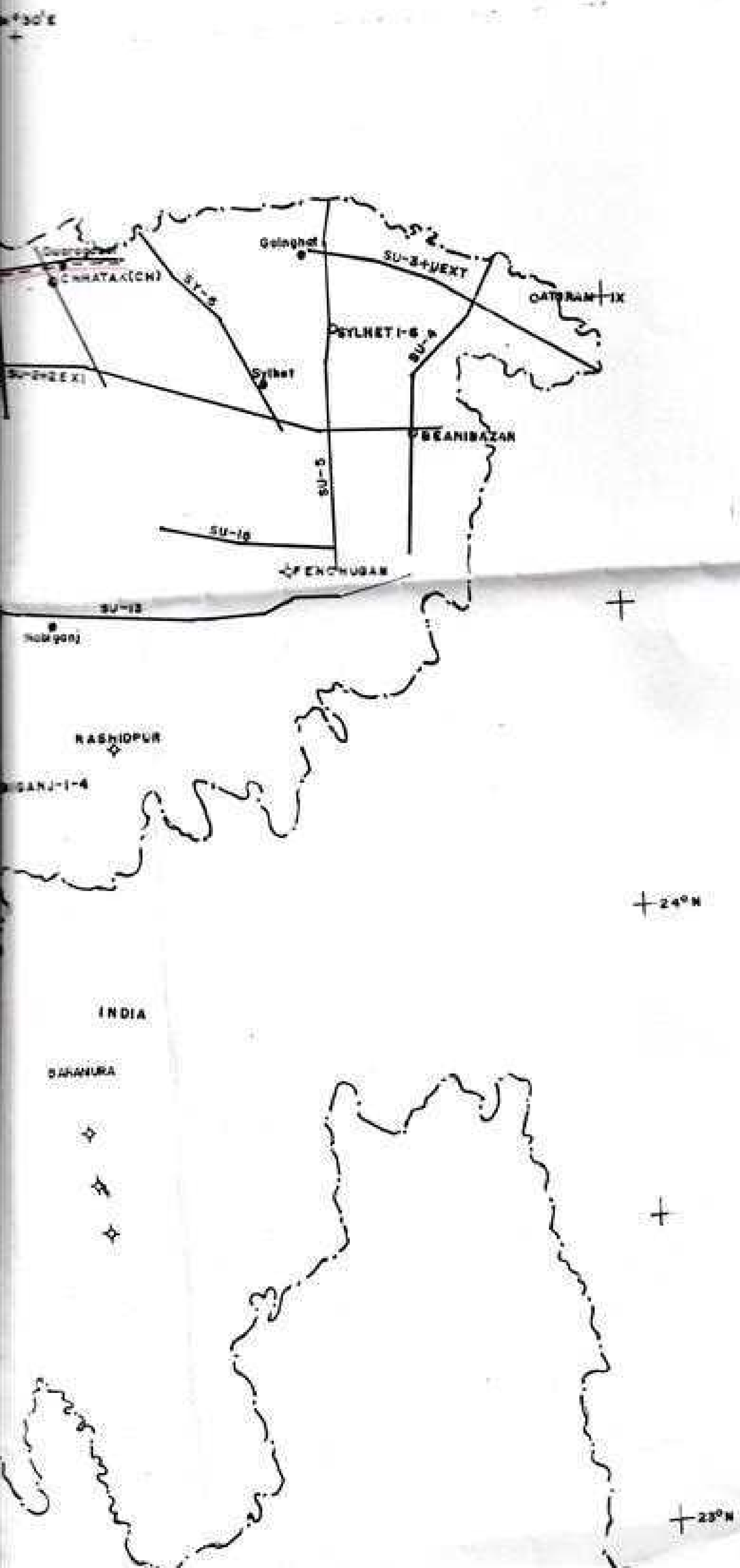
PLATE NO: 1	Prepared by: Md Noor Alam	DATE: April, 1997



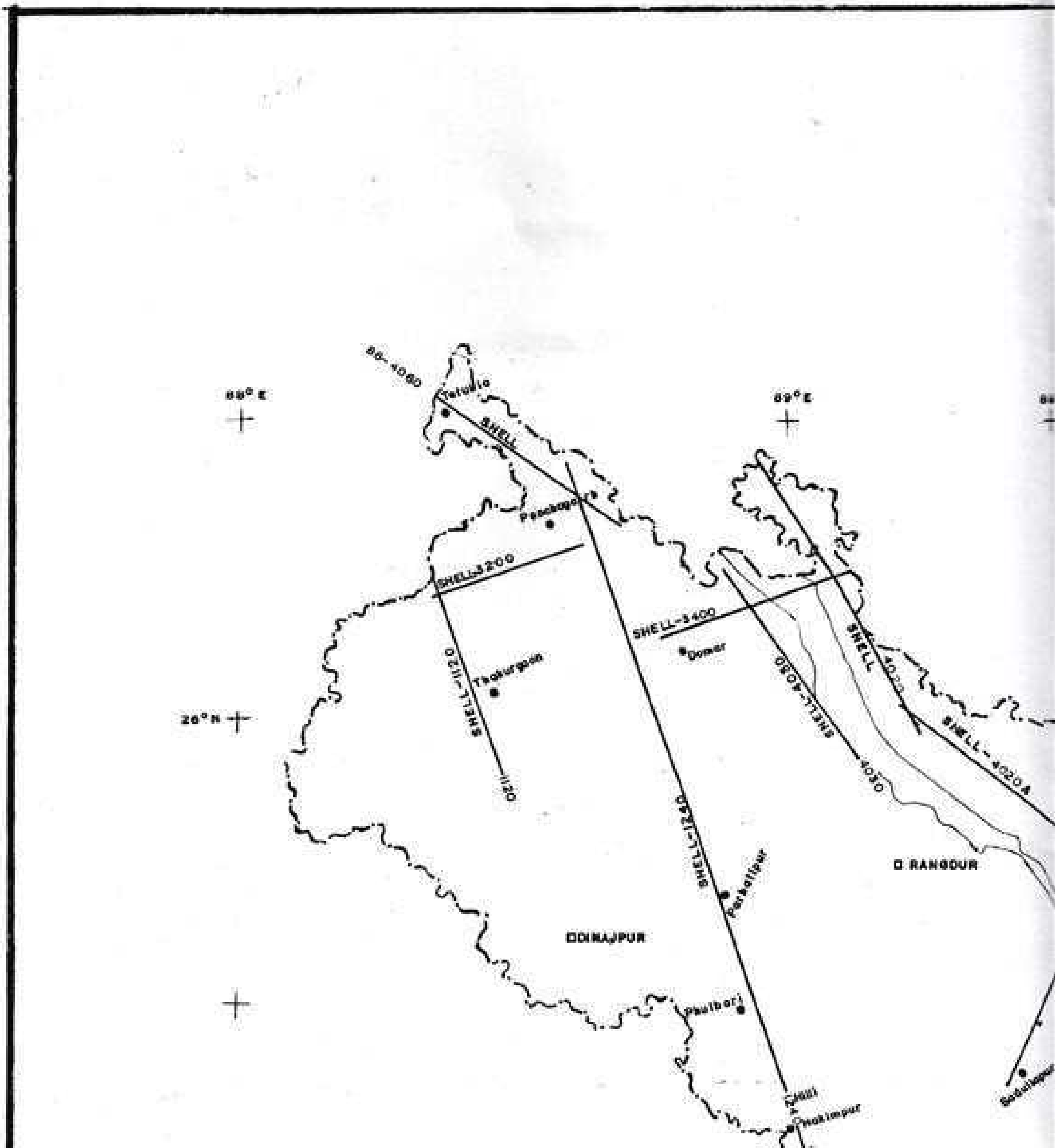
Phulbari
Hili
Hakimpur
Panchbibi
KHR-68
25° N
Nandigram
KUCHMA-XI
COMPOSITE SECTION
PK-7
PK-4
PK-3
SINGRA-IX
RAJSHAHI
8322(PK)
PK-8321
PKI-1
Bagha
PK-15
JALANGI
Daulatpur
ISHURDI
24° N
PABNA
KUSHTIA
Santhia
Sujanagar
NALDAHA
DEBAGRAM
RADHA
PK-8424
PB-84-03
PB-84-04
PB-84-07
Magura
INDIA
Mahespur
W. RANAGHAT
RANAGHAT
BISHNUPUR
JAGULI
JESSORE
23° N



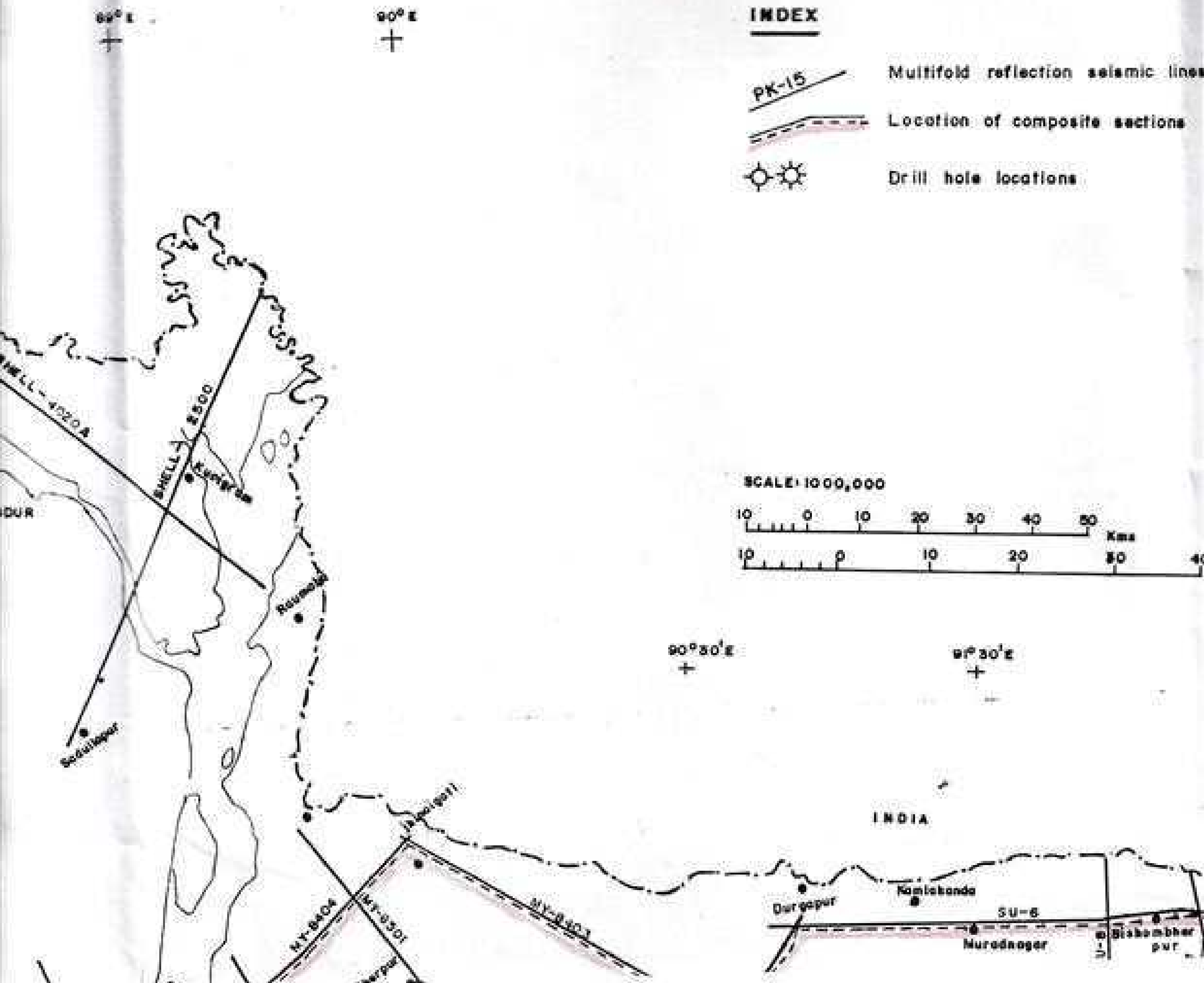
90°30'E
INDIA
Durgapur
Kamlakanda
SU-6
Muradnagar
SU-8
SU-7
SU-9
MY-8404
MY-8501
MY-8403
Sherpur
MY-8401
SU-19
Purbadhala
MY-8402
Melandaha
MY-8405
MY-8505
Azmiriganj
HAZIPUR
COMPOSITE SECTION-3
Ghatail
Kalinati
Tangail
PK-8316
PK-8427
MBK-88
Kuliarchar
Belaba
TITAS
NK-4
A
B
C
Aricha
Nagarbari
KAMTA-1
KD-8
BK-22C
DHAKA
BAKHRABAD
PEP-P
Kalkini
LALMAI
BEGUMGANJ
FENI



Golnghat
SU-3+UEXT
SY-5
SYLHET I-6
SU-4
Sylhet
BEANIBAZAR
SU-5
SU-1a
SU-13
KASHIPUR
INDIA
24° N
23°N



89° E
26° N
SHELL
SHELL-3200
SHELL-1120
1120
Thakurgaon
SHELL-3400
Domar
SHELL-1240
SHELL-4030
4030
SHELL
SHELL-4020A
RANGPUR
DINAJPUR
Parbatipur
Hili
Hakimpur

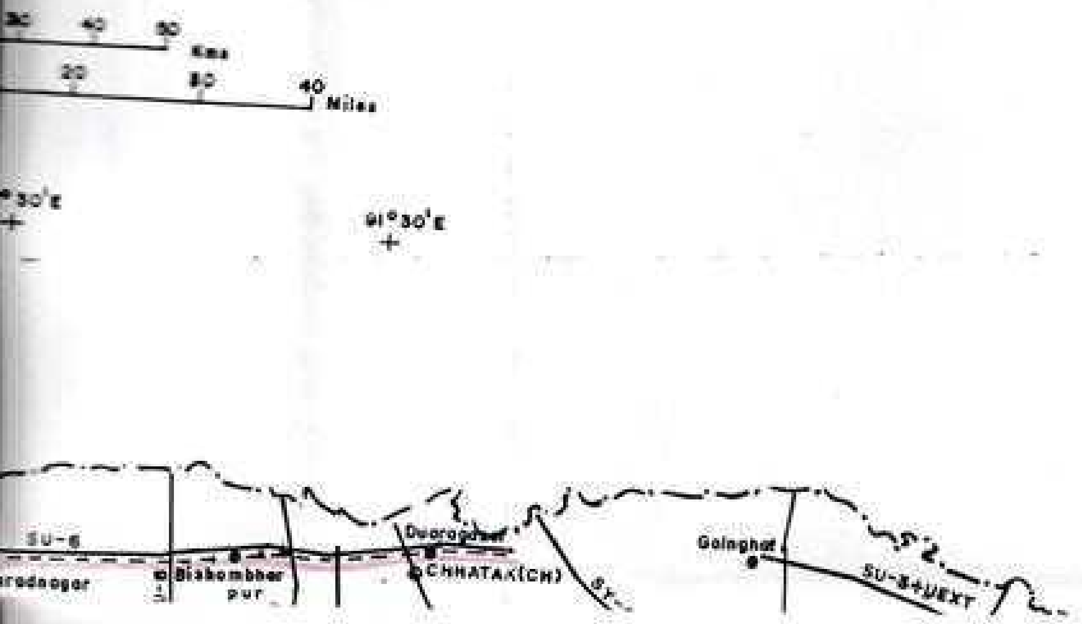


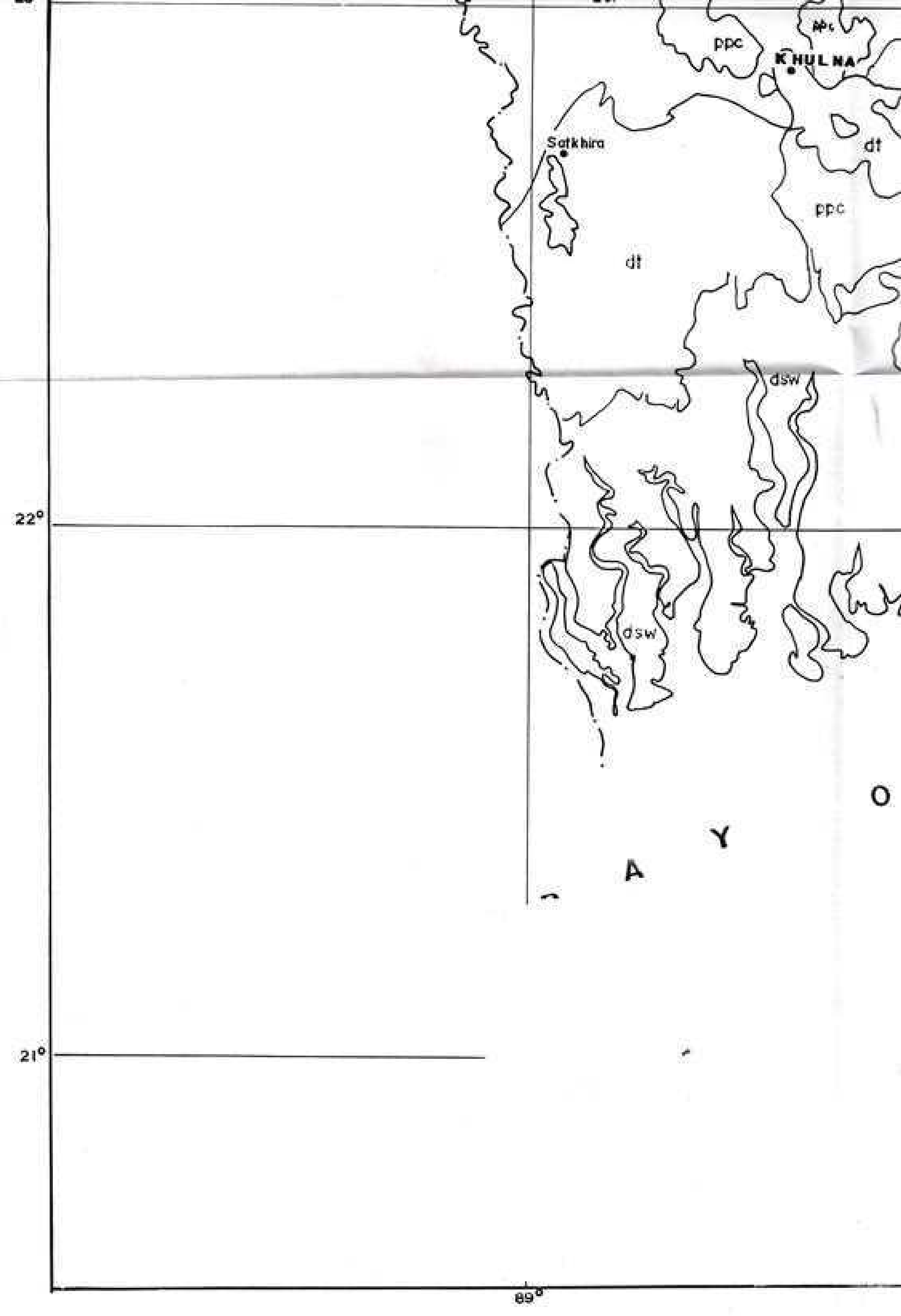
89° E
90° E
INDEX
PK-15
Multifold reflection seismic lines
Location of composite sections
Drill hole locations
SCALE: 1000,000
10 0 10 20 30 40 50
Kms
SHELL-4020A
SHELL-2500
Kurigram
Raumari
Sadullapur
90°30'E
91°30'E
INDIA
MY-8404
MY-8301
MY-8403
Durgapur
Kamlakanda
SU-6
Nurodnagar
Bishombhar pur

reflection seismic lines with numbers.

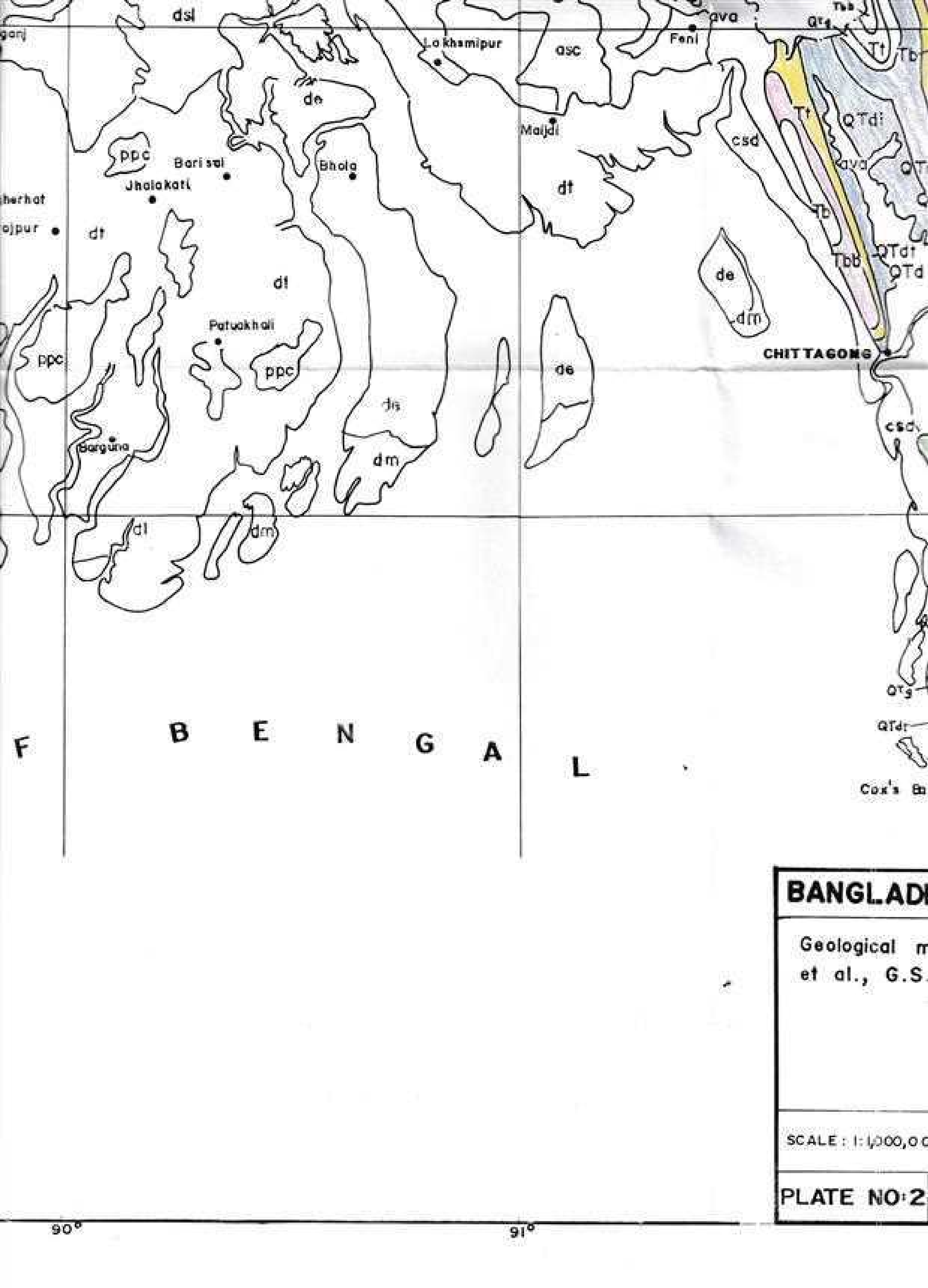
of composite sections

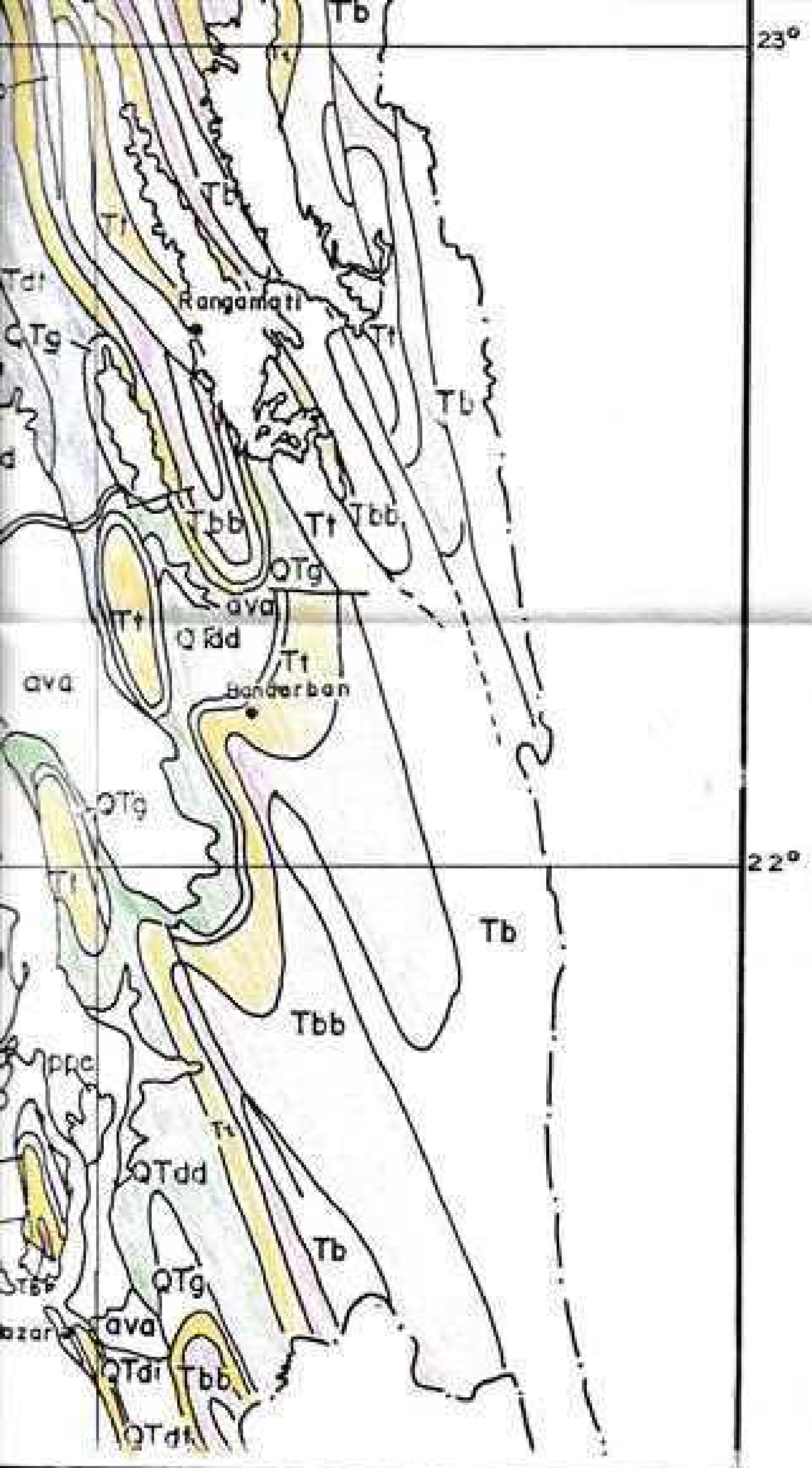
locations





ppc
KHULNA
Satkhira
dt
ppc
dt
dsw
dsw
22°
21°
89°
A Y
O


dsl
Lakhsmipur
asc
Feni
ava
de
Maijdi
csd
ppc
Barisal
Jhalakati
Bhola
dt
Patuakhali
dm
CHITTAGONG
Barguna
Tt
Tb
Tbb
QTdt
Cox's Ba
F
B E N G A L
BANGLADE
Geological m
et al., G.S.
SCALE : 1:1,000,0
PLATE NO:2
90°
91°



…DESH PETROLEUM INSTITUTE

…map of Bangladesh (from Alam, M. K., …S.B, 1990).

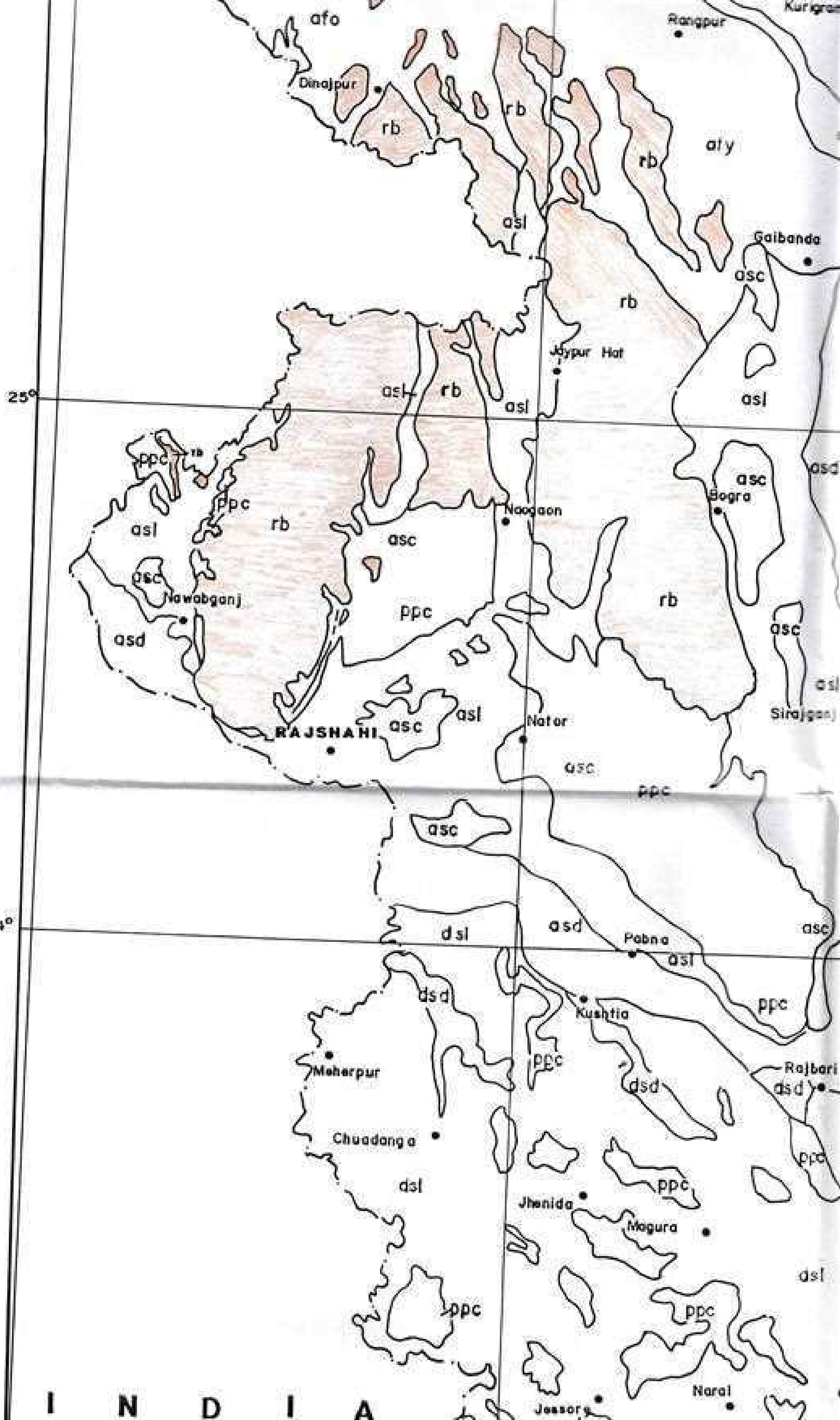
…OO

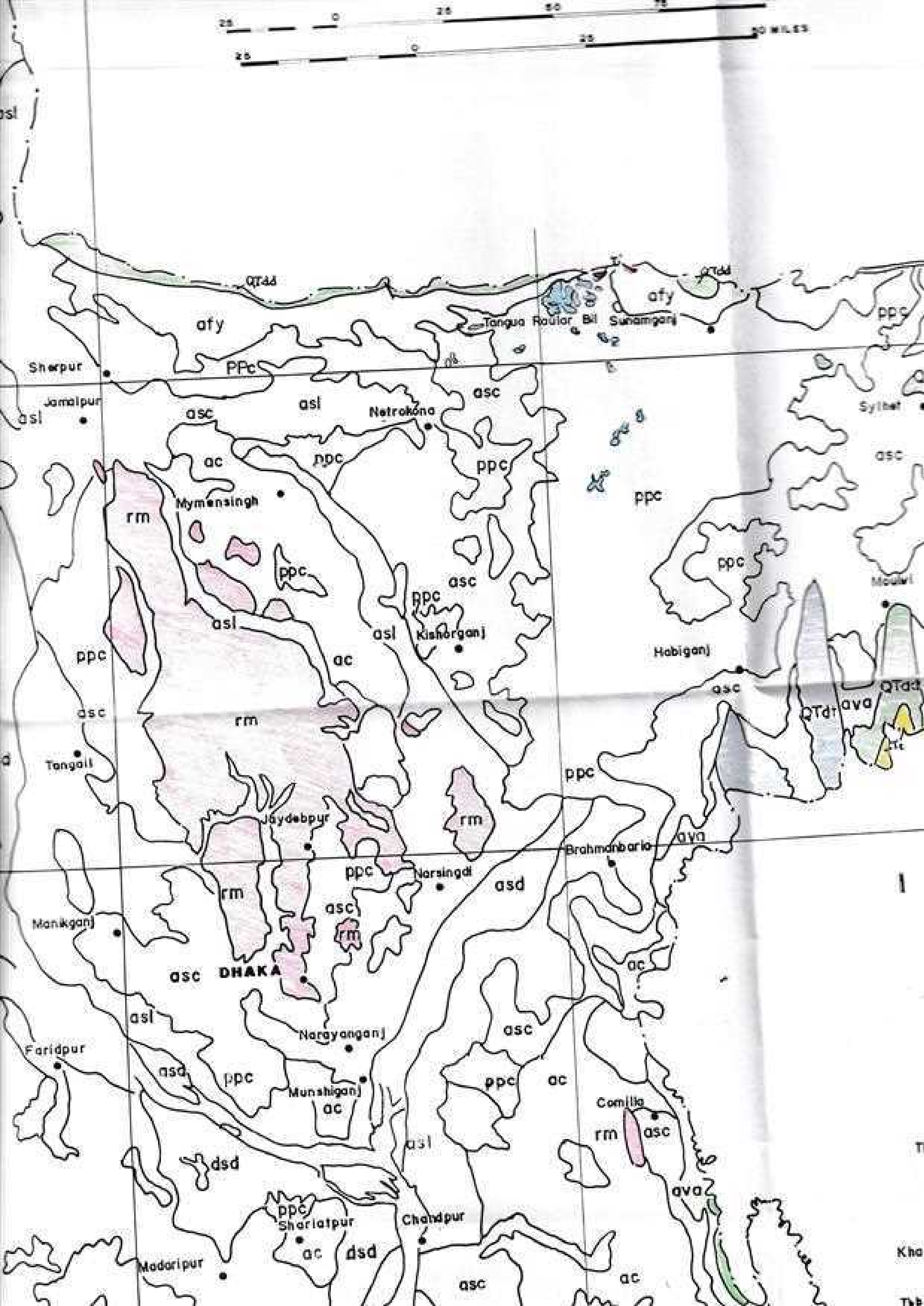
1 Cm = 10 kms (0 1 2 3 4 5 6 7)

1 Inch = 16 miles (0 1 2)

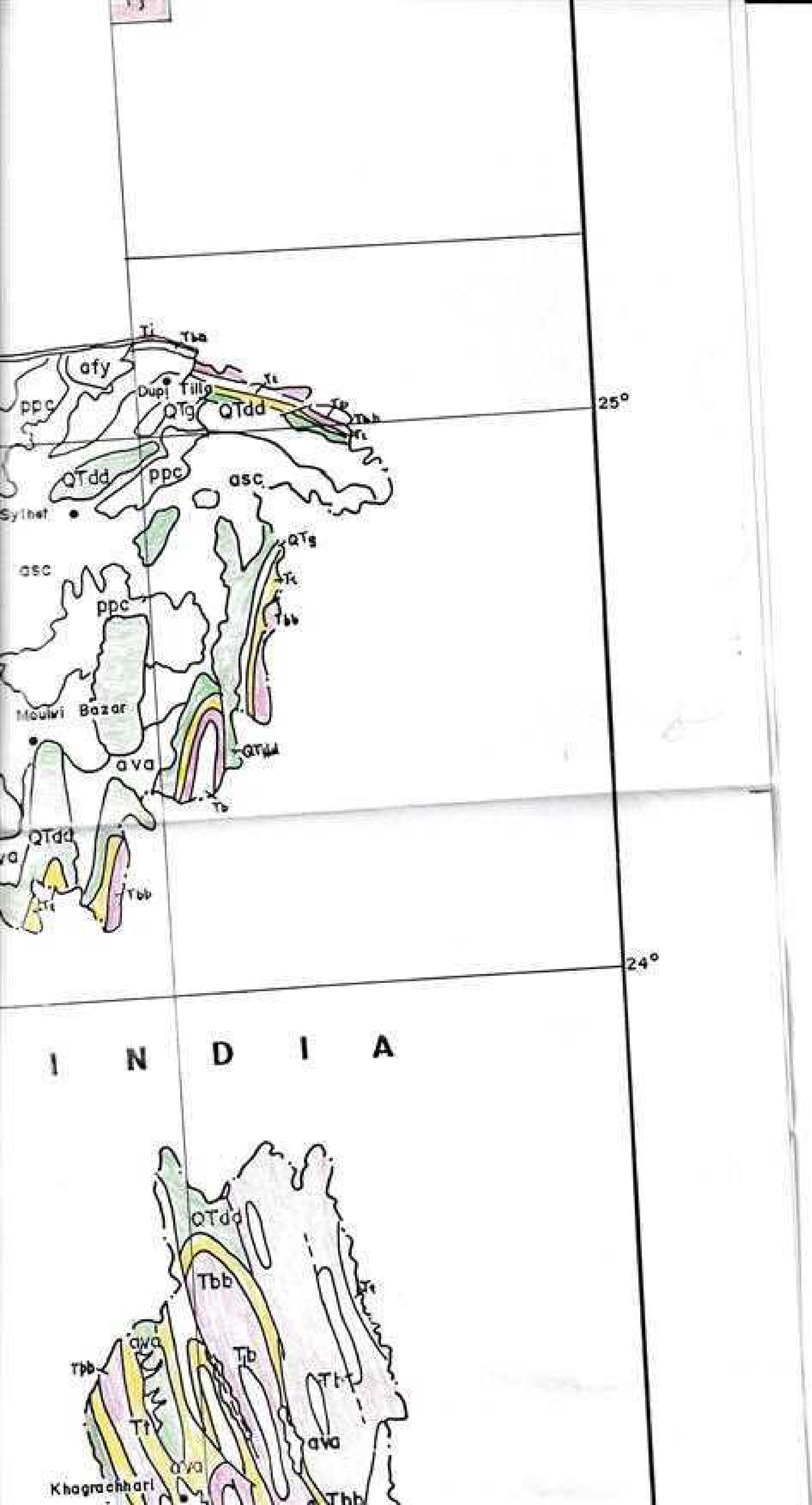
Prepared by: Md Noor Alam	DATE:	April, 1997

92°

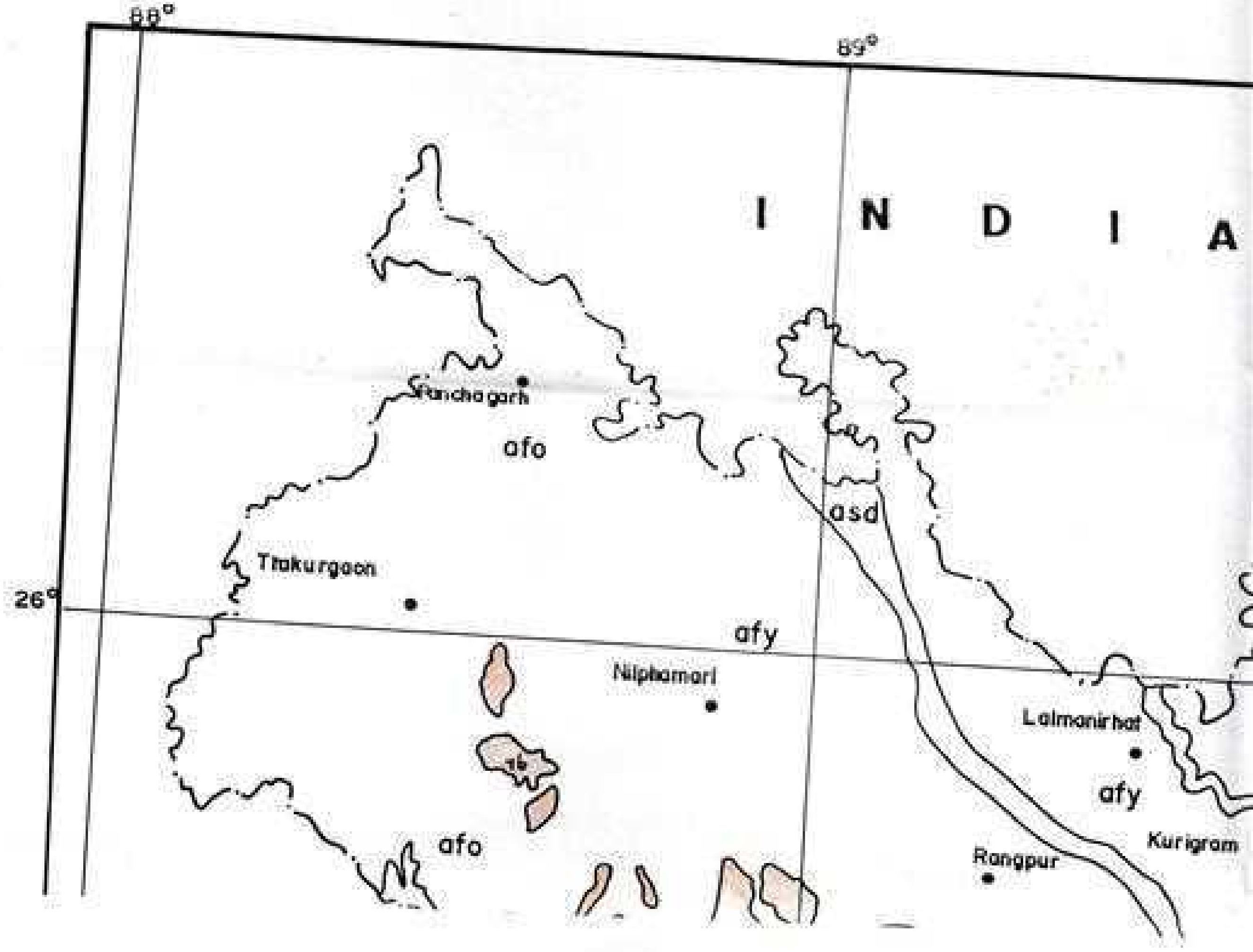

afo
Rangpur
Kurigram
Dinajpur
rb
rb
aty
rb
asl
Gaibanda
asc
rb
Joypur Hat
25°
asl
rb
asl
asl
asd
ppc
rb
asc
Bogra
ppc
Naogaon
asl
rb
asc
asc
Nawabganj
rb
ppc
asc
asd
asl
asl
asc
Nator
Sirajganj
RAJSHAHI
asc
ppc
asc
24°
dsl
asd
asc
Pabna
asl
dsd
Kushtia
ppc
ppc
Meherpur
Rajbari
dsd
dsd
Chuadanga
ppc
dsl
ppc
Jhenida
Magura
asl
ppc
ppc
Narail
Jessore
INDIA



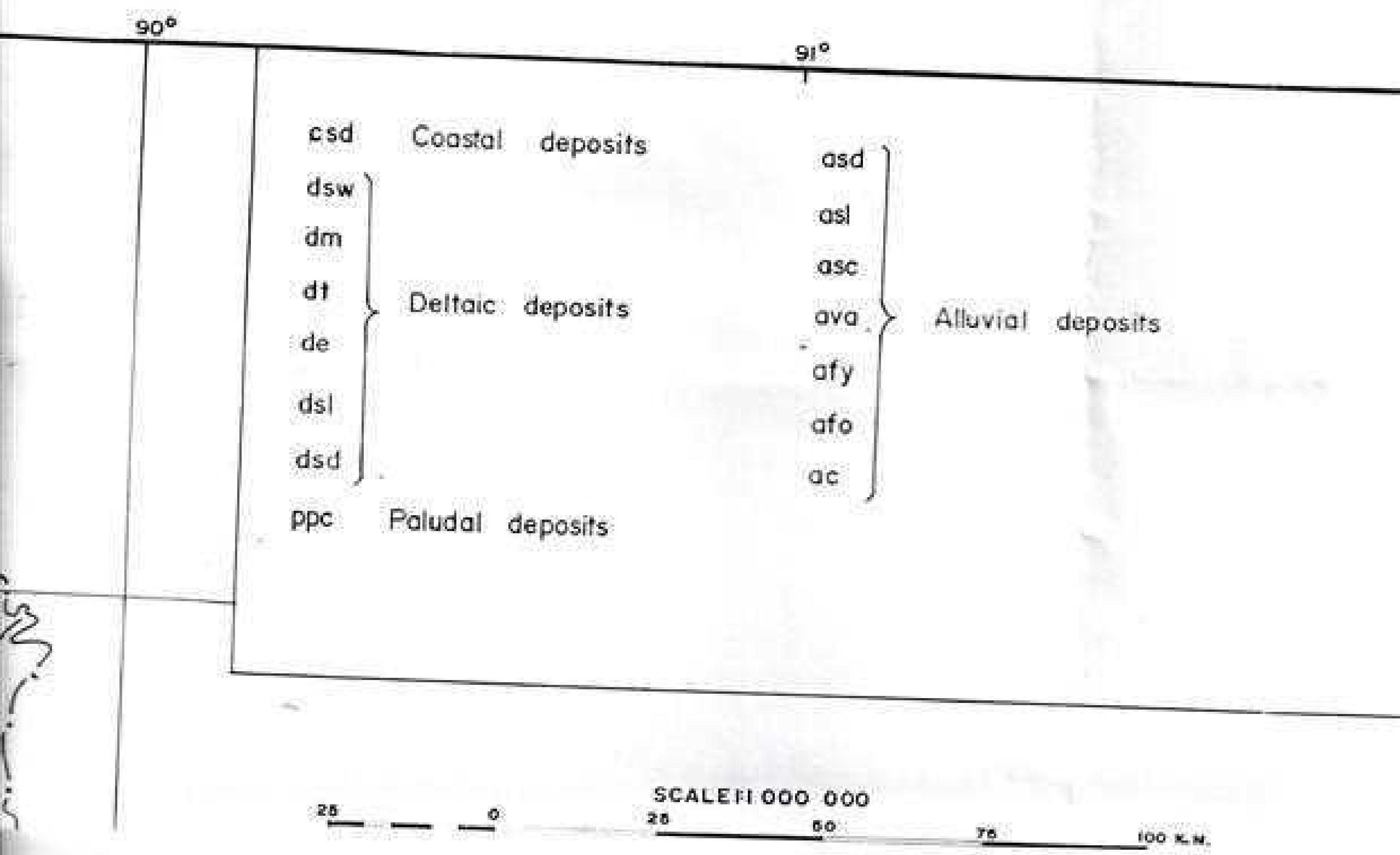
25
0
25
50
75
50 MILES
25
0
25
QTdd
afy
Tangua Haular Bil
Sunamganj
afy
QTdd
ppc
Sherpur
PPc
asl
Jamalpur
asl
asc
asl
Netrokona
asc
Sylhet
ac
ppc
ppc
asc
ppc
Mymensingh
rm
ppc
asc
ppc
ppc
Moulvi
asl
asl
Kishorganj
ppc
ac
Habiganj
asc
asc
QTdd
ava
QTdt
rm
Tangail
ppc
Jaydebpur
rm
Brahmanbaria
ava
ppc
Narsingdi
asd
rm
Manikganj
asc
rm
ac
asc
DHAKA
asl
asc
Narayanganj
Faridpur
asd
ppc
Munshiganj
ppc
ac
ac
Comilla
asl
rm
asc
dsd
ava
ppc
Shariatpur
Chandpur
ac
dsd
Madaripur
asc
ac

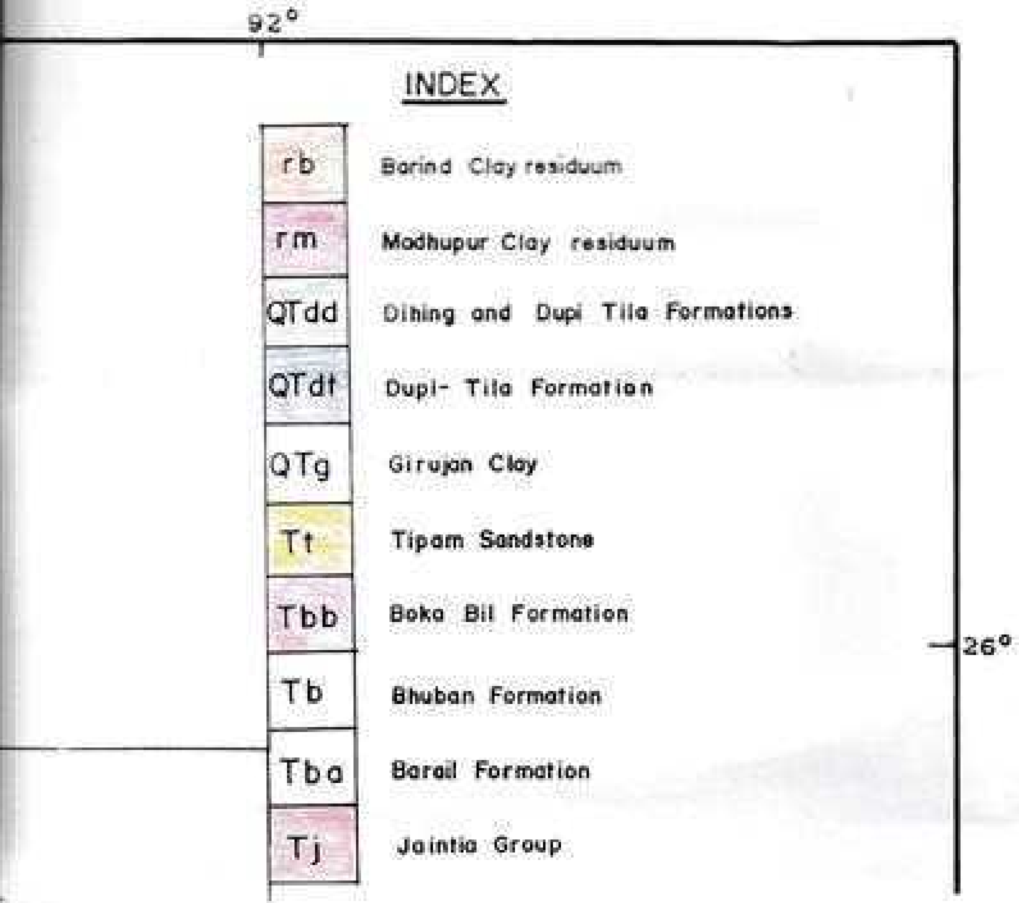


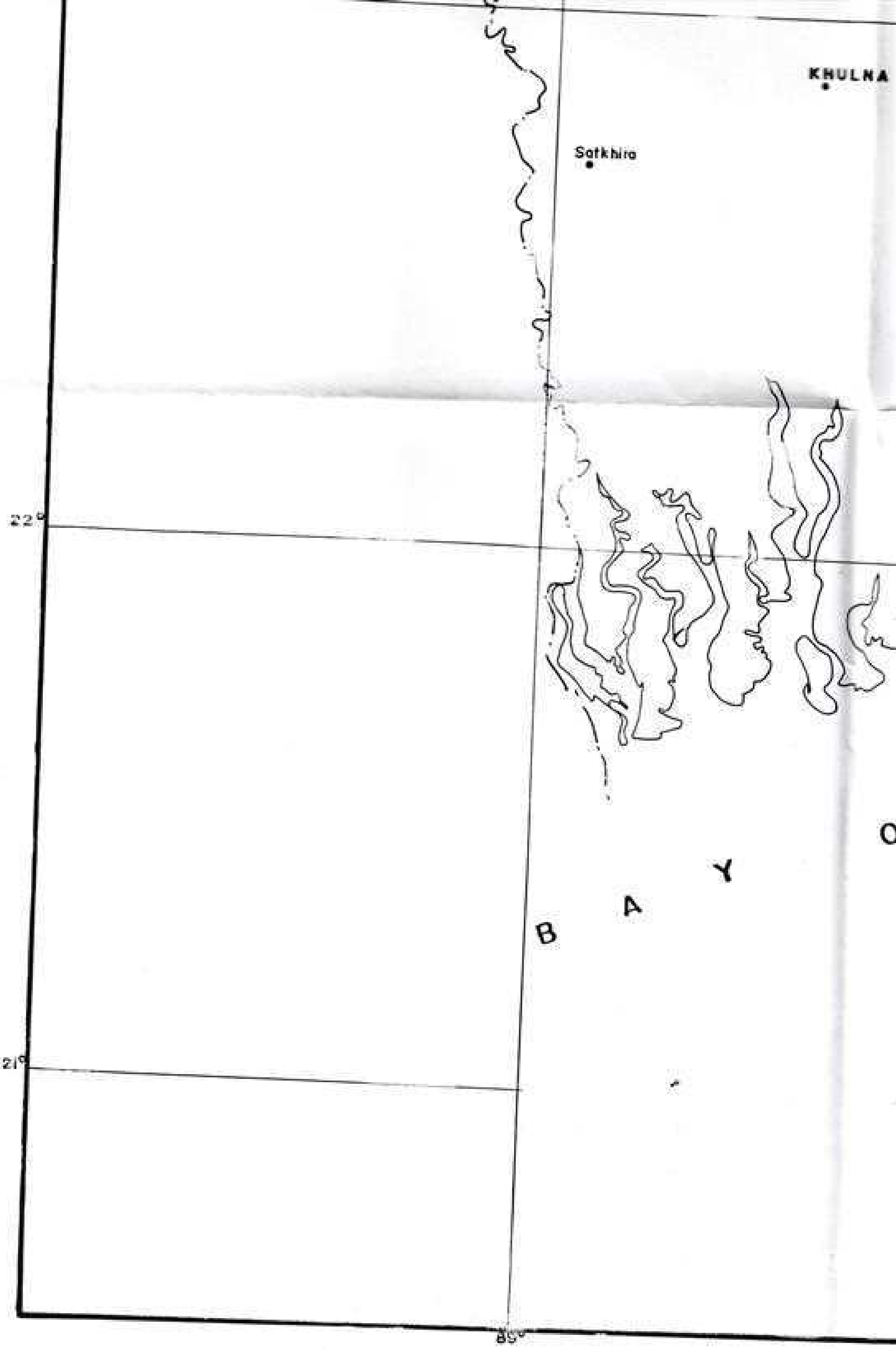
afy
Dupi Tila
QTg
QTdd
ppc
25°
ppc
QTdd
ppc
asc
Sylhet
asc
ppc
Moulvi Bazar
ava
QTdd
Tbb
24°
I N D I A
QTdd
Tbb
ava
Tbb
Tb
Tt
ava
ava
Khagrachhari
Tbb

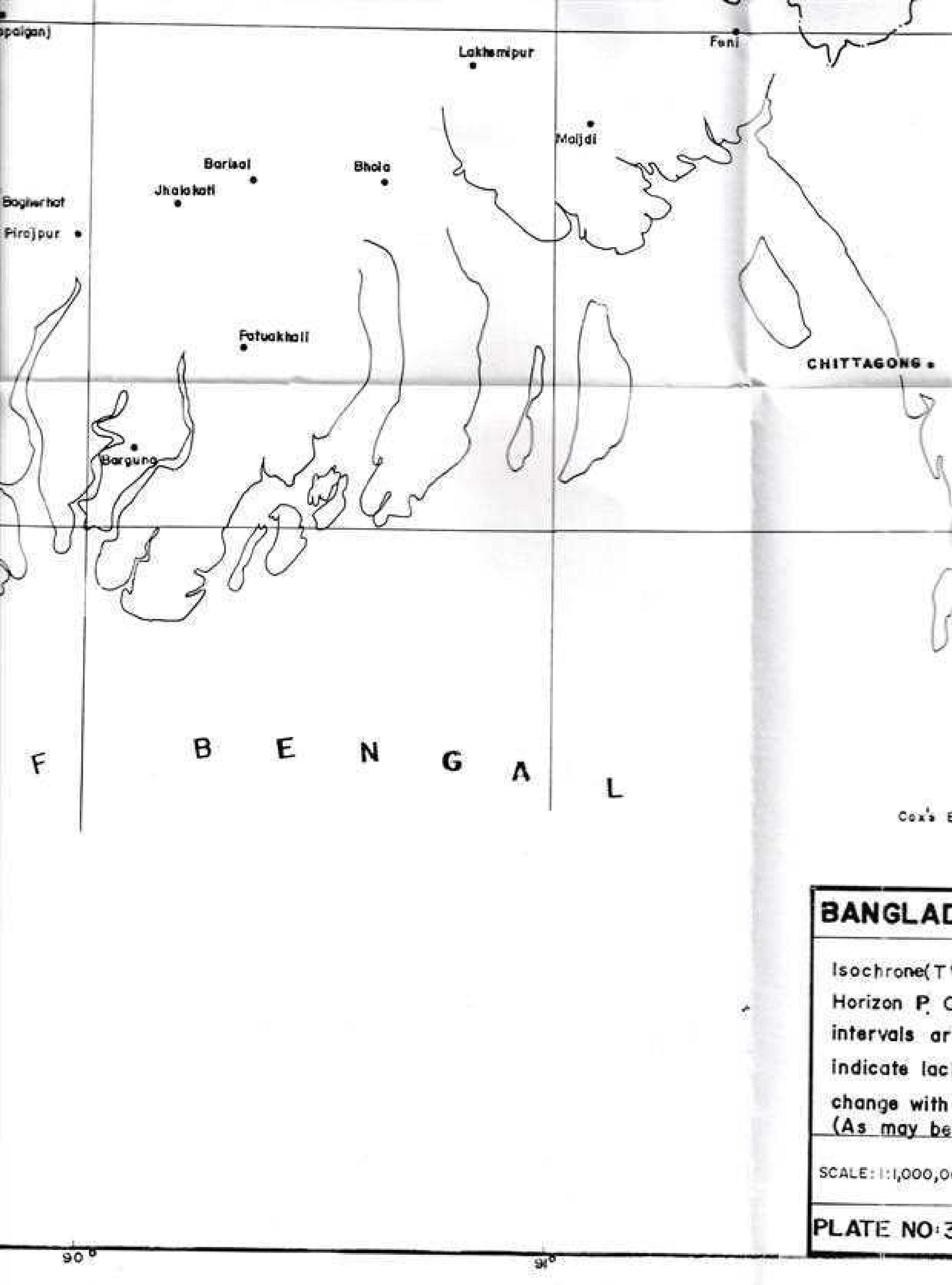


88°
89°
26°
I N D I A
Panchagarh
afo
asd
Thakurgaon
afy
Nilphamari
Lalmanirhat
afy
afo
Kurigram
Rangpur

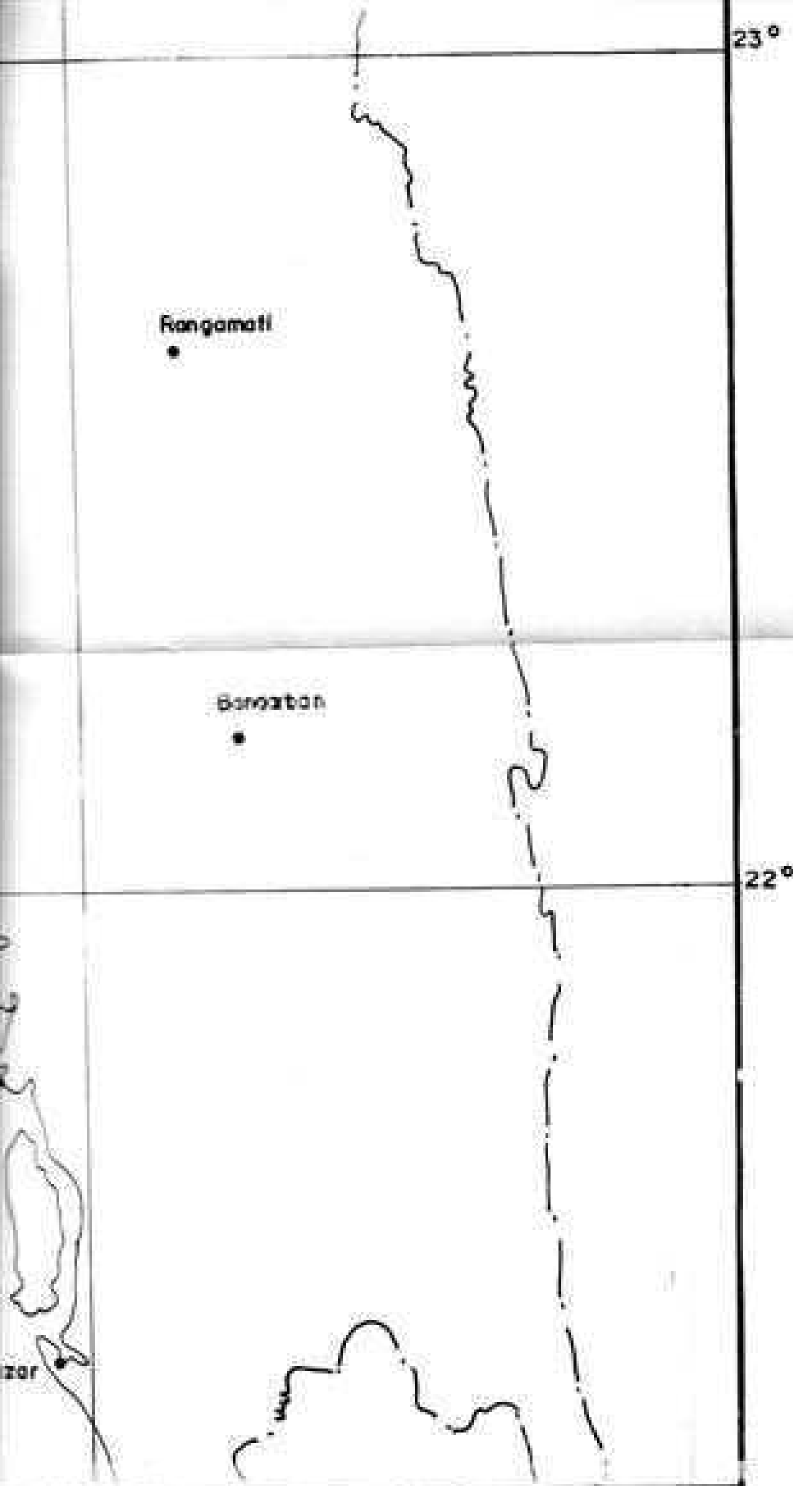

90°
91°
csd Coastal deposits
dsw
dm
dt
de
dsl
dsd
Deltaic deposits
ppc Paludal deposits
asd
asl
asc
ava
afy
afo
ac
Alluvial deposits
SCALE 1:1 000 000
25 0 25 50 75 100 K.M.


92°
INDEX
rb
Barind Clay residuum
rm
Madhupur Clay residuum
QTdd
Dihing and Dupi Tila Formations
QTdt
Dupi- Tila Formation
QTg
Girujan Clay
Tt
Tipam Sandstone
Tbb
Boka Bil Formation
26°
Tb
Bhuban Formation
Tba
Barail Formation
Tj
Jaintia Group


KHULNA
Satkhira
22°
21°
85°
B A Y O



Laktemipur
Feni
Maijdi
Barisal
Bhola
Jhalakati
Bagerhat
Pirojpur
Patuakhali
CHITTAGONG
Barguna
F B E N G A L
Cox's
Isochrone
Horizon
intervals
indicate
change with
(As may be
SCALE: 1:1,000,0
PLATE NO: 3
90°
91°



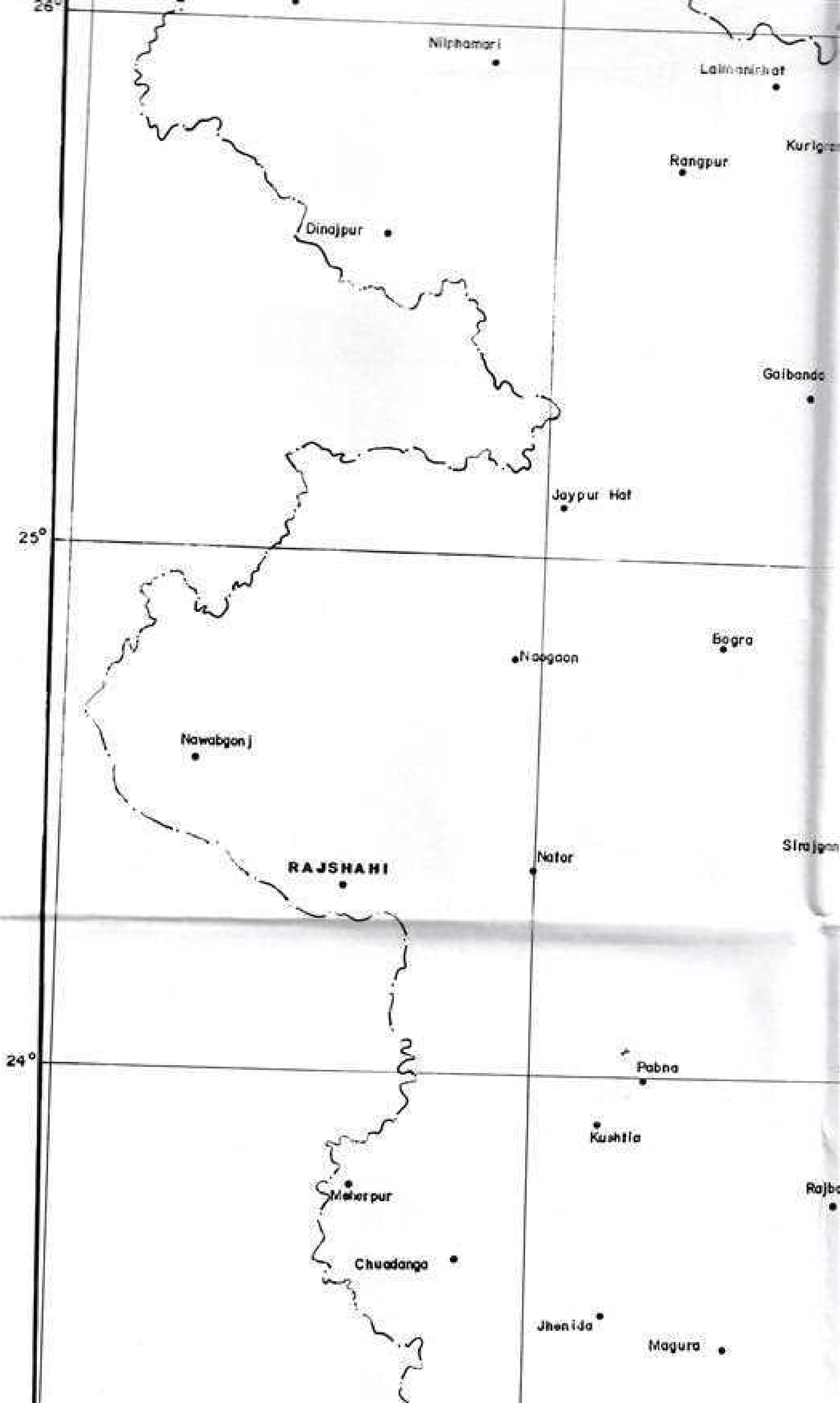
ESH PETROLEUM INSTITUTE

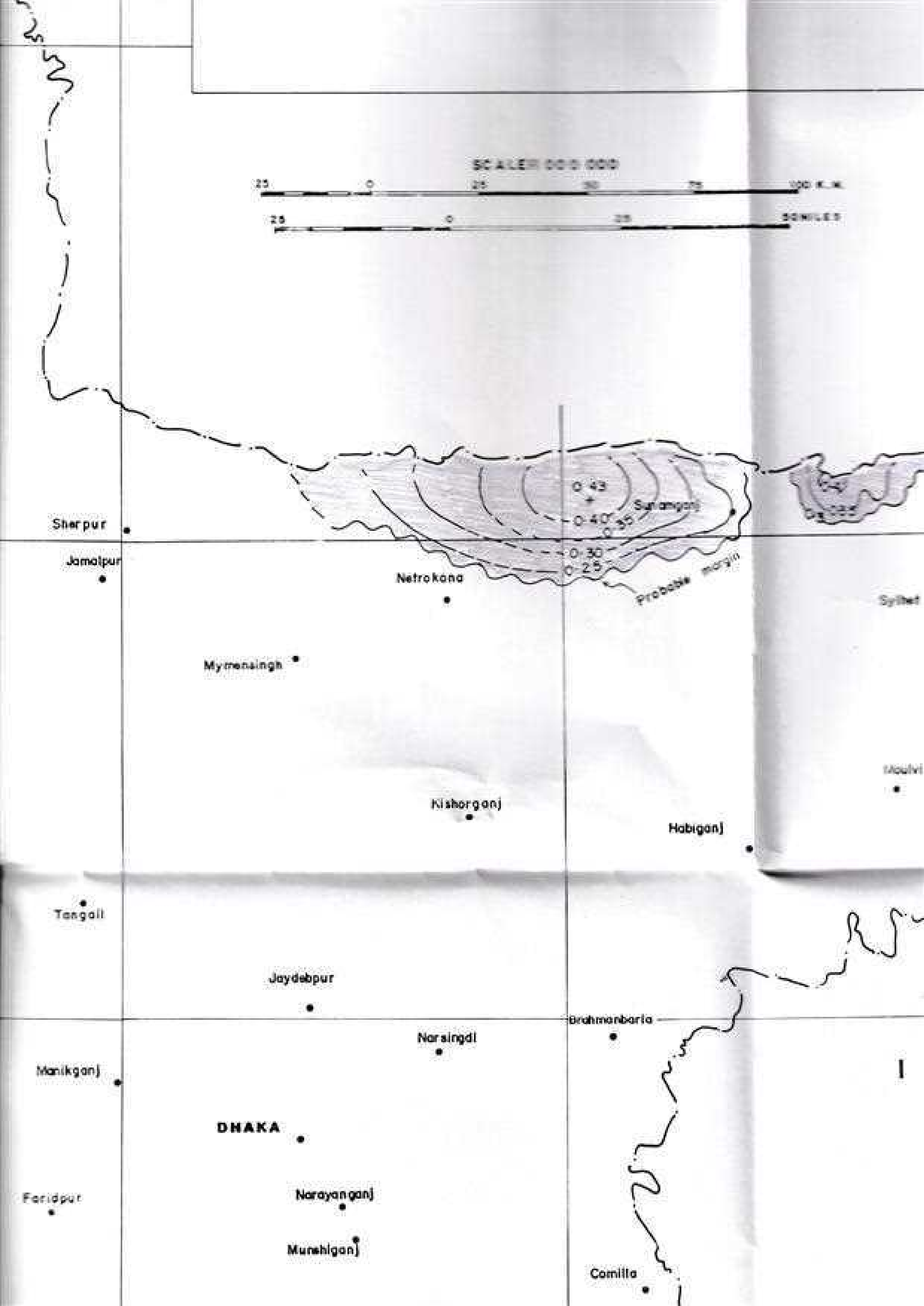
VT contour) map of seismo-stratigraphic
ontour values are marked and the contour
e not always regular. Dashed contours
k of data control and are subject to
new seismic data.
seen below Alluvium)

00

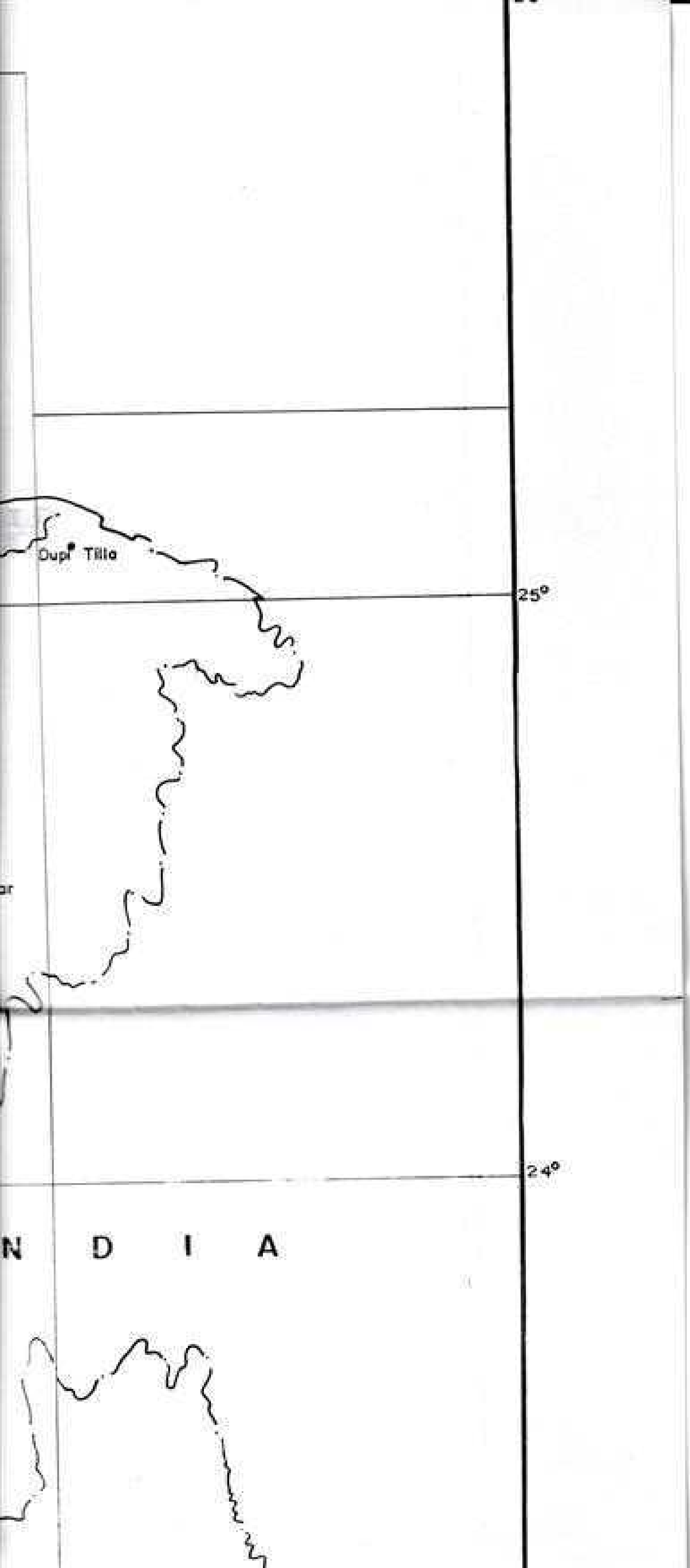
| Cm = 10 kms: 0 1 2 3 4 5 6 7
1 Inch = 16 miles: 0 1 2

5	Prepared by: Md Noor Alam	DATE: April, 1997

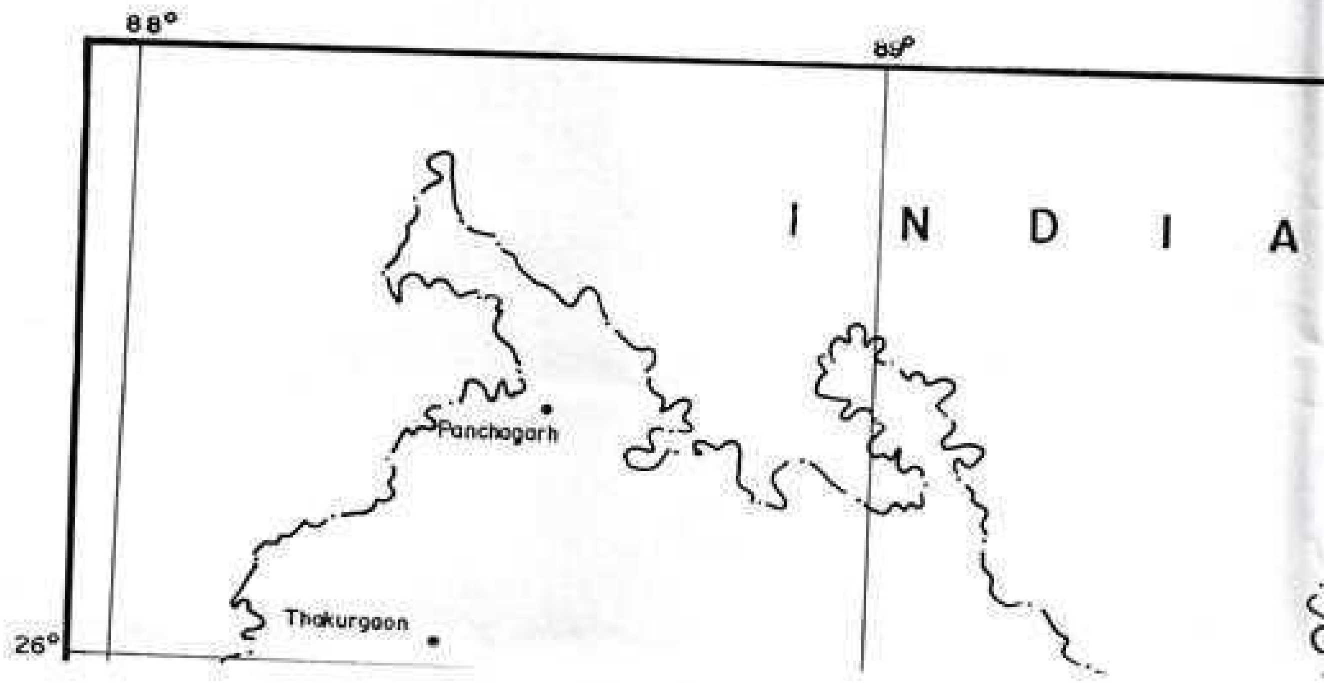

Nilphamari
Rangpur
Dinajpur
Gaibanda
Jaypur Hat
25°
Bogra
Naogaon
Nawabgonj
RAJSHAHI
Nator
24°
Pabna
Kushtia
Meherpur
Chuadanga
Jhenida
Magura

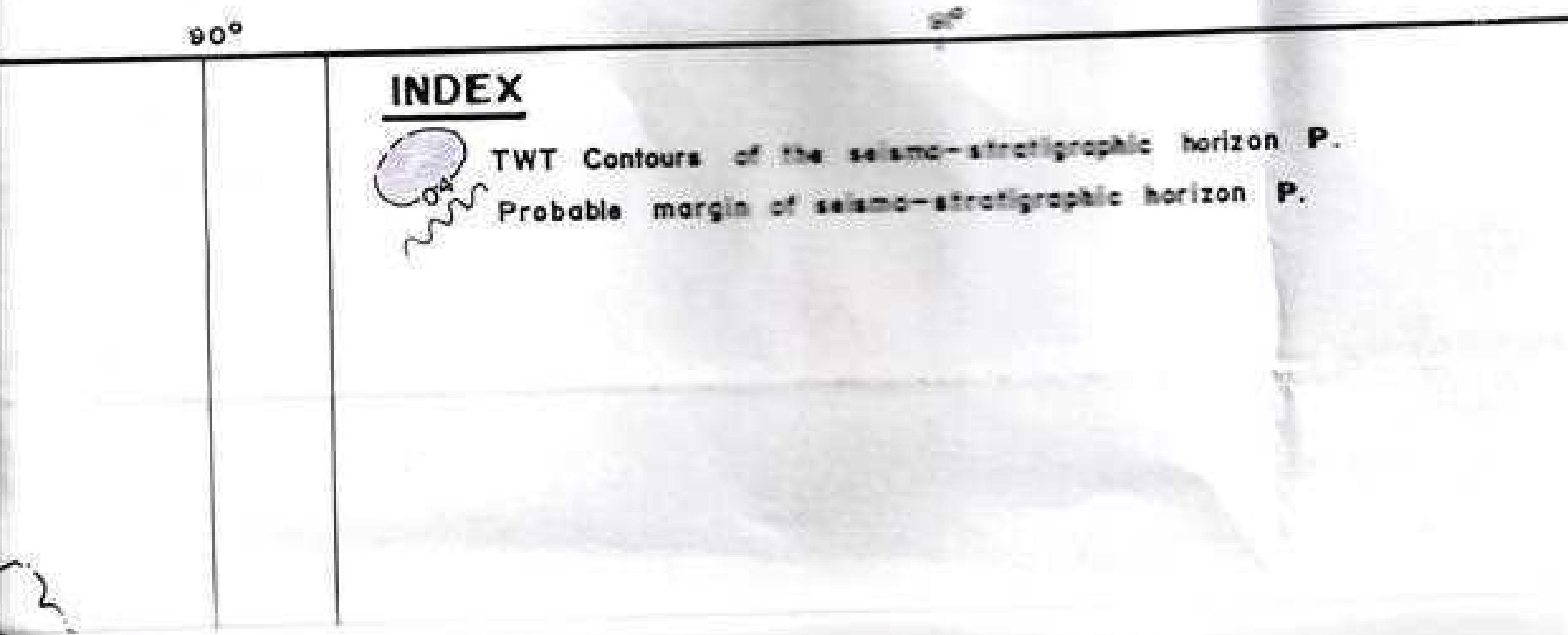


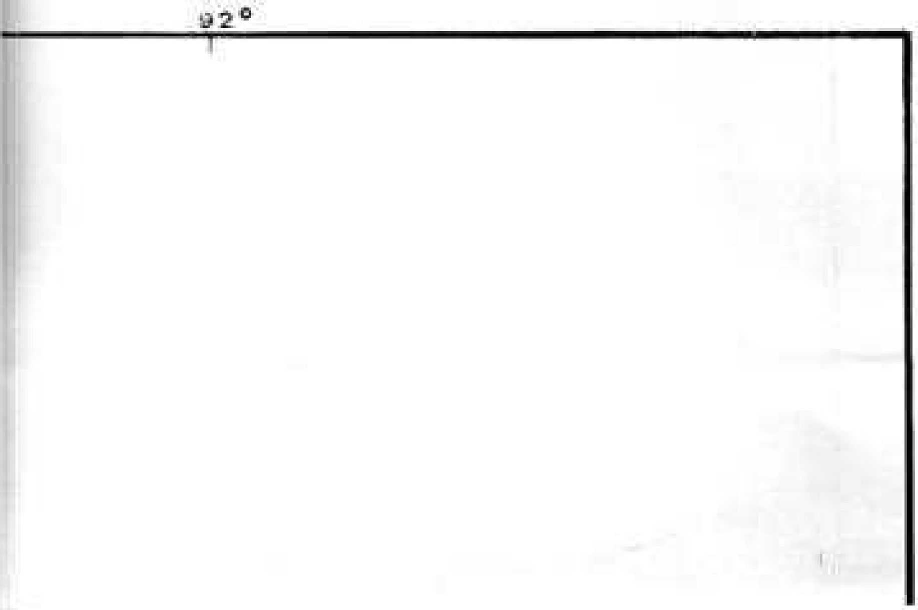
25
0
25
50
75
100 K.M.
25
0
25
50 MILES
0·43
Sunamganj
0·40
0·35
0·30
0·25
Probable margin
Sherpur
Jamalpur
Netrokona
Sylhet
Mymensingh
Moulvi
Kishorganj
Habiganj
Tangail
Jaydebpur
Brahmanbaria
Narsingdi
Manikganj
DHAKA
Faridpur
Narayanganj
Munshiganj
Comilla



Dupi Tilla
25°
24°
N D I A


88°
89°
INDIA
Panchagarh
Thakurgaon
26°


90°
INDEX
TWT Contours of the seismo-stratigraphic horizon P.
04
Probable margin of seismo-stratigraphic horizon P.


92°