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MINISTRY OF ENERGY AND MINERAL RESOURCES
GEOLOGICAL SURVEY OF BANGLADESH

PREPARED UNDER THE DIRECTION OF
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BOUGUER GRAVITY ANOMALY MAP OF BANGLADESH

বাংলাদেশের অভিকর্ষীয় মানচিত্র

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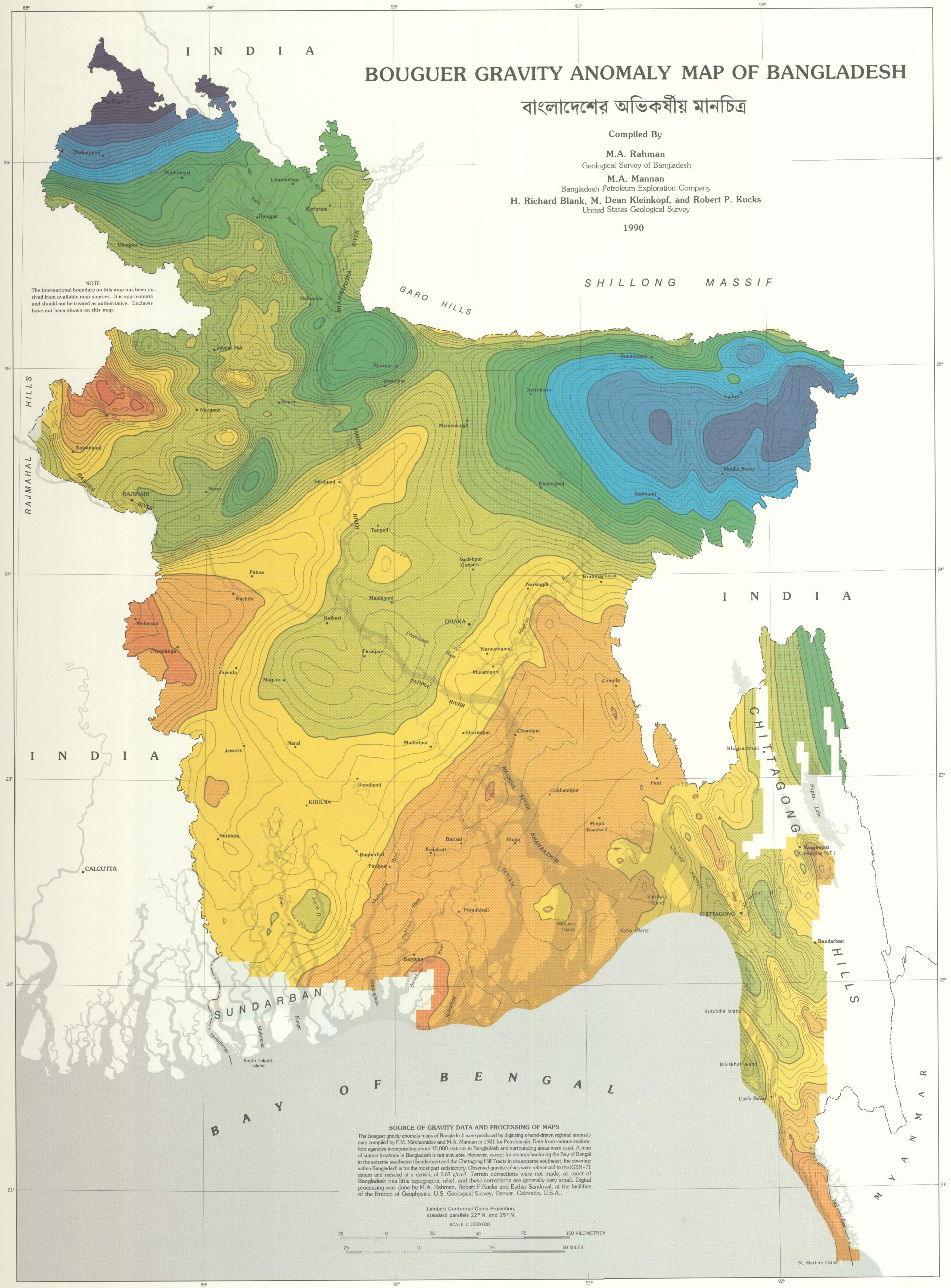
1990



NOTE
The international boundary on this map has been derived from available map sources. It is approximate and should not be treated as authoritative. Enclaves have not been shown on this map.

SOURCE OF GRAVITY DATA AND PROCESSING OF MAPS

The Bouguer gravity anomaly maps of Bangladesh were produced by digitizing a hand-drawn regional anomaly map compiled by F.M. Mirkhamidov and M.A. Mannan in 1981 for Petrobangla. Data from various exploration agencies incorporating about 15,000 stations in Bangladesh and surrounding areas were used. A map of station locations in Bangladesh is not available. However, except for an area bordering the Bay of Bengal in the extreme southwest (Sundarban) and the Chittagong Hill Tracts in the extreme southeast, the coverage within Bangladesh is for the most part satisfactory. Observed gravity values were referenced to the IGSN-71 datum and reduced at a density of 2.67 g/cm^3. Terrain corrections were not made, as most of Bangladesh has little topographic relief, and these corrections are generally very small. Digital processing was done by M.A. Rahman, Robert P.Kucks and Esther Sandoval, at the facilities of the Branch of Geophysics, U.S. Geological Survey, Denver, Colorado, U.S.A..

Lambert Conformal Conic Projection;
standard parallels 22° N. and 25° N.

SCALE 1:1000 000

25 0 25 50 75 100 KILOMETRES

25 0 25 50 MILES

Base compiled from LANDSAT Satellite Digital Mosaic, 1984, with permission of Space Research and Remote Sensing Organization (SPARRSO), Bangladesh, and other available topographic maps.

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BOUGUER GRAVITY ANOMALY MAP OF BANGLADESH
Scale 1:1,000,000

DISCUSSION

This map is one in the map series of Bangladesh prepared and published by the Geological Survey of Bangladesh (GSB) at a scale of 1:1,000,000, in support of geologic framework investigations, mineral and energy resources evaluation, and natural hazards mitigation. The other maps are the Geologic Map of Bangladesh (Alam and others, 1990), and the Aeromagnetic Anomaly Map of Bangladesh (Rahman and others, 1990).

Also displayed on this sheet are a map showing the gravity field of Bangladesh in relation to that of its immediate surroundings, with overprinted interpretive data (figure 1), and a generalized tectonic map of Bangladesh and adjoining areas (figure 2). These maps are at a scale of 1:4,000,000. Gravity data for the regional map of figure 1 were originally compiled by Mirkhamidov and Mannan (1981) at Petrobangla; we have extracted a subset of the regional data set to produce the map of Bangladesh. The same color-coded intensity scheme is used on both large- and small-scale gravity maps, but for clarity black-line contours on the latter have been omitted. A small-scale gravity map of Bangladesh and vicinity was previously published by Ali and Raghava (1985).

Trends of gravity gradient belts shown on figure 1 were obtained through use of software developed by Blakely and Simpson (1986), in which a grid of anomaly horizontal gradient is searched for maxima meeting pre-set criteria. Anticlinal fold axes were inferred from linear anomaly highs and perturbations of the regional field. Other fold axes were interpreted from LANDSAT imagery (SPARRSO, 1984).

Figure 2 (after Alam and others, 1990) differs somewhat from figure 1 in respect to the location of major tectonic elements, including certain features presumably interpreted from gravity anomalies. These features will be referred to in the ensuing paragraphs. Note particularly that the "Bengal Basin" of figure 2 encompasses a portion of the region known to be floored by Archaean rock northwest of the Hinge, and continental crust is inferred to extend southeast of the "Hinge" to the vicinity of the "Barisal gravity high".

The total Bouguer anomaly relief in Bangladesh is about 190 mGal, with values ranging from about +11 mGal to -179 mGal. The most negative values are found in the extreme northwest and are associated with the Himalayan Foredeep; the most positive values are found in the north and are associated with shallow Archaean crystalline basement. Several principal gravity anomaly "domains" can be distinguished on the basis of characteristic anomaly wavelengths, levels, and trends. These domains correspond with tectonic provinces or subprovinces, and consist of the Himalayan Foredeep, the Indian Shield (including the Rangpur Platform and Bogra Shelf), the Bengal Foredeep (central Bengal Basin of figure 2), the Sylhet Trough, (also known as Sylhet Basin or Surma Basin), and the Tripura-Chittagong Fold Belt domains.

The Himalayan Foredeep domain is characterized by nearly east-trending anomaly contours, uniform gradient, and strongly negative anomaly values. This domain reflects the combined effects of a thick wedge of low-density sedimentary rock and a north-dipping, denser substrate in the Himalayan collision zone.

The Indian Shield domain, immediately to the south, is characterized by variable trends, relatively short-wavelength anomalies, and field intensities from +11 mGal to about -60 mGal. This domain is largely or entirely underlain by Archaean crystalline rocks comprising an east-northeast-trending subsurface connection between rocks exposed in the Rajmahal Hills and those in the Shillong Massif, both in India. The Archaean basement forms a broad arch whose crest in Bangladesh, known as the Rangpur Platform or Rangpur Saddle, rises to within 130 m of the surface (Zaher and Rahman, 1980). Short-wavelength gravity highs on the Rangpur Platform generally correspond to local basement highs, although in some places they also reflect intrabasement density contrasts. The highest Bouguer values in this region occur on a long-wavelength anomaly (Malda gravity high) associated with a broad basement high that extends into West Bengal (Mukhopadhyay and others, 1986). On the basis of geomorphic evidence and surface lithology, the area of the Barind Tract (continuation of Malda high in Bangladesh) has been undergoing active uplift during Holocene time (Alam and others, 1990; Huq and others, in press).

Short-wavelength, linear gravity lows on the Rangpur Platform are due to fault-bounded depressions containing Permian sedimentary rocks (Gondwana Group), in which potentially exploitable coal measures occur (Farah, 1973; Zaher and Rahman, 1980; Rahman and others, in press). Upper Mesozoic trap volcanics are also locally preserved. A prominent negative anomaly (Tista Gravity Low) extends south-southeast across the crest of the basement arch from near the mouth of the Tista River. This feature is due to a half-graben of about 300-m maximum structural relief as interpreted by the authors from seismic reflection data. Anomaly lows having longer wavelengths and greater amplitudes occur on the south flank of the basement arch in a region called the Bogra Shelf. They form a northeast-trending anomaly trough that follows a string of deep Gondwana basins referred to as the "Bogra Depression". The maximum depth to Archaean basement in the Bogra depression is about 8 km (Mirkamidov and Mannan, 1981). At its northeast end, the Bogra depression apparently connects with the graben delineated by the Tista gravity low. For most of its extent the depression corresponds to an aeromagnetic high (Rahman and others, 1990) produced by thick sequences of trap basalts overlying the Gondwana sediments.

The anomaly lows of the Bogra depression are bounded on the southeast by a prominent, northeast-trending positive gravity anomaly that extends at least from Calcutta through Pabna to near Mymensingh and has been called the Calcutta-Mymensingh gravity high. This high is caused by elevated basement on the margin of the Bogra Shelf, as indicated by seismic reflection data. Whether the basement is composed of Archaean crystalline rock or younger material such as Mesozoic mafic intrusive rock is unknown. The crest of this anomaly more or less coincides with the upper lip of the "Hinge", which is defined as a zone of monoclinal flexure on a specific seismic reflector (the Eocene Sylhet Limestone). The Hinge is depicted on figure 1 by an unbroken shaded band where its location is well constrained (between two seismic reflection profiles examined by the authors) and by a broken shaded band where its location is merely inferred. It separates shelf facies from geosynclinal facies in the Tertiary sedimentary rocks and is a zone of pronounced differential thickening and subsidence (Evans, 1964). Structural relief on the Eocene across the Hinge is 3-4 km or more and presumably much greater on the basement. The Hinge apparently extends south-southwest from Calcutta into the Bay of Bengal and merges with a southwest-trending structural zone interpreted as a Mesozoic continental margin of peninsular India (Raman and others, 1986; Salt and others, 1986). Comparison of gravity anomaly profiles across the Calcutta-Mymensingh high and the Hinge with typical profiles across continental margins (for example, see Dehlinger, 1978) seems to support interpretation of this region as a continuation of the Mesozoic continental margin of India.

The Hinge is bordered on the southeast by the Bengal Foredeep anomaly domain (we have adopted the term "Bengal Foredeep" to distinguish this region from other regions that are part of the greater Bengal Basin of some authors). This domain is characterized by very long wavelength, low-amplitude, northeast-trending anomalies that parallel the Hinge and have Bouguer values ranging from about 0 to -20 mGal. The principal anomalies, from northwest to southeast, have been named the Faridpur Gravity Trough, Barisal Gravity High ("Barisal-Chandpur" gravity high of Alam, 1972), and Hatia Gravity Trough (see fig. 2). The Hatia Trough is commonly depicted as a north- or north-northwest-trending feature (fig. 2), but its long-wavelength component likely extends southwest from the vicinity of Chittagong into the Bay of Bengal. These three anomalies do not correspond with features observed on seismic reflection records and their origin has not been established.

Seismic, aeromagnetic, and deep-drilling data all indicate the presence of enormous thicknesses of sedimentary deposits in the Bengal Foredeep domain. Estimates of maximum depth to basement range from 10-12 km (Hunting Geology and Geophysics Ltd., 1981) to 18-20 km (Mirkhamidov and Mannan, 1981). The density deficiency of the sediments is not accounted for by the relatively high Bouguer gravity field, as was early recognized by Evans and Crompton (1946); the crust beneath the sediments is required to be either denser than normal continental crust or extraordinarily thin. The observed data can be modeled with a continental crust thinning to 5 km in the vicinity of the Barisal gravity high and a mantle rise (Mirkhamidov and Mannan, 1981). However, recent investigations of earthquake data indicate that the substrate of the domain as a whole is of "continental" thickness (Brune and Singh, 1986; see also Varma, 1974). The substrate may consist of "transitional" mafic crust of Mesozoic age, which might be expected to possess the requisite density and thickness and is typical of rifted continental margins. Depths to basement computed by Mirkhamidov and Mannan (1981) do not reflect basement relief corresponding specifically to the Faridpur, Barisal, and Hatia gravity features but instead delineate a broad, north-northwest-trending depression, which they named the Patuakhali Trough (also see Shamsuddin, 1989, fig. 7). This trough abuts in the north against a basement rise, the Tangail-Tripura high. Their interpreted configuration of the basement surface conforms in a general way to the basement surface interpreted from aeromagnetic data by Hunting Geology and Geophysics Ltd. (1981), although depths calculated from the magnetics are much shallower (see Rahman and others, 1990). Both sets of depth estimates suggest a basement depression more or less aligned with the outer margin of the Tripura-Chittagong Fold Belt, as delineated on the basis of anomaly perturbations attributable to concealed folds.

The Bengal Foredeep domain is bordered on the northeast and east by anomaly domains associated with the Sylhet (Surma) Trough and Tripura-Chittagong Fold Belt, respectively. Both of the latter domains are in areas having thick sequences of sedimentary rock. The Sylhet domain consists mainly of a very deep (minimum anomaly level -85 mGal) anomaly depression, elongated in an easterly direction. Discrete lows within the main depression are produced by the interfering effects of superimposed short-wavelength anomalies due to the northernmost folds of the Tripura-Chittagong Fold Belt. These folds, readily identified on reflection records and, in some cases, on satellite imagery, have variable northerly to easterly trends as a result of the interaction of east-west and north-south plate convergences. The Tripura-Chittagong anomaly domain is distinguished from the Sylhet Trough domain by much higher background anomaly levels and by the dominance of north-northwest- to north-trending short-wavelength linear anomalies. Most of the linear anomalies correspond to folds with pronounced topographic expression. Anomaly values in this domain range from about +10 mGal to -32 mGal. However, the gravity field of the eastern part of the domain (Chittagong Hills) is poorly known.

The regional Bouguer anomaly map (fig. 1) has a total anomaly relief of about 233 mGal, the increase with respect to that of the 1:1,000,000-scale map being mainly due to inclusion of strongly positive anomalies over the Shillong Massif in the north (+44 mGal maximum) and over the continental slope in the Bay of Bengal (+50 mGal maximum). This map (fig. 1) better delineates the negative gravity anomaly of the Himalayan Foredeep, the Malda gravity high, the gravity trough of the Bogra Shelf, the Calcutta-Mymensingh gravity high, and the Hatia gravity trough. The map also reveals a regional gradient belt that extends south from the Sylhet Trough between longitudes 92° and 93° E. This east-deepening Bouguer anomaly field immediately east of the Tripura-Chittagong Fold Belt indicates an accretionary wedge of sediment and a deepening basement. As much as 17 km of Tertiary marine sediment may overlie a substrate of oceanic crust in the Indo-Burman Ranges (Curray and others, 1979).

A general interpretation of the regional map (fig. 1) has been made by Ali and Raghava (1985), building on the work of Verma and Mukhopadhyay (1977), Choudhury and Datta (1973), and many others. An important focus of the Ali and Raghava interpretation is regional-residual separations. They point out that exaggerated residuals and lack of adequate density controls may have led to overestimation of the thickness of sedimentary rock in the Sylhet Trough and elsewhere in previous gravity interpretations. If so, revised gravity-based depths may be more nearly compatible with basement depths estimated from aeromagnetic data. The latter have yielded depths of only 6-7 km for the Sylhet Trough (Hunting Geology and Geophysics Ltd., 1981; see also Rahman and others, 1990, fig. 1). However, the magnetics may be detecting intra-trough mafic lavas rather than the density basement.

Data from the regional map also permit a gravity interpretation of the Dauki fault zone as a tectonic boundary between the Sylhet Trough and the Shillong Massif. The Dauki Fault was originally interpreted as a tear fault with 250 km of right-lateral displacement (Evans, 1964). All available geological information suggests that the Shillong Massif is a continuation of the Archaean of the Rajmahal area through the Rangpur Platform. Recent work indicates that the Dauki Fault is a high-angle reverse fault with a lateral component and is the southern limit of a possible thrust beneath the Shillong Massif (Herd, 1989; Johnson and Alam, 1990; Molnar, 1987). The gravity gradient across the Dauki zone seems to support the concept of a density overhang but requires further analysis. We find no evidence from either the Bouguer gravity anomaly map or the aeromagnetic anomaly map (Rahman and others, 1990) to suggest that the Dauki fault zone continues west across northwestern Bangladesh. Gravity gradient trends (fig. 1) instead suggest that the fault splays to the northwest with decreasing offsets, as though the Shillong block has been rotated about an east-trending horizontal axis along its northern margin.

Archaean crystalline rock of the Shillong Massif occurs at a maximum elevation of about 2 km and a mean elevation of perhaps 1 km above the surface of the Sylhet area (approximately sea level). Yet Bouguer anomaly levels over most of the Shillong Massif are strongly positive (fig. 1), reaching levels of about +25 mGal even where the elevation exceeds one kilometer. Pratt-Hayford residual isostatic anomalies on the Shillong Massif are as large as +100 mGal; those for the Sylhet Trough are negative with a minimum of about -50 mGal (Gulatee, 1956). Isostatic anomalies over most of the remaining area on figure 1 are near zero. The significance of the Shillong/Sylhet anomalies has been addressed by Qureshy (1971), Verma and Gupta (1973), Verma and others (1976), Verma and Mukhadpadhyay (1977), and Ali and Raghava (1985), among others. Verma and others (1976) proposed that mafic material has been intruded along the Dauki fault zone to account for the large positive anomalies of the Shillong Massif. Regionality of isostatic compensation for the Shillong-Sylhet area was advocated by Verma and Gupta (1973); Chen and Molnar (1990) emphasize the role of an underthrust slab in providing the strength of crust necessary to support the Shillong Massif. We speculate that rise of the Shillong Massif is in some way related to northward advance of the Hinge during plate convergence, and perhaps ultimately to differences in crustal competence between initially Archaean and subsequently "transitional" Mesozoic crust that is being underthrust.

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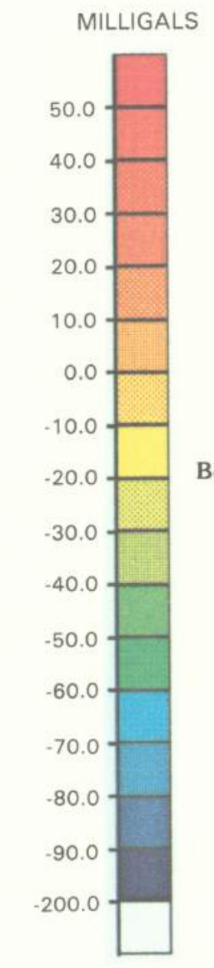
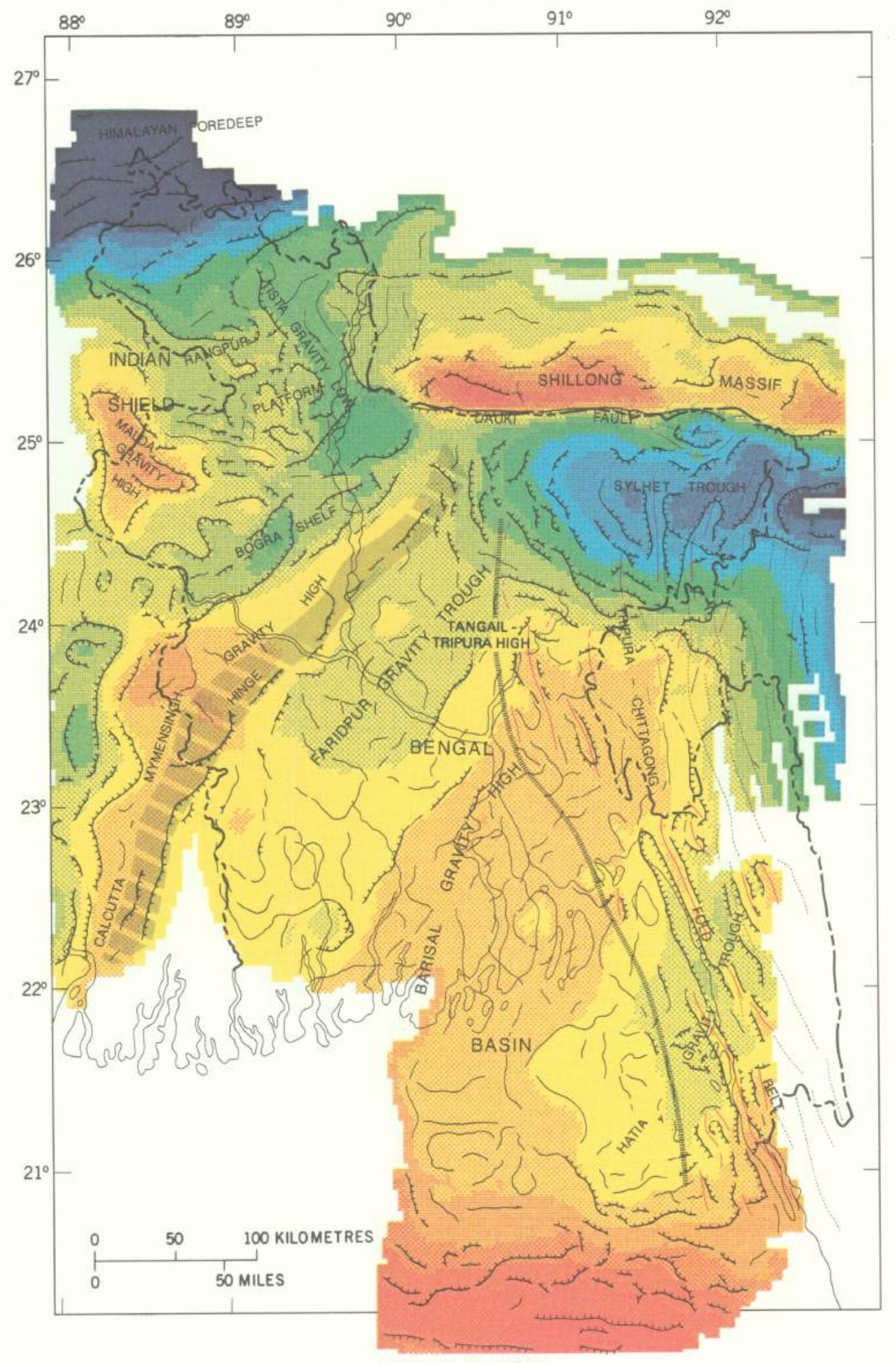


Bouguer gravity anomaly field intensity in 10-mGal intervals

—— -60 ——
Contour showing Bouguer gravity anomaly field intensity —Interval 2 mGal (milligals). Reduction density 2.67 g/cm^3. Datum IGSN-71.

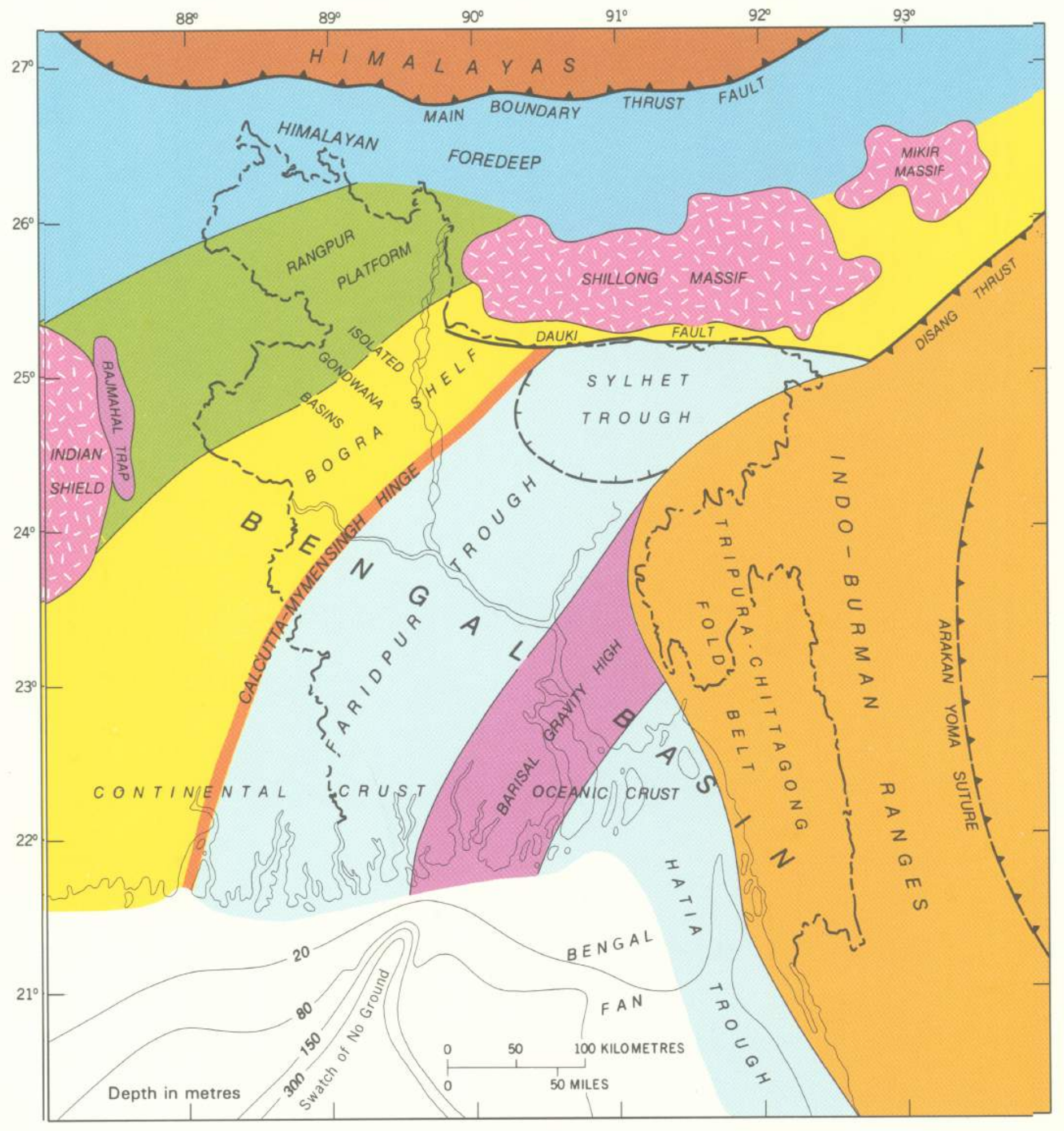
Figure 1 : BOUGUER GRAVITY ANOMALY MAP OF BANGLADESH AND ADJOINING AREAS
Showing gradient trends in relation to major tectonic elements after Mirkhamidov and Mannan (1981) and Ali and Raghava (1985).



EXPLANATION

- Trend delineated by steep gravity gradient—Teeth on side of lower anomaly level
- Trend delineated by gentle gravity gradient
- Axial trace of anticlinal fold inferred from gravity map
- Axis of fold sketched from Landsat imagery
- Western margin of Tripura-Chittagong Fold Belt

Figure 2 : GENERALIZED TECTONIC MAP OF BANGLADESH AND ADJOINING AREAS
Modified from Alam and others (1990)



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