Journal of Nepal Geological Society, 1998, Vol. 18, pp. 135-141

Geophysical interpretation of tectonic features in Bangladesh

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ABSTRACT

Bangladesh occupies the major part of the Bengal basin. It is mainly a plain fluvio-deltaic land. Except the eastern and northeastern Tertiary hilly region, the whole country is covered with thick Quaternary sediments.

Tectonic features in Bangladesh, except the eastern and northeastern hilly structures, are hidden under thick cover of sediments. Gravity anomalies clearly show the locations of major subsurface tectonic features of the country, namely a) Himalayan foredeep, b) Rangpur platform, c) Hinge zone, d) Surma basin and e) Bengal foredeep. Magnetic anomalies and the seismic sections also support the gravity results.

Shape, extent and depth of the tectonic features in Bangladesh are interpreted from geophysical data, particularly from the gravity data supported by available geological and drilling information. Interpretation shows that the Rangpur platform, situated in the northwestern Bangladesh, is the shallowest subsurface tectonic feature in the country. The northern part of the Rangpur platform slopes down to the Himalayan foredeep and the southern part to the Hinge zone. The Surma Basin, containing very thick sediments, lies in north-east corner of the country; and the Bengal foredeep, the most extended tectonic feature, occupies the southern deltaic part of the country. The Fold Belt, the only exposed tectonic feature, lies in the eastern and northeastern hilly region of the country.

INTRODUCTION

Bangladesh is mainly a plain fluvio-deltaic land. Except the eastern and northeastern hilly structures, tectonic features in Bangladesh are hidden under thick cover of sediments.

Geophysical explorations are carried out to explore the subsurface geology and natural resources of Bangladesh. Geophysical explorations have also revealed the subsurface tectonic features of the country. Geophysical interpretation of the tectonic features, their shape, extent and depth are presented in this paper.

Physiography

Bangladesh is mainly a fluvio-deltaic land and it occupies the major part of the Bengal Basin. Physiographically, Bangladesh is divided into four distinct regions (Khan, 1991):

1. The eastern and northern frontier hilly regions,
2. The table land,
3. The flood plain of the Ganges, Brahmaputra-Jamuna and Meghna river Systems, and
4. The delta.

A physiographic map of Bangladesh is shown in Fig. 1. Except the eastern and northern frontier hilly regions, the whole of Bangladesh is a plain land; and the subsurface tectonic features in the country are hidden under thick cover of Quaternary sediments.

Stratigraphy

Bangladesh is covered with thick sediments. Deltaic and alluvial deposits of the Ganges, Brahmaputra and Meghna river systems cover nearly 80% of Bangladesh. Other deposits are the coastal, paludal and residual deposits. These are basically Quaternary deposits (Alam et al., 1990).

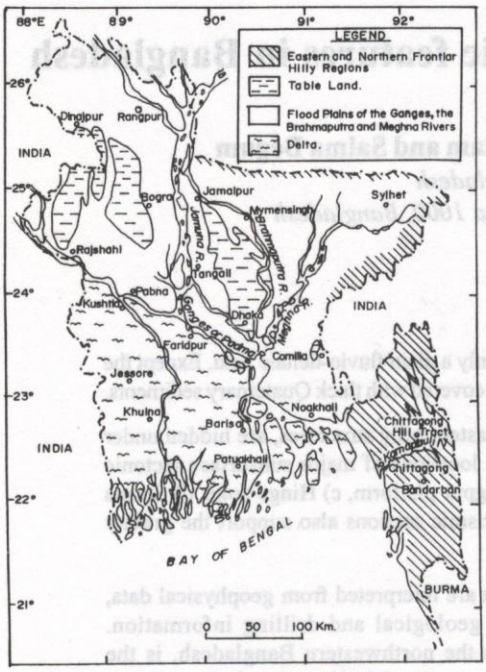

Fig. 1: Physiographic map of Bangladesh.

Table 1: Geological succession of Bangladesh (Khan, 1991).

ERA	PERIOD		EPOCH	GROUP	FORMATION
CENOZOIC	Quaternary		Holocene		Alluvium
			Pleistocene		Unconformity
					Madhupur Clay
					St. Martin's Limestone
					Unconformity
	TERTIARY	NEOGENE	Pliocene		Dihing
			Late Miocene		Unconformity
					Dupi Tila Claystone
					Dupi Tila Sandstone
			Middle Miocene	Tipam	Unconformity
					Girujan clay
					Tipam sandstone
			Early Miocene	Surma	
		PALEOGENE	Oligocene		Unconformity
				Barail	Renji
					Jenum
			Late Eocene		Unconformity
			Middle Eocene	Jaintia	Kopili shale
			Early Eocene to Paleocene		Sylhet limestone
					Tura sandstone
MESOZOIC	Cretaceous		Early Cretaceous		Unconformity
	Jurassic		Late Jurassic	Rajmahal	Sibganj
PALEOZOIC	Permian		Late Permian		Rajmahal
			Early Permian	Gondwana	Unconformity
PRECAMBRIAN					Unconformity

Based on drillhole log data, the generalised stratigraphic succession of Bangladesh comprises of: Basement Complex; Gondwana, Rajmahal, Jaintia, Barail, Surma and Tipam Groups; Dupi Tila Formation, Madhupur Clay and Alluvium. The generalised geological successions of Bangladesh (Khan, 1991) are given in Table 1.

TECTONIC FEATURES

Bouguer gravity anomaly relief in Bangladesh is about 190 mGals with values ranging from +10 to -180 mGals (Fig. 2, Rahman et al., 1990).

The most negative gravity values are found in the extreme north-western part of the country; and the rapid northward fall of gravity values from -50 to -180 mGals indicates the presence of a tectonic feature known as the Himalayan foredeep.

On the other hand, the most positive gravity values are also found in the north-western part of the country; and the gravity anomalies ranging from -50 to +10 mGals along with a number of local

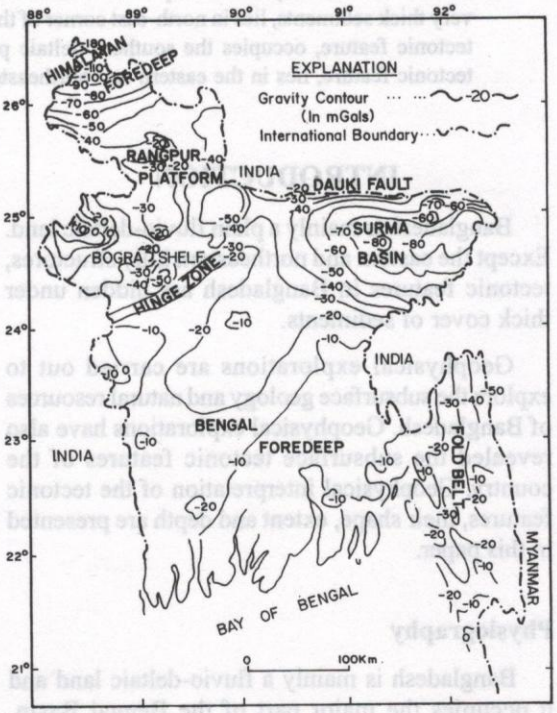

Fig. 2: Gravity anomalies and tectonic features in Bangladesh.

gravity highs and lows spread over a large area indicate the rise of the Archean Basement Complex in the subsurface, which is tectonically known as the Rangpur platform.

The northern part of the Rangpur platform slopes down to the Himalayan foredeep. At the end of the southern slope of the Rangpur platform, in a north-east and south-west trending narrow zone, gravity value changes by an amount of 15 mGals. This narrow zone of sharp gravity change indicates a tectonic feature known as the Hinge zone.

The gravity value drops from -40 to -80 mGals in the north-east corner area of the country. This large drop of gravity values and circular shape of gravity contours in the area indicate the presence of a tectonic feature known as the Surma Basin.

The linear gravity anomalies in the southeastern part of the country correspond to fold features with pronounced topographic expression. Anomaly values in this area range from 0 to -50 mGals. These linear gravity anomalies indicate a tectonic feature known as the Fold Belt.

In an extended south and southwestern part of the country, gravity values change from 0 to -20 mGals. This broad area represents a tectonic feature known as the Bengal foredeep.

Gravity anomalies in Bangladesh, therefore, clearly delineate the existence of the following tectonic features in the country:

1. Himalayan foredeep,
2. Rangpur platform,
3. Hinge zone,
4. Surma basin,
5. Fold belt, and
6. Bengal foredeep.

Tectonic features are outlined more clearly on the north-south and east-west gravity sections drawn across Bangladesh (Fig. 3).

INTERPRETATION

Gravity anomalies of Bangladesh indicate and outline the tectonic features in the country. Shape, extent and depth of the tectonic features are interpreted from geophysical data particularly from

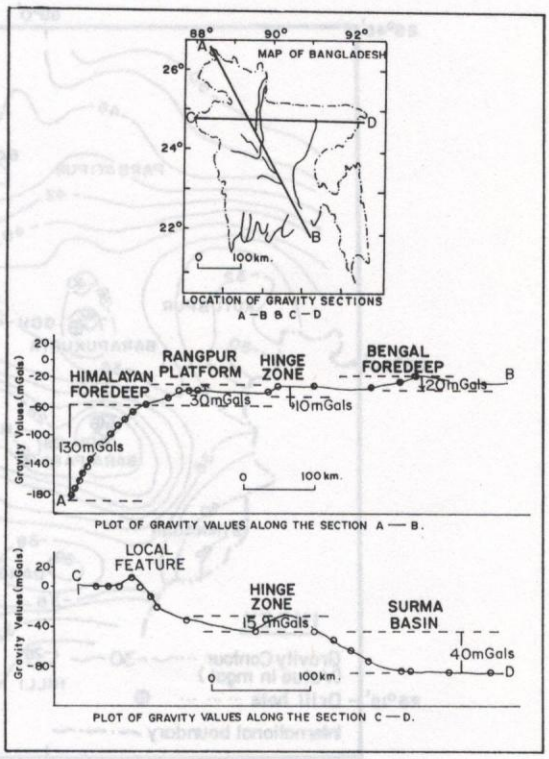

Fig. 3: Gravity sections across Bangladesh.

the gravity data supported by available geological and drilling information.

Rangpur Platform

The Rangpur platform is the subsurface continuation of the Indian Shield in the west to the Shillong massif in the east. Gravity anomalies show that the Rangpur platform slopes down both towards north and south. The north-south length of the Platform is about 150 km. and in the east-west width varies from 75 to 150 km. Though not clearly indicated in the gravity anomaly map, the southern slope of the Rangpur platform is also considered as a tectonic feature known as the Bogra Shelf .

Extensive geophysical explorations have been carried out in the Rangpur platform. Detail gravity anomalies of the platform area are shown in Fig. 4. Gravity anomalies, seismic and magnetic data show that the Rangpur platform is tectonically disturbed. It is composed of horst and graben structures. The depth of the basement in the platform area varies

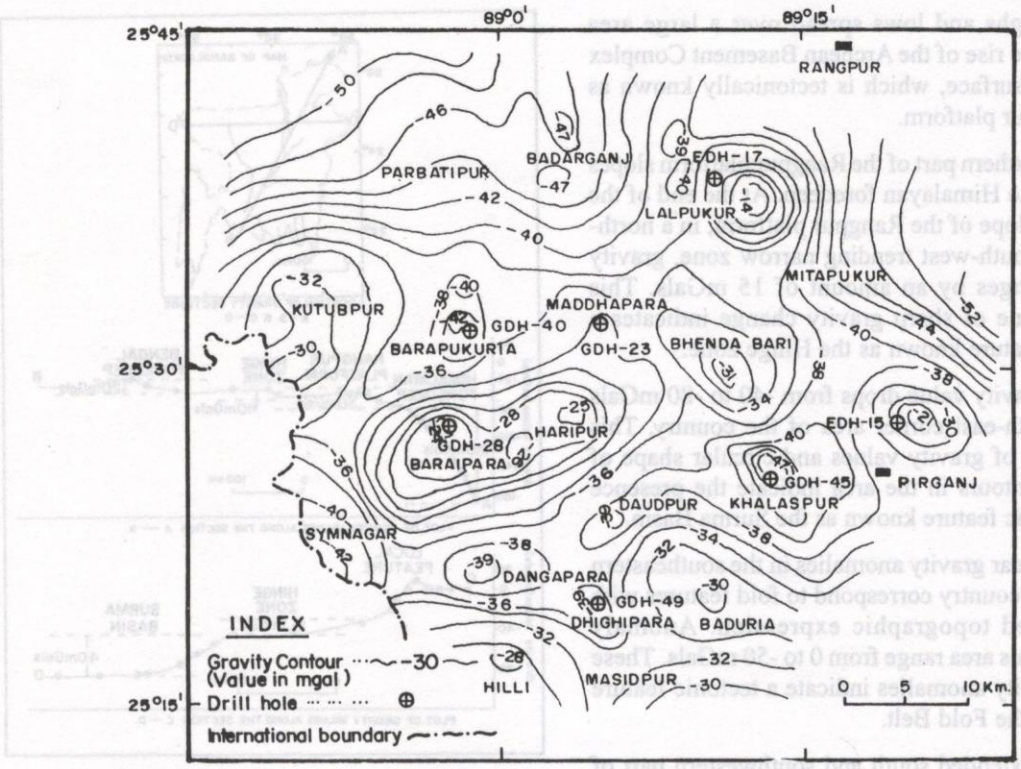

Fig. 4: Gravity anomalies of the Rangpur platform, Bangladesh.

from 110 to 1200 m in the horst and graben structures respectively (Hasan et al., 1997 and Rahman et al., 1990).

Himalayan Foredeep

The Himalayan foredeep is the northern most tectonic feature in the country. The northern part of the Rangpur platform slopes down by an angle of about 2° to the Himalayan foredeep. The gravity anomaly relief in the foredeep area is about 130 mGals. The width of the foredeep area is about 80 km in the northward direction. In the extreme northern part of the foredeep area, the depth of the basement is more than 2.5 km (Alam et al., 1990).

Hinge Zone

The Hinge zone lies between the southern slope of the Rangpur platform and the north-western margin of the Bengal foredeep. It is a south-west and north-east trending narrow zone of 180 km long and 10 km wide. In the north-east the Hinge zone appears to be not well connected with the Dauki Fault. In the south-west, it, however, continues to Indian territory. The depth of the basement in the Hinge zone area is deeper than 3.5 km.

Surma Basin

The Surma basin is situated in the north-east corner of Bangladesh. It is bounded by the Dauki Fault in the north, Fold belt in the south and the Bengal basin in the west. In the east it is opened to the Indian territory. The basin is about 130 km long and 75 km wide. The basin contains very thick sediments. The basement depth is more than 15 km (Rahman et al., 1990).

A very sharp fall of gravity values about 50 mGals along the north-eastern frontier region of Bangladesh delineate a tectonic boundary between the Surma basin and the Shillong massif in India. This tectonic boundary is known as the Dauki Fault.

Fold Belt

The Fold belt, only exposed tectonic feature in the country, is considered to be the result of the interaction of east-west and north-south plate convergence. The Fold belt is 300 km long and 100 km wide and occupies the south-east corner of the country. Linear gravity anomalies indicate fold features with pronounced topographic expression. However, the gravity field of the Fold belt is poorly known.

Bengal Foredeep

The Bengal foredeep is the most extended tectonic feature in Bangladesh. It is bounded by the Fold belt in the east, the Surma basin in the north-east and the Hinge zone in the north-west. In the west it is open to Indian territory and in the south to the Bay of Bengal. The foredeep is 300 km long and 250 km wide. Seismic, aeromagnetic and deep drilling data indicate very thick sedimentary deposits in the Bengal foredeep. The basement depth also varies greatly in the foredeep area. Aeromagnetic data give the basement depth to be about 10 to 12 km (Hunting Geology and Geophysics Ltd., 1980). On the other hand, gravity data indicate the depth to be 18 to 20 km (Mirkhamidov and Mannan, 1981).

The very deep basement depth and small gravity anomaly relief (about 20 mGals) appears to be inconsistent for the Bengal foredeep area. To account for the high gravity values, the crust beneath the sediments is required to be either denser than normal continental crust or extraordinary thin with a mantle rise.

Geophysical interpretation of the tectonic features in Bangladesh, their locations and characteristics particularly their shape, extent and depth are summarised in Table 2. Drillhole correlation sections across Bangladesh support geophysical interpretation of the tectonic features in the country (Fig. 5). These sections clearly demonstrate deposition of thick sediments in the Himalayan foredeep, the Surma basin and the Bengal foredeep areas and upliftment of the Archean Basement Complex in the Rangpur platform area. Location and extent of the tectonic features in Bangladesh are shown in Fig. 6.

DISCUSSIONS

Geophysical explorations have mainly been carried out to explore the subsurface geology and natural resources of Bangladesh. Initially in selected areas, as reconnaissance surveys, gravity and magnetic explorations have been carried out to locate structures for hydrocarbon accumulation and areas of mineral prospect (Hasan et al., 1997). Prospective structures and areas were then explored by the seismic methods to get more detail information about them. So, geophysical data of Bangladesh are localised in different areas scattered throughout the country.

Scattered and nonuniform gravity data of Bangladesh were compiled and a hand drawn regional

Table 2: Tectonic features in Bangladesh, their locations and characteristics.

Serial No.	Tectonic Features	Locations	Characteristics (shape, extent and depth)
1.	Himalayan Foredeep	Extreme northwestern area	Northward inclined feature, extended over an area of 3,000 km^2 having maximum depth more than 2.5 km
2.	Rangpur Platform	Northwestern area	Uplifted faulted feature, extended over an area of 18,000 km^2 having depth varying from 110m to 1200 m.
3.	Hinge Zone	Lies between Bogra shelf and Bengal Foredeep	A narrow elongated feature, 180 km long and 10 km wide and having average depth more than 3.5 km.
4.	Surma Basin	North-east corner area	A very deep basinal feature, extended over an area of 10,000 km^2 and having maximum depth more than 15 km.
5.	Fold Belt	South-east corner area	An exposed folded feature, extended over an area 30,000 km^2 and having depth of the Basement more than 4 km.
6.	Bengal Foredeep	South and southwestern area	A very wide depressional feature, extended over an area of 75,000 km^2 and having depth around 20 km.

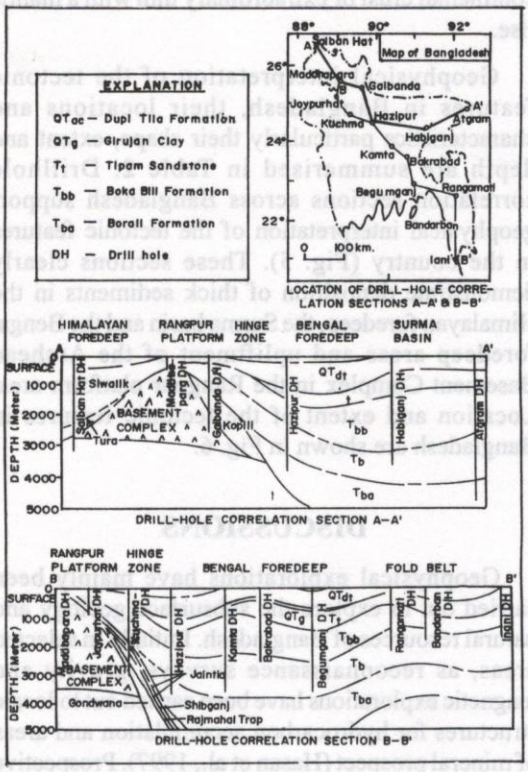

Fig. 5: Drill-hole correlation sections across Bangladesh.

gravity anomaly map was prepared (Mikhamidov and Mannan, 1981) by digitising the above-mentioned hand drawn map, the Bouguer gravity anomaly map was prepared (Rahman et al., 1990). Gravity data were referred to the IGSN-71 and reduced at a density of 2.67 gm/cc. No terrain corrections were made.

Bouguer gravity anomaly map, considered in the preparation of this paper, is good for locating tectonic features of the country. Interpretations of shape, extent and depth of the tectonic features are also reasonably acceptable. However, for more detail interpretation of the tectonic features, Bouguer gravity anomaly map based on uniform gravity data through out the country would be required. At the same time, a few cross country seismic profiles will improve the interpretation. Deep drilling information upto the basement in the Bengal foredeep, Surma basin, Hinge zone and Fold belt areas will be very useful for the geophysical interpretation of the tectonic features in Bangladesh.

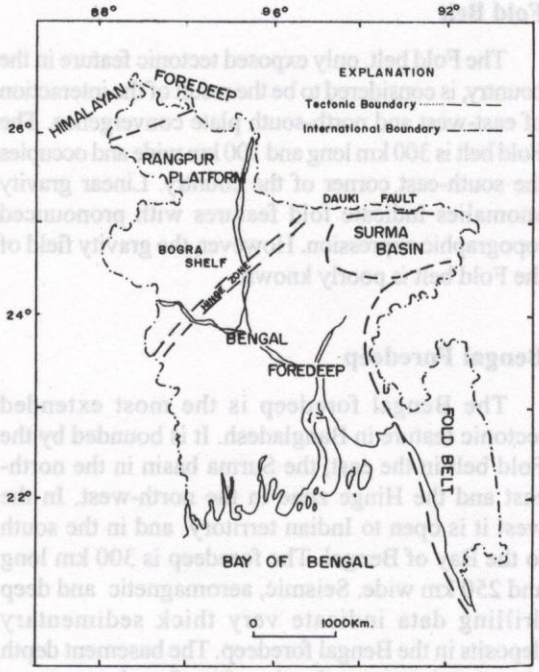

Fig. 6: Location and extent of tectonic features in Bangladesh.

CONCLUSIONS

Bouguer Gravity anomalies of Bangladesh have clearly indicated the subsurface tectonic features of the country. Interpretation of the geophysical data supported by available geological and drilling information has revealed the shape, extent and depth of the tectonic features in Bangladesh.

For better interpretation of the tectonic features in Bangladesh, a gravity anomaly map based on uniform gravity data through out the country is required. Cross country seismic profiles will improve the interpretation. Deep drilling data upto the Basement in the Bengal foredeep, Surma basin, Hinge zone and Fold belt areas will further enhance geophysical interpretation of the tectonic features in Bangladesh.

ACKNOWLEDGMENT

Authors are grateful to the Director General, Geological survey of Bangladesh, Dhaka, Bangladesh for his kind permission to present this

paper at the Second Nepal Geological Congress, November 11-13, 1997, held in Kathmandu, Nepal.

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