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TECTONIC AND GEOTECHNICAL REVIEW OF BENGAL BASIN FOR SEISMIC RISK ASSESSMENT IN BANGLADESH

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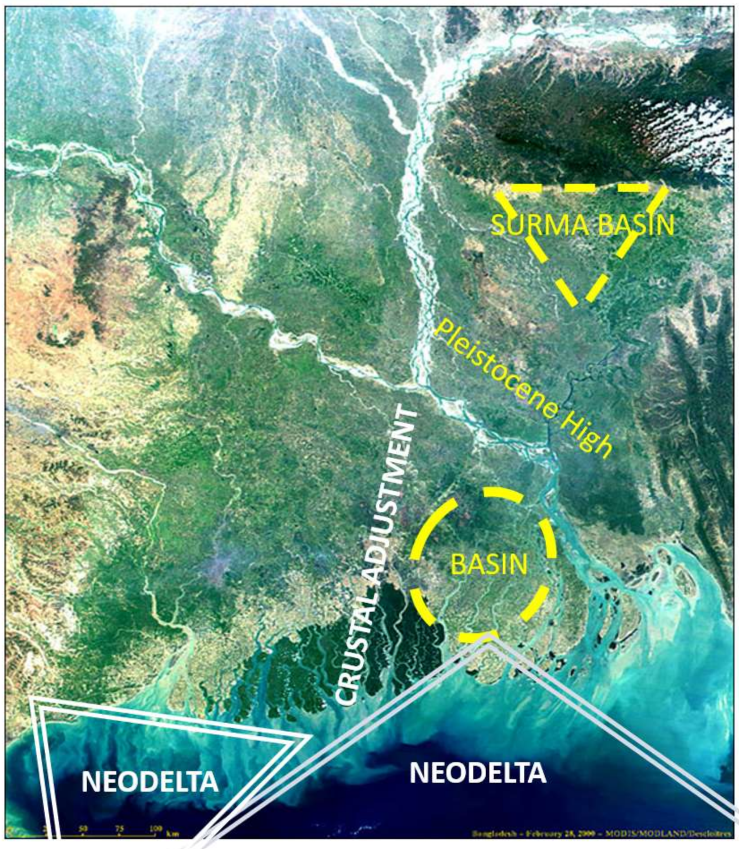
Dr Muhammad Qumrul **HASSAN**, Dept. of Geology, University of Dhaka,, Bangladesh

There is prediction of 9 Magnitude Earthquake in the newly born Bengal Delta, by a group scientists from Columbia University [Lamont-Doherty Earth Observatory …] What is next for >250 millions living in and around this delta.. Any idea for preparedness..?



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Abstract #371261

TECTONIC AND GEOTECHNICAL REVIEW OF BENGAL BASIN FOR SEISMIC RISK ASSESSMENT IN BANGLADESH

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The seismic risk in densely populated areas is one of the major socio-economic concerns that warrant serious attention. Bengal basin covers most of Bangladesh and part of India. The basin is the world's youngest and largest delta, nearly twice the size of the Mississippi delta. It is seismically active due to a complex intraplate tectonic setting and junctions between the Indian shield and a systematically folded Indo-Burma range. The northeast motion of the Indian plate crushed the continental and oceanic crusts, pushed and yielded a deeper ocean basin (15-18 km) over undulated Cretaceous basement, and filled up with Himalayan sediments. 0

Four major geotectonic provinces of the basin are recognized: 1) the continental slope to the west of the Hinge Zone, 2) the stable shelf, 3) the deep central trough (Sylhet-Hatiya) and 4) the Chittagong-Tripura fold belt to the east. The ~300 km long Dauki Fault demarcates the elevated Shillong Plateau, part of the Indian Shield to the north and the deep basin to the south. The basin experienced three strong to major intraplate earthquakes: a) 1885 Bengal earthquake (rev. Mw 6.8) close to the Hinge Zone, b) 1918 Srimangal earthquake (rev. Mw 7.1) on the Sylhet (trough) fault and c) 1923 Mymensingh earthquake (rev. Mw 7.0) at the northern end of the Hinge Zone where it intersects the Dauki Fault. In addition, Bangladesh also experienced similar tectonic energy release from the Shillong Plateau earthquakes like Great Assam Earthquake (1897, rev. Mw 8.1) and moderately active Indo-Burma subduction zone in the east.

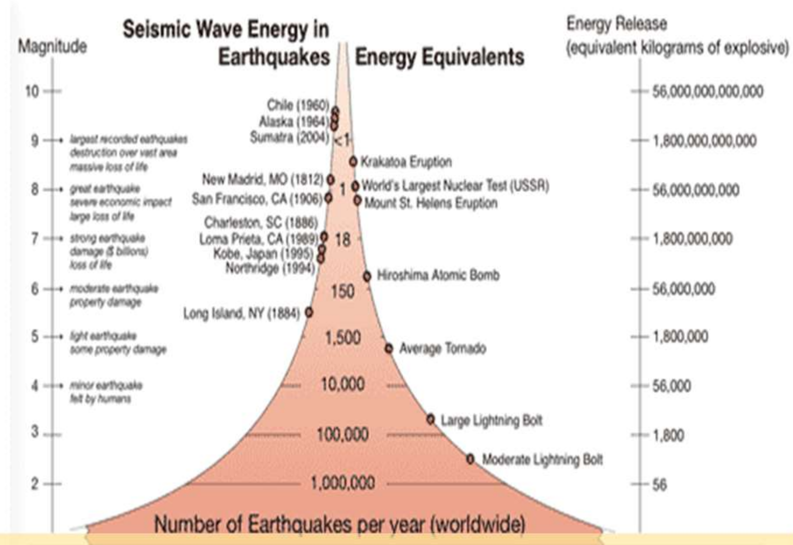
Rational assessment for seismic threats is determined by: hypocenter locations, the intensity of local/regional seismicity, differential tectonic stress condition, the geometry of discontinuities, and states of highest energy release. Site effects are evaluated from geophysical and geotechnical investigations. A 3D site-specific seismic hazard characterization of the capital megacity Dhaka is made to assess the seismic risk. It is observed that lateral and vertical discontinuities are subjected to multiple segmentations that facilitate tectonic movements. 1918 Srimangal event of Mw 7.1 is the largest recorded intraplate earthquake. Generation of enough tectonic stress in Bengal basin is very unlikely which might cause megathrust induced earthquakes (Mw 8-9) in Bangladesh.

Abstract ID#:

The objective of this presentation is to provide an insight into the relationship between tectonics and geotechnical practices in Bangladesh in regards to the associated geological hazards. The modern civil and geotechnical engineering operations have shown globally a positive trend in using geological and geoengineering database for improving engineering design for risk reduction and optimizing rational safety factors through analysis of available geological, geomorphological, subsurface, and exploration results. The authors would like to document the state of the art of tectonics, structural geology, geophysics and remote sensing for visualizing and perceiving the 3D subsurface of Bengal Basin. which is with the thickest sedimentary cover in present active basins of the planet portraying the process of ongoing delta building surrounded by evidence of regional tectonic elements and deformation patterns, in the world's most densely populated area. Bengal Basin is a MASTER PIECE of nature and living geotechnical laboratory for global geoscientists and geo-engineers…!!!

https://news

This graph demonstrates the logarithmic nature of earthquake magnitudes and energy release. (USGS)

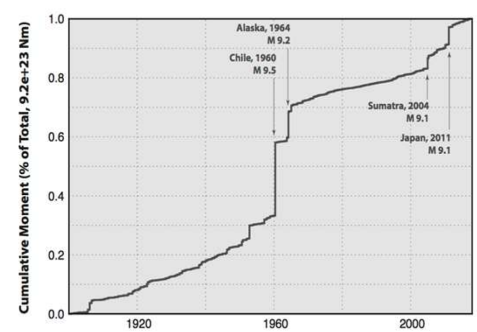


If we sum all of the energy release from all of the earthquakes over the past ~110 years, the equivalent magnitude ~ Mw9.95.
If the San Andreas Fault were to rupture end-to-end (~1400km), with ~10m of average slip, it would produce an earthquake of Mw 8.47.
If the South American subduction zone were to rupture end-to-end (~6400km), with ~40m of average slip, it would produce an earthquake of Mw 9.86.
You would need ~14,000km fault length, with a seismogenic thickness averaging 40km (width of 100km), to slip and average of 30m to produce an Mw 10.

Purpose of this research: To build the vital geo-structures like hospitals, conference centers, bridges, nuclear power stations or any large dams we need to know the possible earthquake risks or deformation of the terrain for risk management. Geologists are giving more importance on geomorphology of the deformed ground and configuring 3D array of subsurface and analyzing land form in relation to active or passive tectonics this poster will attempt to visualize resultant surface morphological and earth's dynamic system for earthquake risk management in the most debated location of the world in terms of seismic risk out of tectonic assumptions.

Funding and time for this project were author's self contribution for the benefit of people living in the Bengal Basin Delta.

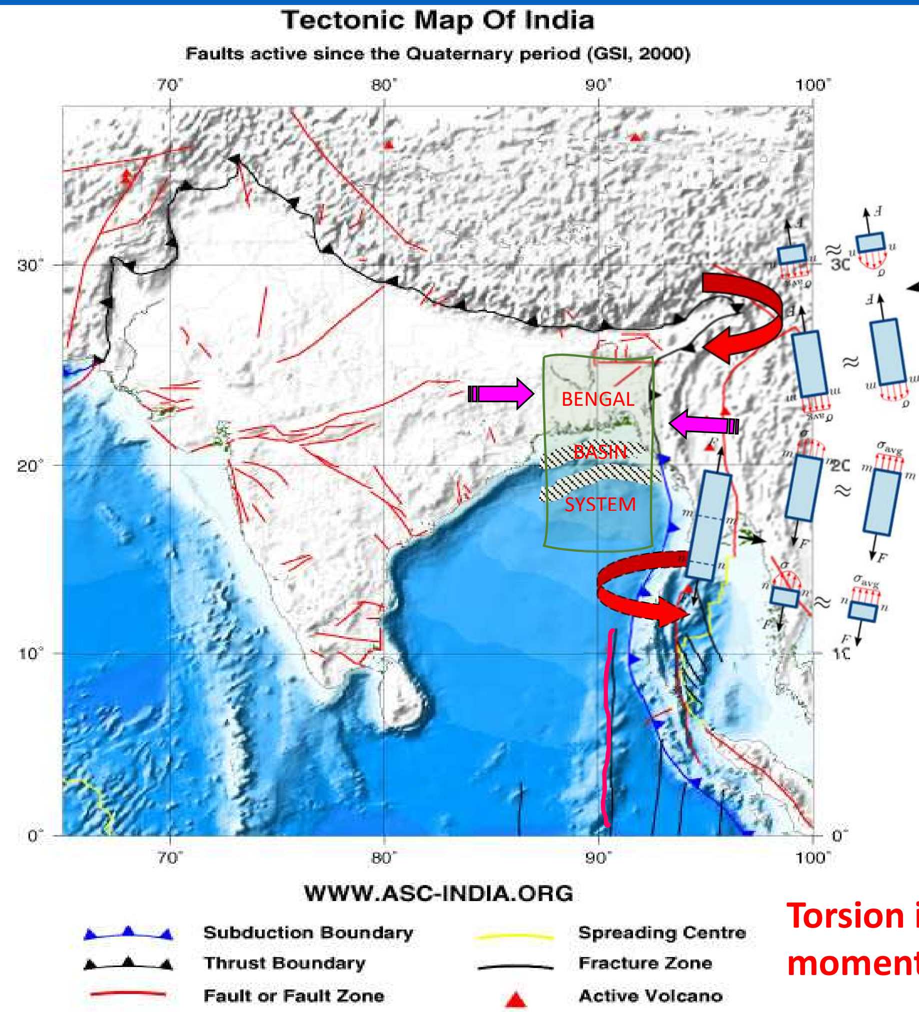
MIR KARIM, Feb 25, 2021

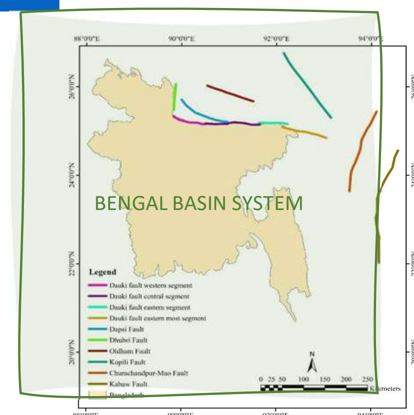


WHY SOME OBVIOUS EARTHQUAKES AND TSUNAMIS ARE WAITING AROUND BANGLADESH? WHAT WOULD BE THEIR MAGNITUDES?

Present study involves detailed field investigations throughout the region, seismic sources identifications and geotechnical analysis of the geologic materials and found that most of the seismic sources and crustal or clastic layers, and both lateral and vertical discontinuities are subjected to multiple segmentation.

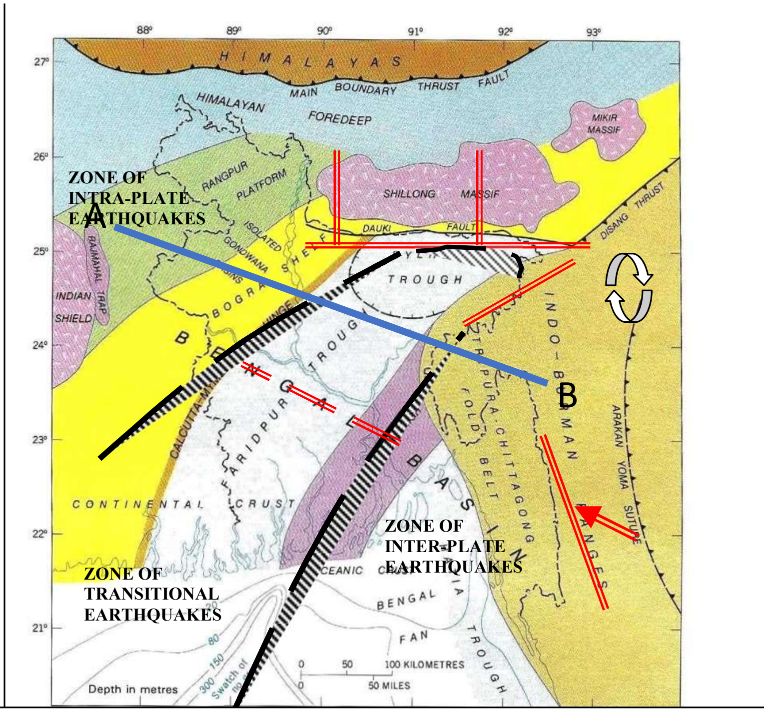
MIR FAZLUL KARIM



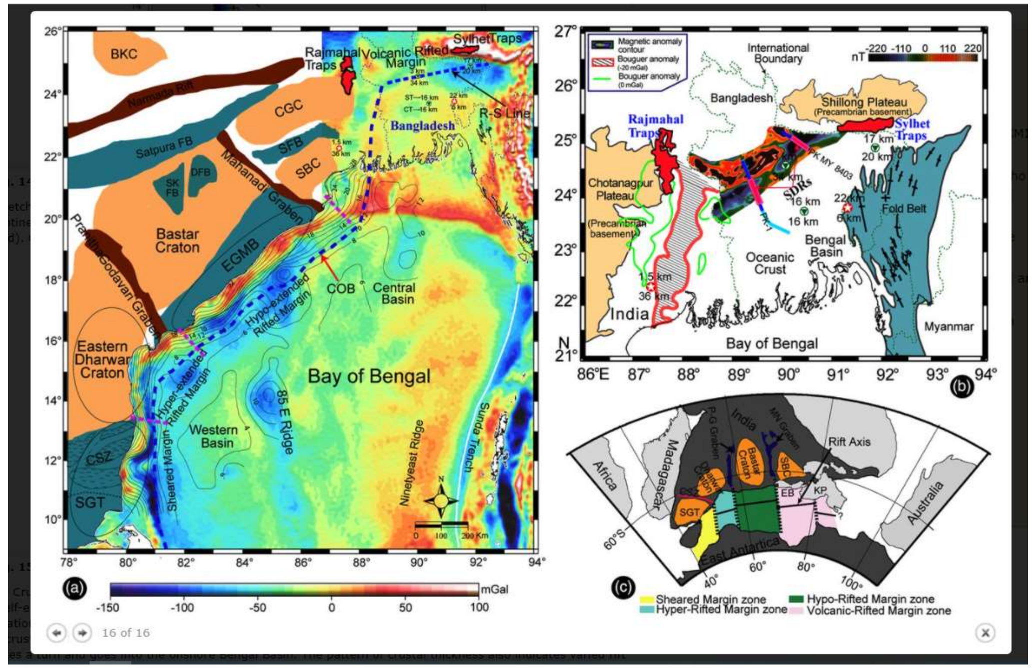


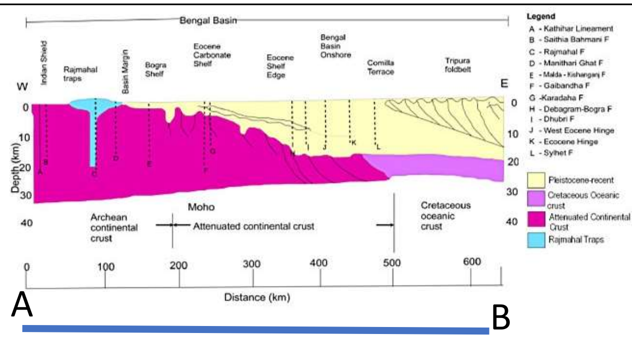
Bangladesh occupies the most active tectonic boundary zone between Indian and Myanmar Plate Stress (IMPS) that reaches up to Sumatra via Andaman-Nicobar zone of severe seismicity. There are two vector zone of tectonic torsion at the tip of the possible subduction zone of this long visible or exposed tectonic boundary

Torsion is twisting of an object caused by a moment acting about object's longitudinal axis..



Generalized Tectonic Map of Bangladesh, showing the possible zone of Crustal Segmentation of Bengal basin and compression (arrow) and rotation forces (curved arrow) along the Indo-Myanmar Tectonic plate boundary (after Alam et al., 1990). The thin parallel lines are areas of recent tectonic strain release





The ~300 km long Dauki Fault demarcates the elevated Shillong Plateau, part of the Indian Shield to the north and the deep basin to the south. The basin experienced three strong to major intraplate earthquakes:

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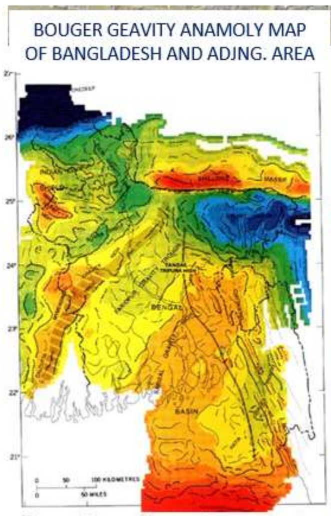
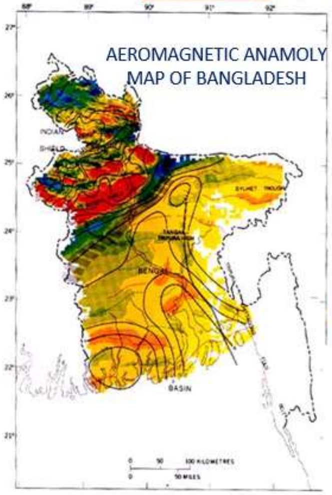
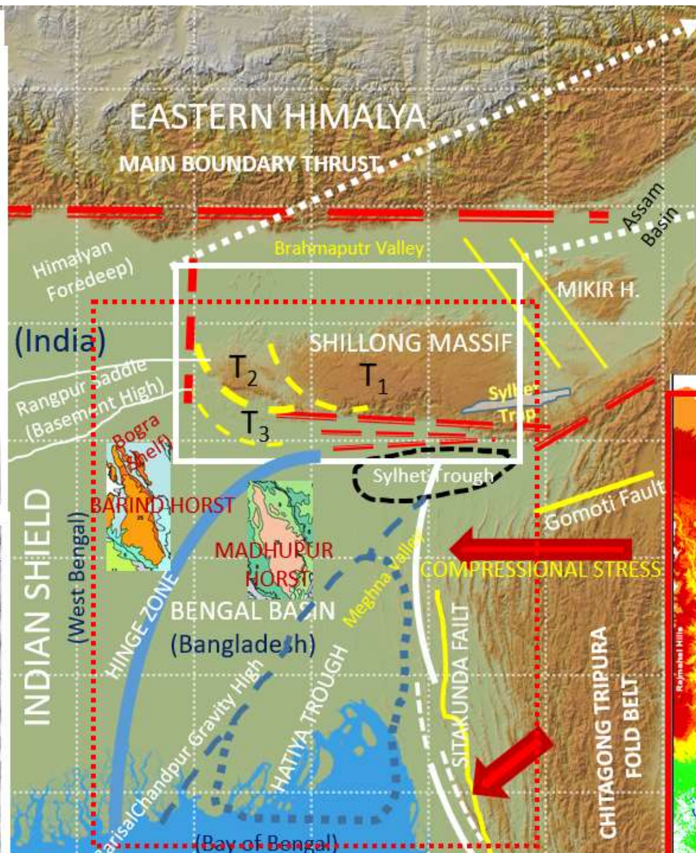
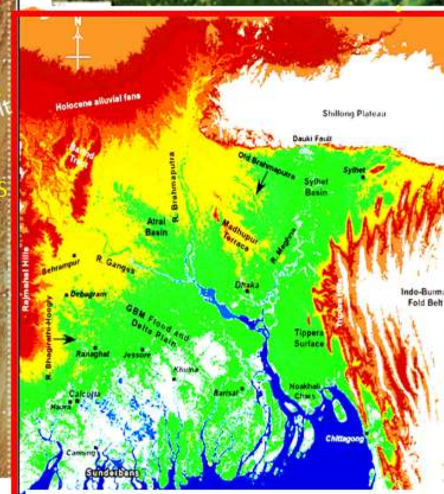
Four major geotectonic provinces of the basin: 1. the continental slope to the west of the Hinge Zone, 2. the stable shelf, 3) the deep central trough (Sylhet-Hatiya) and 4) the Chittagong-Tripura fold belt to the east



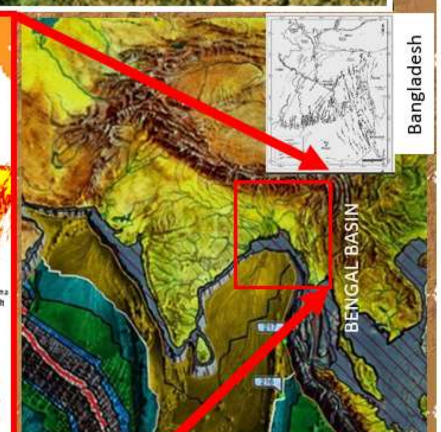




An schematic tectonic map of Bengal Basin and surrounding terrains of Indian shield covering Bangladesh and part of India and Myanmar. Does not show any political boundaries for research interest of the region. The terrain analysis portrayed a unique westward sinusoidal progression of the folds due to steady and uniform compressional stresses from the east with a convergence vector (~N27°E).



DEM OF BANGLADESH AND ADJOINING AREA



Part of oceanic crustal map showing hidden oceanic crust Under Bengal Basin

GEOLOGICAL MAP OF THE OCEAN FLOOR
BY NICOLAS PARUBETS

MIR KARIM, Feb 25, 2021

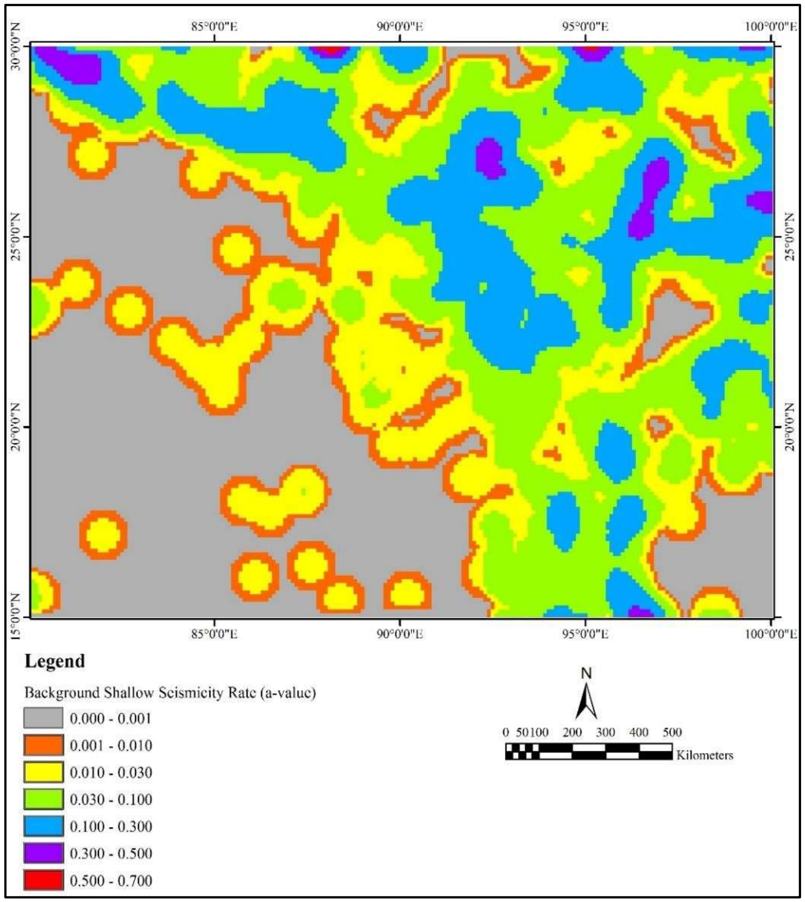


Figure 3.3 Background shallow crustal (focal depth ≤ 40 km) seismicity (gridded and spatially smooth) rate (a value).

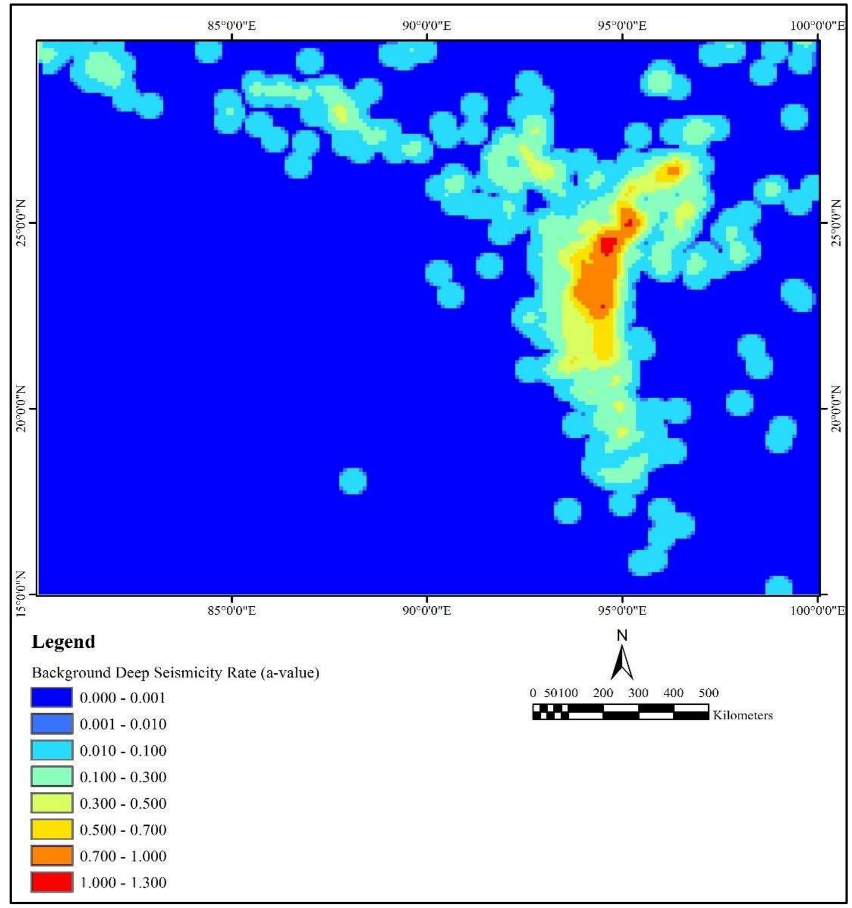
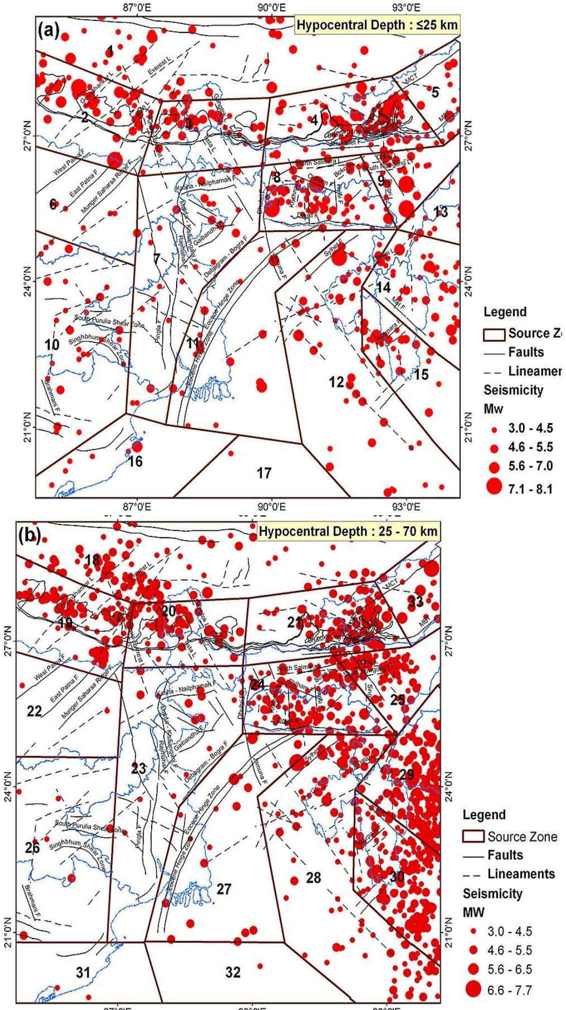


Figure 3.4 Background deep (focal depth > 40 km) seismicity (gridded and spatially smooth) rate (a-value).

Rational assessment for seismic threats is determined by: hypocenter locations, the intensity of local/regional seismicity, differential tectonic stress condition, the geometry of discontinuities, and states of highest energy release. Site effects are evaluated from geophysical and geotechnical investigations. A 3D site-specific seismic hazard characterization of the capital megacity Dhaka is made to assess the seismic risk. It is observed that lateral and vertical discontinuities are subjected to multiple segmentations that facilitate tectonic movements. 1918 Srimangal event of Mw 7.1 is the largest recorded intraplate earthquake. Generation of enough tectonic stress in Bengal basin is very unlikely which might cause megathrust induced earthquakes (Mw 8-9) in Bangladesh.



A layered polygonal seismogenic source framework for Bengal Basin System and its adjoining region modified after Nath and Thingbaijam (2012) for PSHA **(a)** hypocentral depth of 0–25km and **(b)** hypocentral depth of 25–70km.

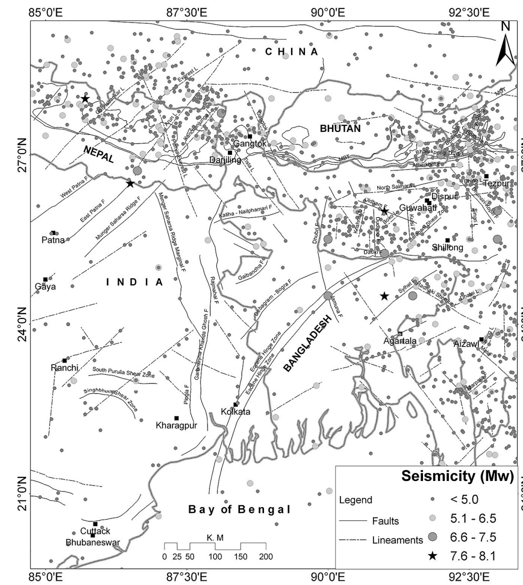
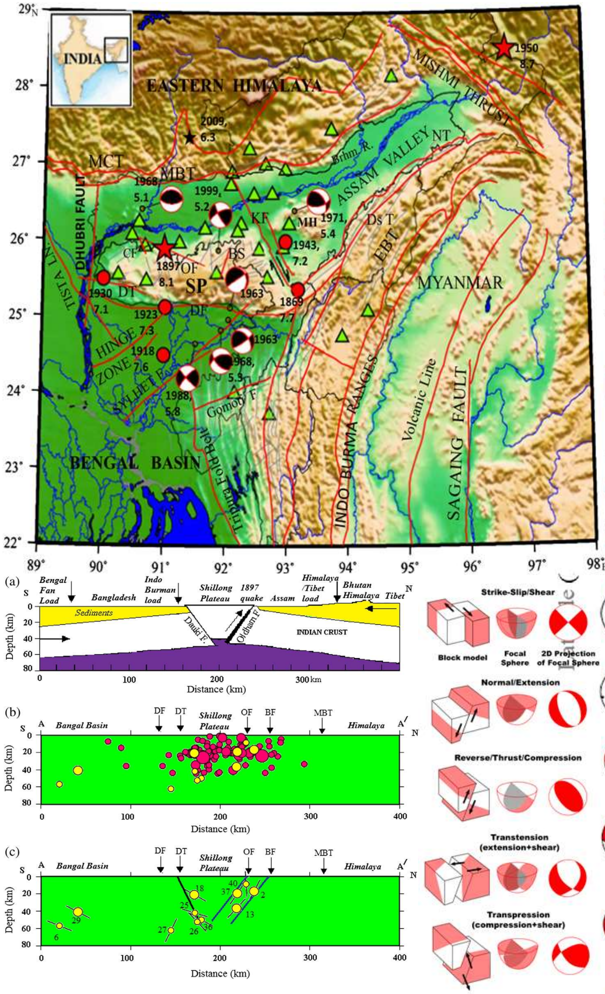
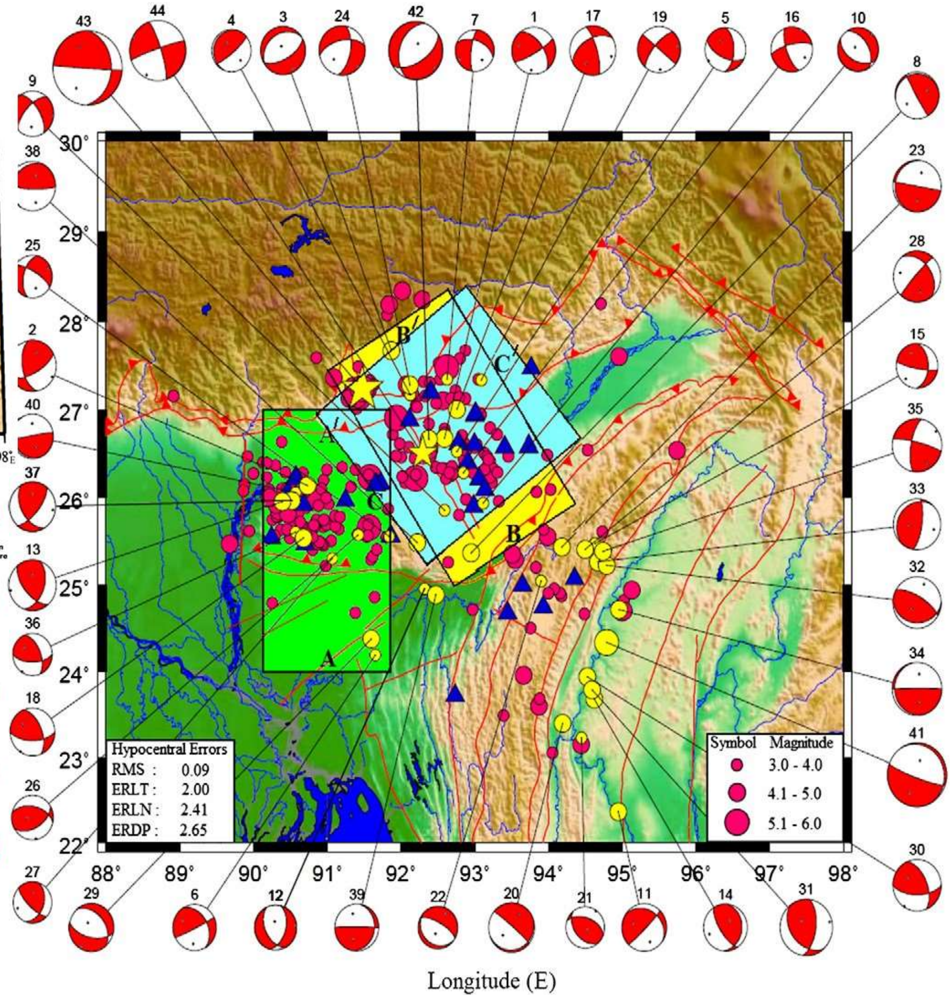


Figure 4. Major active tectonic sources of West Bengal and its ad- rupture dimension and magnitude. Table 1 lists some major joining region. active tectonic sources, their total length (TFL), the associated observed maximum earthquakes ($M_{max,obs}$), the subsurface rupture length (RLD) and the maximum predicted earthquake (M_{max})..

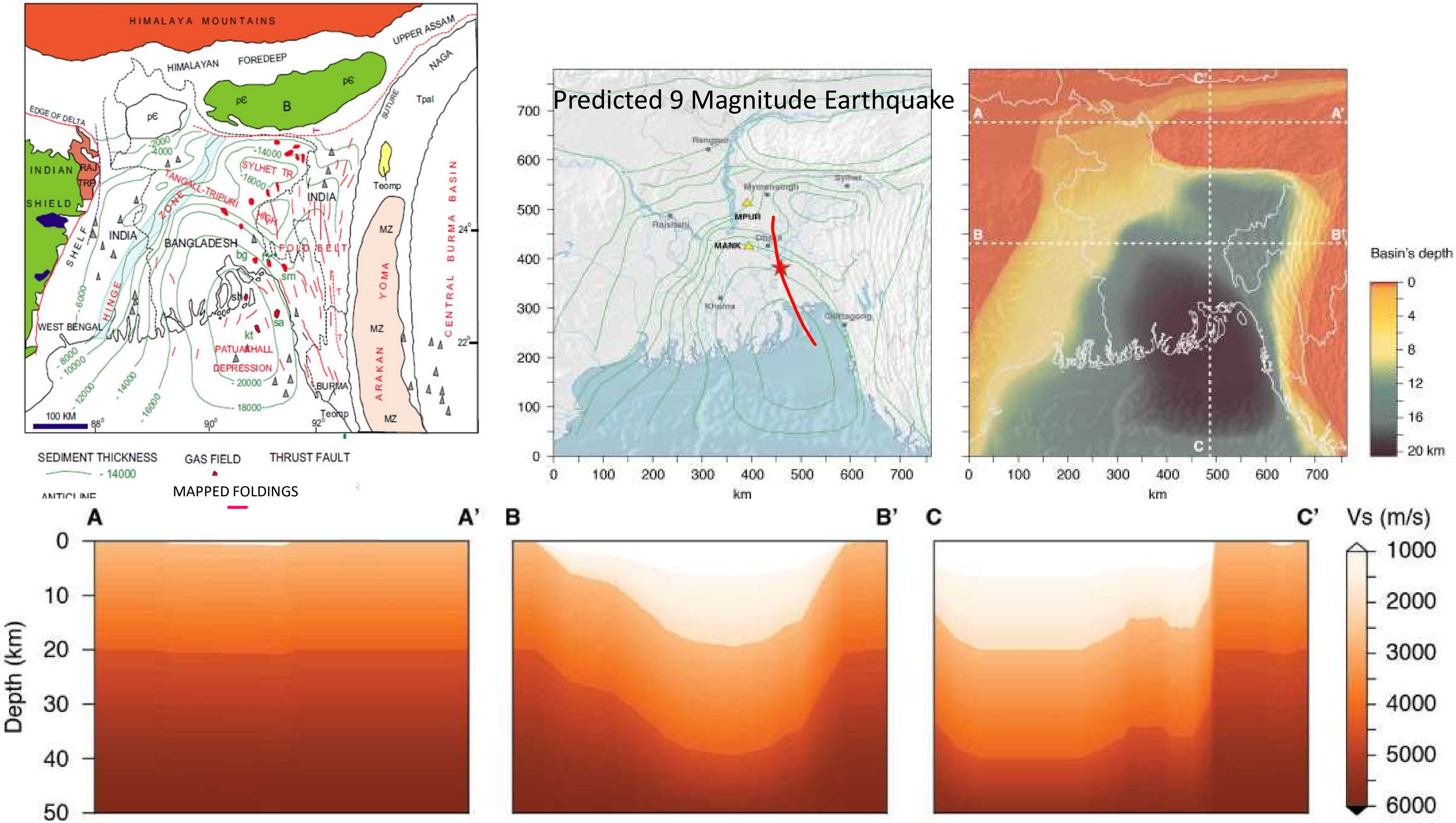
THE LARGEST THREAT STRUCTURE FOR BENGAL BASIN



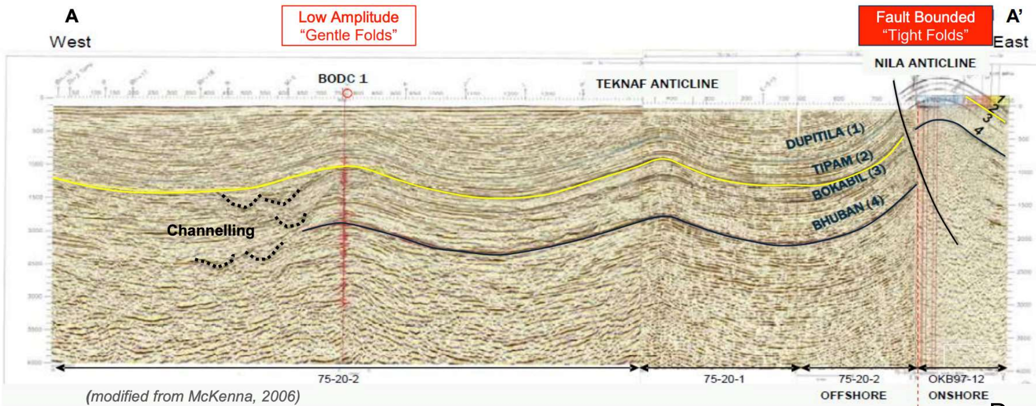


We have examined two large earthquake source zones, the Shillong plateau and the Kopili fault, in the northeast India region using recent digital seismic data. The Shillong plateau generated the 1897 great (M ~ 8.0) earthquake and the 1930 Dhubri earthquake (M 7.1), and the Kopili fault caused the 1869 (M ~ 7.7) and 1943 (M ~ 7.2) large earthquakes. The Shillong plateau shield earthquakes are deeper, down to 50 km, and may be explained by pop-up tectonics between two boundary faults; the earthquakes occur by thrust/reverse faulting with strike slip component.

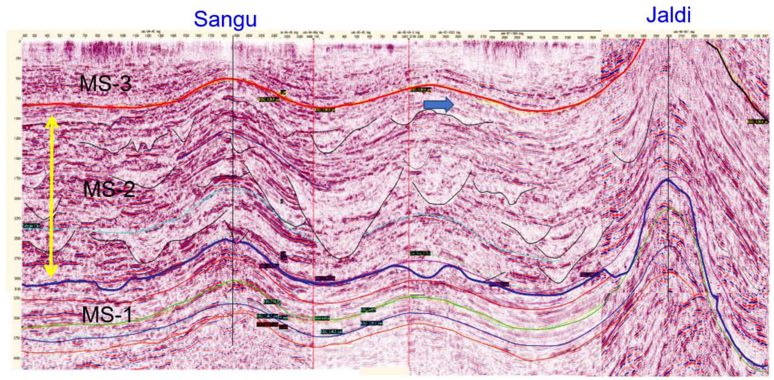
Ref, Large and great earthquakes in the Shillong plateau–Assam valley area of Northeast India Region: Pop-up and transverse tectonics J.R. Kayal, Tectonophysics, http://dx.doi.org/10.1016/j.tecto.2012.02.007



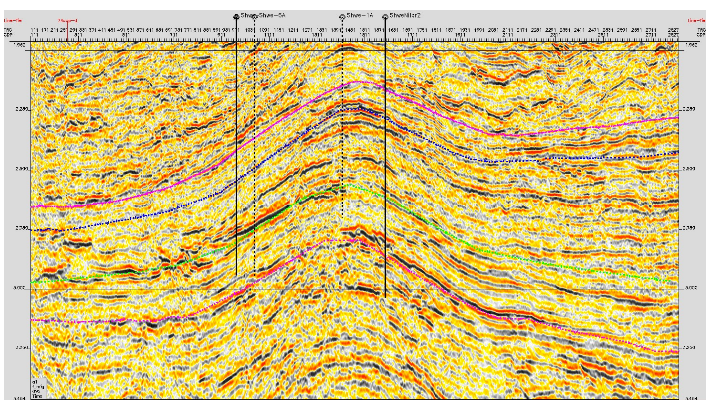
HIMALAYA MOUNTAINS
HIMALAYAN FOREDEEP
UPPER ASSAM
NAGA
SUTURE
Tpal
EDGE OF DELTA
INDIAN SHIELD
RAJ TRP
SHELF
HINGE ZONE
INDIA
BANGLADESH
TANGAIL-TRIPURA HIGH
SYLHET TR
FOLD BELT
WEST BENGAL
PATUAKHALI DEPRESSION
BURMA
Teomp
MZ
ARAKAN YOMA
CENTRAL BURMA BASIN
100 KM
88°
90°
92°
24°
22°
SEDIMENT THICKNESS
- 14000
GAS FIELD
THRUST FAULT
ANTICLINE
MAPPED FOLDINGS
Predicted 9 Magnitude Earthquake
Mymensingh
MPUR
MANK
Dhaka
Rajshahi
Rangpur
Sylhet
Khulna
Chittagong
km
Basin's depth
20 km
A
A'
B
B'
C
C'
Depth (km)
Vs (m/s)



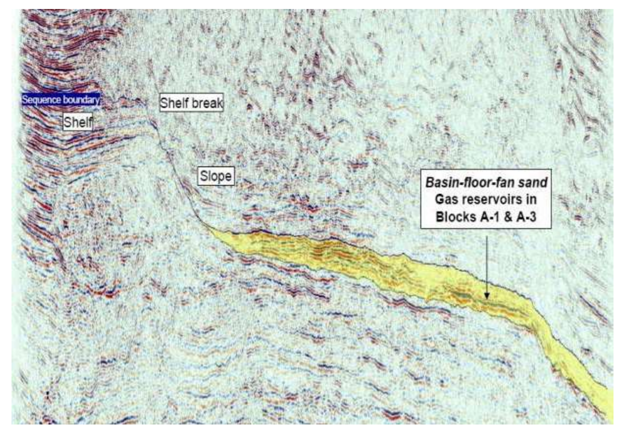
The onshore fold belt structures are typically elongated, asymmetrical, doubly plunging anticline. The axis of the fold is running in NNW-SSE direction, parallel to the general trend of regional strike. The offshore structures are typically sequence remnants gently folded more like a combination of stratigraphic-structural play type.



Depiction of seismic character of MS1, MS2 and MS3 in Hatia Trough. MS1 is recognized throughout the Bengal Basin by high amplitude continuous parallel reflectors, except onshore exposed tight folds . MS2 is represented in the Hatia Trough by sequence remnants preserved between infilled incised submarine canyons. MS3 is characterized in the Hatia Trough by a return to a package of laterally continuous seismic reflectors. Insets show the location of the seismic line (red line) and approximate scale. Blue arrows show the location of onlapping/ thinning of MS3 strata over/onto MS2 anticlines.

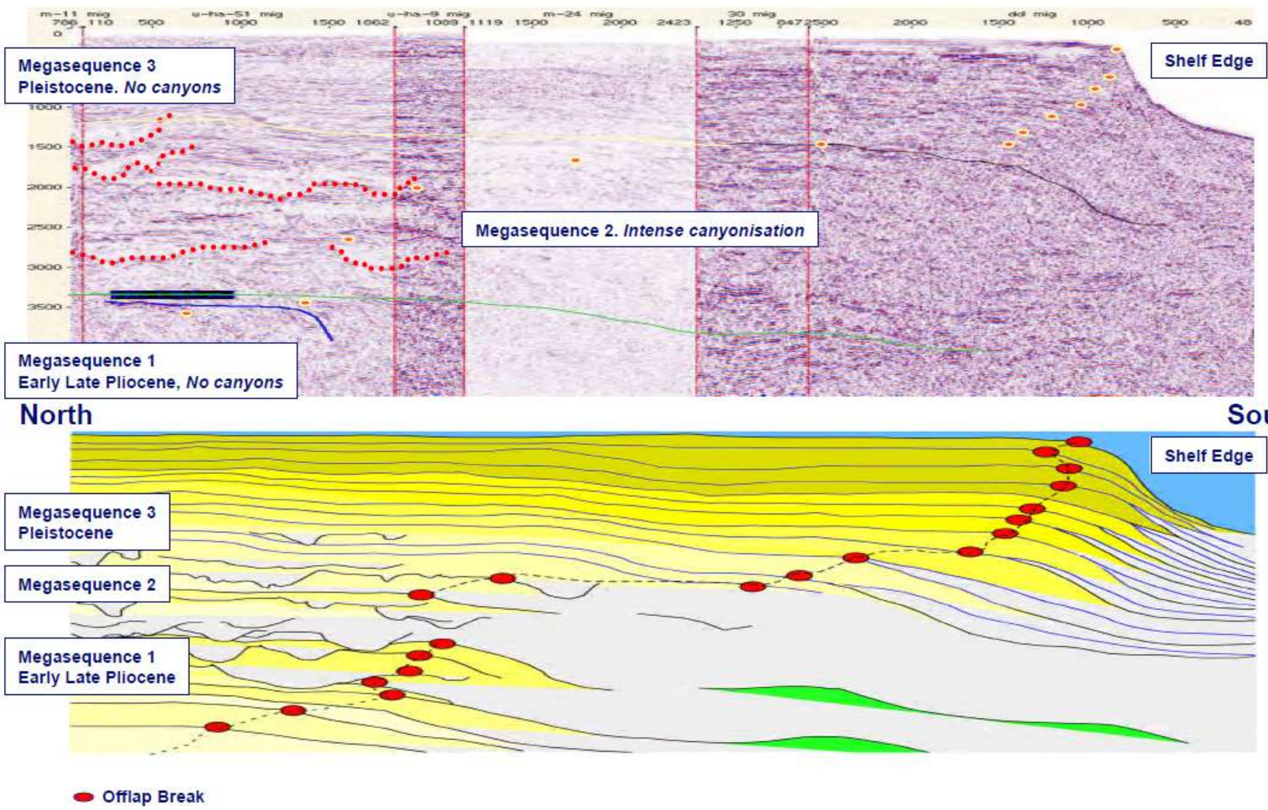


PROVEN PLIOCENE SUBMARINE BASIN FLOOR FAN PLAY TYPE OCCURRED ON THE BACKGROUND OF LOW AMPLITUDE ANTICLINE SHALLOW WATER AREA, SHWE GAS FIELD (BLOCK A-1)



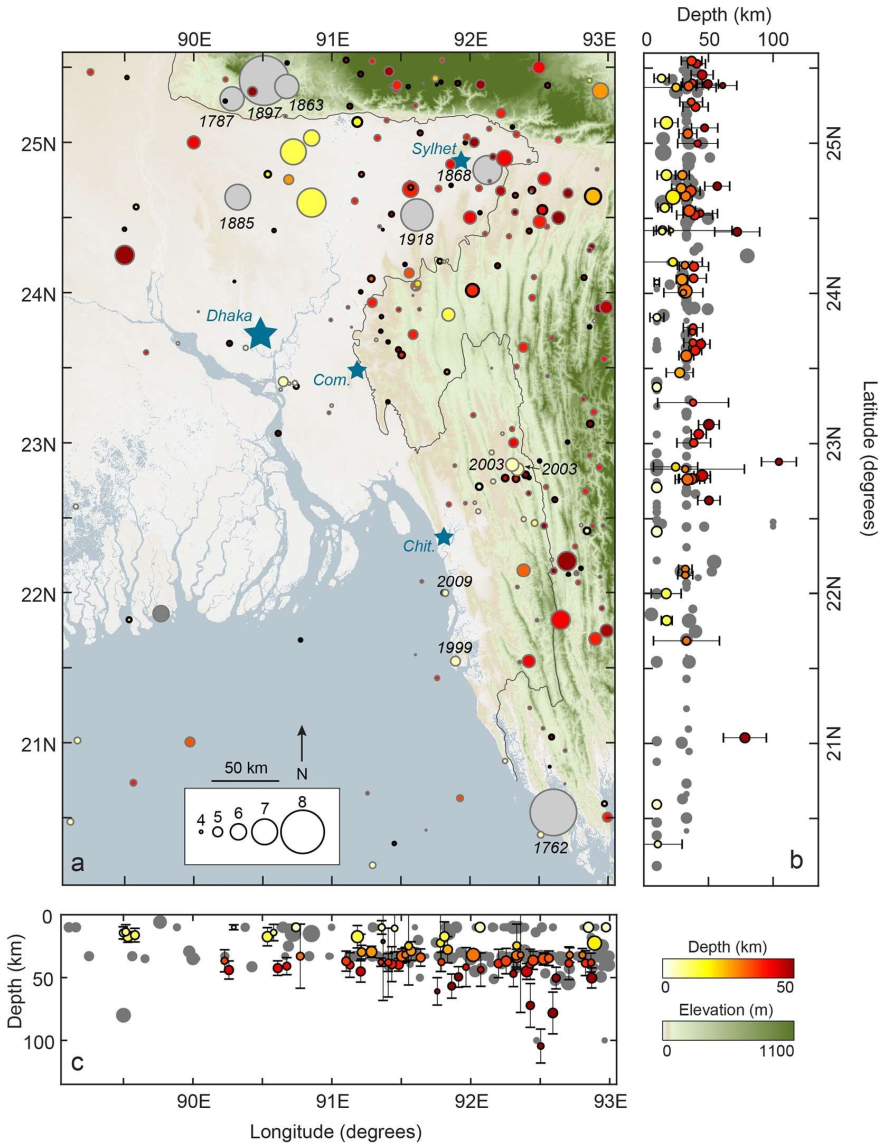
Source: Najman, et.al. (2012). The record of Himalayan erosion preserved in the sedimentary rocks of the HatiaTrough of the Bengal Basin and the Chittagong Hill Tracts, Bangladesh.

Paleo-shelf Edge position, in Passive Continental Margin



Age (approx.)			Traditional nomenclature (Evans, 1932)		Block 22 (Gani et Alam, 2003)	CAIRN - 2007
Quaternary	Recent		Alluvium		Alluvium	MS3
Quaternary	Plio-Pleistocene		DupiTila Fm		DupiTila Fm	MS3
Quaternary	Plio-Pleistocene		Tipam Group	Girujan Clay Fm	Absence of Girujan Clay	MS2
Neogene	Plio-Pleistocene		Tipam Group	Tipam SstFm	Tipam SstFm	MS2
Neogene	Miocene	Late	Surma Group	Boka Bil Fm	Mirinja Group	MS2
Neogene	Miocene	Middle	Surma Group	Bhuban Fm	Sitapahar Group	MS1
Neogene	Miocene	Early	Surma Group	Bhuban Fm	Sitapahar Group	MS1
Paleogene	Oligocene		base not exposed Barail Group		Chittagong Group (in subsurface)	

Shell-Cairn Developed Sequence Stratigraphic Model

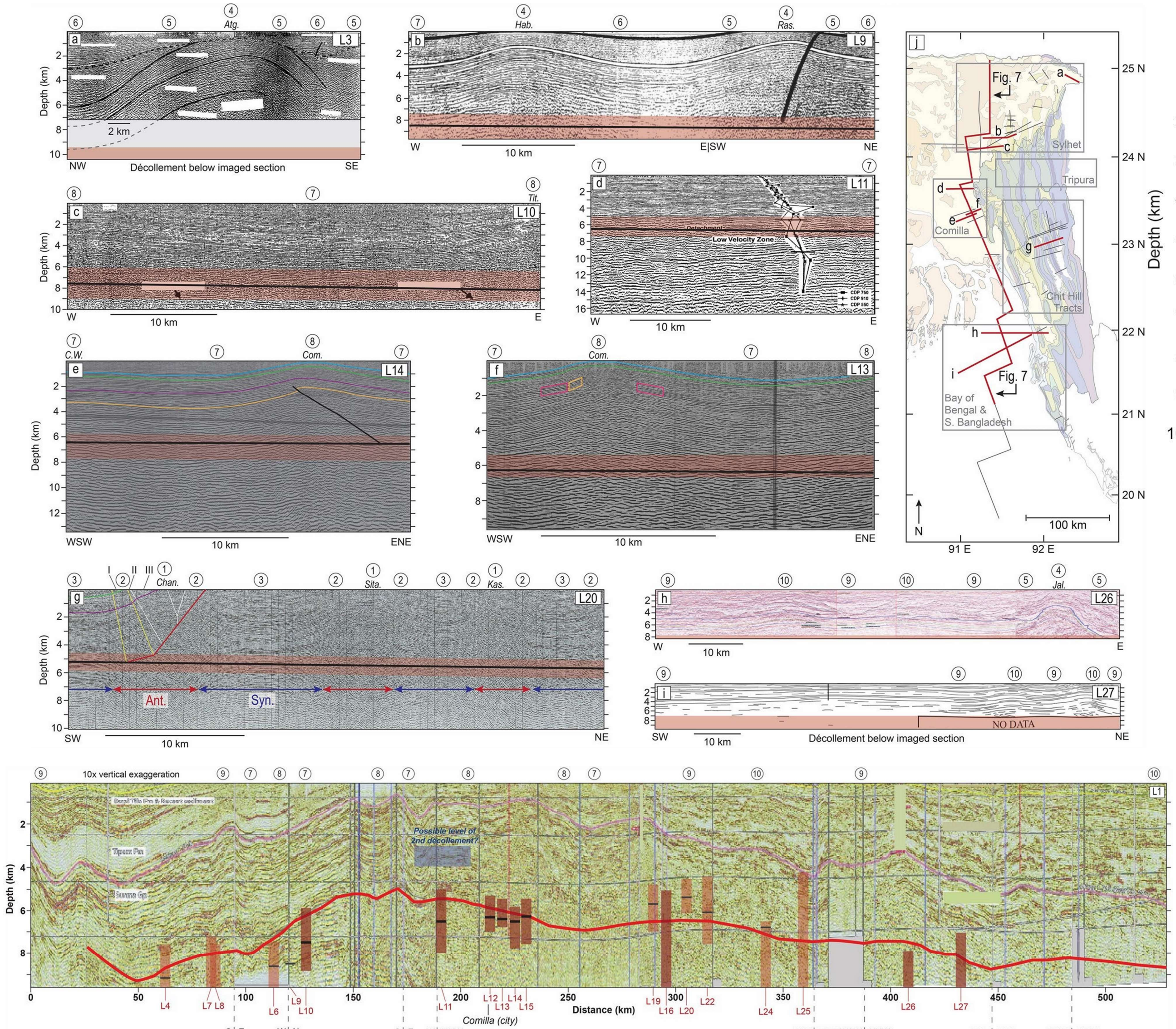


Paula Bürgi[1]

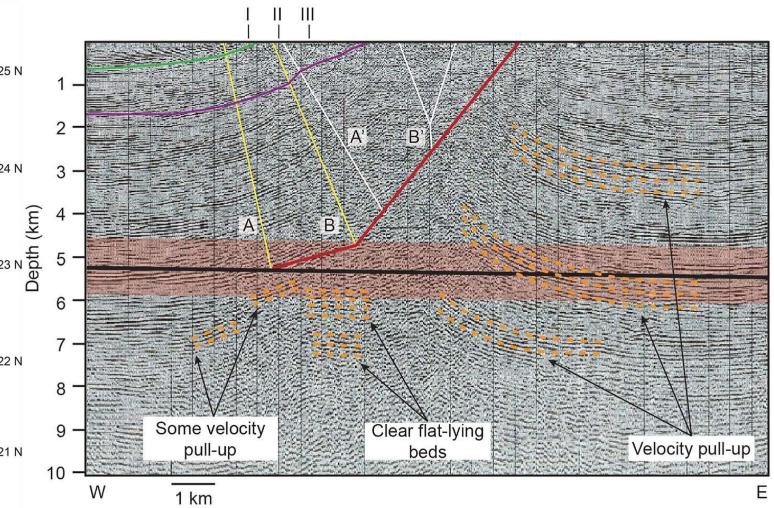
Judith Hubbard[2], Syed Humayun Akhter[3], and Dana E. Peterson[4]

[1]Department of Earth and Atmospheric Sciences, Cornell University, Ithaca, NY, USA, [2]Asian School of the Environment, Nanyang Technological University, Jurong West, Singapore, [3]Department of Geology, Dhaka University, Dhaka, Bangladesh, [4]U.S. Geological Survey, Geology, Geophysics, and Geochemistry Science Center, Denver, CO, USA

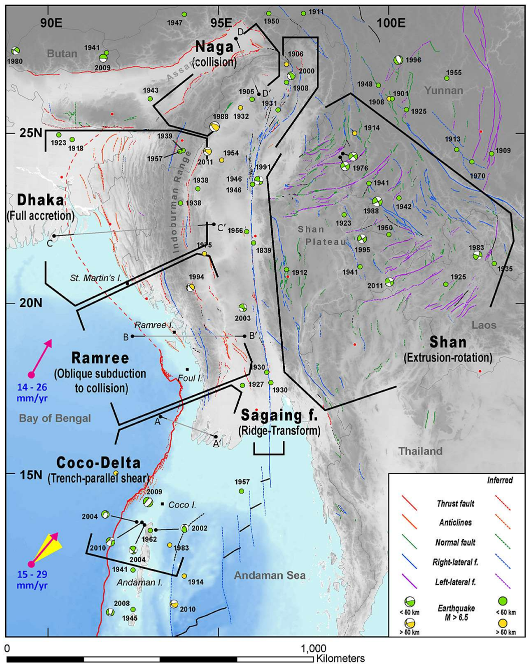
Historical (light gray, approximate locations) and instrumentally recorded (colored by depth) earthquakes within and around the CMFB. Instrumental events that report a depth uncertainty range are outlined in black, and those that do not are outlined in gray. Major cities are marked by small blue stars, and the capital city of Dhaka is marked by a large blue star. Latitudinal (b) and longitudinal (c) cross sections of instrumental seismicity, where events outlined in gray and black in (a) are plotted in gray and colored by depth, respectively

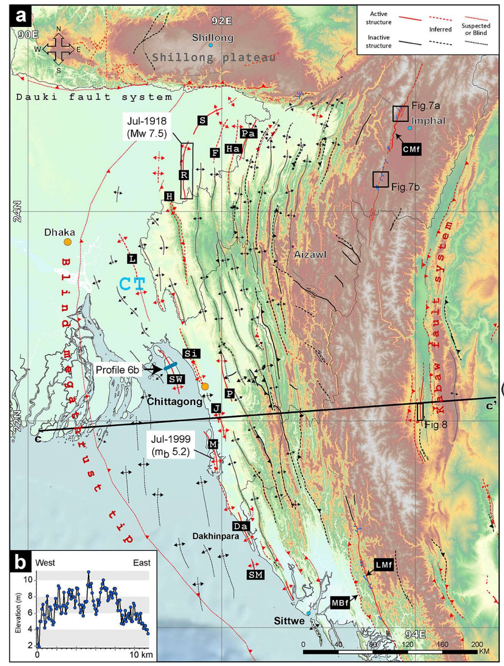


L3
Atg.
Depth (km)
2 km
NW
Décollement below imaged section
SE
L9
Hab.
Ras.
W
10 km
E|SW
NE
L10
Tit.
W
10 km
E
L11
Low Velocity Zone
W
10 km
E
L14
C.W.
Com.
WSW
10 km
ENE
L13
Com.
WSW
10 km
ENE
Fig. 7
Sylhet
Tripura
Comilla
Chit Hill Tracts
Bay of Bengal &
S. Bangladesh
25 N
24 N
23 N
22 N
21 N
20 N
91 E
92 E
100 km
N
L20
Chan.
Sita.
Kas.
Ant.
Syn.
SW
10 km
NE
L26
Jal.
W
10 km
E
L27
NO DATA
SW
10 km
Décollement below imaged section
NE
10x vertical exaggeration
L1
Tipura Fm
Possible level of 2nd décollement?
Depth (km)
Distance (km)
L4
L7 L8
L6
L9
L10
L11
L12
L13
L14
L15
L19
L16
L20
L22
L24
L25
L26
L27
S | E
W | N
S | E
W | NNW
Comilla (city)
SSE | ENE WSW | NNW
SSE | ENE
WSW | NNW

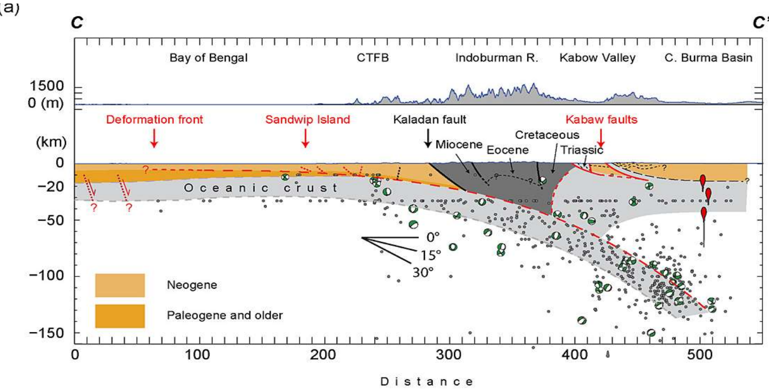


I
II
III
A
B
A'
B'
Depth (km)
Some velocity pull-up
Clear flat-lying beds
Velocity pull-up
W
1 km
E

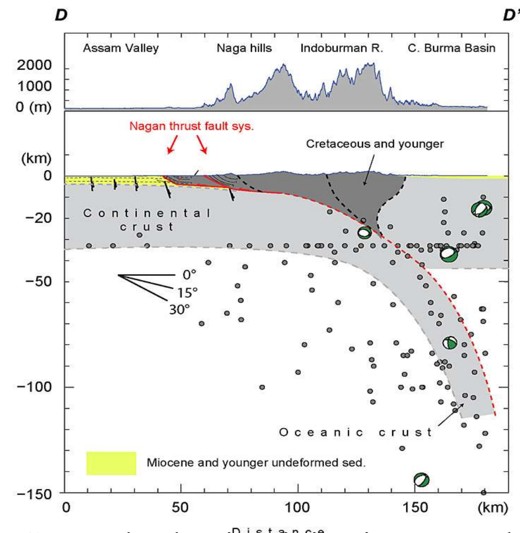


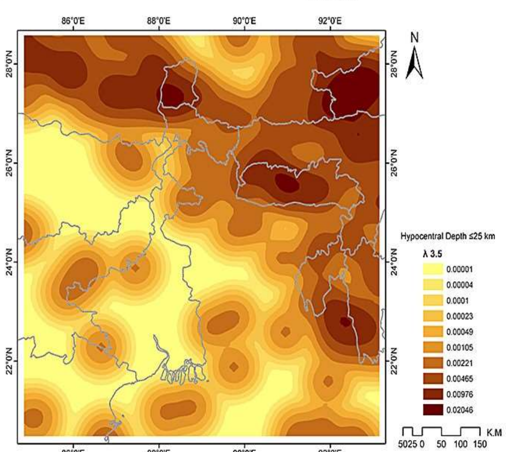


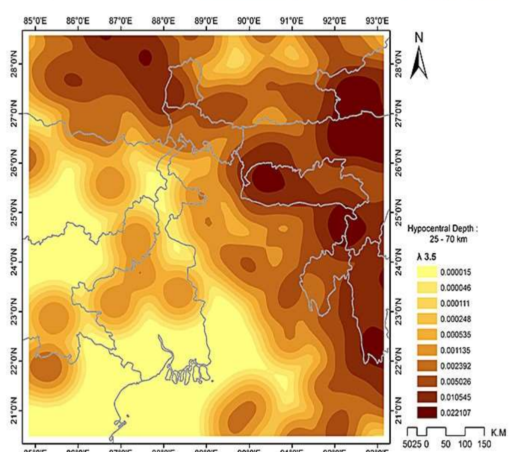
(a)



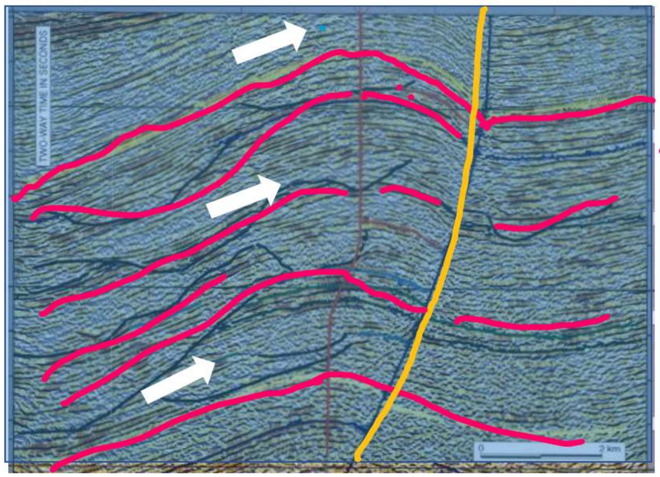
(b)



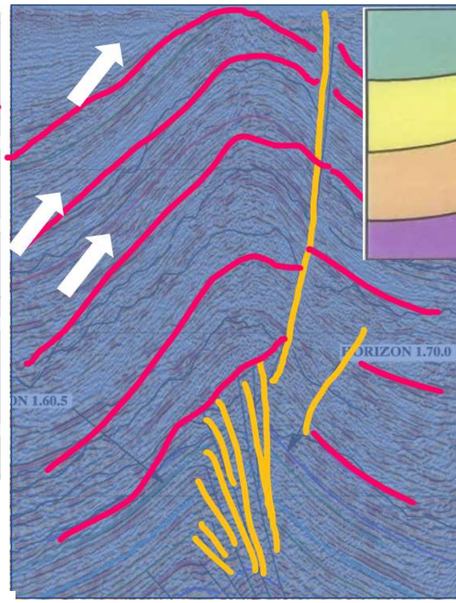




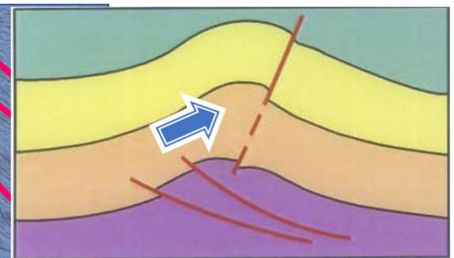
Smoothed seismicity in Bengal Basin and its adjoining region for a threshold magnitude of M_w 3.5 at two hypocentral depth regions (0–25 and 25–70km) indicating the seismic activity distribution



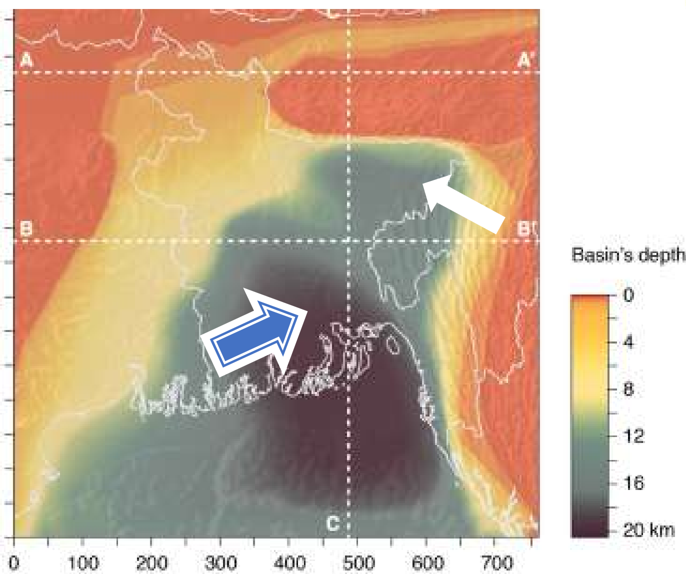
Structural cartoon style-Chittagong Hills Tract



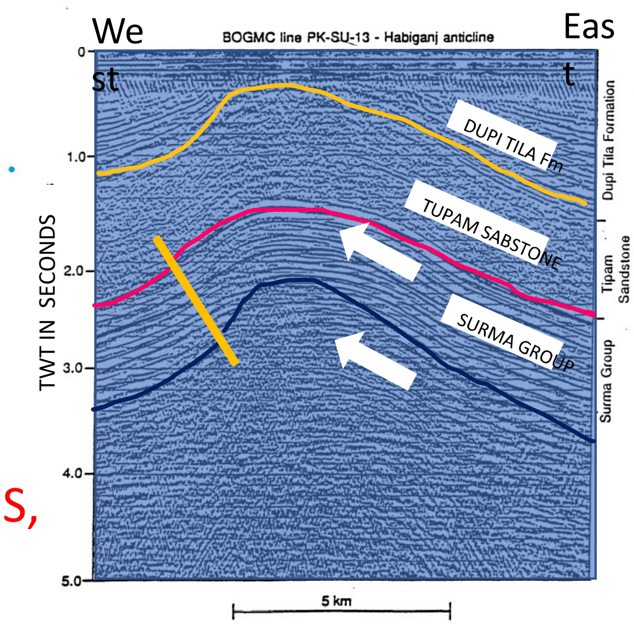
Structural cartoon style-Offshore Bay of Bengal



Structural style cartoon-Chittagong Hills Tract



WHERE IS THE THRUST AND WHAT ARE THE DIRECTIONS, DID IT REALLY CHANGE.... ????

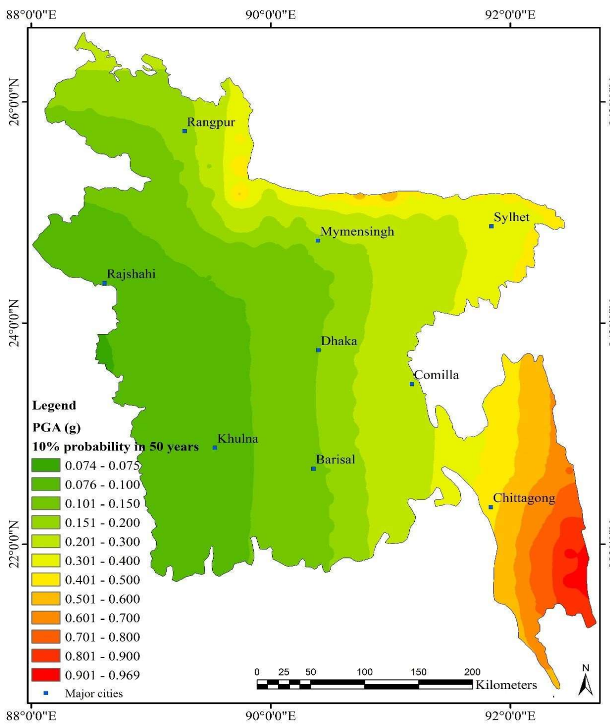


Structural style cartoon North East Bangladesh

Probabilistic Seismic Hazard Maps

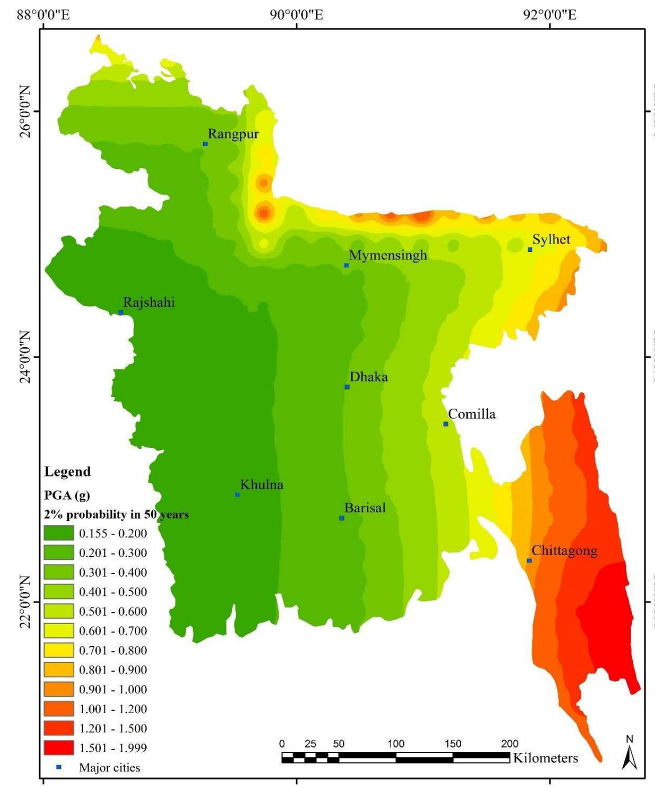
The PSHA was performed for Bangladesh at a grid size of 0.25^0. At each grid, the peak ground acceleration (PGA) and spectral acceleration (SA) for natural periods of 0.2, 0.5, 1.0, 2.0, 5.0, and 10.0 s at 5% damping ratio were estimated for 10% (return period of 475 years) and 2% (return period of 2475 years) probability of exceedance in 50 years. The ground motion parameters were estimated at a reference bedrock condition where time-averaged shear wave velocity in the top 30 m (V_s^{30}) is 760 m/s. This reference bedrock condition is the boundary between the site classes B (rock) and C (very dense soils or soft rock) of the NEHRP (National Earthquake Hazards Reduction Program, USA).

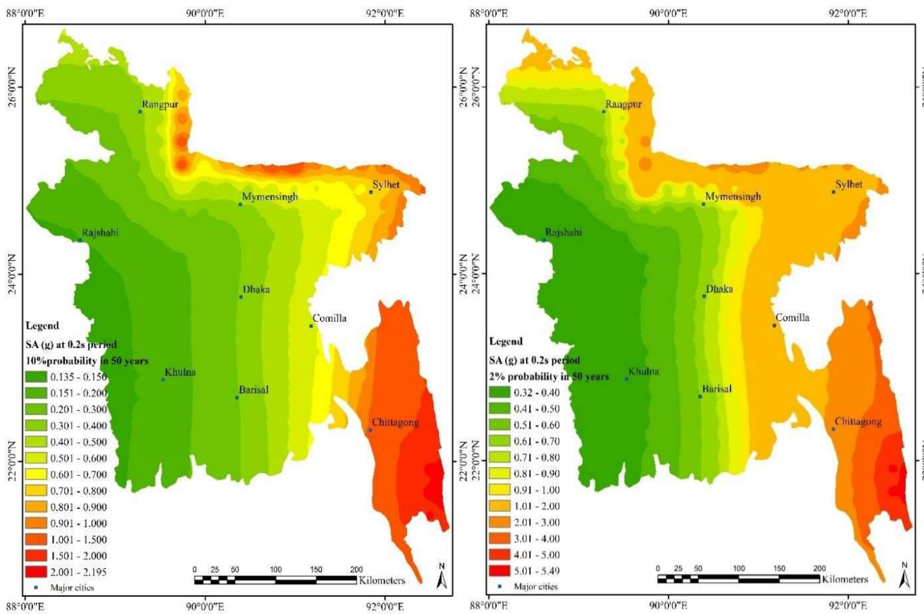
Peak ground acceleration (PGA) maps for Bangladesh were prepared for 10% and 2% probability of exceedance in 50 years using ArcGIS software. The spectral acceleration maps for the periods of 0.2, 0.5, 1.0, 2.0, 5.0, and 10 s were also prepared for Bangladesh for 10% and 2% probability of exceedance in 50 years



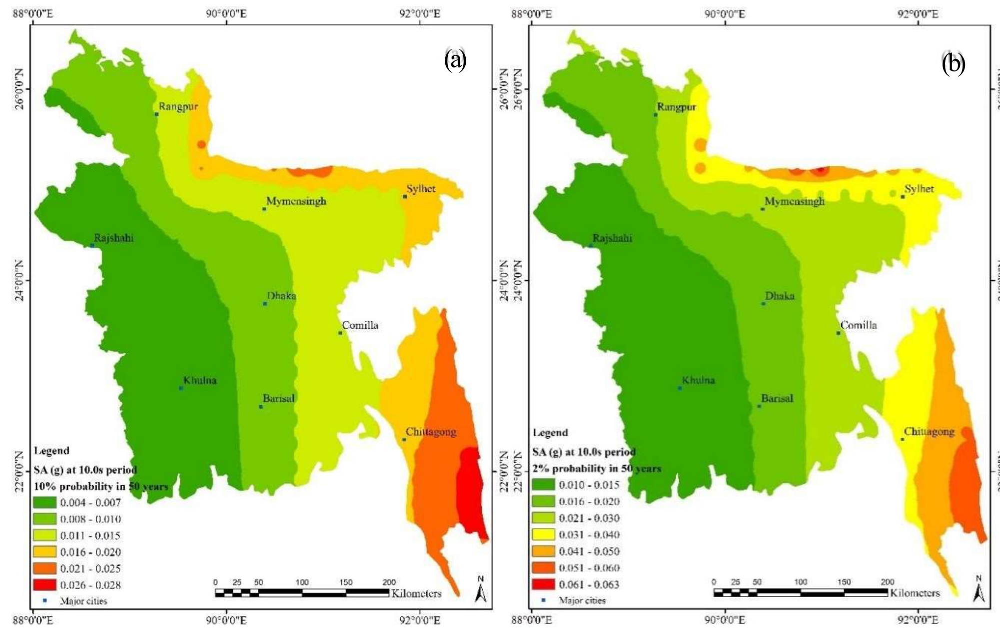
Peak ground acceleration (PGA) in g (gravitational acceleration) for 10 % probability of exceedance in 50 years (475 years return period) for Bangladesh.

Peak ground acceleration (PGA) in g (gravitational acceleration) for 2 % probability of exceedance in 50 years (2475 years return period) for Bangladesh.



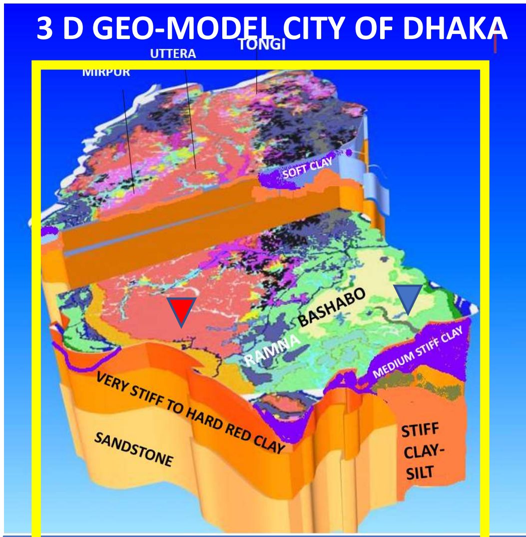


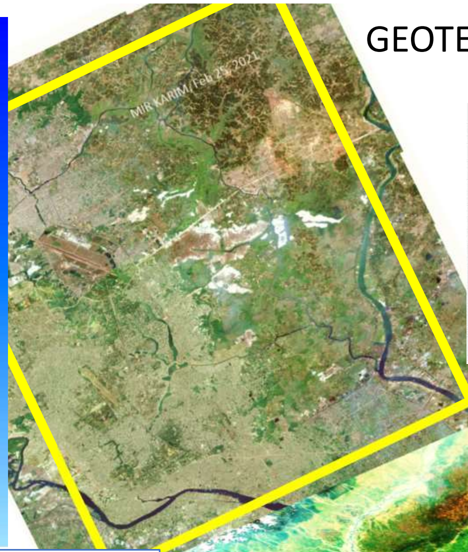
Spectral accelerations (SA) in g (gravitational acceleration) for Bangladesh: (a) at 0.2 second (s) period for 10% probability in 50 years; (b) at 0.2s period for 2% probability in 50 years.

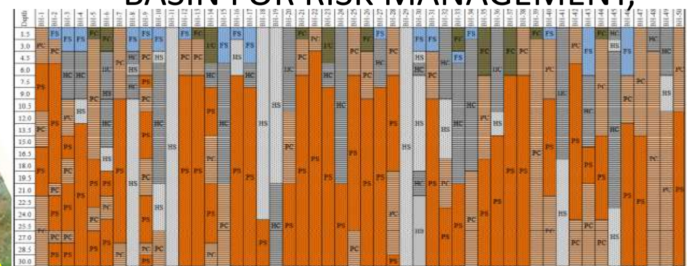


Spectral accelerations (SA) in g (gravitational acceleration) for Bangladesh: (a) at 10.0s period for 10% probability in 50 years; and (b) at 10.0s period for 2% probability in 50 years.

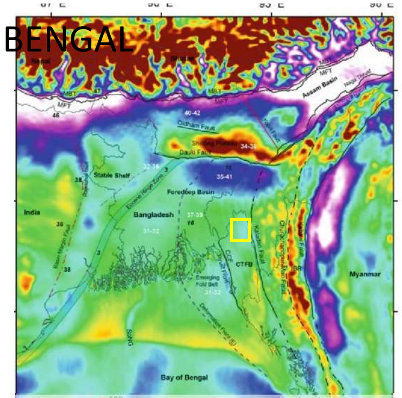
GEOTECHNICAL, GEOLOGICAL AND TECTONICS OF BENGAL BASIN FOR RISK MANAGEMENT,



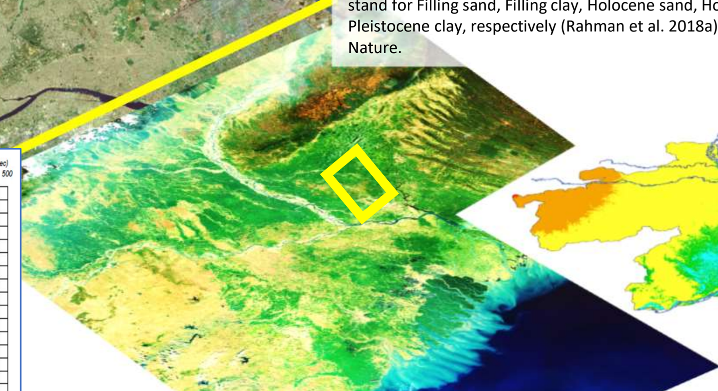


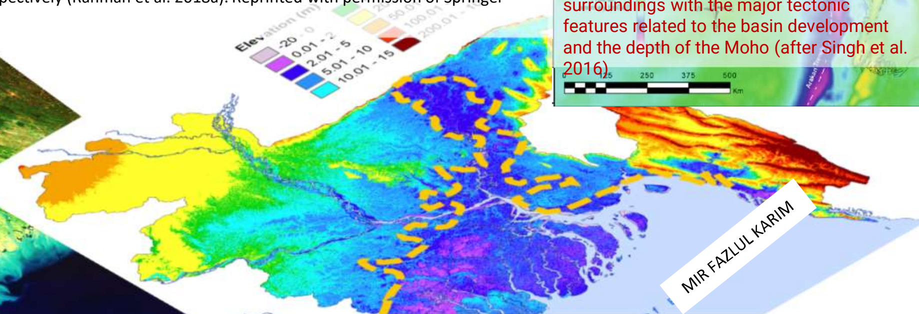


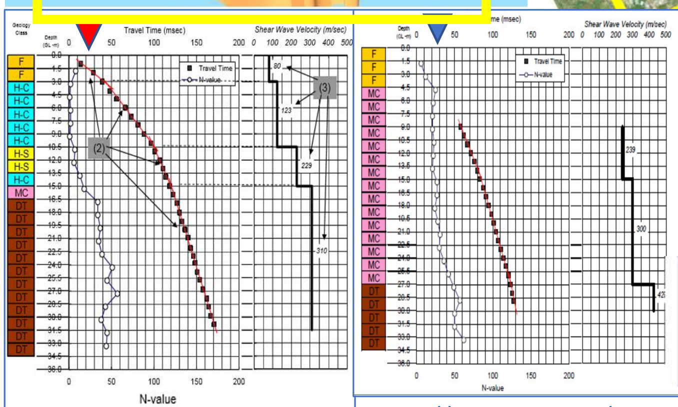
Subsurface geological classification of 50 boreholes in Dhaka City. FS, FC, HS, HC, PS and PC stand for Filling sand, Filling clay, Holocene sand, Holocene clay, Plio-Pleistocene sand and Plio-Pleistocene clay, respectively (Rahman et al. 2018a). Reprinted with permission of Springer Nature.



Free-air gravity map of the Bengal Basin and surroundings with the major tectonic features related to the basin development and the depth of the Moho (after Singh et al. 2016).







Satellite image of Bengal Basin and adjoining areas showing distinct geomorphological divides following basement configuration as show in the gravity anomaly map above.

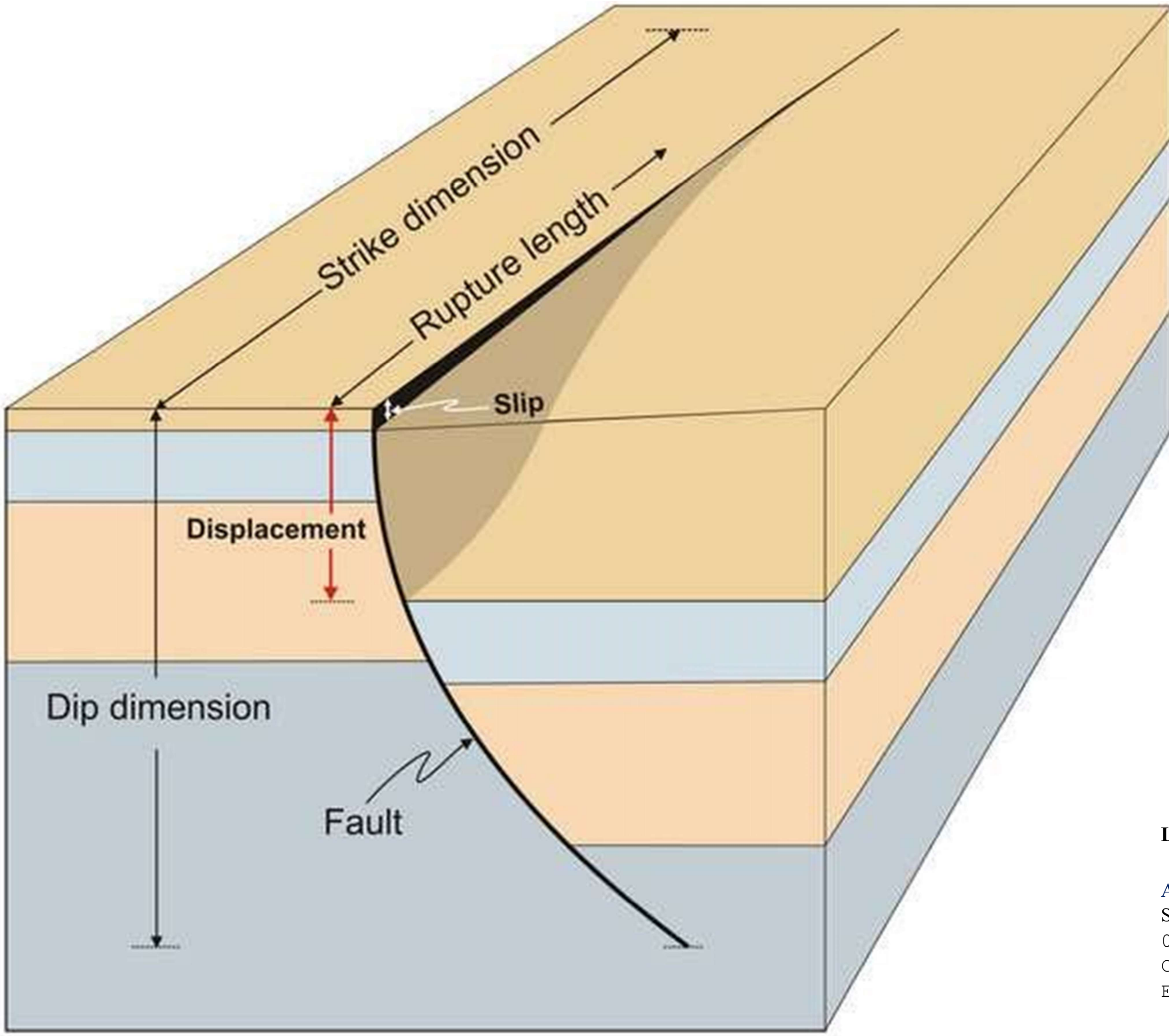
Contour15 ft. Water Height Mark AMSL. A possible surface scar of deeper trench of Bengal Basin Basement Complex, identified as zone of liquefaction.
(Prepared by Mir Fazlul Karim, Feb., 21, 2021)

PLEASE CLICK https://www.scec.org/publication/6833

The seismic risks are manageable provided the engineering structures adhere to the norms of seismic regulations and building codes. A 3D case study on site-specific earthquake hazard characterization of Dhaka Megacity is done by using geological and seismo-tectonic information of the Bengal Basin for determining more accurately updated national building code viz safety factors for sustainable geo-structures and thus seismic risk reductions in Bangladesh.

MIR KARIM, Feb 25, 2021

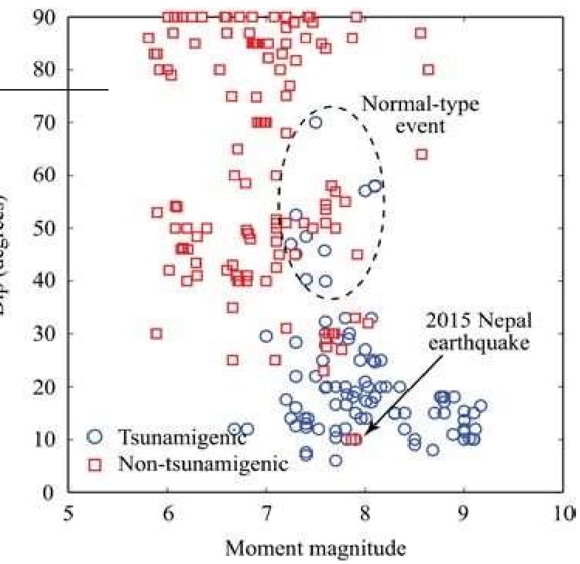
THE CHALLENGE IS PHYSICAL DATA

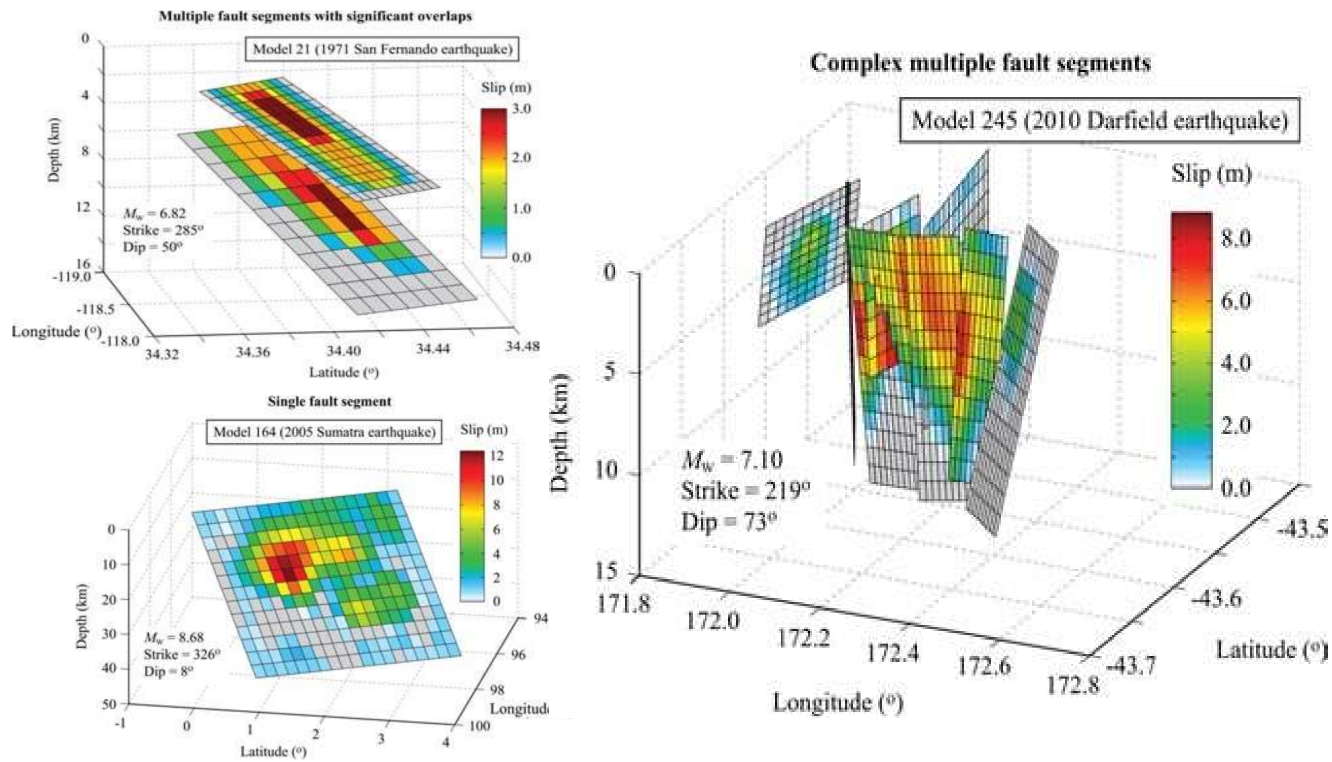


Dimensions needed to calculate earthquake magnitudes from given or imaginary parameters.

Length-displacement scaling and fault growth

Agust Gudmundsson[a*], Giorgio De Guidi[b], Salvatore Scudero[b] [a]Department of Earth Sciences, Queen's Building, Royal Holloway University of London, Egham TW20 0EX, UK. (a.gudmundsson@es.rhul.ac.uk) [b]University of Catania, Department of Biological, Geological and Environmental Sciences, Italy (defudi@unict.it)





New Scaling Relationships of Earthquake Source Parameters for Stochastic Tsunami Simulation

Katsuichiro Goda
Department of Civil Engineering, Queen's School of Engineering, University of Bristol, Queen's Building, University Walk, Bristol, BS8 1TR, UK
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Tomohiro Yasuda
Faculty of Environmental and Urban Engineering,

Three rupture models are illustrated in Fig. 1. In general, a finite-fault rupture model is represented by a set of sub-faults, geometry of which can be characterized by either single segment (model 164; Fig. 1(b)) or multiple segments (models 21 and 245; Figs. 1(a) and 1(c)). The resolution of model discretization is influenced by available data and inversion methods. Each sub-fault has estimated earthquake slip (and other parameters, depending on the details of the inversion models), and thus the rupture models are useful for investigating the spatial features of the earthquake rupture process in addition to geometry parameters.

Kansai University, 3-3-35 Yamate-cho, Suita, Osaka 564-8680, Japan
Nobuhito Mori and Takuma Maruyama
Disaster Prevention Research Institute,
Kyoto University, Gokasho,

Bulletin of the Seismological Society of America, Vol. 84, No. 4, pp. 974—1002, August 1994

New Empirical Relationships among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacementby Donald L. Wells and Kevin J. Coppersmith

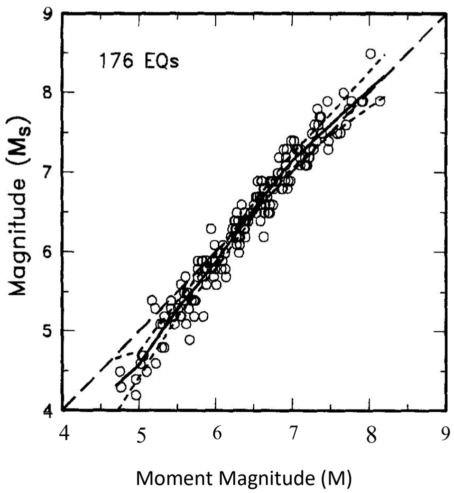


Figure 1 . Surface-wave magnitude (Ms) versus moment magnitude (M) for historical continental earthquakes. Segmented linear regression shown as solid line, with segment boundaries at M 4.7, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, and 8.2. Short dashed lines indicate 95% confidence interval of regression line. Long dashed line indicates equal magnitudes (l to I slope).

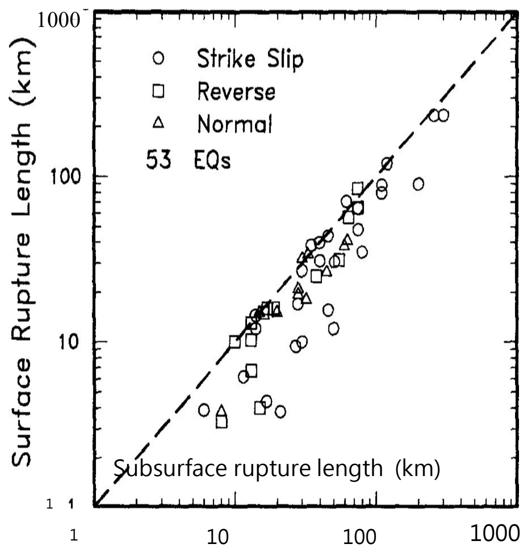
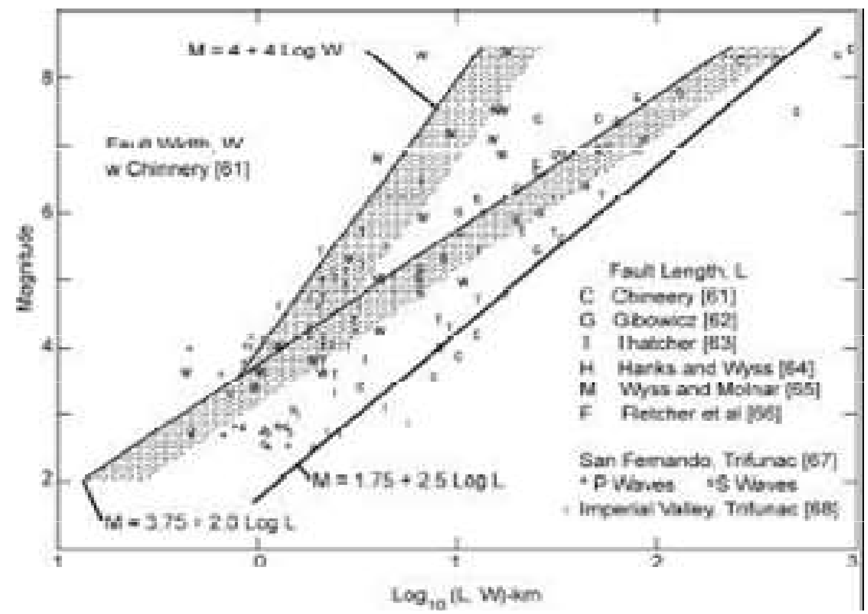


Figure 2. Surface rupture length versus subsurface rupture length estimated from the distribution of early aftershocks of historical continental earthquakes.



CONCLUSIONS

1. **The Role of the Bangla Basin System in Earthquake Engineering for a safer Bangladesh would be our next step and derivation of equations for calculating possible earthquake magnitude from a given structural parameters .. Like Strike, Dip, Rake, Slip, Tectonic Stress and Strain LWD of Faults. Update the National Building Code…….**

2. **Our detailed field investigations and available seismic profiles did not find any physical earthquake generating structures capable of staging earthquakes greater than Magnitude 7.5 in the Bengal Basin System.**

THANK YOU
FOR YOUR KIND HEARING

MIR FAZLUL KARIM
ENGINEERING GEOLOGIST
JOHN TURNER CONSULTING, INC., USA

FORMER DIRECTOR
GEOLOGICAL SURVRY OF BANGLADESH

ANNEXES