Modelling the Moho depth and Flexure parameters across the Indo-Burma subduction zone

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Introduction

Indo-Burma subduction zone is one of the seismically active regions in India where the Indian plate is underthrusting the Burmese arc from the west. The nature of the slab subduction in this region and associated stress-regime are less understood due to the lack of deep crustal information. This work has tried to modelled the crustal structure along the subduction zone.

Data & Methodology

In this study, the **Topography** data from **ETOPO1** is used to model lithospheric flexure along the Indo-Burma subduction zone. Also, the vertical gravity component of '**Gravity Field and Steady State Ocean Circulation Explorer (GOCE)**' is used to estimate the Moho depth interface beneath this zone

Lithospheric Flexure Modelling

- The lithospheric plate is effected by various forces acting on it.
- The ordinary differential equation (Eq.3) represents the vertical deflection known as flexure (*w*) of the lithosphere.
- The solutions of the Eq.3 are Eq.4 and Eq.5, after the application of appropriate boundary conditions.
- Eq.4 and Eq.5 are used to forward model the flexural parameters such as the Effective elastic thickness (Te) Flexural Forebulge (w_b) and Bending moments (Mo) over 8 profiles on Topography map, across the Indo Burma subduction zone.
- Total 40 profiles are taken in between 15° N to 20° N, later staked into 8 profiles at a distance nearly 70 Km.

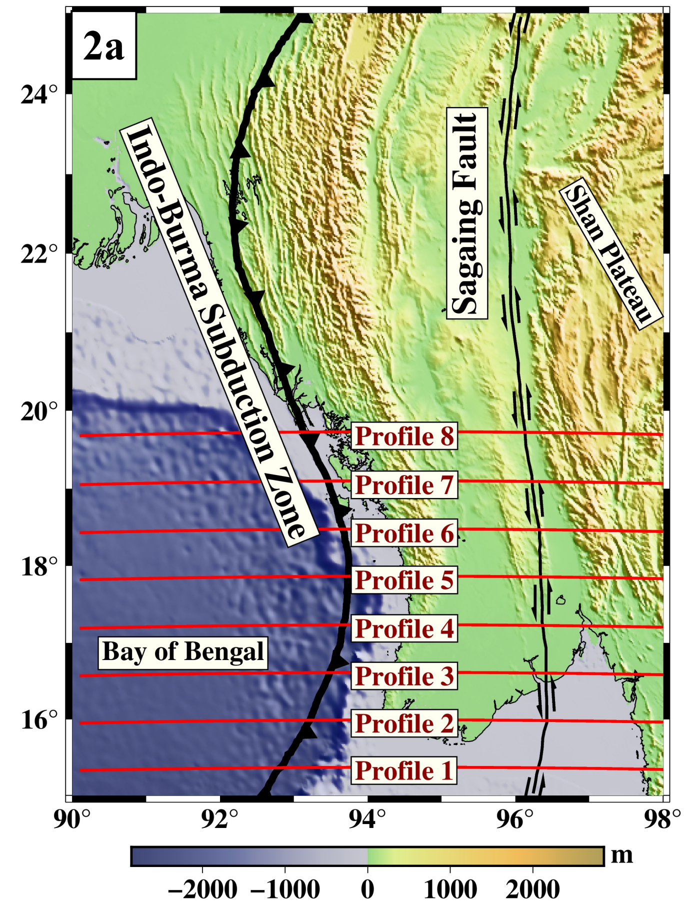
Eq. 3:
$$-\frac{d^2M}{dx^2}+\frac{d}{dx}\left(F\frac{dw}{dx}\right)+(\rho_m-\rho_w)wg=q$$

Eq. 4:
$$w(x)=w_b e^{\frac{\pi}{4}}\sqrt{2}e^{-\frac{\pi(x-x_o)}{4(x_b-x_o)}}\sin\left[\frac{\pi(x-x_o)}{4(x_b-x_o)}\right]$$

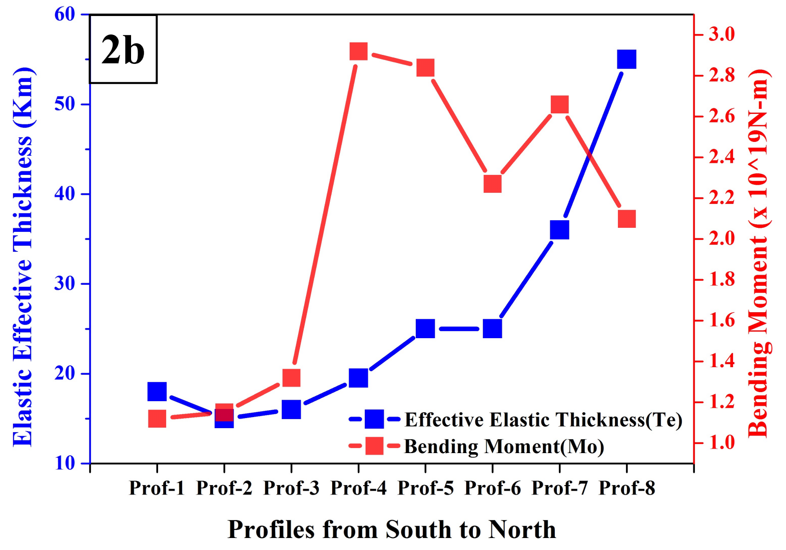
Eq 5:
$$w_b=\frac{\alpha^2 M_o}{2D}e^{\frac{-(x-x_o)}{\alpha}}\frac{\sin\frac{(x-x_o)}{\alpha}}{\cos(\frac{x_o}{\alpha})}$$

Where, E = Young's Modulus; Te = Elastic Thickness of the Plate.; w_b = Hight of the fore-bulge.; D = Flexural Rigidity.; x_o = First zero crossing.; $x_b - x_o$ = Half-width of the forebulge.; Mₒ = Bending Moment at subduction trench.; α = Natural wavelength of the elastic lithosphere.; $w(x)$ = Plate flexure at position x.; g = Gravitational Acceleration.; ρ_m= Mantle Density;ρ_w= Water Density; F = Horizontal Force; Vₒ = Shear force at the trench axis; q = Acting load on the plane.

Topography of Indo-Burma Subduction Zone



Variations of the Elastic Effective Thickness and Bending Moment



Variations of the Flexural Forebulge and Slab Depth

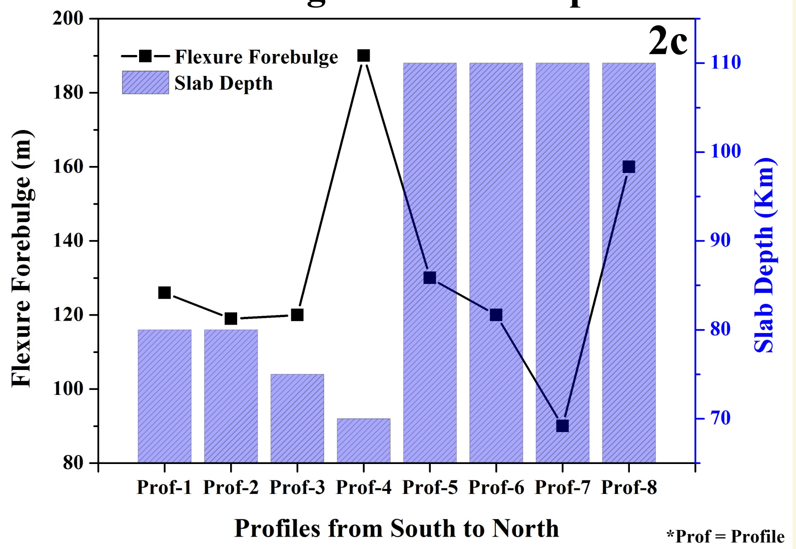
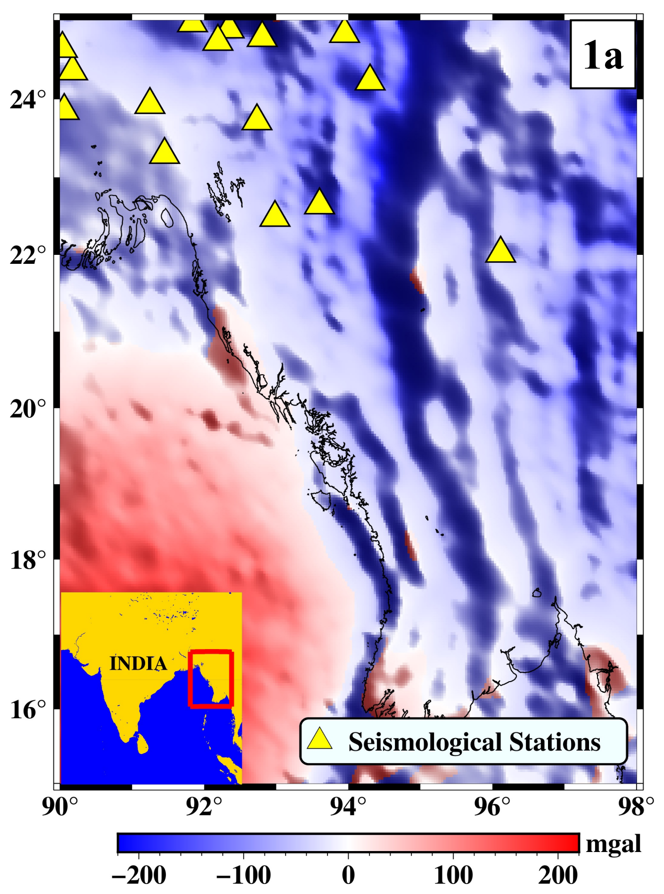
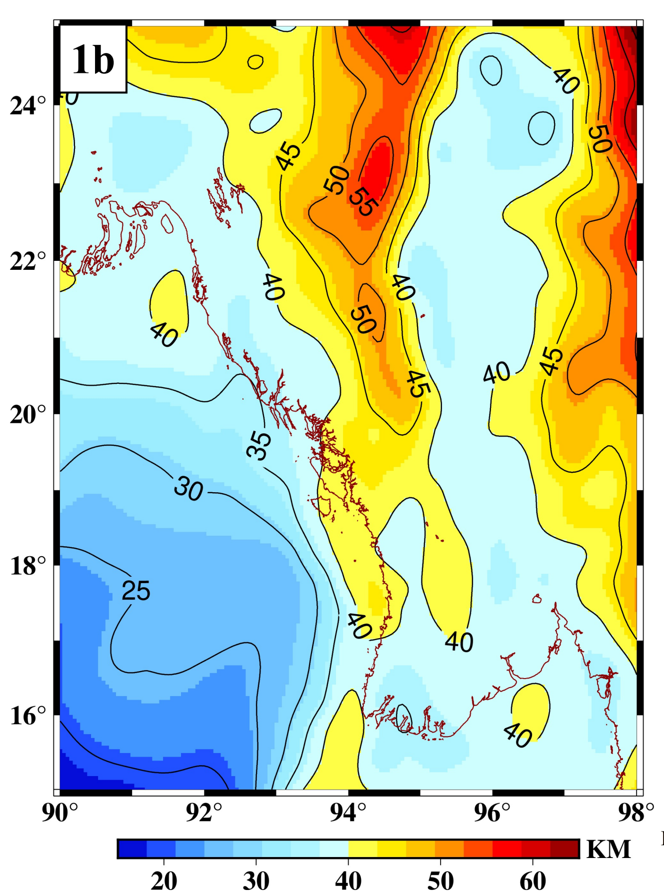


Figure 2a: The Topography Map over the Indo-Burma Subduction zone. **2b:** The Variations of the Elastic Effective Thickness(Te) and Bending Moment (Mo) along the subduction trench for different profiles. **2c:** The Variations of the Flexural fore bulge (w_b) and Slab depth along the subduction trench for different profiles.

Compelete Bouguer Anomaly



Estimated Moho Depth



3-D gravity Inversion: Moho Depth Estimation

- In order to obtain the Moho depths, a regularized nonlinear 3-D gravity inversion was performed using tesseroids in spherical coordinates (Uieda and Barbosa, 2017). This method combines both Bott's iterative inversion technique (Bott 1960; Silva et al., 2014) and Tikhonov regularization to overcome the ill-posed nature of the gravity inversion and obtain stable and smooth solutions. The solution of the inversion at K^{th} iteration the following parameter perturbation vector ($\Delta\rho^k$) represents as:

$$\Delta\rho^k=\frac{A^{kT}\left[g^0(x_i)-g(x_i,\Delta\rho,\rho^{k-1})\right]-\mu R^T R\rho^k}{\left[A^{kT}A^k+\mu R^T R\right]},\ i=1,2,\ldots N \ldots\ldots\ldots\ldots \textbf{Eq. 1}$$

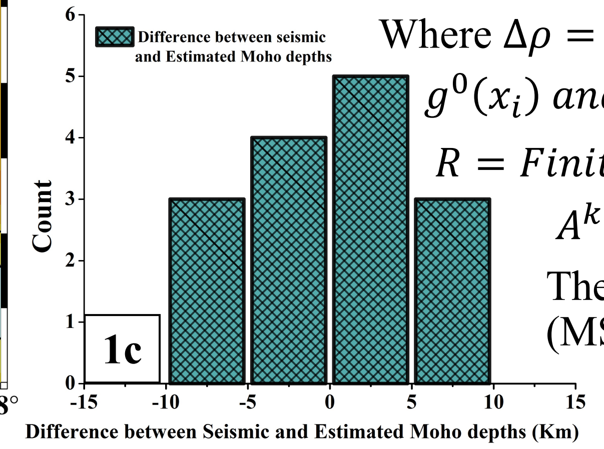
Where $\Delta\rho = density\ contrast\ at\ the\ crust-mantle\ interface$

$g^0(x_i)\ and\ g(x_i,\Delta\rho,\rho^{k-1}) = Observed\ and\ Computed\ gravity\ anomalies$

$R = Finite\ difference\ Matrix\ between\ depth\ of\ adjacent\ tesseroids;$

$A^k = Jacobian\ matrix;\ \mu = Regularization\ matrix;$

The optimal μ value is obtained based on the least mean square error (MSE) between the observed and predicted testing data.



$$MSE_n=\frac{\left\|d^0_{test}-d^n_{test}\right\|^2}{N_{test}}\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{Eq. 2}$$

Figure 1a: The Bouguer Gravity Anomaly Data; **1b:** The Estimated Moho depth; **1c:** Histogram of the difference between the Seismic Moho depths and predicted Moho depths.

Discussion and Conclusion

- The Moho interface in the Bay of Bengal (Indian plate) lies at a depth of 20-30 km and then deepens to a depth of 50-60 km towards the Burmese region.
- Beneath the Shan Plateau, Moho depth varies gently from 35 to 40 km and shows an eastward dip at Sagaing fault.
- The modelling results indicate that both Te (15-55 km) and Mo (1.12×10^{-19} to 2.84×10^{-19} N.m) values vary significantly along the subduction zone.
- Larger values of Te (55 km) and Mo (2.84×10^{-19} N.m) are noticed in the central Indo-Burmese subduction zone, where the slab depth is around 110 km.
- Whereas the lowest values of Te (15 km) and Mo (1.12×10^{-19} N.m) are inferred for the profiles lying in the southern Indo-Burmese subduction.
- Abnormally, High value in Mo around profile 4 while the low value in the slab depth, may indicate the presence of significant horizontal forces acting on the slab.

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*Figures are generated using OriginLab and Generic Mapping Tools