Curie depth point, effective elastic thickness, and 3-D crustal structure of Eastern Indian shield based on the interpretation of satellite gravity (GOCE) and aeromagnetic data.

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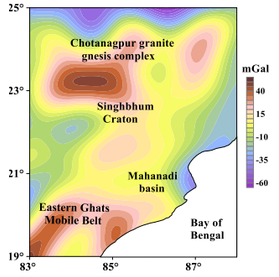
Introduction

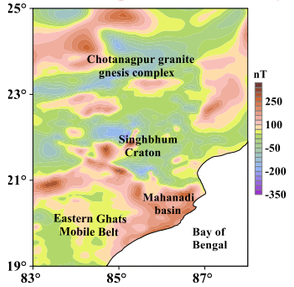
- Eastern Indian shield comprise of the Archean Singhbhum Craton, Proterozoic Chotanagpur granite gneiss complex and Eastern Ghats Mobile belt.
- Crustal evolution and crustal geometry of the region is poorly understood due to the scanty of seismological observations.
- In the present study, analyzing the satellite gravity (GOCE), aeromagnetic, and topography data complemented with seismological constraints to understand the crustal evolution of the region.

Data & Methodology

Free-air gravity anomaly map



Aeromagnetic anomaly map



Estimation of Curie Depth Point (CDP)

According to Blakely (1996), the radial averaged power spectral density P(k) of a magnetized body having infinite extensions in the horizontal direction and depth to the top of the body is small compared with the horizontal scale of a magnetic source which can be written as

$$\mathbf{P(k) = Ae^{-2|k|Z_t}\left(1 - e^{-|k|(Z_b - Z_t)}\right)^2} \quad \ldots\ldots\ldots\ldots (1)$$

- At middle-high wave number band, equation (1) can be approximated as

$$\ln(P(k)) = B - 2\,|k|Z_t \quad \ldots\ldots\ldots\ldots (2)$$

- At low-wavenumber band, equation (1) could also be written as:

$$\ln(P(k)/k) = C - 2|k|Z_o \quad \ldots\ldots\ldots\ldots (3)$$

- Curie Depth Point $\boldsymbol{Z_b = 2Z_o - Z_t}$ (Okubo et al., 1985)

where Z_t is estimated equation (2) & Z_o is estimated from equation (3)

Estimation of effective elastic thickness (Te)

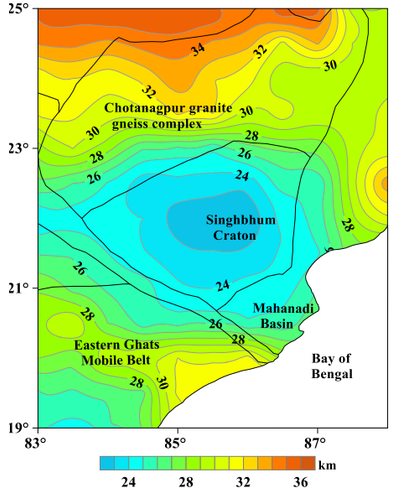
Forsyth (1985) has given expression for wavelet coherency between the gravity wavelet transform and topography wavelet transform, that could be written as follows

$$\gamma_w^2(s,x) = \frac{\langle \tilde{g}_{sx\theta}\, \tilde{h}^*_{sx\theta}\rangle_\theta \langle \tilde{g}_{sx\theta}\, \tilde{h}^*_{sx\theta}\rangle_\theta}{\langle \tilde{g}_{sx\theta}\, \tilde{g}^*_{sx\theta}\rangle_\theta \langle \tilde{h}_{sx\theta}\, \tilde{h}^*_{sx\theta}\rangle_\theta} \quad \ldots\ldots\ldots\ldots (4)$$

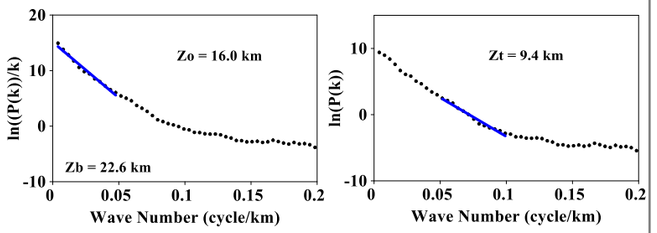
Here, $\tilde{g}$ is the wavelet Fourier transform of the gravity anomaly, $\tilde{h}$ is the wavelet Fourier transform the topography data. *s, x,* and θ are the scale, position, and azimuth of the Morlet wavelet, respectively. $<>_\theta$ represents the averaging over the azimuth (θ).

Results

Curie Depth Point (CDP) map

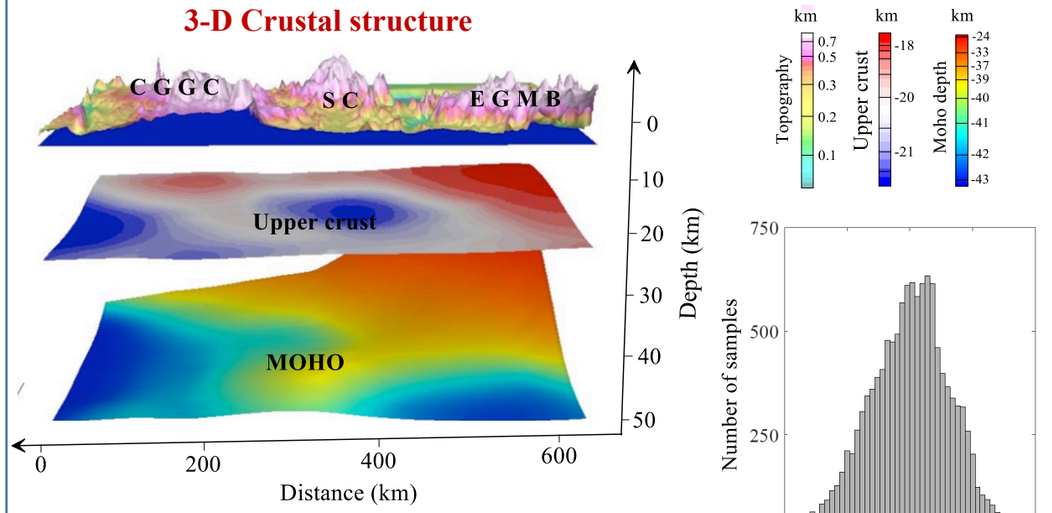


Radially average power spectrum



- Curie depth point (CDP) values were derived from the spectral analysis of the aeromagnetic data range from 23-36 km over the Eastern Indian shield.
- The obtained CDP values range from 25-30 km beneath Eastern Indian shield, 23-26 beneath the Singhbhum craton, and 30-36 km beneath the chotanagpur granite gneiss complex.

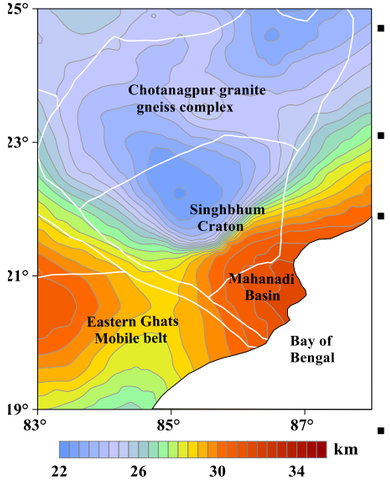
3-D Crustal structure



- The results of Moho boundary lies at a depth of 35-38 km beneath the Eastern Ghats Mobile Belt and 38-40 km below Singhbhum Craton, and it increases gradually towards the Chotanagpur granite gneiss complex to a depth of 40-44 km

Results

Effective elastic thickness (Te) map



- The total range of the effective elastic thickness (Te) values over the eastern Indian shield is 22-32 km.
- The Eastern Ghats Mobile Belt is characterized with deep Te values (27-30 km).
- Beneath the Singhbhum craton (SC) Te values range from 22-31 km in which center and north portion of SC having the shallow Te values (22-24), whereas southeastern portion of SC showing deeper Te values (28-31 km)
- In the chotanagpur granite gneiss complex showing the flat Te values (24-26 km)

Conclusions

- Spectral analysis of aeromagnetic data reveals that shallow CDP (24-26 km) values below the Singhbhum craton.
- Moho depths (34-44 km) from 3-D forward gravity modeling and available seismological studies of this region indicate that CDP values are shallower than the Moho.
- Shallowest CDP values (23-36 km), and low Te values (22-32 km) observed over the Eastern Indian Shield suggests thermal reworking of the cratonic lithosphere in this region.

References

Blakely, R. J. (1996). Potential theory in gravity and magnetic applications. Cambridge university press.

Forsyth, D. W. (1985). Subsurface loading and estimates of the flexural rigidity of continental lithosphere. Journal of Geophysical Research: Solid Earth, 90(B14), 12623-12632.

Okubo, Y., Graf, R. J., Hansen, R. O., Ogawa, K., & Tsu, H. (1985). Curie point depths of the island of Kyushu and surrounding areas, Japan. Geophysics, 50(3), 481-494.

Talwani, M., Worzel, J. L., & Landisman, M. (1959). Rapid gravity computations for two-dimensional bodies with application to the Mendocino submarine fracture zone. Journal of geophysical research, 64(1), 49-59.