Heat flux over Indian Subcontinent from Satellite and Aeromagnetic Data

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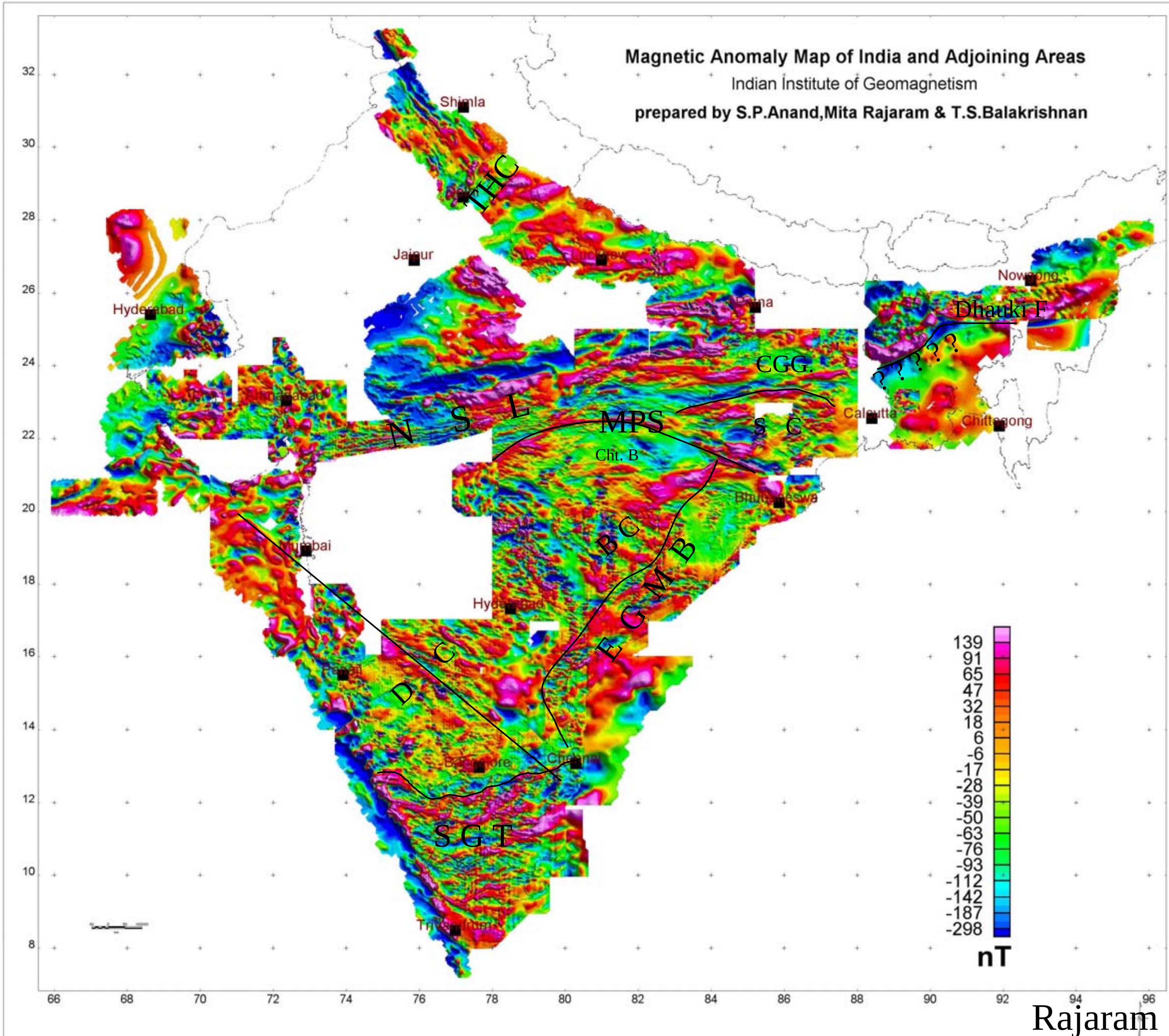
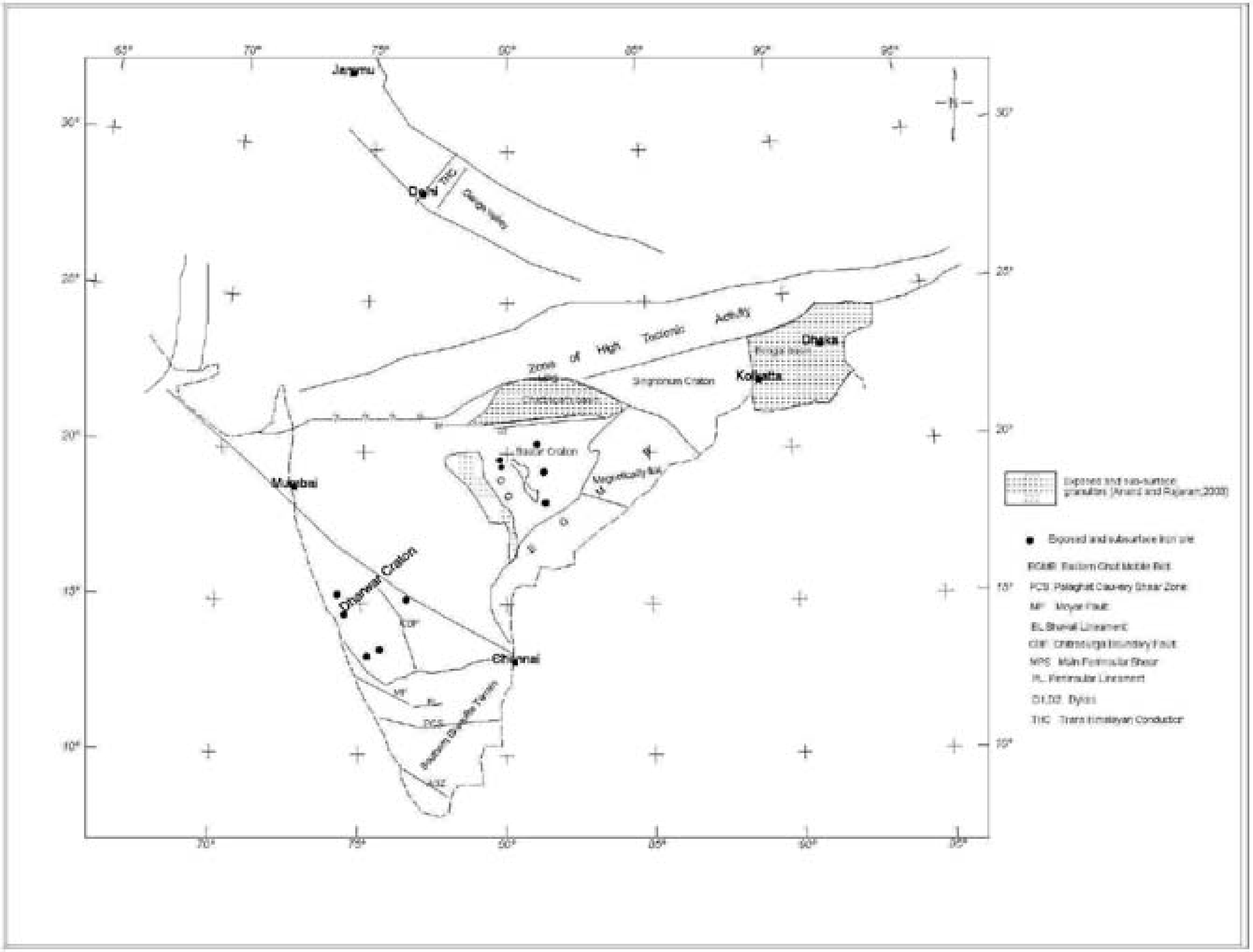
Composite Magnetic Anomaly Map of India



Rajaram et al (2006)

Interpreted map



Rajaram et al, 2006

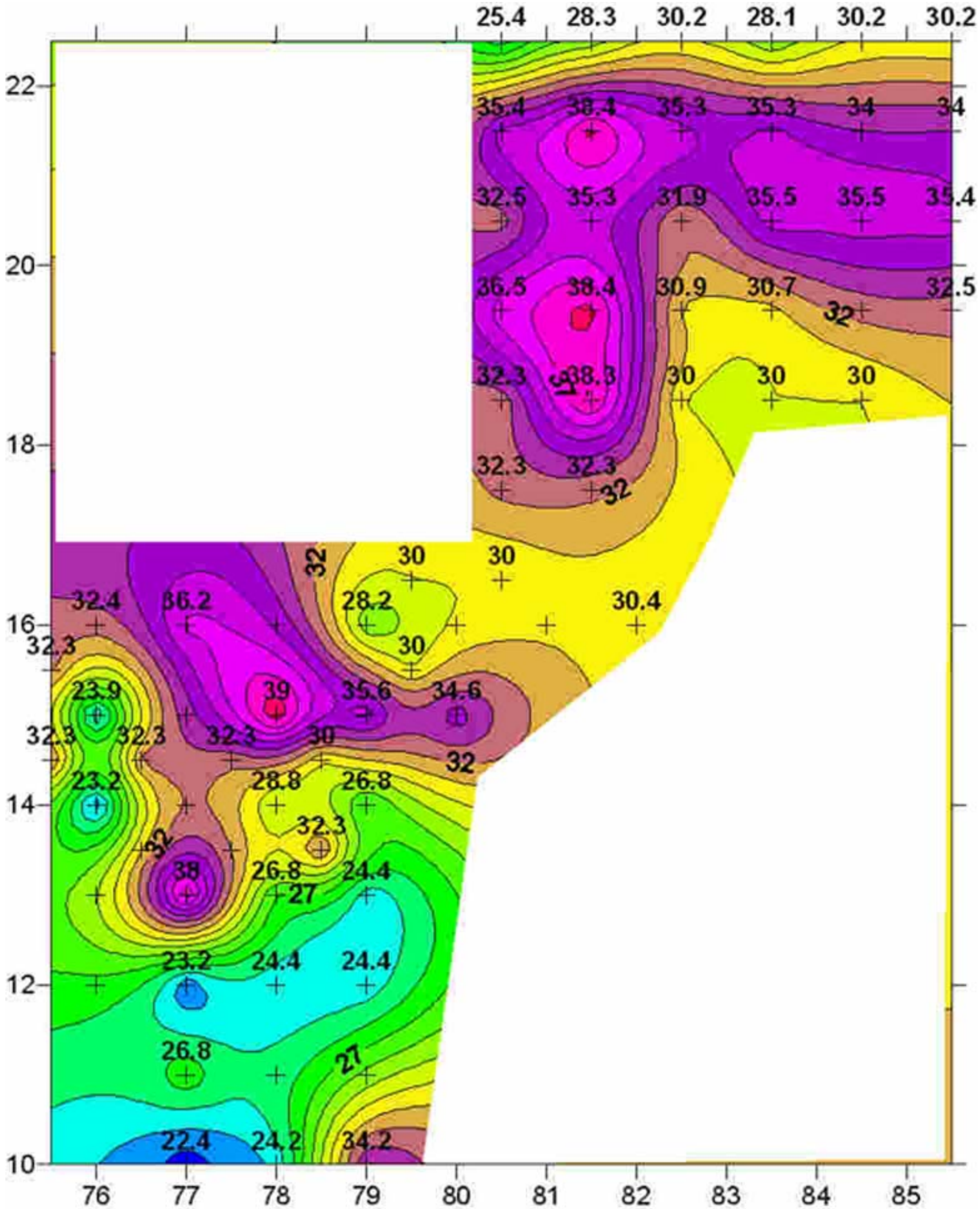
Estimation of Curie isotherm depth

When a significant spectral maximum does occur, indicating that the source bottoms are detectable, the wave number k_{max} of the spectral peak, the mean depth z_t to the source tops and the mean depth z_b to the source bottom are related by

$$k_{\max} = \frac{\log z_b - \log z_t}{z_b - z_t}$$

For determining the depth to the Curie isotherm the power spectral estimates were made for every 2^0 X 2^0 blocks to see if the spectral peak exists and the size of the block was increased; we found that the a significant spectral maxima existed only for 4^0X 4^0.

Curie isotherm depths



Equation for Heat Flux

1-D Heat conduction model:

$$Q(z=0) = -\frac{k(T_c - T_{sur})}{Z_c} - H_0 d + \frac{H_0 d^2}{Z_c}(1 - \exp(-\frac{Z_c}{d}))$$

Q – Heat Flux

d – Scale depth = 8 km

k – Thermal Conductivity = 2.8 W/mK

Z_c – Curie Isotherm depth

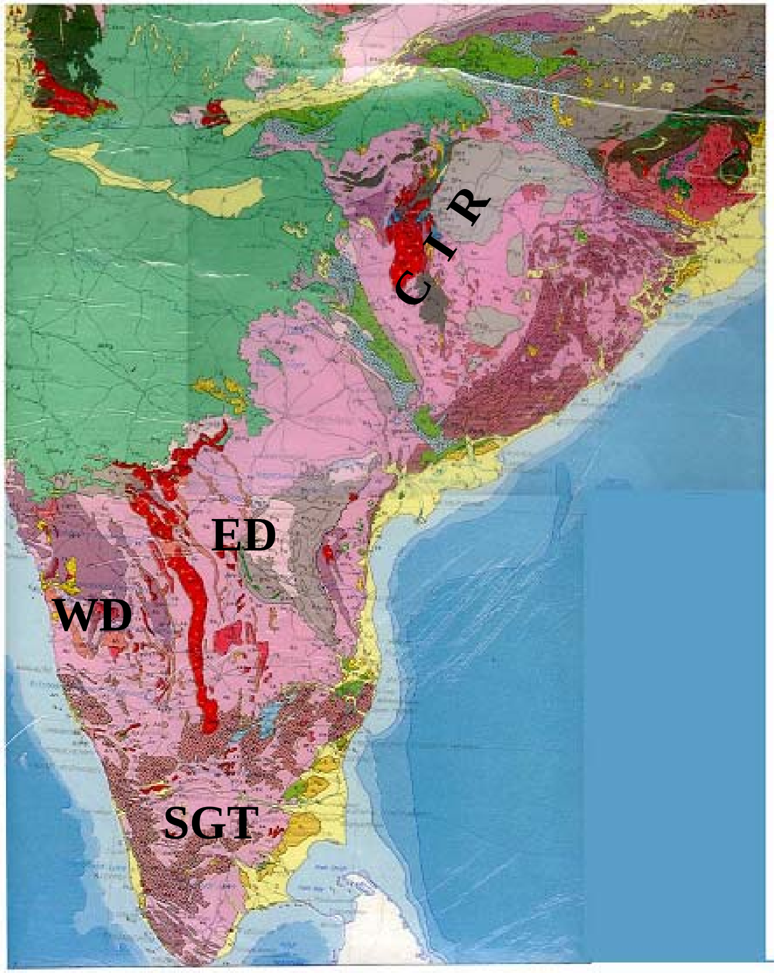
H_o – Surface Heat production = 2.5* 10^{-6} W/m^3

T_c-T_{sur}– Temp difference = 580 K

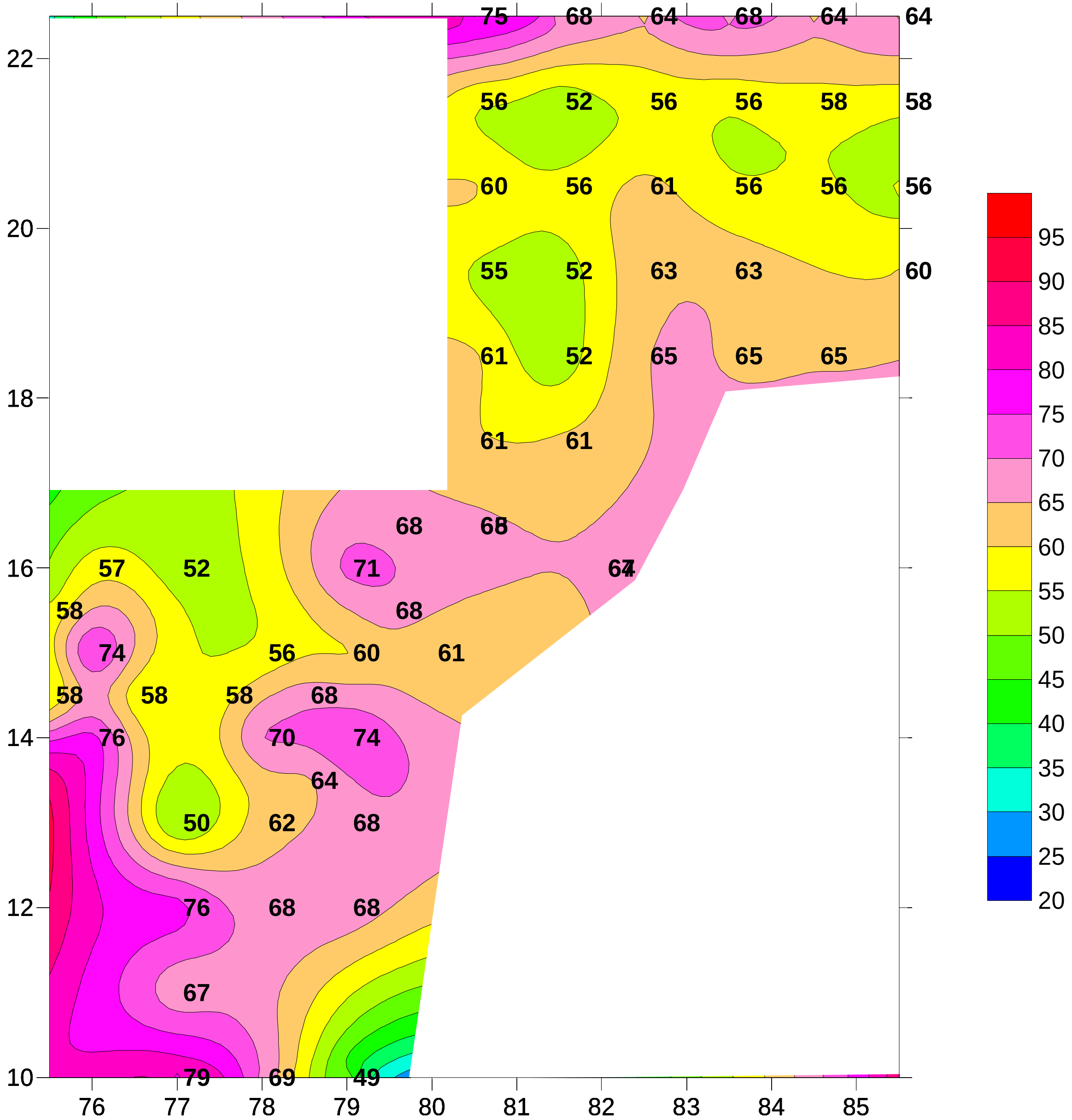
Maule et al, 2005 /science.1106888

Parameters used for Heat flow calculation

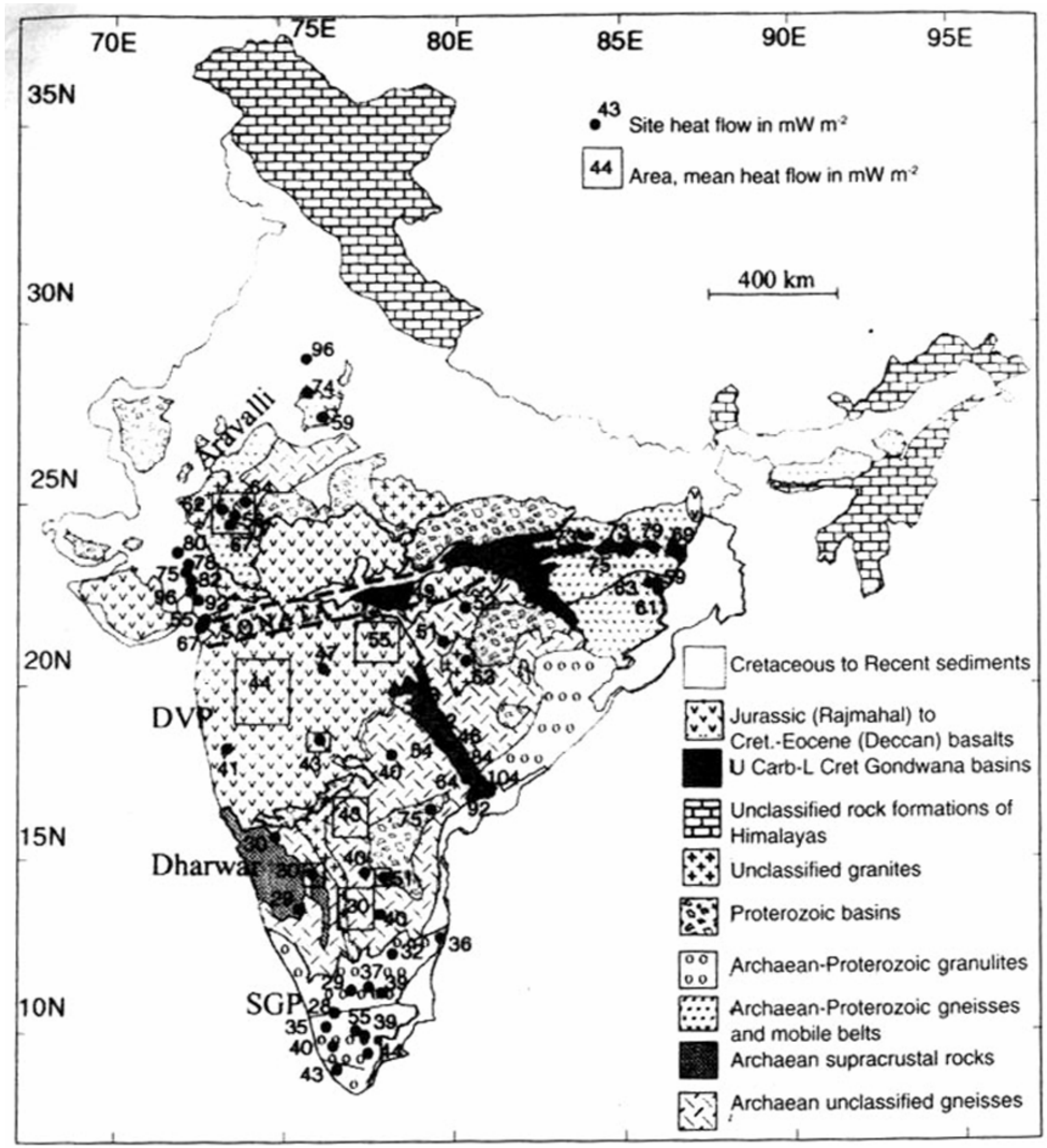
Parameters used:	H_o µW/m^3	k W/mK
Western Dharwar	1.2	2.8
Eastern Dharwar	2.3	2.8
Central Indian Region	1.1	3.0
SGT	0.3	2.8



Heat Flow from Aeromagnetic data



Available Heat flow coverage over India



Rao et al, 2003

Comparison of Calculated and Observed Heat flow

Region:	***Q* mW/m^2** **Cal. Range**	***Q* mW/m^2** **Obs. Range**
Sonata Belt	**64 – 75**	**69 - 79**
Singhbhum craton	**56 – 60**	**59 – 63**
Bastar craton	**52 – 64**	**51 - 63**
Western Dharwar	**50-74**	**25 - 50**
Eastern Dharwar	**56-74**	**40 - 75**
SGT	**49-79**	**28 - 42**

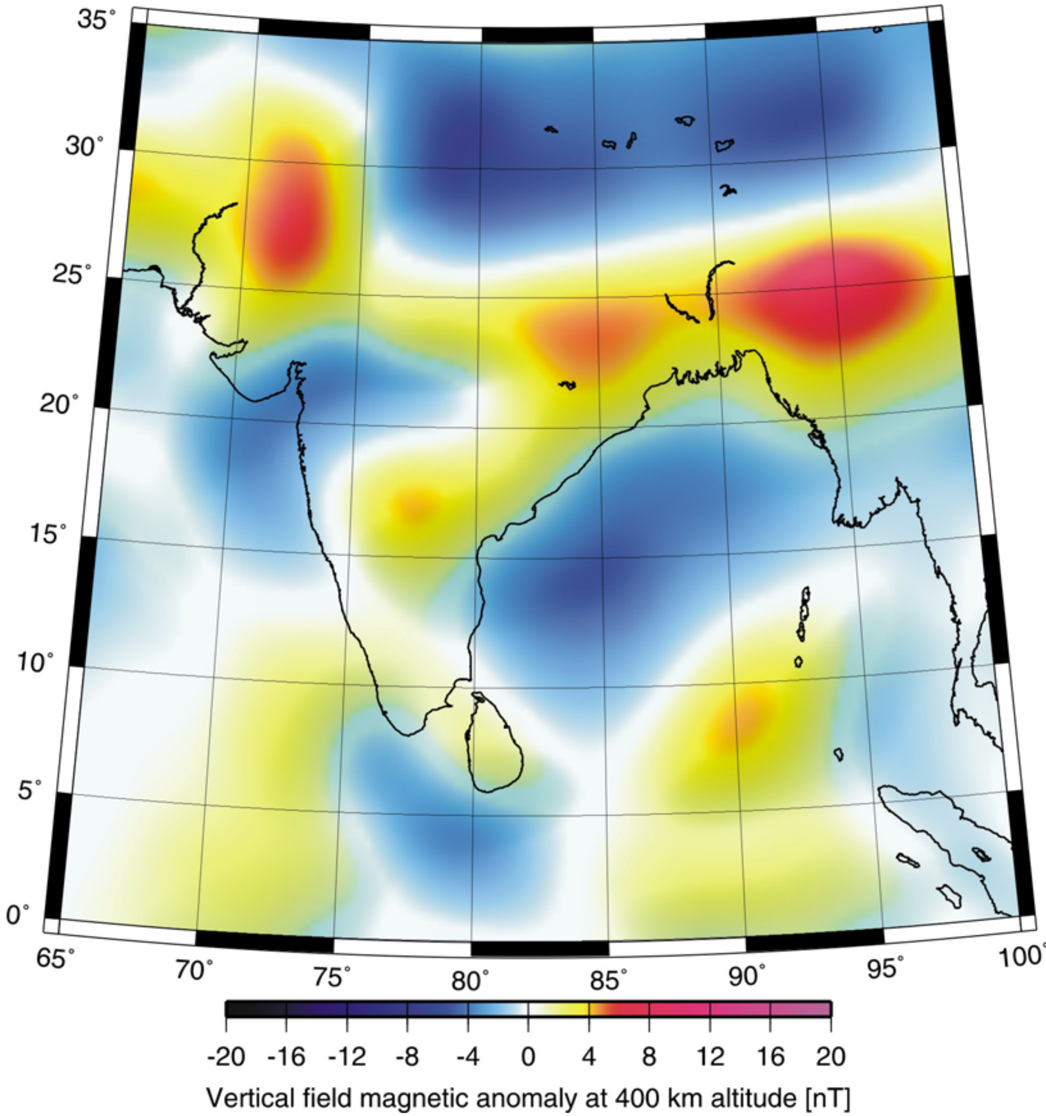
The Composite magnetic anomaly map shows a region of high tectonic activity running across the Indian Peninsula that divides the country into two parts.

The Curie isotherm is shallow in the mobile belts and deep in the cratons.

The calculated heat flux for Sonata Belt, Bastar craton and the Singhbhum craton match very well with the surface heat flow measurements depicting high values in the Central Indian tectonic region.

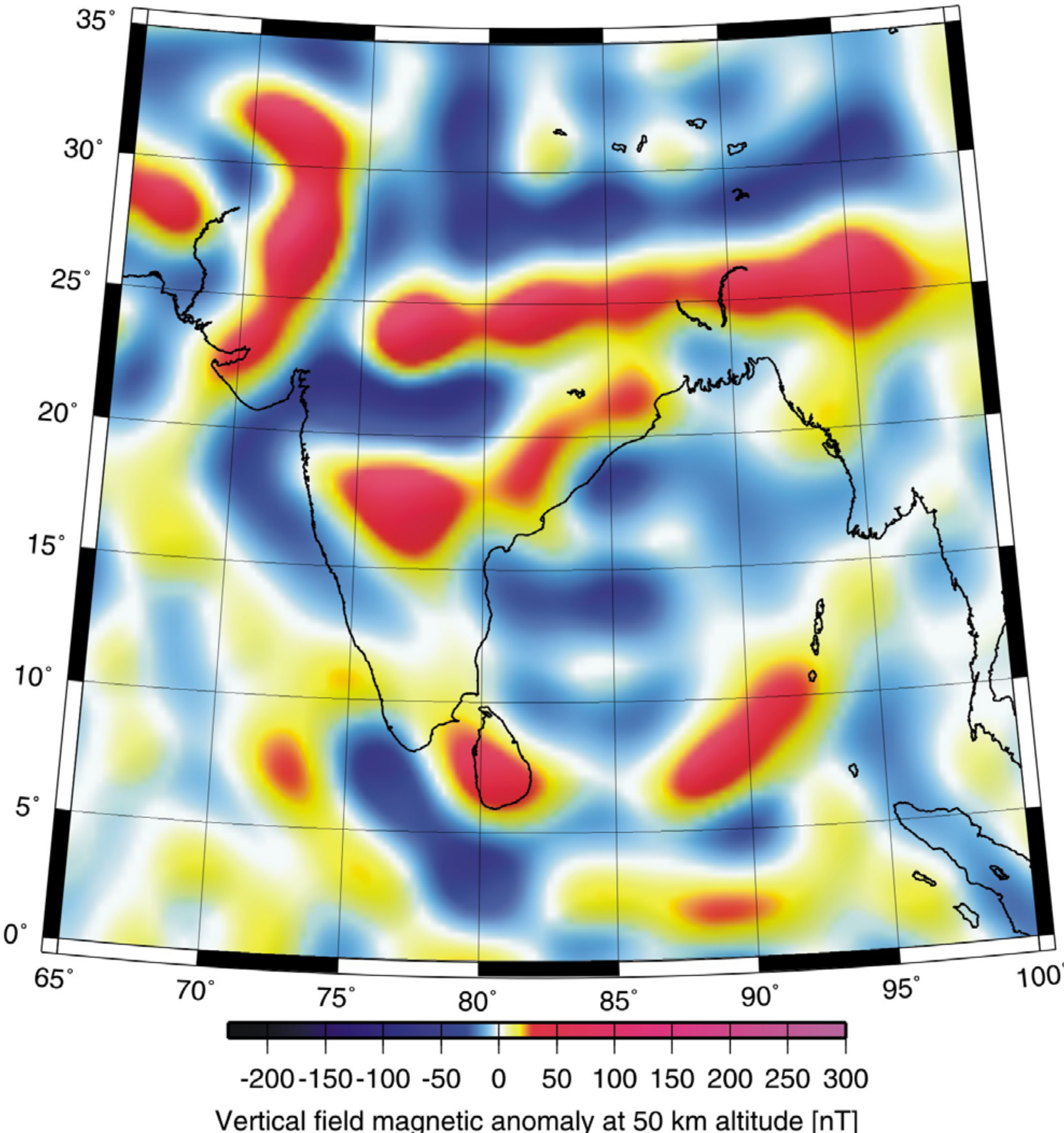
The calculated heat flux are higher for the Eastern Dharwar as compared to the Western Dharwar and this is borne out by the surface heat flow measurements and lend credence to the methodology adopted.

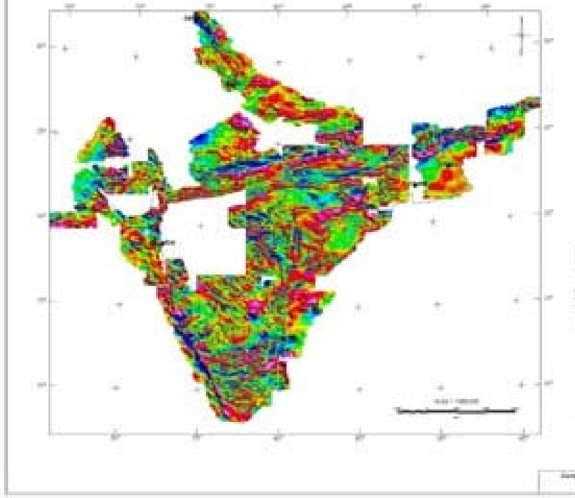
Lithospheric Field at 400 km (MF4)



Maus et al (2005)

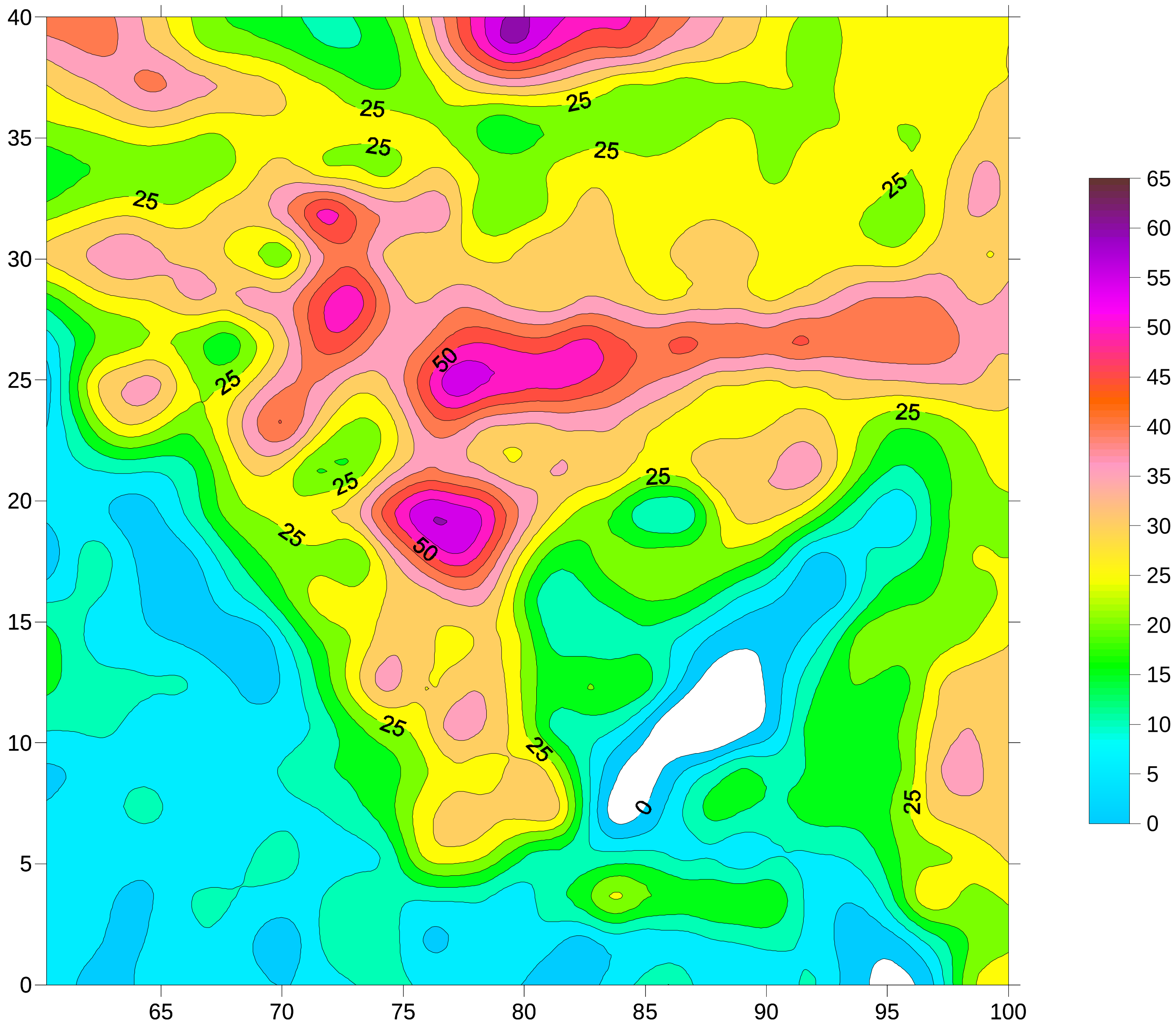
MF4 Downward continued to 50 km





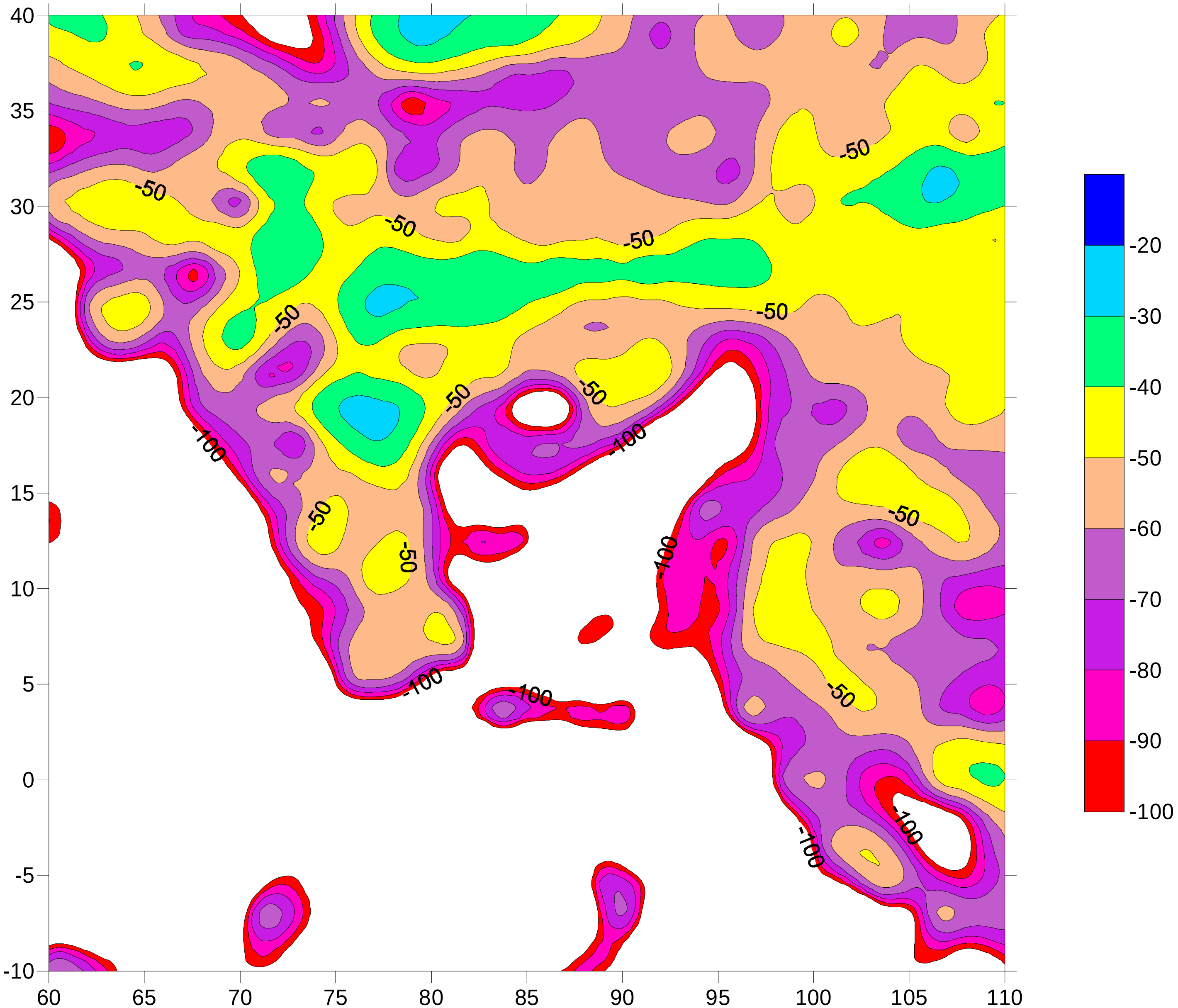
For a better appreciation of anomalies at intermediate wavelength the MF4 model has been downward continued to 50km. The prominent highs overlie Central India extending from 75 to 98° E and divides the country into a northern and southern block, NS trending high stretching from 22 to 33°N, These are also reflected in the composite magnetic anomaly map

MF4 derived crustal thickness

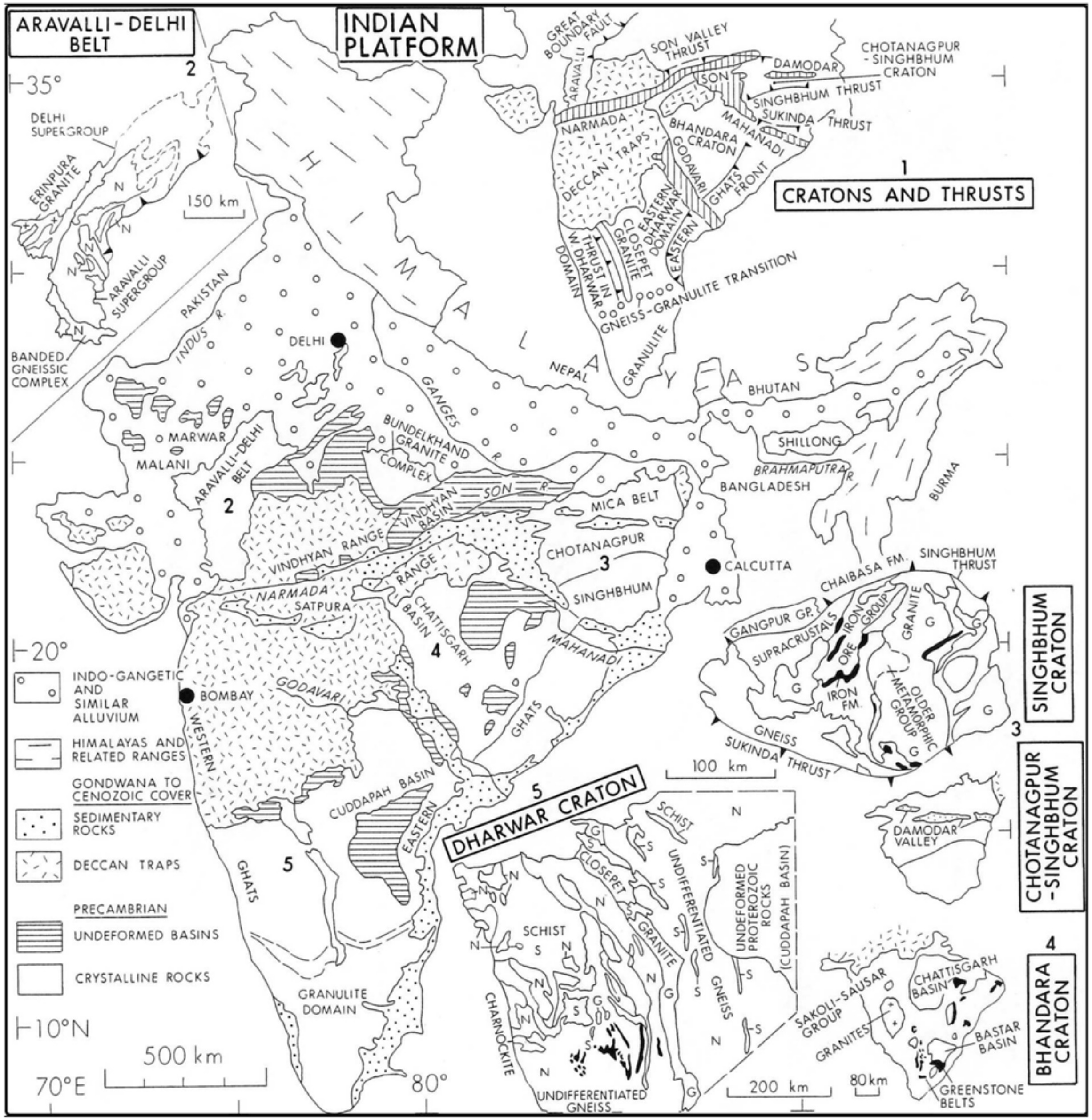


Purucker, 2005, pers. comm.

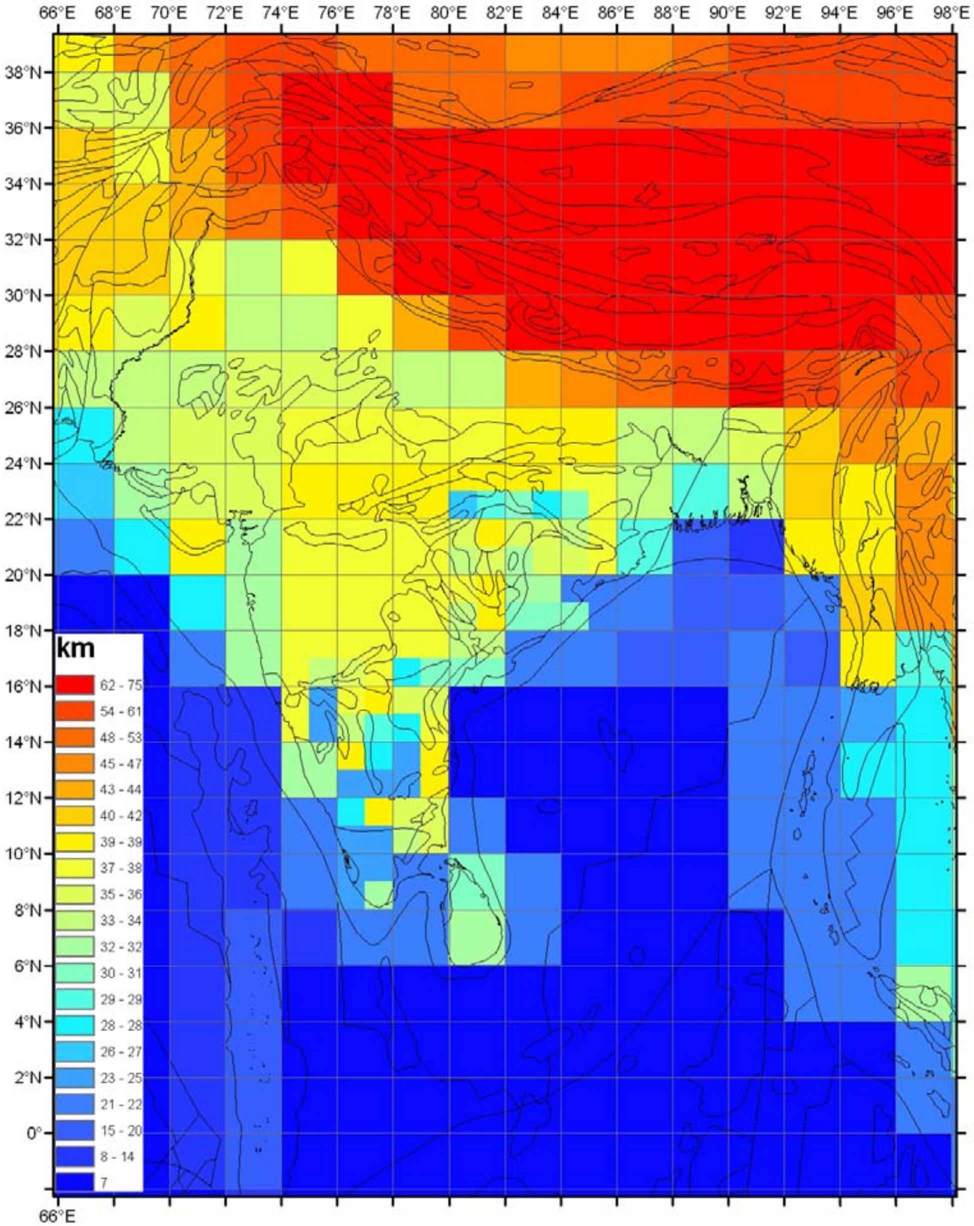
MF4 derived Heat flow

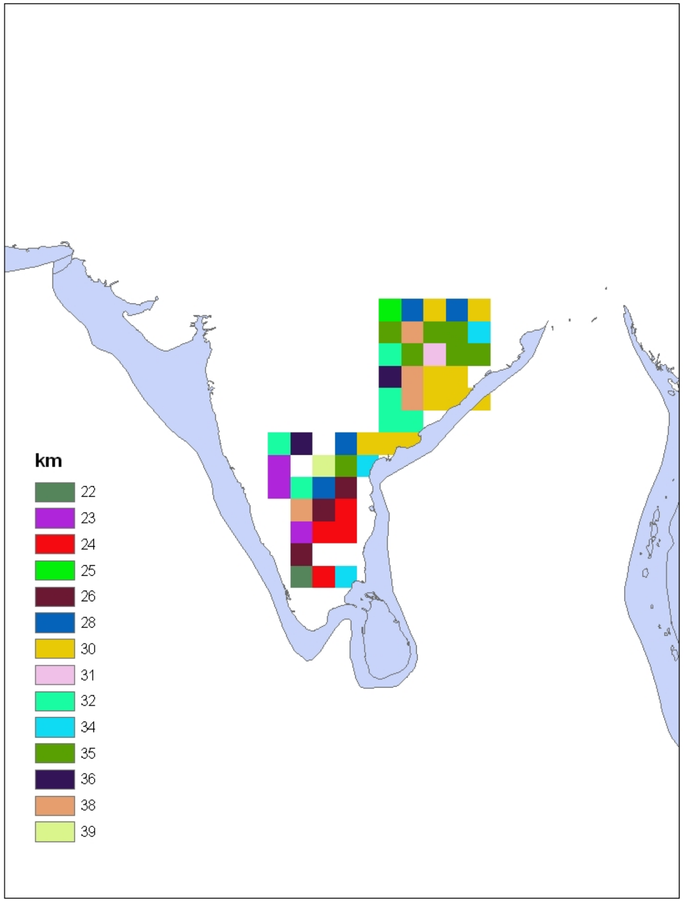


Geology and Tectonic Map of India



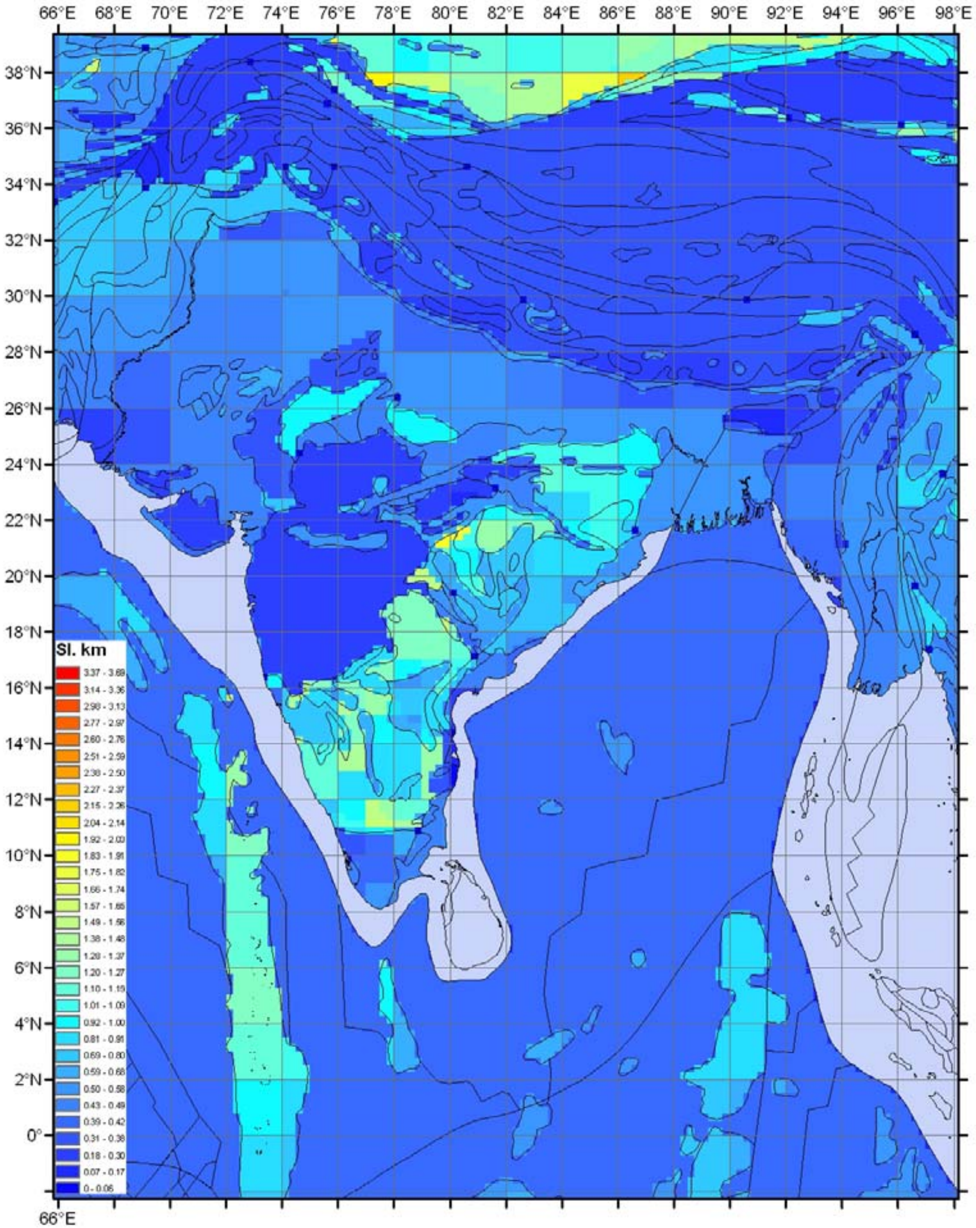
Seismic crustal structure + Curie depths





The crustal thickness are taken from the global seismic model 3SMAC (Nataf and Ricard, 1996) and the estimated Curie isotherm depth estimates from the aeromagnetic data are incorporated

Initial VIS Model

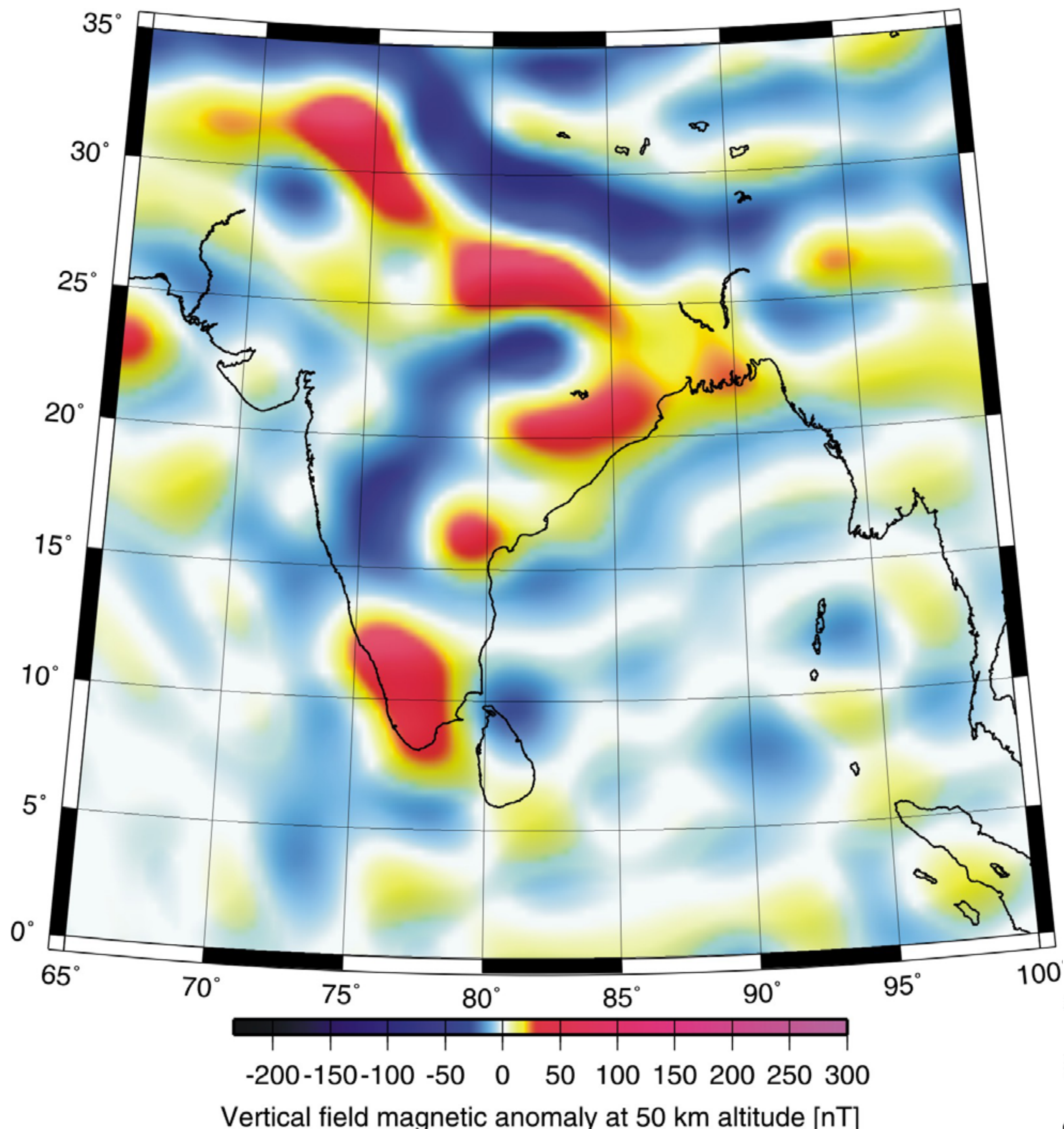


VIS model (Hemant and Maus, 2005) has been computed utilizing the crustal thickness model from 3SMAC. All the known rock types from the geologic map of India are compiled and using their maximum volume Susceptibility (k) value an average maximum k is computed and assigned to the different terrains. A factor of 1.2 is assigned for the Archean and 1.6 for the post-Archean provinces lower crustal susceptibility. VIS value for the Indian region is:

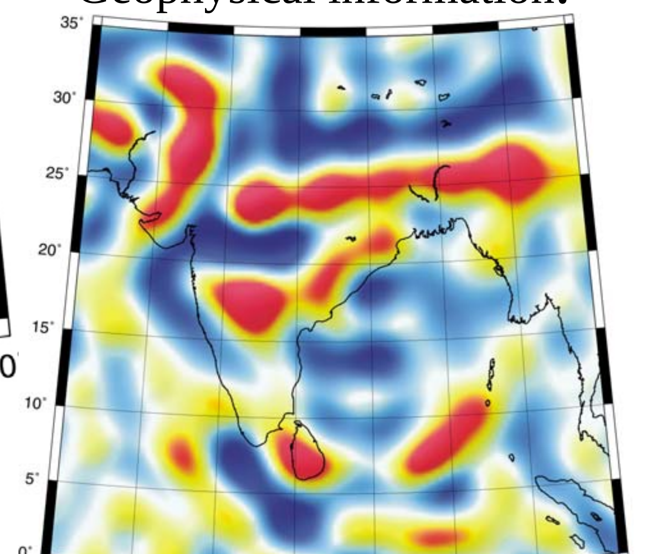
VIS = 0:55 * k * (sm3u + 1.2* sm3l),

where sm3u is thickness of the upper crust & sm3l is thickness of the lower crust.

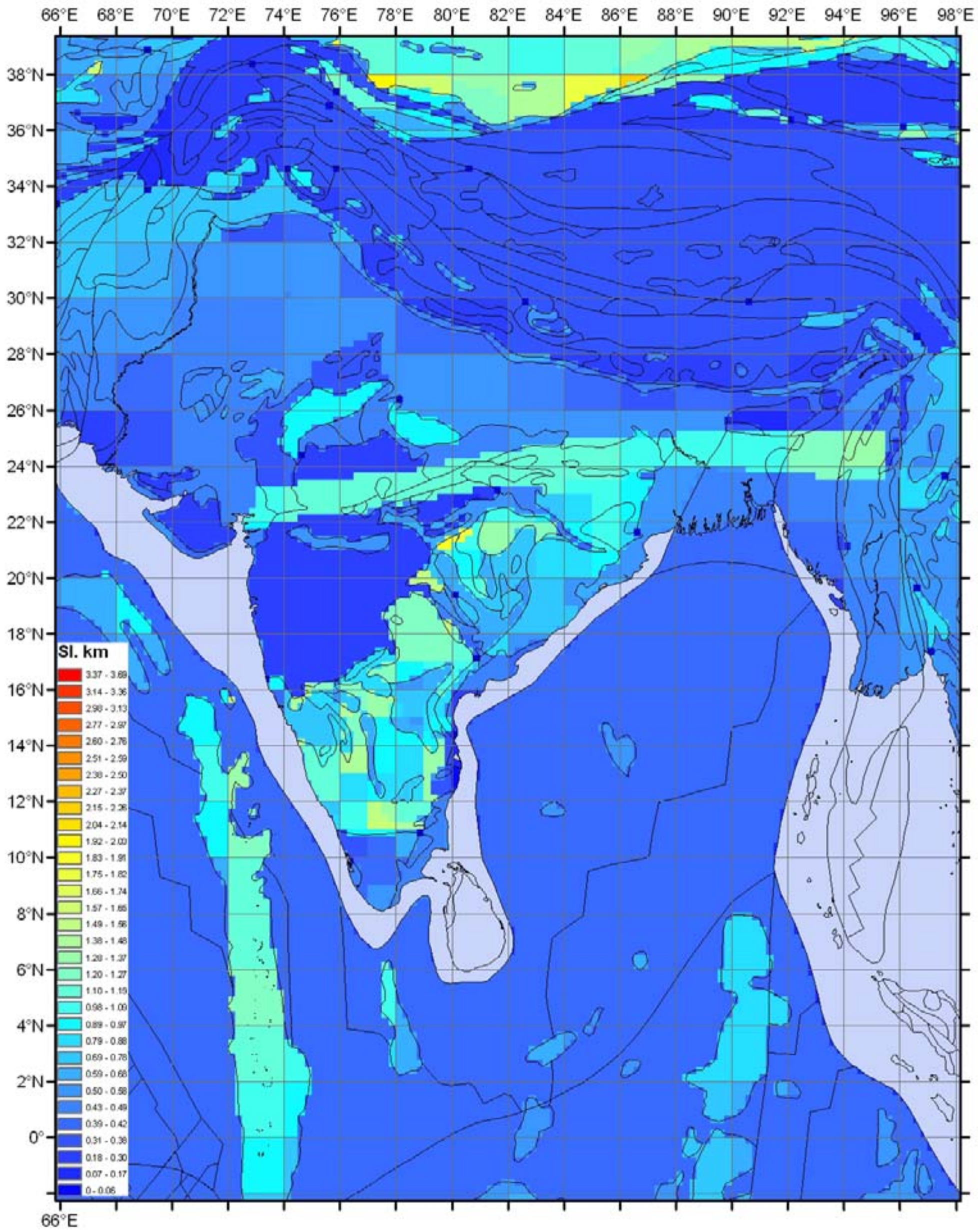
Initial Z at 50 km



A comparison with MF4 model downward continued to 50km we find that the the major Central Indian high is not reproduced. Further the high in the west does not find any expression in this map. This suggest that we need to modify the VIS model incorporating local Geological and Geophysical information.

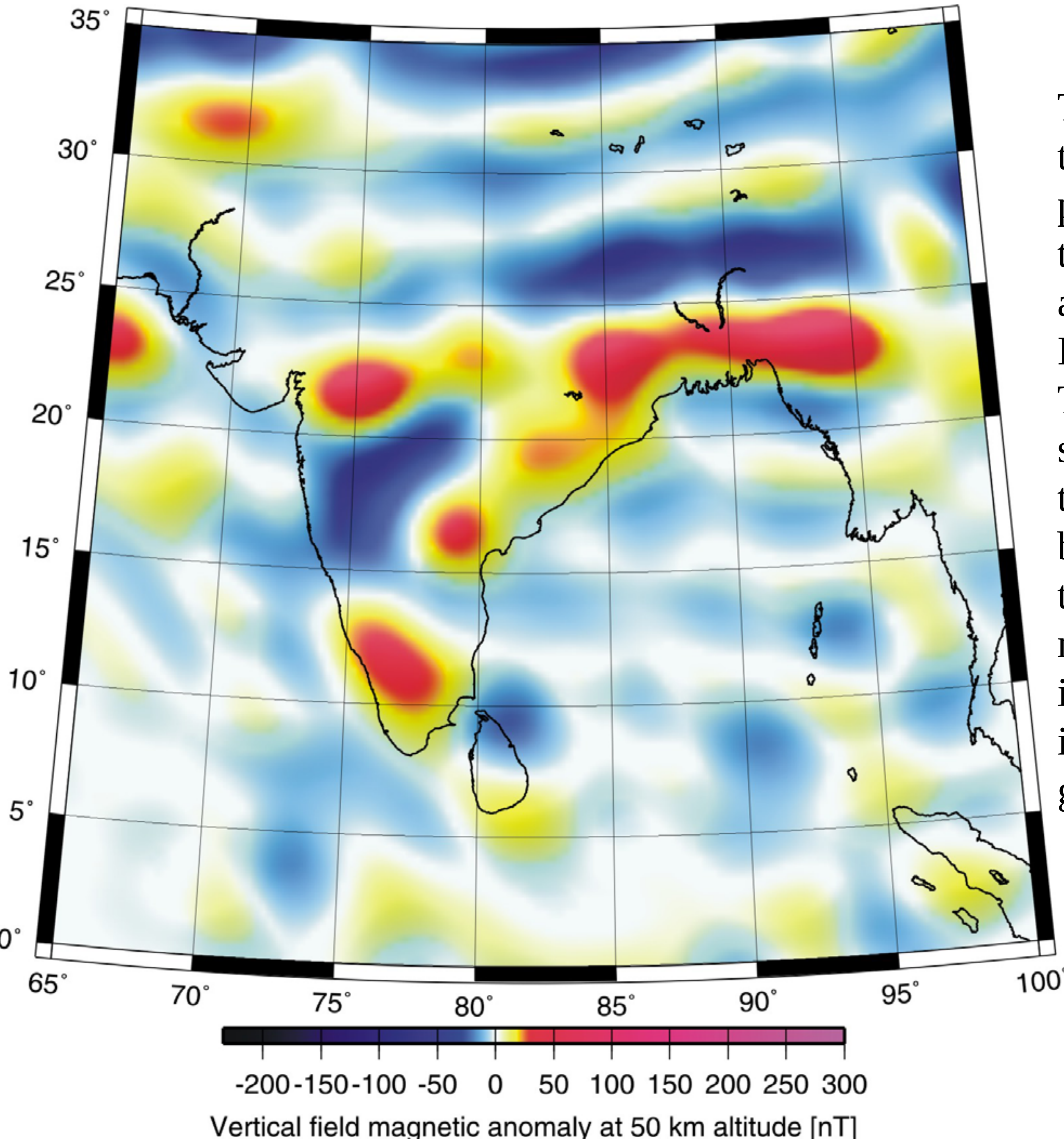


Modified VIS using Central Indian High



The high tectonic zone in Central India (EW trend) as seen in the aeromagnetic map and the estimated Curie isotherm depths are incorporated into the crustal thickness model from 3SMAC together with the known susceptibility of the region to generate the modified VIS model.

Final Z at 50 km



There is an improvement in the magnetic anomalies. The predicted model is closer to the observations. The high anomaly over the Central Indian region is reproduced. The predicted anomalies are shifted south by 2-3 degrees, though. The VIS model can be iteratively modified so that the fit between the modeled and observed improves and this will help interpret the sub-surface geology.

The MF4 model downward continued to 50km depicts prominent highs over Central India which divides the country into northern and southern blocks as seen in the composite magnetic anomaly map

Initial VIS model based on Geology and seismic model, did not reproduce the observed anomaly features especially in the central region of the Indian subcontinent.

Magnetic anomalies predicted using modified VIS model, incorporating information from the aeromagnetic data does result in a high over the central region as seen in the observations.

An iterative improvement in the VIS model should improve the overall fit.

The superior lithospheric model expected from SWARM should help reconstruct the thermal regime of the continents