in one or two places' and 'there will be no significant change in day temperature'. While we now have information on how well parallel machines compute code, we still don't know how well *the code predicts the weather*. Obviously, this involves weather scientists and the enormous infrastructure they require to keep a tab on the inputs of today that determine the weather of tomorrow. What is the cost of predicting weather? What are the returns? How much are we willing to invest on fundamental research to understand weather better? Particularly, on weather that is relevant to *our* sub-continent, like the monsoons. How relevant is the T-80 or next version of code to the Indian context? Our land borders are strung with sophisticated radars ready to track enemy planes in the event of a war. Do we still have money left for hardware like digital radar along the coasts and at metropolitan centres to give accurate short term pictures of *daily* interest to fishermen and city dwellers? What is the investment on such infrastructure and how is such investment affected by the choice of which computer is installed at the NCMRWF? Is there an off-the-shelf solution like Microsoft Outlook or Netscape that comes packaged for weather prediction with the Cray or some other import? Is the challenge perhaps in the nitty gritty of collecting readings from the soil, the seas, the stratosphere and the mountains? Or perhaps in getting a large group of foot soldiers, technicians, engineers and scientists scattered round the country to work together? Or maybe in weaning 'whizz-kids' from the keyboard and mouse and onto the fields? In short, can someone paint the broad picture?

Judging from the reaction of a national daily (*The Hindu*, 7 April 1998), Basu's paper has served its purpose: the ground is being prepared for another ambitious procurement. DST can justifiably take the credit for having got most of the parallel computing groups in the country to rise to the challenge of weather computation. However, this vision was obviously not far-sighted enough to tackle the next challenge.

R. SUNDER

99, 14A Cross, Malleswaram
Bangalore 560 003, India

TECHNICAL COMMENTS

Major tectonic elements of western Ganga basin

The article 'Some major tectonic elements of Western Ganga basin based on analysis of Bouguer anomaly map' (Mishra, D. C. and Laxman, G., *Curr. Sci.*, 1997, **73**, 436–440) is based on the spectral analysis of Bouguer anomalies and residuals obtained by fitting a second order surface to the Bouguer anomalies.

Data limitations

The map used is presumably the NGRI Bouguer anomaly map published on $1:5 \times 10^6$ scale and some maps on 1:250,000 scale available with the authors. The accuracy and source of the primary data are not given. If these maps are the same which were compiled by the gravity group of the NGRI in the 1960s, then the interpretation by using interpolation, as the digitization would imply, does not justify the used numerical techniques. The reason is that such interpolation amounts to assuming that some higher derivatives do not exist which is not true as the gravity field satisfies the La'Place equation. Also, the digitization at a uniform grid interval means that different wavelengths have been mixed together. This makes illogical, then, to break the field again into spectra for power analysis and use the same as a basis for interpretation. It amounts to reinterpreting the assumptions introduced to begin with.

Moreover, the accuracy of the compiled data with which I also was associated does not warrant any reliance on 'kinks' which could just as well be the artifacts of contouring and beyond the error limits of the compilation.

Boundary of the Ganga basin

The authors state that the Ganga basin extends up to the Main Boundary Thrust (MBT) along which the Indian plate is presumed to have subducted below the Eurasian Plate. The India–Eurasia plate boundary is at least 300 km to the north from the MBT[2–4].

Their figure 4 shows the Ganga basin to extend southwesterly from Moradabad through Aligarh to a point south of Jaipur (app. 76°E, 26°15'N), though in the text (p. 436), they state the Ganga basin to be 'an east–west oriented basin along the Himalayan foothills'. It is wrongly stated (p. 436) that the Bouguer anomaly amplitudes vary from – 50 mGals to – 300 mGals over the Ganga basin. Their figure 1 does not show such a variation. The lowest contour shown is – 220 mGals in the NE corner of the map. On the NGRI Map[1], the –300 mGals contour falls far to the north in the neighbourhood of Badrinath.

This makes correlation of Bouguer anomalies with geographical limits of the basin, to say the least, out of context.

The presumed Delhi–Haridwar ridge and the Delhi–Sargodha ridge

The statement that the Delhi–Haridwar Ridge is 'the most important feature' of the map on figure 4 along with a block uplift east of Delhi' is unwarranted. The data limitations apart, as pointed out above, figure 4 does not show the contours corresponding to the presumed Delhi–Haridwar ridge to extend beyond Delhi (see the zero contour west of Delhi), if it exists at all. The small closure shown on the NE end of the broken line (D–H ridge) could be the result of data limitations. Haridwar is more than 50 km to the east of the D–H ridge axis as shown on the figure 4 on the slope of an ENE trending 'block uplift' which makes the correlation suspect. Along the Delhi–Haridwar line, there is a negative saddle though. Further, from the seismic and gravity data, Rao and Sen Gupta[5] and Rao[6] had concluded that the Delhi–Haridwar ridge does not extend beyond Shamli–Muzaffarnagar area. Srinivasan and Khar[7] and Tiwari[8] from drill hole data and CDP seismic reflection profiles show northward thickening of the Tertiary sediments in the region over a peneplained basement. The ground and aeromagnetic anomalous field may be due to high susceptibility intrusives and extrusives that could be present on the peneplained pre-Tertiary surface equivalent to the Bijawars/Mahakoshals as found in the Saharanpur 1 drill hole[7]. These are known to be magnetic.

There is considerable evidence which has established the existence of the NW oriented Delhi–Sargodha ridge[5,9]. The Figure 4 does not bring out this feature, though claimed in the article. The feature marked N–W ridge as a broken line from Delhi northwestward, indeed, cuts across northeast running zero and +5 contour lines.

The Agra–Shahjahanpur basement ridge is mentioned to be synonymous with the Great Boundary Fault separating Vindhyan basin from Aravalli ranges. The isochron maps[8] based on CDP seismic profiling show a northward slope north of the Ganga river on the Siwalik–Vindhyan unconformity, a reflector within the Vindhyans and at the base of the Vindhyans. As such, the cause of the northeastwards nosing on the Bouguer anomaly map cannot be the 'A–S ridge' as suggested by Mishra and Laxman, because no substantive relief is shown by seismic data in this region.

The Sarda depression is shown on the figure 4 by the authors to extend west of 79°E in a northwest direction, though the depression is known to extend east-northeastward from Agra towards Bahraich east of 80°E. The magnetic anomaly map of this part of the Ganga basin in Tiwari[8] shows an ENE trending feature from Kasganj to Navpura with a low around Lakhimpur. This falls over what is termed as Sarda low by Srinivasan and Khar[7]. It may also be noted that quoting Lyon-Caen and Molnar[11], the authors assume the downflexing, preceded by subduction, as cause of the depression of the basement of the Ganga basin. How is one to, then, conceive the extension of the Aravalli ridge across the Ganga basin into the Himalaya, as the authors seem to suggest on their figure 4?

From the spectral analysis an average depth of Moho of 32 km is arrived at. Quoting Tiwari *et al.*[10] (p. 437), it is wrongly claimed that the crustal thickness so obtained is 'in conformity with seismic results in the Vindhyan basin adjoining the Aravallis'. The seismic profile presented in Tiwari *et al.*[10] goes up to Nandsi (figure 6 of ref. 10) which is about 100 km to the west of the Vindhyan–pre-Vindhyan contact (figure 1 of Tiwari *et al.*[10]). Reddy *et al.*[12] give a seismic reflections line drawing (figure 2, p. 356). The Kota–Kunjer section of the profile is over the Vindhyan terrain. Reddy *et al.*[12] sum up their finding by stating that 'the Moho reflection 10–12 S TWT is rather weak'. On their figure 6 they show the seemingly Moho reflection by a question mark. The DSS profiles[13] over the Vindhyan terrain have imaged the Moho ranging between 40 and 44 km. Thus the results of the seismic profile cannot be construed to assert that the crustal thickness of the order of 32 km is in conformity with the seismic results, though against the published value of the order of 40 km in the region[14].

The Agra–Shahjahanpur ridge is stated to separate the Vindhyan basin from the Aravalli ranges. They further suggest (p. 439) the extension of Vindhyan sediments up to this ridge. However, a number of bore holes drilled by the Central Ground Water Board have intersected the Vindhyans and Delhis[15] not the Aravallis (as shown on their figure 4).

Their approach to describing geology is somewhat arbitrary. As for example, the 'Aravalli basement' is shown to be present north of Jaipur on figure 4. The Aravallis occur more than 200 km away to the southwest of Jaipur[12]. The Saharanpur-1 'bore hole[7] ends in the Bijawars/Delhis equivalents at a depth of 2362 m. No Aravalli rocks are found in the region shown as the 'Aravalli basement'. It is, thus, not clear as to what the Aravalli basement connotes.

The spectral and trend surface analysis techniques[17] are well-known tools in potential fields data interpretation and have been used in India for decades. But one needs caution in drawing parallels with geology unless geophysical field data coverage is sound and geological data and feel are adequate. Evidence for these is lacking in the present paper.

1. NGRI, Bouguer anomaly map series of India, NGRI/GPH, 1978.
2. Dewey, J. F., Cande, S. and Potman, W. C., *Ecologae Geol. Helv.*, 1989, **111**, 717–734.
3. Valdiya, K. S., *Philos. Trans. R. Soc. London*, 1988, **A326**, 151–175.
4. Molnar, P. and Taponier, P., *Science*, 1975, **4**, 283–294.
5. Rao, B. M. R. and Sengupta, S. N., *Advancing Frontiers in Geology and Geophysics* (eds Subramanian, A. P. and Balakrishna, S.), Indian Geophysical Union, 1964, pp. 147–157.
6. Rao, B. M. R., *J. Geol. Soc. India*, 1973, **14**, 217–242.
7. Srinivasan, S. and Khar, B. M., *Geol. Surv. India Spl. Publ. no. 21*, 1985, **1**, 295–421.
8. Tiwari, S., *Mem. Geol. Surv. India*, 1995, **31**, 311–328.
9. Qureshy, M. N., Kumar, S. and Gupta, G. D., *Mem. Geol. Soc. India*, **12**, 207–222.
10. Tiwari, H. C., Vijaya Rao, V., Dixit, M. M., Rajendra Prasad, B., Mahadeva Rao, N., Venkateshwarlu, N., Prakash Khare, Kesava Rao, G., Raju, S. and Kaila, K. L., *Geol. Soc. India, Mem. 31*, 1995, pp. 383–404.
11. Lyon-Caen, H. and Molnar, P., *J. Geophys. Res.*, 1983, **88**, 8171–8191.
12. Reddy, P. R., Rajendra Prasad, B., Rao, V. V., Khar, P., Murthy, A. S. N., Sarkar, D., Raju, S., Rao, G. S. P. and Sridhar, V., *Geol. Surv. India, Mem.*, 1995, **31**, 353–372.
13. Kaila, K. L. and Krishna, V. G., *Curr. Sci.*, 1992, **62**, 117–154.
14. Qureshy, M. N., Proceedings of the 2nd symposium on Upper Mantle project, NGRI, 1970, pp. 1–20.
15. Iqbaluddin and Saifuddin, *Curr. Sci.*, 1998, **74**, 6.
16. Dasgupta, A. K., Ghose, A. and Chakraborty, K. K., *Geological Map of India*, Geol. Survey of India, 1993.

17. Quereshy, M. N. and Warsi, W. E. K., Proceedings of the Symposium on Purana Formations of Peninsular India (ed. Lakshmanan, S. and West, W. D.), 1978, pp. 350–358.

M. N. QURESHY

Centre for Lithosphere Studies,
204-1, Kirti Apartments,
Mayur Vihar I Extension,
Delhi 110 091, India.

D. C. Mishra replies:

We are thankful to M. N. Qureshy for his interest in our publication. However, most of the points raised by him are either very obvious or already explained in the above publication. Therefore, we do not intend to reply point wise but some of the points are taken up to show their nature.

(i) According to this writer, Ganga basin is not an east–west basin, rather it is NE–SW. What is shown in figure 4 as NE–SW is a subbasin of the Ganga basin. If somebody looks to the part of Ganga basin in Punjab he may say that strike is NW–SE. So these are strikes of subbasins which may be different in different parts of the main basin.

(ii) NGRI, 1978 is referred in the list of references and digitization is done from an enlargement of this map. For further details about this data set, the writer may kindly refer this.

(iii) Gravity anomalies due to basement ridges are usually of small magnitude and small wavelength. Therefore, the enclosure of 5 mGal along Delhi–Haridwar line is attributed to a basement ridge. The block uplift east of Delhi (figure 4) is quite clear which is for anyone to see.

(iv) Due to small order of gravity anomalies from basement ridges, they rarely get reflected as large gravity enclosed 'highs'. We had to look for small signatures like kinks in gravity contours or saddle between 'highs' to delineate basement ridges. This is the case about N–W ridge, which is shown to be passing over a saddle between two 'highs' in the N–W corner of the map.

(v) 32 km Moho depth is referred under Vindhyan basin adjoining Aravalli (line no. 15, right side page 437 of the above publication). This can be seen from the reference Reddy *et al.*, given by the writer. The two-way travel time package given by Reddy *et al.*, for deepest reflection in Vindhyan basin is between 10 and 11 s and not 12.5–14.5 s as quoted by the writer. This amounts to approximately 31–32 km. In a recent publication on CSS results from this region, the authors have shown even a shallower Moho (24 km) under Vindhyan basin[1]. Deeper Moho is reported only under Delhi fold belt which probably the writer has confused with the Vindhyan basin.

(vi) It has been pointed out that some references pertaining to Ganga basin are missing. After all, only pertinent references can be given in a publication.

(vii) In the end it has been pointed out that spectral and trend surface analysis techniques are well known tools but should be used cautiously. Regarding precautions to be taken for spectral analysis we listed as early as in 1976, the exhaustive list of precautions to be followed in this regard[2].

1. Tewari, H. C., Rajendra Prasad, B., Vijaya Rao, V., Reddy, P. R., Dixit, M. M. and Madhava Rao, N., *J. Geol. Soc. India*, 1997, **50**, 779–786.
2. Hahn, A., Kind, E. G. and Mishra, D. C., *Geophysical Prospecting*, 1976, 24, 287–308.

D. C. MISHRA

National Geophysical
Research Institute,
Hyderabad 500 007, India

NEWS

From copycat to innovator: Science and technology in Japan

Japan, says a recent NSF report[1], invested 2.6% of its gross domestic product in R&D in 1994. At $54 billion, Japan's overall R&D expenditures were 41% of those of the United States. In the same year, USA's investment on R&D was $133 billion – 2.5% of the US GDP of $5.3 trillion. Today Japan leads the United States in the per cent of GDP invested in total and non-defence R&D, as well as government investment in civilian R&D as a per cent of GDP. The difference, in terms of per cent GDP invested in R&D, may be a mere 0.1%, but what is striking is Japan's resolve, at a time of severe recession, to restructure the economy through knowledge and education. Says Phyllis Genther Yoshida[2] of the US Department of Commerce, 'Overall, the Japanese economy remains bogged down. Long-touted structural reforms that could help energize the economy through deregulation and financial reforms have not yet been fully implemented. Indeed, the economic recession caused postponement of many structural reforms.' Perhaps it is this slump which reinforced the commitment of Japan's major companies to R&D and to technology-led economic growth. Another motivating factor is international competition, not only from a resurgent US economy but also from the technology-driven manufacturing economies of South East Asia, in particular Singapore, Taiwan and South Korea. In a country with few natural resources, Japanese policy makers believe that education and S&T are the most valuable resources for prosperity. This abundant faith in S&T is reflected in the decision to invest 17