DISCUSSION

CRUSTAL REFLECTIVITY PARAMETER FOR DECIPHERING THE EVOLUTIONARY PROCESS ACROSS THE PROTEROZOIC ARAVALLI-DELHI FOLD BELT by H.C. Tewari, B. Rajendra Prasad, V. Vijaya Rao, P.R. Reddy, M. M. Dixit and N. Madhava Rao, Jour. Geol. Soc. India, v.50(6), 1997, pp.779-785

Kesavamani M. and **Prasad, R.M.C.**, 214, Star Shelter Apartments, Saidabad Colony, Hyderabad - 500 659 comment:

We congratulate the authors for publishing the combined section of the Nagaur-Jhalawar transect with most of the details (P.R. Reddy and nine others, 1995; H.C. Tewari and nine others, 1995) and giving everybody an opportunity to interpret. We wish to offer some of our observations on the above paper.

1. The authors have divided the entire section into sectors as (a) moderately reflective Mewar Basin (MB), (b) highly reflective Delhi Fold Belt (DFB), (c) poorly reflective Bhilwara Gneissic Complex (BGC), (d) highly reflective Hindoli Group including a thrust zone in the BGC and (e) moderately reflective Vindhyan Basin (VB). This may mean the entire column of reflectors between 4 and 20 secs TWT, in general, indicates the same nature of reflectivity. It may also imply that even stronger reflections and the spectrum pattern like that due to moho may be subdued in a poorly reflective environment. The sub horizontal moho reflector demarcated by the authors from the Nagaur to Alniawas consists of poor to moderate reflectivity with different trends. In such an environment the absence of strong reflections does not mean the absence of moho. But the same criteria has not been applied in the identification of the moho. The authors demarcated the moho in the MB and eastern part of thrust zone, leaving the DFB and BGC areas as thick lower crust zone. Surprisingly, where there is no spectrum of moho reflections, the moho is inferred, albeit with a question mark, to be rising to a level of about 24 km in the Vindhyan basin (Fig.2C). A perusal of the spectrum pattern of reflections about the 12 secs TWT line reveals three distinct elliptical or circular zones (possibly due to the intersection of faults) with varying reflectivity and trends, at different levels, below the MB, DFB and BGC as also in the eastern part of thrust zone. The remarkable parallelism and continuity of the reflections, in spite of the void zones at places, is discernible. On the other hand, it will be interesting to note that there is a marginal rise in all the reflectors, parallel to the 'mid crustal swell' referred to by the authors and also corresponding to the moho spectrum of reflections (which include the M1 and M2 reflectors of the authors) within the DFB and BGC, as evidenced by the circular zone.

2. The absence of reflections in BGC is attributed to high density vertical igneous intrusions (diapirs ?) from the upper mantle. This is contrary to the references cited in the text indicating most of high reflection zones as associated with mafic and ultramafic igneous intrusives with obvious high density. In addition, they have correlated the poor reflective zone to the gravity high anomaly of 80 mGl coinciding with the mid-crustal swell. In fact, the Bouguer gravity high zone of 80 mGl which encloses a saddle zone (gravity low) may correspond to the poor reflection zone, possibly associated with magmatic intrusions of felsic nature associated with low density. In general, a perusal and comparison of the seismic reflective pattern with gravity anomaly suggests poor reflective zones corresponding to gravity lows (e.g. Erinpura granites) and high reflective zones to gravity high zones (Mangalwar complex).

3. In general, a comparison of the structures with gravity anomaly indicates long wavelength gravity high corresponding to the structural highs associated with moho upwarp, while the short wavelength gravity highs correspond to synformal structures. On the other hand, the long wavelength gravity lows correspond to downwarp of moho while the short wavelength gravity lows correlate well with the domal features. Most of the details are self-explanatory and correlate very well with the features identified by Sinha Roy (1995) and correspond to the rift type mechanism associated with moho upwarp. The gravity high zone associated with the moho upwarp may be visualized as major strike-slip with the movement into and away from the observer.

References

SINHA ROY, S and GUPTA, K.R. (Editors), (1995). Continental crust of Northwestern and Central India. Mem. Geol. Soc. India, No.31.

H.C. Tewari, B. Rajendra Prasad and **V. Vijaya Rao**, NGRI, Hyderabad - 500 007 reply:

We are thankful to Dr. Kesavamani and Dr. R.M.C. Prasad for their interest in our paper and our replies to their observations follow:

1. Line drawing represents the seismic section only up to a certain extent and should be used together with the seismic sections, which show the true nature of reflectivity. Our interpretation is based mainly on seismic sections. Based on the qualitative reflectivity characteristics, Nagaur-Jhalawar profile is broadly divided into five sectors. A region is called highly reflective, moderately reflective or poorly reflective depending on the number of reflectors and their strength. It does not mean that the entire crustal column from 4-20 s has the same nature of reflectivity. The stronger reflections can not be subdued in a poorly reflective environment.

The reflectivity is poor to moderate only up to Rian and not up to Alniawas as mentioned. As a matter of fact it is highly reflective from Rian and Alniawas. We have never mentioned that absence of strong reflections from moho means absence of moho. It only means that the moho is not traced or identified. We have demarcated the moho only where it is clearly identifiable. The strong moho band is observed between Rian-Alniawas and from the thrust fault towards east up to Bundi. It is not demarcated below the DFB and BGC because it is not observed in those parts of the profile. We have never inferred moho where no reflections are present. In the Vindhyan basin there are doubts about the identification of moho; hence we have put a question mark (?). It does not mean that we have inferred the moho depth at that level.

The interesting observation that there is marginal rise in all reflections parallel to the mid-crustal swell in DFB and BGC is valid and correct. The region has undergone two episodes of orogenic activity corresponding to Aravalli (Palaeoproterozoic) and Delhi (Mesoproterozoic) fold belts. A reflection band when terminated with opposite dipping reflection band is generally called as bivergent or divergent reflection fabric. Such a bivergent reflection fabric is interpreted as collision signature by many workers world over (Hall and Quinlan, 1994; Rajendra Prasad et al. 1998) for Proterozoic as well as Phanerozoic terrains. Two such collision fabrics are identified at the MB-DFB and MC-HC boundaries which correspond to Delhi and Aravalli orogeny. The observation mentioned above is related to collision fabric.

2. It is clearly mentioned in our paper that internal layering in mafic and ultramafic rocks can offer necessary acoustic impedance contrast to produce reflections and such layering could be responsible for the observed lower crustal reflections. The modest mafic magmatic additions to the crust in the form of discrete sills will produce prominent reflections in the lower crust whereas massive magmatic additions will produce no reflections and behaves as a seismically transparent zone with a mean P-wave velocity in excess of 7.0 km/s.

A comparison between seismic reflectivity pattern and gravity anomaly has been made and it is suggested that poor reflective zones corresponds to gravity lows (Erinpura granites) and high reflective zones with gravity high zones (Mangalwar Complex). No such generalization is possible. Such a generalization is actually not correct in the present context. Close observation reveals a highly reflective zone (not poor reflective zone as suggested) below Erinpura granites corresponding to gravity low. It is pertinent to mention that gravity high is over DFB and Sandmata Complex. The reflectivity is related to the acoustic impedance contrast between two layers and not just the density of a layer. As mentioned earlier, it is very clear that the same magmatic material in massive form is nonreflective whereas in the form of discrete sills it will produce prominent reflections.

3. In general, long wavelength gravity high may correspond to structural high and low to the downwarp of moho but this in not always valid. The ambiguity in interpretation of gravity data alone is well known. So, judging from the dips of the reflectors from either side (M1, Ms etc. from NW and thrust fault from SE), velocity model derived from limited refraction and wide angle reflection data (Tewari et al. 1997) and also from the gravity modelling (Rajendra Prasad et al. 1998), we inferred crustal thickening under DFB and Sandmata Complex. Most of the gravity high is explained due to high density of massive magmatic addition under the mid-crustal swell. We do agree with the proposal of Sinha-Roy (1995) that rift type of mechanism took place in the NW Indian Shield, but the collision which took place subsequent to rifting with the evolution of Delhi orogeny has disturbed the then existing lower crustal structure. We have no comments to offer on the new interpretation of our line drawing. However, we insist that any interpretation without considering the seismic section is incomplete.

References

Hall, J. and Quinlan, G. (1994). A collision crustal fabric pattern recognized from seismic reflection profiles of the Appalachian/Caledonian orogen. Tectonophysics, v.232, pp.31-42.

Rajendra Prasad, B., Tewari, H.C., Vijaya Rao, V., Dixit, M.M. and Reddy, P.R. (1998). Structure and tectonics of the Proterozoic Aravalli-Delhi fold belt in NW India from deep seismic reflection studies. Tectonophysics, v.288, pp.31-41.

Tewari, H.C., Dixit, M.M., Rao, N.M., Venkateswarulu, N. and Vijaya Rao, V. (1997). Crustal thickening under the Paleo-Meso-Proterozoic Delhi fold belt in NW India: evidence from deep reflection profiling. G. J. Int., v.129, pp.657-668.

IMPORTANCE OF RECHARGING THE DEPLETED AQUIFERS: STATE OF THE ART OF ARTIFICIAL RECHARGE IN INDIA by K.C.B. Raju, Jour. Geol. Soc. India, v.51(4), pp.429-454.

(1)

Pradeep Raj, 1-1-298/5, Ashoknagar, Hyderabad, comments:

1. In many places yield in a basin is fully utilised by existing structures or is meant for big dams far away on the downstream side of an area. Hence in such areas, no new structures to impound water are allowed by the State Irrigation Departments.
2. When we are so sure of putting to use only the dynamic resources, how will it help us if we assess static groundwater.
3. KCB writes 15% of the resources (dynamic?) are allotted for Rural, Municipal and Industrial use. Just 15% may not be enough. As the consumption of groundwater resource by the

industry and domestic sector is area specific there can not be broad generalisations (15%) as suggested by KCB.

4. KCB uses phrases like, "good vertical conductivity", "good transmissivity", "water table should be deep". etc. These phrases hardly convey a meaning to practicing technical persons in the field (especially the younger among them). The article would have been more useful if a range of values were given for different soil types and geological formations.
5. KCB writes that sub-surface dykes (SSD) are feasible in hard rock areas in narrow valleys where bedrock occurs at shallow depth. I feel that SSDs are not quite feasible in hard rock areas.
6. KCB writes that the rate of recharge of diffusion-well is related to its specific capacity. But, he makes no mention of recharge of initial moisture level of the unsaturated zone. Does it not influence the rate of recharge?

   KCB says recharge rates of 0.2 to 2 MLD are achieved by recharge-wells; but, then immediately he adds that recharge rates of 6.5 to 40 MLD are also achieved. He does not give where and in which geological formation these recharge rates are achieved.
7. KCB does not say under what circumstances Soil Aquifer Treatment (SAT) is effective.
8. KCB gives a number of artificial recharge methods. These are already very well known and seem to have been taken from the text book by late Mr. K.R. Karanth.
9. Finally I wish to add that for some of the references year and page numbers are not given.

K.C.B. Raju replies:

1. Large amount of rainfall lost as run-off is based on the estimate made by Central Water Commission basin wise.
2. In many parts of the country present rate of groundwater development has exceeded the dynamic resource and are already tapping the static resource. So it is very essential that static resource assessed properly for better water management.
3. Fifteen percent of the dynamic resource is allocated by the Ministry of Water Resource (CGWB) to meet the domestic and industrial requirements. Though quantum of fifteen percent appears to be adequate, I agree that in certain urban and industrial areas, the development exceeds this limit. In view of this , the latest Groundwater Estimation Committee (1997) constituted by the Ministry of Water Resource, Government of India has recommended to asses domestic and industrial requirement separately and also to provide certain percentage for maintaining the ecosystem.
4. The hydraulic parameters mentioned can be obtained from references given as this being a review paper details are not given.
5. Many sub-surface dykes have been constructed by the CGWB in Kerala and by Andhra Pradesh Groundwater Department in Andhra Pradesh and have given encouraging results.
6. Recharge rate depends on the specific capacity and available drawdown refers to normal recharge well and not diffusion well.

   Since this is a review paper, figures available have been quoted from references given including Mr. Karanth's book. However, recharge rates have been given in the case studies of Gujarat and Tamil Nadu.

   Most of the recharge studies are in the sedimentary formation.
7. Regarding SAT for further details he may refer to Waste Water Recharge - Herman Bower (1985) and correspond with Dr. Neema of NEERI and Dr. S.K. Gupta of PRL.
8. As mentioned in item 6, that this is a review paper compiling information from various sources given in the reference.

(2)

B.S. Sukhija, D.V. Reddy and P. Nagabhushanam, National Geophysical Research Institute, Hyderabad - 560 007 comment:

We highly appreciate the commendable effort of K.C.B. Raju in reviewing the state of art Artificial Recharge in India. Of all the methods of aritificial recharge attempted in India, only the percolation tank method had found substantial application. The method is indigenous, and has not been studied well. The author has given some examples of performance of percolation tanks in the states of Maharashtra, Andhra Pradesh, Gujarat and Tamil Nadu. The author has however given the results of studies which have been carried out till 1978 only (Raju, 1985). There have been some more studies recently (Sukhija et al. 1994; Sukhija et al. 1997). These studies are carried out using both the conventional water balance method and a newly developed chloride balance method which, we believe, is more reliable. These studies do not bear out the picture drawn by the author.

We give below the results of the recent studies (Table 1). The performance, as assessed here, does not match the 50-90% recharge reported by Raju. More worrisome is the indication of deterioration in performance with time, resulting from deposition of fine sediments on the tank bed (viz., see the reduction in percolation fraction of tank A and C with time using chloride balance method).

Table 1. Performance of different percolation tanks

Tank	Study period →	1992-1993		1994-1995		1995-1996		1996-1997	
	Method used →	CL	WB	CL	WB	CL	WB	CL	WB
A		0.35	0.49	0.22	0.49				
B				0.45	0.29	0.44	0.42	0.58	0.43
C						0.36	0.57	0.20	0.55
D						0.65	0.74	0.62	0.63

CL - Percolation fraction by chloride method, WB - Percolation fraction by water balance method. A. Singram tank in Granites, B. Kalwakurthy tank in Granites, C. Lakanka tank in Basalts and D. Saper tank in Sandstones.

Since the investment going into the construction of percolation tanks is already substantial and getting larger, it is essential to understand the situation, in detail, so that decisions are based on more reliable numbers. In view of the increasing investment in this area, a concerted research effort using new techniques and study of economic and social issues will be highly useful.

References

RAJU, K.C.B. (1985). Artificial recharge through percolation tanks and sub-surface dykes. Proc. Intl. Seminar on Artificial Recharge of Groundwater, Ahmedabad, India, pp.12c-1 to 21.

SUKHIJA, B.S., REDDY, D.V., NANDAKUMAR, M.V. and RAMA (1994). Development of methodology for estimating groundwater recharge through percolation tanks in semi-arid regions of India - Preliminary results. Proc. Intl. workshop on Groundwater Monitoring and Recharge in semi-arid areas, organised by UNESCO and IAH, held at NGRI, Hyderabad, Jan. 18-20, 1994, pp.SV/23-36.

SUKHIJA, B.S., REDDY, D.V., NANDAKUMAR, M.V. and RAMA (1997). A method for evaluation of artificial recharge through percolation tanks using environmental chloride. Groundwater, v.35, No.1, pp.161-165.

K.C.B. Raju replies:

Dr. Sukhija has referred to Table 7 but probably missed to go through Table 5 which gives the percolation tank performance in Rayan Project from 1989-1994. However, sites for percolation tanks should be selected properly with suitable design.

I fully agree with Sukhija that percolation rate decreases with deposition of silt every year. So it is very important and essential to have people participation to desilt the percolation ponds/ recharge structures every year to have continued effective recharge rate.

*****

ANNOUNCEMENT

INTERNATIONAL SYMPOSIUM ON MULTIFACETED ASPECTS OF TREE-RING ANALYSIS

A five day symposium (including field excursion) covering various aspects of tree-ring analysis in climate, forestry, geomorphology, archaeology, dating of natural hazards, etc. is proposed to be held at Birbal Sahni Institute of Palaeobotany, Lucknow, India.

For details contact at the earliest, Prof. Anshu K. Sinha, Director or A. Bhattacharyya, Organising Secretary, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow - 226 007, India. **Tel:** 0522-324291, 323206, 325945, 325822; **Fax:** 91-0522-381948/ 374528; **E-Mail:** bsip@bsip.sirnetd.ernet.in.