Need for high-resolution deep seismic reflection studies in strategic locales of South India

South Indian seismicity is neither understood properly nor given importance since it is of micro-dimensions. When we look into the geological history of Dharwar craton, it is revealed that the present stable continental crust has evolved by the end of the Archean and was largely stable thereafter. By contrast, the granulite terrains of South India comprise a number of distinct crustal blocks, welded together at various times during the geologic past and dissected by major trans-crustal shear zones including Moyar–Bhavani–Achankovil. With a variety of lithologic assemblages, these granulite blocks associated with intrusives and the network of shear zones have become seismogenically important. This was noticed in the recent past by some active earth scientists[1] after witnessing a spurt of low magnitude seismicity in and around Moyar–Bhavani and Achankovil shear zones. These shear zones are belts of kinematic partitioning associated with recurrent networking of the Archaean crust. Recent integrated studies by NGRI scientists (unpublished report) have also shown that Moyar–Bhavani and Mettur shear zones are important, as they are the terrain boundaries separating distinct crustal blocks. The South Indian mobile belts including Eastern Ghat Mobile Belt (EGMB) and the shear zone region within Southern Granulite Terrain (SGT) seem to be distinctly associated with geodynamic processes of both regional and global importance. The separation of Antarctica from India, even though no longer active, left behind the impact signatures like fault-bounded edges and depressions which with time and due to the accumulation of a thick pile of sediments became unstable, resulting in seismic activity along EGMB from north of Ongole to South of Pondicherry. In addition to the geodynamic processes responsible for break of different segments of East Gondwana super-continent, the super plumes responsible for various tectonic processes, viz. Kerguelen, Crozet, Marion and Re-union, further weakened the zone and adjoining areas causing crustal instability in the form of vertical movements along different deep-seated faults more pronounced.

Recent seismic studies[2,3] especially deep seismic reflection/refraction and seismic tomography studies have clearly shown that both Western Dharwar Craton (WDC) and major parts of SGT are underlain by thick crust compared to the Eastern Dharwar Craton (EDC). In the SGT we come across high topographic individually dominant Nilgiri and Kodaikanal features that have attracted the attention of international geo-scientific community due to their anomalous genetic characteristics. Since there are individual blocks that are significant by different crustal structures compared to the adjoining blocks, in addition to presence of regionally extending crustal scale shear zones, it is extremely essential to study in depth these unique blocks by launching high resolution deep seismic reflection studies that could produce 3-dimensional images of different structures including the depth extension of the mega/macro lineaments that are having pronounced control over the present-day tectonic configuration. Such a study integrated with geological investigations to assess the nature of past movements in blocks of 50 km × 50 km is essential so as to beter understand the seismogenic nature of shear zones that are adjacent to a number of thickly populated cities and towns like Bangalore, Salem, Coimbatore, Chennai, etc.

Deep seismic refraction studies have been carried out along Kavali–Udipi[4] and Kuppam–Palani (unpublished report) transects. And as such we have reasonably good refraction-derived velocity information available to convert two-way time reflection data into velocity-depth models. Since it is essential to map the contact zones of crustal scale shear zones and thrust faults to understand the faults' geometry and thereby seismogenic stuctures' source characteristics, our strategy could be twofold, i.e. cover some specific locales in a grid pattern with a maximum length of each profile to be 50 km and in other areas have single

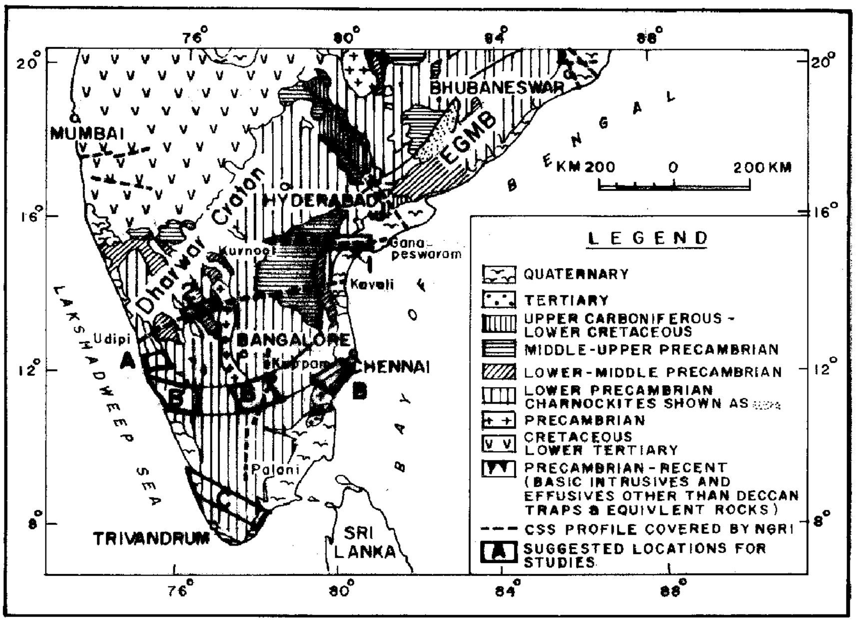

Figure 1. Geological map of South India along with various DSS profiles and mobile belts of various periods. EGMC – Eastern Ghat Mobile Belt; PBMB – (Bhavani–Palghat) Mobile Belt; (M–B) – Moyar–Bhavani Shear Zone: (P–C) – Palghat Cauvery Shear Zone; – after Reddy and Rao (2000) (modified).

long, but not very long, profile of a maximum distance of 100 km to map depth extension and geometry of a series of contact zones. Such a strategy will address both societal and geodynamic problems (including additional inputs) to understand the structure and evolution of an important segment of East Gondwana super-continent – a LEGENDS (Lithospheric Evolution of Gondwana East from Inter-disciplinary Deep Surveys) initiative.

The suggested locales for seismic reflection study and ways of handling the data illustrated in Figure 1 are:

(1) A linear profile across the eastern flank of Cuddapah basin and extending eastwards covering the seismically-active Ongole (AP) belt.
(2) A linear profile from east of Closepet Granite across Chitradurga–Shimoga schist belt.
– For both these profiles reasonably good refraction coverage is available.

(a) 50 km × 50 km grid covering Gurur (Karnataka) and adjoining areas of WDC, as the zone has got thickest crust[4].
(b) 50 km × 50 km grid at the eastern, middle and western segments of Moyar–Bhavani, including the junction where the two shear zones meet and deviate in different directions.
(c) 50 km × 50 km grid or three linear profiles across different segments of Achankovil shear zone.
– For a, b, c velocity information could be taken from both tomographic and adjacent refraction studies.

As NGRI has expertise, experience and infrastructural facilities to conduct seismic reflection studies and as the Department of Science and Technology supports such studies under its deep continental and earthquake hazard studies programmes, this can be effectively launched at the earliest.

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ACKNOWLEDGEMENTS. I am thankful to Dr S. S. Rai, Head, Seismic Tomography Division, NGRI for stimulating discussions. Shri V. Y. N. Sarma helped in preparation of the manuscript and Shri B. P. S. Rana in preparation of the figure.

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The *Bt* cotton story: The ethics of science and its reportage

The paper published recently in *Science* by Qaim and Zilberman[1], purporting to show a dramatic increase in the performance of *Bt* cotton in India has attracted a lot of attention. At the same time, the paper raises serious questions about ethics in the application of science and the societal context of such applications and reportage.

Qaim and Zilberman draw rather sweeping conclusions about the 'Yield Effects of Genetically Modified Crops in Developing Countries' based on meagre and selective data from one single genetically modified crop, cotton, derived from just one country, India. The title is misleading, claiming far more than the scope of the study permits.

On the basis of a single set of trial data of *Bt* cotton from one season in India, the authors project high yields for all GM crops in all developing countries. They base this rather unorthodox prediction, not on any peer-reviewed evidence but on 'crop protection theory'. This amounts to speculative and poor science. Crop yields are known to be multifactorial and have differing dynamics in different countries, based on a number of local factors, which have to be studied for a correct estimation.

The paper of Qaim and Zilberman reports unprecedented yield increase (up to 87%) which strains credibility. Such spectacular performance has not been reported from anywhere else in the world where *Bt* cotton is cultivated. *Bt* cotton does show an advantage in the US and China, but these are in the range of a 10–15% increase in yields reportedly because of better protection against cotton pests found in the region.

Bt cotton, the first GM crop to be grown in India was given approval for commercial cultivation in March 2002, so this is the first GM crop harvested in the country. The sensational data presented in this paper are, however, not based on this harvest, as would be the case in a proper scientific investigation. The data in this paper are derived only from selected field trials plots of Mahyco–Monsanto. No data from farmers' fields or from the All India Coordinated Varietal trials conducted by ICAR (Indian Council of Agricultural Research) have been included in the study. What is really disturbing is that this paper extolling the outstanding performance of *Bt* cotton is based exclusively on data supplied by the company that owns the *Bt* cotton variety in question: Monsanto.

Qaim and Zilberman attribute the 87% yield increase they report as being 'entirely' due to crop losses avoided by the presence of *a single copy of the Bt gene*. Yield in plants is known to be polygenic and there is no known evidence for a single gene being largely responsible for yield. Attributing such large effects on yield to just one copy of the *Bt* gene, is untenable and unscientific.

Actually, to get any real idea about the success or failure of *Bt* cotton in the field, one will need to wait and see the results of at least another two harvests. The authors of this sloppy paper have done a great disservice to science by jumping the gun in this fashion and so have the editors of the journal *Science*, by letting this paper through. These sensational data have led to a spate of media reports about the 'superlative'