

Deep Resistivity Sounding Studies in Detecting Shear Zones: A Case Study from Southern Granulite Terrain of India

S. B. Singh, Jimmy Stephen and U. K. Singh

National Geophysical Research Institute, Hyderabad - 500 007, India

The efficacy of deep resistivity sounding studies to demarcate major shear zones in hard rock terrains has been addressed with a case study from the southern granulite terrain (SGT) of India. SGT, separated from the northern granite-greenstone province by a gradational transition boundary with irregular development of charnockites and other granulite facies rocks, poses a long lasting research problem for geo-scientists. It provides the window for one of the oldest crusts of the world with wide spectrum of metamorphic events comprising a number of shear zones separating diversified crustal blocks (Drury et al., 1984). The presence of large number of deep faults and increased seismicity in SGT indicate that the terrain has undergone many tectonic modifications throughout the geologic history and still continuing (Grady, 1971). Geological and geophysical studies are continuing for last three to four decades in this terrain.

An integrated geophysical/geological approach has been initiated to better understand the tectonics of this typical high-grade terrain (Reddy et al., 2000; Singh et al., 2000). The main idea was to bring out tectonic models to explain the evolutionary history of this terrain. Here we present the results of Deep Resistivity Sounding (DRS) studies carried out along the corridors of a N-S trending geo-transect extending from Kuppam to Palani, which cuts all the major diversified and highly metamorphosed crustal fragments in SGT. Electrical resistivity methods have been well established for delineating lateral as well as vertical discontinuities in the resistive structures of the Earth's subsurface. Here we use the Schlumberger electrode set-up (with maximum AB = 10 km) to delineate the vertical resistivity structures at depths. The distribution of DRS stations is shown in Figure 1, along with the major deep faults obtained on photo-geological studies. Characteristics of the resistivity data in the vicinity of shear zones are studied. The evidence of fluid movements, as manifested by fluid-induced retrograde metamorphism along major weak zones in SGT, leads to low resistivity signatures in the shear zones.

Both qualitative and quantitative analysis of DRS data gives the evidence of shear zones in the terrain. The typical signature of an apparent resistivity sounding curve in a shear zone can be well understood from that of other regions as seen in Figure 2 which shows some of the resistivity sounding curves in the SGT. Here, the curve S-25 represents a typical hard rock terrain where the apparent resistivity curve shows a sharp increase with larger current electrode separation. On the other hand, the sounding curve S-26 shows a decrease in apparent resistivity at highest electrode separation, depicting the low resistivity zones at depths. This type of curves is very common in the terrain. But the nature of resistivity and attitude of these deeper portions are not clear, since we are

restricted to the maximum current electrode separation (AB) of 10 km further which the cable spread for Schlumberger set-up is very difficult. The third type curves S-04 and S-07 shows conductive zones at intermediate depths, where both fall within the vicinity of some prominent N45°E striking deep faults.

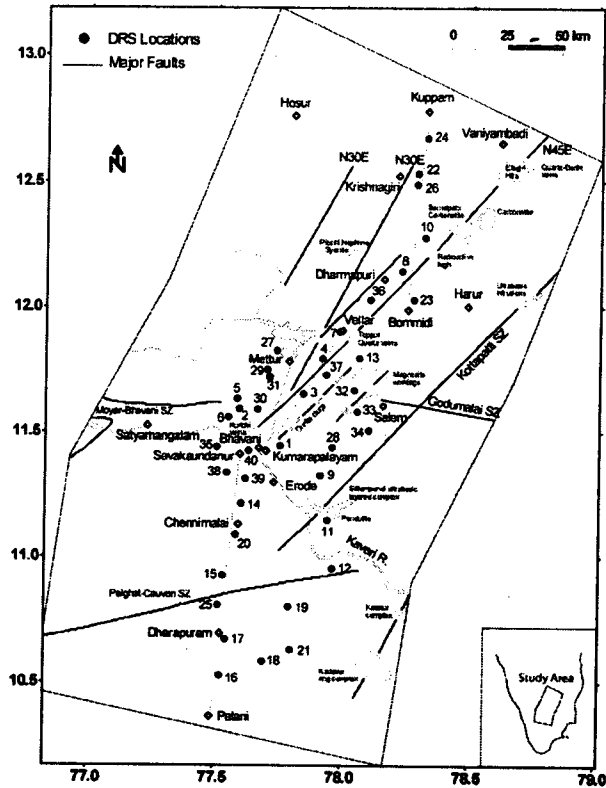


Figure 1. Distribution of Deep Resistivity Sounding stations along the Kuppam-Palani Geotranssect in SGT shown with main deep faults.

Two dimensional cross-sections were prepared to better understand the resistivity distribution within the terrain in three segments, namely, Kuppam-Bommidi, Vellar-Kumarapalayam and Savakaundanur-Palani. The Kuppam-Bommidi segment encounters two major faults, wherein the N45°E fault even cuts the profile east of Dharmapuri, near sounding station S-08. This fault zone is marked with sharp gravity gradients trending NE-SW and supports the existence of deep-seated faults (Reddy, et al., 2000). Effects of these deep-seated faults are clearly visible in the resistivity sounding curves. Mainly low resistive zones are detected at depths in these regions. The Vellar-Kumarapalayam segment is characterized by a deeper low resistivity layer extending from Bommidi to further south and gets thinned out. This segment cuts two major shear zones, Moyar-Bhavani towards west and the Salem-Attur towards east, other than the deep faults. The third segment, Savakaundanur-Palani, is not much influenced by faults, except the major Palghat-Cauvery Shear Zone (PCSZ) cutting between S-15 and S-25. Figure 3 shows the 2D pseudo and true resistivity sections for this segment. PCSZ gathered very much importance, since both sides of this shear zones are characterised by two entirely

different geochronological regimes; Archaean age towards north and Pan-African age towards south. The sounding curves south of PCSZ (S-25 and S-17) shows saturation at a lower resistivity (in the order of 10^3 Ohm-m) compared to that towards north (in the order of 10^4 Ohm-m) as seen in S-39, S-14, S-03, etc.

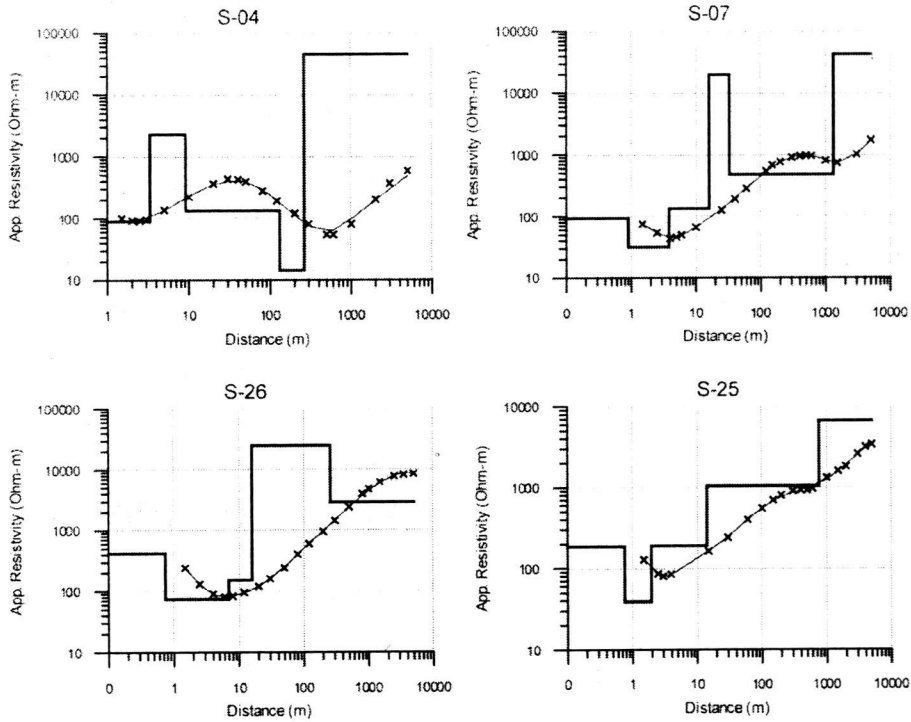


Figure 2. Different types of resistivity sounding curves along with their interpreted 1-D model observed in SGT. Symbols show the observed data and solid curve shows the computed response for the given model.

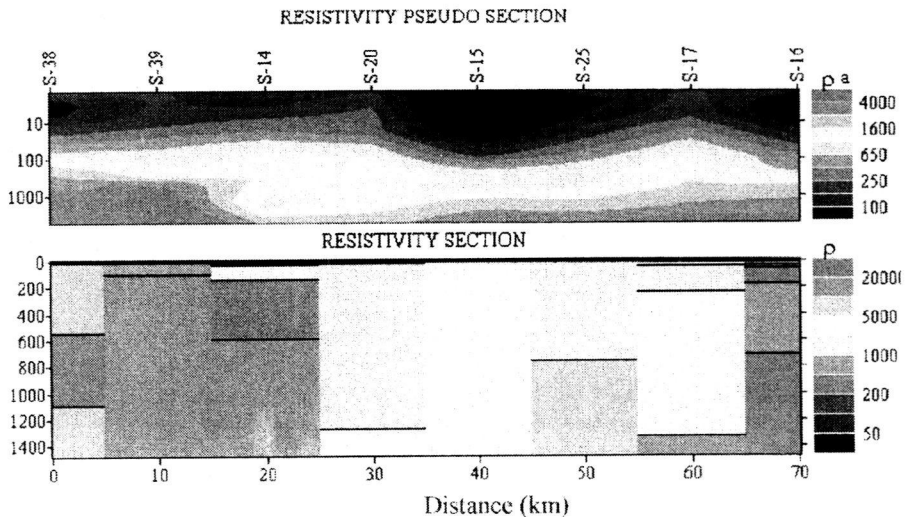


Figure 3. 2-D pseudo and true resistivity sections along Savakaundanur-Palani segment.

The resistivity distribution up to a depth of about 4 to 5 km has been achieved through DRS measurements. Electrical signatures at this depth provide useful information for understanding the characteristics of major shear zones. The complex subsurface geology having compositional variations is reflected in the perplexed variations between sounding curves. Some of the deeper extensions of faults characterized by emplacement of alkali complexes, intrusions and fluid migration were marked by intermediate to low resistive layers. For example, near Bommidi, an intermediate low resistivity layer with an order of few hundreds of Ohm-m exists. This layer occurs below a depth of about 850 m and has a thickness of more than 1000 m. Here the influence of N45°E trending major fault can be expected, since it passes very near to this region. The resistivity distribution at deeper parts support the theory of amalgamation of an Archaean crust in the north with a Proterozoic crust in the south along the Palghat-Cauvery Shear Zone. Here the order of resistivity on either side seems to be different with a higher range for Archaean compared to Proterozoic.

References

- Drury, S.A., Harris, N.B.W., Holt, R.W., Reeves-Smith, G.J. and Wightman, R.T., 1984. Precambrian tectonics and crustal evolution in South India. *Journal of Geophysics*, 92, 3-20.
- Grady, J.C., 1971. Deep main faults in south India, *Journal of Geological Society of India*, 17, 56-62.
- Reddy, P.R., Mishra, D.C., Sarma, S.V.S., Harinarayana, T., Divakara Rao, V., Narayana, B.L. and Singh, S.B., 2000. Subsurface configuration of the southern high grade granulite terrain- Inferences from integrated geological/geochemical/ seismic/magnetotelluric/deep resistivity and gravity studies, *The Indian Mineralogist*, 34,41-47.
- Singh, S.B., Ashok Babu, G., Singh, K.P., Srinivas, Y., Jimmy Stephen, Singh, U.K. and Reddy, J., 2000. Deep resistivity sounding studies in the south Indian granulite terrain along Kuppam-Palani geo-transect, *The Indian Mineralogist*, 34, 48-51.