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Letters to the editor

A comparison of deep geoelectric structure in the Pannonian Basin and on the Baltic Shield

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The deep geoelectric structure of the Pannonian Basin has been investigated since the early 60's (Ádám, 1976a, b) and some new interpretations were presented recently (Ádám et al., 1982b).

A preliminary geoelectrical model for the Karelian megablock of the Baltic Shield (Fig. 1) was presented by Kaikkonen et al. (1983) and its apparent resistivity curve, after a reduction to zero conductance of overburden and sediments, is shown in Fig. 3. Some new magnetotelluric results from Central Karelia (Rokityansky et al., in press 1983) support this model to some extent.

Although the model is obtained for only one part of the Baltic Shield, it is assumed at this stage, that, after a correction for electrical distortions, the model is valid for most parts of the shield. Such an assumption is justified because of the small variation in terrestrial heat flow data, with a low mean value 35 mW/m^2 (Järvimäki and Puranen, 1979). However, different and interesting geoelectrical results have been reported by Jones (1982) from Kiruna on the Northwestern part of the Baltic Shield.

It is interesting to compare the geoelectrical structures of the stable Precambrian Baltic Shield and the Cainozoic active Pannonian Basin. The geoelectrical structures of these regions can be understood against the background of geological and geotectonic differences.

Distortions of deep geoelectric results

Both in the Pannonian Basin and on the Baltic Shield the deep geoelectrical measurements include the influence of the near surface conductivity inhomogeneities.

For the Pannonian Basin, the main distortions are due to the sediment cover of varying thickness (the so-called *S*-effect). A map of the total conductance of the sediment cover can be used to study this kind of distortion and such an *S*-map was constructed by Ádám et al. (1982b) on the basis of geological and geophysical data. Numerical calculations using this map show that the minor axis of the telluric ellipse is not significantly sensitive to the *S*-variations, so ρ_{min} curves were used for deep investigations in the Pannonian Basin.

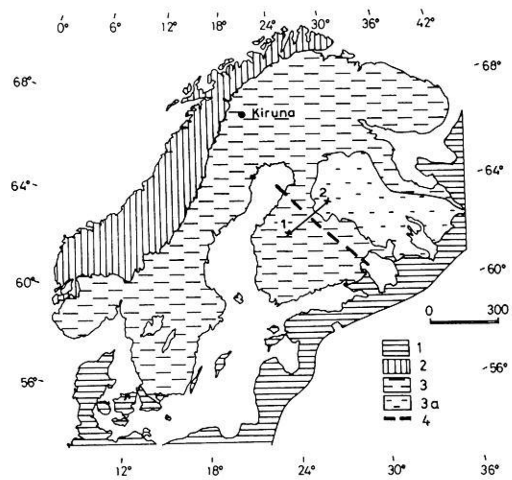

Fig. 1. Karelian megablock on the Baltic Shield. Crosses show the beginning (1) and end (2) points of the profile of the 5 MT points measured in 1980. (1 – Paleozoic and younger sedimentary rocks, 2 – Caledonides, 3 – Baltic Shield and 3a – Karelian megablock). 4 – approximate location of the Lake Ladoga-Bothnian Bay zone

Quite a different situation was observed on the Baltic Shield where the main source of distortion is connected with schist belts. In these belts the conducting bodies often have nearly vertical structures. The sharp distortions which are due to the vertical conductive dykes in schist belts are clearly present in a profile of ρ_{min} and ρ_{max} at a period of 100 s (Fig. 2). This profile was constructed from the results of MT soundings reported by Ádám et al. (1982a). Note the very low resistivity value (about 4 Ωm) at point number 5 which suggests some highly conducting material, such as graphite, sulphide minerals etc., to be the source of the anomaly. The preliminary estimates of the conductance suggest that it can exceed some 10^3 S and similar results were obtained by Rokityansky et al. (1979). Such a high conductivity causes a strong screening effect, which makes it difficult to investigate deep geoelectrical structures.

To date, there is enough information about conductivities and geometrical features from only a limited number of locations on the Baltic Shield. This makes it difficult to construct numerical models for distortion effects. For reliable deep sounding results, it is therefore important to

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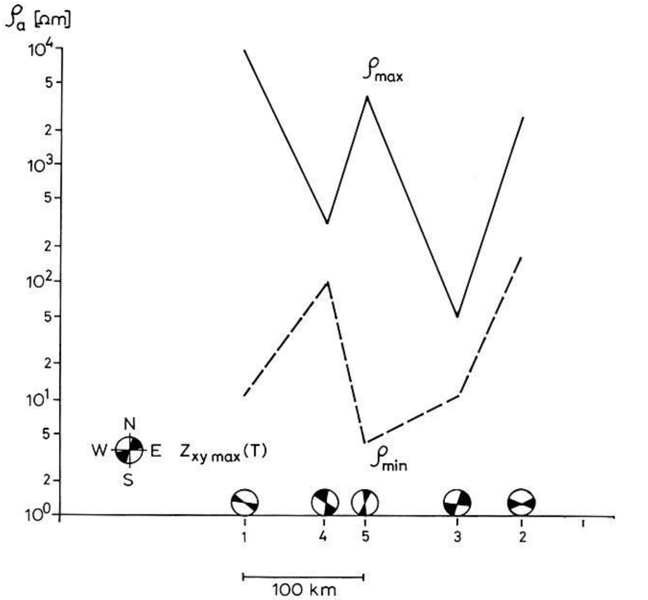

Fig. 2. Apparent resistivity profiles with the period $T = 100$ s for MT measurements in the Central part of the Baltic Shield and the directions of the maximum values of Z_{xy} (T) at the measuring sites 1–5 after Ádám et al. (1982a)

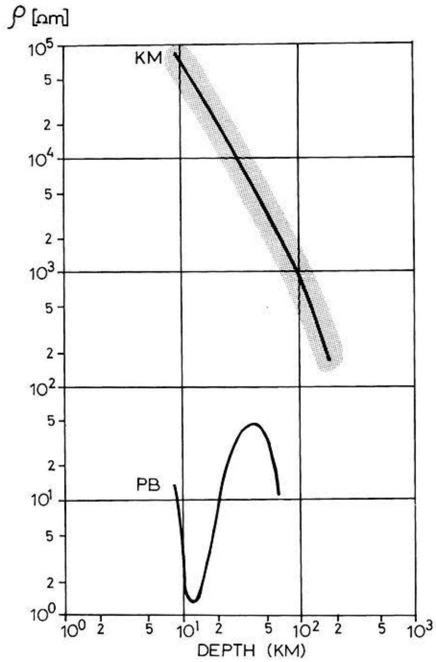

Fig. 4. Comparison of the deep resistivity of the Karelian megablock (*KM*) and the Pannonian Basin (*PB*)

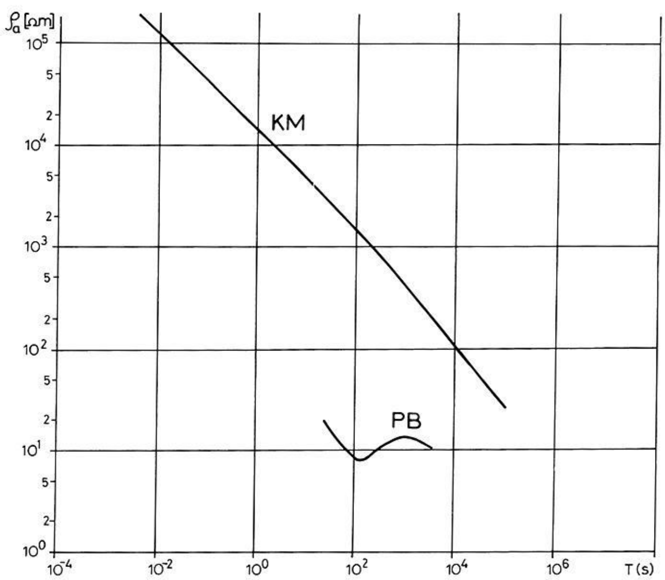

Fig. 3. Apparent resistivity curve for the Karelian megablock (*KM*) (Kaikkonen et al. 1983) and the average curve for the area of the Transdanubian anomaly in the Pannonian (*PB*) Basin. Both curves are transformed to correspond to zero conductivity of the uppermost part

map and locate the conductivity anomalies in the upper crust. The simplest and most valid procedure for minimizing crustal distortions is to locate the subsequent deep MT sounding points as far from the known near surface inhomogeneities as possible. From this point of view the Karelian megablock seems to be one of the most favourable high resistive windows for investigation of the deep geoelectrical structures. The AMT results also confirm that the Karelian megablock has a very high resistivity (Kaikkonen and Pajunpää, in press 1983).

It is interesting to note that there is an anomaly of crustal conductivity in Hungary, the so-called Transdanubian anomaly (Ádám, 1976a). The very sharp decrease of the apparent resistivity to some few Ωm suggests that the conductor has a very low resistivity, which might correspond to graphite schists, sulphide minerals or hydrothermal solutions. In the Pannonian Basin this is the only known crustal anomaly occupying a small part of the basin, while on the Baltic Shield there are numerous geologically recognized anomalies of similar kind.

The geoelectric structures

Figure 3 presents a summary of apparent resistivity curves for the Pannonian Basin and the Baltic Shield (represented by the Karelian megablock curve). The average minimum apparent resistivity curve for the Pannonian Basin (Ádám et al., 1982b) was reduced to zero sedimentary cover conductance.

The level of the Pannonian curve is 1–1.5 orders of magnitude lower than the level of the Baltic Shield curve. The shape of the Pannonian curve differs significantly from the Baltic Shield one, showing a distinct minimum at a period of about 100 s and a decrease at periods greater than 1000 s. These features correspond to crustal and asthenospheric conducting layers.

Using the Niblett inversion (Niblett and Sayn Wittgenstein, 1960) the resistivity-versus-depth profiles are obtained. The profile for the Baltic Shield (Kaikkonen et al., 1983) is compared with the profile for the Pannonian Basin in Fig. 4. The shield profile shows a continuous decrease of resistivity with depth with no conducting layers in the crust or the upper mantle. For the Pannonian Basin the inversion profile indicates a conducting layer in the crust and a decrease of conductivity at depths about 50–80 km, which might correspond to the upper surface of the asthenospheric conductive layer. The conducting crustal layer in the Pannonian Basin has a specific resistivity less than 10 Ωm at a depth of approximately 10 km, while the specific resistivity for the Baltic Shield at the corresponding depth is higher than 10^4 Ωm.

In the asthenosphere beneath the Pannonian Basin the resistivity decreases to about 5–10 Ωm at a depth of 70 km while for the Baltic Shield the resistivity is as high as 300 Ωm even at 150 km depth, without any sign of any more conducting layer. More soundings will be needed to verify whether this condition prevails for all parts of the shield. The recent results of Jones (1982) seem to indicate the possibility of an upper mantle conductor (asthenosphere) at 155–185 km depth in the NW part of the shield. The validity of this result for other parts of the shield and its possible explanation by tectonic differences close to the western edge of the shield will also form an interesting problems for further geoelectric measurements.

The well developed asthenosphere is usually explained as a partially molten layer, while the crustal conductivity, as mentioned above, can be connected with hydrothermal solutions (Hyndman and Hyndman, 1968). Both of these features are in accordance with the high heat flow values measured in the Pannonian Basin (mean value 95.3 mWm^{-2}; Horváth et al. 1979). This correspondence, as well as the correspondence on the Baltic Shield (no asthenospheric conductor, low average heat flow, 35 mWm^{-2}) is also explained well by Ádám's relationships between electrical conductivity and heat flow (Ádám, 1978). Many additional problems in interpretation, e.g., in connection with the high latitudinal position of the Baltic Shield (the source effect) require further investigations.

Conclusions

Comparison of deep geoelectrical models for different tectonic areas is one of the main goals of the international IAGA-ELAS (Electrical Conductivity of the Asthenosphere) project. The results mentioned above suggest significant lateral variations of the electrical conductivity of the crust and upper mantle. This kind of comparison of the results of the multilateral investigations will be very useful in finding out the deep geoelectrical structure.

Further measurements will be needed especially in the area of the Baltic Shield. A better description of crustal conductivity anomalies is needed to improve the validity of the generalized shield curves and to determine possible differences between the geoelectric structure of the various parts of the Baltic Shield.

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