## Examples of ELGI's activities abroad

### *International geological expedition in Mongolia**

Our Mongolian exploration activity has been continued within the framework of the joint International Geological Expedition of the member countries of the Council for Mutual Economic Assistance, and we carried out integrated exploration for the copper- and other mineral resources of the S. Gobi region. The Geophysical Group worked on the sites assigned to the Polish and Hungarian Geological Mapping Groups and to the Czechoslovakian Interpretation Group, using different resistivity, IP, earth magnetic and seismic techniques to gain more detailed information on the dimension and structure of the already mapped ore indications. The final geological interpretations and their compilation into a summary report are in progress.

### *Multifrequency electromagnetic sounding*

ELGI's methodological development in the field of electromagnetics the Multifrequency Electromagnetic Sounding (MFS) with induced coupling has earlier been reported (Annual Report, 1980). MFS instrumentation is based on the Maxi-Probe EMR—16 type equipment of Geoprobe Ltd. Computation of the electromagnetic field parameters, over a horizontally layered model and for magnetic dipole excitation, has been solved in cooperation with foreign and Hungarian University departments. This made possible to analyse the resolving power of the method and to compare various routes of data processing. Routine MFS processing is solved, on the basis of the know-how purchased from Geoprobe Ltd., by means of an HP–9845 S desk-top computer mounted in a cross-country vehicle. Theoretical problems connected with the computation of dipole excitation are reported in Section 2.2.1.

The following short reports present some of the measurements carried out abroad, with the kind preliminary permission of our foreign partners.

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### *a) MFS measurements in Czechoslovakia**

In September, 1982, ELGI carried out electromagnetic frequency soundings with the Maxi-Probe EMR–16 equipment, upon the invitation of the Geofizika Slovensky Geologicky Urad and the Geofizika u.p. Brno, Závod Bratislava (Dr. Igor Tuny, Ing. Ivan Marusiak). From the Czechoslovakian side D. Obernauer actively participated in the preparation and geological interpretation of the measurements. The aim of the tests had been to prove the sufficient resolution and effectiveness of the Maxi-Probe electromagnetic frequency sounding method for a complicated geological model. The measurements were carried out along a section at 25 m intervals. Borehole data indicated the coal seam at about 60–90 m depth, surrounded by shaly, marly, pebbly sediments. The resistivity of the surrounding rocks varies from a few times 10 $\Omega$m to a few times 100 $\Omega$m, the same values were obtained from the electric well logs. Even though the surrounding rocks do not possess characteristic resistivity values, the well logs indicate that the coal seam is always a better conductor than its vicinity (we experienced a 3–4 fold resistivity contrast). Seam thickness is 5—6 m, which is about 5–10% of its depth below the surface.

Before commencing measurements we had to make sure whether a thin coal seam could be indicated at all by electromagnetic frequency soundings. We carried out experimental frequency soundings on one of the boreholes, using three different transmitter–receiver distances. The $L=140$ m spread did not give any interpretable result. With $L=100$ and $L=120$ m transmitter–receiver distances, however, quite meaningful $\varrho_a(H)$ curves were obtained *(see Fig. 103)*. Detectability has been defined by the following criteria: in the $\varrho_a(H)$ curves corresponding to different L values the investigated layer boundaries should be unambiguously indicated by break-points, the depth of the break-points should be independent of $L$ and there should be a good correlation with the geological section and/or the electric well log of the respective borehole. In the $\varrho_a(H)$ curve belonging to L$=100$ m there appears a layer between 63–67 m which is unambigously better conducting than its vicinity, for $L=120$ m a similar layer appears between 64–67.5 m (see break-points $C_1$ and $B_1$, respectively). The drilling indicated coal between 64.4–69.2 m. These data prove that the coal seam can be fairly reliably detected by the Maxi-Probe system, the deviation between the depths indicated by geophysics and the actual one is less than 2 m. The final survey was carried out using the more informative $L=$ 120 m spread. A part of the interpreted section is shown in *Fig. 104*. It had been a basic assumption throughout the field work and the subsequent interpretation that the coal seam acts in its totality as an homogeneous layer of high conductivity as compared to its vicinity, and that it can be indicated along

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the whole section, not only at the places of the pilot survey. These assumptions have been verified by the soundings.

The identification of the thin high conductivity layer would seem more problematic in the presence of faults for, at least in principle, several high conductivity layers could be interpreted as coal seams between outstanding points of the $\varrho_a(H)$ curves. However, the geophysical interpretation can be made extremely certain by taking into account the continuity of the layers between adjacent break-points. It has been a decisive step for the "discovery" of the coal seam that we could recognize the layer boundaries $E_2-D_2$, $D_2-C_2$ and $D_2-C_1$, respectively, and the correlation of the layers sandwiched between them. The $E_2-D_2$ layer of medium conductivity overlies a relatively higher conductivity, though rather inhomogeneous formation: the $D_2-C_2$ and $D_2-C_1$ layers, respectively. The coal bed should be sought for below this formation. The coal seam is cut by a small fault, as evidenced by the same throw of the boundaries of the characteristic layers above the coal (e.g. between soundings Nos. 4 and 5). The tectonic picture seems to be confirmed by the behaviour of a further layer boundary $A_2$ ($A_3$), below the coal seam (between soundings Nos. 0–8).

### *b) MFS surveys in Baden-Württemberg (FRG)**

In 1982 we were contracted by the BEB Erdgas-Erdöl Co. to carry out a detailed MFS survey prospecting for thin near-surface layers. The investigated sedimentary layer was hidden in a variagated series, its thickness frequently being less than 10% its depth from the surface. In spite of all these obstacles we have succeeded in tracing the layer over a continuous area, and located faults at least of 3 m amplitude, by means of electromagnetic sounding.

In the geophysical interpretation the situation of the layers could be followed by determining the correlation between the curves. The obtained boundaries were identified with the actual geological layer boundaries by means of comparing the measured curves with the MFS curves obtained on boreholes and by following the layers recognized in outcrops. The real resistivities of the layers had been determined by means of dc sounding. *Fig. 105* presents the geological column of a borehole and the MFS curve measured on the borehole. It is easy to recognize the high resistivity layer corresponding to the limestone bed between boundaries *X* and *A* and the low resistivity shale–marl formation including the thin layer sought for. *Fig. 106* shows the clear-cut correlation of the layers and the recognizability of the fault. In spite of the rough terrain we could trace the nearly horizontal layers, though at some places their thicknesses have not even reached 5% of their depths. On the section of Fig. 106 locating of the fault has been made easier by the change in the character of the

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curves (cf. MFS curves Nos. 4 and 5). The interpreted depth data were used to construct, by means of the colour plotter of the HP 9845 S computer, the depth contour maps and the axonometric views of some of the horizons.

Thanks are due to dr. H. Dürschner, Chief Geophysicist, and dr. W-D. Karnin, Chief Geologist of BEB, for their help and advice during the preparation of the survey and in the final interpretation.

### *c) MFS survey in Upper Austria*[*]

We had to determine the depth of the crystalline basement, and to give a fine subdivision of the sedimentary cover, by electromagnetic frequency sounding. The geological column of the borehole drilled on the study site and the MFS curve obtained the same place are shown in *Fig. 107.* The basement could be very accurately traced by means of the sharp break-point at 345 m depth. The four characteristic layers of the overburden are clearly discernible on the curve. It should be emphasized that we could also determine the thin high conductivity layer surrounded by high resistivity formations (between 175–190 m).

The help of Prof F. Weber, of the Montanuniversität, Leoben, in the design of the survey and in interpretation is gratefully acknowledged.

### *d) MFS survey in Bavaria (FRG)*[**]

The aim of the project was to check the applicability of electromagnetic frequency sounding for the detection of the crystalline basement and for the subdivision of the overburden. The surface of the basement had been assumed to correspond to the geophysical boundary denoted by *I*, at a depth of 376 m according to the geological column of *Fig. 108*. The accuracy and reliability of the determination of the high-resistivity basement have been greatly improved by the fact that its surface is directly overlain by a thin high conductivity layer that can be clearly followed through the section *(Fig. 109)*. There is a similar, easily traceable high conductivity layer in the overburden as well, between boundaries *C* and *II*. Further fine structural details can be observed both in the cover and the basement, which have been duly utilized for the correlation of the curves.

The particular measurement conditions have brought to the light the flexibility of the method, due to the following properties:

- the transmitter–receiver distance can be changed within wide limits in accordance with the depth range studied,
- the transmitter–receiver distance does not exceed twice the study depth, i.e. it is relatively small,

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- in the absence of major structural changes the direction of the spread is arbitrary, transmitter and receiver can be interchanged.

Consequently, the method can be applied in cultivated or built up regions, without environmental damage. The reference point can be placed at locations with difficult access.

The help of Prof. J. Homilius of the Niedersächsische Landesamt für Bodenforschung ($NL_fB$) in the execution and interpretation of the measurements is gratefully acknowledged here.

### *a) MFS survey in Lower Austria**

The electromagnetic frequency sounding can also detect a relatively thin layer, if its resistivity is greater than that of the surrounding medium. An example is shown by *Fig. 110*, where the exploration target was an Eocene limestone layer, its thickness being some 10% of its depth. We also had to determine the thickness of that karstic limestone. Evidently, the limestone is easily separated from the low resistivity overburden and form the slightly higher resistivity basement. The circled distortions on the curve are due to the nearby electric line (the frequencies of the distorted points unambigously coincide with the basic 50 Hz and upper harmonics of the mains).

We acknowledge the help of dr. H. Unterwelz, Chief Geologist of the Österreichische Mineralöl Verwaltung (ÖMV) in planning the survey and in the interpretation.

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*In 1982 the following publications were issued:*

- Annual Report of the Eötvös Loránd Geophysical Institute of Hungary for 1981
- Geophysical Transactions, vol. 28, Nos 1, 2
- Annual Report 1980 of the Tihany Geophysical Observatory.