1 GEOPHYSICAL PROSPECTING

1. GEOPHYSICAL PROSPECTING

Locations of the field works of ELGI in 1980 are presented in *Fig. 1.*

The geophysical investigation of the *Transdanubian Central Range* continued according to the directives of the Central Office of Geology. Plans were coordinated between the Hungarian Geological Survey (MÁFI), and the coal mining corporations. Bauxite exploration was carried out under the guidance of the Hungarian Aluminium Corporation (MAT) and financed by the Bauxite Prospecting Enterprise (BKV).

The most important results of the past five years' exploration were:

— delineation of the coal field of Mány-East—Zsámbék with its resources of 80 million tons;
— detection of 8 smaller coal fields and bauxite lenses in the area of Héreg, Bajna, and Tükrös;
— detection of 56 bauxite lenses in the area of Iharkút and Bakonyoszlop.

The exploration phases of the geophysical investigation fit into the system of the geological survey: to the regional survey of the scale of 1:25,000 are linked the detailed Bouguer anomaly maps and several filtered variations. In the second phase come the geoelectric and seismic profiling. The boreholes drilled after the first phase are also used as geophysical parameter wells. After the second phase of geophysical measurements come boreholes aimed at stratigraphy and structure. Borehole data may be able to correct former geophysical interpretations thus preparing the area for the more detailed, 1:10,000 scale "discovery" survey.

The first phase of regional exploration of Senonian brown coal in the area of Sümeg is shown in *Fig. 2.* From the Bouguer anomaly map the area where the Triassic basement is less than -500 m deep can be delineated (thick line), this being the limit of profitable exploitation. The gravity map enable the second phase of the exploration—started in 1981—to be planned.

In the area of Magyarpolány the uplifted block and its immediate surroundings were the object of the regional survey. The filtered gravity anomaly map of the first phase presented in *Fig. 3/a* shows the location of the block. This and the seismic reflection profiles shot in the second phase of the regional survey proved the much smaller extension of the block than supposed earlier (only 9.5 km^2 instead of 19 km^2). At the same time, reflection time sections called attention to the undisturbed stratification of the Senonian coal-bearing Ajka Formation to the west of borehole Mp—42 *(Fig. 3/b)*. Thus it is possible to find the coal seam not much deeper than -500 m to the west and south-west.

The regional survey of the Kolontár—II area belongs to the Senonian coal exploration programme as well, and came into the limelight after the negative result of the Magyarpolány project. To prepare for the siting of exploratory boreholes gravity and seismic reflection measurements were carried out. The secondary gravity anomaly map *(Fig. 4)* already shows the complicated structure: several criss-crossing fault systems cutting the basement into small blocks of different depth.

Brown coal and bauxite exploration in the "discovery" and "detailed" phases was carried out in the south-eastern foreland of the Gerecse Mts. The area of exploration is shown in *Fig. 5*. During the regional survey it was found that the high quality coal seam of the Bajna basin is strictly limited horizontally *(Fig. 5/a)* and that the bay of Epöl proved to be unproductive *(Fig. 5/b)*. In the basin of Tarján and Mány—Zsámbék, where the regional survey suggested the presence of large, extended coal seams, geophysical methods of higher resolution power were used viz. reflection seismics, down-hole—surface potential mapping and multifrequency electromagnetic sounding (the last of these is described in Chapter 2.2). In cross section DD′, which is enlarged vertically four times, horizontally twenty times in relation to cross section CC′, one can see the increase in resolution power.

To work out the methodology of detailed bauxite exploration in areas of Eocene limestone cover an experimental programme was carried out in 1979—80.

It is pointed out that

- the proportion of high resolution methods—such as multifrequency e.m., multicoverage shallow seismics and 3D seismics—should be increased to eliminate the confusing effect of rapidly changing overburden;
- to increase the effectiveness of exploration, data of bauxite analysis should be incorporated into the automatized Exploration Information System (see Annual Report, 1979).

With regard to the area of investigation illustrated in *Fig. 6* the detailed geophysical survey was extended to about 5 km^2 (marked in yellow). Besides this, geophysical mapping on scales of 1:25,000 and 1:10,000 was carried out over an area of about 30 km^2 (areas of prospect marked). In *Fig. 7* the course of exploration of the area (marked A in *Fig. 6*) is presented. In *Fig. 7/a* the map of the original geological information can be seen showing the Triassic and Eocene outcrops, and two unproductive boreholes (A and B) reaching the dolomite basement to depths of 16 and 86 m respectively. The σ_a parameter map of down-hole—down-hole potential mapping *(Fig. 7/b)* suggests the existence of four independent cavities in the basement. The boreholes located on them (C, D, E) hit bauxite. The fourth suggested borehole is not yet drilled (F). With the σ_a parameter map and the borehole results the boreholes of the detailed drilling project can be marked out. To the right of the NNE—SSW direction fault line, where the down-hole potential map could not show any detail, exploration should continue by a compact network of e.m. measurements.

In *Fig. 8* the detailed exploration of area B of *Fig. 6* is presented, where at the beginning of the work three bauxite lenses were already known *(Fig. 8/a)*. The task was to determine whether any more bauxite lens exists or whether there is any connection between the known lenses. To answer the questions down-hole—surface potential mapping (using a distant borehole) and multifrequency electromagnetic mapping (MFM) were carried out. The σ_a parameter map *(Fig. 8/b)* and the $\Delta\varphi$ phase difference map *(Fig. 8/c)* indicated the presence of several conducting zones. Results of geophysical exploration are synthesized in the map of *Fig. 8/d*, together with the suggested drillings. Borehole A hit bauxite, boreholes B and C proved the cavity, but without bauxite. *Figure 8/e* shows a characteristic geological section, *Fig. 8/f* the integrated interpretation together with the suggested boreholes.

In-mine exploration represents a new branch of bauxite-geophysics. In 1980 a series of expriments was initiated on mines under exploitation to determine the bauxite boundaries of deep karst cavities. The best results were achieved by geoelectric conductivity mapping (a combination of surface and down-hole—down-hole potential mapping), by three electrode AMN profiling and seismic refraction. *Figure 9/a* shows the interpretation on level +339 m, on which areas of thick bauxite (thicker than 6 m) and covered dolomite cliffs are marked. Mining proved the existence of these cliffs with nearly vertical walls (sometimes even overhanging). The photo *(Fig. 9/b)* shows one side of the bauxite lens with cliffs A and B marked on the map and with a smaller and a bigger bay (C and D) filled with bauxite. In the foreground a dolomite cliff (F) forming the south-western border of the bauxite lens is seen. After the exploitation of the first slice, on level +331 m, the location of the dolomite cliff is given by the geological service of the particular mining company concerned *(Fig. 9/c)*. As a further development the integration of electromagnetic methods and shallow seismic reflection into the measurement complex is advised.

The regional exploration of the Velence hills continued with a dual task: structural- and ore exploration. The location map of the geophysical measurements is shown in *Fig. 10*. As a special topic the relationship between gravity and magnetic anomalies was studied. On the ΔZ_m residual magnetic anomaly map

(Fig. 11), long anomaly zones can be detected which appear on the gravity maps as well. These are supposed as being linked with structural lines. The analytic downward continuation gravity map *(Fig. 12)* shows, in the vicinity of Pázmánd, an about 6 km diameter ring-shaped anomaly with a somewhat asymmetric minimum in the centre. The southern rim consists of a strongly weathered metasomatite range. The anomaly picture suggests a covered, tilted volcano. Several more ring-shaped anomalies can be detected. The analytic downward continuation map after band-pass filtering *(Fig. 13)* correlates with the former map with regard to main features, but the delineation of the south and south-eastern anomalies is more accentuated.

The relationship between gravity and magnetic anomaly maps is not unambiguous, rocks of higher susceptibility can have either higher or lower density than their surroundings causing a local gravity anomaly (maximum or minimum). In the first case it is supposed that the anomalous bodies have lower density, therefore the residual magnetic anomalies were shifted northward to coincide with gravity minima. This possibility is presented in *Fig. 12*. It should be noted that the direction and size of the shifts (marked on the map by straight lines) are mostly uniform in given districts.

If the magnetic bodies are connected to higher density rocks, magnetic and gravity maximima should coincide (naturally after shifting). This possibility is presented in *Fig. 13*. The correlation in this case seems to be better although the size of the shifts is bigger.

On both maps — it is to be noted — the ΔZ_m maxima had to be shifted much more than justified by the induced magnetization and the calculated depths of the anomalous bodies (not more than 1000—1500 m). This means either greater depths, or the effect of strong remanent magnetization.

From among the reflection profiles, shot for the delineation of the volcanic centre, the migrated depth sections Go—10 and Go—13 are presented *(Figs. 14 and 15)*. The frequency, energy and alignment of reflections enable us to draw conclusions on the deep structure and separate units of differing structure even in geologically practically unknown areas.

In the framework of direct ore exploration the detailed induced polarization network started in 1979 was continued. The 1600 m long supply line of the gradient array guaranteed a penetration of 400 m. On the map of apparent polarizability, P_a *(Fig. 16)* two directions dominate: NE—SW, marking the boundary between granite and slate and the E—W strike of the metasomatite outcrops.

In addition to the mapping of anomalies their classification started as well (see Chapter 2.2).

In 1980 the *regional geophysical survey of the Mátra Mts* commenced. The ore occurences, extending over a large area, and the hydrothermal alteration of rocks promote the possibility of the existence of near-surface disseminated sulphide mineralization, to be explored by induced polarization and deeper subvolcanic bodies of similar mineral content. As a first step the area of the uplifted basement—formerly explored by in-mine boreholes of the Gyöngyösoroszi Mine and seismic refraction—was investigated by gravity and reflection seismic measurements *(Fig. 17)*. The three VIBROSEIS® profiles shot in 1980 are presented in *Figs. 18, 19*, and *20* in the form of amplitude coloured depth sections. The results are summarized in *Fig. 17.*

The dome ("A"), observed in profile Ma—1 coincides with the largest IP anomaly, therefore detailed mining geological exploration and exploratory drilling is suggested for that site. Structural exploration suggests that the line of uplifts A—B—C represents the strike of the main uplift, but the volcanic focus is most probably in areas A and D.

Exploration for the near-surface disseminated mineralization was started by a 400×50 m IP profile grid. From the schematic anomaly map *(Fig. 21)* it can be seen that the area of uplift, shown by seismics coincides with a large, northerly non-delineated anomaly. Geochemistry also indicated anomalies in the area.

The *regional study of the tectonics of Transdanubia* continued with seismic reflection and magnetotelluric measurements on the Little Hungarian Plain *(Fig. 22)*. From the point of view of magnetotellurics the most important part is the vicinity of the Dabrony—1 borehole. The results are presented on the migrated time section MK—1/79 *(Fig. 23)*. Under the Triassic—Cretaceous high resistivity formations a layer of about 2 ohmm resistivity was found at a depth of about 5000 m. Its thickness cannot be determined exactly from the sounding curves measured up to a period time of 100 sec; it is possible only to estimate the maximum thickness as 2—3 km. This conducting layer wedges out after point 13.

With seismic measurements the profile was continued towards the NW; the most important task being to investigate the depth interval between the basement and the Mohorovičić discontinuity. Two portions of the profile are presented: in *Fig. 24* reflections between 6.0 and 6.6 sec of good energy dip steeply towards the NW; in *Fig. 25* strong reflections, characteristic to the are of the Mihályi maximum, appear below 3.0 sec terminating at the Rába dislocation zone.

The reflection profile MV—1 of 1979 was recorded along the broken line of the location map of *Fig. 26*. The 97^{00}—178^{00} portion of the profile was reprocessed by the "slalom line" program of the GEOMAX computer of Geofyzika Brno (Czechoslovakia). On comparing the resulting time section *(Fig. 27)* with the original one (*Fig. 22* of the 1979 Annual Report) the improvement—first of all in the sedimentary complex—is quite clear.

From *water exploration and engineering projects* two topics are presented: the use of the IP method in the exploration of the alluvial cone of the River

Maros, and the check survey of flood protection dams by geophysical methods.

The theoretical basis for using the IP method in water exploration results from laboratory measurements *(Fig. 28)*. By the simultaneous determination of the two geoelectric parameters (apparent resistivity, ϱ_l and apparent polarizability, η_l) data on the reservoir characteristics of the water bearing lenticular young sediments can be deduced. Results of the areal measurements are presented in *Fig. 29* (apparent polarizability distribution) and in *Fig. 30* (apparent resistivity map). Interpretation of the different resistivity and polarizability anomalies was performed with the aid of borehole measurements. In both geological base drillings and in parameter drillings IP measurements were carried out by two methods which correlate perfectly well *(Fig. 31)*. Synthesized results are presented in *Fig. 32*. Thus the maps for different depth intervals can be interpreted: on areas of high resistivity and low polarizability more and clearer sand layers can be found than of equal resistivity, but higher polarizability. On areas of good polarizability thin layers of very fine grained sand and shale can be found.

The need for geophysics in the check survey of flood protection dams was brought up on the occasion of reconstruction works after the Kettős-Körös dam failure. So far as we know, there is no literature on geophysical methodology in dam protection. By experience the following working process is suggested:

a) analysis of air photos. Without much expense disturbed zones and areas of different character can be separated, and abandoned courses marked out; this notwithstanding, it can be stated that it is not necessary that dangerous dam portions coincide with abandoned courses on the one hand, and on the other not all abandoned courses can be traced in the present morphology;

b) horizontal resistivity profiling. This is the basis for further detailed, pointlike exploration (engineering geophysical sounding, soil mechanical drilling);

c) engineering geophysical sounding for the recording of four parameters: mechanical resistivity (consisting of peak force and lumped pressure), statistical mean value of natural gamma activity and in situ density. If necessary, more parameters can be recorded. Apart from determining the detailed geological log, it is very important to identify the impervious layer and the porous beds communicating with the river;

d) soil mechanical drillings and laboratory tests. The last stage of the exploration process, only on the critical sections of the dam;

e) additional examinations, according to the demands of the design engineers (e.g. filtration coefficient).

In *Fig. 33* the profile, located 4—5 m from the dam on the protected side, is to be seen with two different penetration resistivity profiles, the engineering geophysical soundings and the resulting geological cross section. No. 3 engineering geophysical sounding was located on the high resistivity zone appearing on both resistivity profiles and found an abandoned course, which could not be traced in the present morphology.

Within the theme *investigation of the structure of the Mecsek Mountains*, the delineation of the Lias coal bearing complex was continued in 1980 *(Fig. 34)*. Tasks of the geomagnetic ΔT profiles and of the reflection seismic measurements were the preparation and support of the geological survey for prospects. Surface distribution of volcanics and the computed magnetic bodies are in good agreement *(Fig. 35)*, thus enabling the use of geomagnetic results in geological mapping. Results of reflection seismic measurements are illustrated in *Figs. 36* and *37*. On the time sections the underlying formations of the Jurassic (Triassic or older) appear as marker reflections (marked in red). Even from within the Jurassic reflections have quite good energy (blue marking).