POSSIBILITIES OF GEOPHYSICAL METHODS IN PROTECTING MINES AGAINST WATER INRUSH

T.Majkuth, L.Szabadváry

Hungarian geophysical Institute "Loránd Eötvös"
Budapest, 1145 Columbus u. 17-23.

N.Szabó

Central Geological Office
Budapest, 1011 Iskola u. 13.

S.Végh

University of Sciences "Loránd Eötvös"
Budapest, 1088 Muzeum krt. 4/a.

SUMMARY

The authors discuss the results of a geological and geophysical survey conducted in the SE foreland of the Gerecse mountain /central part of Hungary/ within the framework of the Eocene brown coal exploration project. These results led to a better and many-sided knowledge of a new coal field.

Up-to-date surface geophysical methods used in the survey permitted a preliminary evaluation from the viewpoint of protection against water inrushes. The authors present the results of an investigation by integrated geophysical methods of the main fracture system which divides the coal field into blocks and contours it. They analyse the application of high resolution geophysical methods /electromagnetic frequency sounding, seismic reflection measurements/ for determining medium- and small-scale tectonic features controlling the coal field. An evaluation of the formations overlying and underlying the coal bed of basal character from the viewpoint of protection against water inrush is offered on the basis of a complex analysis of geophysical parameters.

INTRODUCTION

Complex geophysical exploration in the SE foreland of the Gerecse mountain has been carried out on commission of the Central Geological Office /KFH/ by the Hungarian Geophysical Institute /ELGI/ in several stages.

Preliminary geophysical prospecting with a scale of 1:100 000 was conducted coordinately for individual prospects from 1970 to 1977, this was followed by geological mapping with a scale of 1:25 000 /by the Hungarian Geological Institute and the Dorog Coal Mines Projecting Bureau/ and concluded by geophysical reconnaissance with a scale of 1:25 000.

The integrated geological and geophysical survey determined the main tectonic units within the area indicating their spatial position and structural forms.

The Tertiary basin bottom is built up of a series of asymmetric tectonic grabens and elevated blocks with a strike in NNW-SSE direction and tilted to E, which are limited on the south by a fault running in E-W direction.

At this S end of the first three tectonic grabens /proceeding from W/ there are already known coal fields. This suggested the idea concerning the geology of brown coal deposits that the fourth significant coal field should be searched for at the S end of the fourth /eastern/ tectonic graben, upon understanding that a structure in support of said idea could be revealed by geophysical methods between existing unproductive boreholes. Such a structure was successfully determined in the result of works conducted in 1974-75.

The boreholes marked by 5 and 9 were sunk on the basis of these works in 1977 penetrating coal beds 35 m thick on the average /Fig. 1 and 2/. This gave the impetus to the reconnaissance survey in this prospect.

The Central Geological Office provided for directing exploration, coordinating drilling, geological and geophysical activity. The Mány comission rendered most significant help in solving current problems.

In these stages of exploration the former practice of relying on the complex interpretation of the total geological and geophysical background when locating new drilling sites or geophysical prospects was continued. In doing so our up-to-date geophysical methods contributed to answering the following questions about hydrogeological conditions:

- spatial position of the main fracture systems /with throws over 50 m/ cutting the coal field into individual blocks and limiting it;
- position of faults with medium throws /20-30 m/ within the coal field;

- internal structure of the karstified Triassic basin bottom in the underlying formation, e.g. to determine the marly complex which is more favourable in hydrogeological respect;

- thickness and distribution of porous, water-bearing Miocene limestone and sand complex in the overlying formation.

Geophysical results concerning these questions related to the protection of mines against the inrush of water will be discussed in two sections.

FAULTS DIVIDING THE COAL FIELD INTO BLOCKS

The exploration area of 24 km^2 where the industrial value of coal deposits had to be cleared up lies to W of Budapest. At the beginning of the survey the data of several old barren holes and of one drilling by the Geological Institute were available calling attention to the area as an eventual prospect of brown coal exploration.

As a first result of geophysical prospecting the map of residual gravity anomalies is presented of the area /Fig. 1/.

On the secondary gravity map corresponding best to the given geological model one can readily recognize the fault system running in NNW-SSE direction and the asymmetric tectonic graben in its foreground where several barren holes had been drilled already. There appeared, however, a minimum zone in E-W direction, too, which falls in the continuation to E of the known coal fields, where so far no hole has been sunk at all.

Using high resolution geophysical methods the survey was conducted along the axis of the abovementioned minimum zone, and on a network of profiles running parallel and perpendicular to it. In the result of geophysical survey with resolution meeting the demands of the individual survey stages and of drilling and geological investigations a contour map of the Tertiary basin bottom in reduction to sea level has been compiled /Fig: 2/.

In Fig. 3 presented is the profile "A" running along the axis of the minimum zone. On the top section it can be readily seen that the curve of optimum residual anomalies gives a picture more in detail as compared to the Bouguer anomalies and indicated every fault with throws over 100 m. In the middle section presented is the high velocity refraction boundary. The low value of boundary velocity of the refraction horizon /V_h=4000 m/s/ indicated the occurrence of marly formations. The results of several vertical electric soundings are also plotted on this section. While the survey and processing were underway, only two boreholes on the W margin /Fig. 2, marked by 1.2/ existed. Of them the borehole No.1 was productive, it was sunk at the edge of the known coal field; while borehole Nr.2 is an unproductive hole drilled outside of the known coal field. In the geological section of this figure the contemporary geological interpretation is represented. According to this, the profile crosses two tectonic grabens dipping slightly to E, which are limited on E by a fault with a throw of 300-400 m.

In the middle part of these two tectonic units showing a quiet bedding the boreholes 5 and 9, then on the upthrown wings the boreholes 7 and 10 were drilled. All four holes penetrated industrial coal seams of good quality in similar facies suggesting the occurrence of an uniforn coal field. The underlying formation of Triassic age in these holes was Karnic marl which is favourable for protection against inrush of water.

Detailed geophysical prospecting in the proper sense started at this stage. The eastern main fault was precisely located by electromagnetic profiling using an optimally selected frequency /Fig. 4; Fig.2, Prospect "B"/. The shape of the anomaly called attention to that the fault is built up of two steps with a terrace 100 m wide between them. Between the two boreholes /holes Nr.5 and 7/ it was possible to clear up in the form of a map the spatial position and shape changes of the fault. A detailed investigation of the foreground of the fault was conducted by the aid of seismic reflexion measurements /Fig.5/.

ELGI has been carrying out seismic reflexion survey in the region of the Transdanubian Middle Range - including the Gerecse mountain - from the beginning of the 70-es with the primary purpose of prospecting for coal and bauxite. In addition to traditional shooting techniques in areas with unfavourable nearsurface geological conditions and in the proximity of inhabited localities vibroseis measurements were conducted almost simultaneously to the introduction of the Vibroseis[R] method in Hungary.

The technical conditions have continuously progressed in the course of years. High power drilling rigs, modern cable and geophone systems were used in the work. Analog recording apparatus was replaced by digital instrumentation.

Processing has been made on big computer.

Modernization of condition contributed to making horizontal and vertical resolution of reflexion profiles correspond to the scale of 1:10 000. In addition to better technical condition substantial methodological experience was also obtained in the area. Decisive for projecting and execution of measurements was the depth range of investigation being between 150 and 600 m in the said prospect. The adaptation of the reflection method used earlier almost exclusively in prospecting for deep oil-bearing structures to shallow investigation caused the main problem. It should not be forgotten, too, that in the Gerecse mountain like

---
[R] registered Trade Mark of CONOCO

other areas of the Transdanubian Middle Range frequent variations in topographical conditions and in the thickness of the covering complex, the nearsurface geological conditions affect unfavourably the result of seismic reflection survey.

Along the trace of the profile /Fig.2, Trace "C"/, in the foreground of the main fault, CDP measurement with 6-fold coverage using vibroseis apparatus was conducted. The time section and its geological interpretation are presented on the next figure. In the time interval 0,4-0,7 s very good reflections were obtained from the surface of the Triassic basin bottom, and particularly from within the coal-bearing complex. On the right side of the section the shape of reflections indicates a slightly dipping quiet bedding. The left side of the section shows more fractured structural forms. This section permits to distinguish the older and younger structures, especially on the geological version.

On the middle evenly bedded part of smaller tectonic units detected by the reflection survey more drillings were located /boreholes Nr. 3, 4, 6/. Each of them was located over a characteristic structural element. All drillings penetrated industrial coal seams, but the thickness of these seams varied by 400% and called attention to conditions permitting or restricting the use of the longwall method in subsequent mine planning.

To investigate the upthrown wing of the main fault electromagnetic frequency sounding was used. Due to nearsurface high resistivity formations of considerable thickness the area is unfavourable for D.C. methods. In the result of the proximity of borehole Nr.8, while the lower boundary of the porous water-containing Miocene limestone complex appeared as a most conspicuous horizon /Fig.6; Fig.2; section "D"/.

FAULTS LIMITING THE COAL FIELD

The determination of the main fault assumed to limit the coal field on the south with its strike running from E to W is shown on another example of electromagnetic frequency sounding /Fig.7; Fig.2, section "E"/. Borehole No.11 located on the basis of this section at 100 m from the main fault on the downthrown wing confirmed preliminary depth data of the measurements with a deviation of 3%. The boundaries Miocene-Ologicene, Oligocene-Eocene and Eocene Triassic can be reliably correlated. The existence of the fault is also indicated by a change in bottom conductibility.

Basic information to determine a fault forming the southern limit of a second coal field lying to N of the said field at a depth of 200 m at most was furnished by DC geoelectric methods.

Vertical electric sounding /VES/ and superficial potential mapping with underground /downhole/ electrode /UPM/ were carried out in the area. The map of the σaE parameter measured from an external well marked 17 /Fig. 8/a/ outlined already structural conditions of the prospect. Boreholes No.13 and 12 were located on the basis of this map and VES data. It was assumed, that the basin bottom occupies an upthrown position at the hole 12 and a downthrown position at the hole 13 with the occurrence of a coal seam at the latter. This assumption was reaffirmed by drilling. In Fig. 8/b a contour map of the Tertiary basin bottom with the indication of faults is presented which was plotted from the parameter map.

The depth calculation method of UPM measurements was elaborated in 1980. The method gives depths with an accuracy of 5-10% for units of the basin's bottom with boundaries not being vertical or near vertical, with depths not deviating from the average in access of $\pm$30-40% and horizontal dimensions coinciding with or exceeding the average depth. The depth calculation procedure consists essentially in correcting the ρaE map for cover resistivity and then transforming these corrected value into depth values. The resistivity of the covering complex for the measuring points is taken from a resistivity map plotted of VES data or well logs.

Finally, the determination of the S main fault of the first coal field by geophysical survey is shown on a migrated depth section version of a seismic reflection section made by shooting techniques. The migrated version was plotted according to reflection energies /decreasing in succession of colors red-yellow-blue/ /Fig.9; Fig.2, section "G"/. After the profile was measured, preliminary assumption made on hand of seismic results were reaffirmed by drilling holes on the upper /Hole 16/ and lower /Hole 15/ wings of the fault. On the upthrown wing eroded were by a subsequent denudation not only the coal beds, but the Eocene complex on the whole.

The presented results confirm the efficiency in shallow basin areas of geophysical methods used earlier for greater depths. They permit to determine horizontal and vertical characteristics of structural elements with a high accuracy /throws of 20-30 or exceptionally of 10-20 meters can be detected/.

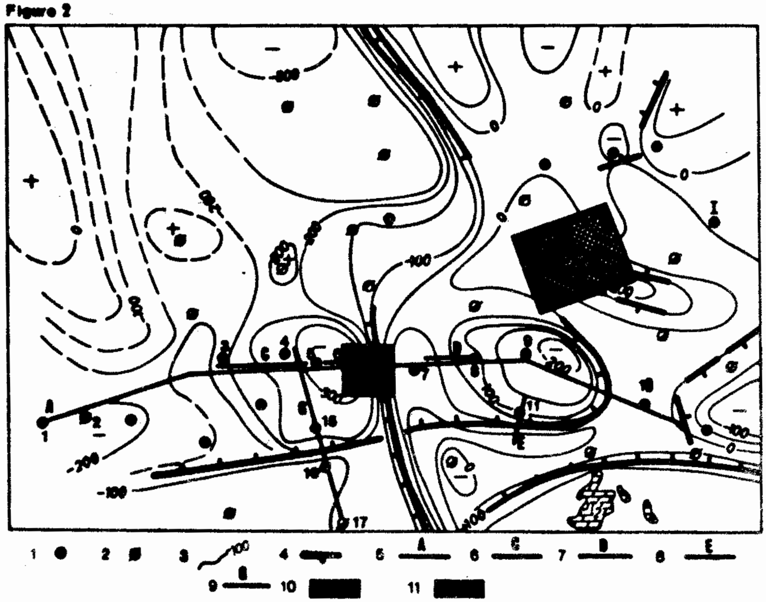
The method permits to distinguish typical Miocene-Eocene water-bearing formations and on the basis of physical parameters the karstic dolomite complex in the basin's bottom as well as the impermeable marl series embedded and intersecting it. Conclusions can be drawn also on the structural character of the deep underlying formations.

LIST OF FIGURES

0 1km

Figure 1

Figure 2



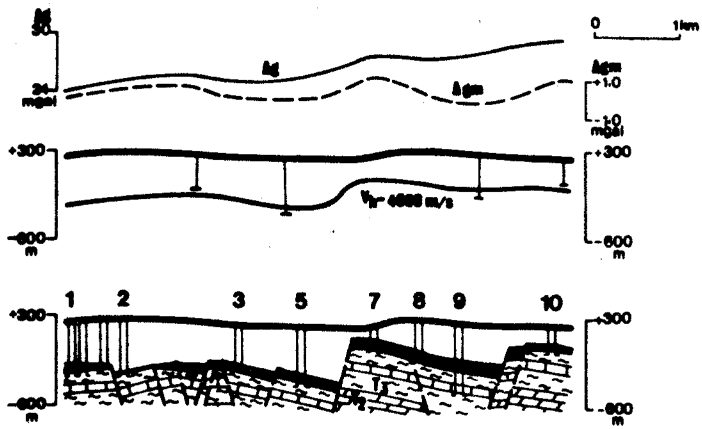


Figure 3

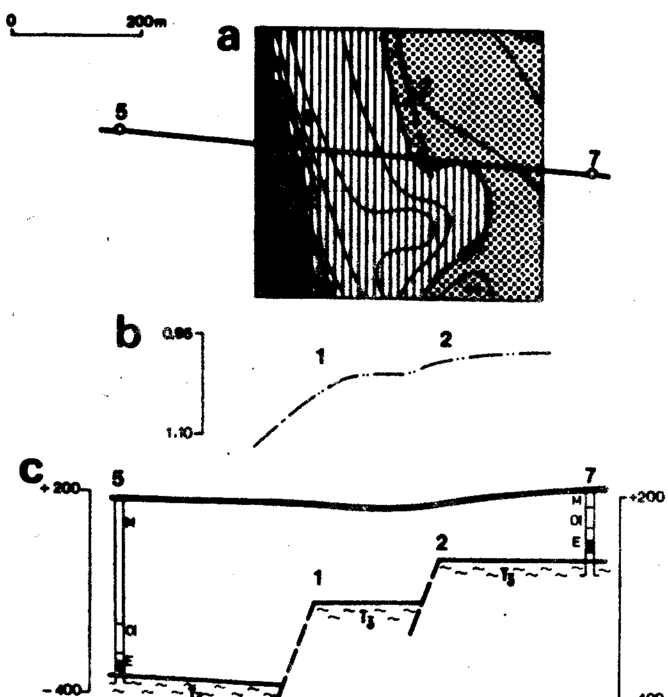


Figure 4

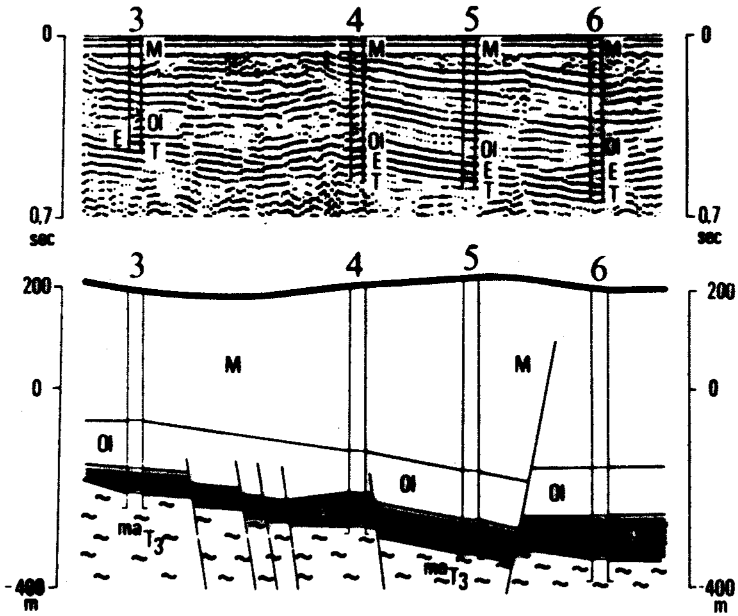


Figure 5

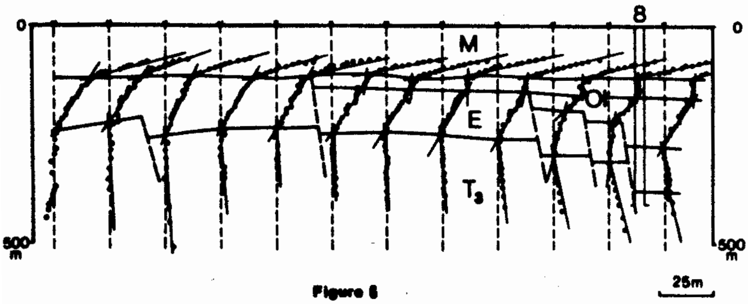


Figure 6

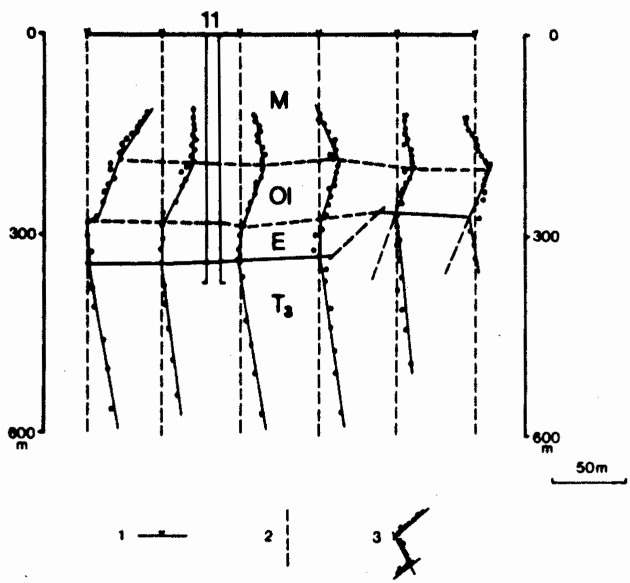


Figure 7

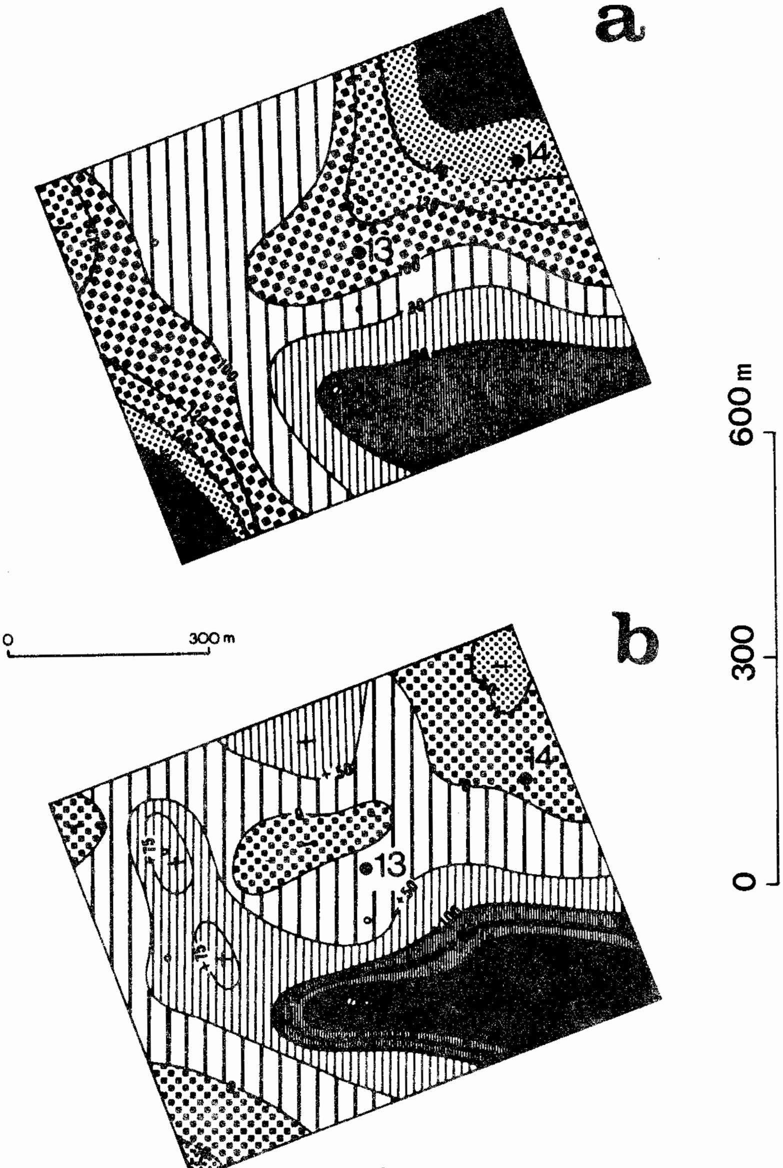
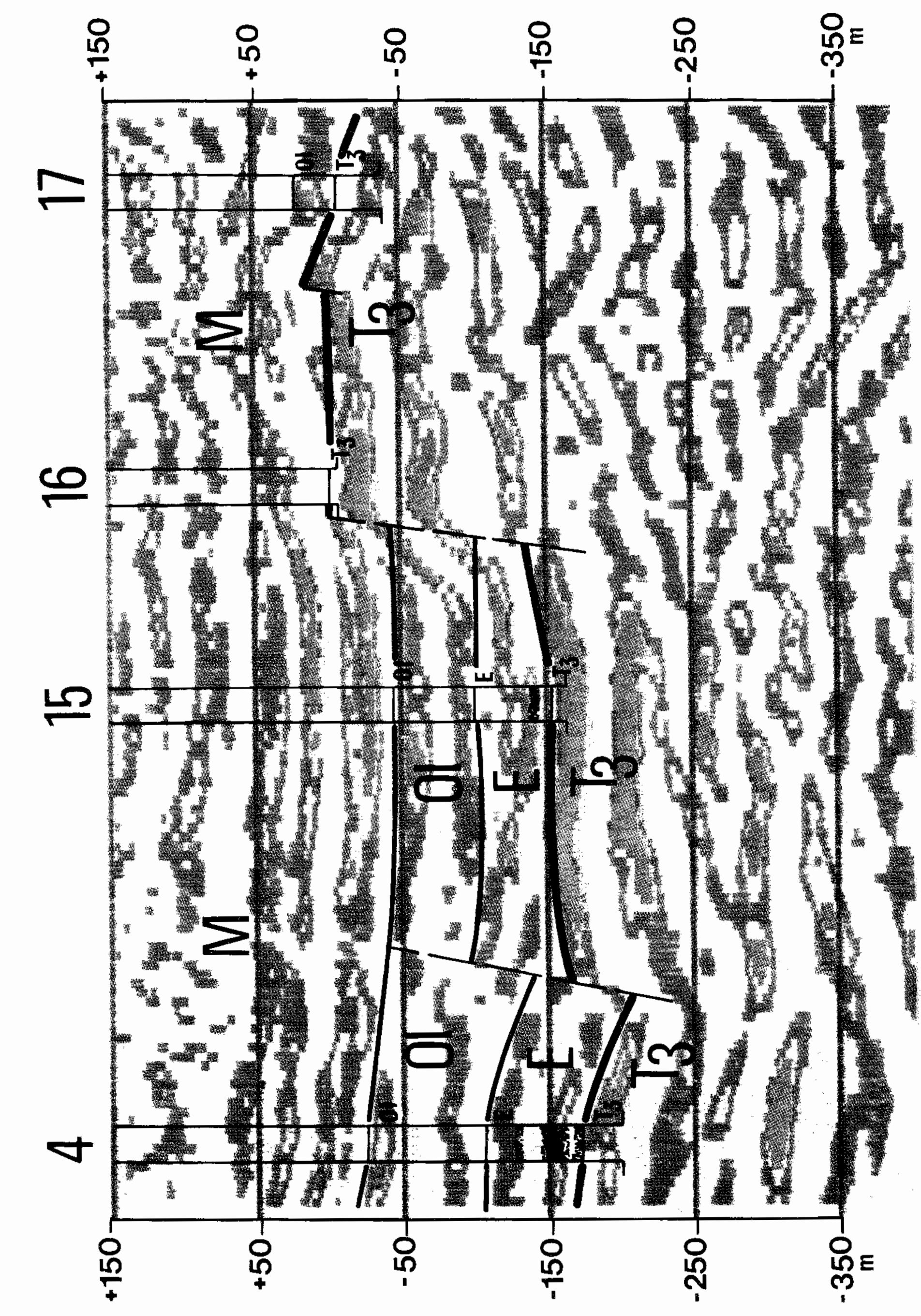


Figure 2


+150
+50
-50
-150
-250
-350 m
4
15
16
17
M
Ol
E
T3