2 INSTRUMENTAL AND METHODOLOGICAL RESEARCH

2.1 SEISMIC INSTRUMENTAL AND METHODOLOGICAL RESEARCH

In 1973 our main efforts in *seismic instrumental research* have centered around the further development of the *digital field equipment* type *SD–10*. The 1971–72 prototype, made in international cooperation, was supplied with a 9-track field-tape unit since this is the format most readily accepted by computer centres. Equally realizing an existing need for 21-track recording we have developed since then, simultanously with the 0 series of the basic type (Figs. 29 and 30), the prototype of the 21-track version.

The new magnetic tape, controller and formatter was developed by VEB GEOPHYSIK, Leipzig, while ELGI re-designed the home-made units.

The prototype has been finished in 1973 and underwent a field test in a comparative measurement with National Oil and Gas Trust's DFS-III.

New developments towards a more up-to-date gain system, A/D converter and field play-back units are also under way. It was also found convenient to build the system encoding shot command and time-break together with shot-circuitry.

As a new line of instrumental development we began to work out an *off-shore complex* based on SD-10. The instrument has been tested for waterproofness and the necessary technological changes have been determined.

In view of *computer technology* the connection of a SPERAC MD-17 disc to our MINSK-32 deserves attention (Fig. 31). For this task we redesigned the selector channel of the CPU as to control the 156 Kbyte/sec information rate. The new interface can handle 4 discs and belongs to the third generation.

The disc package consists of 6 discs, 200 tracks on each side of a disc and tracks consisting of 20 sectors. The basic unit of information consists of 3601 symbols in track-mode, 126 symbols in sector-mode, the maximum information, transfered in a single step, being 10 tracks (a MINSK-32 symbol consists of 7 bits).

The first command from the CPU transmits the mode of transfer and the localization of tracks or sectors to be used to the control unit. The control unit stores these data in its address- and mode-registers, commands the disc to the given location and indicates when it is ready. After a second call from the CPU specifying the type of transfer (read, write or write with control) the control unit checks the track- resp. sector headers and starts the information transfer.

Using the *universal periphery interface* (UPI) developed in 1972 two small computers have been interfaced as satellites to the MINSK-32. The aim of both systems was to establish front-end resp. intelligent-terminal systems for teleprocessing purposes.

The system MINSK-32–TPA (manufacturer: Central Research of Physics) was displayed at the 1973 Unified Computer System Exhibition in Moscow. The experimental setup with VIDEOTON's 1010 B has also found favourable reception at national demonstrations.

Our seismic data processing package has been completed by the following programs: fast horizontal migration, vertical migration, nonlinear horizontal migration, linearly resp. parabolically interpolated NMO, resampling, computation of auto- and retrocorrelation sections, optimally weighted stack, automated estimation of residual statics, fan filtering, digital notch-filtering, digital filtering via FFT.

Our advanced program for NMO corrections serves for a high-fidelity execution of the transformation

$$S\left(\sqrt{t_o^2 + \frac{x^2}{v^2(t_o)}}\right) \to S^*(t_o).$$

Since in most cases the time instant $\sqrt{t_o^2 + \frac{x^2}{v^2(t_o)}}$ *is no sampling place the functional value to be transferred is determined from the neighbouring values by means of linear or parabolical interpolation.*

In the routine exploration for deep structures we have not experienced the superiority of interpolated NMO over the usual one, so far. In shallow seismics, however, where we have to deal with higher frequencies and lower velocities, interpolation is anticipated to have a definite role in suppressing the distorting effect of NMO.

The basic ideas of auto- and retrocorrelation *are, of course, well known (cf. ANSTEY, N.A. – NEWMAN, P., 1966: The sectional auto-correlogram and the sectional retro-correlogram. Geophysical Prospecting, Vol. 14, N°. 4). The autocorrelation section reveals the periodicities due to multiples inherent in the section while the retrocorrelation points to the multiples themselves. The procedure has been successfully applied to the section* Nagyegyháza – 5/73 *where we were intrigued by the strong multiple activity (Fig. 32). Inspecting the autocorrelation section we cannot but gain the vague idea about the multiples' coming into being somewhere between 360–500 ms. Using the retrocorrelation section the source of multiples is precisely localized and identified as the basin-floor situated at 450–500 ms, appearing with a large velocity contrast.*

The optimal weighted stack *performs summation of CDP traces in a time-variant fashion. The weight applied to a given trace in some time-gate expresses the similarity of that trace to the unweighted stack trace. A convenient feature of the procedure is that it eliminates the energy differences between CDP traces.*

The program for automated estimation of residual statics *can be applied to CDP traces after NMO and primary static corrections. The time shifts between CDP traces are determined from the cross-correlation functions in a predetermined time-gate and residual statics are computed from these shifts by an iterative approach (cf. HILEMAN, J. A. – EMBREE, P. – PFLUEGER, J. C., 1968: Automated Static Corrections. Geophysical Prospecting, Vol. 16. N°. 3). To improve the performance of the method in case of strong noise an advanced version has been developed where the reference trace can be chosen arbitrarily. In our new program the reference trace i.e. the one which cross-correlations are referred to can be, at will, the stacked trace, the minimum offset trace or a sine wave of a given frequency.*

Figure 33a shows the histogram of the distribution of residual statics during subsequent iteration steps. The distribution is approximately Gaussian, the second iteration does not bring considerable improvement about as compared to the first one.

As shown by Fig. 33b with minimum-offset reference traces the scatter of the original data is somewhat less. Interestingly enough, after the first iteration step the distribution of residual statics is much the same as in the first case.

Our *migration* program has been further developed as to be applicable for any number of traces according to the wave-chart. Fig. 34 presents some results of a model experiment about the effect of the number of traces and the inaccuracy of the velocity function on the diffraction eliminating capability of migration stack.

2.2 GEOELECTRIC INSTRUMENTAL AND METHODOLOGICAL RESEARCH

In 1973 the serial production of the *low frequency AC shallow sounding equipment* (see: *Annual Report* 1972) has begun. For sounding medium depths an up-to-date *DC equipment* has been under construction.

The construction of the *IP equipment* operating in *frequency domain*, established in previous years (see: *Annual Report* 1972), has been finished and the equipment underwent field tests to set the parameters of the prototype.

Field tests and simultaneous laboratory tests have shown that certain theoretical considerations do not hold under field conditions. In its present build-up the equipment does not seem adequate for ordinary work.

In geoelectric methodological research the computer processing of the most common methods, i.e. MT, TE and VES, has been solved since years. In the last year, however, the novel geological tasks brought into the foreground some new geoelectric techniques. For the explorations of bauxite at shallow depths we have developed the Underground Potential Mapping (UPM) method, while for the deèper structures beneath an interbedded high-resistivity layer the Electromagnetic Transient Method has been used.

Underground Potential Mapping is an advanced version of the potential mapping technique, combined with drill-hole measurement. PM measurements performed on the surface cannot cope with intricate bauxite models. Because of the screening effect of the high-resistivity Eocene carbonates, only a small fraction of the current penetrates to the Triassic basin floor. Since the depth of the latter is 100–200 m and the depressions on its surface are some 10 m deep and of 100–300 m lateral extension, they do not cause but very slight anomalies, if any, on the resistivity map. In the UPM method this effect is less disturbing for one of the electrodes is lowered into the drill-hole below the screening layer (Fig. 35). For interpretation purposes tha geological model (Fig. 35a) is approximated by a theoretical one (Fig. 35b), i.e. the basin floor is substituted by an ideal plane surface. Measuring *the field-strength above the real model* $E(_M$ *section) and eliminating the effect of the theoretical one* (E_0 *section) the resulting section* (σ_0) *will be due to the fine structure of the basin floor.*

The computer program for theoretical field-strength distributions has, as input values, the inter-electrode spacings and the parameters measured in the drill-hole; from these data it computes the field-strength E_0 *of model 35b i.e. normal field. For the characterization of the above-mentioned anomalies the quotient* $E_0/E_M = C$ *is used. Dividing by the resistivity,* ϱ_0,*of the theoretical model we obtain the apparent conductivity*

$$\frac{C}{\varrho_a} = \sigma$$

which gives a more contrasty picture than that obtained by surface measurements.

Since in the UPM method the x and y components of the potential gradient can be zero, for sake of an increased computational accuracy we use the absolute value of the field-strength. The method is similar (as for electrode configuration) to the method of charged body, but instead of the size of an explored body it shows the variations of conductivity near the surface of the basin floor. Our first theoretical and field results in connection with this method are reported in Section 1.1 of this Report.

The first ideas of ETM (electromagnetic transient method) has been advocated by Soviet authors, but the method is still in stage of development from the methodological and also instrumental point of view. Theoretically from among all geoelectric methods the ETM has the greatest resolving power and it also seems capable to penetrate through a high resistivity thick (screening) interbedding. These convenient features have proved in course of the measurements in the Nyir-region.

The basic configuration of ETM measurement is illustrated in Fig. 36a. A square wave energizes dipole AB and either the time-course of the electric field is measured on electrode MN or the time-derivative of the magnetic field is measured in coil C. Since we get a better signal to noise ratio when measuring the derivative of the z component of the magnetic field rather than the electric field itself, in ordinary work we always use the configuration dipol AB – coil C.

No matter which is recorded, the electric field or the magnetic field's derivative, their time course depends on the conductivities (S) resp. on the thickness (h) and specific resistivities (ϱ) *of the layers. The result of the measurement is a time-summarized conductivity curve which can be processed as follows. The decay curve of the field strength is recorded and subsequently digitized by a converter type KAD-69. To eliminate random* *errors averages of 4–5 records are generally taken. For the configuration dipole AB – coil C we have, according to SIDOROV:*

$$\frac{d\varepsilon}{dt} \Big/ \varepsilon^2(t) = \varphi(m) = \frac{K}{\mu . R} (1 + 4\,m^2)^{3/2} \left(\frac{1}{m^2} - 16\right),$$

where ε *is the voltage induced in the coil,* K *a geomatrical factor.* $\mu = 4\,\pi 10^{-7}$. *From SIDOROV's equation*

$$m = \frac{h}{R} + \frac{t}{\mu . S . R.}$$

and we can compute the auxiliary function.

$$F(m) = \frac{m}{(1+4\,m^2)^{5/2}}$$

related to the summarized longitudinal conductivity by

$$S(t) = \frac{F(m)}{K(\varepsilon)}$$

The formulae given above for S(t) and φ *(m) hold under the assumption* $\frac{AB}{R} \ll 1$ and $\sin \Theta = 1$.

Outputs of our computer program are tabulated values of the function S(t).

2.3 WELL-LOGGING INSTRUMENTAL AND METHODOLOGICAL RESEARCH

This activity in 1973 was guided by the following considerations: technical improvement of all equipments, enquickening the industrial application, broadening digital recording and processing.

Shallow equipment *K-500* has been *completed* with an IP tool, inclinometer and gamma spectrum analyzer, as required.

Medium depth equipment *K-3000* has almost been completed. Resistivity logging units have undergone field tests. Mounting of nuclear units was just finished towards the end of the year. Program-connectors, ensuring complex operation, have been constructed, and the first matching measurements with the digital recorder were carried out. Photorecorder of stepping motor drive, and the automatic winch-system have remained subjects to modification.

The choice of nuclear downhole tools has been widened, as required by industry. A 43 mm diameter probe for CH production purposes, and another probe, detecting soft (10 KeV) gamma-radiation have been added to the stock, the latter allowing downhole observation of X-ray fluorescence effect.

In compliance with our endeavours for standardization, equipment K-3000 has also been furnished with the universal nuclear surface unit which is equally suitable to run probes of detector (up to 3 channels) and spectral mode.

Methodologically, the determination of lead-concentration has been strived at (Figs. 37, 38), further, apart from several theoretical investigations, the ash-content of Pleistocene turf-deposits was determined with probe KRG-180-43 spl of plastic housing (Fig. 39, 40).

Through improving the collimation system of probe KRGG-1-80-43, its density detecting capability increased and the tool has got industrial application.

With a change in the source – detector distance in high temperature nuclear probe KRGG-1-86-200, its sensitivity has been increased to $165 \frac{cpm}{0{,}05\ g/cm^3}$.

Model experiments have been carried out to determine the m o d u l u s *of bauxites, without success, however, so far.*

Two varieties of *digital recorders* (belonging to K-3000) have been set into operation. One of them is suitable, through multi-channel amplitude-time analysis, to receive acoustic wave patterns and nuclear energy spectra. Field test started.

The sub-routine package of the i n t e r p r e t a t i o n s y s t e m *has been completed with a program to correct natural gamma-gamma measurements (diameter, mud-density, excentricity, cement-thickness, casing thickness).*