2 METHODOLOGICAL AND INSTRUMENTAL RESEARCH

2.1 SEISMIC METHODOLOGICAL AND INSTRUMENTAL RESEARCH

In the *geophysical survey of the Nyír region* (NE Hungary) the year 1971 saw a more intimate relation of the seismic and geoelectric methods again, backed by both scientific and financial considerations. Hence, the geoelectric survey of the region will be described in this chapter, preferring research affinity to the homogeneity of chapters. The geoelectric survey – besides its methodological character – is, in a sense, a forerunner of the seismic method, therefore let us start with the geoelectric results .The plans of both measurements are demonstrated in Fig. 25.

With regards to past experiences and the intricate geology of the site the g e o e l e c t r i c s u r v e y encounters a double task. The one is the determination of the thickness and geoelectric parameters of the Neogene. The Neogene thickness is geologically important enough in itself, but its hydrocarbon prospects being of minor significance here, the other task steps into the foreground, namely the prospecting of Oligocene or older, presumably conducting, sediments overlain and screened by Miocene volcanites. A success in solving either of the tasks renders a better located seismic network. A qualitative solution of the second task means the conductivity (ΔS) determination and mapping of the lower conductor.

The best result of the geoelectric survey is the geological differentation of areas of different types. Three area types have been encountered.

1. In the first one the methods of different penetration (DE, MT, BEMF-DZ, BEMF-NZ)* indicate the upper bad conductor only. Its depth is about 1500–2000 m (Fig. 26). Horizon ϱ_∞ might be supposed as a volcanite top, due to the Δ Z anomaly of the site. According to the refraction measurements of the OIL AND GAS TRUST the deep refractor (the basin floor) is 2500 m deeper than the ϱ_∞ horizon.

2. The second area type is characterized by a build of four geoelectric layers. The topmost one of 1500–3000 m thickness contains everything down

* DE dipol equatorial sounding
MT magnetotelluric sounding
BEMF–DZ build up of the electromagnetic field (distant zone)
BEMF–NZ build up of the electromagnetic field (near zone)

to the volcanic layers (Figs. 26–27). Its specific resistivity varies between 4 and 8 ohmm, and it is electrically well defined also in other respects. The next is the "screening" layer (high resistivity). Its thickness, in the nearness of the frontier, can be estimated as 500–1000 m. The third layer is the lower conductor. Its tracing is one of the best results for its hydrocarbon prospects. Its size is characterized by ΔS anomalies (Fig. 26). According to BEMF-NZ its thickness may attain 1500 m. *Ad analogiam* of the Roumanian results it may be Oligocene (of Flysch character) or any older complex of low resistivity. The fourth layer is the ϱ_∞ horizon of "infinite thickness" probably identical with the refractor basin floor of high velocity. This horizon is indicated by a few BEMF-NZ data.

3. The area to the south from the township Mátészalka represents the third area type of two layered model. Horizon ϱ_∞ is deeper than 3000 m (Figs. 26–27). Magnetic anomalies do not occur. A refractor lies 1000–1500 m deeper than the ϱ_∞ horizon. The subsided ϱ_∞ horizon may suggest a thickening of the Neogene. The data, however, are sporadic to venture a definite interpretation.

This same theme contains the pure methodological research which is spent in favour of these field measurements: the field and interpretation procedures of BEMF, computer processing of data and some instrumental problems.

*

During the past three years of the seismic survey of the Nyír region the instrumentation and methodology have covered the same way as the world's seismic development has in the past decade. The work started (in fact) in 1969 with analog equipments, analog centres and single coverages, although the multiple stacking started in the same year. Analog processing was later replaced by digital processing in the "minicentre" (SDC-1), which first worked with analog tape records (converted), then with field digital records obtained in CDP systems. By 1971 the digital recording has been exclusive and the records are fed into the high speed Computer Centre MINSK-32 provided with a special seismic program package.

The development can be sized up also through the reliability of geological information supplied. In the beginning we were faced with wave generation (the region is a typical "badlands" area), penetration and serious signal to noise ratio problems. The present digital methodology helps in eliminating these basic problems, increases efficiency and economy.

The slicing up of thick volcanic slabs, nevertheless, still causes serious difficulties, mainly because of diffractions. The solution is expected from a migration program package. As a matter of fact, such areas are of minor significance in view of hydrocarbons.

Areas without magnetic anomalies (unscreened by thick volcanites) are more important, especially if thick Neogene or older sediments are at hand. Two such favourable spots have been revealed by the measurements carried out so far: in the southern part of the present network (along the frontier), and in the vicinity of Mátészalka.

The southern area is also characterized by a large ΔS anomaly. The area is demonstrated by Figs. 28 and 29. The advantages of the digital way are obvious.

A deep horizon's isochrones are shown in Fig. 30. It is supposed to be a Miocene horizon, but this still needs verification.

At the crossing of profiles N-7/69 and No-18/71 a small closed structure, surrounded by the 1400 msec isochrone (a depth of about 1800 m), is revealed. Profile No-18/71 is shown in Fig. 31 ("minicentre" processed).

The other area can be characterized by profile No-19/71 (Fig. 32). A deep drilling is located in the nearness (based on this profile and on the refraction profile BoR-3b of the OIL AND GAS TRUST) with the aspect to hit the basin floor. When closing the manuscript the drilling is in a depth of about 2500 m having penetrated after some Pliocene sediments 1000 m of volcanites (!) without bottoming out.

The stacking profile in question shows correlating horizons and in accordance with the refraction profile mentioned it suggests a basin floor depth of 5000 m.

From the purely methodological investigations the ground roll analysis deserves mentioning (Figs. 33–36). The results help in designing grouping, offset and other parameters for field work.

The details are accessible in the *Archives* of ELGI.

*

The instrumental research is preceded by a thorough *theoretical-methodological research.* The methodological field activity has been touched upon earlier. The real *theoretical* task, however, was to establish an interpretation program package.

An automatic seismic package started working on our Computer Centre MINSK-32 utilizing the sixfold stacking survey data of the *Nyir* region. The main characteristics of this package are the following.

Its denotation is DSI (Digital Seismic Interpretation). The control, commands and parameters are comprised in an easy computer language. It is variable and renders plotting possible in any phase of the interpretation. The programs of this system are adapted to the language of the computer (YASK) of assembler level, except the feed-in from the digital tape recorder and demultiplexing, which are more convenient to handle in machine codes.

The processing is carried out, with regards to the large memory, record-wise and with a fixed point arithmetics.

The feed-in from the digital tape recorder (SDC-15) proceeds in multiplex form. Plotting takes place in a wiggle trace or a VA system.

The programs completed in 1971 are the following.

INPUT	= feed in		
DEMU	= demultiplexing with BGC recovery		
EDIT	= correction and sorting		
	MUTE	=	zeroing of first arrivals
	NOISE	=	elimination of sound waves
	DEAD	=	killing of dead channels (or parts)
	REV	=	polarity reversal
	KILL	=	complete cancellation of records
STATC	= static correction		
DINCR	= NMO correction		
TG	= trace gathering (CDP)		
STACK	= stacking for any number of stacks		
SXFIL	= time-varying frequency filtering		
TAR	= true amplitude recovery		
MIX	= mixing		
DEC	= deconvolution		
WRITE	= plotting in VA form and/or in wiggle trace.		

The sixfold stacking profile No-5c/71 of the *Nyír* region has been negotiated with this system, with velocity values obtained in the "minicentre". The results obtained in either way, agree (Figs. 37–38). The final section underwent SXFIL and DEC (Figs. 39–40).

The operations are applied to records of 4 sec duration with a sampling interval of 2 msec. The time-need of basic operations is 1–2 minutes/record, in average.

The program booklet is available in the Computer Centre of ELGI.

*

As a result of earlier *instrumental research* a *digital* seismic *field equipment* (type SDT-1) has been finished. This equipment meets all essential requirements of a digital field unit. Its main parameters (e.g. dynamics, noise level, gain, etc.), however, need improvement.

This equipment was applied in 1971 in the field program of the *Nyír* region, and based on the experiences the work for an improved variety has been set into operation, in two main lines.

The *first* (in international cooperation) involved the design of the gain system, multiplexer, AD converter, field playback and automatic broadcasted shot, as well as the construction of their test models. Three times were these test models mounted together with those of the *Partner* (pre-amplifier, tape band unit with the logics) and tested both in laboratory and in the field. The complete unit has fulfilled the demands (gain by channels, low distortion, wide dynamic range). The noise level, reduced to the input, is still higher than specified $(0\mu\,1, V)$.

The *other* line of development has been represented by a universal seismic digital field equipment of lower requirements. This "third generation" of the home-made equipments is designed to serve the prospecting for solid minerals. In 1971 the development of the pre-amplifier and filter circuits has been finished. The specification set up has been met, except the harmonic distortion below 10 cps (0.3–0.5% instead of the required 0.2%). The test model of a 24 channel amplifier system has been finished and tested in laboratory.

The design and construction of the central control and test unit have also been finished and the system (format, recording control, deformat, demultiplexer, playback control) was tested.

The completion of the unit is a task of the next year.

The fundamental technical conditions for a series of an up to date seismic digital equipment have been established. Technical details are partly patented, partly they are available in the *Archives* of ELGI.

Another type of instrumental research activity is the design of a *seismic digital equipment for shallow, engineering work.* It includes capability for stacking of quick, periodically repeated shocks. In the first phase a 24 channel recorder, tape storing, control unit, playback unit and a monitor has been designed and partly constructed.

It is not a final unit, therefore no block diagrams or specification are given. Details are accessible in our *Archives.*

A jet vibrator has been patented. Three vibrators are finished with technical description.

2.2 GEOELECTRIC METHODOLOGICAL AND INSTRUMENTAL RESEARCH

The *automation research* has been concerned with the elaboration of computer routines for our most important geoelectric methods: VES and MT (frequency sounding).

The existing programs have been economized and adapted to the Computer Centre MINSK-32. The program computing theoretical VES nomograms has been improved, then, to have the curves plotted, the software of the plotter CIL has been set up.

With this improved program any number of layers of arbitrary resistivity can be plotted within ± 0.1 mm accuracy. To all field curves one can calculate nomograms of two varying parameters (h, ϱ), without any rise in the cost.

In 1968 a MINSK-2 program computing a three-layered curve cost $20, without plotting. In 1971 a MINSK-32 program computing, including CIL plotting, cost $3, and was through overnight, if needed.

In magnetotelluric data-processing an earlier MINSK-2 program has been adapted to the MINSK-32 so as to enable it for complex filtering. The filter-function was selected as a triangular wave (instead of the square wave hitherto used) for if transforming it the amplitude decreases as $\frac{1}{t^2}$. The filtering gives complex vectors with amplitude and phase values.

A program for computing theoretical nomograms for MT–FS has been also set up. For computing the apparent resistivity a recursion process is applied. This program provides an analytic evaluation of the MT sounding curves measured in 5–6 representative sites.

The "equivalence" interpretation, described in our Annual Report for 1970 has been re-written and in many ways simplified. This refers, in the first place, to nomograms of curves of the type K ($K_{0,05}$; $K_{0,1}$; $K_{0,25}$; $K_{0,5}$; $K_{0,75}$. K_1) The procedure has been successfully applied in field practice.

The results of methodological and theoretical research will be published in details in *Geophysical Transactions*.

*

In *instrumental research* the theoretical foundation of an IP equipment started. Maxwell's equations have been treated in such a way as to disclose the phenomenon of the induced potential. This treatment yielded quantitative relations well agreeing with solutions published in the literature both for time domain and frequency domain methods. Backed by these theoretical considerations a new type of IP equipment is going to be constructed of which a more characteristic – energization-dependent – rock parameter is expected.

Details will be published in *Geophysical Transactions*.

2.3 WELL-LOGGING METHODOLOGICAL AND INSTRUMENTAL RESEARCH

A limited effort could be afforded for pure *methodological* research, still a number of themes have been negotiated.

For a *quick analysis of copper ores* under 1% metal content *neutron activation analysis* has been studied. Six samples irradiated with neutron generator (14 MeV) could be analyzed per hour with an accuracy of ± 0.01% (single back scatter).

Some *volcanic rocks* (rhyolite, andesite, basalt, phonolite) have been irradiated by *nuclear reactor* in quantities of 5 mg, and an energy selective measurement with Ge/Li semiconductor detector disclosed, apart from the main components, qualitatively some *trace elements* (Sc, Eu, Hf).

In improving the *automatic bauxite analyzer* (type MTA-1527) an IC measuring and control unit has been constructed to calculate and print Al_2O_3 and SiO_2.

Resorting to labor tests of a *pulse controlled downhole generator* (IGN-4) a time analyzer (with operating control) and a supply generator (Fig. 41) has been constructed. The routine *tests* started with a double core cable of 4500 m length.

In determining *volume weights in situ* (density) radiometric probes KRG-2-120-60 (7.23 mCi Cs^{137}) and KRG-2-200-86 (55 mCi Cs^{136}) have been applied.

For a gamma sensitivity test and for comparison's sake a μr/hour and a volume weight calibration was carried out (Fig. 42).

Modelling nomograms to calculate mud cake effect has been in progress. Both the density and the thickness of the mud cake can be changed within wide range.

For the case of thin layers ($h > 1$ m) a *nomogram* has been set up to take thickness, time constant and hoisting speed into correction (Fig. 43). The procedure is characterized by Fig. 44. The plotting of results contains the following parameters: depth, X, Y, ϱ (g/cm^3), d_h measured (mm), d_h measured $- d_h$ nom (mm), average lateral penetration (cm).

The effect of geological-technical factors on *neutron logs* has been determined both theoretically and experimentally, in our *H model.* These factors are: porosity, hole diameter, chlorine content of mud (Figs. 45–46).

The *calibration* of the *induction probe* of 5–6 coils (ELGI pat.) was finished in our model-well.

The stability, with reliable sensor head and local earthings, is good.

The six coil probe meets all requirements (Fig. 47), the five coil probe needs improvement.

The problem of calibration of induction logs has been solved.

The first part of the *model system* (U, Th) for *energy test* (and else) is finished. The largest hole diameter is 214 mm.

For *processing natural gamma logs* two *programs* have been written for our Computer Centre in YASK language. The programs find the peaks, delimitate them, calculate their right and left background noise, determine the entire and specific peak areas, the standard deviation of the latter in percentage and pulse number, and perform energy calibration (channel number–energy in KeV).

Another computer program which has been written solves *downhole rock determination* based on the litho-porosity correction. Two parameters derived from three curves (gamma-gamma, neutron-neutron, acoustic) decides the number of main rock-components (1, 2, 3, or unknown).

The first phase of *selective gamma-gamma experiments* is finished, the log is independent from the density variations (Fig. 48). The results are shown in Figs. 49–51.

*

In the line of *instrumental* activity *nuclear well-logging equipments* have been constructed for the Experimental Dept. and Methodological Dept., for test. Two parameter nuclear downhole tool KRNG-2-120-60 together with surface equipment KRF is suitable to detect natural gamma and neutron-neutron radiation.

For ϱ logging a probe of 86 mm diameter has been constructed (Fig. 52). It works up to 200 °C (see the corresponding methodological sections).

SPECIFICATION OF THE SURFACE UNIT KRF-2-12A

supply voltage	12 V ± 5%
current	~ 1 A
linearity	above 1%
zero stability	≤ 1/100
dead time	~ 25 μs
ind. galv.	0—10 mV ± 2% (R_T = 6 kOhm)
ind. contr.	± 5%
zero adjustment	discharge
size	500 × 270 × 320 mm
weight	~ 7 kp

SPECIFICATION OF THE RADIOMETRIC DOWNHOLE TOOL KRNG-2-120-60

diameter	60 mm
length	~ 2.5 m
supply voltage	30 V
current	40 mA ± 5%
detectors	4 NG 420 GM and 4 SNM-11
working temperature	+ 5—+ 120 °C
cable	5000 m 2 cores
sensitivity	$4.8 \frac{\text{CPM}}{\text{n/cm}^2}$ resp. $44 \frac{\text{CPM}}{\mu\text{r/h}}$

Besides this a number of radiometric equipments have been on sale as results of contracted research.

In the line of *electronic well-logging equipments* the experimental work initiated in the previous year has been going on. Some units reached the stage of field test. The electric base unit is shown in Fig. 53. It contains the resistivity, laterolog and SP channels.

A special work has been spent to the design of the carrier as well as the mechanical accessories (armoured cables, winch, brakes).

The recorder has been improved and the mechanical scale shift has been replaced by an electronic one.

Ore investigations required a special *induction probe* of four coils, mud compensated. In the given areas short sonde spacing provides higher resolving power than any focussed system.

Basic parameters are as follows:

main coil spacing	40 cm
diameter	60 mm
sensitivity range	0.03–5 ohmm
temperature limit	100 °C
pressure limit	150 atm.

The unit is transistorized, in some parts built of IC. The probe is connected to a seven-core easily clicking cable head.

For *digital* recording and processing of well-logging data a field *recorder and* a labor *playback* unit have been designed and operated on an experimental basis.

The field recorder, tape recorder, and the adjusting panel (providing traditional analog recording too) are truck-mounted. The truck carries the cable winch.

The labor playback (Fig. 54) with operative memory, short-cutting unnecessary computer operations, provides a fast interpretation, sorting and qualification of tape recorded signals. Numerical values and arrays appear on a punched tape or line-printer.

The principal electronic tests in laboratory have been finished. Specification will be given at a later date.