2 METHODOLOGICAL AND INSTRUMENTAL RESEARCH

2.1 SEISMIC METHODOLOGICAL AND INSTRUMENTAL RESEARCH

The most valuable results of seismic methodological and instrumental research in 1977 were as follows:

1) A migration method was developed whereby the signal-to-noise ratio is increased considerably. Its application enabled the investigation of the structure of formations below the Tertiary basin floor;

2) the real-time data processing system developed—within the framework of the COMECON Ocean Research Program—was put in routine use;

3) the VIBROSEIS method was applied successfully on areas where conventional seismic methods failed;

4) the summing type seismic equipment for engineering applications was completed;

5) the off-line colour plotter was put in routine use and with it the plotting technology developed.

1) The *weighted migration program* was developed in 1976 and an example of its application was presented in the Annual Report of the same year. In the first experimental applications amplitude equalization was performed before migration. By examining the results it became clear that by amplitude equalization the noise is amplified considerably at poor signal-to-noise ratio. Thus migration noise reached such a level that horizons of poor correlation disappeared in it.

In 1977, by using the digital colour plotter, the visual dynamic range was increased. Therefore, migration could be performed with original amplitudes. The migrated time sections were coloured according to reflection amplitude in either logarithmic or linear scale. On the sections so migrated the deeper horizons appear with better signal-to-noise ratio and are separable from the migration noise.

On Figs. 44, 45 and 46 various processing results of section Vé-24/76 are shown.

On the time section (Fig. 44) in the 2.0–3.5 sec interval the fragmentary reflections do not give any information about the structure. In the migrated sections correlation of these deep arrivals improved, thus outlining the structural set up. By comparing Figs. 45 and 46 it can be seen that under favourable conditions (within the respective amplitude ranges) the seismic horizons are enhanced better by using linear scale (and also the migration noise may be better suppressed) than by using a logarithmic scale. It can be seen as well, that migration stacking with the original amplitudes improve signal-to-noise ration especially in the deeper parts of the section.

2) The *real time data processing system based on R-10 computer* was applied for the processing of domestic seismic profiles as well.

The aim was to compare the results and the necessary running times of MINSK-32 and R-10 type computers. The time section Vé-24 processed by the R-10 computer is shown in Fig. 47. Processing time was shorter more than an order by R-10, than by MINSK-32 computer. The main steps of the program package are as follows:

— Input, demultiplexing and transformation to R-10 floating point format. (Input from SD-10 or SSC-3 seismic recording instrument, from 21 or 9 track field magnetic tape or directly from the analogue magnetic drum.)
— Writing the input data onto magnetic tape in channel sequential format;
— NMO correction with predetermined velocity function;
— horizontal stacking;
— frequency filtering;
— deconvolution;
— automatic gain control and scaling;
— presentation of the results on plotter.

This program package extended by a handler and static correction program will be suitable for seismic land data processing.

3) The *VIBROSEIS system* was applied in experiments on previously unexplorable regions, such as: areas of strong ground roll, difficult mountainous terrain and densely populated areas. The results are encouraging. Two examples are given below.

Parts of the Hortobágy puszta (NE Hungary) and around Debrecen town large areas were unexplorable because of strong ground roll. Three such areas were selected for the VIBROSEIS experiments. Field parameters for all three areas were equal and similar to those applied in routine work on the area: geophone base distance: 50 m, 12×100% coverage, offset: generally 300 m, at Józsa village 150 m.

The main point in the experiments was the application of a new energy source. Thus, the attention was focussed on the selecting of the sweep parameters. Long test series were performed for determining the optimum frequency and bandwidth, sweeplength and rate, and number of compositing.

As a result of the tests the 2 octave, low frequency (12–48 Hz and 13–52 Hz at Józsa and Hortobágy, resp.) 7 sec long sweep and 16 times compositing was found the best.

50 m geophone groups with 30% mixing and 100 m long vibrator groups provided the cut-out of the first arrivals.

The VIBROSEIS system produced better results than the formes conventional techniques on all three areas. The improvement was especially striking at Józsa as Fig. 48 proves it.

As a conclusion it can be stated that, although the VIBROSEIS method does not solve all the problems it produced a major breakthrough.

The VIBROSEIS system opened up new vistas in the seismic exploration of volcanic mountainous regions. In 1977 a research program in the Börzsöny Mountains comprised tests for both field and processing parameters.

In the Central Börzsöny a geophone base distance of 25 m and two different sweeps were used. The high frequency sweep (40–100 Hz) is suitable for the separation of the thin beds of the strato-volcanic series. The lower frequency sweep (12–48 Hz) provides deeper penetration (2 sec) and a better picture about the basement and the structural conditions. Profiling with the low frequency sweep and filtering in the 12–24 Hz band resulted in the time section of Fig. 49. Beside the basement which appears with prominent energy around 0.9 sec certain objects can be contoured below and above the basement (e.g. the intrusion around point 30^{oo} between 0.2–0.3 sec).

At processing it is important to pay more than usual attention to the factors affecting stacking. Because of the great elevation differences and rapid near-surface velocity changes continuous shallow seismic refraction measurements are necessary to determine the static corrections. Due to the horizontal velocity changes (sediments—subvolcanic bodies) continuous velocity analysis seems to be necessary.

Other VIBROSEIS test areas were in the Bükk Mountains on basement outcrops.

4) The construction of a *summing type seismic equipment for engineering applications* was completed. It was part of the COMECON "INTERGEOTECHNIKA" co-operation contract. The block diagram of Fig. 50 explains its operational principles.

The geophone signals are passed from amplifiers $E_1 \ldots E_{12}$ through multiplexer *MX* to the *AD* analogue to digital converter. The digital signals are stored in memory *T* after having passed through adder *S*.

From this stage the signals are fed back to the adder and at the same time after passing through the *DA* digital-to-analogue converter transmitted to the display screen *K*, to the rotating drum *D*, or to the oscillograph *O*. The digital data stored in the memory can be recorded onto a magnetic cassette (by recorder *M*) for further processing. On the effect of the starting signal *I* given by the energy source the control unit *V* starts the process of digitalization and the data are stored in *T*. After each shot the data are recalled from the memory and the new data are added to them. The sum is stored again in memory *T*.

This process is repeated until the record becomes satisfactory. The quality of the record can be monitored continuously on screen *K* and played back sequentially on thermosensitive paper drum *D*.

The photograph of the equipment is shown in Fig. 51.

Specifications of the equipment:

Number of channels: 12 (extendable to 24)

Amplification: 96 dB (in steps of 12 dB)

Frequency range:	20–250 Hz; 20–500 Hz (switch-over) or with change of antialias filter 20–1000 Hz; 20–2000 Hz (switch-over)
Sampling interval:	1 msec, 0.5 msec, 0.25 msec, 0.125 msec
Resolution of the AD converter:	10 bits (9 bits + sign bit, 2 complements)
Word length:	16 bits
Summation:	max. 64
Recording length:	in case of 1 msec sampling interval 0.682 sec (depending on memory capacity)
Capacity of memory:	8 K (extendable to 24 K in the basic configuration)
Delay of recording:	till 10 sec, in steps of 10 msec

5) The *off-line colour plotter* (Fig. 52) was put in routine work. Apart from various displays (amplitude, frequency) of the reflection time section the presentation of refraction seismic time section has been started. On Fig. 53 refraction arrivals are shown coloured according to apparent frequency. The successive records belonging to the same shot point—normalized to the maximum amplitudes of the respective channels—are plotted in wiggle trace form (black line) while the frequency content appears in variable area.

GEOELECTRIC METHODOLOGICAL AND INSTRUMENTAL RESEARCH

During 1977 already four *DIAPIR-4005 type digital, automatic induced polarization receivers* were in routine use on domestic and foreign ore exploration projects. DIAPIR samples the decay curve according to the following time series:

$$t_k = a_j b^k$$

and automatically calculates the apparent polarizability value (P_{a_k}) at the given time instants. For the DIAPIR-4005 type unit

a_j, the time of the first sampling is 0.125 sec;
b, the factor determining the sampling rate is 2;
k, serial number of sampling: $0 \leq k \leq 4$ that is altogether 5 readings are obtained.

It war proved that in most cases such a short segment of the decay curve can be approximated—within a few percentage of accuracy—by the sum of two exponential components. The processing program for HP-97 calculator was based on this experience. The main steps of the program are as follows:

1) The averaging of an arbitrary number of readings (P_{a_k})
2) The calculation of the amplitude (w_1) and time constant (τ_1) of the first component (of longer time constant) from the values of P_{a_3} and P_{a_4}.
3) The subtraction of the calculated amplitudes of the first component from the respective readings, and the calculation of parameters w_2 and τ_2 of the second component from the residue.
4) The calculation of the values of w_1/w_2 and $w_1 + w_2$.
5) Determination of the percentage discrepancy between the readings and the exponential approximation.

After smoothing, the parameters are presented as sections or as maps. A typical section of an IP middle gradient profiling in the Börzsöny Mountains is presented on Fig. 54.

It was established formerly (see 1976 Annual Report) that long recordings of decay curves after long duration of charging enable the classification of IP anomalies. This method, however, is time consuming both in recording and processing.

Therefore, the possibility of replacing the long recordings by shorter ones, like those of the DIAPIR-4005, was studied. Typical devay curves were processed by using the above described program after the results of multi-component approximations were known. It was found that:

— the sum of the amplitudes hardly depends on the method of processing, that is

$$w_1^D + w_2^D \simeq \sum_{i=1}^{5} w_i$$

(where subscript D indicates results of DIAPIR measurements)

— the parameters of the second component correspond with a good approximation to the parameters of the component of shortest time duration, that is:

$$w_2^D \sim w_5 \text{ or } \tau_2^D \sim \tau_5.$$

A large number of field measurements proved the correctness of the above statements. Similarly to the w — τ curves of the long duration recordings the distribution of the w_1/w_2 values are different over sulfide and graphitic bodies (Fig. 55). Even though time constants do not show such prominent differences theoretical studies suggest that τ_1 increases primarily above sulfide ore deposits. Thus the most perspective areas were marked at places where the values of both w_1/w_2 and τ_1 increased above average.

Curve shape analysis demands stricter accuracy on field measurements than the conventional TD method. Thus, the reading of one single point with DIAPIR takes longer time than by IPR-7 or GESKA. On the other hand, however, the quantity of information increased considerably and since DIAPIR is an ELGI made instrument the field groups provided by several units, can exploit time more efficiently.

With the two new members of the DIAPIR family, the R and 4010/N type, no field work was yet performed. DIAPIR-R provides an increase of 1–2 orders in the dynamic range of the analogue recorders (Fig. 56). If both the primary and secondary signals (U_T and U_t) are recorded with identical gain then there is a 1–2 order difference in amplitude between the two signals (Fig. 56A). Subtracting the value recorded at switching ON ($U_{T_{00}}$) from the primary signal, the dynamics of the two signals will match (Fig. 56B). The subtraction is performed by an analogue circuitry. The further increase in the dynamic range is achieved by the use of an automatic gain controlled D/A converter (Figs. 56C and D).

The DIAPIR-4010/N type instrument samples and stores the values of P_{a_k} of 10 times till $t_k = 3$ sec. After 3 sec the values of P_{a_k} are measured and displayed in 3 sec intervals. Having performed the measurement of required duration the first ten data can be read sequentially from the memory. This type of instrument will be useful at the investigation of lode and vein type mineralization of long time constant and unknown decay curve.

After years of development work the construction of an *AC IP instrument type SEF-4* was completed. The power supply unit of 300 W produces amplitude stabilized (within 0,1%) quasisinusoidal signals. Maximum output current: 1 A. The four frequencies (of 0.1, 0.4, 1.6 and 6.4 Hz) are produced by a high accuracy quartz oscillator.

A quartz oscillator of the same type is built into the receiver unit as well, so the synchronization guarantees a phase angle measurement accuracy of $\pm 0,1°$ during the whole work day. The determination of apparent resistivity is performed by measuring mean integral values by maximum sensitivity of 0.1 μV.

Readings of SEF-4 are processed by a program written for HP-97 calculator. After the input of readings the following data are calculated and printed:

— the apparent resistivity values at the four frequencies;
— the values of the phase angles at the four frequencies;
— the value of the phase angle extrapolated to 0.0 Hz;
— the six possible PFE values;
— the MF value calculated from data of frequencies of 0.1 and 0.4 Hz;
— the normalized real and imaginary parts necessary for the construction of the Cole-Cole diagram.

Measurements were carried out on three sites—formerly investigated by TD survey—in dipole-dipole configuration generally used for FD measurements. The length of the dipole was between 25 and 100 m. The most important experiences were the followings:

1) It was proved that—especially on low resistivity ($\varrho_a \sim 0.1$ ohmm) medium—for similar penetration SEF-4 requires an order smaller transmitter power than TD measurement.
2) In most cases phase angle and PFE value correlate well.
3) Even at small depths extrapolation to 0.0 Hz may be necessary because of the electromagnetic coupling.
4) Comparison of TD and FD parameters is difficult because of the different electrode configurations. In spite of it correlation is acceptable, as it can be seen from Fig. 57.

The construction of a *high power equipment for the exploration of deep sulfide ores* and methodological research for its use has been commenced in joint financing of the State Office for Technical Development and ELGI.

As preparation for the ESR computer investment program planned for 1978 *geoelectric processing programs* were written and tried on IBM-370/145 compatible with the ESR computer to be installed.

During the processing of magneto-telluric records (see Annual Report, 1975) produced by the DEF-1 type digital electromagnetic recording instrument (see Annual Report, 1976) new demands arose.

The block diagram of the new processing program is shown in Fig. 58. The algorithm provides the following methodological advantages over the previous processing system:

— the maximum number of input data is increased from 40 000 to 160 000 for all frequencies, thereby the reliability of statistical processing is increased;
— noisy impulses or segments are recognized and omitted;
— besides the impedance tensor the independent admittance tensor is determined as well;
— the error of the calculated tensor components is estimated.

Experiences prove that the accuracy of impedance increased by half an order without any cost increase.

A successfull and fruitful aspect of the automatization of geoelectric data processing is the further development of the program system of the *field computer centre* based on the HP-9845 calculator and plotter. Apart from processing geoelectric mapping data (see Annual Report, 1976) the evaluation of VES curves has been commenced as well. The graphic interactive possibilities provided by the calculator system eliminate the need of using master curves. Plotting of resistivity data and theoretical curves for the gradually corrected parameter sets are drawn within minutes. Thus, the interpreting geophysicist can obtain information about the reliability of evaluation and the conditions of equivalence as well.

It provides insight into the causes of structural distortions. Computation of master curves is based on the discrete convolution algorithm of P. Salát and D. Drahos (Geophysics dept. Eötvös University, Budapest).

The multifrequency electromagnetic methodological research program for bauxite, braun coal and water exploration was commissioned by the Central Office of Geology and the State Office for Technical Development.

The field measurements were started in 1977 by using the Scintrex SE-77 type equipment. The magnetic field of the inductively coupled magnetic polarization loop was measured in Turam arrangement with fixed frequencies of 35, 105, 315, 945 and 2835 Hz.

Field tests for the effectiveness of the method were carried out at Bakonyoszlop for the localization of bauxite bodies covered by Eocene limestones. The tests were successful at the frequency of 315 Hz; the anomaly of 7% is in close correlation with the Triassic contour underlying the bauxite. The processing and correction of field data by the normal fields of the homogeneous half space is carried out at the field computer centre.

The applicability of the method is still being investigated primarily for the exploration of two dimensional structural elements (tectonic zones, ore bodies).

2.3 WELL-LOGGING METHODOLOGICAL AND INSTRUMENTAL RESEARCH

The scope of *nuclear instrumental research* activity was extended to the field of isotopic X-ray fluorescent (XRF) analysis. An experimental equipment was developed which is suitable for determining element concentration of Fe, Cu, Zn and Pb.

The detectors of 43 mm diameter combined probe are proportional tubes of good resolution power which are pressed to the wall by a spring. Two exchangeable detector units belong to the probe. One of the units contains a proportional tube equipped with adjustable radiation source holder and a surface controlled, mechanically equalized filter pair. The single channel energy selective electronics of low noise transmits the signals produced by the detector through the conventional well-logging cable with a noise threshold of 0,5 KeV to the surface unit. Thus continuous, or in the case of filter pair point measurements can be realized. The characteristic spectrum of radiation of the copper and iron samples recorded by the probe is shown in Fig. 59. The second detector unit contains two proportional tubes with fixed arrangement of a filter pair. By connecting this unit the probe electronics switches over automatically to the two parameter detection mode of operation and the signals are processed by the conventional surface unit. In both cases there is a berillium window built into the wall of the probe casing in front of the detectors and the radiation source (^{238}Pu).

The block diagram of the surface units mounted in the standard instrument casing can be seen in Fig. 60. Depending on the measurements the ratemeters can be changed to scalers to which a four-channel 6 digit thermal printer may be connected. For the four-channel spectral mode of operation a four-channel analyser of 50 mm width was developed for which different energy windows may be selected by using various "program plugs". The setup is shown in Fig. 61.

The suitability test of the instrument proved that in the spectral mode of operation the sensitivity of the probe is adequate for separation of elements with atomic number difference exceeding 3. In case of smaller differences the energy measurement must be supplemented by using a filter pair. The result of such a combinative measurement of energy and filter pair is shown in Table I.

The energy range (ΔE) was altered for iron, copper and powdered rock samples, while the window and the Ni/Co filter pair were selected for copper. For example, it can be seen that at a window of 8.35–9.25 KeV the 100% iron content resulted in 39 counts. The filter pair test can be performed by keeping the count number difference of the "unmeasured element" (iron) between the following limits:

$$o \pm 5\delta \text{ (count/s)} = o \pm 5 \sqrt{\frac{2T-D}{t}}$$

where

T = count number of the band-pass
D = filter count number difference
t = duration of measurement,

—which is fulfilled in the selected adjustment. It must be remarked however, that this count pertains to 100% iron content and it could be even more favourable under rock conditions.

Within the framework of the *nuclear methodological research program* the KRGNN-3-150-76sHY type three channel neutron probe equipped with a ^{252}Cf type neutron source of $1.44 \cdot 10^7$ neutrons/sec intensity was calibrated in four different probe positions: centrically, at 20 mm from the bore-hole wall; at 10 mm from the wall and pressed to the wall. The parameters of the diagrams are the bore-hole diameter (134 and 214 mm) and the probe length. The diagram plotted for the wall-pressed position is shown in Fig. 62.

The application of the calibration diagram shown in Fig. 62 is presented on the experimental neutron logs recorded in the well of Tarnabod. The calculated neutron porosity values for the depth intervals of 1850–1910 m is tabulated in Table II.

To improve the porosity measurements the study of neutron spaces has been started by using single and double groups of neutron diffusion equations under modeling conditions.

The aim was to calculate master curves for thermal and epithermal neutrons by various probe lengths and bore-hole diameters. The master curves counter-checked by calibration diagrams, are suitable for determining Φ_N porosity. Using published data and relationships the group constants (D — diffusion coefficient and L — diffusion path) of the diffusion equations were calculated for sand and limestone matrices (see Table III.) The calculations allowed to clear the relationship between the epithermal-thermal flux ratio and bore-hole diameter. The quotient

Φ_2/Φ_1 tends towards a constant value as the probe length increases. In the range of 30–90 cm probe length, the change of the quotient is significant only at small bore-hole diameters.

Recently the demand for *combined probes* in *solid mineral exploration* drillings is increasing. To satisfy this demand three different probe combinations were produced.

1) Common electric and radioactive probe; size of the electric probe: $B2.73A0.1M_10.35M_2$ and $M2.83A0.35B$ in the normal and lateral arrangement, respectively. The radioactive probe is of KRG-2-120-43 type with the upper channel measuring gamma-ray and the lower one some type of induced radiation (gamma-gamma, neutron-gamma). In the four parameters combination the electric probe is located on the top.
2) Microresistivity and selective gamma-gamma probe; the springing plastic part standing out separately from the rigid plastic mandrel forms the pad of the microprobe on which three electrodes are placed with 2.5 cm spacing. The selective gamma-gamma probe is in plastic housing as well. Both probes are furnished by springs pressing them to the wall.
3) Continuous fluid resistivity and temperature probe; in the closely packed probe the sensor of the temperature probe is located at the bottom.

In *field methodological investigations* the IP (induced polarization) measurements were continued partly by continuous logging and partly by digital recording of decay curves. Our aim was to find a relationship between IP and the permeability of clear sands and sandstones. The results can be expressed in the following relationship:

$$\varkappa = \frac{\xi^2}{L_{33}\varrho_o}$$

where $\varkappa$ is the polarization susceptibility characterizing rock IP properties,

ξ streaming potential

ϱ_0 resistivity of the rock matrix

L_{33} quantity characterizing pure permeability; element of the thermodynamic two-phase system matrix.

Further development of the *computer program package* for the *K-3000 type digital field well-logging equipment* enables the processing and interpretation of data from solid mineral exploration wells. It consists of the following phases:

1) Writing field data into the computer and storage in the multi-log data base system.

2) Transform certain logs into physical units and rewrite it into the data retrieval system.
3) Depth adjustment (see Annual Report, 1976).
4) Perform log corrections including forming the difference between neutron activation and gamma-ray logs.
5) Lithological identification and boundary determination by lithological probability distribution (see Annual Report, 1975).

It should be remarked that data can be written into the data retrieval system from the punch tape output of the office log-digitizer as well.

An example for computer interpretation is given using the following logs of well Cs-248: two resisitivity logs: (B2.73A0.1M), (B2.73A0.4M), gamma-ray, gamma-gamma, neutron-neutron and neutron-activation logs. The result of depth adjustment is shown in Fig. 63.

For lithological identification the lower and upper limits for each geological formation is given from empirical data of the area as well as the probability with which the log characterizes those beds. It was accepted as a criterion that the neutron activation log locates unambigously—that is with a probability of unity—the bauxite layers. From the given limits and the log values the program calculates point by point which geological formation has the highest probability and locates the bed boundaries as well.

On the log shown in Fig. 63 the successive layers obtained by computer processing and manual interpretation can be compared and seen that they match closely. Deviations can be found in case of thin layers (10–20 cm) only as manual interpretation can be performed by averaging them, whereas the computer identifies them as separate layers.

The application of the *Well-logging Interpretation System (KÉR)* developed for the MINSK-32 computer is illustrated by the processing of logs obtained from a South-Hungarian oil-producing area.

The logs of Fig. 64 were recorded in the depth interval of 1750–1940 m. The detailed lithological probability distribution of a 5 m long section marked on Fig. 64 is shown on Fig. 65. Fig. 66 presents the physical parameters of the beds as determined by the computer. The NG curve indicates the neutron-gamma counts exceeding a certain threshold which refer to the presence of gas. The cross-hatched region below the porosity curve (Φ) is proportional to the hydrocarbon saturation [$\Phi (1—S_w)$].

The program system is based on mathematical-statistics using the empirical constants of the area as parameters. The storage in the data retrieval system enables us to link the successive operations. Each processing program operates from magnetic tape to magnetic tape of identical format. Loading the data from the magnetic tape into the memory is in steps of depth intervals, depending on the free capacity of the memory, the number and length of the logs to be used.

The geophysical interpretation is performed in steps of sample points but after having determined the lithology further calculations are carried out at sections of high permeability only. The main points of the processing are as follows:

— digitalization of the logs and checking by replotting;
— having converted to physical values, the digitized logs are stored on a magnetic tape;
— automatic depth adjustment of the logs;
— normalization of the SP and gamma-ray curves between the automatically determined clay and sand lines;
— formation of the difference of micro curves;
— statistical lithological interpretation in steps of depth points;
— determination of porosity and clay content by diagrams characteristic to the area and the probe;
— determination of water saturation by different methods;
— calculation of CH saturation;
— presentation of the results on plotter and line printer.

Within the framework of the *COMECON Ocean Research Program* the *XRF analyses* were continued by using a Hungarian made equipment consisting of a Si/Li semi-conductor detector, coded preamplifier and an interfaced data processing and interpreting "Automatic Spectrum Analyser" (ASA) (Fig. 67).

The energy resolution power of the semi-conductor detector is better than 200 eV on the 5.9 KeV line of the Fe-55 isotope (on board). The construction of the Automatic Spectrum Analyser is simple, its size is small and its control is easy. Its operational characteristics: the time duration of the amplitude analysis of 1024 bits resolution can be preset and only the program selected portions of the energy spectrum are stored in the 16 memory cells. The routine analysis of off-shore placer samples consists of the following steps:

— energy calibration of the Automatic Spectrum Analyser;
— selection of spectrum ranges (windows);
— measurements on standard samples;
— construction of the calibration curves from the test results and the known concentration values;
— serial measurements.

The method was applied for the real-time evaluation of the titanomagnetite placer samples of the South Continental Shelf of the Black Sea. 270 samples were analysed for Ca, Ti, Cr, V, Mn, Fe, Ni, Cu, Zn, Sr and Pb content on-board.

Furthermore, the intensity of inelastic and elastic scattered photons and their ratio were determined as well. This latter contains information about the average atomic number of the samples and it enables to perform matrix correction. The results proved the presence of titanomagnetite sands, carbonate sands and muds. The concentration range of each element of the samples is shown in Table IV.