BIOGEOPHYSICAL, GEOPHYSICAL AND GEOCHEMICAL RESEARCH ON THE WESTERN BLACK SEA SHELF

Glicherie CARAIVAN[(1)], Viktor P. REZNIC[(2)], V. P. VASILIEV[(3)], Adrian TEACĂ[(1)], Priscila OPREANU[(1)]

[(1)]National Institute of Marine Geology and GeoEcology – GeoEcoMar, Constanta Branch, 304 Mamaia Blvd., 900581, Constanta, Romania
gcaraivan@geoecomar.ro
[(2)]Odessa State University, Ukraine
[(3)]Institute for Mineral Resources, Simferopol, Russia

Abstract. Expeditionary research along the western Black Sea shelf took place in 1990 within the International INTER-GEO-ECO-MONITORING Programme. The programme included continuous bathymetric recordings, measurements of the electromagnetic field and emissions of atmospheric Mercury, and biogeophysical applications. The high degree of correlation between the results of the four methods used, which are very different, considering the parameters examined, reveals the existence of a common denominator. Thus, the fault planes represent the transmission paths of some elements (like Mercury) from the Earth's Mantle to the surface, generate anomalies in the electromagnetic field and induce biogeophysical anomalies reflected in the microrelief of the sea floor.

Key words: geophysical methods, geochemical anomaly, biogeophysical prospecting, geological cartography, Black Sea

1. INTRODUCTION

This paper expounds the results of complex research carried out in September 1990 on the western shelf of the Black Sea (Ukrainian and Romanian territorial waters) aboard the Odessa State University ship Antares (Ukraine). Participants in the expedition included specialists from the Odessa Marine Geology and Geochemistry Laboratory, the Simferopol Institute for Mineral Resources and the Marine Geology Laboratory of IGR Constanta; currently INCD GEOECOMAR. The proceedings took place within the international INTER-GEO-ECO-MONITORING programme. The expedition included measurements on four profiles, comprising 104 geoecological stations: one profile along the shore, between Odessa and Mangalia, and three other profiles perpendicular to the shore, reaching a maximum of 100 km offshore (Fig. 1).

2. MATERIALS AND METHODS

In addition to the usual geoecological proceedings, the expedition included continuous profile measurements by means of both traditional methods (recording the sea bed profile using an echosounder) and experimental methods: recording areas of tectonic stress by measuring the terrestrial electromagnetic field impulse (EIEMPZ), determining atmospheric mercury emissions (VGRS), assessing the geological and structural characteristics of the sea bed using biogeophysical methods.

Methods of determining atmospheric mercury concentrations (VGRS) were first employed in the 1980s, allowing the identification of active tectonic structures on the sea floor.

A spectrographic analysis was used, using atomic absorption and based upon the absorption of mercury on a gold substrate. This permits an increase in sensitivity and selectivity. Heating the Au-Hg amalgam to 150°C, during the accumulation reduces the influence of atmospheric humidity, which is very important when working at sea.

The sensitivity of the equipment used (RIFT-3) was 10-30 ng/m^3, the lower level of detectability of mercury in the atmosphere being ng/m^3. Measurement of the atmospheric concentration of mercury was made every two minutes, which corresponds to a distance of around 370m at the ship's

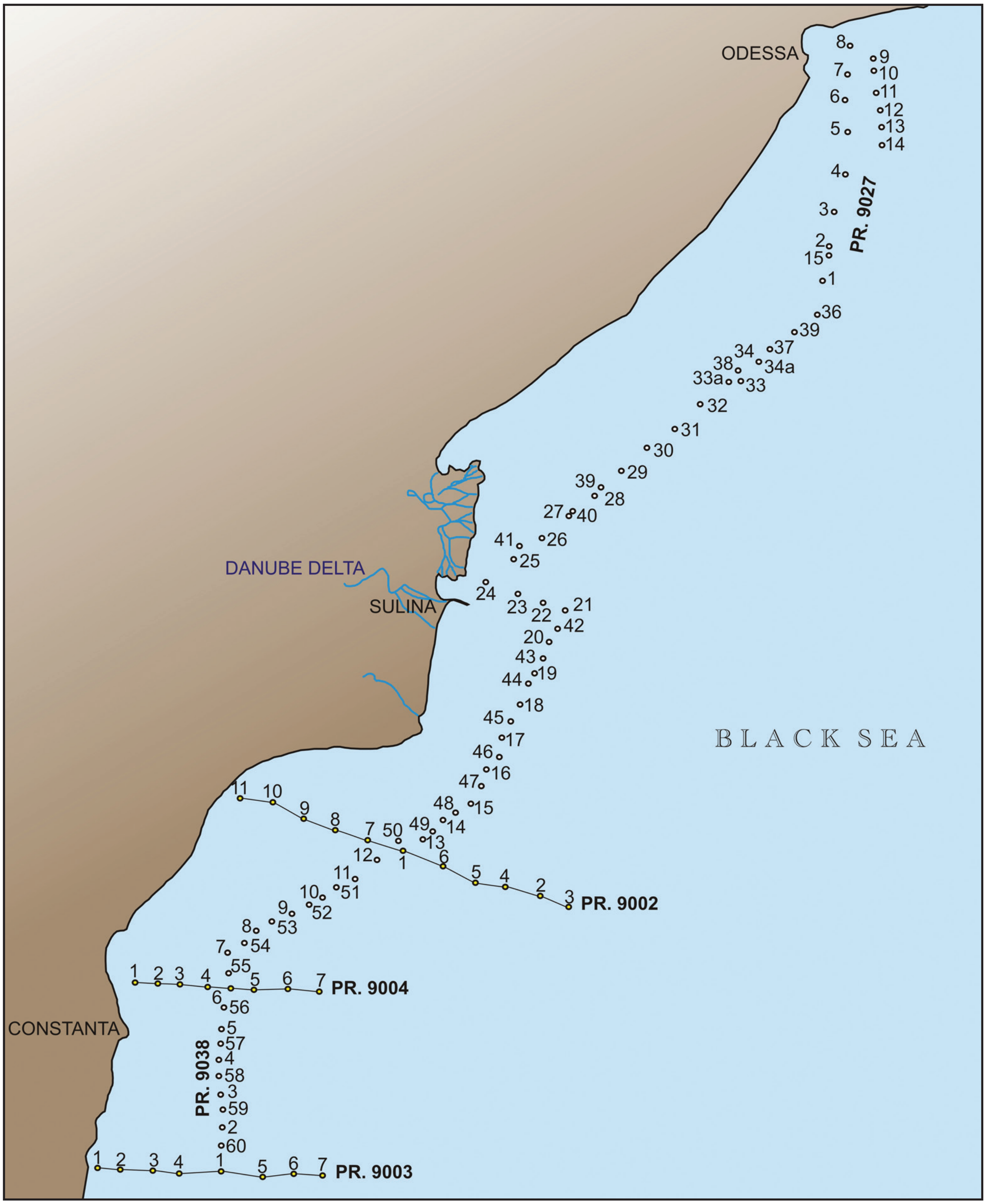

Fig. 1 Route of geoecomonitoring profiles undertaken in the western area of the Black Sea.

average speed of 6 knots. Numerous corrections were made during data processing.

The method for calculating the effective strength of the earth's magnetic field (EIEMPZ) was devised by prof. A.A. Vorobiov.

All rocks containing dielectric materials, or capillaries containing electrolytes, when exposed to pressure, generate impulses in the electromagnetic field proportionate in frequency and amplitude to the pressures undergone by the geological formations in question. Various geodynamic phenomena (earthquakes, landslides etc.) may be predicted using these methods. A radio wave receiver (SRP-2) and RVIND-II recorder were used. The research was undertaken continuously. After applying some correction factors, some anomalous zones were observed in the earth's magnetic field (both positive and negative) on the profiles surveyed.

Bathymetric methods consisted of continuous cerograph recording of the profile of the sea floor using a GEL-3 echo-sounder, the accuracy of these measurements being to within 0.5 m at the survey depth of 10-70 m.

Biogeophysical prospecting techniques were based on the sensitivity of some individuals to certain 'bio-perturbing' geological bodies (those inducing bioenergetic anomalies) found underground or at the bottom of the sea (Simu, 1939; Svoronos, 1983). This action is known as dowsing, radiestesia, biodetection, the biophysical effect or biogeophysical prospecting.

These physical perceptions are reflected through the reaction of certain specialised instruments of differing appearance, which are held in the operator's hands: L-shaped frames, a bifurcated Y-shaped steel rod, a vertical pendulum, a horizontal pendulum etc.

Fig. 2 shows typical reactions of the three instruments used, as the operator passes over a source (S) at depth (h). The source (S) emits a specific beam of energy in the vertical plane. Laterally, a weaker 'proximity' radiation may be detected, incident with the horizontal surface of the earth, at an angle, a, of 45 - 60°. In the first case (a =45°), applicable where the land is relatively homogeneous, distances 1-2 (l_1) and 3-4 (l_2) are equal to the lower and upper depths of the source. The difference between the positions of the sun in the sky is also a factor.

Operators' reactions to different sources of radiation are individual. A personal 'calibration' is thus indispensable (Caraivan, 1990, 1994, Caraivan *et al.*, 1996). The author has recorded the following reactions from the rod when passing it over a source (S), from left to right, towards the sun (Fig. 2):

1) Before reaching point 1:
- The rod, held with the palms facing downwards, remains in a horizontal position, pointing ahead.
- The L frames are parallel, pointing forwards.
- The pendulum is immobile

2) Between points 1 and 2:
- The rod is pointing downwards, at 90°, a point reached immediately following point 1.
- The L frames cross at an angle of 90°.
- The pendulum oscillates in a plane perpendicular to the edge of the source.

3) In the interval 2' -2:
- The rod tends to return slowly to the horizontal.
- The L frames cross at an angle of between 90° and 180°.
- The pendulum alters its plane of oscillation, from the left, oscillating in a plane parallel to the edge of the source.

4) Between points 2 and 3, above the source:
- The rod performs rotations specific to the source.
- The L frames become parallel (180°), with their tips pointing together.
- The pendulum rotates in a clockwise or anti-clockwise direction according to the energy characteristics of the source. Thus, an anti-clockwise rotation of the pendulum indicates areas of reduced mass (*e.g.* evaporite bodies, karstic voids, cavities, suffusions holes etc.)

5) In the interval 3 -3':
- The rod ceases its rotation, returning to the horizontal.
- The L frames cross at an angle of between 180° and 90°.
- The pendulum's rotation ceases, decaying to an oscillation parallel to the edge of the source.

6) In the interval 3' - 4:
- The rod returns to the -90° position, vertical, pointing downward.
- The L frames are crossed at 90°, with their tips pointing forwards.
- The pendulum alters its plane of oscillation, from the left, oscillating in a plane perpendicular to the edge of the source.

7) After passing point 4:
- The rod returns to the horizontal.
- The L frames become parallel once more, with their tips pointing forwards.
- The pendulum is inert.
- Calibration of the biogeophysical signal.

Each biogeophysical operator must 'calibrate' his own reactions (through the instruments used), relative to different sources, thus arriving at the definition of a set of personal reactions. In order to appreciate the qualities of biogeophysical sources, the operator calibrates the reactions of the rod (held with palms facing downward) to different samples, both in the laboratory and in the field, under controlled conditions.

The author has thus recorded the following reactions from the rod when passing it over a variety of sources, as follow:

One rotation, plus 60°	pyrites
One rotation, plus 150°	crystalline salt
One rotation, plus 210°	brown coal
One rotation, plus 240°	lignite
One rotation, plus 270°	graphite
Two rotations, plus 270°	subterranean cavities
Two rotations, plus 300°	filled land
Three rotations plus 270°	iron
Three rotations, plus 300°	brass, bronze, aluminium
Three rotations, plus 330°	copper
Four rotations	uranium
Four rotations, plus 150°	lead
Four rotations, plus 120°	gold
Five rotations	liquid hydrocarbons
Seven rotations	gaseous hydrocarbons
Continuous rotations	water, faults

Biogeophysical prospecting should be conducted specifically to, or with reference to the orientation of the profile, state of the weather, time (day/night) and the 'condition' of the operator (feding). The operator records the reactions of the biogeophysical apparatus, noting the coordinates at which they occur. The biogeophysical data is then added to a map, at a convenient scale, to produce an image of the distribution of the biogeophysical signal in the zone in question, containing: The contour outline of the source, its quality and sometimes its depth.

The problem of depth must be tackled with great attention and prudence. Any buried source emits a sphere of radiation, which is sectioned by the earth's surface. Thus, a zone of weaker signal will be recorded surrounding the primary radiation cone from the source. The angle may vary from 45° (in homogenous land) to c. 25 - 30°, depending on the geological structure (Fig. 2). In general, the depth of a biogeophysical source can be estimated on the ground as being equal to up to double the length of segments 1 of Fig. 2 (h=1×ctg a).

With an end to obtaining a better appreciation of the depth of biogeophysical sources, supplementary measurements must be taken, in known geological conditions, in order to determine the correlation coefficient.

3. RESULTS AND DISCUSSION

The complex data obtained from all adopted working methods are shown in the graphs in Fig. 3-5. The horizontal scale used for representation of the bathymetric profiles is 1:500 000, while the vertical is 1:1000.

Major physiographical units The Odessa bank, Bug plateau and Prut, Dniester and Sarata paleovalleys are for the most point, tectonic divisions

Regional faults in evidence on dry land (Sf. Gheorghe, Odessa, Capidava-Ovidiu, Pecineaga-Camena and others) continue in the marine environment, being marked by microforms of negative and positive relief and with a deformation to the seabed measurable in metres (Fig. 3-5).

The graphs showing bathymetric profiles also show the data obtained using the other three research methods: The real strength of the earth's electromagnetic field (EIEMPZ);

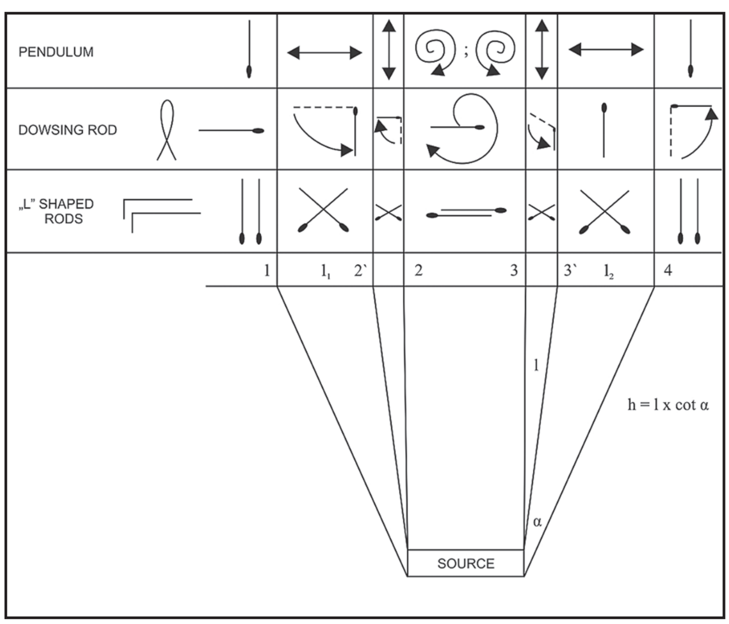

Fig. 2 The specific reactions of each tool used (explanation, see text)

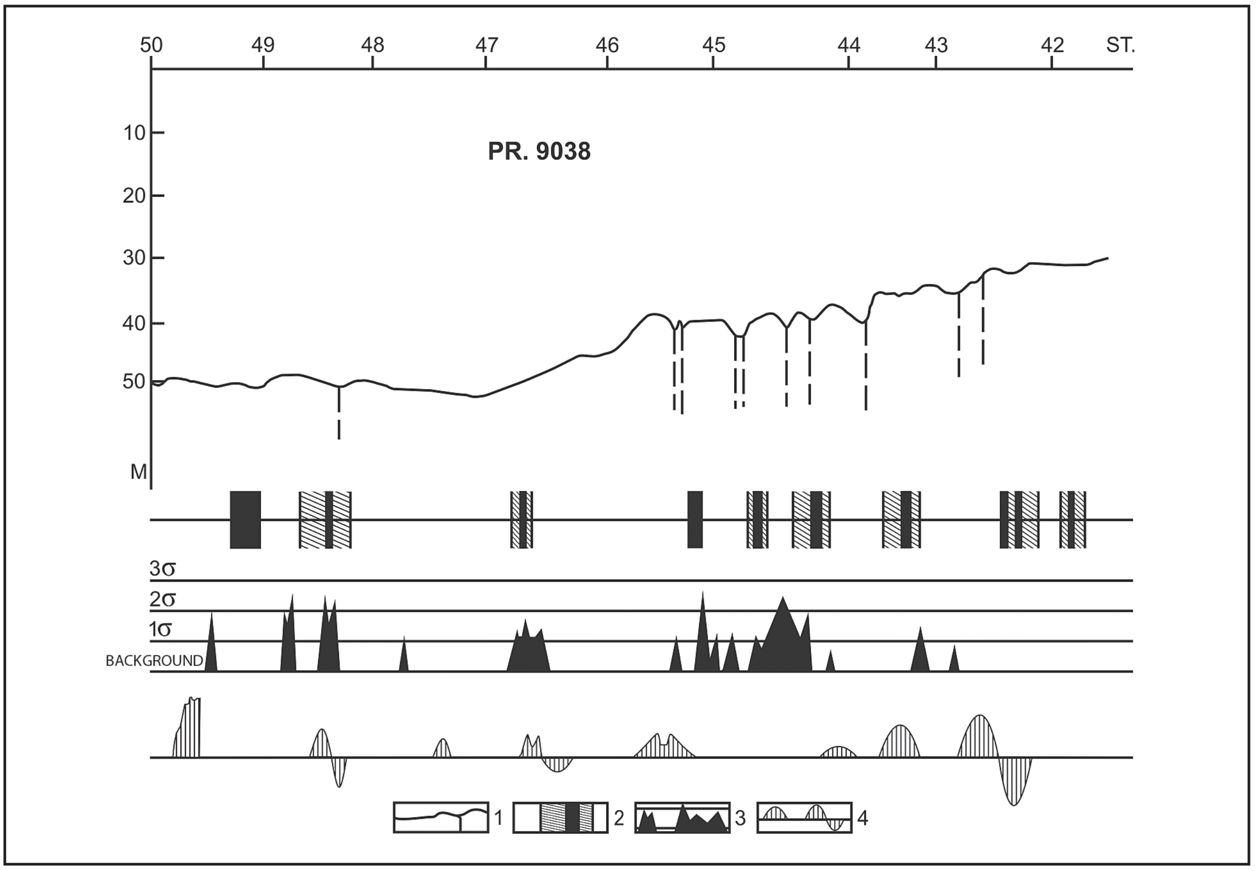

Fig. 3 Comparative data for the methods used (profile 9038). **1** – bathymetric profiles and tectonic impacts, echosounder data; **2** – anomalous zones, biogeophysical data; **3** – anomalous concentrations of mercury in the atmosphere; **4** – anomalies in the earth's electromagnetic field.

level of mercury in the air (VGRS); biogeophysical anomalies. It may be stated that tectonic dislocations appearing in the bathymetric profile are accompanied by geochemical, geophysical and biogeophysical anomalies.

Unfortunately, the methods mentioned here could not be used continually. Of the 1,570 km covered, the bathymetric profile was recorded over 1,545 km, biogeophysical readings over 1,245 km, atmospheric mercury over 460 km and the earth's magnetic field over 220 km. This fact reduces the possibility of comparison of results. Nevertheless, certain conclusions may be drawn. Thus, the bathymetric records identified 51 relief features, the biogeophysical survey 37 faults, the atmospheric mercury readings 34 anomalies and the EIEMPZ method 16 anomalies.

However, a coincidence was noted (to within one km of the fault locations identified by the 4 methods) in 6 out of 21 cases (29%) in relation to all faults identified, or in 6 out of 10 cases (60%) in relation to the bathymetric data. The coincidence of data for three and four methods is 20 out of 48 (41.6%), and 20 out of 28 (71%) respectively, in relation to the bathymetric data. The coincidence of data for two methods is 46 out of 77 (59.7%), or 46 out of 51 (90%). The most striking correlation, that between the biogeophysical and bathymetric data (86.5%), cannot be chance.

Fig. 3-5 show the profiles, along which all four methods were used, to a greater extent, simultaneously. For example, in profile 9038 (Figs 2, 3), in the vicinity of the St. George fault (station 45), the following were detected: An uneven submarine relief feature with troughs and peaks; anomalies in the biogeophysical and electromagnetic fields. Between stations 48 and 49 the deep Frunze-Artaz fault was encountered. This is also featured on profile 9002, between stations 1 and 6 (Fig. 5).

4. CONCLUSIONS

The close correlation between results derived from the four different methods, with such diverse analysis parameters, presupposes a common denominator. Thus, the fault planes constitute transmission paths for emanations from the earth's mantle to the surface, generate anomalies in the earth's magnetic field, cause biogeophysical anomalies (bioperturbations) and are reflected in the microrelief of the seafloor.

The collective use of these methods offers possible solutions to certain problems of geological cartography and the identification of submarine mineral resources. It would even be possible to build a theoretical model relating to the mechanisms of biogeophysical methods, with an end to broadening their application.

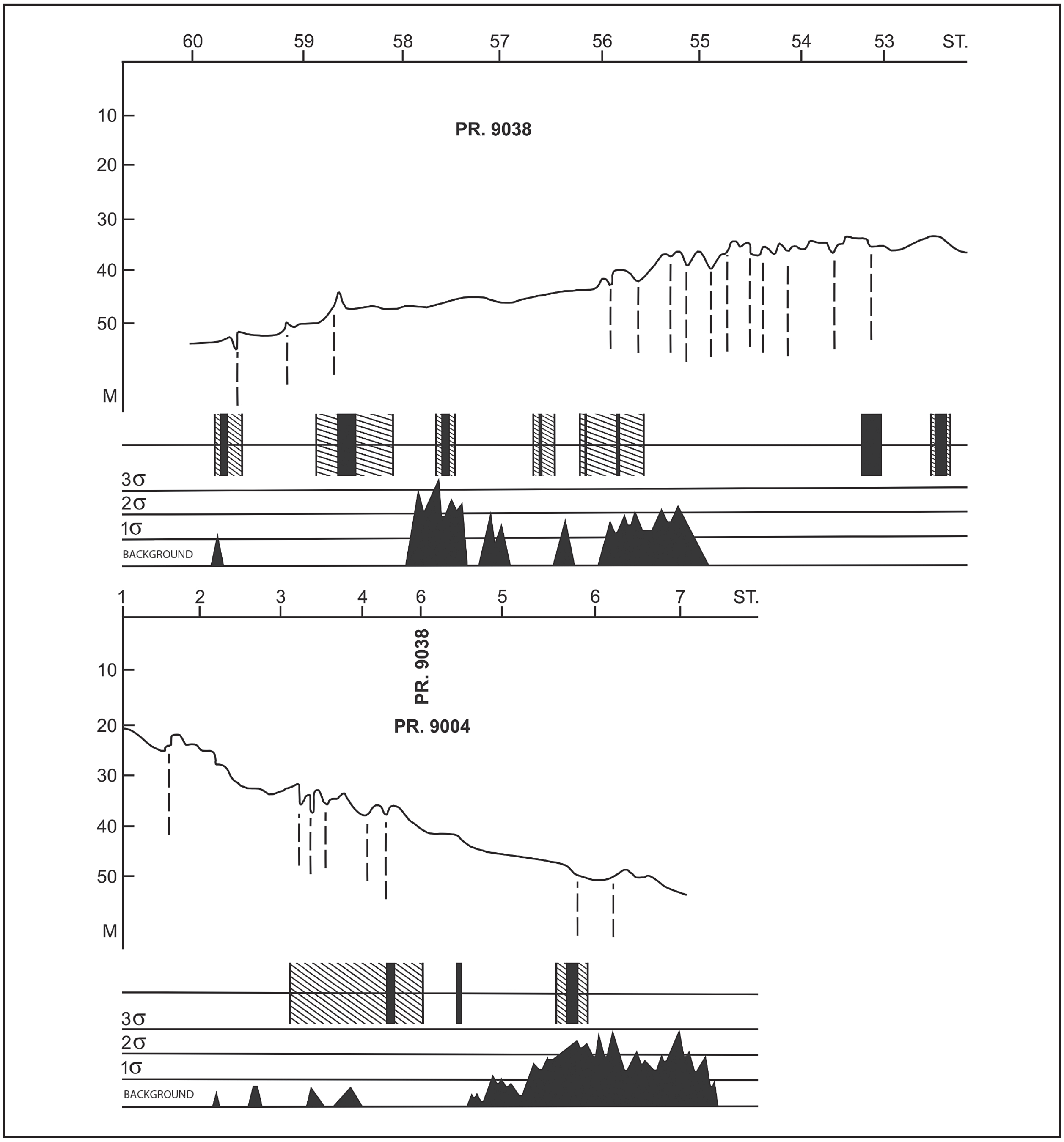

Fig. 4 Comparative data for the methods used (profiles 9038 and 9004). Legend as in fig. 3.

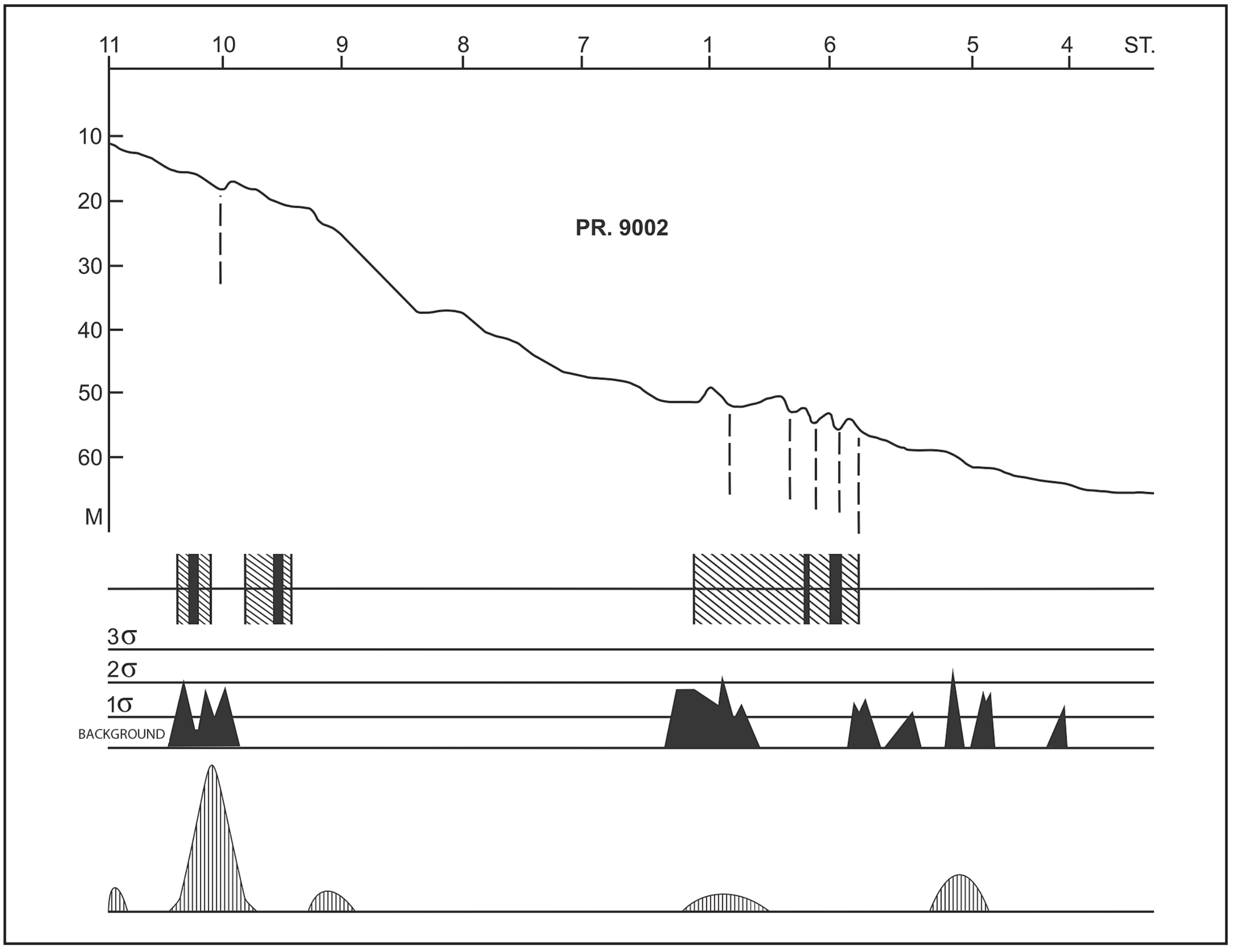

Fig. 5 Comparative data for the methods used (9002). Legend as in fig. 3.

REFERENCES

Caraivan Gl. 1990. Cercetări de biolocaţie. Rezultatele preliminare ale expediţiei comune româno-sovietice în partea de nord-vest a Mării Negre. Arhiva I.G.R.

Caraivan Gl. 1994. Report concerning the activity performed on board *RN* Mirfak. Contract no. 94.29.29. ENTERPRISE Oil Exploration Ltd. Archive S.C. Gera, Constanţa.

Caraivan Gl., Sisman Maria, Tambrea Dorina, Carp V. 1996. Offshore biogeophysical prospection versus geological and geophysical data in the western part of the Black Sea shelf. *I.G.R. Annual*, vol. **69**, suppl. no. 1, p. 48-51.

Simu S., 1939. Bagheta unghiulară. Editura Atheneu. Bucharest.

Svoronos D. 1983. Biogeofizica, instrument de lucru în inventarierea subsolului. *Bull. de Inf. Şt. şi tehnică*, **III**, I.G.G., Bucharest.