استخدام تقنية المسح الجيوكهربائي عالية السماحية في الكشف المباشر عن الهيدروكربون على مثال حقل أبو رباح- سورية

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ملخص

تبين من خلال تطبيق تقنية المسح الجيوكهربائي عالية السماحية في حقل أبو رباح ، حسب معطيات طريقة **الكمون المحرض**، ظهور شواذ عكست مساحة إجمالية لمناطق الأمل تصل إلى أكثر من 125 كم² وذلك طبقا" لمعطيات طريقة تثبيت الحقل الكهرطيسي مع استعمال تأثيرالحقل الكهروسيزمي الثانوي، وبتوافق مع شاذ باراميتر الكمون المحرض مع المحدبات,حسب معطيات طريقة المسح الجيوكهربائي مع **الكمون التحريضي**.

سمحت لنا هذه التقنية بالحصول على معطيات جديدة هامة.فقد أمكن تحديد عمق توضع الهيدروكربون من خلال طبيعة شواذ باراميتر الكمون المحرض وأن التشبع في حقل أبو رباح هو غازي, والأهم من هذا هو تحديد عمق التوضع الذي قدربحدود 3000م و أبعاده التي نوقشت وحددت في ضوءتفسير النتائج .

مفتاح الكلمات: تقنية جيوكهربائية عالية السماحية, الكشف المباشر عن الهيدروكربون , حقل أبو رباح – سورية .

Introduction

The study examines the results of electrical works by the methods of sensing electromagnetic field formation (SEFF) in the near-zone using the secondary seismic electrical effect,IIP method and IP method in the region of Homs (experimental site Abu-Rabah).

First, the geologists used the traditional methods of geological survey (Krenke).In 1924-1941 he conducted the investigations of formation of Syria. In 1930-1933 L.Dubertret has compiled a geological map of Syria and Lebanon in a scale of 1:100,000,which shown all the formations of studied region. In 1953 C.Safadi conducted the investigations of Al-Daw Basin which has a synclinal form. In 1958-1963, a Soviet geologist V.P.Ponikarov and a group of Soviet specialists have compiled geological maps covering all the territory of Syria in a scale of 1:200,000 and 1:500,500;

then the geologists passed to the use of geophysical methods which gave the positive results. It was a big, major step in the development of seismic methods 2D and 3D. In recent years was developed the horizontal drilling (SPC).

At the present time a new technology- high-resolution electrical prospecting is used for direct exploration of hydrocarbons (Horizon group co.and Soliton).The use of electrical methods for direct exploration of oil and gas allow to reduce the time and the expenses on the stage of forecast of oil and gas at least 50-60% in comparison with application of traditional methods and methodologies.

A new technology was used at the experimental site of Abu-Rabah.The biggest oil companies including Shell,Al-Furat,SPC,GPC are interested in this site. The research carried out in this site gave the positive results. Based on the results of research, it was decided to carry out the additional studies in Abu-Rabah and in other parts of Syria.

The integrated electrical works, including the methods of IP, SEFF-SSEE and SEFF-IIP,carried out in the volume of 2 profiles, total length of 24 km. Additionally worked out a control profile, a length of 6.0 km.

2.Studied area.

The studied area is the oil field of Abu-Rabah. This field is located in the south-east of the city of Homs at a distance of 54 km.,and in the north-east of Al-Faid,at a distance of 23 km. Its coordinates are 37 15 31.2 E,34 29 31.6 N-37 13 28. 6 E,34 28 24.2 N(Fig.1).

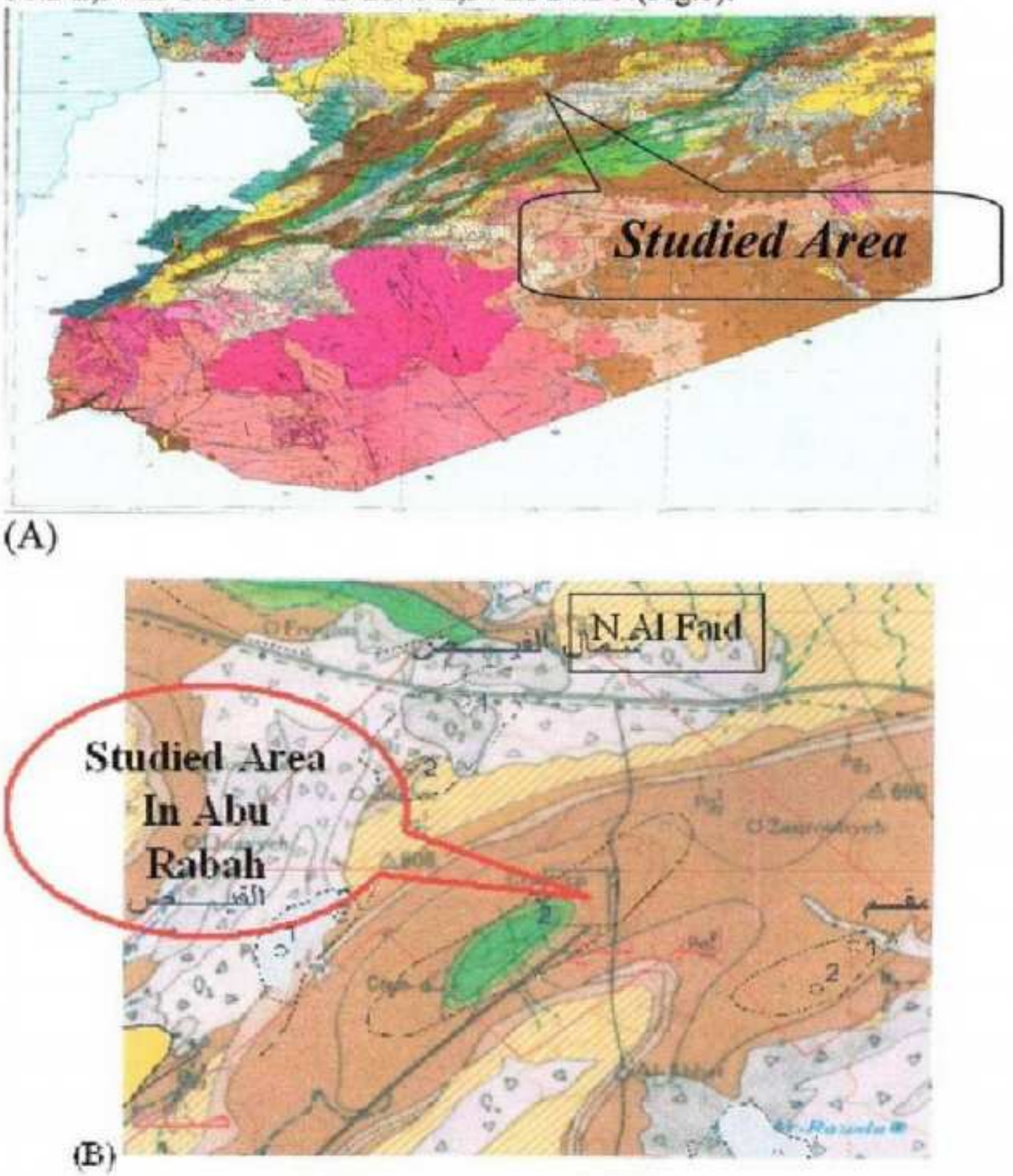


Figure 1: A-Localization of the studied area on the map of Syria, B-Geological map of the studied area.

The structure of this area is clearly shown on the time map as an anticline of 24 to 7 km.long.(Fig.2).
Two faults were identified in the north-east and south-east which divide them into two blocks. The first block is in the north- west and the second block is in the south-east.
This area was the object of general petroleum and sedimentary studies(SPC). Many wells have been drilling in this area for which the lithologic columns are identified.(Fig.3).
The principal formations are: Butman,K.A,K.D.
All formations are increasing in the direction of N.Al Faid.
The specific nature of anomaly of IP parameter indicates that in the region of Abu-Rabah we are dealing with pure gas reservoir. The analysis of the materials was shown that we can conduct additional research determining the accuracy of the forecast of oil production with using of a new technology. The use of a new technology gave the good results in comparison with application of traditional methods .In the study we showed the results of research carried out in this field.

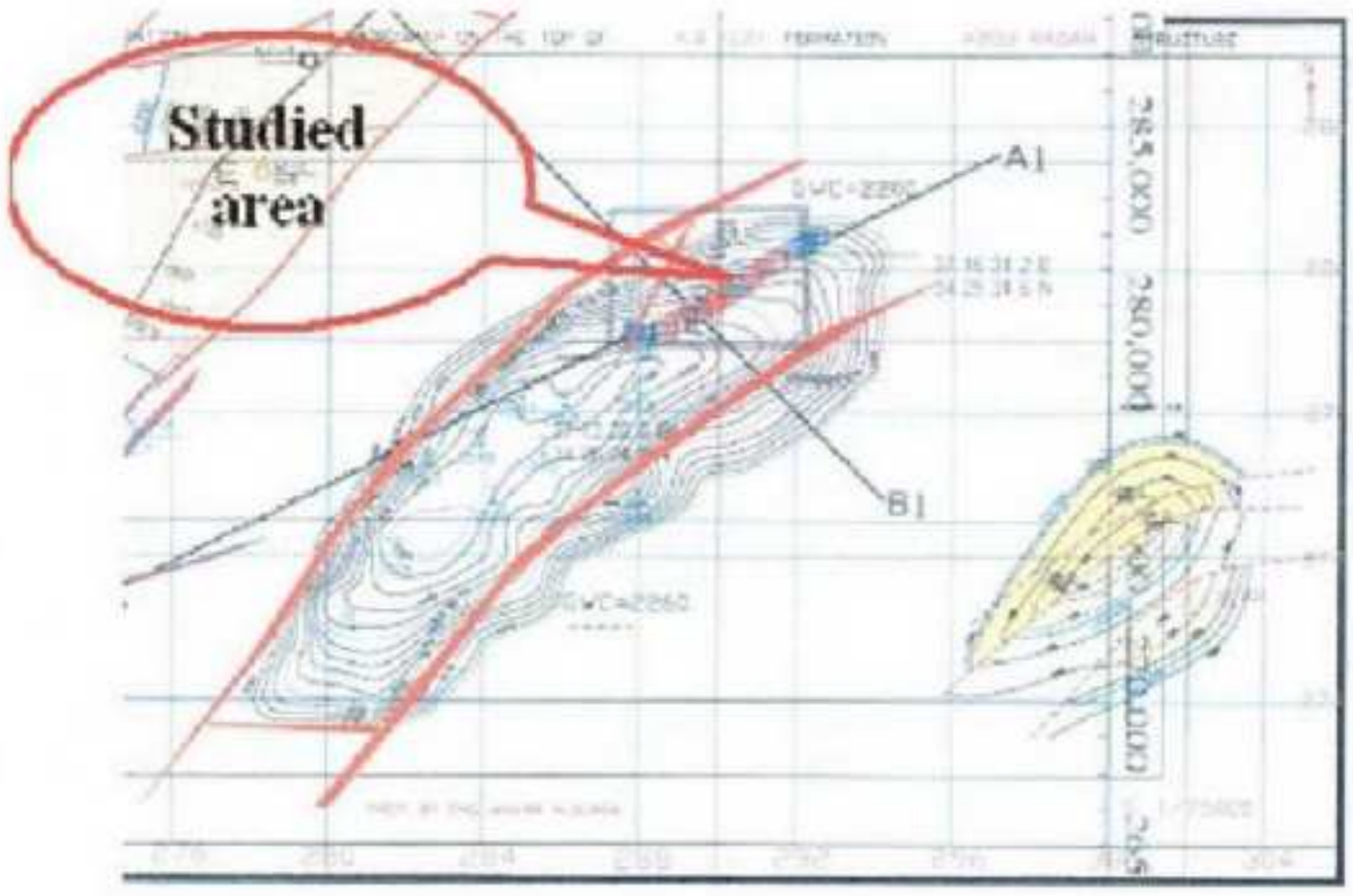


Figure 2.Time-map of formation of Abu-Rabah.

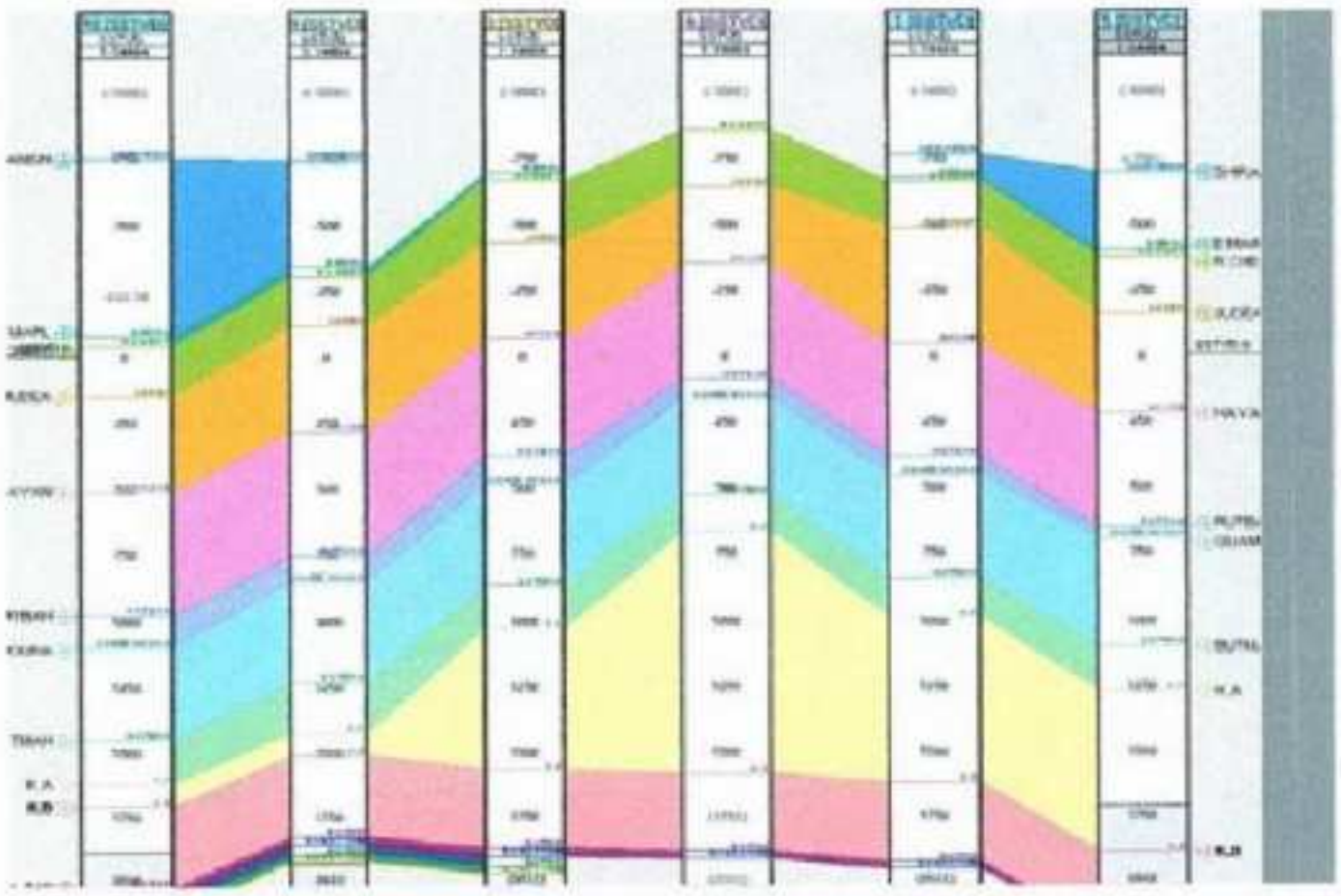


Figure 3.Lithologic columns of well of Abu-Rabah.

3.Methodology and aim of the study.(Direct exploration of hydrocarbons):

For direct exploration of hydrocarbon deposits is applied a new technology which consists in three independent electrical methods (IP,SEFF-IIP,SEFF-SSEE).

By the end of the seventies the geophysicists became clear, that the obtaining of information about the geometry of occurrence of geological formations (structural factor) does not lead to serious successes in finding hydrocarbons. Not all the anticlines are found with oil or gas, and vice versa, the hydrocarbon deposits were found in other geological forms, even in the synclines. That prompted the appeal to the direct searching for hydrocarbon deposits through observations of effects in the geophysical fields from hydrocarbon deposit (physical factor).

The largest changes in the presence of hydrocarbon deposits in the reservoir arose with specific electric resistance (SER) that predetermined the application of electrical methods.

The application of great number of different electrical methods and techniques, all the same has led to the certain successes. Thanks to the work of Z.D.Kruglova, R.S.Seifullin and V.S.Moiseyev, was able to

show, that hydrocarbon deposits are reliably observed in the field of induced polarization. [2, 3, 8]

Currently, from the set of electrical methods the most reliable and applicable in oil and gas exploration studies is the method of Induced Polarization. Numerous studies have shown, that practically all hydrocarbon deposits observed anomalies in the field of IP. The method studies the relaxation processes, arising in the geological environment after the removal of the electric field, generated through the supply line at the time of a current passing through it. In recent years, thanks to the research of V.S.Moiseyev, was proved a connection between the hydrocarbon deposits and increased pyritization over it in the upper part of the section of 200-400m., regardless of the occurrence depth of hydrocarbon deposits. The studies confirmed and substantiated a lot of previously obtained data on the relationship of IP anomalies with hydrocarbon deposits [8]. But, such anomalies of IP parameter can be caused and by other reasons, often arising in the upper part of the section. IP anomalies may be associated with an increase in power or pockets of clay, humidity in changes breeds, changes in resistivity. For inspecting of identified IP anomalies should have additional information. In the first place, it is integration, both within the electrical methods and with the involvement of data of other methods.

It is useful to note, that the various geophysical methods of search of hydrocarbons are developed and used by authors of more than thirty years.

It was used magnetic survey, gravity survey, thermometry, radiometry, the method of natural electric field, the method of continuous profiling by the resistance, the various methods of SEFF and IP including DNM (differential – normalized IP method, the founders -N.I.Ryhlinsky, V.P.Bubnov, P.J.Legejdo).

It is curious to give the results of comparison of electrical prospecting by IP method in the different modifications- „ classical" IP, DNM and SEFF-IIP on Golitsinski deposit.(Fig.4).

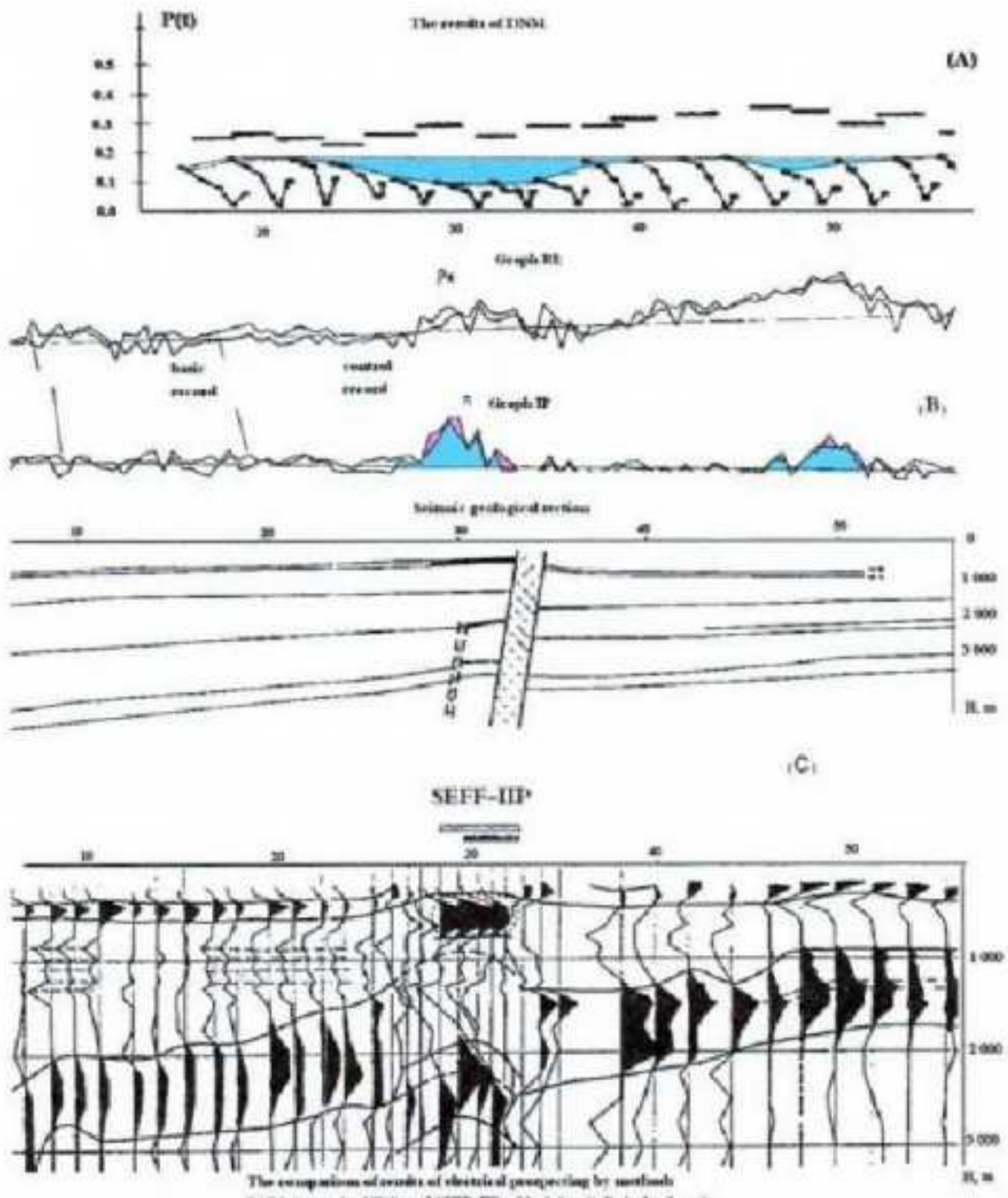


Fig. 4. The comparison of results of electrical prospecting by technique of DNM (A), standard IP (B) and SEFF -IIP (C), the Black Sea, Golitsinski deposit.

As seen from the given drawing: all three IP modifications note the drilled hydrocarbon deposit in the district of pickets 29-33.

Except the drilled hydrocarbon deposit, by all three modifications of IP is noted less intensive anomaly of IP parameter on the pickets 47-51.

But, only modification of SEFF-IIP allows to assess the occurrence depth of hydrocarbons – the first deposit is about 500 metres and the second is about 2 200 metres. (The high-amplitude oscillations are in the zone of pickets 29-33 and in the depth interval 500 - 700 metres, and 2 200 -2 500 metres). The anomaly according to IP method and

DNM on the pickets 47-51 in the parameters of SEFF-IIP almost not reflected. With share of excessive optimism may be noted only certain increase in the amplitude of oscillations at depths of 1 200 – 1 700 metres.

The data of other methods are less informative and stable.

Thus, IP method is one of the most promising geophysical methods for the direct prediction of existence of hydrocarbon deposits in the section.

Based on experimental studies was found that the process of formation of the electric field is accompanied at least by two types of oscillations. They are relatively low-frequency oscillations.0.2-0.5Hz) diffluent with time and more high-frequencies (5-2500Hz) with a practical conservation of frequency of the total time of registration to 10-15sec. It was theoretically proved that the first kind of oscillations caused by effect of Induction Induced Polarization (IIP). The amplitude of the oscillations is proportional to the ratio of polarization.

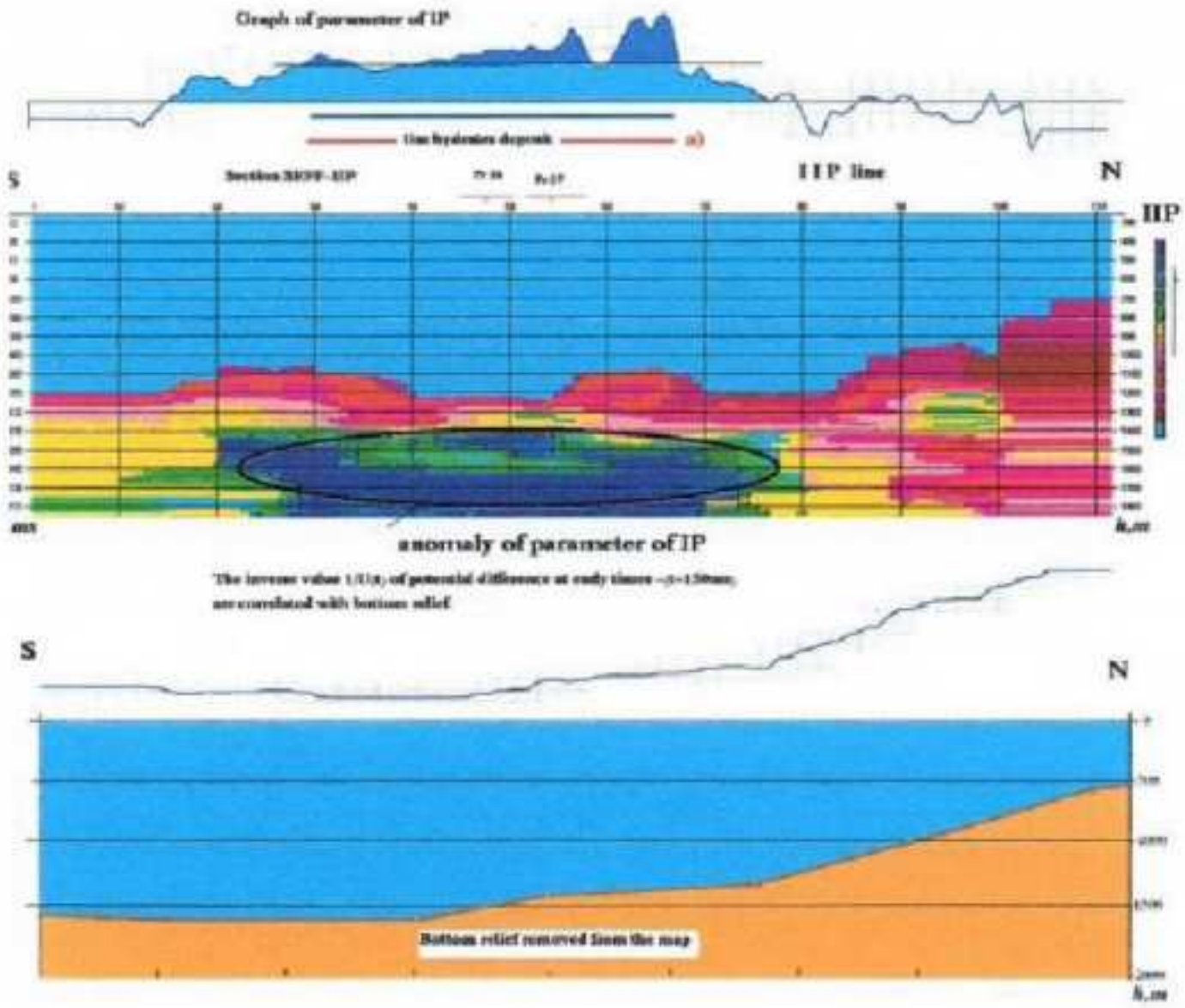


Fig. 5. Allocation of IIP effect on gas-hydrates deposit from Russia.

The fact that hydrocarbon deposit has the higher polarizability, in comparison with host rocks is shown by V.A.Sidorov on experiments with samples [9].
The same results are obtained by V.C. Moiseev directly in the productive and empty wells.
Here is one example of allocation of effect of IIP in "a pure kind" in studies of gas hydrates-GH, installed on the sea, within the slope, adjacent with Kerch-Tamansk shelf, according to seismic acoustic data and the selection of soil.(Fig.5).
GH deposit is almost located at the bottom of the sea at depths of 1000 -1500 m, i.e. only the water column, obviously, not containing, the accumulations of pyrite is located above it. The studies have clearly shown a manifestation of gas-hydrates in the effects of IIP (A.G. Nebrat, V.V.Sochelnikov).
Thus, the anomaly of IIP-it is an effect of induction induced polarization of hydrocarbon deposit. The successful allocation of this very weak effect allows us to position the hydrocarbon deposit in terms of size and depth.
The second type of oscillations is due to the secondary seismic electrical effect. The application of second type of oscillations allowed to create the technology of SEFF-SSEE.
Diffusing electromagnetic field created with the help of the supply line reacts with the geoelectric heterogeneous geological environment. Electromagnetic field affects cations and anions which are always shown into liquid, bring them in motion. In the presence of rather thin and water content layers in particular characteristic of the breaks of sedimentation, it is a very tangible electrical seismic effect known to science. In turn, electrical seismic effect causes seismo electrical effect, electric field of which is measured on the receiving line.
Such is the mechanism formation of oscillations on the curve of formation of the field.
Thus, for direct prospecting and exploration for hydrocarbon deposits is proposed lightweight, mobile set of IP methods, SEFF-IIP and SEFF-SSEE.
The works by these three methods are simultaneously carried out in a single technological cycle.
1. IP standard method allows to obtain information on the presence or absence of hydrocarbon deposits in terms without reference to the depth.

2.Methods of SEFF-SSEE allow to obtain information on the presence of hydrocarbon deposits with reference to the depth. (Authors-Nebrat A.G.,Sochelnikov V.V.)

3. Methods of SEFF-IIP allow to get temporary geoelectric sections and to study the structural plan of deposits.

As an example the results of integrated geoelectric studies at one of the largest fields of Krasnodar territory, located on the shore of the Sea of Azov, directly near of a studied area. As seen from the figure, on the curve of IP parameter is closely marked the contour of hydrocarbon deposit, drilled by several tens of wells.(Fig.6).

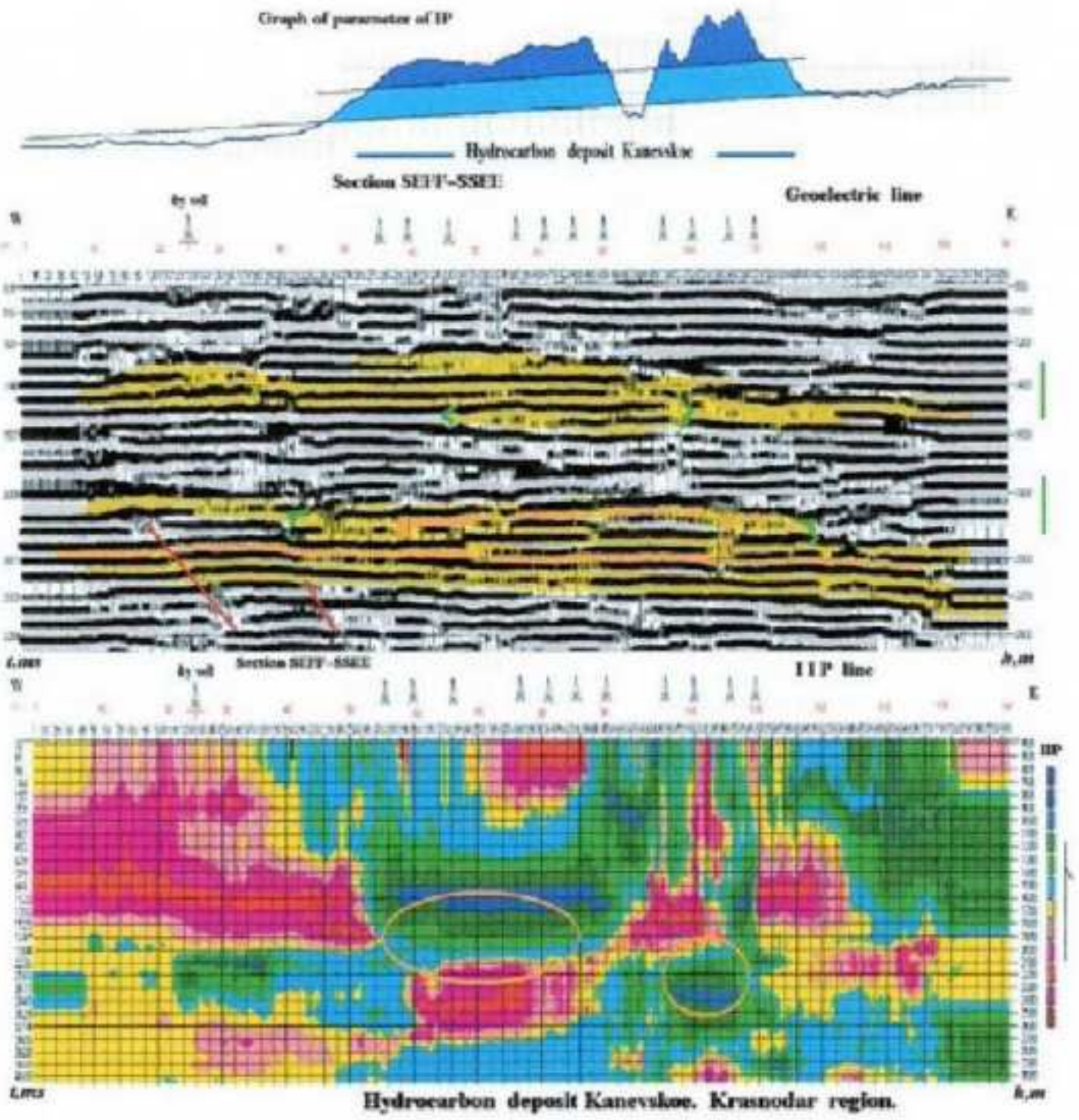
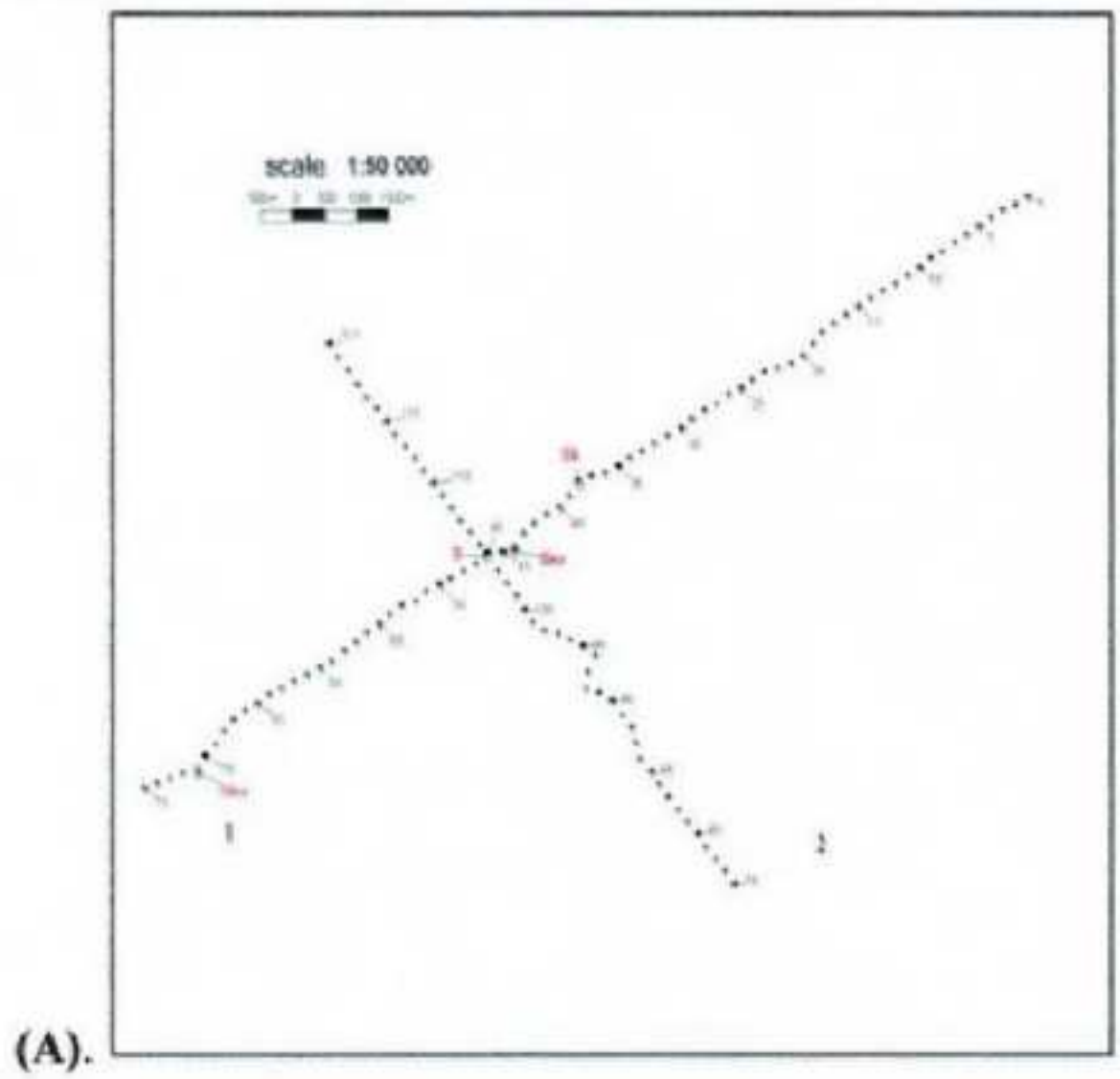
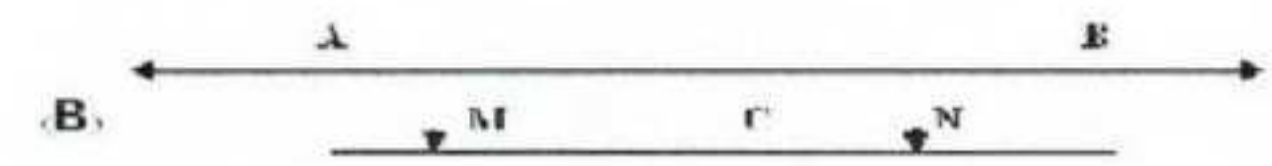


Fig. 6. Example of efficiency of the complex of electrical methods – IP, SEFF-SSEE and SEFF-IIP on "Standard" - deposit.

Below IP curve is located the temporal geoelectric section, which allows to assess the traps for hydrocarbon deposit. In this case the anticlinal hinge at depths of 1300- 1900 metres is marked. Where, as is known for drilling data, several hydrocarbon deposits are located. The data of SEFF-IIP, presented in the form of section of SEFF-IIP allow to evaluate both in terms and depth the location of hydrocarbon deposits. The anomaly of parameter of SEFF-IIP is located at an interval of 1 250 to 1 800 metres, which coincides in terms with anomaly of IP parameter, received according to the IP method and by anticlinal hinge, allocated according to the method of SEFF-SSEE.
(In the figure the anomaly of IIP circled and shaded in pink. The different colors indicate different levels of IIP).



(A).



(B).

Figure7: A-Map of geoelectrical profiles in Abu-Rabah. B-Scheme of observations by IP method.

The main aim of integrated electric studies is the direct exploration of hydrocarbons on the work areas.

4.Methods and technique of works IP, SEFF-SSEE, SEFF-IIP

4. 1. Methods of works.

Total was performed 2 profiles, total length of 24 km. Additionally, worked out
a control profile, a length of 6.0 km.(Fig.7)

The cable of 200 metres long is extended along the profile line. The electrodes are grounded. The excitation of electromagnetic field is excited in the radiating antenna of supply line AB. The registration of signals –the response of the geological environment - is produced on the receiving antenna - line MN. One of the possible schemes of observations is given above.

The recording time, for geoelectric conditions of work area, with an average specific electrical resistance of 25 – 30 ohm, and by geological task of study of section to the depths of 4 000 metres was 750 ms. The quantity of accumulation is 160 (5 x 32) impulses on one point.

Every 100 metres by special geophysical equipment is produced the radiation of electromagnetic field, penetrating into the Earth's mass. Its response is recorded on the receiving equipment. One of the possible modes of transmitting station –the mode of current pulses: (Fig.8).

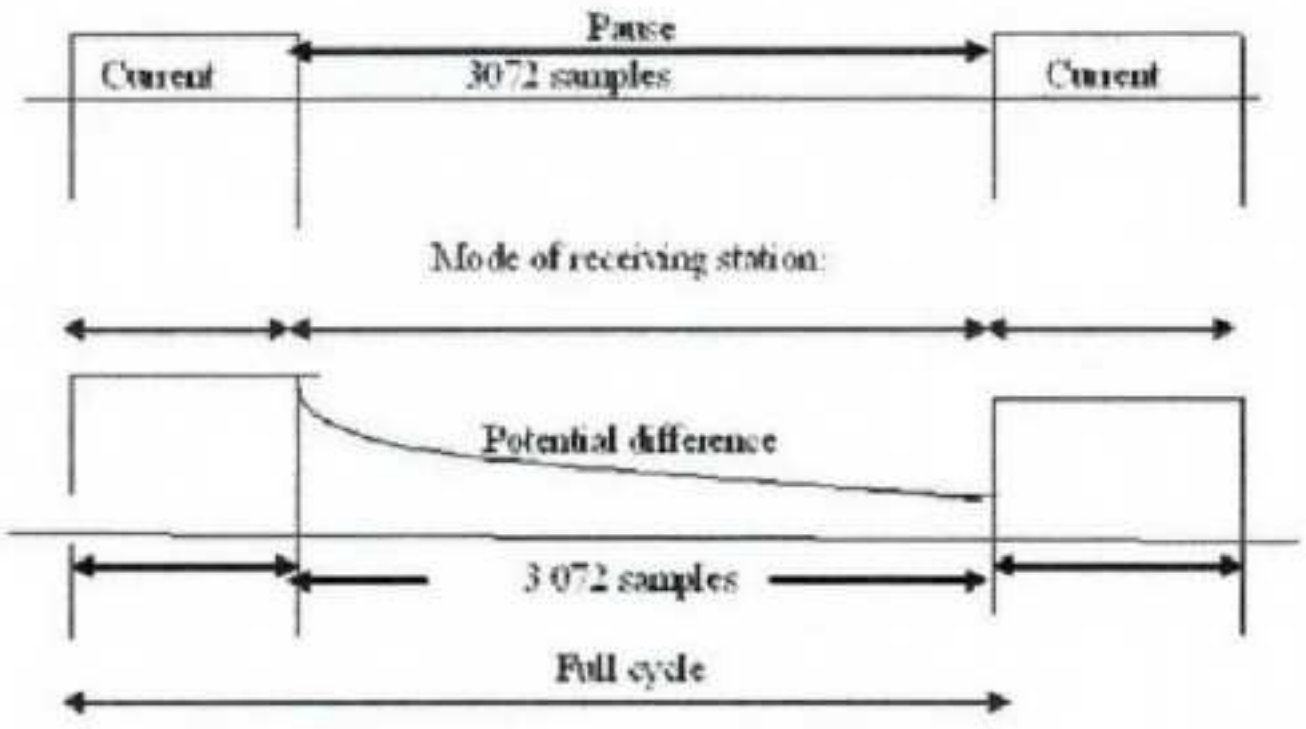


Fig.8. Scheme of work showing the transmitting and reception stations.

4. 2.The apparatus and the equipment.

The registration of information is carried out by electrical station„ELLISS-E",

Main technical characteristics „ELLISS-E'':

1. Number of channels - 2
2. Bandwidth - 0 – 10 000 Hz
3. The limits of measurement - 0.1 μV – 10V
4. The basic error is not worse than 0.5 % at each limit of measurement.

5 Input resistance of the channel is not less than 700 Mohm.

6. Spectral density of intrinsic noises applied to the input of the channel is not more than 20 nV
7. Number binary discharges - 24.

4.3. Parameters of surveillance schemes and registration.

1. Length of the line AB is 200 metres.
2. Installation: symmetric,
3. An interval between the lines of the temporal section is 50 m.
4. Number of channels - 1
5. Recording time is from 750 to 3 000 ms
6. Interval of sample is 0.5-1 ms
7. Estimated depth study of the section is 4 000 (2 500) metres.
8. Signal level-100mV-1μV.

Metrological assurance:

The works carried out in accordance with the Instruction for electrical prospecting. It was applied the digital geoelectric station - "ELLISS-E" (Number of the certificate of conformity № SSGP 01)

Before the field works and in the process of them monthly performed the following tests of parameters of equipment: The linearity of the scale of the measuring channel – the error does not exceed 0.5 %.The stability of a graduation signal - maintained with an error of not more than 0.15%.

The stability of the scale of a measuring current in the supply line is not worse than 0.5 %.

Condition of transmitting and reception spits: checking daily and in addition, after repair, insulation resistance is not worse 10 мohm.The intrinsic polarization of non- polarizable electrodes is not more than 25 mV. The equipment characteristics correspond to the indicated passport data.

4.4. Quality assessment of field data.

The recording is mainly characterized by low level of industrial noises. At the points of intersections the anomalies of IP parameter are well correlated.

Very good correlation of IP parameter between adjacent profiles is also noted.

4. 5. Topographical works:

Geodetic reference of items measurements was carried out by receiver GARMIN (GPS-48) in system WGS-84. The instrumental (relative) accuracy of a reference was 5-10 metres. The absolute accuracy, on the basis of independent definitions of the location on a triangulable point was 7,4 metres.

The necessary accuracy of the reference in the works of twenty five thousand scales – 20 metres – was performed. On the results of definitions the following reporting material were compiled:

1. The table of co-ordinates of the worked profiles in the systems KR-42, WGS-84, rectangular.
2. The table of co-ordinates of the worked pickets.
3. The scheme of the worked profiles of scale 1: 25 000.

5 Processing and interpretation of electrical materials:

The technology of high resolution electrical prospecting allows to study both a geological structure with a temporal geoelectric section, and to allocate the direct effects of the hydrocarbon deposit with reference in terms and depth.

1.Induced polarization method. The processing consists in the allocation of IP anomalies on the profile. For this purpose data obtained-a potential difference, measured on the reception line – are filtered, and normalized on the value of current transmission. Sometimes, where is necessary, the regional background is removed. The criteria of allocation of anomalies are standard, adopted in ore geophysics. This presentation of anomalies is in levels 1, 2, 3 sigma. The value of « sigma» characterizes the average spread of values in the profile. All values of IP parameter exceeding the level «1 sigma» or «2 sigma» are anomalous. The obtained curve changes of IP along the profile are printed.

2. For the convenience of further interpretation usually put them over the temporal geoelectric section (TGES). .TGES is obtained by allocation on the curve of the formation of electromagnetic field concerning of high-frequency (9-95 Hz) oscillations. It is quite complicated procedure of processing, including:

-Data input;
-Preprocessing;
-Filtration (median and arithmetic);
-Frequency filtration (transformation Furhiy);
-Accumulation of results (total section);
-Output on a plotter.

This procedure is completely computerized. The reference to the depth of the horizons, revealed by temporal geoelectric section is carried out by the classical way, adopted in the method of formation of electromagnetic field:

$$H=\sqrt{900 \quad Rk \times t}$$

Where:
H – depth, in metres,
Rk – specific electric resistance (the processing laid down the multi- curves Rk, determined by well logs, located at the site of work),
t - time of formation of electromagnetic field.

Recent works showed that the smaller the spacing AB the better unknown objects are allocated. The main thing is that with decreasing spacing not to degrade the signal to noise ratio.

The results of geophysical interpretation are presented in the report by sets of combined graphs of IP parameter with the sections of SEFF-SSEE and SEFF – IIP for each area of performed works and cards of graphs of IP parameter.

6. Results.

The results of work are presented by following materials:
- The graphs of IP parameter;
- Temporal geoelectric sections- sections of SEFF-SSEE.
- Maps of graphs of IP parameter.

All worked out 24 km of electrical profiles by methods of SEFF-SSEE and IP on the network, consisting of 2 profiles. The carried out work gave an idea of the geological structure of the studied area and allowed to evaluate the distribution of IP anomalies on the area about 125 sq. km.

The results by IP method. The results of studies by IP method are presented in the form of graphs of IP parameter, as well as maps of profiles of IP parameter.In the areas of research identified the anomalous zone of IP parameter of the total area of 125 sq.km.

Unfortunately, profile 1, southwestern part, is not emerged from the zone of deposit, so the anomaly of IP parameter is not closed here. The specific nature of anomaly of IP parameter–a decrease in values on the background indicates that in the region of Abu-Rabah we are dealing with pure gas reservoir.

Similar results were obtained in the gas field in Russia-Beisugskoi deposit and in China-Huabey Province.

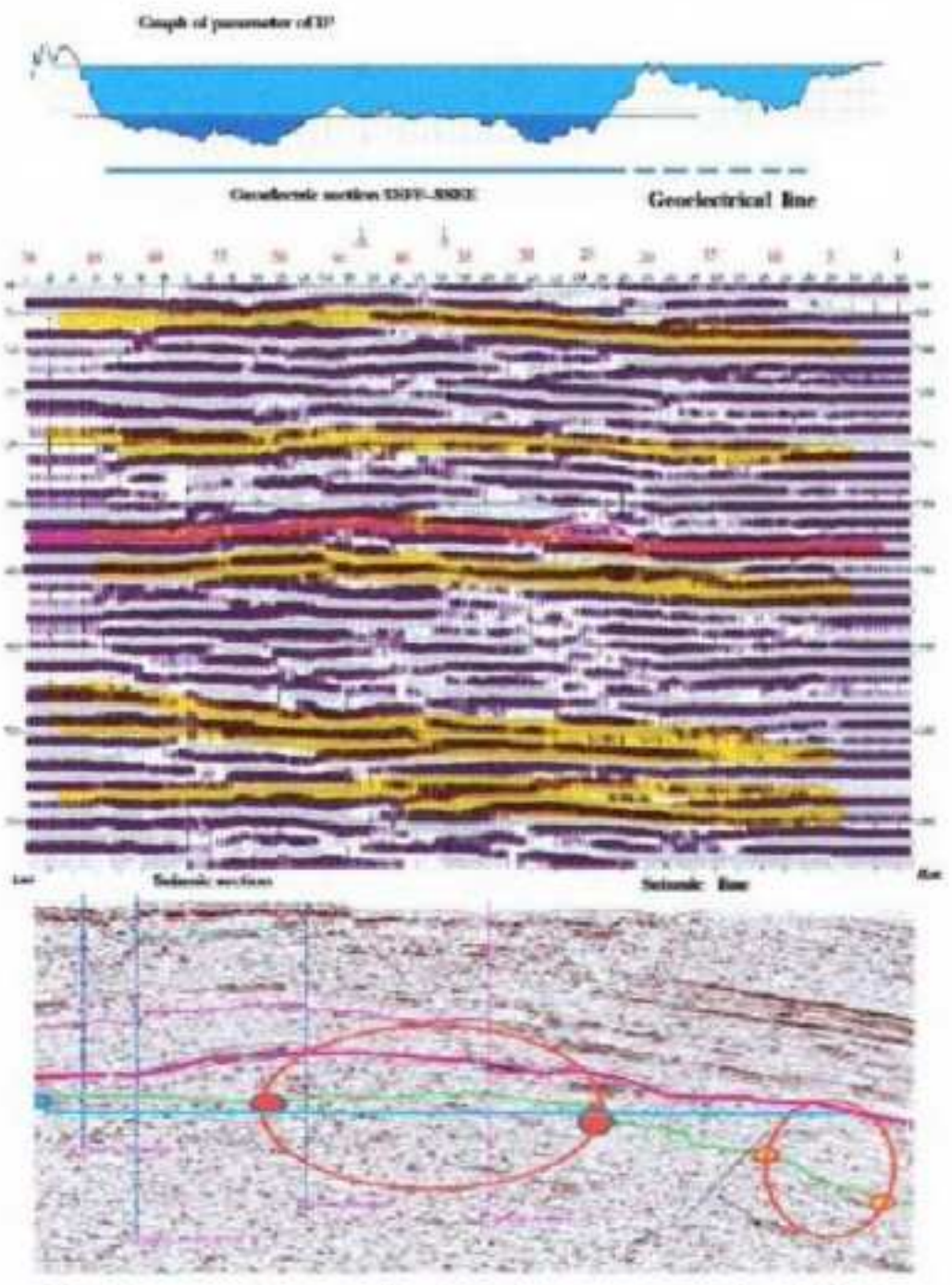


Figure 9. Comparison of seismic and geoelectric temporal sections. Gas field of Abu-Rabah.Syria.

According to the methods of SFEF-SSEE on the temporal geoelectric sections in the depth interval 2000- 3 000 metres is noted a number of elevations. The anticlinal objects are very reliable correlated on profile 1. According to the methods of SEFF-IIP,

received on the second profile, hydrocarbon deposit located in the depth interval 2 000 – 3000 metres. The coincidence of the data of three independent methods indicates the high probability of detection of hydrocarbon deposits here. The comparisons of results of electrical studies with the seismic data are given in figures 9,10,11. In general, there is a very good correlation of geoelectric and seismic horizons.

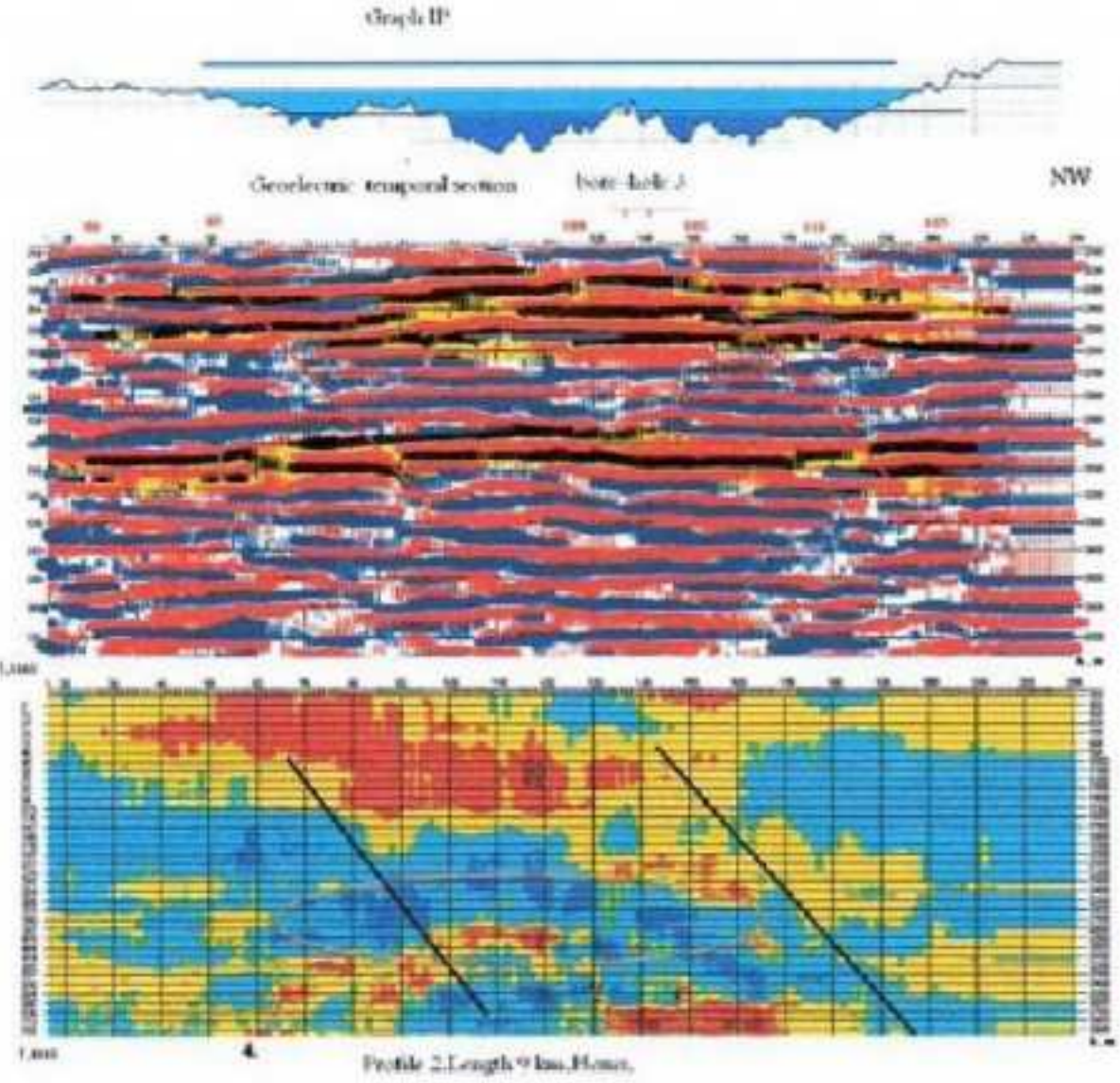


Figure 10. Interpretation of data of geoelectrical method. Abu-Rabah.

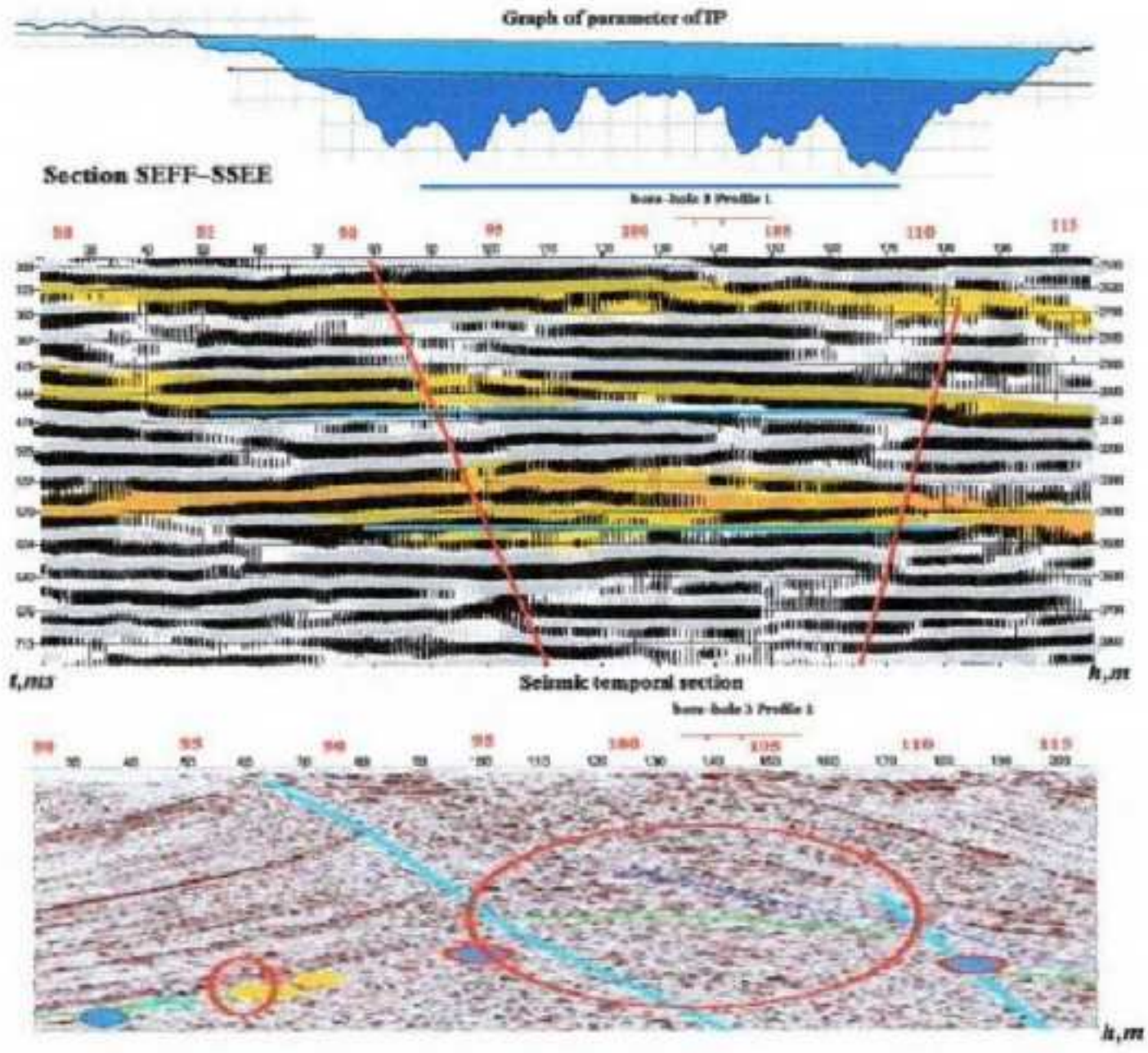


Figure 11. Comparison of seismic and geoelectrical prospecting data.Abu-Rabah.

CONCLUSION

This study using the interpretation of materials of three electrical methods permit to draw the following conclusions:

- The maps of anomalous objects of IP parameter compiled for each of the two areas of performed work.
- The sections of SEFF-IIP, SEFF-SSEE and the graphs of IP parameter prepared on all spent electrical profiles.
- The materials of three methods allowed to allocate the geoelectric heterogeneities (geological objects) in different parts of the studied section, to assess their prospects for oil and gas and the possible nature of hydrocarbon deposits.

- As a result of carried out electrical works according to IP method selected one anomalous object at the site of Abu-Rabah. According

to the methods of SEFF-IIP was evaluated the occurrence depth of hydrocarbon deposit.

- By the nature of anomalies of parameter of IP was established, that the object in the region of Abu-Rabah has the nature of the gas saturation.
- In general showed high efficiency, mobility and cost -effective of technology of high resolution electrical prospecting in the search for hydrocarbon deposits.
- The high resolution technique tested both on land and at sea to a depth of 3000-4000m.
- Application of electrical methods for direct exploration of oil and gas allow to reduce the expenses on the stage of forecast of oil and gas at least 50-60% in comparison with application of traditional methods and methodologies.

- Especially effective is the use in extreme shallow water as well as in other remote for seismic survey places.(Mountains, forests, estuaries etc.).

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Use of high resolution geoelectrical technology for direct exploration of hydrocarbons on the example of Abu-Rabah's field -Syria.

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Abstract

The application of high resolution geoelectrical technology in Abu-Rabah's field shows the anomalies in accordance with the data of IP(Induced Polarization), the total surface of the prospective area is over than 125 sq.km.
This result is based on the methods of SEFF-SSEE, the anomaly of IP parameter in plan coincide with the elevations and also the methods of SEFF-SSEE have permitted to estimate the occurrence depth of hydrocarbon deposit to 3000 m.
By the nature of anomaly of IP parameter it was established, that the object at the site of Abu-Rabah has the nature of gas saturation.

Keywords: high resolution geoelectrical technology , direct exploration of hydrocarbons, Abu-Rabah field-Syria.