P052 NEW ELECTRICAL PROSPECTING FOR OIL. SOME RESULTS

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SUMMARY. Some advantages and problems of a new geoelectrical prospecting method, vertical electric current soundings (VECS) are discussed here. This method is based on using a new source, the circular electric dipole (CED). The source is installed in the following way. One of the transmitter poles is grounded in the central point. The other pole is uniformly grounded around a radius determined by the depth of investigation desired. It can be defined as a noninductive source, generating a transverse magnetic (TM) non-stationary field. The most interesting CED properties in the low frequency regime are as follows. CED has no magnetic field of its own. It is a pure galvanic source, which differs from a loop (a pure inductive source) and from a line, which is both galvanic and inductive (a "line" here means a cable or insulated wire grounded at its end points). The normal magnetic field on the earth's surface is absent (within the quasi-static approximation), and only a radial electric component exists. Taking into consideration the pronounced vertical character of the currents under the central electrode and current circulation in the vertical planes we propose to term the electrical prospecting technique using the CED as the 'vertical electric current soundings method' (VECS). At present, real measurements of the magnetic components with an attached CED-array are the most promising. The authors consider results of the field tests in the Tatarstan (oil pool).

THEORETICAL. So, why CED? The variety of transmitter systems located at the Earth's surface or at any other boundary and formed by wire and grounding segments, can be formally described with the use of the surface density of synchronously varying excitation current. In the general case the field (any component) is represented by two members generated by the **inductive** and **galvanic** modes (H and E fields, H and E modes, TE and TM fields, etc.). These members correspond to two types of transient processes, which contribute to the total field, depending on various properties of the excitation current distribution. The contribution of the TE (**transverse electric**) field is determined by the **rotor** of the excitation current, and that of the TM **(transverse magnetic**) field by the **divergence** of the excitation current.

Explaining the approach developed in this paper, we can say that an ungrounded loop is the purely inductive source generating only a transverse electric field (H mode). Another conventional source - horizontal electric (grounded) dipole is the combined source actually consisting of three sources: a segment of linear current (inductive source) and two point groundings (galvanic sources). Note that because of the more rapidly attenuating TM process the exponential attenuation in a medium (with the insulating base), the horizontal grounded line (combined source) behaves mostly as inductive, particularly in the late stage. This situation is dem-

demonstrated in Fig. 1. This two-uniform physical and mathematical model of electrical prospecting shows:

1) **all traditional electrical prospecting (in time or frequency domain) is founded only on the application of a TE polarized field;**
2) **the electrical prospecting (in time or frequency domain) with the use of a TM field has never been implemented until now.**

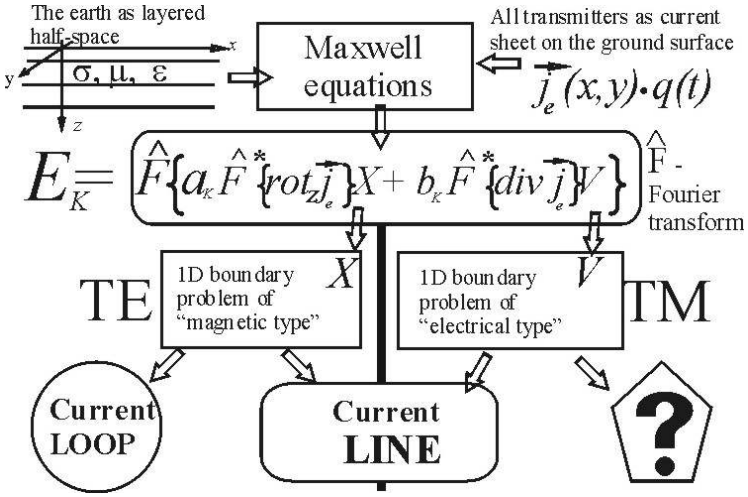

Fig. 1. The physical and mathematical model of induction electrical prospecting

The behavior of an inductive source (loop) and a TE process are well known. The properties of the TM transient process have been poorly studied and little used (in the best case, only in problems of applying a little suited vertical electric line). The most remarkable properties of the field in this process include the absence of the normal (quasi-static) magnetic field at the outer surface of a layered medium, as well as the dependence of the process on the vertical geoelectrical structure (rather than on the overall longitudinal conductivity only, which is typical of the processes excited by inductive means).

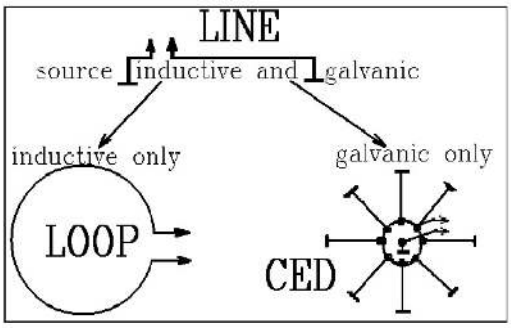

Fig.2.

Now we supplement electrical prospecting, offering to use the TM process. For this purpose first of all it is necessary to offer transmitter, excitating a pure TM field. We should use such allocation of an extraneous current, that

$$rot_z \vec{j}_e(x,y) = 0$$

It is possible to realize by a set of radial currentlines, grounded in the centre and on a circle with a radius determined by the depth of investigation desired. As in Fig. 2. **The circular electric dipole (CED) is the purely galvanic source generating a transverse magnetic non-stationary field** (Mogilatov, 1992, 1996)**.** The CED field is at right angles to the loop field and has azimuthal symmetry. The CED field is always governed by a vertical medium structure (at the latter transient stage as well) rather than by the total longitudinal conductivity. An interesting result was obtained: in marine electrical prospecting a sea water layer will not play such a crucial role when a CED is used as in applying a loop or a line. In a medium

with a non-conducting basement the decay of the CED field is exponential. The transient process is faster than in the case of a loop or a line. The CED can also be considered as a ground analogue of another known source, a vertical electric line. Besides the CED as a pure galvanic source does not excite a long-term transient field. Thus it seems to be a new useful means to study IP processes.

VERTICAL ELECTRIC CURRENT SOUNDINGS (VECS). Mogilatov and Balashov (1996) presented the first result of theoretical and experimental works on creating a new method of transient soundings based on the circular electric dipole as the source. At present, area measurements of the magnetic components with an attached CED-array are the most promising.

As a rule an anomalous contribution of local objects or disturbances in the horizontal homogeneity of the section in transient field sounding methods is recorded against an intense background of host rock mass response. On the one hand, this makes recording the response difficult and, on the other hand, this hampers the interpretation which consists in separating an anomalous part of the response at the first stage. The problem of suppression of the normal background of the host medium can be solved, among other factors, by optimizing the field source. One can consider the circular electric dipole as the optimized source with the lack of the normal magnetic field in mind.

The technique is illustrated in Fig. 3. The CED-array is placed on terrain. The impulse feeding is used. The currents are aligned in radial lines by special devices. The measuring system (one or several) is moved on a square grid. The system includes an inductive sensor and meter for transient signal. The measuring system is synchronized with an impulse current in CED and becomes located on terrain by means of signals from the satellite (GPS). For a solution the oil problems, CED has a radius of 500 m, current in the each ray up to 10 A, the measuring system has a maximum range of 5 radii of CED. As the result of field works, an area map of signal intensity is formed for each temporal reference. On a contour of a signal it is possible to determine a contour of a heterogeneity (oil reservoir, for example).

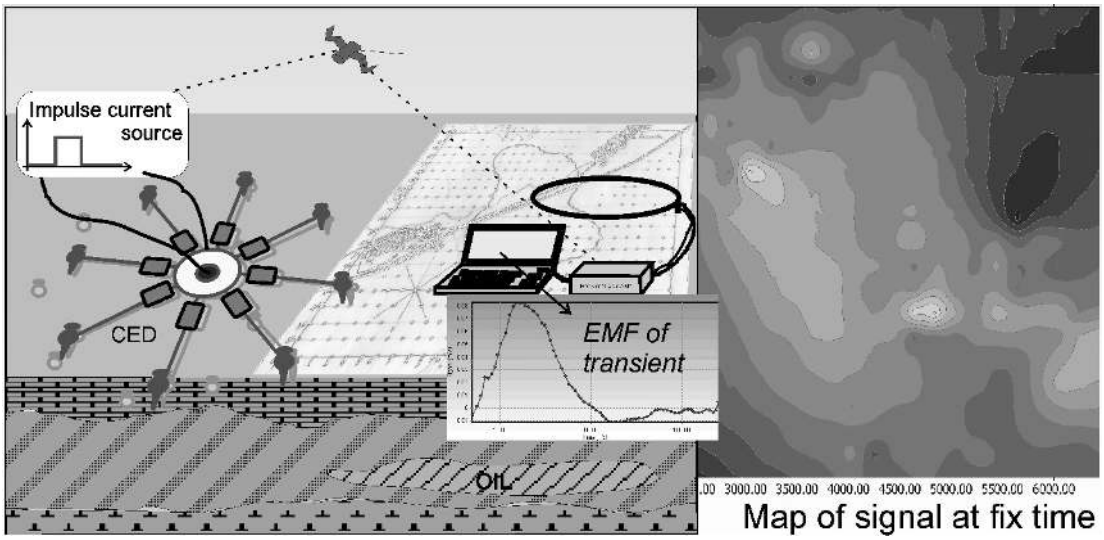

Fig. 3. Vertical electric current soundings (VECS)

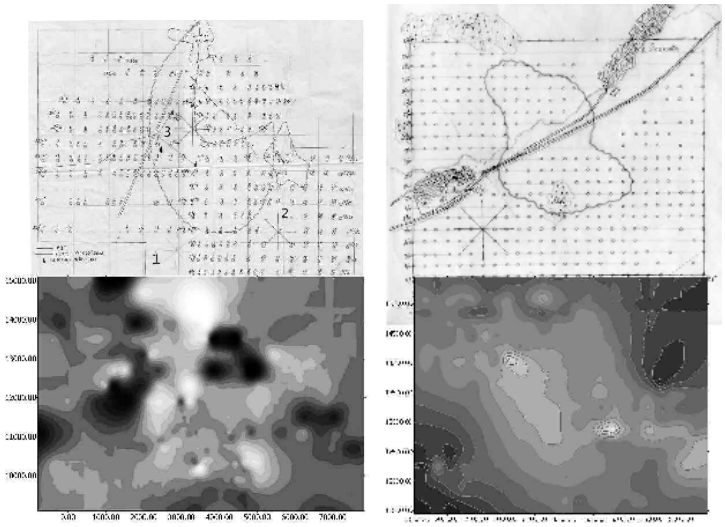

Fig. 4. Shuganskaya and Akbyazovskaya pools

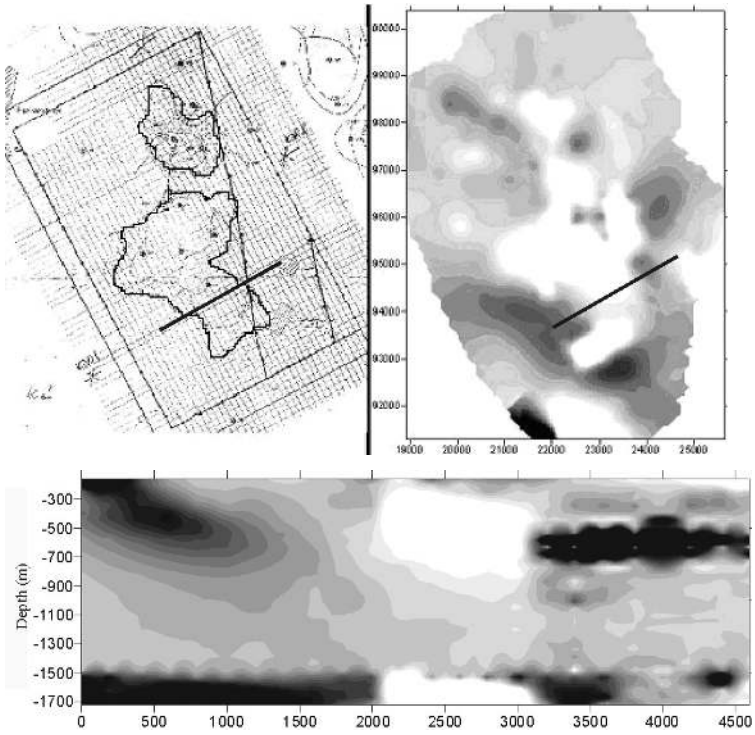

Fig. 5. Krasno-Oktyabrskaya oil pool. Plan and section.

THE FIELD TESTS. We have interesting results for various objects (ore bodies, kimberlite pipes). However, the greatest success we have is in the contouring of oil pools. Such works are conducted systematically in Tatarstan now. Here we exhibit results of field tests on known deposits of oil. |The contour of deposit (known from other data) is selected by the boosted signals. On the pool "Shuganskaya" three installation CED were used. The pool "Krasno-Oktyabrskaya" is disposed in two horizons. In Fig. 5 the apparent section is presented, on which the double storied vertical structure of the pool is really visible. All these images in Fig. 4 and 5 are formed by filed signal directly.

CONCLUSION. The field of the conventional sources (i.e loop and horizontal electric dipole or line) is defined by the horizontal currents. This means that we use the TE field only. It is safe to say that the traditional electrical prospecting mainly investigates the longitudinal conduction. If you want to study IP, permitivity, multiphase or fractal structure of the medium and other subtle items, you must exclude the TE process and use the TM field. CED ensures it.

REFERENCES. Mogilatov, V.S.,1992. A circular electric dipole as a new source in electric survey. Izv. RAS. Ser. Fizika Zemli, 6, 97-105.

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