Introduction

There are numerous publications analyzing the technology and results of marine EM hydrocarbon reservoir exploration methods devoted to frequency-domain soundings with controlled source (f-CSEM - Control Source ElectroMagnetic). In the case of onshore EM soundings, there is another situation: the pulse methods operating in the time-domain (t-CSEM), and the frequency (f-CSEM) methods occupy equivalent positions. In this paper we consider potentials of both methods in two configurations: inline source-receiver *HED-Ex(f)* and pulse *HED-Ez(t)* setup operating with horizontal electric dipole (HED) as source and horizontal (Ex) and vertical (Ez) receiver respectively. The possibilities and limitations of both methods we consider on the model examples.
As an electrical model of an HC reservoir, we have chosen a rectangular plate of 100-m thickness with a resistivity of 20 Ohm-m. The plate lies in a sediment column with a resistivity of 1 Ohm-m at a depth of 1 km or 2 km BSF. The water column has a resistivity of 0.28 Ohm-m and a depth of 50 to 1000 m. The *HED-Ex(f)* and *HED-Ez(t)* setups are arranged on the seabed. In the case of f-CSEM, the frequency band $0.01 \leq f \leq 10$ Hz and offsets of $1 \leq R \leq 10$ km with the observation point in the centre of the configuration are analysed; in the case of t-CSEM, the time range $0.1 \leq t \leq 16$ s at a fixed offset of R = 1.5 km is analysed. The noise level of 10^{-15} V/(Aм^2) is accepted for both configurations.
The Figures 1-3 demonstrate some results of the consideration

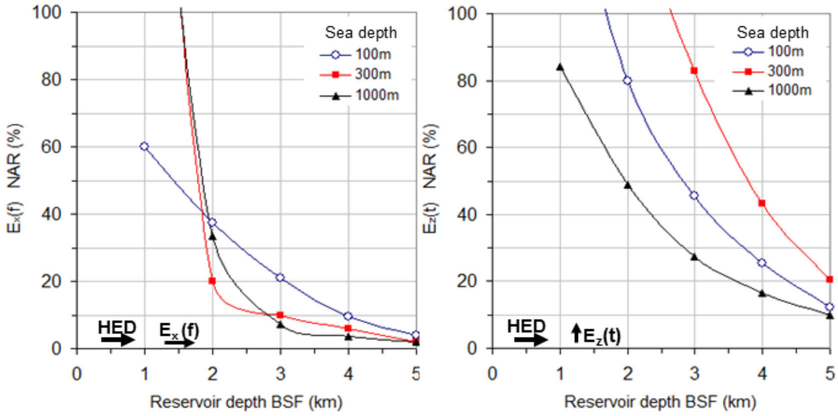


***Figure 1**. NAR(%)=100(|E_{anom}/E_{norm}|-1) dependence versus depth of the reservoir of 5×10 km size, 100 m thick, 20 Ohm-m resistivity*

The graphs in Figure 1 allow us to estimate the maximum possible detection depth of the reservoirs. For example, at NAR=30% and sea depth of 300 m the maximal detection depth is about 2 km for *HED-Ex(f)* and 4.5 km for *HED-Ez(t)*.

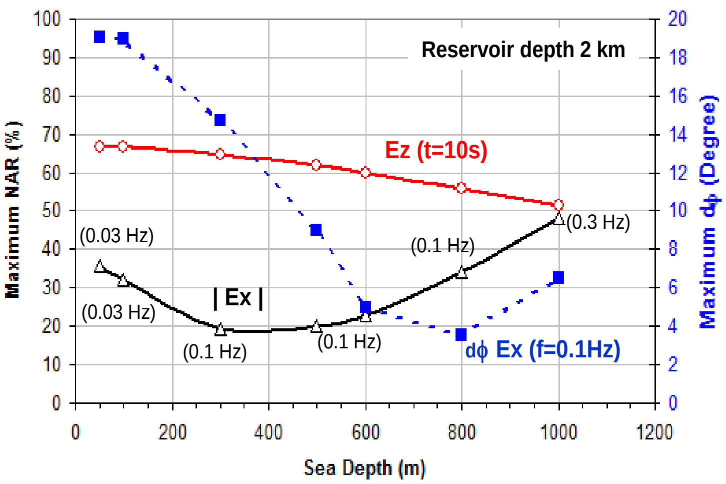
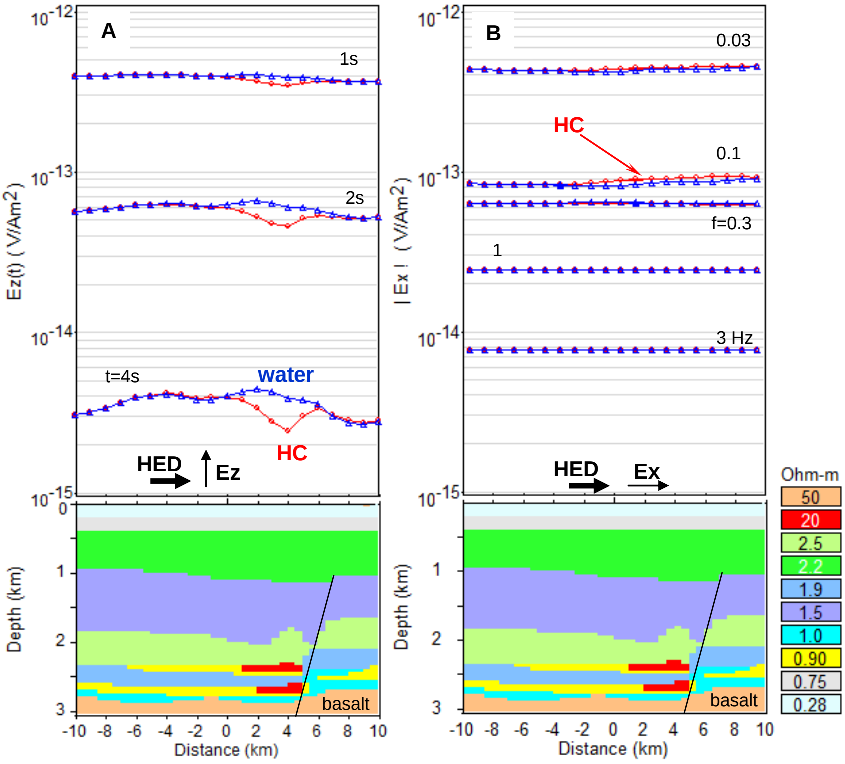


***Figure 2**. The maximum anomalous effects for the HED-Ex(f) and HED-Ez(t) setups versus sea depth. The reservoir 5×10 km size, T=2000 Ohm-m^2, depth H is 2 km BSF. The frequencies that correspond to the maximal effects are shown in the brackets. The offset is 6 km for f-CSEM and 1.5 km for t-CSEM.*

In the time domain, the *Ez* NAR decreases monotonically from 68% to 50% as the water depth increases from 50 m to 1 km. In the frequency domain, the NAR reaches at least ~ 20% in the sea-depth range 250 to 500 m, and at greater depths of up to 1 km, the NAR increases and becomes comparable to the NAR for t-CSEM.The phase anomaly of *HED-Ex(f)* at the optimum frequency 0.1 Hz amounts to ~19^{o} for shallow water but decreases sharply to ~4-8^{o} at sea depths of more than 600 m.

Figure 3. The pulse (A) and frequency (B) responses from the reservoirs with “HC” and “water” fluid. The responses are masked by the underlying basaltic layer



Conclusions

On the results of the modelling, we can conclude: the most favourable conditions for the sounding of HC reservoirs located at a depth of 2 km, using the *HED-Ex(f)* configuration, are sea depths of up to 200 m or more than 800 m. In the sea-depth range 200-800 m, the anomalous effects are minimal and do not exceed 30%. Anomalous effects in the *HED-Ez(t)* configuration are weakly dependent on the sea depth and reach ~50-70%. In deep-sea conditions, the relative amplitude of the anomaly and the responses of both configurations are almost identical.
The lateral resolution of *HED-Ez(t)* with respect to deep-lying reservoirs at shallow and moderate sea depths is higher than for *HED-Ex(f)* because of the significant difference in the offsets. For deep-sea, the resolution for both configurations is approximately the same.
The range of burial depths for which reservoirs that are identical in size but different in resistivity produce responses that are indistinguishable within the error of surveying is wider for *HED-Ex(f)* than for *HED-Ez(t)*.
High-resistivity formations overlying or underlying the reservoir screen the anomalous effects in the fields registered by both configurations, but in the pulse configuration, the anomalies remain relatively high.
For the stable inversion of marine CSEM data, it is appropriate to apply the "seismic skeleton" based on the results of the geological interpretation of a seismic survey. Inversion in the scope of geoelectric models that contain fixed borders between rock blocks can be achieved only with respect to the resistivities of geological formations.

THE PROSPECTING POTENTIAL OF FREQUENCY AND PULSE CSEM

The depth of exploration, sensitivity and resolution of two methods of marine electromagnetic soundings using a horizontal electric dipole as a source of the field are investigated. An inline dipole-dipole setup measuring a horizontal electric field in the frequency-domain, and the vertical electric field in a pulsed mode (time-domain) in the near-field source are analyzed. It has been shown that the sensitivity of the pulse method in shallow water is higher than of the frequency one. In water depths of more than 800 m the sensitivity of both methods is approximately the same. The horizontal resolution of the pulse method is higher in the whole range of depths. A new approach to the inversion of the results of soundings is demonstrated on the model of the geological section.