P-18 RELATIOS BETWEEN THE HYDROCARBON MIGRATION CHIMNEY AND ELECTRIC SELF-POTENTIAL FIELD

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In the paper presented the 3D model of the distribution of electric self-potential field over the oil reservoirs in Albania. Analyzes field surveys results in oil reservoir areas located at different depths, theoretical synthetic models, and relations between self-potential anomalies and hydrocarbon migration chimney.

METHODIC

Electric self-potential field distribution is observed in several oil and gas reservoirs in Albania. Carbonatic and sandstone oil reservoirs are located at different depths, from 900 up to 3500 meters. Geoelectrical surveys have been carried out by the measurement of the electric self-potential in observed lines, located at Earth surfaces and in depth oil wells.

Mathematical 3D models of scattering of electric current over oil reservoir have realized. To performed the modeling, the Electro-motor force have calculated by equation:

$$E_{Fem} = -\frac{RT}{F} \cdot \left(\frac{d}{dx} \ln C_{Fe^{+3}} - \frac{d}{dx} \ln C_{Fe^{+2}} \right) = -\frac{dE_h}{dx} \quad (1)$$

Where: E_h - the oxidizing-reducing potential, which have calculated by equation:

$$E_h = E_0 + \frac{RT}{F} \cdot \ln \left(\frac{Fe^{+3}}{Fe^{+2}} \right) \quad (2)$$

Where: $C_{Fe^{+2}}$, $C_{Fe^{+3}}$ - two and three valence iron ions concentrations,

E_0 - potential of standard system, taken conventionally as $E_0 = 0$

R - gas universal constant

F - Faraday's number,

T - Solution temperature, in Kelvin degrees.

Parallel we have calculated the reducibility coefficient of the rocks:

$$K = \frac{C_{Fe_{HCl}^{+2}} + Fe_{FeS_2^{+2}}}{E_{Fe}} \quad (3)$$

Where: $C_{Fe_{HCl}^{+2}}$ - the content of two valence iron ions abstracted by HCl.

$Fe_{FeS_2^{+2}}$ - the content of two valence iron sulphide

$E_{Fe} = Fe_{HCl}^{+2} + Fe_{HCl}^{+3} + Fe_{FeS_2}^{+2}$ - The total sum of two and three valence iron ions

content, participating in chemical reactions.

$C=0.236$ - a constant

The scattering of electrical field has been calculated by the Poisson equation:

$$\Delta U = \nabla \vec{E}_{Fem} = f(x, y, z) \quad (4)$$

Function $f(x, y, z)$ expresses the distribution of the Electro-motor force E_{Fem} :

$$f(x, y, z) = \frac{d}{dx}(\gamma E_{Femx}) + \frac{d}{dy}(\gamma E_{Femy}) + \frac{d}{dz}(\gamma E_{Femz}) \quad (5)$$

The solution of the equation (4) has been found using numerical methods.

DISCUSSION OF THE RESULTS

Self-potential anomalies at Earth surface have amplitude between -20 up to 100 mV (fig. 1, 2). Redox potentials E_h in the area of the reservoir have been observed too.

The presence of E_h anomaly show that over oil deposits, in side of the oil-water contour, is located reducible rocks chimney, or hydrocarbons migration chimney. Oxidable surrounding rocks are located outside of the chimney. Chemical analysis of the rock samples from geological section over the oil reservoir shown in fig. 1, result that the epigenetic geochemical facies changes from little reduced in the flysch rocks at depth towards reduced at Earth surface, where are located neogenic molasses (Fig. 3). Reductibility coefficient of the rocks changes with an average vertical gradient of $-0.021/100$ m. The oxidizing-reducing potential E_h increases at the depth with a vertical gradient of $3.6-9.6$ mV/100 m in the rocks of the chimney over the reservoir:

$$E_h = 9.6 H - 6 \text{ (mV)}$$

The reductibility coefficient decreases at depth:

$$K = -0.079 H + 0.54$$

Where: H- observed station depth, in meters

The gradient of K and E_h depended from the distance (r) from the reservoir epicenter, too. They have great values near the epicenter and decreases toward the oil-water contour of the reservoir. They are zero outsides of the reservoir oil-water contour. These changes has determined by the equation:

$$E_h = K \cdot (Z-H) \cdot (a-r) + C$$

Where: H - the depth of reservoir

Z - the depth of the station where the potential is calculated

R - the horizontal distance of this point to the epicenter of the reservoir,

a - radius of the reservoir,

C - constant.

This oxidizing-reducing system chimney of the rocks over oil reservoir represents the "generator" of the electric current.

The self-potential anomalies are extended at depth, too. This fact has been proved through the positive drift at depth of the "zero line" or "clay line" of the Spontaneous Polarization well logging plots (SP) (fig. 4). The vertical gradient of the SP reaches up to 10 mV/100m in wells in side of the oil-water contour area. It becomes zero in wells located out side of the oil-water reservoir contour area. SP gradient values changes in different sectors in side of the reservoir area (fig. 5). In the map of the PS gradient were

observed several hearths with higher gradient values. This fact demonstrates that the reducing process of the rocks does not occur equally everywhere of the rocks of geological section. The same phenomena have been observed at vertical plane, too. Necessary to mentioned that the PS vertical gradient has been observed also in some wells, with oil imprint only.

The field surveys results have been verified using the results of mathematical modeling (Fig.6 and 7). In the first case, the reservoir is located at the depth 900 m and the intensively reduced rocks lies near of the Earth surface. In the model of the fig 7 the reservoir is located at the 3500 m depth and the intensively reduced rocks there are in the middle of the geological section. Complicated anomaly shapes are observed in the case of two reservoirs, located close to each other.

Electric field of the natural currents is accompanied with weak magnetic anomaly, 5-8 nano Tesla (fig. 8). The magnetic field over the oil reservoir represented very "noisy". This fact could be explained by the heterogeneous distribution of the secondary magnetite in the subsurface ground, which is an element of the multielementary geochemical anomaly. pH anomaly over the reservoir is weaker (Fig. 9).

Over syngenetic gas reservoirs, generally, have not observed anywhere SP anomalies in the Earth surface. In some anomaly cases, the amplitudes have been very low, of the order -20 up to -30 mV and isoanomal contours represent a mosaic shape.

The studies of SP in various areas of Albania have observed the existence of some anomalies connected the processes of diffusion-adsorption or filtering as well. To select the anomalies linked with the presence of epigenetic reducing geochemical facies over the oil reservoirs is necessary that geoelectrical and magnetic surveys to be performed in complex with geochemical studies of the redox potential E_h , gas, bitumen and microelements anomalies.

In fig. 9 are presented the complex geophysical-geochemical anomalies in the line I-I in the oil reservoir presented at fig. 1.

CONCLUSIONS

1. Over the oil reservoirs in Albania, located at depth from 900-4000 meters have been observed ground SP anomalies of magnitude up to -100 mV.
2. SP anomalies have been observed at the depth, with a positive drift of the SP plot "Zero line", which have the vertical gradient up to 10 mV/100 m.
3. SP anomalies represent element of the complex multi-element geophysical and geochemical anomaly over the oil reservoirs.
4. Complex geophysical-geochemical anomalies represent indicator for the possibility of the presence of commercial oil reservoir at the depth.

Fig. 1 Self potential anomaly map of Balish oil and gas reservoir in Albania
 1 - The oil-water contour;
 2 - The oil-gas contour;
 3 - The potential contours (the numbers in the contour are in mV)

Fig. 2 Theoretical model of the self potential field scattering on a oil reservoirs and the expected surface and depth anomalies (a), to compare with observed anomaly of the 1-1 line of the oil and gas reservoir to display in fig. 5 (b)

- 1 - the reduced rocks zone over the reservoir;
- 2 - the plot of reduction coefficient in the horizontal and vertical directions;
- 3 - top of the oil reservoir