Theoretical bases for mapping oil-&-gas fields within Black Sea North-Western shelf by means of seismic-and-gravity modeling

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High cost of oil&gas exploration and production within marine areas requires highly effective techniques of geophysical data integration and interpretation. Gravity data bring a valuable information in geophysical survey package. In this connection the question of presence and magnitudes of gravity anomalies from oil & gas fields is important for successful hydrocarbon prospecting.

To answer this question the forward modeling of gravity effect from discovered hydrocarbon fields was made for the territory of Black Sea North-Western shelf and Crimean oil-and-gas bearing regions of Ukraine. 2D modeling was done for totally 21 field on the territory.

Subsurface model. It was assumed constant reservoir properties within the field. Different types of trap saturation were taken as possible. Rock density differences (as a result of fluids densities difference) cause deviations in calculated gravity fields and presence of negative gravity anomalies.

Modeling procedure:

- 2D structural and property model creation for each field.
- Setting reservoir density calculated for water-saturated rocks according to known petrophysical model:

  $$\sigma_r = \sigma_m(1 - K_p) + K_p\sigma_w,$$

  where σ_m – solid matrix density, K_p – rock porosity; σ_w - formation water density.

  Forward calculation of gravity field for acquired density model.
- Creation of density model with gas saturated reservoir and forward gravity modeling. The petrophysical model used was as follows:

  $\sigma_r = \sigma_m(1 - K_p) + K_p(\sigma_f K_{ogs} + \sigma_w(1 - K_{ogs}))$,

  where σ_f - in-place hydrocarbon fluid density, K_{ogs} - coefficient of oil-&-gas saturation.
- Calculation the difference between obtained gravity fields and their root-mean-square values. The last ones were used as estimation of gravity contrast ratio of the field.

Results. The analysis of gravity contrast ratio values of all fields highlighted significant negative gravity anomalies related to hydrocarbon saturated reservoirs. Average root-mean-square values of gravity anomalies (up to 0.184 mGl) highly exceed modern accuracy of gravity survey which means that these effects are present in measured gravity field! The point is that by no means one can extract this anomalous component from gravity field. The only way to detect the prospects is joint seismic-and-gravity inversion performed by means of 3D model construction and inverse problem solution. That's what was done for regional study of the Black Sea North-Western shelf and local study of Golitsuno gas-condensate field. 3D integral models created for these territories showed high accuracy and reliability of prospects.

Conclusions. The investigation made showed a principal possibility of hydrocarbon reservoirs mapping by means of joint seismic-and-gravity inversion. The successful experience of its application in different sedimentary basins is a strong argument for it's usage for de-risking of exploration and production offshore Black Sea.