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USING THE NFG METHOD TO GRAVITY DATA OF THE HASANKALE-HORASAN PETROLEUM EXPLORATION PROVINCE

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Summary. The effects of the hydrocarbon presence were shown on the NFG sections by the application of NFG downward continuation operations on the theoretical models. As the application of this method, important results were obtained for the Hasankale-Horasan petroleum area by applying this NFG method to the gravity data for the purposes of hydrocarbon presence. It was shown that more effectively signs of the hydrocarbon structures on the NFG section obtained field and models data at low harmonics. Mass geometry and location of the mass giving rise to the anomaly can be used to be determined from the knowledge of singular points at the mass and its borders.

Introduction

Hydrocarbon containing structures can be determined by comparing the calculated field with the observed gravity field. Second derivatives, downward analytical continuation, horizontal gradient vector, Andrew-Griffin variation method, statistical methods and downward continuation of Normalized Full Gradient (NFG) values of the gravity field are commonly used methods in hydrocarbon exploration (Griffin W.R, 1949; Andreev and Klushin, 1962; Berezkin and Buketov, 1965; Berezkin, 1973; Ciancara and Marcak, 1979; Mudretsova, 1984; Molovichko et al., 1989; Lyatsky et al., 1992; Aydın, 1997; Aydın, 2000; Pašteka, 2000; Aydın et al., 2002).

Normalized Full Gradient (NFG) method depends on the downwards analytical continuations of normalized full gradient values of gravity data. Analytical continuation discriminates the certain structural anomalies which can't be distinguished in the observed gravity field. Analytical properties are lost at the singular points of the borders of mass giving rise to the anomaly in the gravity potentials and derivatives. Mass geometry and location of the mass giving rise to the anomaly can be used to be determined from the knowledge of singular points in the mass and its borders. Downwards analytical continuations values of the observed gravity data show irregular variations during the passage of the mass giving rise to the anomaly. The initial values of these irregular variations describe the depth to the upper surface of mass giving rise to anomaly. The application of this method is restricted since the errors in the gravity data become more effective in the downward analytical continuation values with the increasing depth (Aydın, 1997).

Since residual gravity signals of oil and gas reservoirs are rather weak, gravity data in hydrocarbon exploration purposes should be handled specifically. NFG data were obtained from the calculations of Fourier series coefficients of the gravity data by Filon method (Davis and Rabinowitz, 1989). Afterwards the effects of hydrocarbon existence in the NFG sections were put forward with the model calculations by utilizing the NFG data. Also the hydrocarbon potentials of the Hasankale-Horasan area were interpreted using the NFG method for the gravity data.

Method

The NFG operator GH(x, z) is defined in two dimensions by Berezkin (1973) as

$$G_H(x_i, z_j) = \frac{\sqrt{\left[\left(\frac{\partial U(x_i, z_j)}{\partial x}\right)^2 + \left(\frac{\partial U(x_i, z_j)}{\partial z}\right)^2\right]^{\nu}}}{\frac{1}{M}\sum_{i=0}^{M}\sqrt{\left[\left(\frac{\partial U(x_i, z_j)}{\partial x}\right)^2 + \left(\frac{\partial U(x_i, z_j)}{\partial z}\right)^2\right]^{\nu}}},$$

where M is the number of observation points, (i = 0, 1, 2, 3,…., M ; j= 0, 1, 2, 3,…,z). $U(x_i, z_i)$ is the function defining the gravity anomaly values along the *x* axis, $\frac{\partial U(x_i, z_j)}{\partial x}$ and $\frac{\partial U(x_i, z_j)}{\partial z}$ are derivatives of the function $U(x_i, z_i)$ with respect to x and z respectively, and ν is known as the degree of the NFG operator and controls the peak amplitude. The degree of the NFG can be taken as 1, 2, 4, etc., ν = 1 is generally used for the potential field data (Aydın, 1997).

Discussion

A profile was selected which is 53 km long in the Erzurum-Hasankale-Horasan region and is concurrent with the SW-NE trending seismic section as given in Figure 1. The whole profile which stratigraphically overlies the Jurassic Mudurnu Formation overlaid conformably by the Cretaceous Sakaltutan Ophilites is on top of the alluvium units. The beginning of the profile is made up the faulted Eocene Bulkasım Formation which is overlaid unconformably by the Pliocene Karakurt Formation, and the latter one is covered up jointly by the Aras Formation and the Quaternary alluvium. Application of the NFG method to the gravity model obtained from a complex geological structure: a) Δg(x,z) curves calculated for the geological models having and not having hydrocarbons, b) Second derivatives, c) Andreew-Griffin variation method curves calculated for N1-N2=1-5, N1-N2=1-10 and N1-N2=1-15 harmonics, and c) Seismic section having hydrocarbons at 10 km in Figure 1. It is seen 45 mGal anomaly duing to the change in the basement topography gravity increasing along the whole profile (Figure 1a). The NFG sections of the profile were calculated and drawn for the harmonics of N1-N2=1-10, N1-N2=1-15, N1-N2=1-20, N1-N2=1-25, N1-N2=1-30 and N1-N2=1-35 (Figure 1g). The effect of the rise in the middle of the profile was shown as the minima closing area between two maxima at the N1-N2=1-10 harmonics. This effect was observed at all the other harmonics too. Characteristic minimum singular point was observed at 10 km for the anticlinal area for N1-N2=25 harmonics. This situation was also observed at the harmonics of N1-N2=1-25, N1-N2=1-30 and N1-N2=1-35. The depth of a structure which could be considered as reservoir character is at 35 km. A minimum singular point was observed at the harmonics of N1-N2=1-20, N1-N2=1-25, N1-N2=1-30 and N1-N2=1-35 at 45 km of the profile and the depth of this point is about 2-2.5 km. These parts are against the limestone units in the interpreted seismic and geological sections. These parts shown with the shaded rectangles and ellipses (in the Figure 1g) were considered as the areas having reservoir characteristics.

Conclusion

By using the Filon method for the calculation of the Fourier series coefficients, singular points were determined at the lower harmonics with better congestions. Density variations which are caused by the presence of hydrocarbons make up the minimum closure between two maxima for the reservoir. These advantages were put forward by the NFG method for the hydrocarbon exploration, this method has shown that it could be used at the initial and final stages of the hydrocarbon explorations by applying to the gravity data for the promising areas. Therefore it is a reality that this method could be used to determine the areas for detailed seismic and borehole sites.

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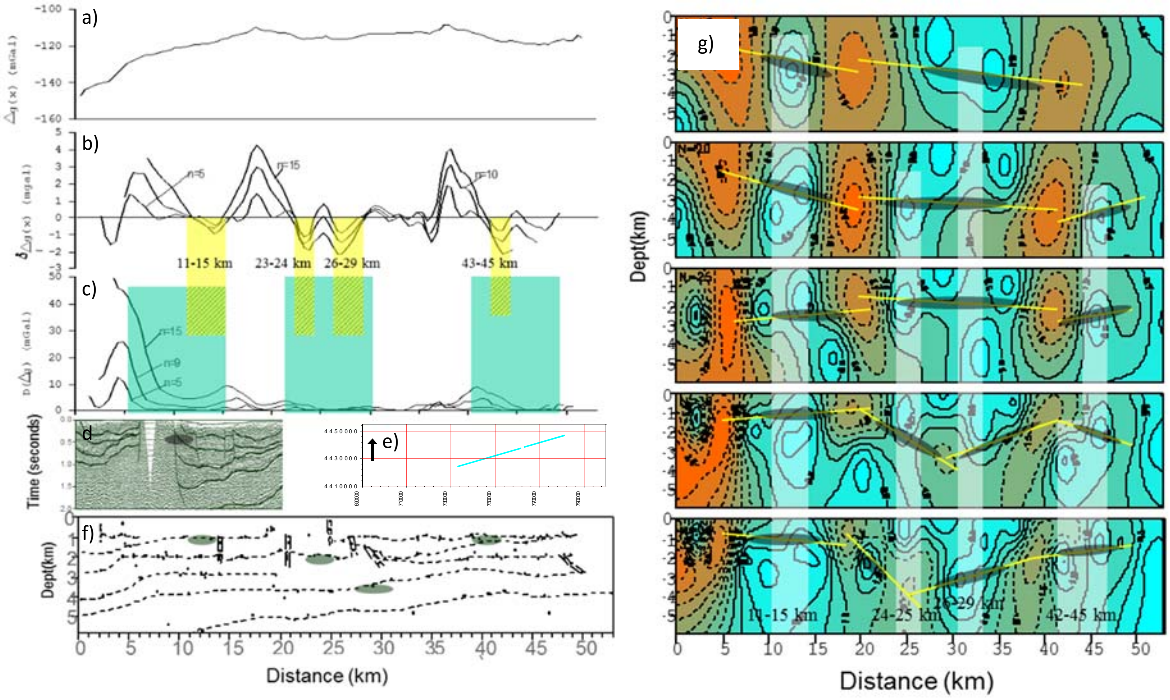

Fig. 1. In the survey area, a)Δg(x,z) gravity profile, b) Second derivatives, c) Andreew-Griffin variation method curves calculated for N1-N2=1-5, N1-N2=1-9 and N1-N2=1-15 harmonics, d) seismic line, e) profile position, f) singular points was observed for the various harmonics and the NFG sections calculated for the Δg(x,z) data of the profile for 1-15, 1-20, 1-25, 1-30 and 1-35. The shaded rectangles and ellipses correspond to anomalous zones for considering as the areas having reservoirs.

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