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Three-Dimensional Estimation and Modeling of Sediment Thickness on Basement to Explore Hydrocarbon Reserves Using Geophysical Data, Case Study: South of Netherlands

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INTRODUCTION

The purpose of the inversion of the gravity data is to estimate the parameters such as density and body geometry using the observed gravity data and geological information of the study area. In inversion of gravity data, we face two basic problems, namely, the non-uniqueness of the solutions and instability, which can be limited by using basic information such as geology, estimated depth and density differences. One of the applications of nonlinear inversion method for estimation of granitic data is the estimation of sedimentary basin characteristics [1,2,3].

Moreover, inversion problems are divided into linear and non-linear inverse problems. In nonlinear inverse problems, there is a nonlinear relationship between observational values and model parameters. To solve nonlinear inverse problems, using a linear expansion in the neighborhood of a reference model is used. In each iteration, the model is updated after applying the changes made from the previous iteration, and the reference model is used. Continuing this process is continued until the desired convergence is reached. Most nonlinear inverse problems can be determined by specifying the minimum point that the target function is defined in vector space. To achieve this goal, more gradient methods are used, but if there is a large number of data and parameter parameters in the inversion problem, this can be solved by the subspace method, which will inversion the data in a small er space of data or model parameters, resulting in the inversion Matrices will be made with more stable conditions [4]. In this paper, the sub space method is used to invers of synthetic and real data. This method is a suitable method for inversion of the geophysical data which has a high noise level due to its noise-instability potential. This method can simultaneously model the two layer. The novelty of the article is to model the two layers of the appropriate base vectors at the same time. This method, in addition to selecting the appropriate base vectors, allows two layers to be modeled with a data set, with a very high stability versus noise. This process is done to determine the depth of the sediments or basement. In this method, the geometry of the basement is approximated with a set of prisms, and the length of these prisms reflects the depth of the basement.

EXPERIMENTAL PROCEDURE THEORY

In modeling, we deal with three general concepts of data, parameters, and models. The data is the same as the values measured on the surface. The parameter, density, or subsurface geometry is meant to be estimated. The geometric relationship model is between data and parameters. The matrix is known as the kernel and is represented by the following equation [5]:

$$\vec{d} = \vec{G}\vec{x} \qquad (1)$$

In Eq. 1, d is the data vector, x is the vector model parameter, and G is the kernel matrix. To solve nonlinear inverse problems, by minimization an objective function, which is based on observed data and predicted data and is defined as Eq. 2 [6]:

$$\phi(x) = \frac{1}{2}\phi_d(x) + \frac{\alpha}{2}\phi_x(x) \qquad (2)$$

Where $\phi_d(x)$ and $\phi x(x)$ are a data misfit between observed data and predict data and property model, respectively. Also is regularization parameter.

CHOOSING THE BASIS VECTORS

In each iteration, variations in the model parameters are obtained using minimization and variation, so vectors that are essential in the changes of these functions in successive repetitions are base vectors. In order to select the basis vectors, the separation of the objective function and the gradient of the functions forming it is used. Basic vectors are chosen so that they are easily comprehensible and contain information from both the data space and the model parameters.

INVERSION OF SYNTHETIC DATA

Therefore, in order to test the inversion method, a synthetic two-layer model with a dimension of 15,000 × 33,000 m, with a density difference of -0.2 gr/cm^3 for the second layer and -0.4 gr/cm^3 for We have used the first layer.

In Fig. 1, the synthetic model in three separated panel.is shown Moreover, Fig. 2 shows the inversion results of synthetic data with 0% (or without any) white Gaussian noise, and Fig. 3 shows the inversion results of synthetic data with 5% white Gaussian noise.

INVERSION OF REAL DATA

In this paper, the gravity data of a Hydrocarbon reservoir in the south of the Netherlands, located in the sandstone layer, has been used.

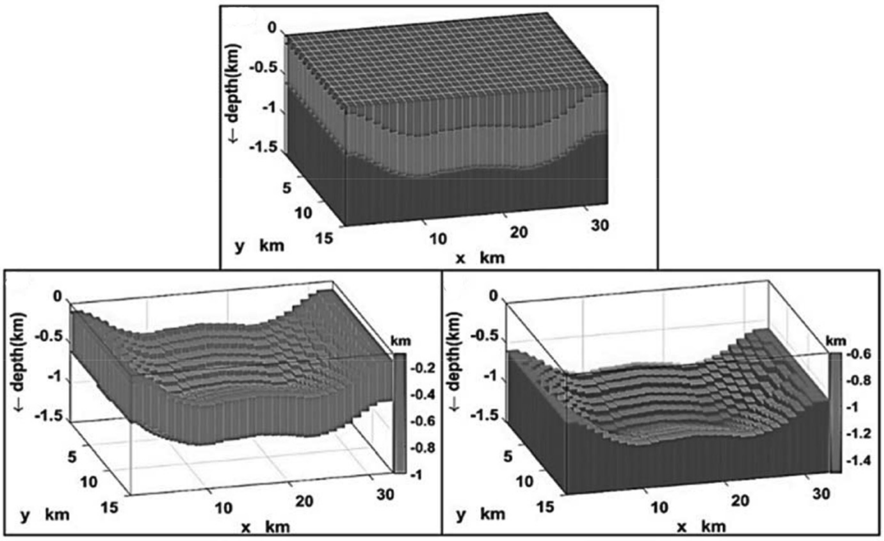

Figure 1: Synthetic model: (a) Three layer model, (b) second layer, and (c) first layer.

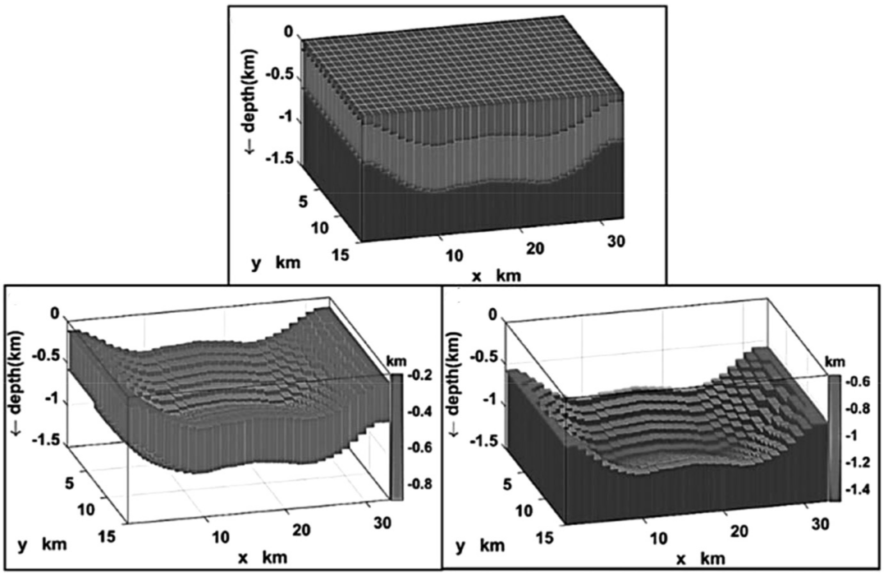

Figure 2: the result of inversion synthetic model without noise: (a) Three layer model, (b) second layer, and (c) first layer.

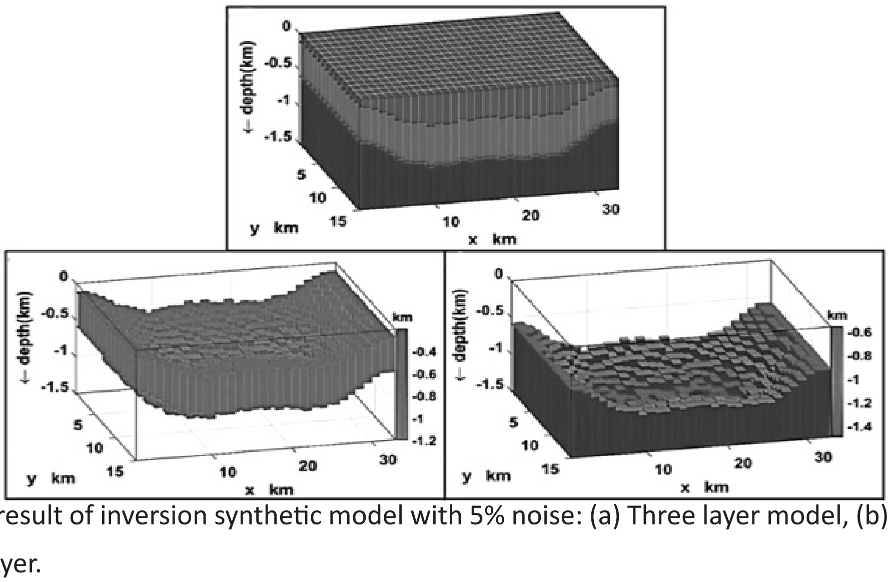

Figure 3: the result of inversion synthetic model with 5% noise: (a) Three layer model, (b) second layer, and (c) first layer.

The purpose of the inversion of these data is to model the high and low depth of this layer, which is not well resolved by seismic data [7]. These data are sampled in a 14,000 × 14,000 meter regular grid on 27 profiles and in each profile of 27 points, as shown in Fig. 4.

Fig. 5 shows the 3D inversion results of the real gravity data. The depth of second and third layer has appropriate agreement with drilling results.

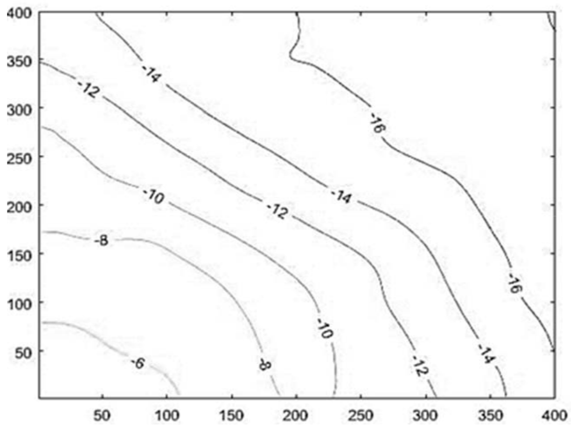

Figure 4: Gravity data from study area.

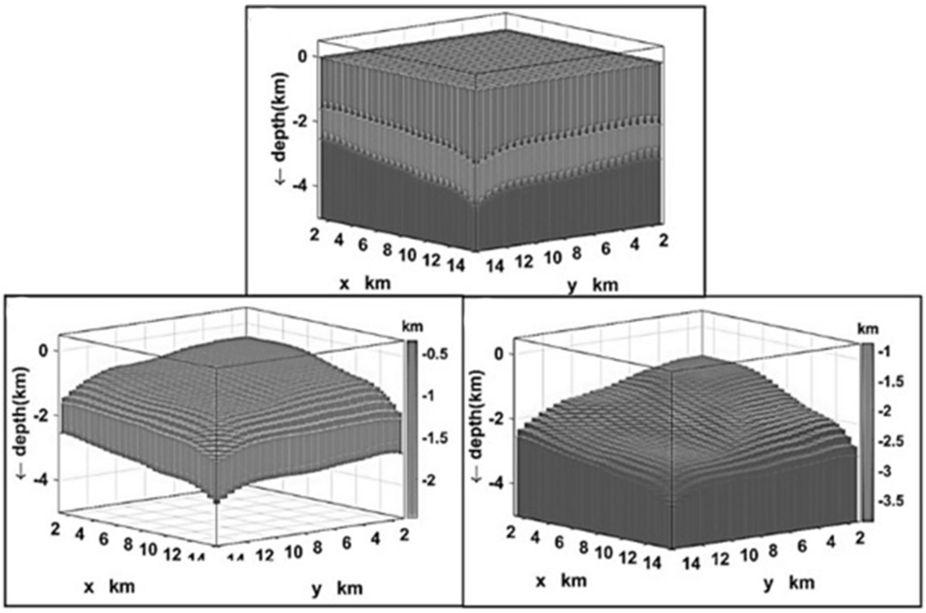

Figure 5: 3D inversion results of real gravity data panel a, b and c show the whole inverted model, second layer and third layer respectively.

Conclusions

The subspace method allows us to select the base vectors that affect the second layer, and if we select all the vectors of the base, our model will not converge. In addition, this method can simulate two layers simultaneously without using auxiliary data and with a data type. Finally, in this algorithm, due to the use of base vectors, the dimension of the matrix of sensitivity becomes smaller and, as a result, the size of the inverse matrix becomes smaller, hence the speed of modeling increases.

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