TWO DIMENSIONAL MODELING OF GRAVITY ANOMALIES CAUSED BY A FAULT USING A FOURIER ITERATIVE TECHNIQUE

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Abstract- This paper presents a method of modeling gravity anomalies caused by geological faults. This is a modification of a method published previously. The new method provides enhanced freedom to the person carrying out the modeling process which will help in producing geologically realistic structures as opposed mathematical artifacts. The method is applied for the interpretation of gravity anomalies caused by geological faults and found working satisfactorily.

Keywords- Fourier Transform, gravity anomalies, faults

I. INTRODUCTION

This paper describes a Fourier iterative technique that can be used to model gravity anomalies caused by a geological fault. Most geological faults are formed as a result of breaking a massive rock unit into two pieces and moving one relative to the other. A large void is created in the case of vertical movements and this void is very often get filled with sediments of lower density creating a lateral density contrast.
This is will give rise to a gravity anomaly across the fault and by modeling of this anomaly it is possible to determine the parameters of the fault such as its vertical displacement which same as the thickness of sediments present. This type of information has useful applications in the oil exploration work.

II. THEORY

Parker (1972) showed that the Fourier transform of the gravity anomaly caused by a sub-surface body with one horizontal surface and having a thickness $h(x,y)$ can be written as,

$$F[\Delta g] = -2\pi G\rho\left\{F[h] + \frac{k}{2!}F[h^2] + \frac{k^2}{3!}F[h^3] + \cdots + \frac{k^{n-1}}{n!}F[h^n] + \cdots\right\}e^{-kz_0} \quad (1)$$

Where, $F[h]$, $F[h^2]$ ……. represent the Fourier transform of h, h^2….., k represents the wave number and z_0 represents the elevation of the horizontal level at which the gravity anomaly is calculated above horizontal surface mentioned above.
Oldenburg (1974) used equation to model gravity anomalies caused by sedimentary basins. He first assumed all the terms of the right hand side of the above equation are zero except the first one and determined $F(h)$ and h. Then he determined a better value for $F(h)$ and h assuming the first two terms of the right hand side of the equation are non-zero and substituting the previous set of hvalues obtained in the second term. This process was repeated adding a new term each time until observed and calculated anomalies agree reasonably well. In this paper a modification to this method which will provide more freedom to the modeler has been suggested. In this method the modeler first make an initial guess for the h and substitute that value to the second term assuming only second and first terms of the series are non-zero and obtain a set of values for h. Then it is assumed that the first three terms of the series are non-zero and substitute values obtain in the previous step in the second and third terms and determine a better set of values for h. This process is repeated until a good agreement between observed and calculated anomalies are obtained. As mentioned earlier this method has the added advantage that the information with regard to the causative body obtained using other methods can be incorporated in the modeling process.

III. TESTING THE METHOD

A series of numerical experiments (Rodrigo, 2012) have been conducted to ascertain the suitability of this method to model gravity anomalies. These numerical experiment involved computation of the gravity anomaly caused by a hypothetical body of known dimensions and to model this anomaly using the method formulated in this study. Then the dimensions of the resulting model is compared with those of the hypothetical body and examined whether the method produces acceptable results by visual inspection of their shapes and also considering root mean square value of the difference between dimensions of two bodies.

IV. MODELING OF SIMULATED GRAVITY ANOMALIES CAUSED BY A FAULT

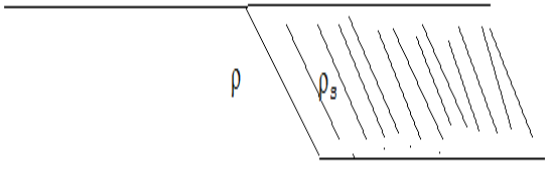


FIGURE 1. Schematic diagram of a fault

Gravity anomaly caused by a normal fault of known dimensions(Fig. 2) has been calculated using Talwani et al. (1959).In this case it has been assumed a part of the horizontal rock layer of density □□has been faulted down and the void created by the faulting is filled with sediments of density $\rho_s$as illustrated in Figure 1. The density contrast between original rock layer and the sediments is causing the anomaly.

Results of the third iteration have been depicted in Figure 3 and have an rms error of 0.05km between original and computed heights and therefore this can be considered as an accurate representation of the causative body.

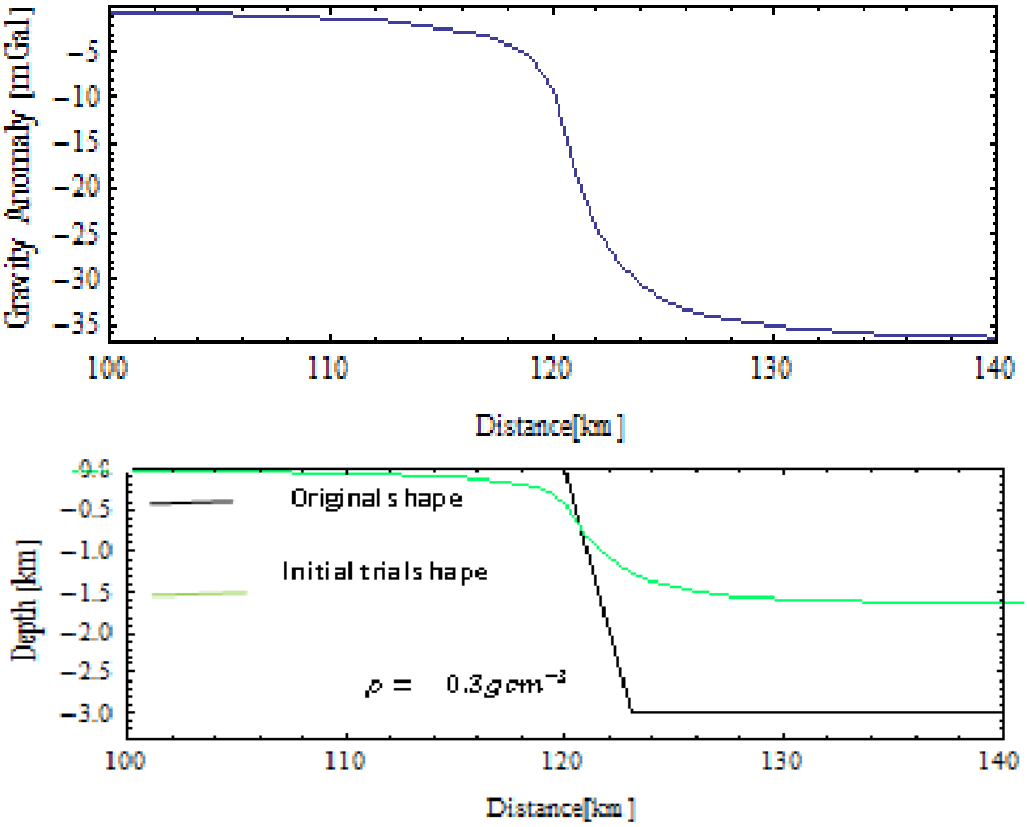


FIGURE 2: Gravity anomaly due to a fault of known dimensions calculated using Talwani et al. (1959). Green line depicts the initial trial model.

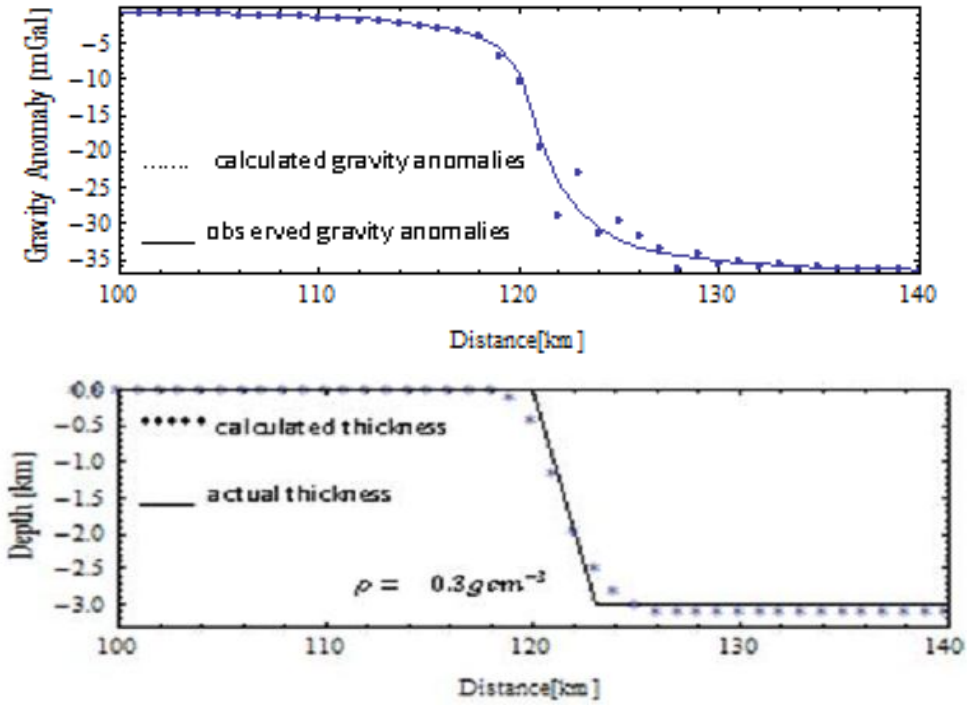


FIGURE 3: Results of modeling of gravity anomaly depicted in Figure 2 after the third iteration.

rms error(gravity anomaly) = 0.54mGal, rms error(body dimensions) = 0.05km

DISCUSSION

Iterative technique presented in this study allows modeling of gravity anomalies in terms of geologically faults. The main advantage of this method is that it provides better freedom to the modeler increasing the probability of obtaining structures with realistic geological shapes. This method can be used to model both normal and reverse faults and can be extended easily to model faults in three dimension. A large amount of data has to be used in the modeling process, especially in the case of three dimensional modeling. The situation becomes verse as this is an iterative process which involves repetition of calculations many a time. The efficiency of this method can be increased several folds by the use of fast Fourier transforms.

REFERENCES

[1] D.S.Rodigo," Modeling of gravity anomalies using a Fourier iterative technique", unpublished.
[2] D.W. Oldenburg," The inversion and interpretation of gravity anomalies", Geophysics, 39(4), 526-536,1974.
[3] M.Talwani, et.al." Rapid gravity computation for for two dimensional bodies with application to the Mediocino submarine fracture zone", Journal of Geophysical Research, 64, 49-59,1959.
[4] R.L.Parker," The Rapid calculation of potential anomalies", Geophysical Journal of the Royal Astronomical Society, 31,447-455,1973.
[5] Thatrigoda, DA & Rodrigo, DS,Numerical Implementation of Fourier Transforms and Associated Problems, International Journal of Multidisciplinary Studies, Vol.1,2014

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