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(E) Gravity anomaly (MP) method

## Inversion of Gravity Anomalies due to Basin Structure

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### ABSTRACT

Before going to an iterative process for the inversion of Bouguer gravity anomalies, proper choice of an initial model assures convergence of the error of fit to an absolute minimum. Thus for determining the shape of the floor of a sedimentary basin, the representative starting model can be a homogeneous semi-ellipsoidal cylinder. A simple method is presented in this paper to estimate the maximum depth of a basin structure from its Bouguer gravity profile.

### INTRODUCTION

An observed gravity profile can be due to an infinite number of different mass distributions. Some of the uncertainties may be reduced if certain assumptions are legitimately made from geological and/or geophysical knowledge. A sedimentary basin may be viewed most conveniently as a homogeneous semiellipsoidal cylinder. In fact, the deposition of sediments under the earth's gravity action gives rise to density gradient in the downward direction. Although this aspect needs particular consideration in the iterative processes, it poses little problem in the estimation of maximum depth for a starting model.

Geology usually supplies information regarding the span of the basin. Density of the sediments in relation to the surrounding and underlying rocks can be assumed because the rocks are exposed. The only unknown parameter that remains to be determined is the maximum depth of the basin. This may be obtained readily by graphical evaluation discussed in the following section and generalise inversion of potential field data due to two-dimensional interface (Pedersen, 1977)

### MATHEMATICAL FORMULATION

The generalised cross section of a sedimentary basin is shown in Fig. 1. XOX is the ground surface. 2a and b

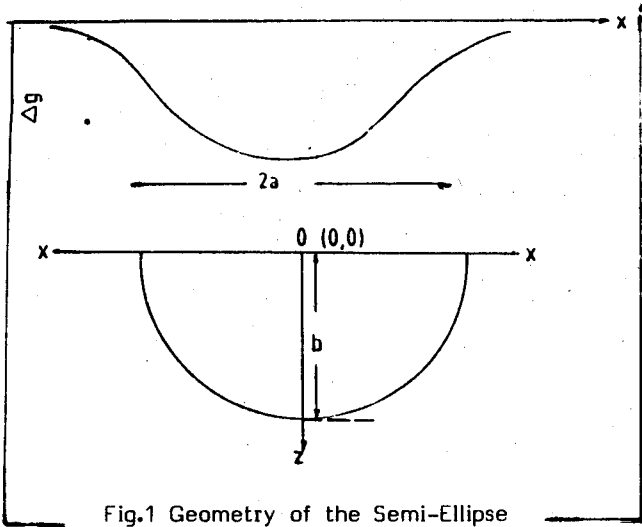


Fig.1 Geometry of the Semi-Ellipse

are the span and maximum depth of the basin.  $\rho$  is the density contrast. Agarwal and Singh (1969) derived expressions for the gravitational attraction of a semi-elliptical shaped body at any point on XOX for three distinct cases of  $b/a \leq 1$ . In the present paper their (1969) expressions particularly for the peak gravity value are considered and a simple procedure is outlined for estimating the maximum depth.

(i) when  $b/a < 1$ , the peak gravity anomaly is given by

$$\Delta g_m = 4G \rho a \left[ \frac{\tan^{-1}(A^2 - 1)^{1/2}}{(A^2 - 1)^{1/2}} \right] \dots\dots 1$$

where  $A = a/b$  and  $G$  is the universal gravitational constant. Rewriting this expression, we have

$$\frac{\Delta g_m}{4G \rho a} = \left[ \frac{\tan^{-1}(A^2 - 1)^{1/2}}{(A^2 - 1)^{1/2}} \right] \dots\dots 2$$

(ii) when  $b/a = 1$ , the peak gravity anomaly is given by  $\Delta g_c(o) = 4G \rho a \dots\dots 3$

Which is nothing but the peak gravity value of a semicircular lamina of radius  $a$ . If we denote this as  $\Delta g(o)$ ,

We have  $\Delta g(o) = 4G \rho a \dots\dots 4$

(iii) when  $b/a > 1$ , the peak gravity value is

$$\Delta g_m = 2G \rho a \left[ \frac{\log \left( \frac{b/a + (b^2/a^2 - 1)^{1/2}}{b/a - (b^2/a^2 - 1)^{1/2}} \right)}{(1 - a^2/b^2)^{1/2}} \right] \dots\dots 5$$

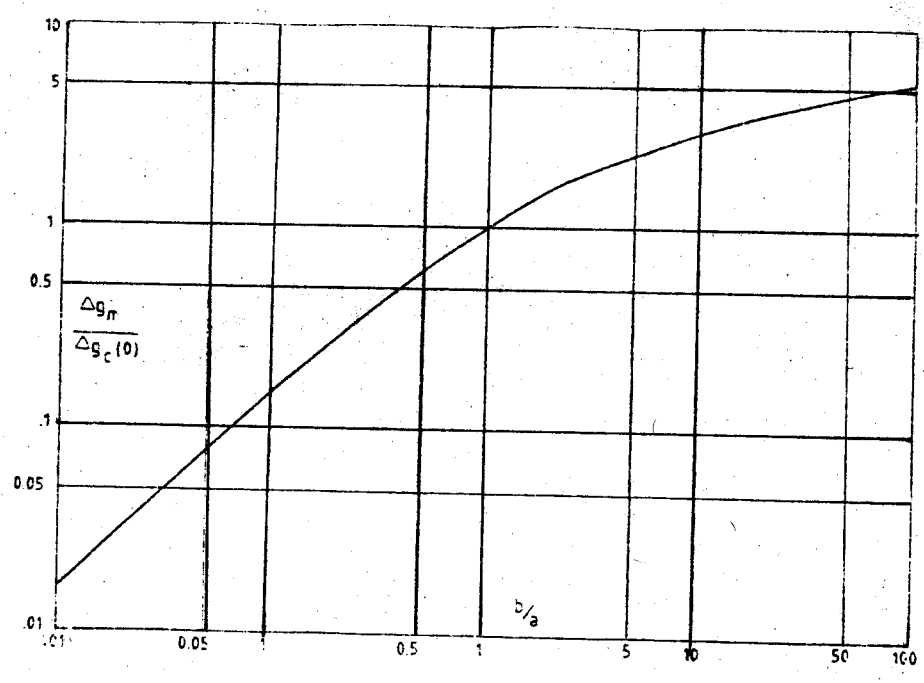
Rewriting this expression, we have

$$\frac{\Delta g_m}{4G \rho a} = \frac{1}{2} \left[ \frac{\log \left( \frac{b/a + (b^2/a^2 - 1)^{1/2}}{b/a - (b^2/a^2 - 1)^{1/2}} \right)}{1 - a^2/b^2} \right] \dots\dots 6$$

The numerator and denominator on the left side of equations (2) and (6) are observed and known quantities respectively. On the right side of these equations, we have functions of  $a$  and  $b$ . Based on equations (2) and (6), we can calculate the ratio of observed peak gravity value,  $\Delta g_m$  and the calculated peak gravity value corresponding to a semicircular lamina,  $\Delta g_c(o)$  and represent the resulting data graphically as shown in Fig.2.

**INVERSION PROCEDURE**

For the known values of the density contrast and the span of the basin, calculate the peak gravity values of a semicircular lamina using the relation  $\Delta g_c(o) = 4G \rho a$



ig.2 Graph showing the normalized peak gravity anomaly and b/a

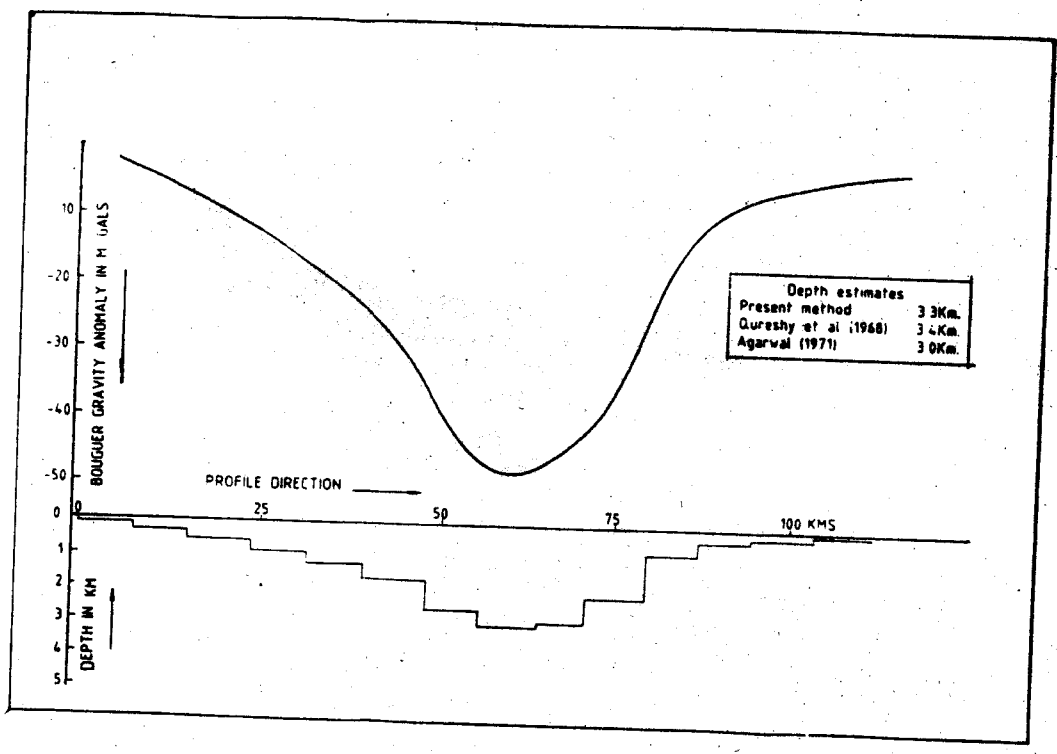


Fig.3 Structural Configuration below - profile CC' of Qureshy et al (1968) across Godavari Valley (India) obtained by assuming a constant density contrast of -0.4 gm/c.c.

Measure the peak gravity anomaly value  $\Delta g_m$  on the bouguer gravity anomaly profile.

Calculate  $\Delta g_m / \Delta g_c$  (o)

Corresponding to this ratio on the ordinate of Figure 2, read the appropriate value of  $b/a$  on the abscissa. Substituting the known value of  $a$ , determine  $b$  which is the maximum depth.

### VERIFIED EXAMPLE

We have determined the maximum depth of the Godavari basin (India) on the basis of the bouguer gravity anomaly map (Qureshy et.al. 1968) along a profile CC' situated to the north of Nagpur using the proposed method. Figure 3 shows the bouguer anomaly profile and the computer generated sedimentary section of Agarwal (1971) with a density contrast of  $-0.4$  gm/cc. For the same density contrast, we have obtained the maximum thickness of sediments as 3.3 km which is in reasonable agreement with the values, 3.4 km and 3.0 km, of Qureshy et.al. (1968) and Agarwal (1971) respectively. The example demonstrates the efficacy of the proposed simple method for designing a starting model for the basin.

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