Interpretation of Vertical Gravity and Magnetic Profiles

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Summary – Methods have been developed by quantitatively interpreting gravity and magnetic data in vertical bore-holes or shafts for geological bodies that can be approximated by spheres and cylinders. Master diagrams that can be directly used by the interpreter are provided.

1. Introduction

Subsurface geophysical measurements in mining prospects for location of new ore bodies or for tracing the extension of known ores are not infrequent (Rogers 1952 [2] 2); Domzálski 1955 [1], for instance). Such data are usually presented either as contour maps at various levels or as profiles along drives, cross-cuts, shafts, etc., or both. While methods of interpretation are available for data collected on horizontal planes or profiles, not much seems to have been published for dealing with measurements along vertical bore-holes, shafts, and the like. In this paper, procedures are developed for the quantitative interpretation of gravity and vertical component magnetic anomalies along such vertical profiles, in cases when the target can be approximated by sphere or cylinder.

2. Vertical gravity profile due to sphere

2.1. Bore-hole not passing through sphere

Consider the origin of co-ordinates to be located on the ground surface directly above the centre of the sphere with the z-axis pointing downwards. If \( d \) is the depth of the centre below the surface and \( x \) is the horizontal offset of the bore-hole or shaft, then

\[
d = \frac{z_1 + z_2}{2}, \quad \text{and} \quad x = \frac{z_2 - z_1}{\sqrt{2}},
\]

where \( z_1 \) and \( z_2 \), measured from the ground surface, are the positions of the two gravity extrema. The depth \( d \) is also given by the value of \( z \) where the anomaly crosses from positive to negative values.

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2) Numbers in brackets refer to References, page 38.
2.2. **Bore-hole passing through sphere**

The nature of the anomaly in this case is shown in Figure 1. For all values of $x > \sqrt{\frac{2}{3}} R$, $R$ being the radius of the sphere, the maximum and the minimum of the vertical profile fall outside the segment of the bore-hole that intersects the body. In such a case, (1) can be used to determine depth and offset. When $x \leq \sqrt{\frac{2}{3}} R$ – as will be evident by the observed extrema coinciding with the extreme intersection points of the bore-hole with the body – (1) cannot be used for depth and offset determination. Under such circumstances, one can use Figure 2 for finding the offset.

![Figure 1](image)

**Figure 1**
Typical vertical gravity profiles when bore-hole intersects sphere for various offsets. $g_e$ is value of gravity at topmost intersection point.

The ordinate $p$ in Figure 2 is the ratio (always less than unity) of two observed gravity values of the same sign and external to sphere, and the abscissa is the ratio (also always less than unity) of the distances of the two points from the zero anomaly point. It is to be noted that only the external portion of the anomaly profile is useful for quantitative interpretation. The internal portion, that is, the straight line, can be used for computing the density contrast, $\rho$, if that is necessary.

When the offset is such that external maximum and minimum occur, the radius