

## CHAPTER 2

### ELEMENTARY THEORY

#### 2.1 Newton's law of gravity

The theory behind gravity prospecting originates directly from Newton's law of gravitational attraction. This law states that between two objects, there exists a force of mutual attraction whose is proportional to the product of the masses and inversely proportional to the square of the distance between them. The force acts in the direction of  $r$  and is expressed by:

$$F = G m_1 m_2 / r^2 \quad \text{_____} \quad (2.1)$$

where  $F$  is the force between two particles of mass  $m_1$  and  $m_2$

$G$  is the universal constant of gravitational ( $6.67 \times 10^{-11} \text{m}^3 \text{kg}^{-1} \text{s}^{-2}$ )

$r$  is the distance between them

The force per unit mass on a particle at any point in space at a distance  $r$ , in this case,  $F$  is defined as the gravitational field of the particle  $m_1$  or the particle  $m_2$  is in a field of force due to  $m_1$ . Since, the acceleration of the particle  $m_2$  caused by the gravitational field of  $m_1$  will be,

$$g = F / m_2 = G m_1 / r^2 \quad \text{_____} \quad (2.2)$$

It is called variously the gravitational field, the gravitational acceleration, or the acceleration of free fall (Grant and West, 1965). If  $m_1$  is the mass of the earth,  $M_e$ ,  $g$  becomes the acceleration of gravity and is given by (Telford and others, 1990) :

$$g = G M_e / R_e^2 \quad \text{-----} \quad (2.3)$$

where  $R_e$  being the radius of the earth, it is customary to use the same symbol  $g$  whether it is due to the earth or a mass  $m$ .

As a consequence, a point mass placed in the vicinity of any body will be in the gravitational field of the body and experience an acceleration if free to move. The total force on the mass due to the body (and acceleration) in any desired direction can be calculated by applying Newton's law to infinitesimal, point mass elements of the body and integrating over the entire volume.

## 2.2 Application to gravity survey

Although the measurement of an absolute value of gravity is extremely difficult because of the requirement in sophisticated apparatus and lengthy period of observation, it may be obtained by referring to the International Gravity Standardization Network (IGSN) of 1971, a network of stations at which the absolute value of gravity have been determined by reference to sites of absolute gravity measurements. By using a relative reading instrument to regulate the difference in gravity between an IGSN station and a field location, the absolute value of gravity at that location can be determined (Kearey and Brooks, 1991).

In geophysical prospecting, the measurement of relative values of gravity, the differences of gravity between an observation point and a base point, is the preferable standard procedure (Kearey and Brooks, 1991, and Parasnis, 1986). Appropriate corrections must be applied to the differences measured within any region to take account of any known courses of the differences. The corrected gravity values, called the

anomalies, yield information about the changes of density within the earth as well as about the surfaces that bound regions of differing density.

The number of gravity field instruments, gravimeters, have been developed over the years in order to measure these variations. The gravity meters effectively respond only to vertical component of the gravitational attraction of an anomalous mass. In the SI system, the dimension of acceleration is meters per second squared, but in exploration work, an acceleration of  $\text{cm} / \text{sec}^2$  is preferred. The unit of measurement is referred to as Gal ( $1\text{Gal}=10^{-2} \text{ m/sec}^2$ ). Typically, the milliGal (mGal,  $1/1000 \text{ Gal}$ ) has become the standard unit of measurement for gravitational field reading (D'Andrea, 1990). Another unit, less commonly used, is the gravity unit,  $\text{gu} = 0.1 \text{ mGal}$  (Dobrin and Savit, 1988).

It is clear from above that anomalies are only very small fractions of the earth's total field and the anomalies from geologic sources may be as small as 0.1 to 1 mGal. They thus must be measured in a total field of the order of  $980 \text{ Gal} = 980,000 \text{ mGal}$ . Then relative gravity measurements must be made with an accuracy better than a few parts in  $10^7$ , preferably, with an accuracy approaching 1 to 5 parts in  $10^8$  (Parasnis, 1986).