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Gravity Center Determination of Aljalamid Phosphate Ore Deposit

Gamal M. A. Mahran
Deanship of Graduate Studies,
King Abdulaziz University,
Jeddah 21589, Saudi Arabia
gamalmahran@hotmail.com

Hussin A.M. Ahmed
Mining Engineering Dept.,
King Abdulaziz University,
Jeddah 21589, Saudi Arabia
hussien135@gmail.com

***Abstract*—Aljalamid phosphate ore deposit, in the northern part of Saudi Arabia, is spread on three different locations that are Fish area, Southern area and Western area. Thus, determination of the gravity centers of the three locations represent the first step to satisfy the minimum transportation cost. Therefore, this study aims to calculate the center of gravity of each location to build a mathematical model to find the location of the intended processing plant. The method of gravity center determination consists of four steps. The coordinates of the gravity center of the three locations of Aljalamid phosphate ore deposit were obtained.**

Keywords— Gravity Center; Moment method; Ore reserves; Mining

I. INTRODUCTION

The gravity center is a geometric property of any object. The center of gravity is the average location of the weight of an object. In general, determination of gravity center is a complex method because the mass (and weight) may not be uniformly distributed throughout the object. In the general case the center of gravity (C.G) can be determined by calculus [1]. A mechanical method consists of two steps as shown in Fig.(1). In the first step, the object is hanged from any point and a weighted string is dropped from the same point. Draw a line on the object along the string. For the second step, repeat the method from another point on the object, Now you have two lines drawn on the object. The point of intersection of two lines is the center of gravity. This method is suitable for irregular objects in shape.

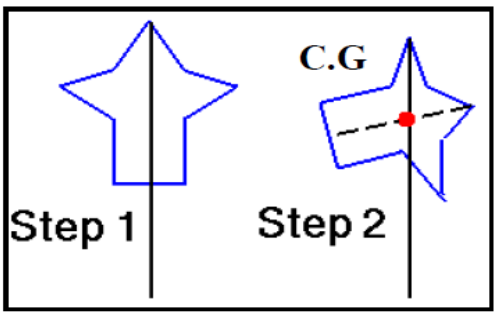

Fig. 1. *Center of gravity determination for general shape*

A lot of tables in many books of the center of gravity for simple shapes with uniform mass. These tables were prepared by using the following equations:

$$C.G\ w = \int x\, d\, w \qquad (1)$$

$$C.G\ w = g \int \int \int x\, \rho\, dx\, dy\, dz \qquad (2)$$

Where:

ρ = density = ρ(x,y,z)

w = total weight

Abilla [2] stated that "The Center of Gravity Method is an approach that seeks to compute geographic coordinates for a potential single new facility that will minimize costs". Abilla suggested a method to determine the center of gravity. This method depends on the market locations, goods volume and cost of shipping. The center of gravity of a block in two dimensions can be determined as follows (Seyhan method): Plotting a grid over the area of the block as shown in Fig. (2) systematically measuring the location of all the knots of the grid x_i and y_i according to a predetermined x, y co-ordinates system and calculating [3], [4].

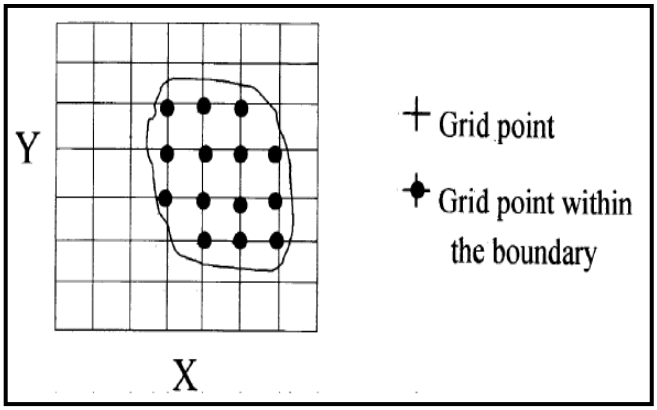

Fig . 2. *Seyhan method for calculation of the center of gravity of ore block*

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n} \qquad (3)$$

$$\overline{Y} = \frac{\sum_{i=1}^{n} Y_i}{n} \qquad (4)$$

Where:

x - = x co-ordinate of the center of gravity.

Y = y co-ordinate of the center of gravity.

xi = x co-ordinates of the grid points within the boundary.

yi = y co-ordinates of the grid points within the boundary.

n = number of the grid points within the boundary.

The previous studies did not present any trials to determine the center of gravity of ore reserves, Therefor this study aims to present a method to find ore deposit gravity center.

II. Theoretical Consideration

The purpose of center of gravity calculation is to accumulate the reserves of each location at a certain point that has xi, yi and zi coordinates. The resultant of the weights, or parallel forces of gravity, on all the particles of a body always passes through a certain point fixed with reference to the body is turned. This particle or point is the center of gravity of the body [5]. Calculation of the center of gravity of ore deposit can be calculated as in the following steps.

First Step: The ore deposit area is divided into triangles. Each triangle consists of three boreholes(Fig. 3).

Second Step: Calculation of the ore reserves and center of gravity of each triangle. The center of gravity of a triangle (Fig. 4) is the intersection point of its medians [6].

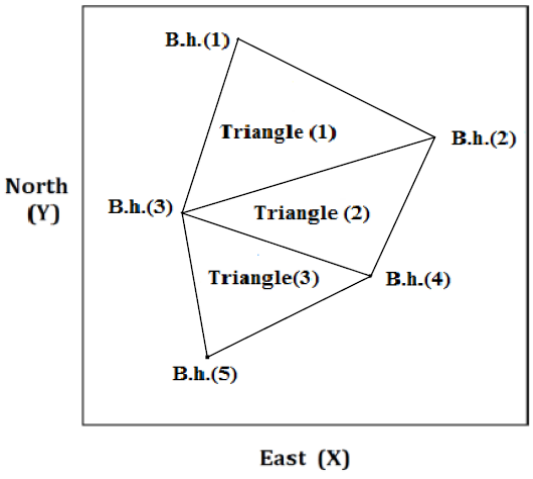

Fig. 3. *The ore deposit area divided into triangles.*

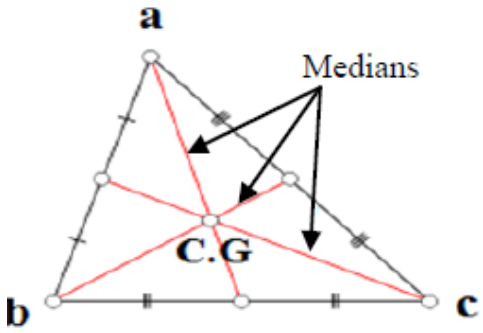

Fig. 4. *Determination of the center of gravity of a triangle.*

The center of gravity divides each of the medians in the ratio 2:1, which is to say it is located ⅓ of the perpendicular distance between each side and the opposing point. Its Cartesian coordinates are the means of the coordinates of the three vertices. That is, if the three vertices are:

$a = (x_a, y_a)$, $b = (x_b, y_b)$, and $c = (x_c, y_c)$, then the x and y coordinates of the center of gravity are $\overline{x}, \overline{y}$ and can be calculated as shown in equation (5).

$$C.G = \frac{1}{3}(a+b+c) = \left[\frac{1}{3}(X_a + X_b + X_c), \frac{1}{3}(y_a + y_b + y_c)\right] \qquad (5)$$

Third Step: Determination of Z coordinate of the center of gravity of a triangle. Z coordinate of gravity center of a triangle can be determined for the point, which was determined in the second step. Z coordinate of gravity center of the triangle can be calculated from equation (6).

$$\bar{z} = z - t_{o.b} - \frac{t_b}{2} \qquad (6)$$

Where:

z-: z coordinate of the gravity center of the triangle.

z : z coordinate of ground surface.

$t_{o.b}$: The thickness of overburden.

t_b : The thickness of the bed of required block.

Fourth Step: Determination of the center of gravity of ore deposit that consists of a number of triangles (Fig. 5) by using the following equations (7-9).

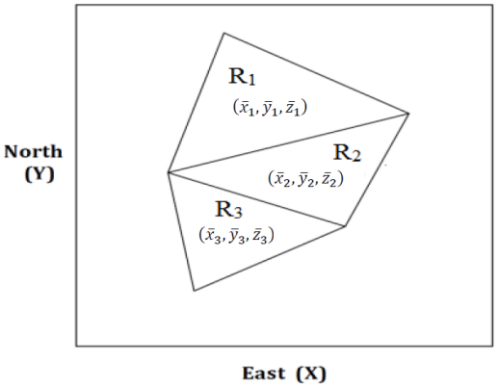

Fig. 5. *Ore deposit consists of a number of triangles*.

$$x = \frac{\sum_{i=1}^{n} R_i \bar{x}_i}{\sum_{i=1}^{n} R_i} \quad (7)$$

$$y = \frac{\sum_{i=1}^{n} R_i \bar{y}_i}{\sum_{i=1}^{n} R_i} \quad (8)$$

$$z = \frac{\sum_{i=1}^{n} R_i \bar{z}_i}{\sum_{i=1}^{n} R_i} \quad (9)$$

Where:

x = x coordinate of the center of gravity of the ore deposit.

y = y coordinate of the center of gravity of the ore deposit.

z = z coordinate of the center of gravity of the ore deposit.

$\bar{x}_i$ = x coordinate of the center of gravity of the i th triangle of ore deposit.

$\bar{y}_i$ = y coordinate of the center of gravity of the i th triangle of ore deposit.

$\bar{z}_i$ = x coordinate of the center of gravity of the i th triangle of ore deposit.

R_i = The reserves of the i th triangle of ore deposit.

n = Number of triangles of ore deposit.

III. Results and Discussions

Data of 500 boreholes were obtained from Ma'aden Company for Aljalamid deposit. These boreholes represent the different three locations. Calculation of the coordinates of the gravity center of ore deposit consists of two steps. The first is calculation of the gravity center of each block (triangle) of ore deposit using equations (5, 6). The second step is the application of the moment method (Equations 7, 8, 9). The ore reserves and gravity center of different locations of Aljalamid phosphate ore deposits were calculated and shown in Table 1, which illustrates that the Fish area has the highest reserve approaching 451 million tons. Fig. (6) shows that the calculated centers of gravity of different ore deposit locations of Aljalamid phosphate ore.

TABLE 1: *Reserves and coordinates of center of gravity of different locations of Aljalamid phosphate ore deposit.*

Location No.		1	2	3
Ore deposit location		Fish Area	Southern Area	Western Area
Reserves (Tons)		450,765,474	361,831,423	338,756,461
Center of Gravity	x(m)	291095	290119	242008
	y(m)	245985	191354	216954
	z(m)	756	712	723

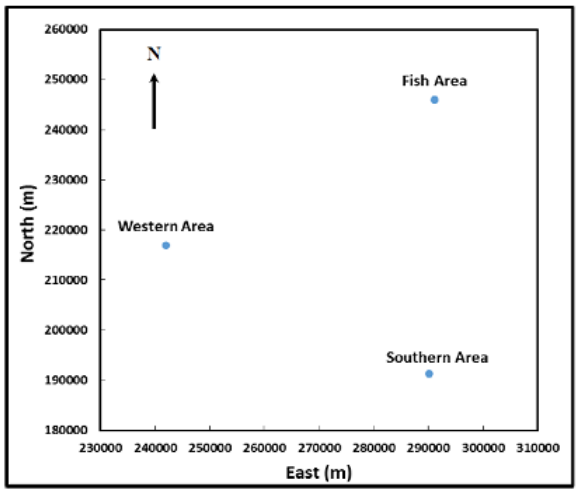

Fig. 6. *Calculated centers of gravity of different ore deposit locations of Aljalamid phosphate ore.*

IV. Conclusions

From this study, the following conclusions can be drawn:

1. The phosphate ore in Aljalamid area is a scattered deposit with three main locations that are: fish area, southern area and western area having ore deposits of 451, 362, and 339 million tons of phosphate ore respectively.

2. The gravity centers of the different ore deposit locations were determined and found to be of approximately 55 km far from each other.

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