International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 03 Issue: 08 | Aug-2016 www.irjet.net p-ISSN: 2395-0072

GEOSTATISTICAL MODELING OF SOME PHOSPHATE DEPOSITS IN EGYPT

H. A. Farag[1], A. F. Ismael[2], M. A. Gouda[3] and S. M. Sleem[4]

[1,2,3,4] Al-Azhar University, Faculty of Eng., Mining and Petrol. Dept., Nasr City, Cairo, Egypt

Email:hussinfarag@yahoo.com

Abstract- *Geostatistical analysis plays an important role to study the mineralization behavior within the ore deposits. Variograms, as the first step in any geostatistical study, are constructed for P_2O_5% of three phosphate deposits near the River Nile of Egypt, namely; Um Salama, Um Hugara and Wadi El Shaghab areas. Also, the available data are analyzed statistically to show the distribution of P_2O_5% through the three areas. After fitting the variogram of each area to suitable variogram model, kriged model are established for each area.*

Key Words: **Geostatistics, kriging, GS+, Variogram, Um Salama, Um Hugara, Wadi El Shaghab**

1. INTRODUCTION

Geostatistics now plays a wider role in mining with matters such as the flow of methane in coal mines and the disposal of waste and its subsequent fate [1]. The variogram can be described as the variation in values among samples some distance apart as a measure of their spatial correlation [2]. Constructing of an experimental variogram is the first step in any geostatistical analysis. It can be computed from a set of randomly spaced data through finding pairs of data that are oriented in the required direction, determining the distance between the samples, then summing the squared differences of the grades and dividing by the number of pairs [3].

Kriging provides the best estimate of the mean value of a regionalized variable. It provides the Best Linear Unbiased Estimator (BLUE) of the grade. During kriging, each sample is assigned a sample weight. The weighted samples are then linearly combined to give the best estimate. It is the 'best' estimate because the procedure minimizes the expected error between the estimated grade and the true grade. Sample weights are calculated such that the variance of the estimate is a minimum. That variance can be calculated using the sample positions and the variogram function. Having the estimation variance is extremely useful because it allows the user to explore the risk of the estimate [4].

In this research geostatistical technique is used for modeling the P_2O_5% distribution in the three studied areas by using GS+ (Geostatistics for the Environmental Sciences) software. GS+ allows for user to readily measure and illustrate spatial relationships in geo-referenced data. Also, it can used to analyze spatial data for autocorrelation and then uses this information to make optimal, statistically rigorous maps of the area sampled [5]. Experimental variogram was constructed for each area to characterize the spatial variability of the measured P_2O_5% values depending on the available data. These data are x and y coordinates and P_2O_5% for each sample location area. Spherical and exponential variogram models were selected as more suitable fitted to the experimental variograms. Depending on the parameters of the variogram models for each area, ordinary kriging techniques was used to present distribution model of P_2O_5% which could be used in mine planning and production.

2. LOCATION OF STUDIED AREAS

Phosphate deposits are distributed in several locations in the Eastern Nile Valley. The studied areas are a part of El Sebaiya east including; Um Salama, Um Hugara and Wadi El Shaghab mines as shown in fig.1. Phosphate ores are exploited by using open cast mining method.

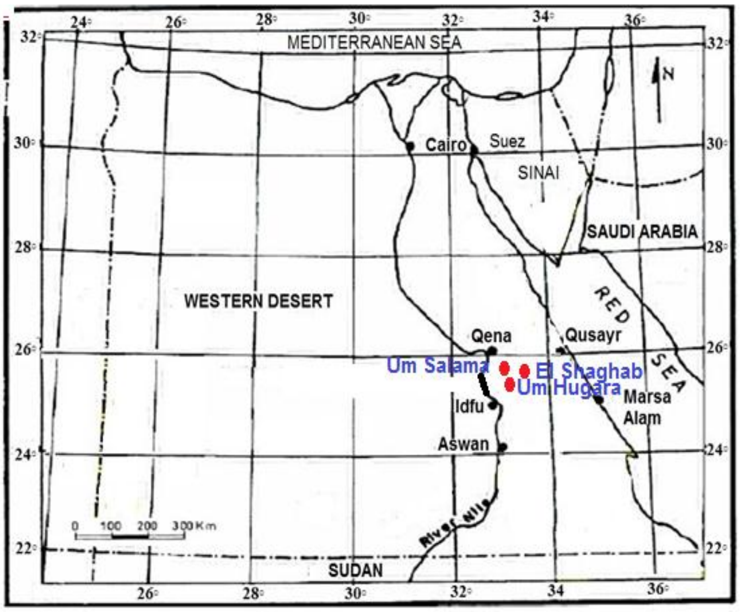


Fig. 1: location map of studied areas.

3. STRATIGRAPHIC OF STUDIED AREAS

In the studied areas, Duwi Formation consists of differed successive layers for the three areas as shown in fig.2. The phosphate of this formation can be classified into two horizons (A and B from base to top). The horizon (A) represents the high economic phosphorite bed in all studied sections where it has largest thickness and high phosphorus content [6, 7].

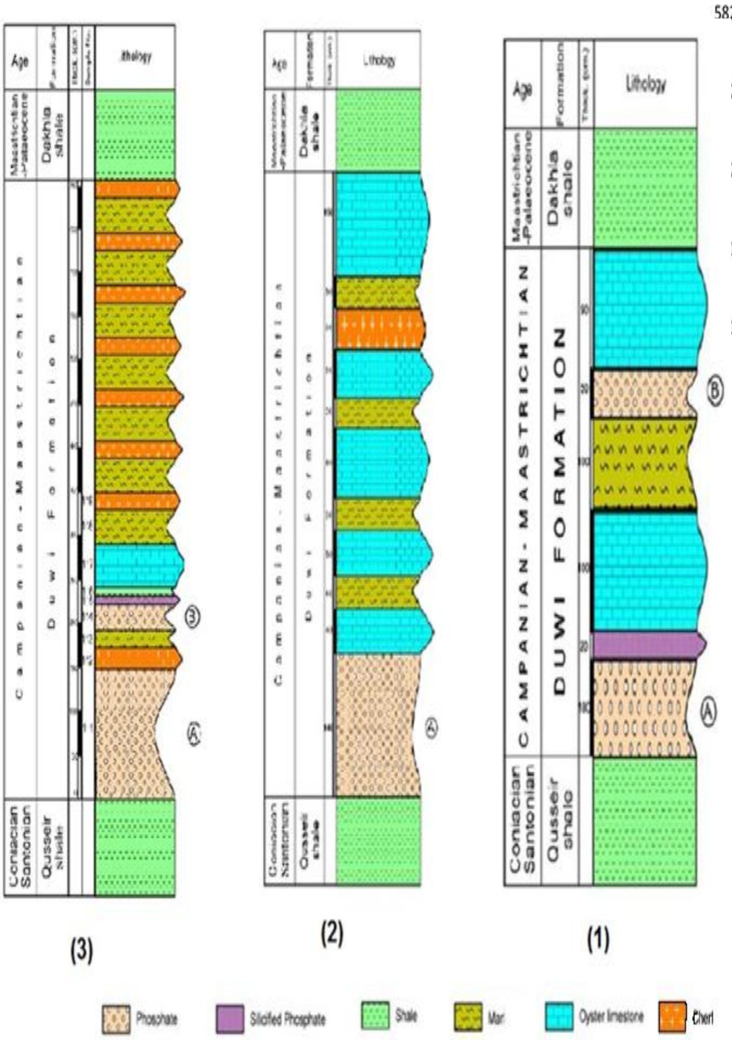


Fig. 2: Lithostratigraphic succession of Duwi Formation exposed in studied areas where, (1) Um Salama, (2) Um Hugara and (3)Wadi El Shaghab [6,7].

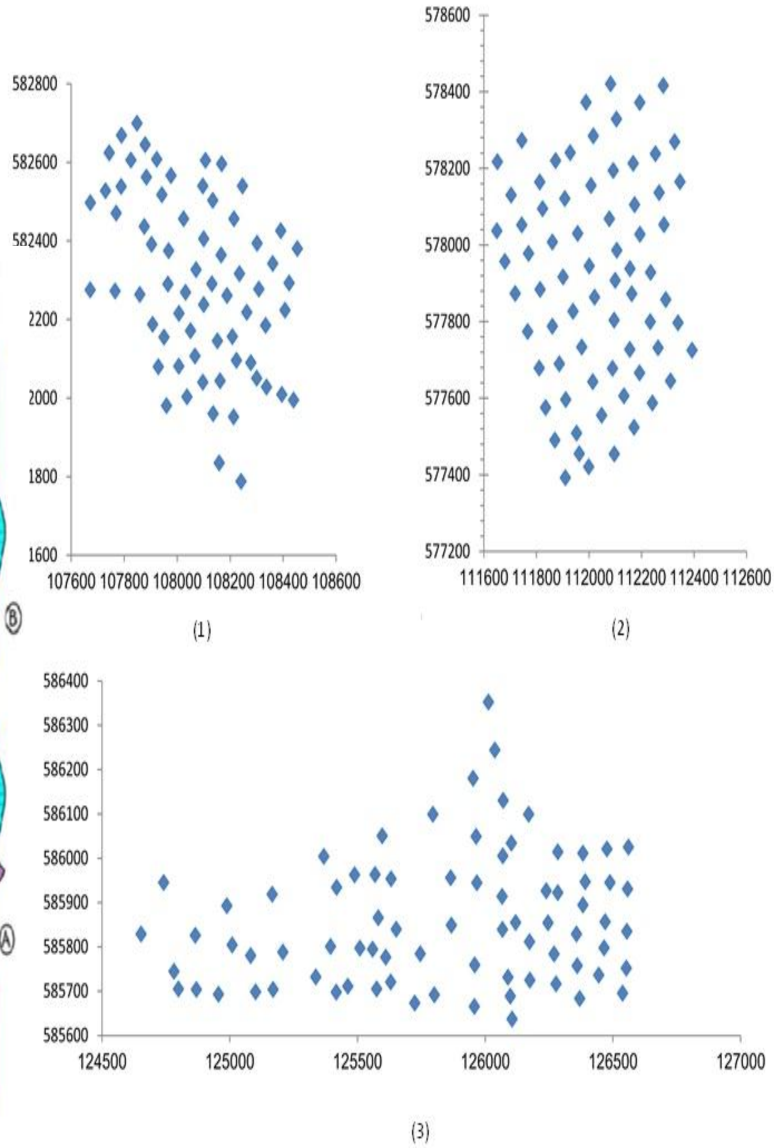


Fig.3: Scatter plot of studied areas where, (1) Um Salama, (2) Um Hugara and (3) Wadi El Shaghab.

4. THE AVAILABLE DATA

The sample collected from boreholes where analyzed for P_2O_5%. The scatter plot of the boreholes within the three areas as shown in fig.3.

5. PREPARING DATA FOR USING GS + SOFTWARE

The dataset for studied areas are created by scanning the site surveying maps to convert it to digital raster maps, then converting the coordinate system of the site surveying maps from geographic coordinate system to ETM (Egyptian Transverse Mercator). The digital raster maps were imported to Auto CAD map software and oriented it in the correct position using ETM coordinates then, digitizing all points (bore holes locations) in the oriented raster maps and finally Exporting all points (bore holes locations) produced from digitizing process in excel sheet form.

The database of study area created by import the excel sheet into GS+ software. Therefore many statistical and geostatistical analysis can be done on the phosphate ore body. These analyses include frequency distribution, variogram modeling and Kriging modeling.

6. STATISTICAL ANALYSIS

Statistical analysis gives the distribution of P_2O_5 % content and the standard parameters; minimum, maximum, mean, range, median, standard deviation, variance, skewness, kurtosis and coefficient of variation. Table1 gives the summary statistics of the data sets for P_2O_5% of studied areas. Fig.4 shows the histogram of P_2O_5% that constructed for studied areas. The results show that the distribution is negatively skewed and the P_2O_5% content does not have the same distribution within the studied areas.

Table.1: Summary statistics of P_2O_5 % in studied areas.

Statistical parameters	Um Salama	Um Hugara	Wadi El Shaghab
number of bore holes	67	70	78
Min.	27.04	23	23
Max.	32.8	32.45	32.52
Range	5.76	9.45	9.52
Mean	30.38	29.107	29.633
Median	30.5	29.18	30.045
Standard deviation	1.255	1.824	2.044
Variance	1.575	3.327	4.179
Skewness	-0.374	-0.726	-0.909
Kurtosis	2.740	3.87	3.347
Coefficient of variation	0.0413	0.0627	0.0690

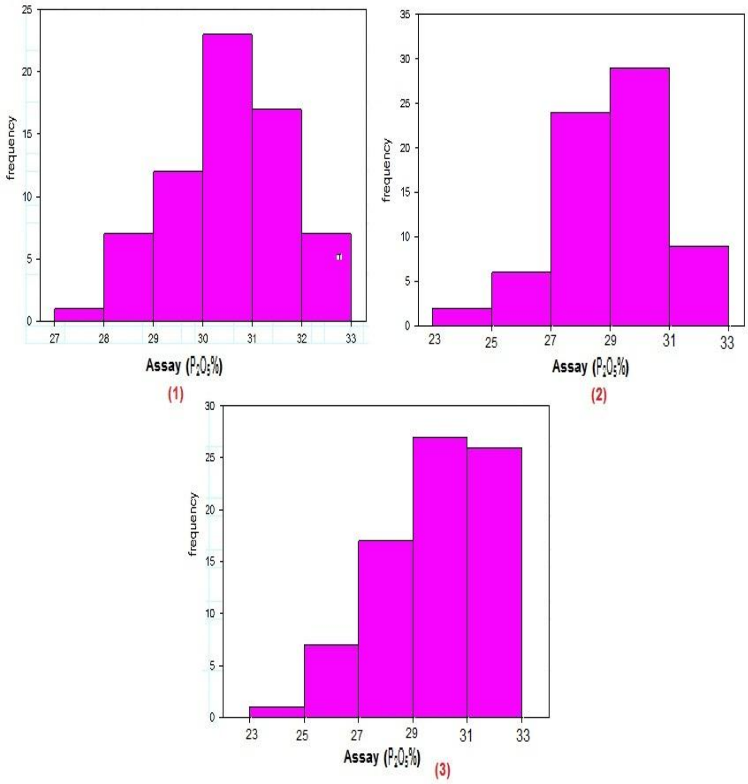


Fig.4: Histogram of P_2O_5 % in studied areas where, (1) Um Salama, (2) Um Hugara and (3) Wadi El Shaghab.

7. VARIOGRAM MODELING

Depending on the available data for each area isotropic variogram were constructed and fitted to a suitable model as shown in fig.5. The variogram parameters for P_2O_5% in studied areas were summarized in table.2.

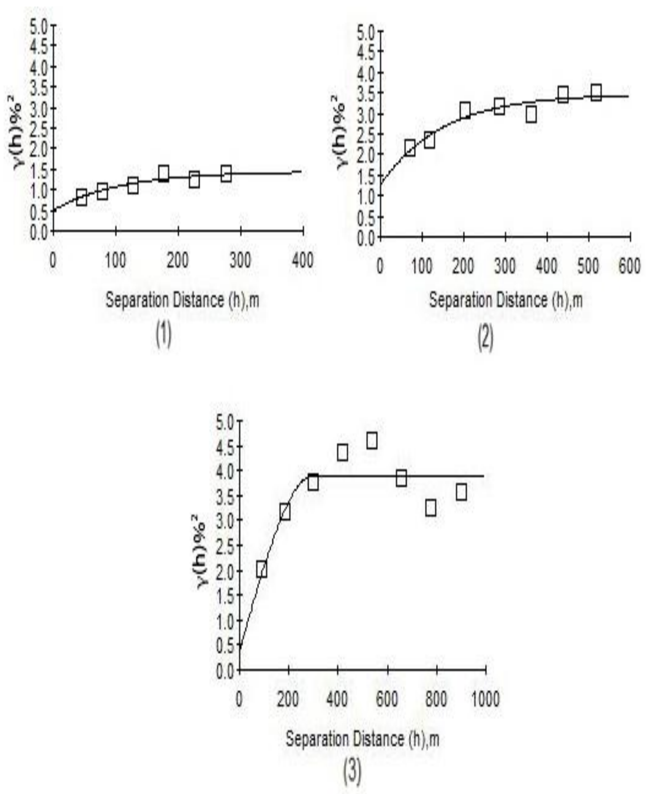


Fig.5: Variogram models for P_2O_5 % in studied areas where, (1) Um Salama, (2) Um Hugara and (3) Wadi El Shaghab.

Table.2: Variogram parameters of P_2O_5 % in studied areas.

Variogram parameters	Um Salama	Um Hugara	Wadi El Shaghab
Type	Exponential	Exponential	Spherical
Direction	Global	Global	Global
Range, m	325	453	298
Nugget effect (C0), $\%^2$	0.505	1.276	0.360
Sill (C), $\%^2$	1.446	3.478	3.895

As shown from the variogram models in figs.5 and geostatistical parameters in table 2, it is clear that P_2O_5% distribution is characterized by different ranged variation through three locations. Um Salama area has a small value of sill, but it has a moderate value in both nugget effect and range of influence. On the other hand Wadi El Shaghab area has the extreme value of sill and small values in both range of influence and nugget effect. Um Hugara area has a high value of nugget effect and range of influence, but it has a moderate value of sill.

From the variogram parameters of models of the three areas it is noticed that P_2O_5 % through Um Salama and Um Hugara tends to have less variation, and hence high mineralization continuity. But on short distance scale area Wadi El Shaghab has less variation. This result could be referred to the present of intercalations within the deposits horizontally.

8. KRIGING

Ordinary Kriging is used to interpolate the unknown locations by creating map analysis that showing the distribution of P_2O_5% in studied areas as shown in fig.6. This map is classified into classes, each class represent specific percentage from P_2O_5% and colored with specific color, which helps in showing the distribution of P_2O_5% in different locations in the studied areas.

The results indicate that the P_2O_5% tend to be decreased to the east direction while the deposit become apart from the River Nile at Um Salama area. Also, it is clear from this model the majority of Um Salama area tends to have high grade of P_2O_5%. The high grade value within the other two areas is clearly less than Um Salma area and wide grade distribution is noticed. This information will assist mining engineers to take appropriate decisions during exploitation stage.

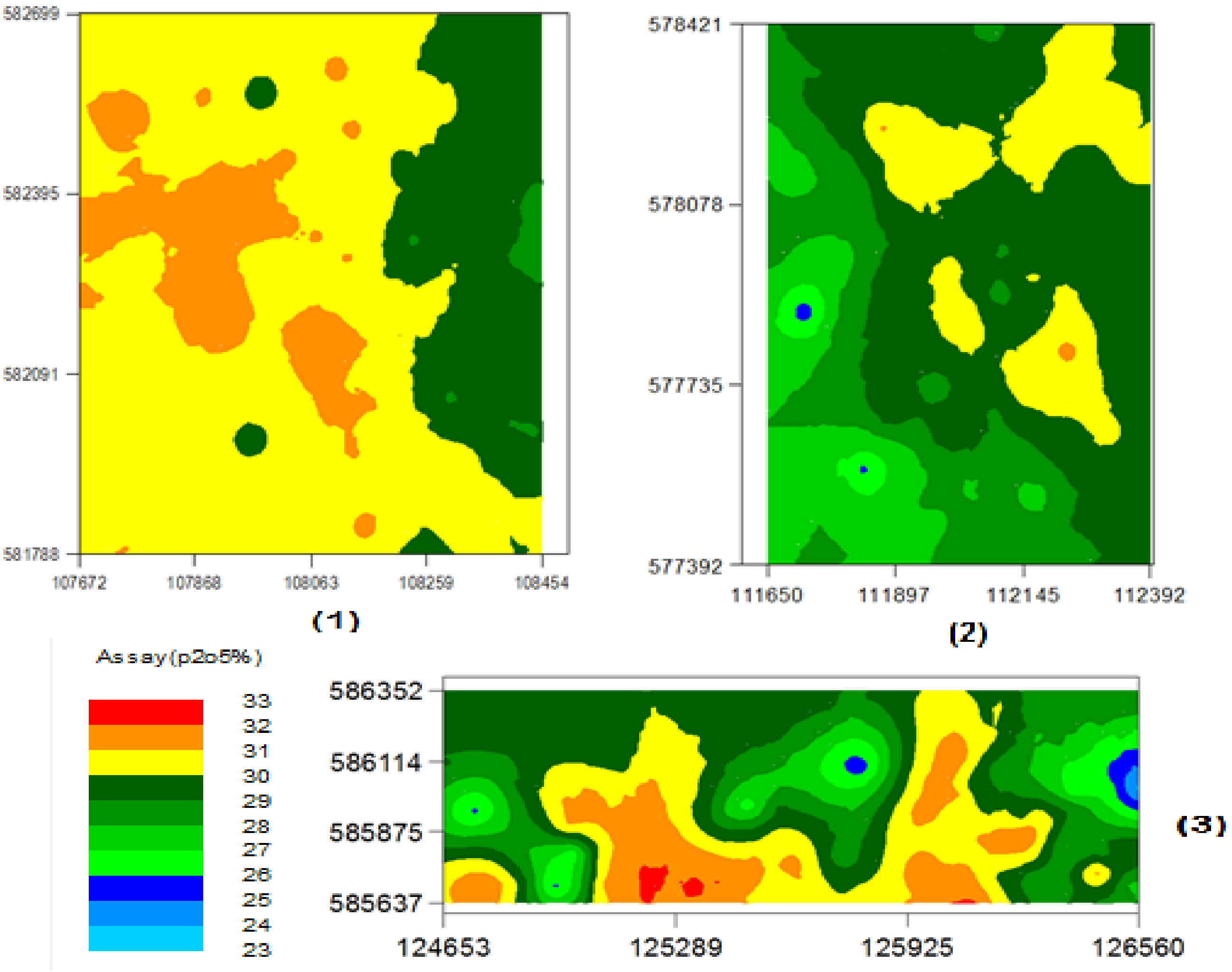


Fig.6: kriged models showing P_2O_5% distribution in studied areas where, (1) Um Salama, (2) Um Hugara and (3) Wadi El Shaghab.

9. CONCLUSION

The conclusions drawn from the present study can be summarized as follows:

1. Statistical analysis reflects the clear difference between the distributions and statistical parameters of phosphate within the three areas.
2. Applying geostatistical techniques revealed the behavior of mineralization within the deposit as reflected by the variograms.
3. Variogram parameters indicated high continuity through Um Salama and Um Hugara areas on the large distance scale; on the other hand, Wadi El Shaghab area represents high continuity on short distance scale.
4. Kriged models illustrated the distributions of P_2O_5% through the deposit where it can be useful when planning the mine for production.
5. The variogram models and the kriged models proved that P_2O_5 % tend to be increased as close to the River Nile.

10. REFERENCES

[1] Bush, D., 2010 An overview of the estimation of kimberlite diamond deposits, Southern African, Institute of Mining and Metallurgy, Source to Use 2010, Johannesburg, pp. 73–84.

[2] Stephen, A., 1993 A variography primer, Gibbs Associates.

[3] Clark, I., 1979 Practical Geostatistics, Applied Science, Publishers Ltd, London, 129p

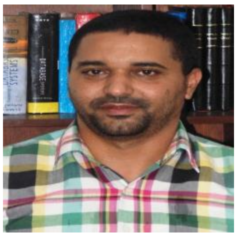
[4] Matheron, G., 1962 Traité de Gé ostatistique Appliqué e, Vols. 1 and 2.

[5] Anon, 2015. Geostatistics for the Environmental Sciences. Manual of software produced by Gamma Design Software, LLC Plainwell, Michigan 49080.

[6] El-Nasr Mining Company, 2010. Un published Technical Report about Mining Works which is Conducted in El Sebaiya, East Nile Valley, Egypt.

[7] Alameer, Z., 2015. Job planning and management in some Egyptian surface mines. M.Sc. Thesis, Faculty of Engineering, Al-Azhar University, Cairo, Egypt.

BIOGRAPHIES



H. A. Farag is currently a master student at Al Azhar University, Faculty of Eng., Mining and Petroleum Dept., Cairo, Egypt. His area of interest is mining Engineering.
*Email:*hussinfarag@yahoo.com

A. F. Ismael is currently working as lecturer at Al Azhar University, Faculty of Eng., Mining and Petroleum Dept., Cairo, Egypt. His area of interest is Mining Engineering.
Email: ashraffahmy72@yahoo.com

M. A. Gouda is currently working as professor at Al Azhar University, Faculty of Eng., Mining and Petroleum Dept., Cairo, Egypt. His area of interest is Mining Engineering.
Email: magouda2005@yahoo.com

S. M. Sleem is currently working as professor at Al Azhar University, Faculty of Eng., Mining and Petroleum Dept., Cairo, Egypt. His area of interest is Mining Engineering.
E-mail: Samir_sleem@yahoo.com