

# GIS Technology for El-Gedida Iron Ore to satisfy the Requirements of Egyptian Blast Furnace

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**Abstract**—In recent years Geographic Information Systems (GIS) has been developed and used extensively in mining industry. It is a powerful tool in many operations that support the decision-making, to search for new economic deposits. This paper aim to use GIS technique to find the locations that satisfy the requirements of blast furnace of Egyptian Iron and Steel Company from El-Gedida iron ore and to calculate the volume of iron ore that can be extracted from these locations. ArcInfo 9.3 software package was used to achieve this work.

**Index Terms**— GIS, El-Gedida iron ore, Requirements of blast furnace.

## 1 INTRODUCTION

GIS is one kind of computer system gathering, storing, managing, analyzing, demonstrating and applying geographic information. It is a general technology that can analyze and process enormous amounts of geographic data. It takes a geographic space database as its foundation, uses a geographic model analysis method to provide many kinds of spatial and dynamic geographic information and serves as a geographic research and decision making tool. GIS has some basic functions such as electronic mapping, spatial data management and spatial information analysis. GIS has been applied in many fields to establish all kinds of spatial databases and decision support systems, each with different criteria and provide answers to many different formal spatial inquiries, spatial analyses and assistance plans and decision-making functions [1].

GIS play an important role in today's mining industry. Not only does a GIS help to locate a mineral deposit, it also saves time, money, and is more reliable than traditional methods of resource exploration. GIS packages can help to visualize the geography of an area, helping to eliminate potential problems and hazards [2].

World production of iron ore increased again to another all time high in 2007 at 1,480 million tonnes and crude steel production increased to 1,340 million tonnes, 7% higher from a year earlier. Growth remains strong and the market consensus is that it will remain strong over the next five to seven years. The blast furnace remains the principal iron-making route while the Basic Oxygen Furnace (BOF) remains the principal steelmaking method accounting for 60% of production [3]. Therefore the objective of this study is to use GIS technique to find the locations that satisfy the requirements of blast furnace of Egyptian Iron and Steel Company from El-Gedida iron ore and to calculate the volume of iron ore that can be extracted from these locations.

## 2 Data Models Used in GIS

Spatial data are presented in various models that represent the main GIS types, raster, vector, and Triangulated Irregular Network (TIN). Vector data models are suitable for producing various types of high quality and conventional maps. Raster data models are suitable for representing data that varies continuously over geographic area and surface analysis, or overlay functions [4]. A Triangulated Irregular Network (TIN) represents a surface as a set of irregularly located points, joined by lines to form a network of contiguous, non-overlapping triangles that vary in size and proportion. Each triangle node stores an x, y, and z value [5]. Utilizing TIN is easy to draw contours, make a three-dimensional view of an area and calculate areas and volumes [2].

## 3 GIS Query and Exploration

GIS Queries, which are often created as logical statements or expressions are used to select features on the map and their records in the database. A common GIS queries are determining what exists at a particular location. In this type of query, the user knows where the features of interest are, but wants to know what characteristic are associated with them. This can be accomplished with a GIS because geographic features on the map display are linked to their attribute. Another type of GIS query is to determine which location or locations satisfy certain conditions. In this case, the user knows what characteristics are important and wants to find where the features that have these characteristics [6].

## 4 Description of Study Area

El-Gedida area is located in the north-eastern plateau of El-Bahariya Depression. The centre of El-Gedida area lies approximately at latitude 28° 27' N and longitude 29° 10' E [7]. Fig. 1 shows the location map of El-Gedida area.

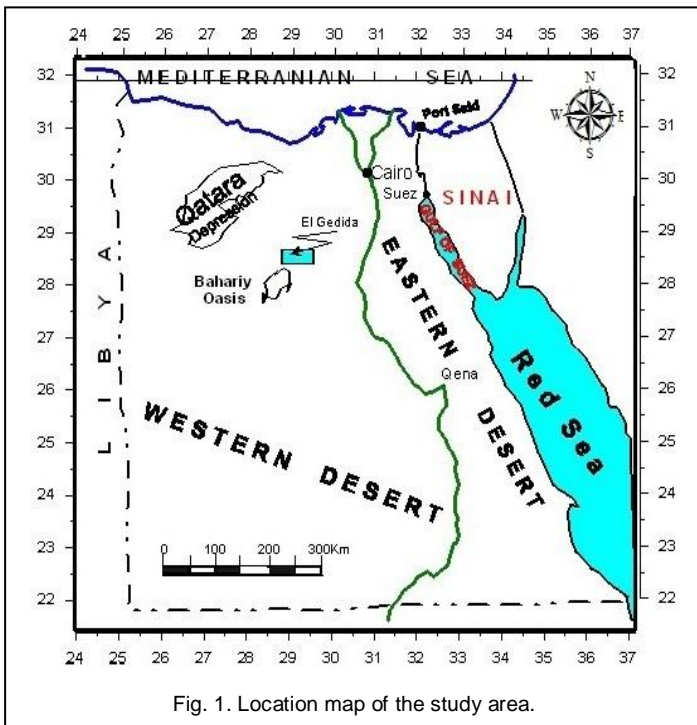


Fig. 1. Location map of the study area.

### 5 Geology and Geomorphology of the Study Area

El-Gedida mine area is an oval-shaped depression, situated within the degraded karst cone hills of the Naqb Formation. The central part of the depression is characterized by a high relief, upon which conspicuous hills are scattered. The highest is Lyon's hill, up to 254.5 m above sea level and 42 m above the plateau surface of the high central area. These hills consist of highly silicified nummulitic limestone of the Naqb Formation. Passing upward to a very hard crust of silcrete. The high central area and the associated relict hills are surrounded by the low wadi area, up to 198 m above sea level. Some hill-ocks of silcrete stand on the floor of the northern part of the depression. With exception of the conspicuous hills, the high central area and wadi area are composed mainly of iron ore deposits, unconformably overlaying the Bahariya Formation. The main structural elements of El-Gedida mine area are a major anticline and normal major faults. The anticline has been affected by Bahariya Formation. It strikes NE-SW and plunges to the NE. The faults trend to NE-SW, N-S and NW-SE. These major faults may be related to the tectonic phase that prevailed at the end of Oligocene, activating old structure [9]. Fig. 3 shows geological and geomorphological map of El-Gedida mine area.

El-Gedida iron ore deposit is considered to be the largest and richest iron ore deposit of the Bahariya Oasis located in the Western Desert of Egypt [7]. Iron deposits abound in the Bahariya oasis region and are mined at El-Gedida, where hematite occurs as a horizontal bed of considerable thickness as shown in Fig. 2. At El-Gedida and other areas in and around the Bahariya Depression, hematite and limonite are exposed on the surface. These occurrences are believed to be important because they provide a source of sand-size iron grains that are mixed with the sand in the Western Desert [8].

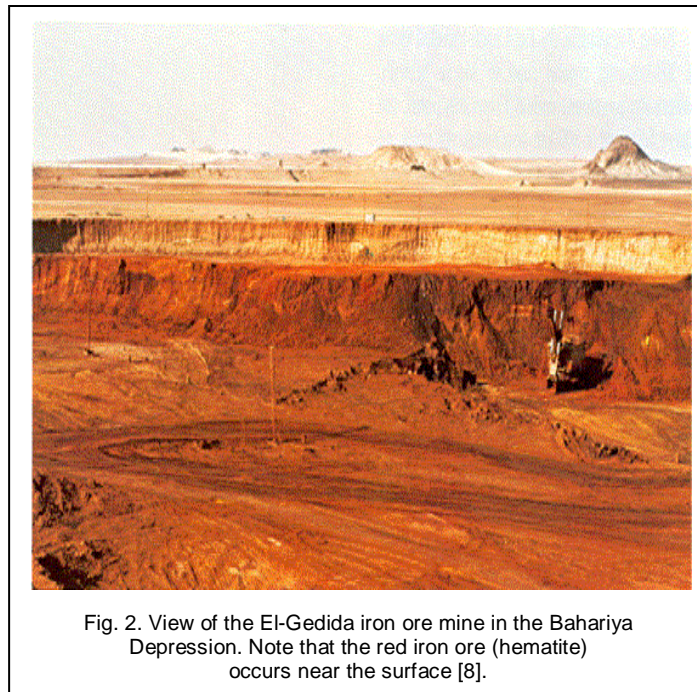


Fig. 2. View of the El-Gedida iron ore mine in the Bahariya Depression. Note that the red iron ore (hematite) occurs near the surface [8].

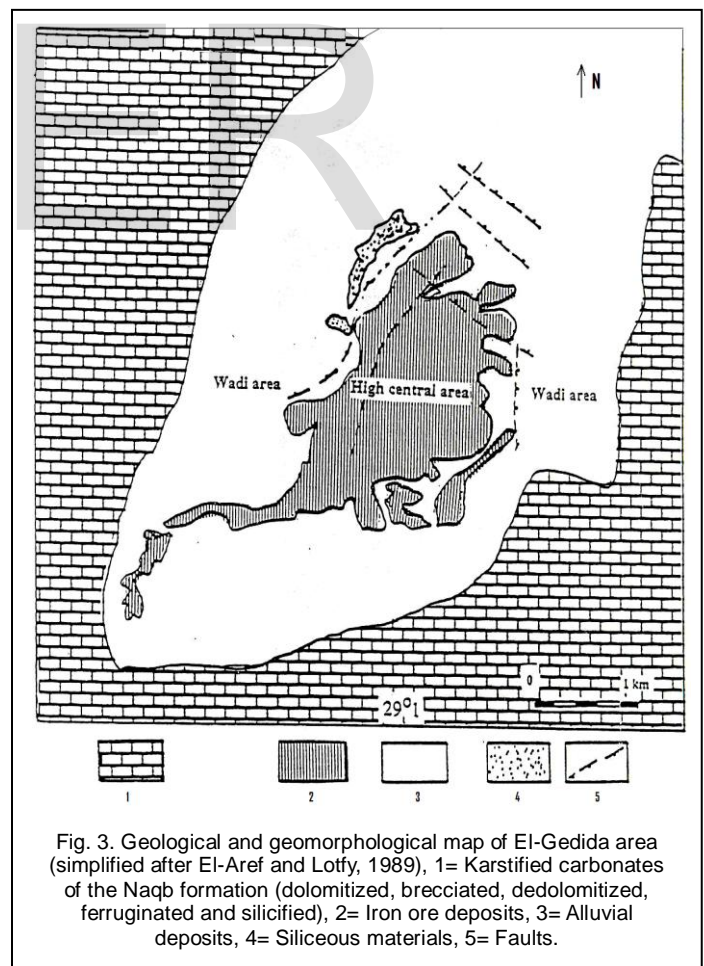


Fig. 3. Geological and geomorphological map of El-Gedida area (simplified after El-Aref and Lotfy, 1989), 1= Karstified carbonates of the Naqb formation (dolomitized, brecciated, dedolomitized, ferruginated and silicified), 2= Iron ore deposits, 3= Alluvial deposits, 4= Siliceous materials, 5= Faults.

## 6 Data Source

The data used in this study are obtained from the Egyptian iron and steel Company. This data considered that, the bore-hole data comprise about 117 drill holes and pits. Tables containing coordinates, elevations, ore thickness and chemical analysis of samples which taken from bore holes (Fe%, Mn%, P%, Cl%, S% and SiO<sub>2</sub>%).

## 7 Requirements of Blast Furnace from El-Gedida Iron Ore

Egyptian Iron and Steel Co. operated the El-Gedida Mine, which is located about 23 km North-East of the El Bahariya Oasis in the Western Desert. All production was captive and shipped by rail to Egyptian Iron and Steel's Helwan plant where it was smelted [10]. The required specification of iron ore for the metallurgical blast furnace at Egyptian Iron and Steel Company are given in Table 1.

TABLE 1  
THE REQUIRED SPECIFICATION OF IRON ORE FOR BLAST FURNACE [11].

Element	Percentage (%)
Fe	= 52 ± 1
SiO <sub>2</sub>	= 7.5 ± 0.5
BaO	≤ 2
Al <sub>2</sub> O <sub>3</sub>	≤ 2
Cl	≤ 0.6
MnO	≤ 3

## 8 Finding the Locations that satisfy the Requirements of Blast Furnace from El-Gedida Iron Ore

The process of finding the locations that represent the different concentrations of ore elements is important process in mining industry, which help in the exploitation of the ore by using the optimum method. The following procedures have been used to find the locations that satisfy the requirements of blast furnace from El-Gedida iron ore, and to calculate the volume of iron ore that can be extracted from these locations:

1. The bore hole data associated with study area is imported to Microsoft Excel 2012 software and exported in dbf (data base file) extension to ArcInfo 9.3 software. Then the point features (bore holes) and associated tables are generated and converted to shape file.

2. Creating interpolated TIN for El-Gedida iron ore elements, which are consistent with the requirements of blast furnace by using 3D Analyst menu.

3. Convert the interpolated TIN for each element of iron ore elements to raster. Then convert this raster to grid of points.

4. The shape file of all converted points is created by join the grids of points of iron ore elements based on spatial location.

5. Using GIS query to find the locations that satisfy the requirements of blast furnace from El-Gedida iron ore elements.

7. The area of satisfied locations and the volume of iron ore can be extracted from these locations are calculated, by extracted these locations from the interpolated TIN of iron ore thickness and using area and volume from 3D Analyst menu.

### 8.1 The Locations that satisfy the Requirements of Blast Furnace from Fe element

The required percentage of Fe element for steel industry by using blast furnace ranges from 51% to 53 %. A query is made to find good locations for producing this percentage and the result of the query explains that there are many suitable locations that satisfy the requirements of blast furnace from Fe element as shown in Fig. 4.

### 8.2 The Locations that satisfy the Requirements of Blast Furnace from Cl element

The required percentage of Cl element for steel industry by using blast furnace not more than 0.6 %. A query is made to find good locations for producing this percentage and the result of the query explains that there are many suitable locations that satisfy the requirements of blast furnace from Cl element as shown in Fig. 5.

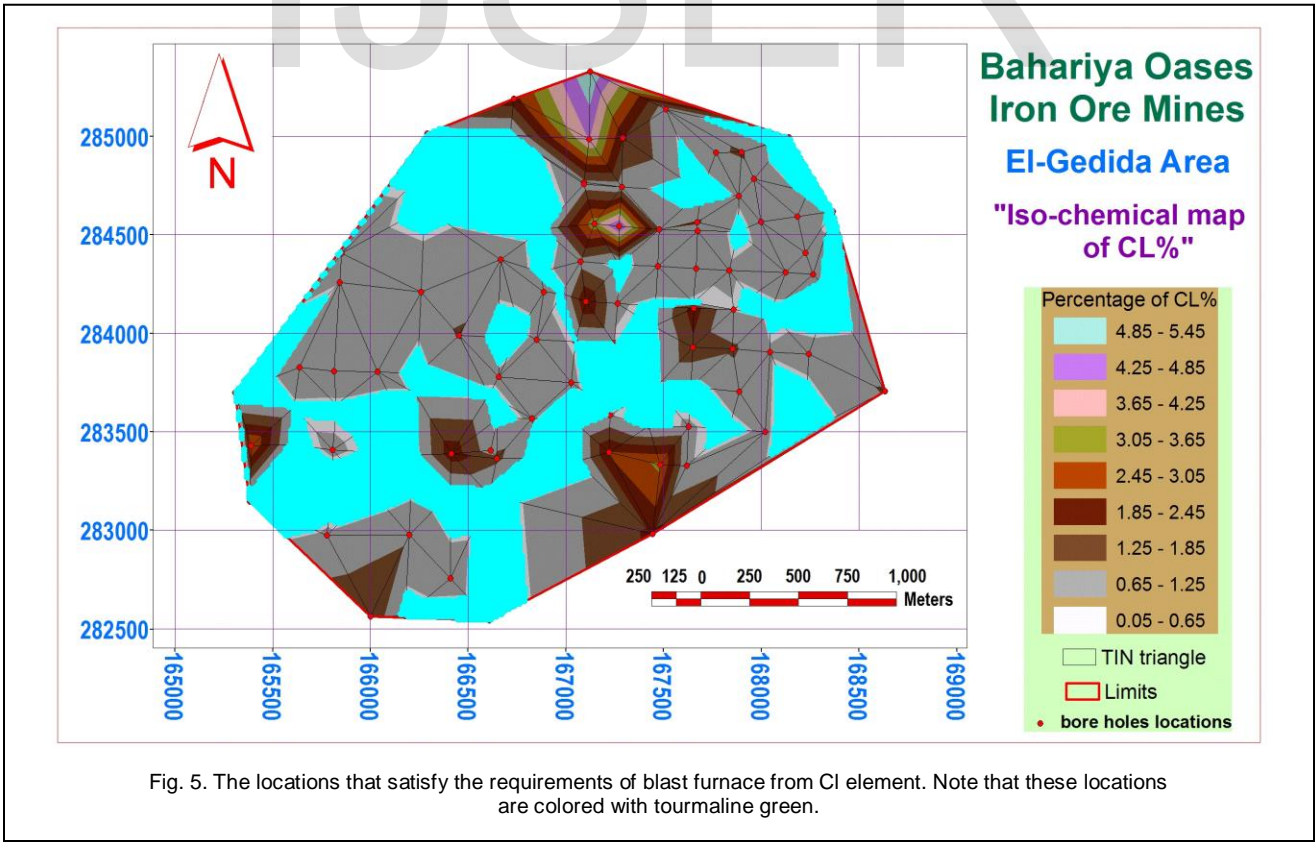
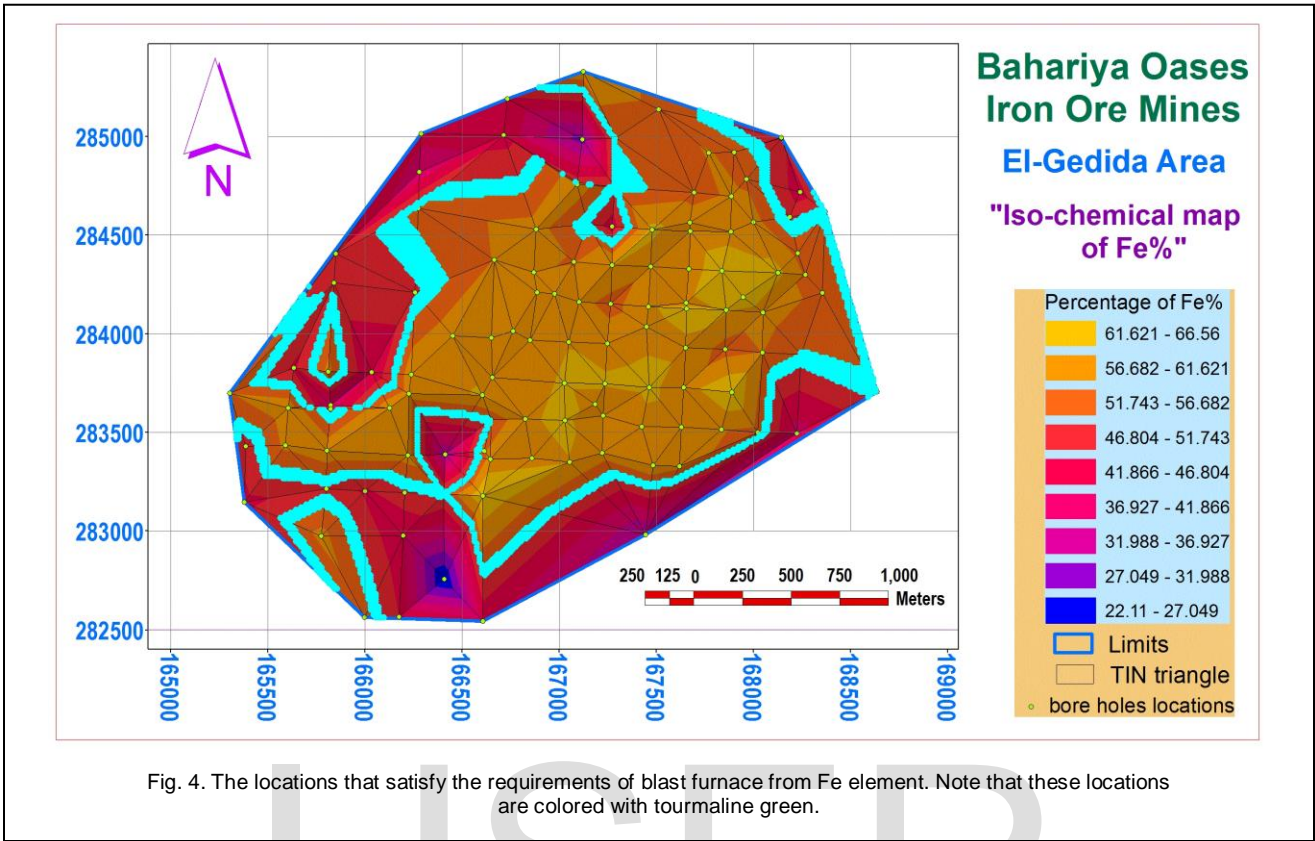
### 8.3 The Locations that satisfy the Requirements of Blast Furnace from SiO<sub>2</sub>%

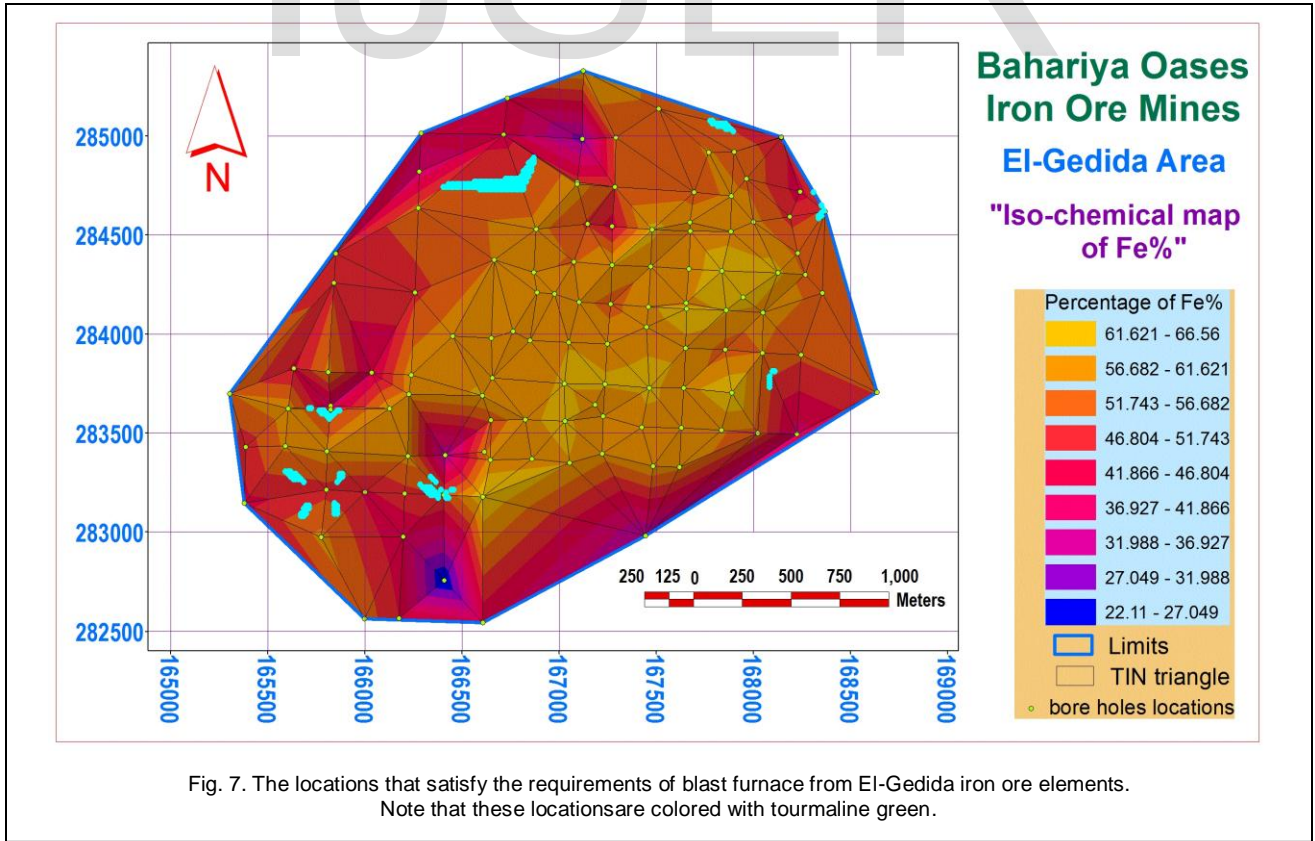
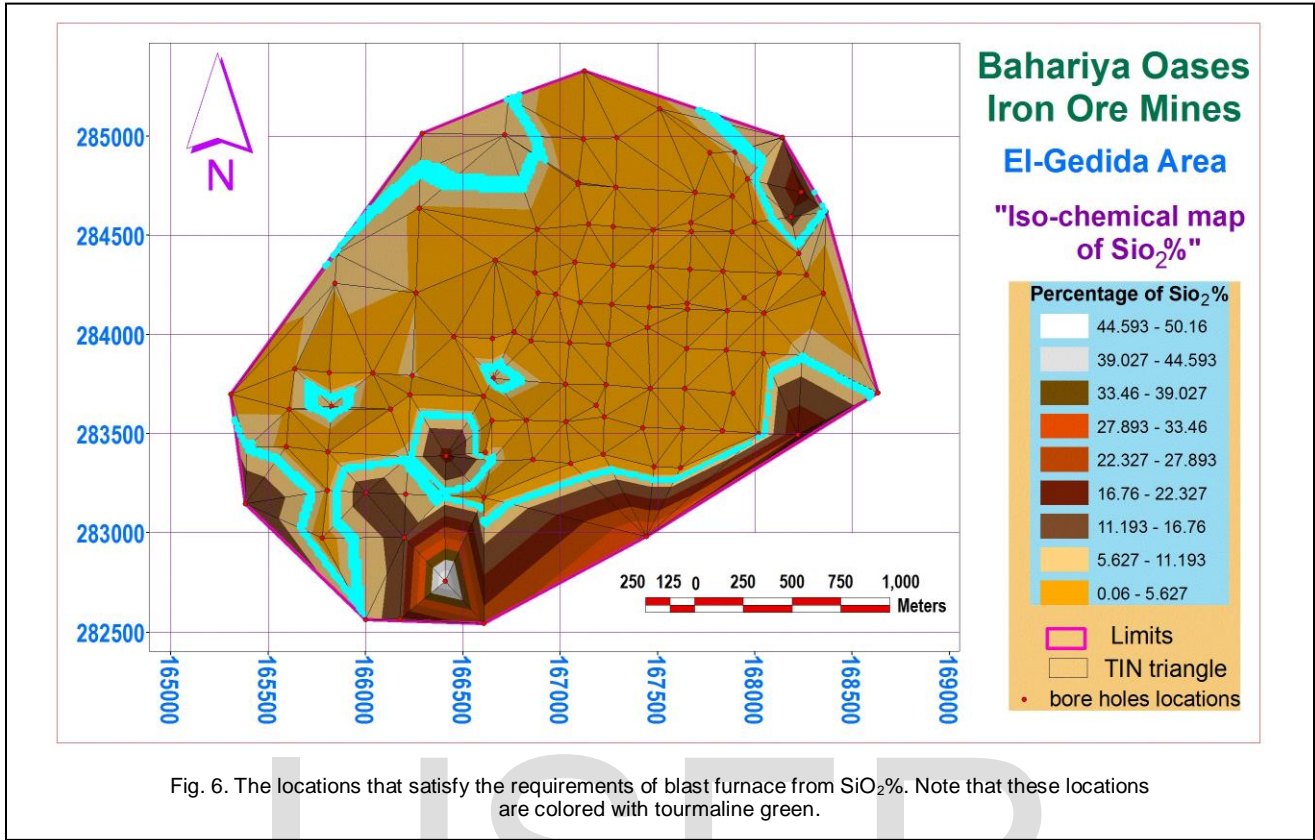
The required percentage of SiO<sub>2</sub>% for steel industry by using blast furnace ranges from 7% to 8 %. A query is made to find good locations for producing this percentage and the result of the query explains that there are many suitable locations that satisfy the requirements of blast furnace from SiO<sub>2</sub>% as shown in Fig. 6.

### 8.4 The Locations that satisfy the Requirements of Blast Furnace from Iron Ore elements

The required percentages for steel industry by using blast furnace from El-Gedida iron ore elements are the percentage of Fe element ranges from % 51 to 53 %, the percentage of SiO<sub>2</sub> ranges from % 7 to 8 % and the percentage Cl not more than 0.6 %. A query is made to find good locations for producing these percentages and the result of the query explains that there are a few suitable locations that satisfy the requirements of blast furnace from El Gedida iron ore elements as shown in Fig. 7.









### 9 Area and Volume Calculations

The results of calculating the area and volume for the interpolated TIN of El-Gedida iron ore thickness as shown in Fig. 8, indicate that the planimetric area of the study area is approximately 6,188,927 m<sup>2</sup> and the total volume of the iron ore deposit that can be extracted from El-Gedida area is approximately 50,596,637 m<sup>3</sup>.

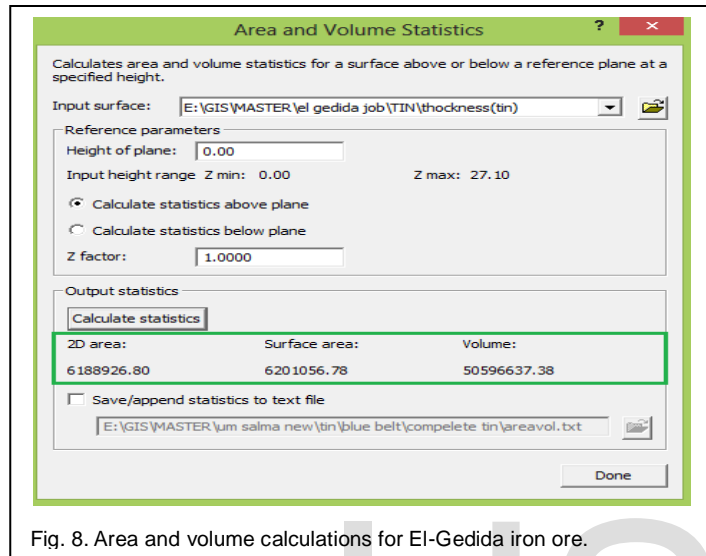


Fig. 8. Area and volume calculations for El-Gedida iron ore.

The results of calculating the area and volume for the interpolated TIN of iron ore thickness in the locations that satisfy the requirements of blast furnace from Fe element as shown in Fig. 9, indicate that the planimetric area of the locations that satisfy the requirements of blast furnace from Fe element is approximately 561,874 m<sup>2</sup> and represent approximately 9% from planimetric area of the study area. The volume of iron ore can be extracted from these locations is approximately 4,614,703 m<sup>3</sup> and represent approximately 9% from the total volume of iron ore that can be extracted from El-Gedida area.

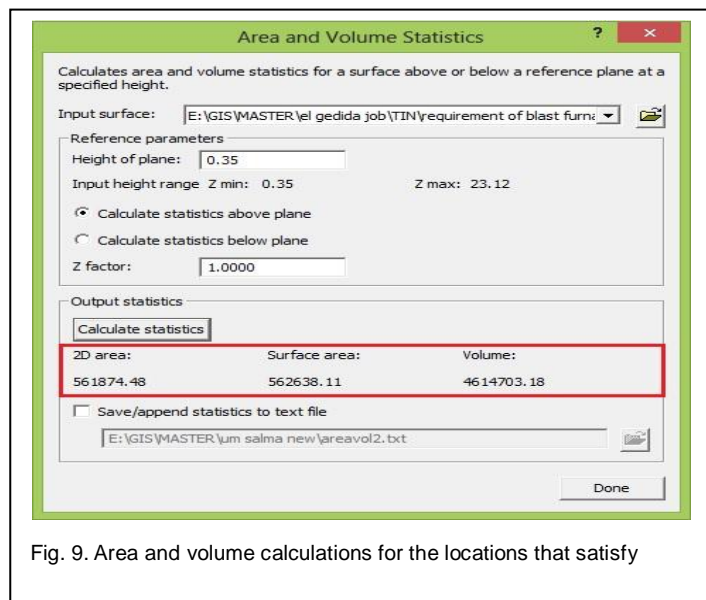


Fig. 9. Area and volume calculations for the locations that satisfy

The results of calculating the area and volume for the interpolated TIN of iron ore thickness in the locations that satisfy the requirements of blast furnace from Cl element as shown in Fig. 10, indicate that the planimetric area of the locations that satisfy the requirements of blast furnace from Cl element is approximately 1,959,106 m<sup>2</sup> and represent approximately 32% from planimetric area of the study area. The volume of iron ore can be extracted from these locations is approximately 14,502,001 m<sup>3</sup> and represent approximately 29 % from the total volume of iron ore.

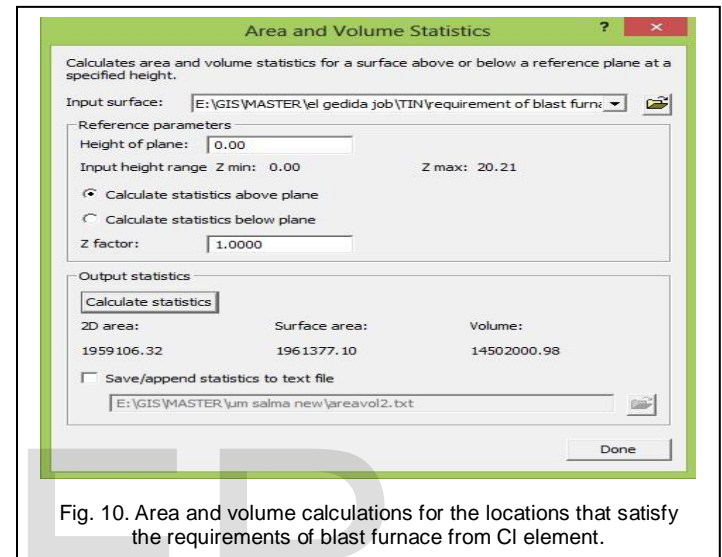


Fig. 10. Area and volume calculations for the locations that satisfy the requirements of blast furnace from Cl element.

The results of calculating the area and volume for the interpolated TIN of iron ore thickness in the locations that satisfy the requirements of blast furnace from SiO<sub>2</sub>% as shown in Fig. 11, indicate that the planimetric area of the locations that satisfy the requirements of blast furnace from SiO<sub>2</sub>% is approximately 270,410 m<sup>2</sup> and represent approximately 4% from planimetric area of the study area. The volume of iron ore can be extracted from these locations is approximately 2,203,498 m<sup>3</sup> and represent approximately 4 % from the total volume of iron ore.

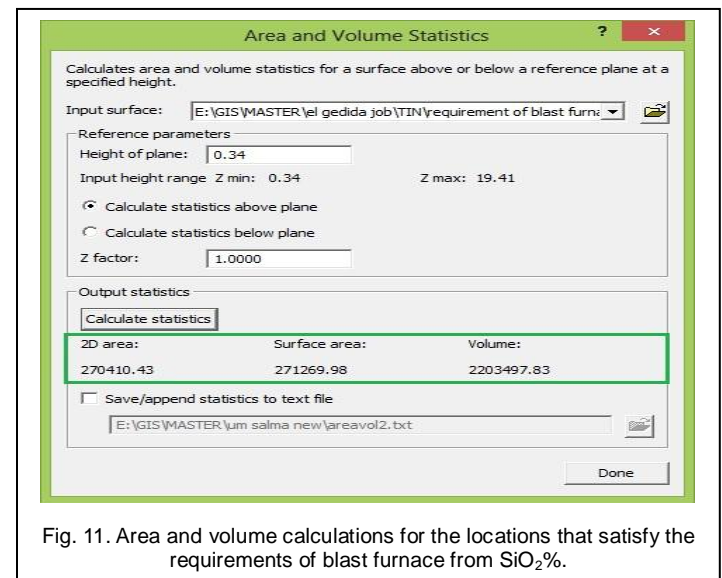


Fig. 11. Area and volume calculations for the locations that satisfy the requirements of blast furnace from SiO<sub>2</sub>%.

The results of calculating the area and volume for the interpolated TIN of iron ore thickness in the locations that satisfy the requirements of blast furnace from El-Gedida iron ore elements as shown in Fig. 12, indicate that the planimetric area of the locations that satisfy the requirements of blast furnace from El-Gedida iron ore elements is approximately 41,972 m<sup>2</sup> and represent approximately 1 % from planimetric area of the study area. The volume of iron ore can be extracted from these locations is approximately 369,672 m<sup>3</sup> and represent approximately 1% from the total volume of iron ore.

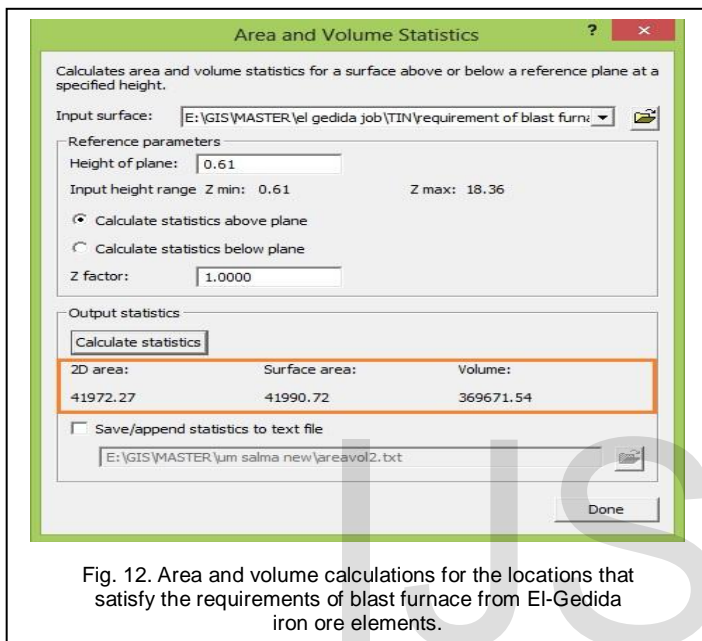


Fig. 12. Area and volume calculations for the locations that satisfy the requirements of blast furnace from El-Gedida iron ore elements.

The above mentioned results and analysis for the locations that satisfy the requirements of blast furnace from El-Gedida iron ore indicate that the iron ore of El-Gedida area cannot go directly to the blast furnace of Egyptian Iron and Steel Company without treatment for upgrading, because the planimetric area of the locations that satisfy the requirements of blast furnace from El-Gedida iron ore elements are small if compared with the planimetric area of the study area and the volume of iron ore can be extracted from these locations are small if compared with the total volume of iron ore can be extracted from El-Gedida area.

## 10. CONCLUSIONS

1. GIS is a powerful tool in many operations in mining industry that support the decision-making to search for new economic ores.
2. The locations that satisfy the requirements of blast furnace of Egyptian Iron and Steel Company from El-Gedida iron ore are selected, using GIS query.
3. The application of GIS on El-Gedida iron ore area proved that the iron ore cannot go directly to the blast furnace of

Egyptian Iron and Steel Company, without treatment for upgrading.

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