Evaluation of Extracted Ores from Stoping Faces of Blocks of El-Gedida Area by Using GIS Technology

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Abstract - *Due to the advancement in the computer industry and information technology and evolution of Geographic Information Systems (GIS), the world is moving towards to automating the mining industry to overcome traditional operations that require more time, effort and have many sources of errors. Therefore this research aim to use GIS technique to calculate the planimetric areas of stoping faces of blocks of El-Gedida area and the volumes of extracted ores from these faces. Also the planimetric areas and the volumes of extracted ores are calculated by using traditional method that based on digital planimeter. Then the results of this method are compared with the results by using GIS method. The results indicated that the GIS are a powerful tool for calculating the planimetric areas of stoping faces and the volumes of extracted ores from these faces.*

Key Words: El-Gedida area, GIS, stoping faces, digital planimeter

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 (Geodatabases) 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].

Prospecting, exploration, development and exploitation are the four stages in the life of a mine. The longest stage in the life of the mine is exploitation stage, and the main process in this stage is a production. There are many industries based on the ores that extracted from El-Gedida area such as steel industry, ceramic industry and cement industry. Therefore the objective of this study is to use GIS technique to calculate the planimetric areas of stoping faces of blocks of El-Gedida area, and the volumes of extracted ores from these faces. Also the planimetric areas and the volumes of extracted ores are calculated by using traditional method that based on digital planimeter to evaluate the potential of using GIS.

1.1 GIS Technology in Mining Industry

GIS technology creates efficiency and productivity opportunities in all aspects of mineral exploration and mining. GIS enables a mineral exploration geologist and mine operator to mine intelligently, efficiently, competitively, safely, and environmentally [3]. GIS can be applied to many operations in mining industry such as land ownerships, exploration, borehole calculations, volume computations, stoping faces calculations, planning, production and selective mining, development of three-dimensional modeling, 3D analysis, site selection for dumping and waste rocks, transportation, mine reclamation, safety and others.

1.2 Planimeter

A planimeter is a table-top instrument for measuring areas, usually the areas of irregular regions on a map or photograph [4]. They were once common, but require more time and effort to complete tracing process. In present study digital planimeter placom kp-81 as shown in figure 1 was used to calculate the planimetric areas of stoping faces blocks of El-Gedida area. The accuracy of estimated areas can reach ± 0.2%
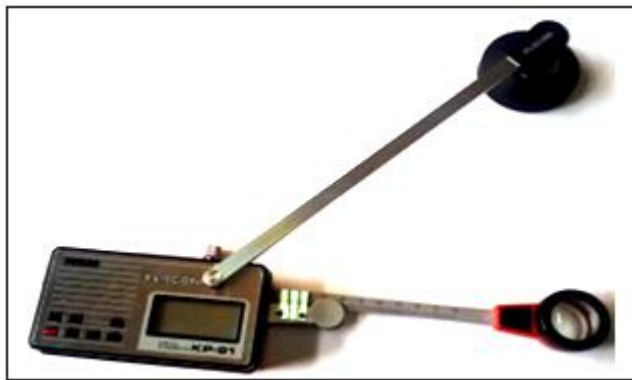
Fig. 1: Digital planimeter placom Kp-81

1.3 GIS Software Packages

GIS software packages can help to visualize the geography of an area as well as helping to eliminate potential problems and hazards [5]. ArcInfo is a powerful, easy-to-use tool that brings geographic information to desktop. ArcInfo gives the users the power to visualize, explore, query and analyze data spatially. In the present study GIS ArcInfo 9.3 software package was utilized with its extensions.

2. Description of Study Area

El-Gedida area is located in the north-eastern plateau of El-Bahariya Depression as shown in figure 2. The centre of El-Gedida area lies approximately at latitude 28° 27' N and longitude 29° 10' E. 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 [6]. Iron deposits abound in the Bahariya oasis region and are mined at El-Gedida, where hematite occurs as a horizontal bed of considerable thickness. 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 [7].

3. Geology and Geomorphology of the Study Area

El-Gedida mine area is an oval-shaped depression, situated within the degraded karast 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 hillocks 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 [8]. Figure 3 shows geological and geomorphological map of El-Gedida mine area.
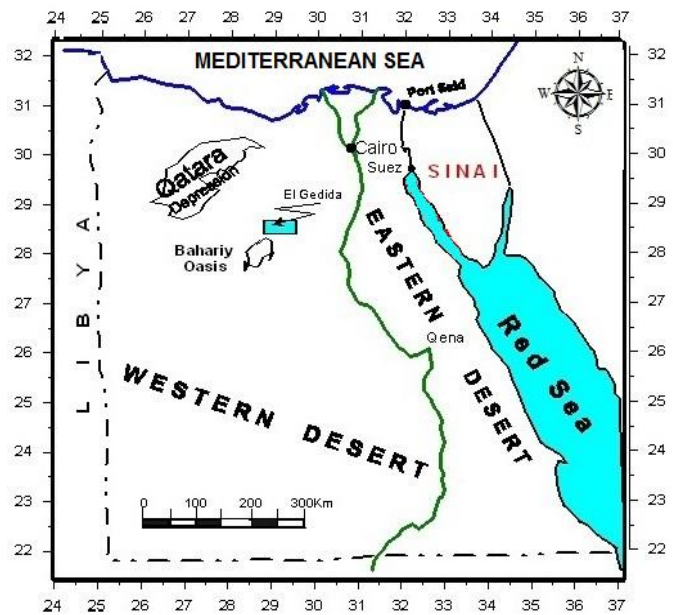

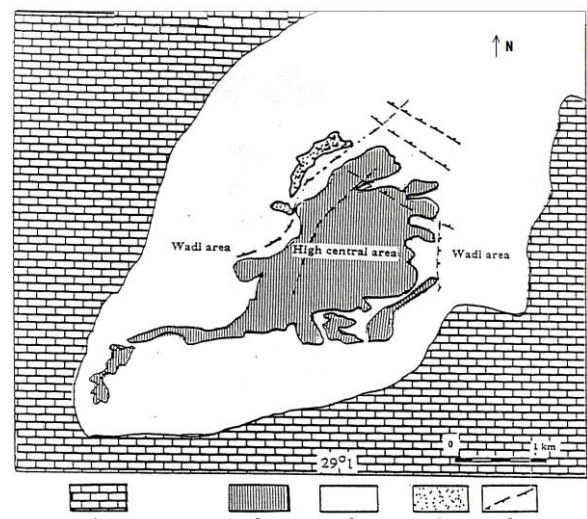**Fig. 2**: Location map of El-Gedida area.

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.

4. Data Source

The data used in this study are obtained from the Egyptian Iron and Steel Company. This data is the site surveying map of stoping faces of blocks for iron and shale ores in March 1, 2014. This map is classified into the extracted faces in the period from 1/1/2014 to 1/3/2014 for blocks i, viii, ix and xi, where each face classified into groups of areas, each area has code (ID). Also this map contains the upper and lower levels of ore thicknesses.

5. GIS Database for Stoping Faces Of Blocks Of El-Gedida Area

A key geodatabase concept is the dataset. It is the primary mechanism used to organize and use geographic information in ArcGIS software. The geodatabase contains three primary types of dataset which, feature classes, raster datasets and tables. Creating a collection of these dataset types is the first step in designing and building a geodatabase [9]. The following procedures have been used to create geodatabase for stoping faces of blocks of El-Gedida area from previous mentioned data:

1. Scan the site surveying map of stoping faces of blocks for iron and shale ores to convert it from hard copy form to digital raster from.

2. Import the digital raster map to ArcInfo 9.3 software and rectified it in the correct position using georeferencing menu.

3. Creating feature class for polygon features and add all features (stoping faces) by digitizing it from the rectified digital raster map.

4. Add all data associated with stoping faces (area number, shovel number, ore type, ore thickness…..ect) to attributes of the created feature class using data entry functions built-in the GIS software.

6. GIS Analysis Operations

The change from paper maps to digital data, in various kinds of geographical data analysis and applications, has made easy to use the same spatial data for different applications and also for combining several layers into quite complex spatial models [10]. The created geodatabase for stoping faces was utilized to produce the digital maps that showing the geometry of these faces which help in calculating the planimetric areas and the volumes of extracted ores. Also it can be used for storing, editing, analyzing, retrieving, updating and presentation any data about these faces.

6.1 Retrieving Attributes of Features

Any information in geodatabase of stoping faces such as (block number, ore thickness, coordinates …….ect) which associated with any feature can be retrieved in ArcInfo 9.3 software by using identify icon from tools menu as shown in figure 4.

6.2 Area and Volume Calculations

ArcInfo 9.3 software and the traditional method based on digital planimeter were used to calculate the planimetric areas for stoping faces of blocks i, viii, ix and xi and the volumes of extracted ores from these faces as explained in the following subsections.

6.2.1 Area and Volume Calculations for Iron Ore Bed of Block i

Stoping faces map of block i for iron ore bed is created as shown in figure 5 to show the geometry of this bed, which help in calculating the planimetric area and the volume of extracted iron ore.

The results of table 1 shows area and volume calculations for iron ore bed of block i using both methods. The results of calculating the area and volume for iron ore bed of block i by using ArcInfo 9.3 indicate that the total planimetric area for iron ore bed is 2,861 m^2 and the volume of extracted iron ore from this bed is 4,534 m^3. The difference in calculating the total planimetric area for iron ore bed of block i between traditional method (digital planimeter) and ArcInfo 9.3 is approximately 41 m^2 and represent approximately 0.01 % from the total planimetric area for this bed by using traditional method. This difference in area calculation lead to difference in calculating the volume of extracted iron ore by 0.01% (46 m^3) from the total volume of extracted iron ore calculated using traditional method.

6.2.2 Area and Volume Calculations for Iron Ore Bed of Block viii

Stoping faces map of block viii for iron ore bed is created as shown in figure 6 to show the geometry of this bed, which help in calculating the planimetric area and the volume of extracted iron ore.

The results of table 2 shows area and volume calculations for iron ore bed of block viii using both methods. The results of calculating the area and volume for iron ore bed of block viii by using ArcInfo 9.3 indicate that the total planimetric area for iron ore bed is 1,707 m2 and the volume of extracted iron ore from this bed is 6,148 m3. The difference in calculating the total planimetric area for iron ore bed of block viii between digital planimeter and ArcInfo 9.3 is approximately 1 m2 and represent approximately 0.06 % from the total planimetric area for this bed by using traditional method. This difference in area calculation lead to difference in calculating the volume of extracted iron ore by 0.1% (6 m3) from the total volume of extracted iron ore calculated using traditional method.
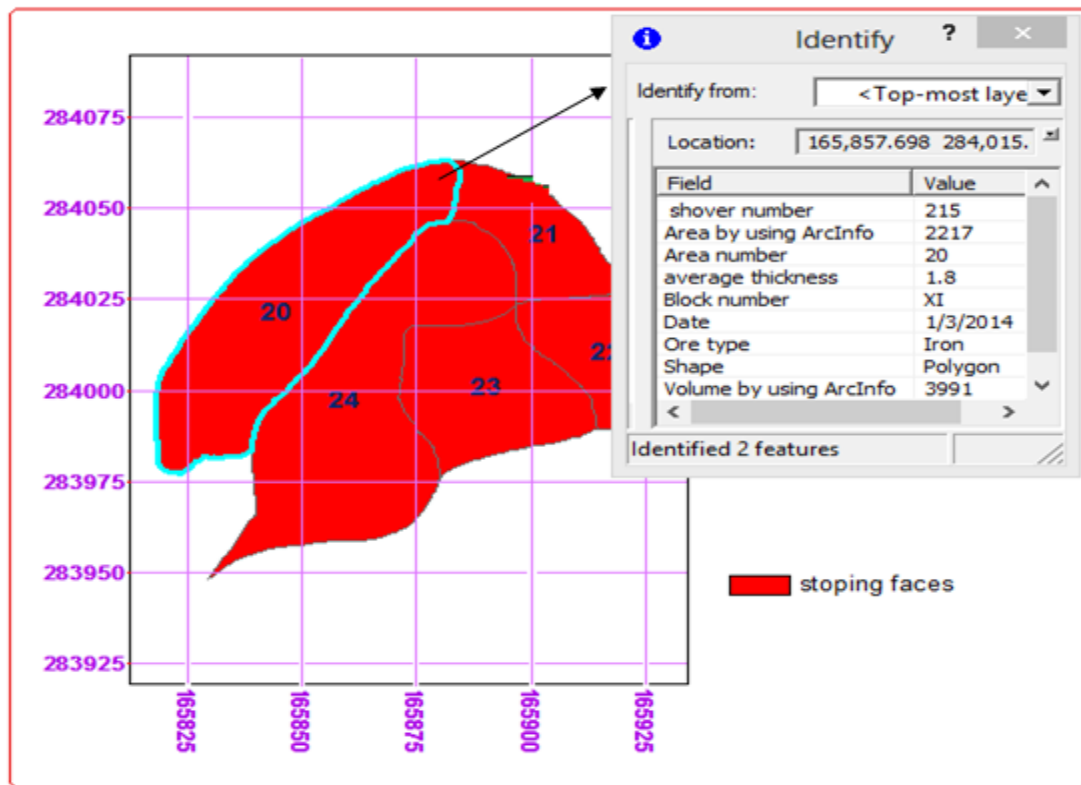
Fig. 4: The attributes associated with features in geodatabase of El-Gedida area.
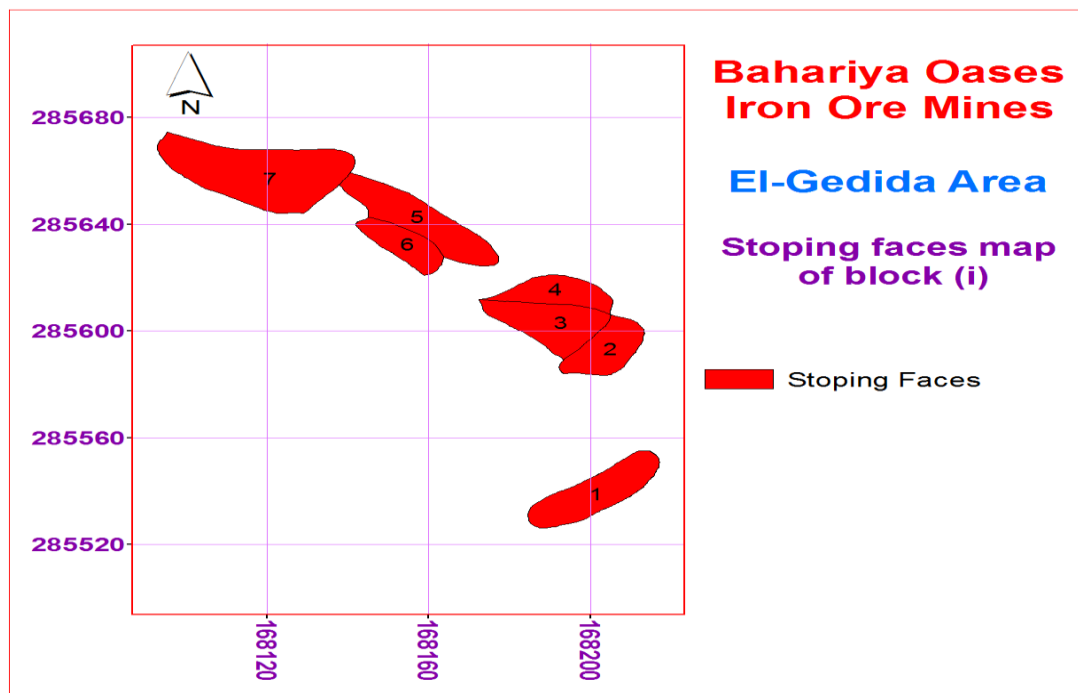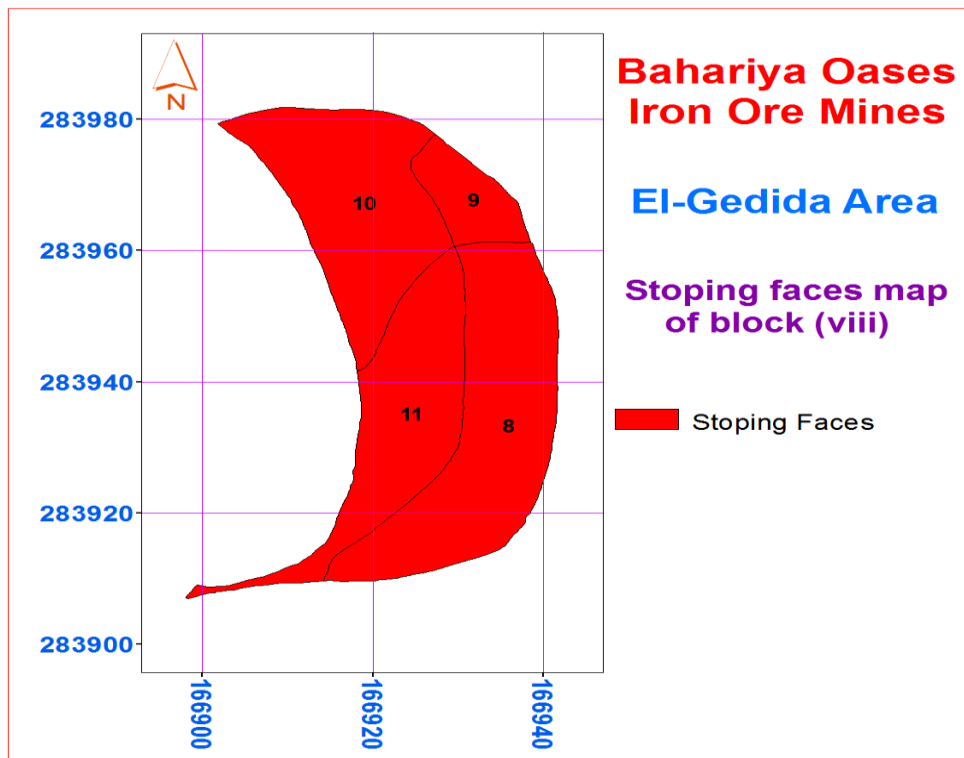

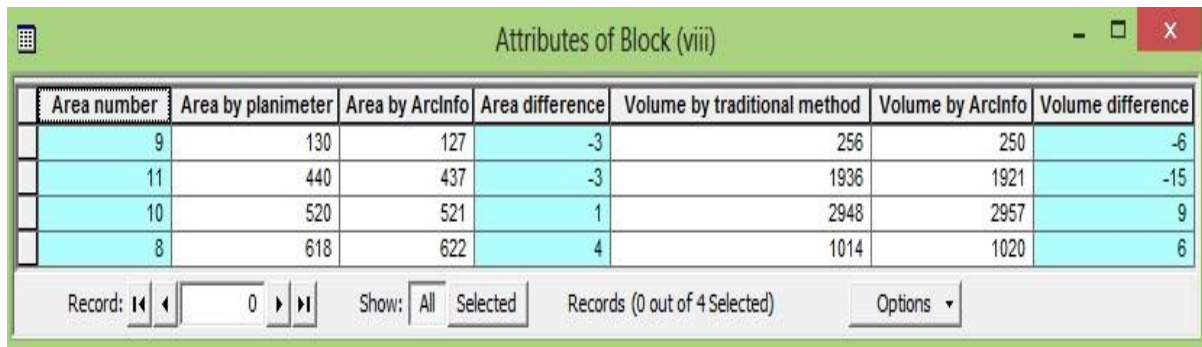
Fig. 5: Stoping faces map of block i for iron ore bed.

Table. 1: Area and volume calculations for iron ore bed of block i.

Area number	Area by planimeter	Area by ArcInfo	Area difference	Volume by traditional method	Volume by ArcInfo	Volume difference
3	400	382	-18	1112	1063	-49
5	480	469	-11	720	704	-16
4	260	243	-17	185	172	-13
6	210	217	7	452	467	15
1	390	412	22	339	358	19
2	260	273	13	442	464	22
7	820	865	45	1238	1306	68

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Fig. 6: Stoping faces map of block viii for iron ore bed.

Table. 2: Area and volume calculations for iron ore bed of block viii.

Area number	Area by planimeter	Area by ArcInfo	Area difference	Volume by traditional method	Volume by ArcInfo	Volume difference
9	130	127	-3	256	250	-6
11	440	437	-3	1936	1921	-15
10	520	521	1	2948	2957	9
8	618	622	4	1014	1020	6

6.2.3 Area and Volume Calculations for Iron Ore Bed of Block ix

Stoping faces map of block ix for iron ore bed is created as shown in figure 7 to show the geometry of this bed, which help in calculating the planimetric area and the volume of extracted iron ore.

The results of table 3 shows area and volume calculations for iron ore bed of block ix using both methods. The results of calculating the area and volume for iron ore bed of block ix by using ArcInfo 9.3 indicate that the total planimetric area for iron ore bed is 9,412 m^2 and the volume of extracted iron ore from this bed is 22,700 m^3. The difference in calculating the total planimetric area for iron ore bed of block ix between digital planimeter and ArcInfo 9.3 is approximately 50 m^2 and represent approximately 0.53 % from the total planimetric area for this bed by using traditional method. This difference in area calculation lead to difference in calculating the volume of extracted iron ore by 0.80% (180 m^3) from the total volume of extracted iron ore calculated using traditional method.

6.2.4 Area and Volume Calculations for Shale Bed of Block ix

Shale ores in El-Gedida area are exploited by the company, due to their economic value in many industries such as ceramics industry. Therefore stoping faces map of block ix for shale bed is created as shown in figure 8 to show the geometry of this bed, which help in calculating the planimetric area and the volume of extracted shale ore.

The results of table 4 shows area and volume calculations for shale bed of block ix using both methods. The results of calculating the area and volume for of shale bed of block ix by using ArcInfo 9.3 indicate that the total planimetric area for shale ore bed is 385 m^2 and the volume of extracted shale ore from this bed is 3,436 m^3. The difference in calculating the total planimetric area for shale ore bed between digital planimeter and ArcInfo 9.3 is approximately 4 m^2 and represent approximately 1.05 % from the total planimetric area for this bed by using traditional method. This difference in area calculation lead to difference in calculating the volume of extracted shale ore by 1.06% (36 m^3) from the total volume of extracted shale ore calculated using traditional method.

6.2.5 Area and Volume Calculations for Iron Ore Bed of Block xi

Stoping faces map of block xi for iron ore bed is created as shown in figure 9 to show the geometry of this bed, which help in calculating the planimetric area and the volume of extracted iron ore.

The results of table 5 shows area and volume calculations for iron ore bed of block xi using both methods. The results of calculating the area and volume for iron ore bed of block xi by using ArcInfo 9.3 indicate that the total planimetric area for iron ore bed is 7,628 m2 and the volume of extracted iron ore from this bed is 32,097m3. The difference in calculating the total planimetric area for iron ore bed of block xi between digital planimeter and ArcInfo 9.3 is approximately 41 m2 and represent approximately 0.54 % from the total planimetric area for this bed by using traditional method. This difference in area calculation lead to difference in calculating the volume of extracted iron ore by 0.50% (159 m3) from the total volume of extracted iron ore calculated using traditional method.

The below mentioned results and analyses for stoping faces of blocks of El-Gedida area indicate that the differences in calculating the planimetric areas of stoping faces and the volumes of extracted ores from these faces between traditional method and ArcInfo 9.3 software are small. Taking into consideration that the traditional method requires more time, effort and could have many sources of errors. Therefore the GIS is a powerful tool for calculating the planimetric areas of stoping faces of blocks of El-Gedida area and the volumes of extracted ores from these faces.
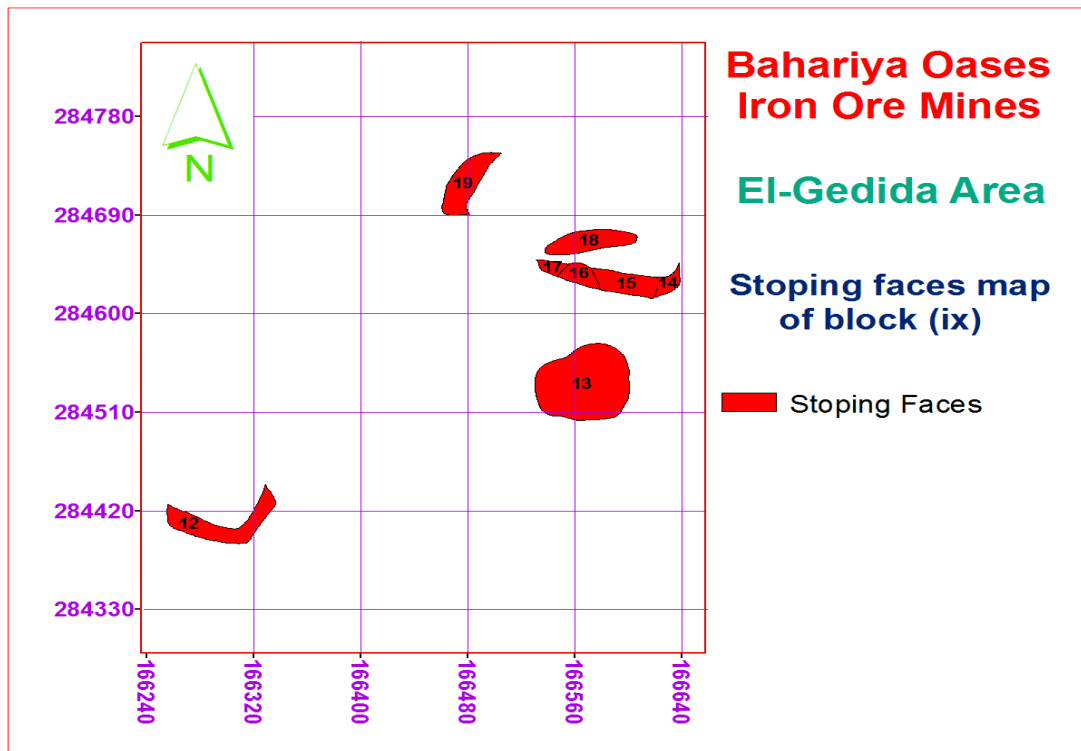
Fig. 7: Stoping faces map of block ix for iron ore bed.

Table. 3: Area and volume calculations for iron ore bed of block ix.

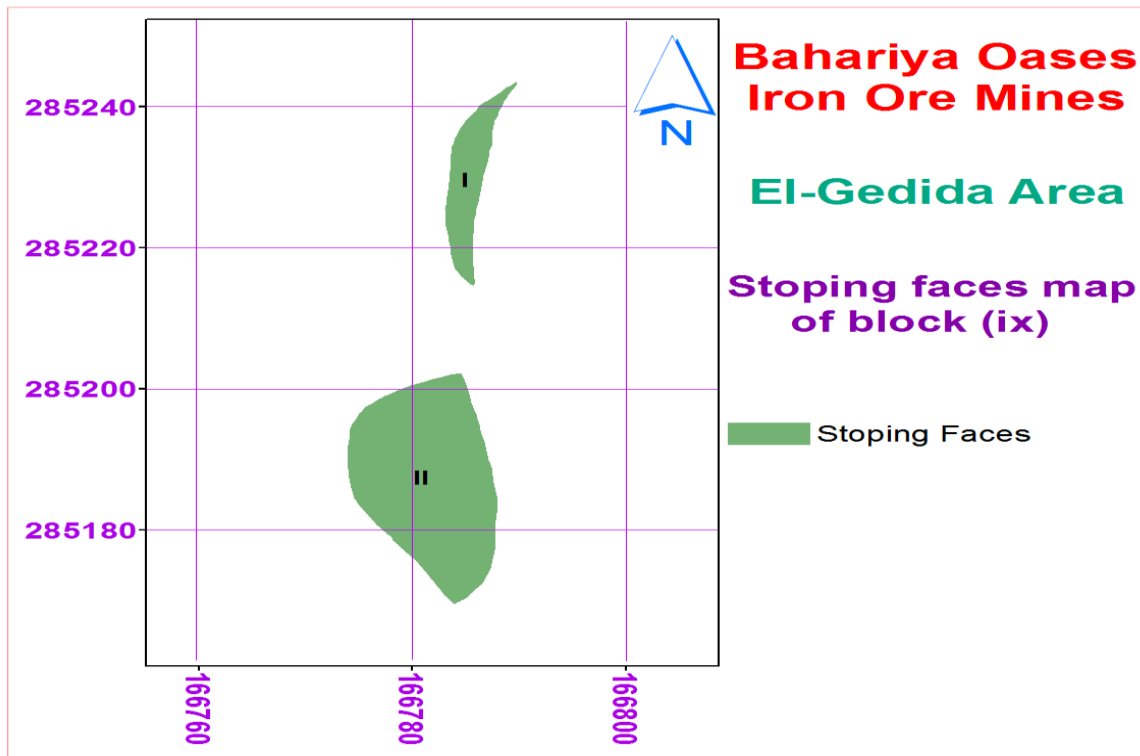| Area number	Area by planimeter	Area by ArcInfo	Area difference	Volume by traditional method	Volume by ArcInfo	Volume difference
12	1425	1435	10	4731	4764	33
13	3960	3971	11	1386	1390	4
14	276	279	3	2401	2430	29
15	862	869	7	8491	8555	64
16	434	438	4	1367	1379	12
17	205	208	3	1630	1656	26
18	1040	1047	7	426	429	3
19	1160	1165	5	2088	2097	9

Fig. 8: Stoping faces map of block ix for shale bed.

Table. 4: Area and volume calculations for shale bed of block ix.

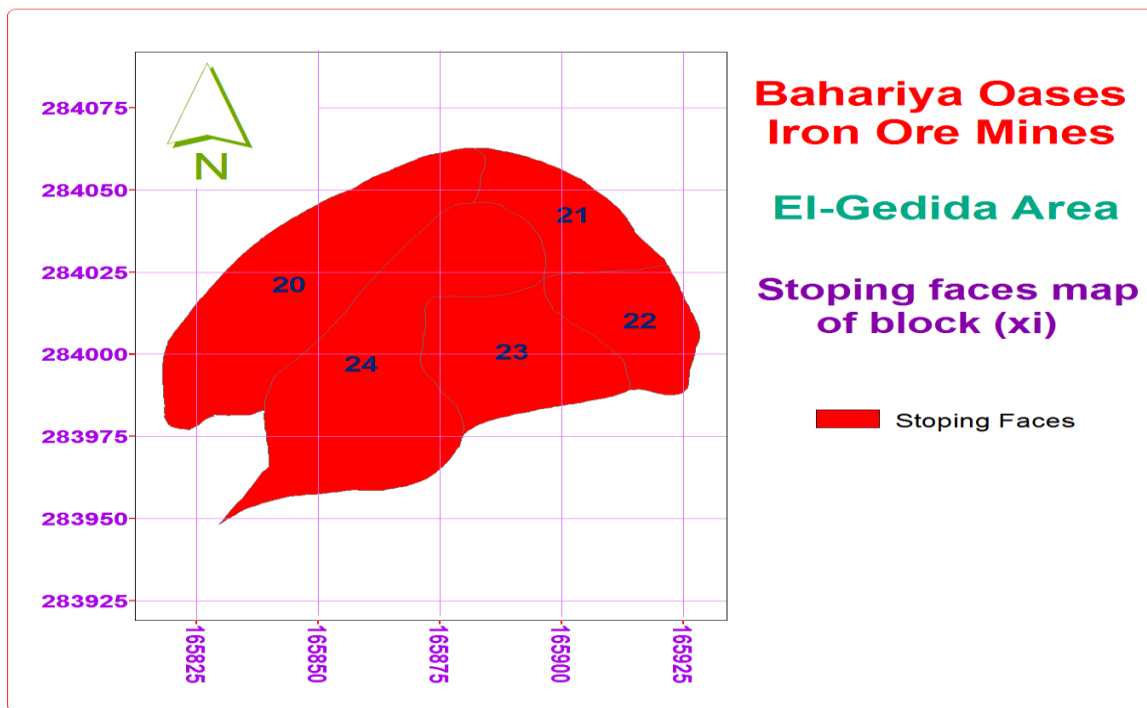| Area number	Area by planimeter	Area by ArcInfo	Area difference	Volume by traditional method	Volume by ArcInfo	Volume difference
II	310	313	3	2775	2801	26
I	71	72	1	625	635	10

Fig. 9: Stoping faces map of block xi for iron ore bed.

Table. 5: Area and volume calculations for iron ore bed of block xi.

Area number	Area by planimeter	Area by ArcInfo	Area difference	Volume by traditional method	Volume by ArcInfo	Volume difference
24	2621	2631	10	19972	20046	74
23	1225	1237	12	5157	5207	50
22	780	783	3	874	877	3
21	756	760	4	1966	1976	10
20	2205	2217	12	3969	3991	22

7. Conclusions

1. The calculations of the planimetric areas of stoping faces of blocks of El-Gedida area and the volumes of extracted ores from these faces by using traditional method which is based on digital planimeter and comparing the results with the results of GIS method proved that GIS are a powerful tool for calculating the planimetric areas of stoping faces and the volumes of extracted ores from these faces.

2. The created GIS database for stoping faces of blocks of El-Gedida area help in storing, editing, analyzing and retrieving any data associated with these faces.

3. GIS ArcInfo software package is friendly for users that facilitate many operations in mining industry.

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