Exploration of Valuable Evaporate Minerals in Central Iran

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ABSTRACT: Many playa are found in Iran but most of them were not extracted. One of the important playa is Mighan in central Iran. The purpose of this research is exploration of valuable evaporate minerals in Mighan Playa. In this playa 148 boreholes were drilled which has 6 meters depth and grid drilling was 500×500 m. Then 105 samples were taken and analyzed in order to determine the contents of the components. 8 piesometeric boreholes were drilled and deby, transmisivity and storativity were calculated. Finaly the playa was 3D-modeled basing on mineralogy and stratigraphy as well distributions of Na_2SO_4, Mg_2SO_4, NaCl, $CaSO_4$ and their reserves. Calculation of mineral reserves shows that mirabilite reserve is equal to 42.9 Mt and gluberite reserve − 127.4 Mt. The studies on 3D-modeles show that the best accumulation for mining extraction is situated in centre, south and south-western part of the studied area.

KEYWORDS: Mighan playa, 3D-modeling, extraction

INTRODUCTION

Nowadays, because of wide varieties of evaporate mineral applications; it is becoming one of the most demanding minerals in the world (Kostick 1997). Taking into consideration the fact of the wide variety of minerals deposits located in Iran, the government put the large amount of money in exploration projects. One of the most favourable exploring areas from the economic point of view is Mighan Lake in central Iran. The project of the exploration of valuable evaporate minerals in Central Iran, which is named Mighan playa, is one of the most important projects among all current exploration evaporate minerals in Iran (Hezarkhani, Motallebi 2005).

Estimated world-wide production of sodium sulfate in 1970 was about 3.8 Mt and it amounted approximately 5.750 Mt during the time period from 2000 to 2004. These statistics show that the world production from 1970 to 2000 increased. That are the reasons that the project focus on Na_2SO_4 in the form of mirabilite and glauberite – in fact they became the main purposes of this ex-

ploration project. Sodium sulphate is produced from natural brines and crystal deposits in alkaline lakes, or as a co-product of various chemical processes. Currently, the world production ratio of sodium sulphate is about 50:50 between natural and co-product production (Bettany 2007). One of the main mining industry tasks to be solved in the possibly simple way by computer applications is creating the 3D digital models of ore deposits. The RockWorks 2006 was applied to this study (Berg, Keefer 2004).

GENERAL AND GEOLOGICAL CHARACTERISTICS

Mighan playa is situated in Markazi province (Central Iran). The studied area is located in 387,750 to 399,500 X (East and 3,781,000 to 3,789,500 Y (North), covers the surface of about 67 km^2 (Fig. 1). Mighan watershed has two main faults named Talkhab and Tabarthe. Based on two faults, this watershed divides into three zones. First zone (Sanandaj – Sirjan) is metamorphic weak. They characterize by plutonic rocks, no volcanic and medium water potential. The second zone consists from sedimentary rocks, characterizes by no plutonic and volcanic origin and high water potential. The third zone consists from sedimentary, plutonic and volcanic rocks and low potential water (Ghadimi 2004).

Its morphology is regular and there are few small hills. Topographical unevenness of this province is part of Zagross mountains and Rasvand mountains, which are located in southern part of the province (Ghadimi 2004).

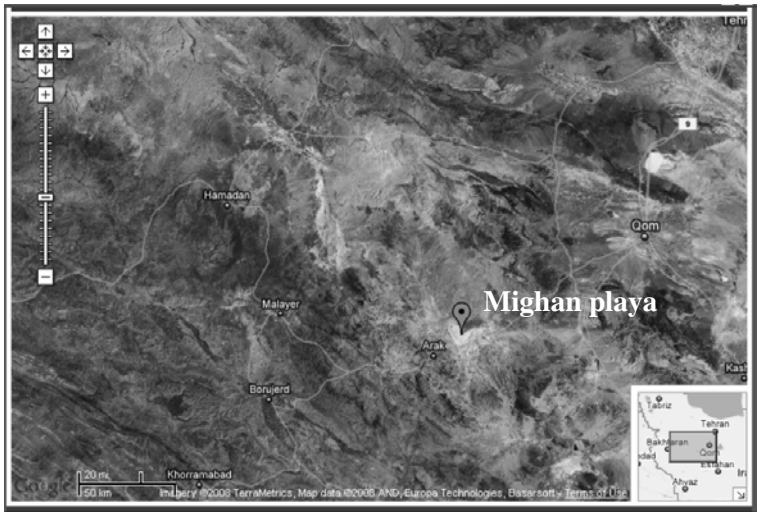


Figure 1. Mighan playa situation

METHODOLOGY

First step in this study was to drill 148 boreholes, each of 6 meters depth. The grid drilling was 500× ×500 m. 105 samples were taken from these boreholes and they were analyzed in order to determine the contents of Na_2SO_4, Mg_2SO_4, NaCl and $CaSO_4$. Then, the statistical analysis was performed for these composites. Data originated from 8 piesometeric drilled boreholes was collected and water level, deby, transmisivity and storativity were calculated. Finally, the playa was 3D-modeled

basing on mineralogy and stratigraphy as well the Na_2SO_4, Mg_2SO_4, NaCl, $CaSO_4$ distributions. The reserves were evaluated on their basis.

STATISTICAL STUDY

Analyses on 105 taken samples from drilled boreholes were performed in order to determine the most valuable evaporate minerals and chemical analysis showed that average contents of Na_2SO_4, Mg_2SO_4, NaCl and $CaSO_4$. are recpectively 8.75%, 3.05%, 21.51% and 0.5%. Next, their histograms were drawn. Their distribution is similar to normal and most of cumulations are within the averages values (Fig. 2).

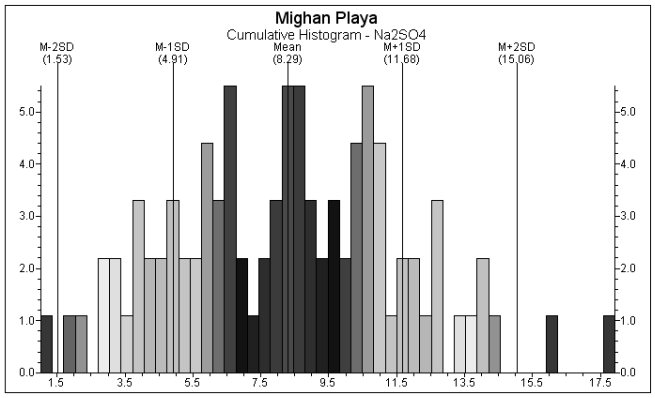


Figure 2. Na_2SO_4 histogram

HYDROGEOLOGY

Researching the hydrogeology in playa, 8 piezometric boreholes in purpose to determine the hydrogeological parameters were drilled. These parameters included water level, deby, transmisivity and storativity. The average water level equals to 38 cm. The depth of water in most of the piezometric boreholes was more than 50 cm, especially in central part of the playa (Fig. 3).

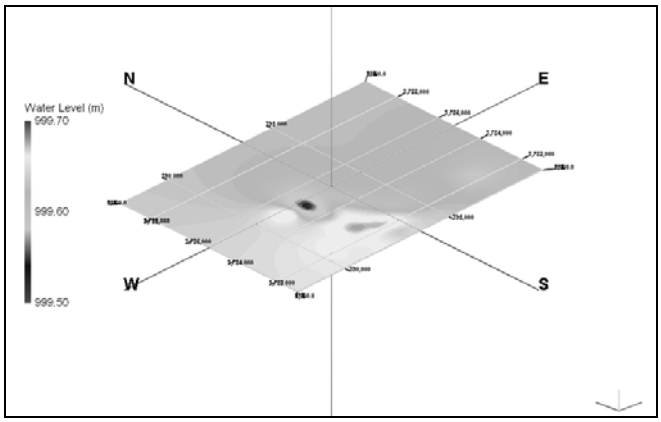


Figure 3. Water level distribution in Mighan playa

The average of deby equals to 23.1 m^3/d. High rate of deby is about 55.3 m^3/d which was found in southern part of this playa. In northern part of the analyzed region, deby is higher than 20 m^3/d but in SW is lower (Fig. 4). The average value of transmisivity is approximately equal to 311.6 m^2/d. High rate of transmisivity equals to 650.78 m^2/dwhat was found in southern part of this playa. In eastern part of the playa transmisivity is lower than 300 m^2/d but in central part is higher (Fig. 5). The average value of storativity is about 2.99. The high rate of storativity is approximately equal to 10.6 which is found in the central part of this playa. In eastern part of the playa, storativity is lower than 2 but in central part is higher. Also, NW part features by the high amount of storativity (Fig. 6).

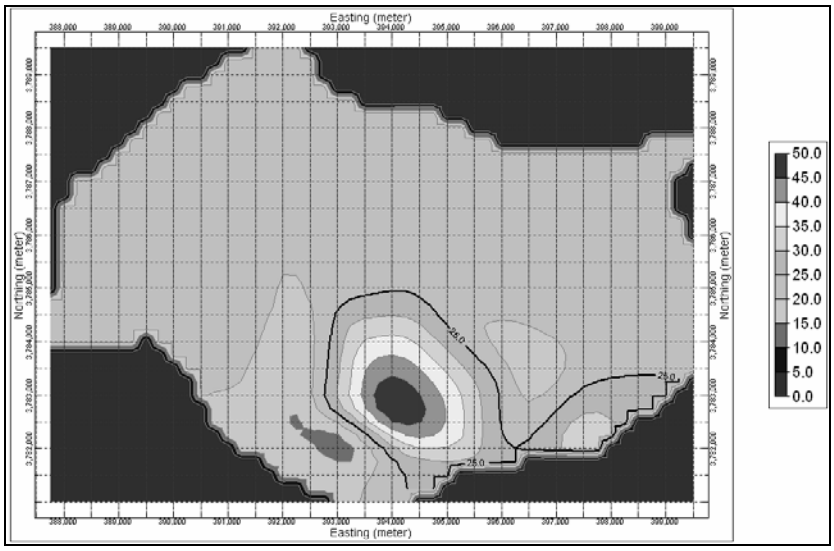


Figure 4. Deby distribution in Mighan playa

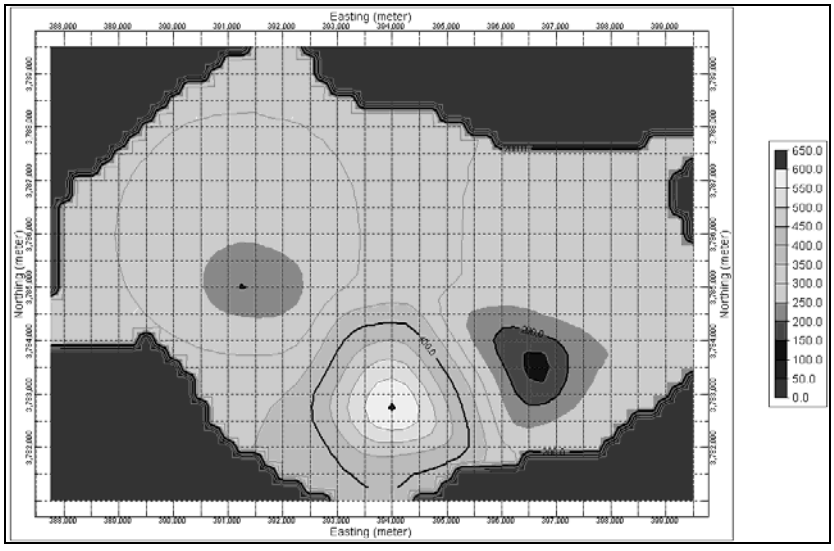


Figure 5. Transmisivity distribution in Mighan Playa

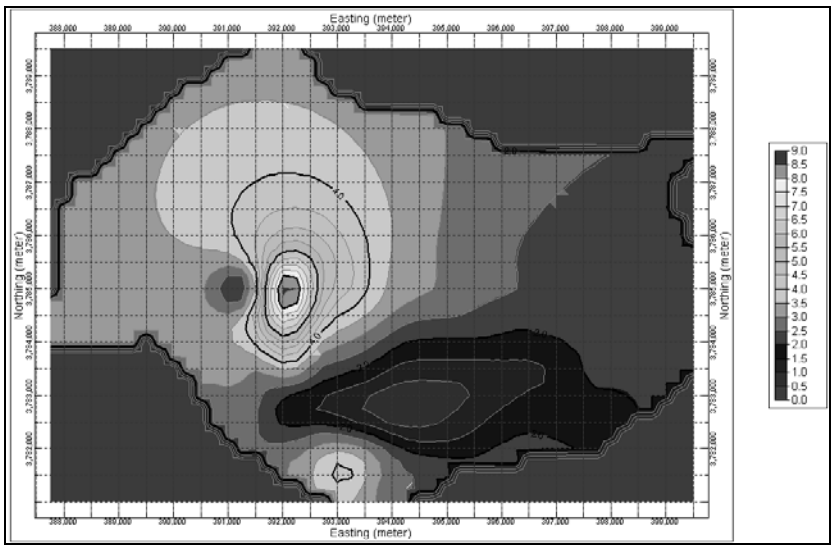


Figure 6. Storativity distribution in Mighan playa

3D MODELING AND RESERVE EVALUATION

3D geometrics aims to build graphs that allow correct estimating and general understanding the geological and mineral contents of the deposit. The project dimensions were 11 750 m, 8500 m and 6.6 m for X, Y and Z respectively. Numerical analysis and modelling were conducted by application 250× ×250×0.2 m voxels. Selection of block size for a computerized 3D dimensional ore body model is a result of compromises (Hulse 1993). First, 3D models were constructed on the basis of mineralogy. It was done for clay, mirabelite and gluberite (Fig. 7). The study showed that mirabelite and gluberite reserves are equal to 42.9 Mt and 127.4 Mt, respectively. Gluberite is occurring in many parts of the playa but the highest amounts of mirabelite are located in the northern part (Fig. 8).

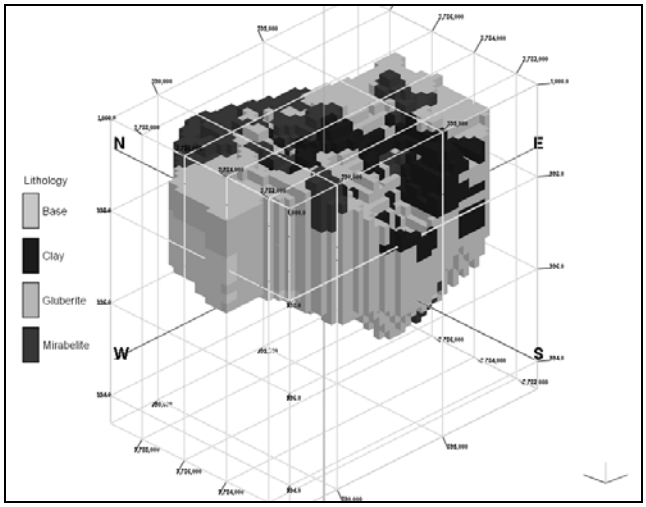
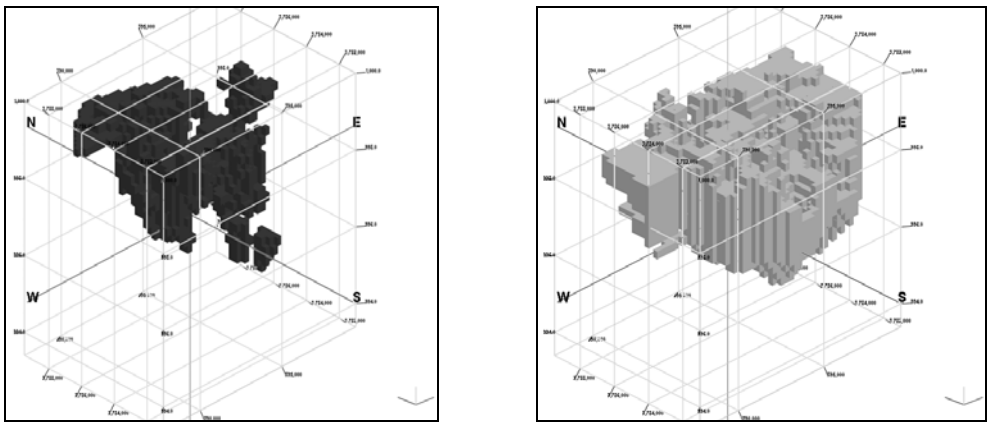


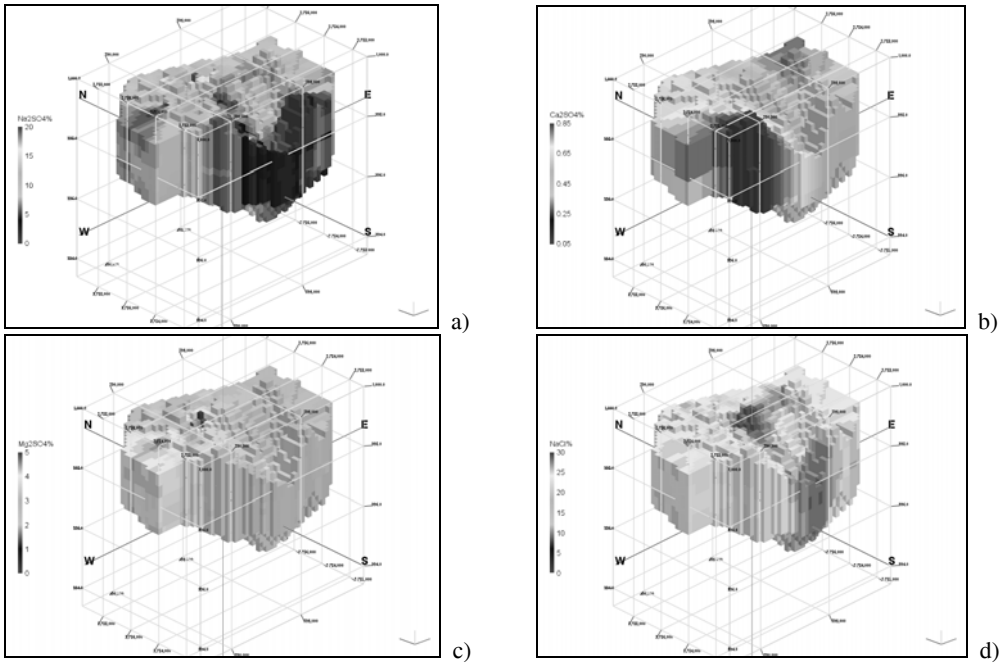
Figure 7. Mirabelite and gluberite in Mighan playa



a) b)

Figure 8. Mirabelite (a) and Glubrite (b) models

Next, Na_2SO_4, Ca_2SO_4, Mg_2SO_4 and NaCl distributions were modeled in 3D (Fig. 9). Basing on these models, high grade of Na_2SO_4 (higher than 15%) was found in southern and western parts of the region (Fig. 9a). The highest grade of Ca_2SO_4 (0.85%) is located in south-western part of the playa (Fig. 9b). Mg_2SO_4 grade is near to 5% in central part but in the many parts of the playa, the amount of Mg_2SO_4 is between 2% and 4% (Fig. 9c). High grade of NaCl (25–30%) is occurring in central and southern parts of the playa (Fig. 9d).



a) b) c) d)

Figure 9. Na_2SO_4 (a), Ca_2SO_4 (b), Mg_2SO_4 (c) and NaCl (d) distribution models

Finally, the reserves were generally evaluated by application of the inverse distance squared algorithm (Tab. 1). Reserves content 9% and more of Na_2SO_4 in 50 Mm^3. Also, there are over 70 Mm^3 with 0.5% and higher amount of Ca_2SO_4. The reserve of Mg_2SO_4 is more than 64 Mm^3 with 3% and higher grade of the compound. Over 127 Mm^3 of reserves features by 20% and higher amounts of NaCl.

Table.1. Reserve evaluation on the basis of Na_2SO_4, Ca_2SO_4, Mg_2SO_4 and NaCl in Mighan playa

Component	Grade range [%]	Reserve [m^3]
Na_2SO_4	0–9	96,237,500
	9–16	49,612,500
	higher than 16	287,500
Ca_2SO_4	0–0.5	74,062,500
	0.5–0.7	53,725,000
	higher than 0.7	17,812,500
Mg_2SO_4	0–3	81,478,500
	3–4.5	63,975,000
	higher than 4.5	375,000
NaCl	0–20	17,862,500
	20–25	123,762,500
	higher than 25	4,225,000

CONCLUSION

This study showd that Mighan playa has high potential for Iran demands for valuable evaporate minerals, especialy Na_2SO_4, Ca_2SO_4, Mg_2SO_4 and NaCl. The calculation illustrates that the total amount of mirabilite and gluberite is 170 Mt, approximately. Fortunately, water level is suitable in this playa for extraction. The 3D models and hydrogeological studies showed that the best accumulation for mining extraction is located in the central, southern and south-western part of Mighan playa.

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