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The analysis of consistency and effective factors on falling of Jajarm Bauxite mine, North East of Iran

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Abstract

Mineral zone of Jajarm alumina is located in anticline of Zou mount in northern part of Jajarm desert and southern margin of tectonic zone of Kopeh-Dagh and eastern end of eastern Alborz. Mubarak formation with *carboniferous age, Elika formation with* Triassic age and Shemshak formation with Jurassic age have been outcropped. The heights of this zone have been extended from north east to south west, which are correspondent with tectonic structure of eastern Alborz. This mineral zone has cut by extending faults of various slips. The function of such discontinuities in this zone led to formation of more than 12 longwalls for extracting mineral materials. Regarding this issue that understudied zone is located in eastern part of Alborz, on anticline of Zou mount, it can be inferred that the main stress direction is north west-south west. This issue can be confirmed by strike-slip faults, the extension of Zou anticline and identified direction of stratified slope. Several quoins and blocks are formed by intersection of aforementioned faults in various longwalls, and if they haven't been identified, they may fall or slip. Present study considers the reason of falling in Zou 2 mine, the main reason is intersection of strike-slip faults and function of reversed fault in pivot of quoin.

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Introduction

Tectonic and pressure conditions existed in this region make several formations and discontinuities in the region. One of the most important and greatest formation of this region is anticline of Zou mount, this anticline mostly extended from east to west.

Exploration, designation and safety supply of mines during extraction and long term consistency for extraction from lower parts are those issues that should be considered by designers of outdoor mines, because operation of such mines in sand are the most problematic and costly projects. In analysis of such formations, wide and deep recognition of designer about geological issues, underground water and geotectonic characteristics of rocks are necessary (Dadkhah, 2007).

On the basis of carried out studies and existed reports in the zone, it can be mentioned that understudied zone is located in eastern part of eastern Alborz. Tectonic and pressure conditions existed in this region make several formations and discontinuities in the region. One of the most important and greatest formation of this region is anticline of Zou mount, this anticline mostly extended from east to west. The process of formations of this region is affected by specific tectonic conditions of this zone, in a way that under the effect of subduction of ocean crust of Caspian Sea under continental crust, Alborz heights are formed in one side, and in the other side, anti-clockwise motion of Loot block from south and east part led to creation of stress and anomaly in the region. The location of understudied region that is between two stressful zones has led to development and growth of these formations and discontinuities (Darvish Zadeh, 1982). Zou 2 mine in alumina mineral zone is located 20 km far from Jajarm town, Northern Khorasan province, in longitude of 458500 to 459500 and latitude of 4102000 to 4101000. This mine is separated from Zou 1, 3 by two big strike-slip faults extending north west to south east and its own positioning has north east to south west extension (Dadkhah, 2007). The aim of this study was analysis of consistency and effective factors on falling of Jajarm Bauxite mine, North East of Iran and confirmed by strike-slip faults, the extension of Zou anticline and identified direction of stratified slope.

Material and methods

Area under study

Understudied zone is located in eastern Alborz zone extending from north east to south west, which is correspondent with tectonic structure of eastern Alborz. Following formations are observable in this region regarding geological calibration.

Mubarak formation

The oldest formation existed in the zone is Mubarak formation with carboniferous age. This formation in this zone is sequence of lime layers along with shale layers to lime shale and thick lime layers with shale inter layers, at the end dolomite mass rocks are located 93).

Elika formation

Elika formation with unconformity erosion is located on Mubarak formation. This formation's age is Triassic and its lower layer is formed by red shale unconformity erosion, above that marney lime and dolomite lime with regular stratification are located. In upper part of this formation dolomite is located along with lime with thick stratification (Fig. 1, 4 & 5). Shemshak formation has Jurassic age. This formation in mine zone is divided into 3 parts, itys first part mostly includes sandstones and is located on Bauxite B zone, the second part contains green to gray shale and some signs of coal, and at the end a sequence of shale and sandstones can be seen (Fig 1, 4 & 5).

Fig. 1. The face of rock mass of Shemshak and Elika formations in Zou 2 mine (view is toward east).

Results and discussion

Structural and tectonic geology of Zou mine

Regarding desert scaling and geological surveys, discontinuities and side effects of tectonic forces existed in this zone are determined and in following parts they will be considered (Dadkhah, 2007).

Anticline of Zou mount

Regarding extension and direction of dominant forces in the zone, the big anticline of Zou mount is formed with approximate extension of east to west. Regarding existed reports, the big fault of Jajarm causes relocation of anticline's southern crest till several kilometers. On the basis of dominancy of pressure forces from northern side, the slope of this fault is toward north side.

Region's faults

On the basis of cap breakdown theory of *Mohr-Coulomb, when an object is affected by pressurized forces it will break down along with those plates that make 15° angle with main forces. These plates are named shear plates that have appeared as strike-slip faults in this zone and several blocks are formed under the effect of* their activities. The relocation amount of these faults in some segments of mineral region of Jajarm is more than 200m (Fig. 2), in addition outcropped ultra-bazik dikes in this mineral region determine direction of main stress (Fig. 3,4).

Fig. 2. The face of strike-slip fault with relocation of more than 200m in Jajarm zone.

Fig. 3. The face of strike-slip fault along with ultra-bazik dikes in Zou 2 mine (the view is toward south).

Fig. 4. The face of Ultra-bazik dike in Zou 2 mine (the view is toward south).

In addition to strike-slip faults existing in mineral region of Jajarm, reversed faults that mostly have extensionsparallel to stratification can be observed, and under the effect of these faults' activities absence of layers can be observed clearly (Fig. 5). It should be mentioned that these faults are hidden because of structural and tectonic conditions of the Earth, and they have appeared after excavation and digging in these blocks. These faults have east-west extension and its slope is toward north.

Fig. 5. Floors repetitions under the effect of reversed faults' activities in the zone (the view is toward North West).

Geological consideration of Elika formation engineering of Zou 2 mine

Regarding existed information and desert studies, mass rocks of Elika formation are formed by lime to dolomite along with kaolin layer at its final part. Mass rocks of this formation have 2 sets of discontinuity along with stratification and accidental discontinuity. Joint set No. 1, 2 are along with strike-slip faults that make angles less than 15 degrees with direction of tectonic forces and have high slope; on the basis of this issue, it seems that the direction of main stress is north west-south east. Moreover, joint set No. 3 mostly are along with trast and reversed faults existing in the region (Table 1 and Fig. 6-9). Discontinuities of rock mass of this formation have low-average weathering conditions, their joints' opening amount are 1-5 mm, discontinuity distances are 200-2000mm, discontinuity length is more than 20m, and they have flat surface with calcite-clay fillingmaterial that have soft-slightly hard form and it is classified in dry group from moisture aspect (Dadkhah, 2007).

Table 1. Discontinuities characteristics in rock mass of Elika formation in Zou 2 mine.

Discontinuity	ID	Dip	Dip Direction
Js1	1	83	*284*
Js2	2	68	*082*
Js3	3	60	*190*
Bedding	*4*	*30 – 40*	*10*

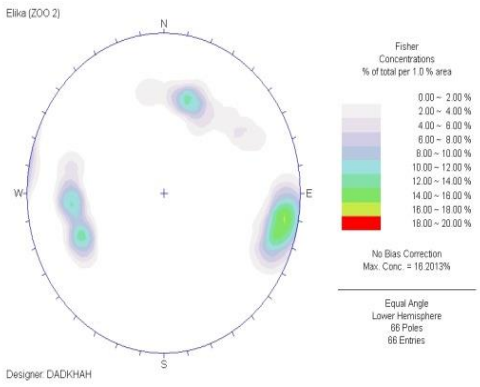

Fig. 6. Stereography picture of existed discontinue-ties in Elika formation Zou 2 mine.

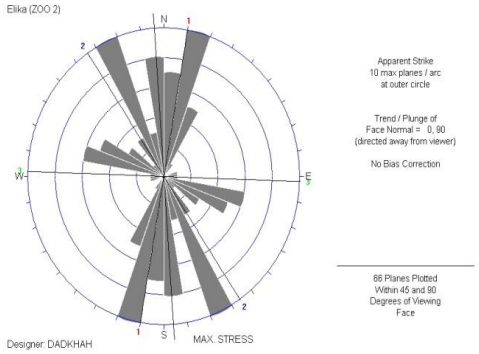

Fig. 7. Rose diagram of discontinuities existing in Elika formation of Zou 2 mine.

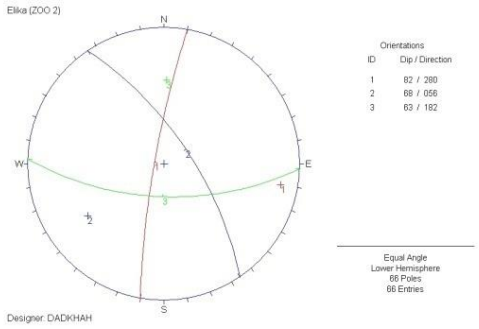

Fig. 8. Stereography of discontinuities existing in Elika formation of Zou 2 mine.

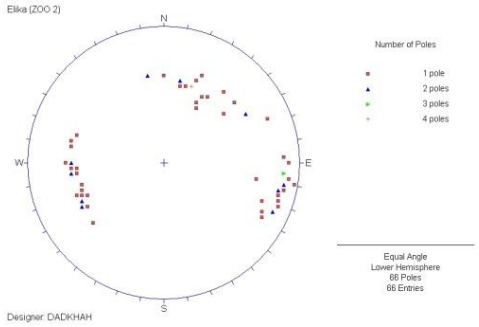

Fig. 9. Stereography of polra spots of discontinuities existing in Elika formation of Zou 2 mine.

Ranking of rock mass of Zou 2 mine

To classify rock mass of Zou 2 mine, geo-mechanic classification of RMR (Bieniawski, 1989), quality index of tunneling in Q rock (Barton *et al.*, 1974) and geology strength index GSI (Hoek&Marinos, 2005) were used. Achieved mean and range of GIS, Q and RMR for rock mass of Zou 2 mine are indicated in Table 2 (Fig. 3, 4, 5).

Table 2. Classifications of rock mass of Zou 2 mine (a is numerical mean).

Parameters	GSI	Q	RMR
Elika	57-68	2.63-2.72	37-52
Formation	62 [a]	2.67 [a]	44 [a]

Consideration of inconsistency in Zou 2 mine

One of the main aim of this study is to identify the effective factors on falling of rock blocks existing in Jajarm mine region and determine inconsistent mass, quoins and rock blocks. As it was observable in geology considerations of desert scaling engineering, this zone mostly includes 3 sets of discontinuity and stratification which show different level of weakness and intensity regarding their type of lithology. Tectonic studies of zone show north-south direction of pressure forces. These forces make discontinuity sets and under the effect of discontinuities' collision rock blocks and quoins are made. These quoins may fall or slip after appearance of reversed faults in the mine.

Reversed faults in this zone have north slope that are made by the effect of pressure forces in anticline region of Zou mount, because of limited space rock layers of existed formations have slipped on each other and these faults have been made as inter layer faults. The slope of these faults is more than 50˚, these faults along with shear discontinuities have made rock blocks at the middle of Zou 2 mine; it is necessary to identify them and after analyzing its inconsistency reason, proper holding system should be design and operate for them.

Among probable inconsistencies is falling of quoins and blocks that have relatively high weight. In *Fig*. 10-14 two samples of falling rock blocks are shown. After construction of stairs in the mine, existed discontinuities have been exposed to weathering, in cold and rainy seasons, moisture pervades among walls of these discontinuities and their freezing situation causes their motion and fall them down.

Fig. 10. Rock blocks falling in Longwall of Zou 2 mine (the view is toward east).

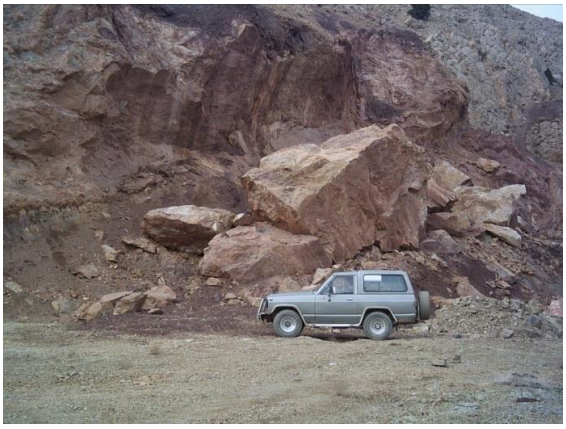

Fig. 11. Rock blocks falling in Longwall of Zou 2 mine (the view is toward south).

Fig. 12. Rock blocks falling in Longwall of Golbini mine.

To identify these quoins, first main discontinuities such as strike-slip and reversed faults should be determined carefully and after identification of their geo-mechanic parameters, safety coefficient should be

calculated and then holding system should be designed. On the basis of desert scaling and geological considerations, a sample quoin in the wall of this mine is modeled and is shown in *Fig*.s 13 and 14 from different views.

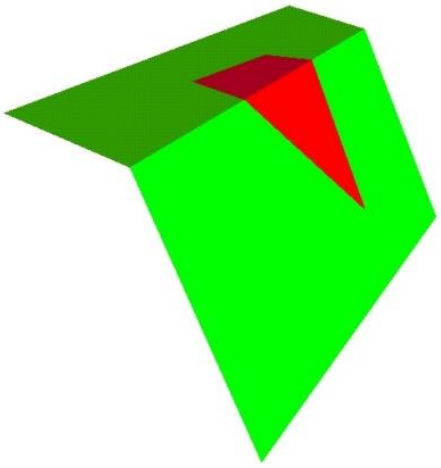

Fig. 13. 3-D view of probable quoin in southern wall of Zou 6 mine.

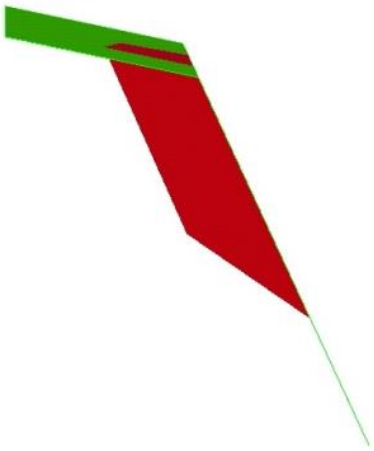

Fig. 14. A side view of probable quoin in southern wall of Zou 6 mine.

Conclusion

After analyzing consistency in Zou 2 mine, it can be inferred that in northern wall of the mine falling and slipping of mass are observed because of low level of geo-mechanic parameters and high frequency of joints in its rock mass. In southern wall, most of the inconsistencies happen as falling of rock blocks under the effect of intersection of cutting joints and discontinuities that have North West slope. These blocks are formed mostly in faults' walls and it is suggested that during excavation, these blocks become identified regarding dominant conditions. It should be mentioned that rock blocks have been formed along with separating strike-slip faults of each longwalls.

To identify and analyze the rocks, strength parameters of rock mass are necessary and sampling and rock mechanic experiments should be carried out regarding existed standards. After determination of geo-mechanic parameters through laboratory results, northern wall should be analyzed through limited components and southern walls should be studied via separated components.

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