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Mining Design System for Exploitation of Fat'ha Formation(M. Miocene) in Makhul Anticline, IRAQ

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Abstract:

This study deals with the emphasis on the economic value of Makhul Anticline rocks in Mid-Region of Iraq, and it includes a mining design system suitable and profitable to exploit these raw materials. Here, the recommendation is to use and apply the open pit bench mining to extract the rock beds because of thin overburden, and the waste materials which cannot be dumped inside the excavation site. The rock beds which are outcropped dipping on both sides of the anticline flanks have irregular topography. Development of the mine is usually quite simple. Enough overburden should be removed to expose sufficient rock beds for production and construction of new access roads. This kind of mine operation is worked on one side of flank sequentially downwards in series of steps or benches whose height is usually determined by the machines selected and which are recommended in this study with the height of bench in range of (4 – 5) m, the sidewall

angle in range of almost (18 – 20)° from the vertical and the bench or haul road width in range of (8 – 10)m.

Access to the bottom of the mine should be cut- across the benches down to the next step. The equipments recommended in this kind of exploitation are Front - End Loader, diesel powered, rubber – tiered shovel for loading broken rocks in Lorries, and Jack Hammer Poclaine machine for Digging and breaking rocks. The mining operation become more profitable and economic when the whole rock beds of different types are extracted all together for multifarious uses, and the use of the facilities available around the area, such as the paved main roads, railway crossing the area, main power line, Tigris river, cheap labors and different types of machinery are ready for use.

Key words: mining; mining design system; industrial rocks; Hemrin Anticline; Makhul Anticline; Iraq.

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المستخلص:

التصميم المنجمي لاستغلال صخور تكوين الفتحة (المايوسين الاوسط) في طية مكحول المحدبة، العراق

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يتناول هذا البحث دراسة التكوينات الجيولوجية لطية مكحول المحدبة مع التركيز على القيمة الاقتصادية لهذه الصخور التي تقع في المنطقة الوسطى من العراق. تتضمن هذه الدراسة تصميم نظام التعدين المناسب لاستغلال هذه الصخور بصورة اقتصادية ومربحة. التوصية التي خرج بها البحث هي باعتماد وتطبيق المنجم المفتوح ذو المدرجات لاستخراج واستغلال الطبقات الصخرية من اماكن تواجدها ، بسبب انكشاف الطبقات الصخرية فضلا عن وجود غطاء صخري بسيط. صخور الغطاء الصخري تحتاج الى نقلها خارج موقع المنجم وردمها في الوديان والمنخفضات القريبة لحين الانتهاء من الاعمال المنجمية ثم يعاد تسوية الارض لجعلها صالحة للاستخدامات الزراعية او السياحية مع الحفاظ على النظام البيئي للمنطقة. الطبقات الصخرية المنكشفة على سطح الارض تمتلك ميل باتجاهين اعتمادا على ميل جناحي طية مكحول ، تتميز المنطقة بطبوغرافية غير منتظمة وذلك بامتلاكها مظاهر وتراكيب طبوغرافية وتركيبية متعددة مثل وجود التعرية التفاضلية، ظاهرة الكويستا، السقوط الصخري فضلا عن وجود المناطق الرديئة (Badland) التي تجعلها ذات تضاريس معقدة. ان عملية فتح المنجم السطحي مفضلة من الناحية الاقتصادية كونها غير مكلفة. يجب إزالة الغطاء الصخري الذي هو عبارة عن ترسبات العصر الرباعي والترسبات الحديثة التي تؤدي لانكشاف الطبقات الصخرية على سطح الارض فضلا عن امكانية تصميم وانشاء طرق الوصول الى الطبقات الصخرية السفلى. يتم فتح المنجم من جانب واحد من جناح الطية حيث يتم تصميم المدرجات بما يتلائم ونوع المعدات المستخدمة في الانتاج التي اعتمدت في هذه الدراسة وهي ان يكون ارتفاع المصطبة (٤-٥) متر وبدرجة ميل امان قدرها (١٨-٢٠)درجة ، وعرض المصطبة او المدرجة الواحدة هو (٨-١٠) متر، يبدأ العمل ابتداءاً من الطبقات العليا ثم بالتتابع نزولا في سلسلة من المدرجات نحو الاسفل باتجاه ميل الطبقات حفاظاً على استقرارية المنحدرات الصخرية.

يتم تصميم وانشاء طرق المواصلات عبر قطع المدرجات نحو الاسفل بزاوية ميل آمنة نحو واجهات الاشغال المنجمية. المعدات المنجمية الموصى بها هي من المتوفر في السوق العراقي مثل (شفل مدولب، سيارات حمل ٢٠طن ، حفارة هيروليكية للتحميل واخرى لتكسير الصخور). لا تحتاج عمليات الاستخراج المنجمي الى استخدام المتفجرات لوجود محددات امنية وعسكرية في استخدامها حيث يتم تكسرها وتحميلها آلياً لوجود انظمة من الكسور والفواصل التي تسهل عملية قلع واستخراج الصخور. أن العمليات المنجمية تصبح اكثر اقتصادية اذا تم استخراج واستغلال كامل الطبقات الصخرية الموجودة في المنطقة بما يتلائم والاستخدامات المخصصة لها مع

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الاستفادة من التسهيلات المتوفرة في المنطقة من طرق مواصلات ، سكك الحديد ، ايدي عاملة رخيصة ، مصادر الطاقة الكهربائية ، قربها من نهر دجلة والمدن السكنية فضلا عن اسواق الاستهلاك الكبيرة .
الكلمات المفتاحية: التعدين؛ تصميم نظام التعدين؛ الصخور الصناعية؛ طية مكحول؛ العراق.

1. Introduction:

The increasing demand for raw materials, and industrial rocks for the construction industries, and the need for conservation of environment is a concern in Iraq, which necessitates providing information about Quarries, Mining and the procedure of exploitation and extraction.

The shape, type and the nature of the deposits which occur at the surface can be worked by cheap open pit mine, and then carrying out the next steps which are exploitation and uses. Emphasis has been made on accurate approaches of open pit mining and quarrying, and on the importance of bench method which is used in the exploitation and extraction of Fat'ha formation within Makhul Anticline in the mid-region of Iraq. The emphasis should also clarify the effect of geological and structural setting throw designing the mine. The economic importance and the productivity of the open pit step mine design have been explained.

The advantages of the surface mining can yield high outputs at high manpower productivity because of the large scale equipment. The operation is concentrated to easy to supervision and provision of services. Low cost allows exploitation of low grade deposits and raw materials, and planning is simple and fewer hazards for work face.

The disadvantages are summarized in some volume of waste rocks and overburden must be removed with environmental disruptions.

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During the mining planning system, attention should be paid to design criteria, the most important of which is the safe side wall angle because it affects the stripping ratio markedly. The next criteria include the location and gradient of access roads owing to the high topography difficulties. The height of working face, which is usually controlled by the loading equipments is selected, and the distance of the marked or site use.

The aim of study is to find and design a systematic mining exploitation system that makes use of the highly economic value of the raw materials and the industrial rocks found in the Makhul Anticline. In addition, the huge reserve of these deposits with the greater growth of uses by the private sectors that have found a randomly scattered quarries to exploit these materials, are also found worthy to deal with in this study. The mining designing system which is suggested in this study is cheap, economic, high productive and of environmental concern, so as to be used in scientific control in producing these raw materials and industrial rocks.

2. Location of the study area:

The area of study represents Makhul Anticline, which is represents a part of Makhul-Hemrine Anticline, located within Salah Al – Deen, Mosul and Kirkuk governorates in mid – region of Iraq, north of Baghdad about (140) Km. The Tigris river flows between the anticlines that separate it to two anticlines by a strike slip fault. At the north-west is the Makhul anticline and at the south east is the Hemrin Anticline. Fig. (١). The Axis trend extends NW – SE , the area represents the foot hill region [8], created by the movement of the Arabic plate during the opening of the red sea that occurred at the end of the last Alpine Orogeny the geometrical shapes of the Iraqi anticlines.[1].

3. Regional Geology and Stratigraphy of the Study Area:

The geological formations that have been excavated within Makhul – Hemrin Anticline ranged from M.Miocene up to the Recent Age, which represents the Fat'ha Fn, Injana Fn, Mukdadyiah Fn, Quaternary and Recent Deposits. Fig(2) shows the regional geological map of the general area. The area of study is specialized within Makhul

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Anticline, Fig.(3a & 3b) were selects as a sample boreholes, shows the stratigraphic succession as the field description of these formations that are excavated in the study area .

Fig.(1): Image for the Area of Study Shows Makhul and Hemrin Anticline

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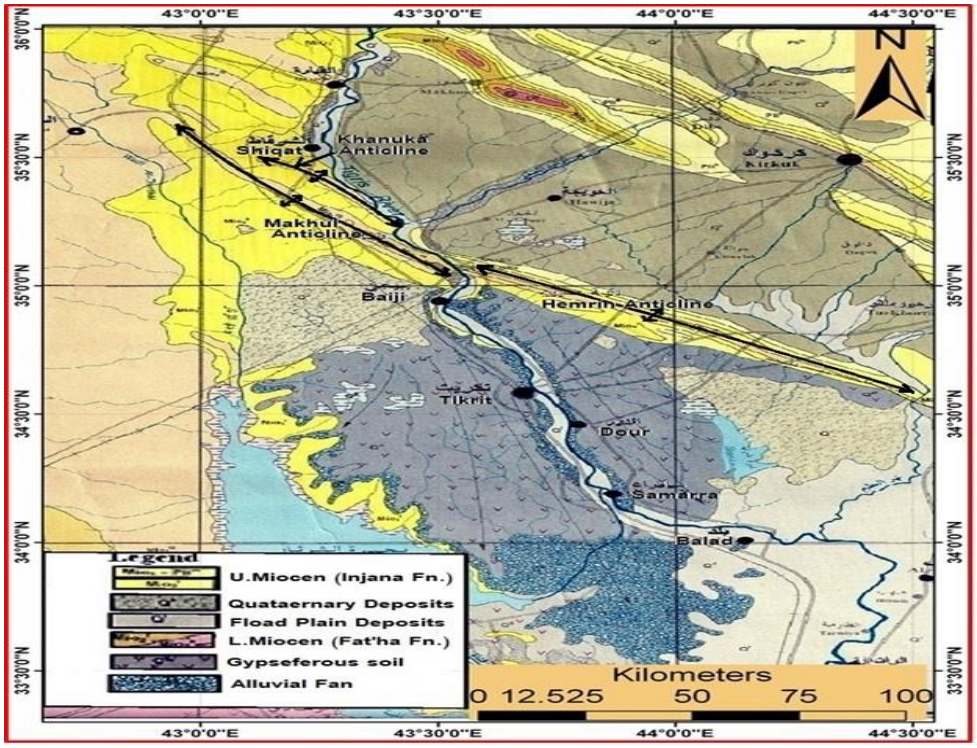

Fig(2): Geological map of the studied area

المصدر: خريطة مقتطعة من خريطة العراق الجيولوجية، إصدار الشركة العامة للمسح الجيولوجي والتعدين، ٢٠٠٠

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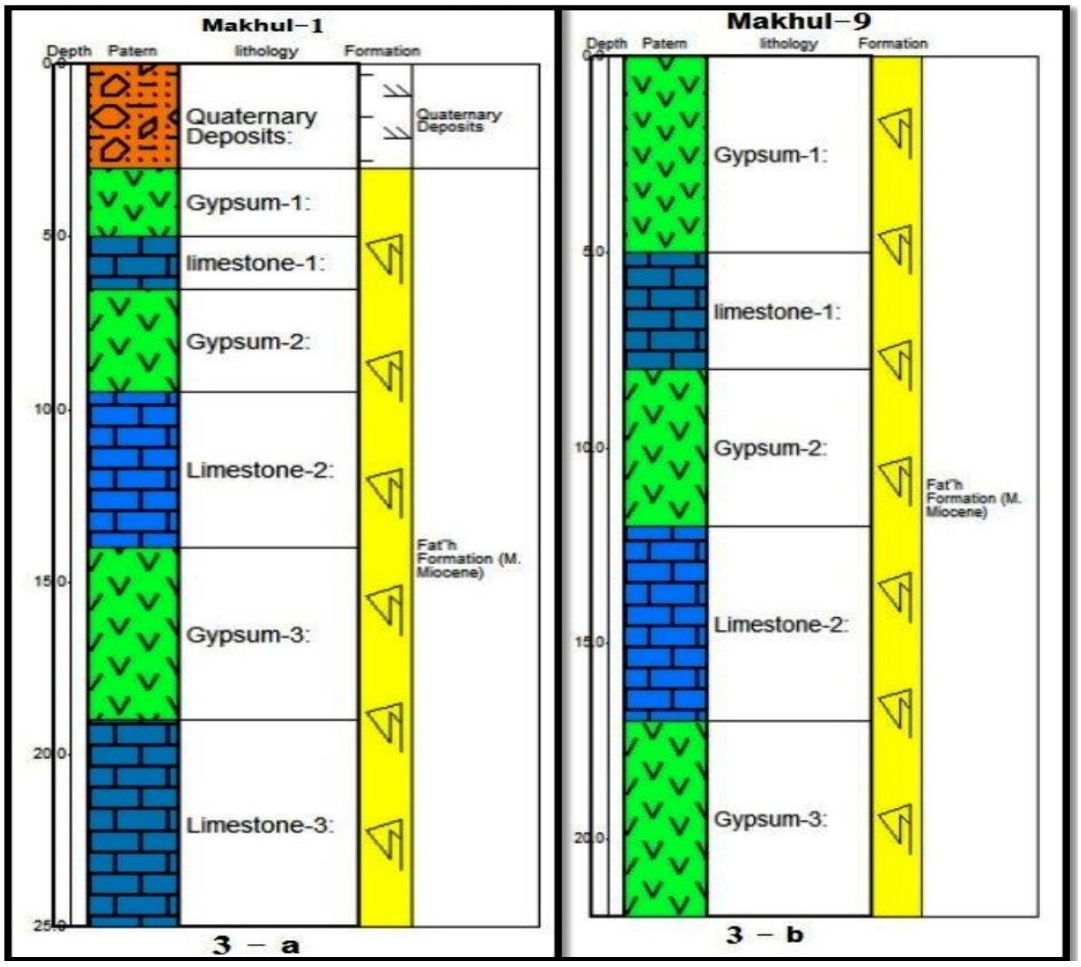

Fig(3-a and 3-b) Stratigraphic succession of Fat"ha formation on Makhul Anticline

3.1. Fat'ha Formation (Middle Miocene):

This formation represents all evaporate deposits in Iraq, comprising mainly of Anhydrite, Gypsum and Salt rocks interbedded with Limestone and Marl. The recent description of the formation was carried out by [2] & [3], depending on first appearance of the red mudstone bed. The formation was divided into two members; the lower member comprises a succession of Organodetrital limestone, cycle of Gypsum with Green marl and Limestone. The upper member is characterized by lateral variation of thicknesses which comprises a succession cycle of Green and Red Marl, Gypsum, thin bed of highly fossiliferous Limestone and bed of Calcarenite which occurs near the top.

Fat'ha formation was deposited in a rapidly subsiding lagoon basin with high salinity and outlying closed gulfs separated from the sea. The lower contact of the Fat'ha formation with the underlying Jeribe Formation (Early Miocene) is conformable, consisting of Dolomitic Massive limestone. The upper contact with Injana formation (Upper Miocene) is gradational and dischronous.[4].

3.2. Injana Formation (Upper Miocene):

This formation comprises a cycle succession of Terrigenous rocks which represents Sand, Mud and Silt Rock beds covering a wide area in northern Iraq as Albian Mollase,[5] and absent in southern Iraq. The Injana formation excavated in the eastern side of Tigris river in thickness up to (750)m represent a cycle succession of pale brownish Silty Claystone, Calcareous claystone, Gravel and fine to coarse grain of Rock sand,[6].

This formation was deposited in littoral deposit environment and the upper part deposited as Fluviolacustrine system,[7]. The upper part is indicated by appearance of pebbles of different sizes in rock sand.

3.3.Mukdadyiah Formation (Lower Pliocene):

The outcrop of this formation is widely spread in Hemrin Anticline comprising of fining upward depositional cycle of pebbly sandstone, successes with sandy silty rocks, extending for several kilometers in Hemrin Anticline. The formation was deposited in a fluvial environment in a rapidly subsiding fordeep basin.[8]. The formation is underlying conformably with Injana formation.

3.4. Quaternary Deposits (Pleistocene):

The Quaternary deposits veneer and covers a large area in both Makhul and Hemrin Anticline extended with varied thickness ranging from (1.5 – 7.0) meters [2]. These deposits are derived from the oldest rock formations mentioned before by the weathering and erosion activity which give out non – homogeneous mixing sediments of different

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grain size ranging from fine grain of clay materials up to coarse conglomerates with different thicknesses.

3.5. Recent Deposits:

The recent deposits represent the slope sediments, valley filling deposits, flood plain deposits and river terraces. This consist of gypsum, limestone, rock fragments, sand, mudstone and siltstone.[9 &10]. The valley filling sediments are exploited nowadays as gravel and sand quarries along the north east flank of Hemrin Anticline.[11].

4. Geomorphology of the study area:

The main factors controlling the topography and the morphology of the study area are: The differential erosion, Rock types and the Tectonic uplifts of the geological formations. The most geomorphological features found in Makhul Anticline are:

a) Top plateau on the axis of the anticline, longitudinal surface with (0 – 5)° dip.
b) Anticlinal ridge, developed by the differential erosion that removed Fat'ha gypsum rocks.
c) Questa as ridges, found as hard solid rocks with dip less than (35)°.
d) Hogback, found on solid rocks with dip more than (35)°, these units developed in between Fat'ha and Injana formations. Fig.(4).

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Fig.(4): Questa and Hogback phenomenon showing the drainage system

e) Accumulation, Erosional and Dissected Glacis. These features developed as a longitudinal fluctuated surface with dip (1 – 7)° on both flank of the anticline consisting of recent Terrigenous and fine grain sediments.[12].

f) Bad land, found on area around both anticlines, characterized by deep valley on different directions.

g) Units of fluvial origin like Flood Plain, River Terraces and Alluvial Fan. These features developed along Tigris River flank near Makhul Anticline, containing Coarse Gravel fining upward. (Field Work).

h) Toppling rocks, Rock fall and Collapse rocks. These features were developed by the differential erosion in different direction.[13].

i) Other morphological features found in the study area are: Cavities, Sinkholes, Karstifications, Flat Iron Topography and Natural Ridges. These features are developed due to the rapidly dissolving of gypsum rocks and limestone and the existing of joints. Fig.(5).

Fig.(5): Sandstone Ridge and Cavities in Makhul-Hemrin Anticline

The study area is characterized by widespread of different kinds of valley types, like longitudinal and subsequent valleys, which have a dendritic drainage system, Transvers and Consequent Valleys which have a parallel drainage system. Generally, the

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Makhul Anticline has a hard Morphological and Topographical surface because of the different kinds of rock type outcrops and the active differential erosion with different kind of drainage system. All these factors control the topographical surface that reflects the difficulty in land use. Fig.(6), shows the topographic contour map of Makhul Anticline.

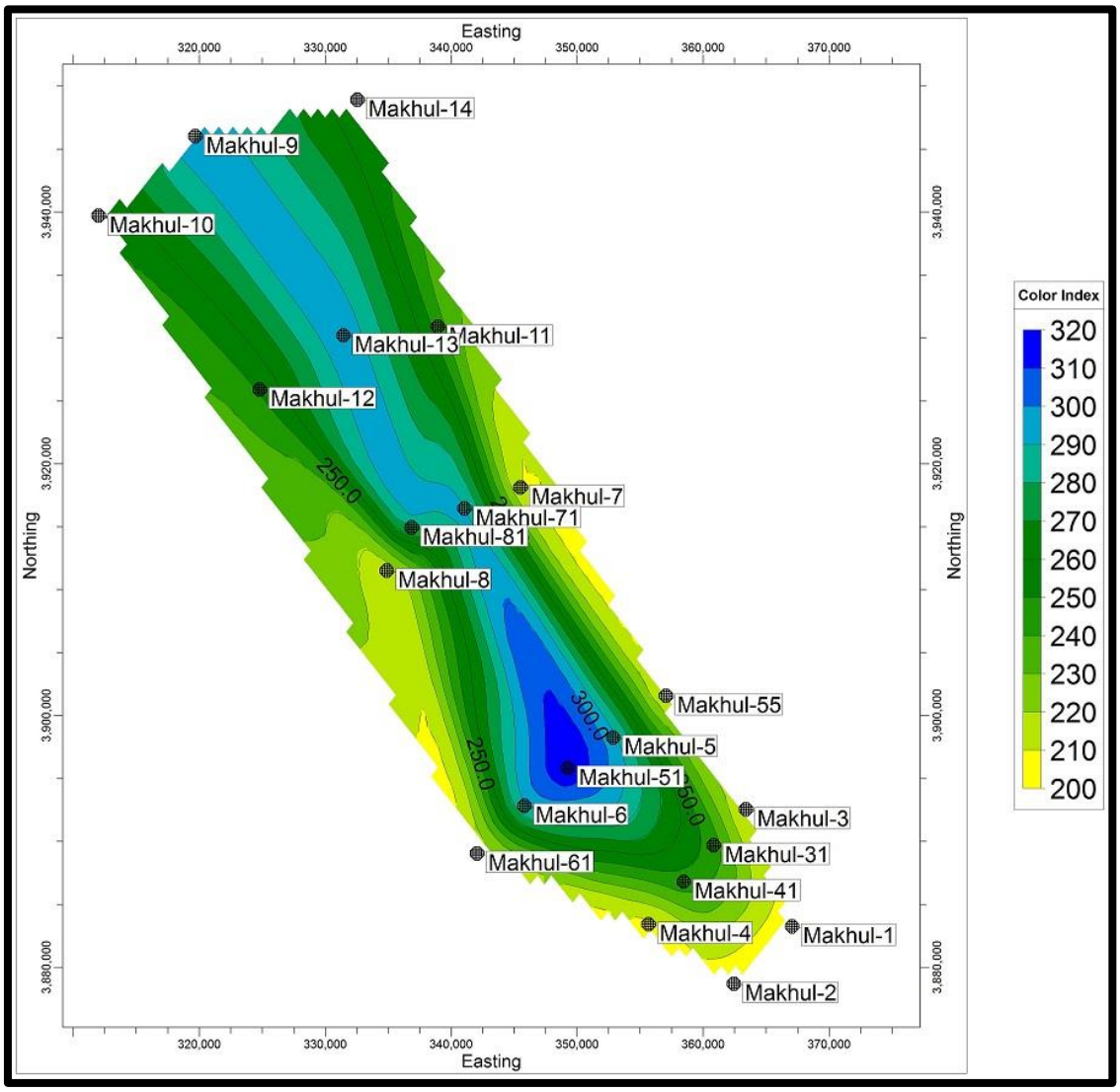

Fig.(6) Topographic Contour Map of Makhul Anticline

5. Tectonic and Structural Setting of Makhul – Hemrin Anticline:

Makhul – Hemrin Anticline is described as Asymmetrical double - Plunging open fold, general trend is (NW – SE) in about (292)°, [6], elongated more than (75)Km each , the width is almost from (4 – 6)Km. The top elevation is ranged from (220 – 500)m a.s.l. , the slop of the bedding on the north east flank almost varied with about (22-60)° NE . The slope of the bedding on south west flank about (20 -55)° SW.

In general, the Makhul – Hemrin Anticline has several sets and systems of discontinuities, systematic and non-systematic fractures which are (hko),(okl), (hkl), and sets , (ac) and (bc), the internal friction angle (Ø ≅ 17.5), the slope angle is greater than the dip angle of the bed which cause rocks slide failure [13], with frequency ranging from (1 – 2.5) m for each set, widely scattered along both anticlines (Fig.7). These sets of fractured generated tension stress parallel and perpendicular to the fold axis. Also, there is shear stress caused by conjugated joints system and complementary joint system oblique to the fold axis.

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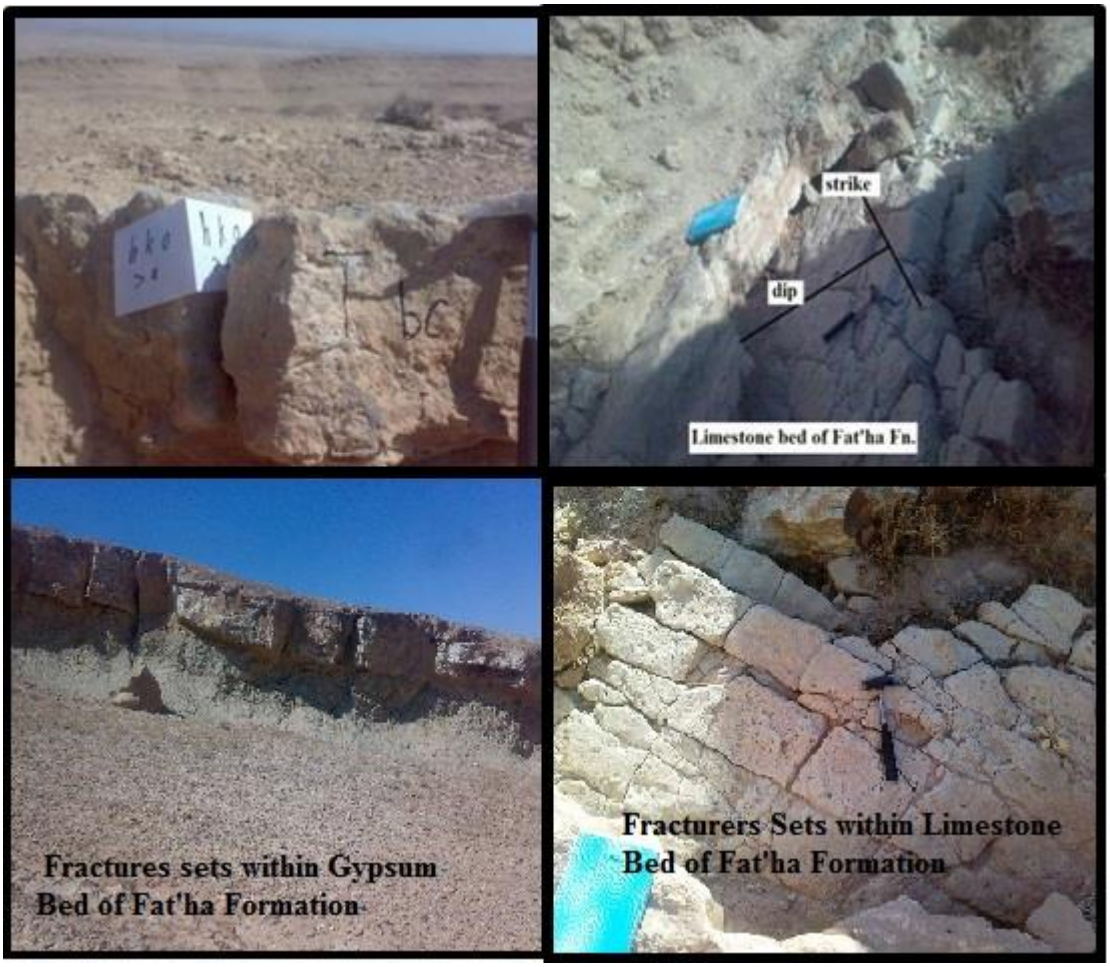

Fig.(7): Fractures sets within the Fat'ha Formation.(after, ward,2012)

Fissures and veins are found as well, characterized by opening and precipitation of calcite and gypsum generated by perpendicular tensile stresses and by erosion and dissolving processes [6]. All these sets of joints and fractures create weakness and failure within the formation rocks which are: Plan Sliding, Toppling and Rock fall, the weakness of marl beds that are interbedded within Fat'ha Fn. in strength. Weathering played the main role in the occurring failures. In addition to attitude and frequency of discontinuities and bedding, all these factors controlled the failures of rock beds [13].

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The structural analysis of tectonic indications is carried on the top bed Gypsum and limestone of Fat'ha Fn. that is widely exposed in the area as well as it becomes more economic and valuable for production and exploitation.

6. The Economic Value of the Fat'ha Rocks:

The most important raw materials that have been widely used in Iraq are the Gravel, Sand, and Limestone, Gypsum and clays, which meet the increasing demand for industrials rocks and the raw materials for the civil engineering and constructions industry, because of the increasing development of the Iraqi society in the recent years.

This study is involved in designing a mine suitable for exploitation and extraction of the raw materials which are exposed within Makhul Anticline, comprises of Fat'ha Fn. The economic value of these deposits is represented by:

A. The geological formations which are exposed on the earth surface with less covering of overburden.

B. Location in mid – region of Iraq, closed or nearby to the main paved roads and the railway connection between Baiji city and Kirkuk governorate ,Mosul and Baghdad, close to the marketing and cities without needs for high cost of transportation and mine infrastructures.

C. The Gypsum bed exposed on the earth surface possess a thickness ranging from (4-6) meters, The density almost ranges between (2.25 – 2.15) gm/cm^3. Gypsum can be used as heating insulation in range (30 – 100) C°, and the heating conductivity from (0.41 – 0.64) watt [14]. Gypsum is also used for producing Calcium Oxide (CaO) by private sectors in the study area Fig.(8), by calcination gypsum in rotary kiln with (750)C°, and producing $CaSO_4.½H_2O$, because of its high quality and less contains of clay and silt by calcination in kilns with (200-300)C^0, which have moderate hardness in selected parts within the area of study. Table (1) explains the chemical and physical analysis of some samples of gypsum location in Makhul1.[14 & 15].

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Table (1): chemical and physical analysis of gypsum sample

	Specific Gravity	Density gm|cm^3	Water Absorption %	Porosity %	I.R. %	CaO %	SO_3 %	L.O.I. %
Makhul-1	2.20	2.23	1.42-2.5	3.9-5.5	0.77	32.8	46.76	20.76

D. The Limestone rocks of Fat'ha Fn. Are exposed most widely in the area of study by erosion processes. These rocks compose of less percentage of dolomite in Makhul anticline while in Hemrin anticline it contains calcite and quartz and less percentage of feldspar. The average density is equal to (2.3-2.6) gm|cm^3 [16]. The economic value of Fat'ha limestone rocks are :

I. Can be used for Portland Cement Industries in selected area.[16].

II. Limestone is still used in walling stone builds and municipal buildings, Decorative and tasteful choice for architects and builder nowadays is used as dimension stone by private sectors as building materials, covering and decoration of walls. Fig.(9).shows a random Quarry of private sectors. The crushed stone used as cemented building materials, concrete is composed of cement, aggregate made from crushed rocks of limestone.

III. Brocken Stones used as Riprap materials along the Tigris river flanks.

IV. Limestone is easily cut and is used to create a variety of bespoke used in construction ranging from window cills, mullions and door sets to steps, flooring and fireplaces.

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Fig.(9):Limestone Quarry in Makhul Anticline

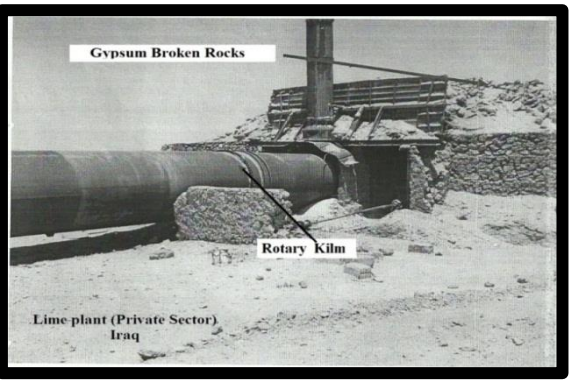

Fig.(8):Rotary kilm for producing of calcium oxide

V. The limestone rocks of Fat'ha Formation are widely exposed on surface area in Makhul Anticline, which is very suitable for using as dimension stone, walling and decorative stone and In portland cement industries. The density ranges from (2.06 – 2.5)gm|cm^3 , the coefficient of capability is (0.59 – 3.08)gm|cm^2, which suitable for walling stone and decorative.[17]

7. The Mining designing System:

Because of the highly economic value of the Fat'ha formation (M.Miocene), and the increasing demand for the industrial minerals and rocks and the raw materials for civil engineering and the construction industries, this necessitates giving a surface mining design to extract and exploit these materials. The mining method can be used and designed for stratified or mostly dipping stratified deposits with thin cover of overburden (1 – 1.5 meters), or it can be worked as surface outcrops. The recommendation method here is to use the open pit bench mining on one side or one flank of the Makhul Anticline.

Designing and development of the mine are usually quite simple because of the rock formations possess two sets of joints and fractures which make it easy for extraction and exploitation by using suitable machines. Enough overburden has to be removed to expose sufficient rocks for production and for the construction of access roads. (Fig.10). The steps should be worked on one side of the anticline flank in a series of steps or

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benches worked sequentially from the top surface to downwards to the bottom of the oldest rock beds, with the dip angle of the beds in order to keep the stability of rocks fixed during working time.

Fig.(10): Construction of haulage and access roads

The oldest rocks exposed after removing off the upper most of the rock beds. Fig. (11) Shows the designs of the mining bench steps on one side of Makhul flank.

The heights of benches whose is usually determined according to the slope stability case of the rocks. The rock beds are weak and have two sets of joints in different directions as discussed before, which control the face slope and the height of the benches. In this case, the height of the benches is usually stable in the range of (4 – 5) meters. The face wall can usually stand at a gradient of about (18-20)° from the vertical [a = (18 – 20)°] (Fig. 1١). The design of the bench width depends greatly on the type of the machinery used, transport system and the rock fragment loaded.

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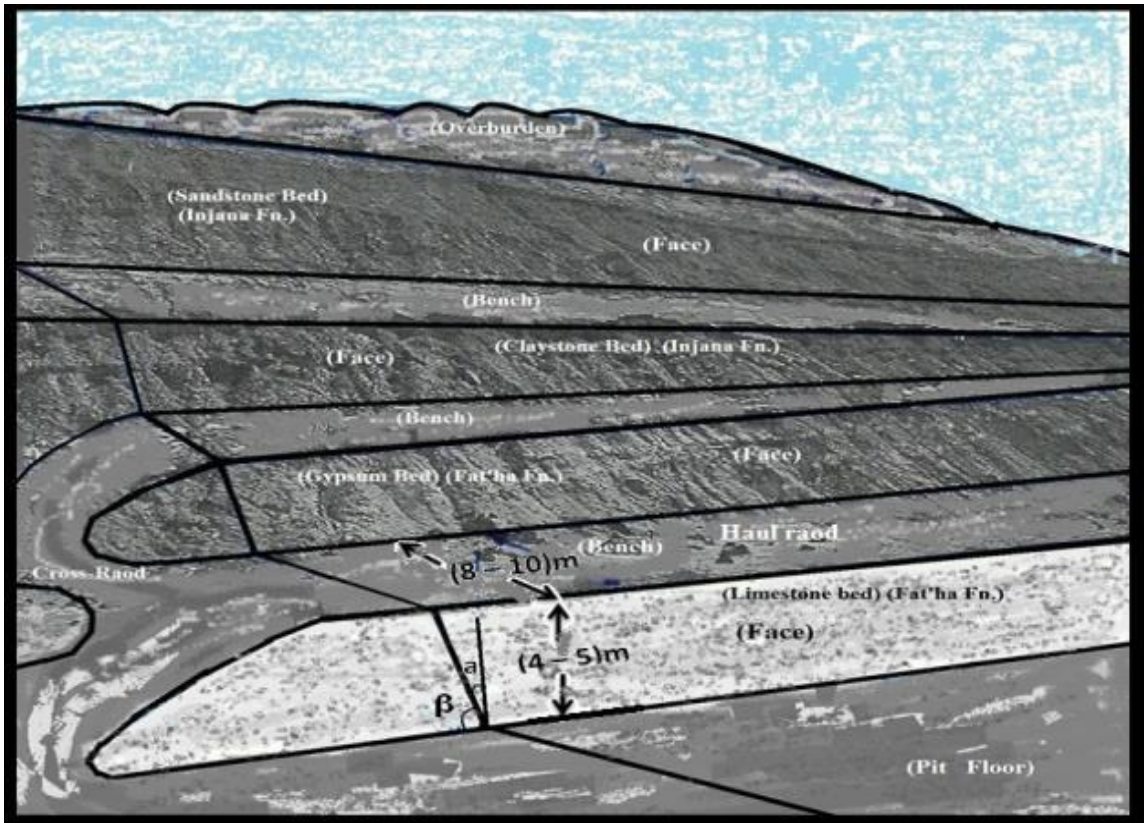

Fig. (11): Design of the benches and faces

In Iraq it is used the front – end loader (3-4) m^3 , Fig.(12), with rubber tyre for loading the Brocken rocks out to the Lorries to transport for beneficiation plant or marketing and uses. Several benches worked downwards simultaneously. Access roads should be extended to the bottom of the next bench, cutting across the benches as shown in Fig.(10). The gradient of the roads should be limited on the heavy rubber - tired front – end shovel equipments and Lorries for (10 – 15) ton loading. The width of the bench should be sufficient to accommodate the loading and haulage equipments used. The recommended bench width is ranged from (6 – 8) meters to meet the manouver of the equipments during the laoding of the raw materials and sutable for the truck haulage.(Fig.١٢).

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Fig.(12): The Machinery equipments used in surface mining exploitation in Iraq

The overburden and the waste cannot be dumped inside the excavation site, because there is no space available for the mine working. It should be removed and dumped out's side the working area, in a place , spot or valley not to be used during the mine operation until all the rocks are extructed from the bench down to the earth surface or to some meters deeper down to the earth surface. Then, the waste should be loaded again and dumped inside the pit mined, leveled and covered by the top soil of overburden. The environmental impact caused by this kind of open pit mine is the disturbing of the land. In order to restore the land for acricultural productivity and reclamation of soil and vegitation at the mine site, there should be some process like modifying slopes and other surfaces and planting vegetations as part of the stabilization process of the soil materials and preventing erosion and surface water infilterations.

The method of extraction and exploitation is very simple and cheap, because of the existing of several joint sets in different directions that can help to excavate and extract the rock masses just by using hydraulic jack – hammer or poclain jack – hammer to break down and remove the broken rocks from its place, so as to be loaded out for uses. There is no need for blasting, it is not important as the choice of the correct exrtaction shape

design. The benching design can be achieved by digging down and breaking the first strip of rocks, then laoded out by lorries, and facing the bench width, hight and face slope, then moved down to the next step, and so on by keeping the construction of the haul and cutting-access roads along the benches established in zig – zag shape which created the gradient of the haul roads suitable for the machinery uses.

The rock beds have to be benched down in succesion intervals for about (8 - 10) m width and (4 – 5) m height. The procedure in which this is done depends on the topography of the area and the thickness of each rock bed. Mining should be started from the hill or its outcrop, because it is more resistant to weather which represents the appearance of the gypsum and limestone layers of the Fat'ha Formation. Benching must start near the crest of the hills, the rocks are progressively flattened out and mined downwards.

The Reserve Estimation:

It is recommended in this research to estimate the reserve of the limestone and Gypsum horizone in Fat'ha Formation which outcropped of the selected area to support the economic value of these deposits in Makhul Anticline.

The Limestone and Gypsum beds are considered to establish contineous strata beds, spreading on the whole area becouse it is deposited in the same geological basin which has a slightly varied thickness due to its depositional condition. Fig.(13), show the E-W and NE-SW cross-section of Makhul Anticline.

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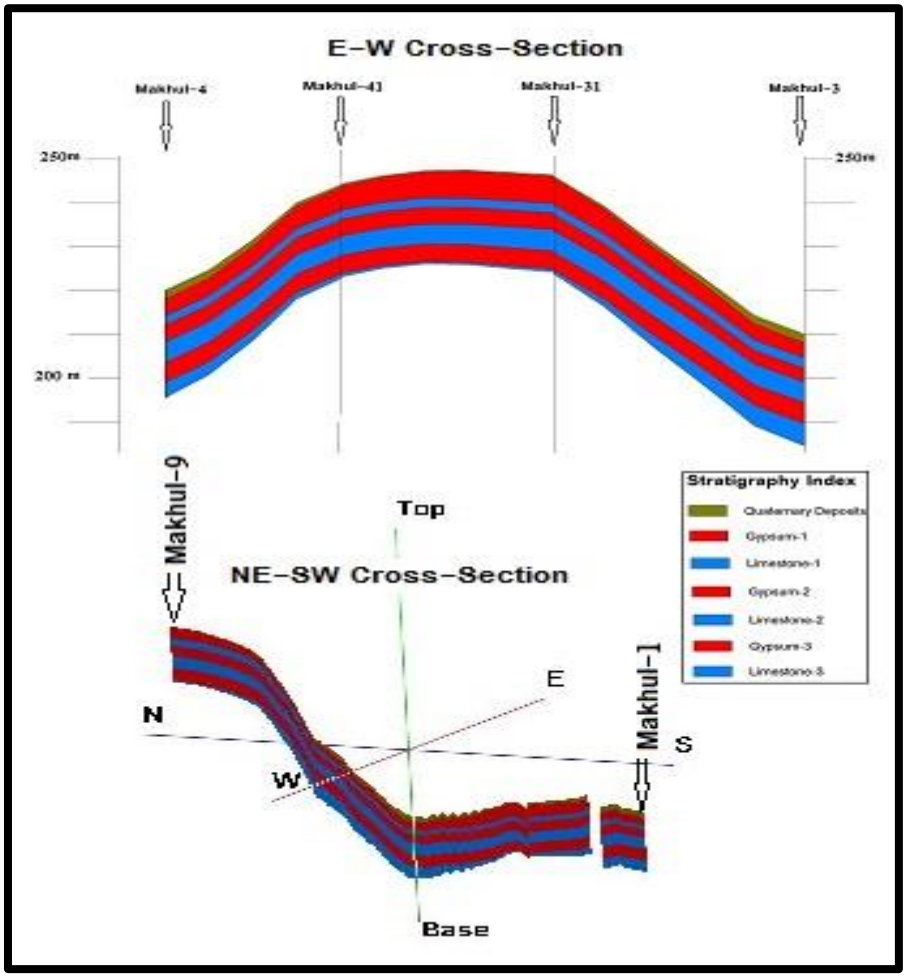

Fig.(13): Cross-Section of Makhul Anticline

In this research we use the Rockwork16 software package for computing the reserve of limestone and gypsum horizones shown in Fig.(14).

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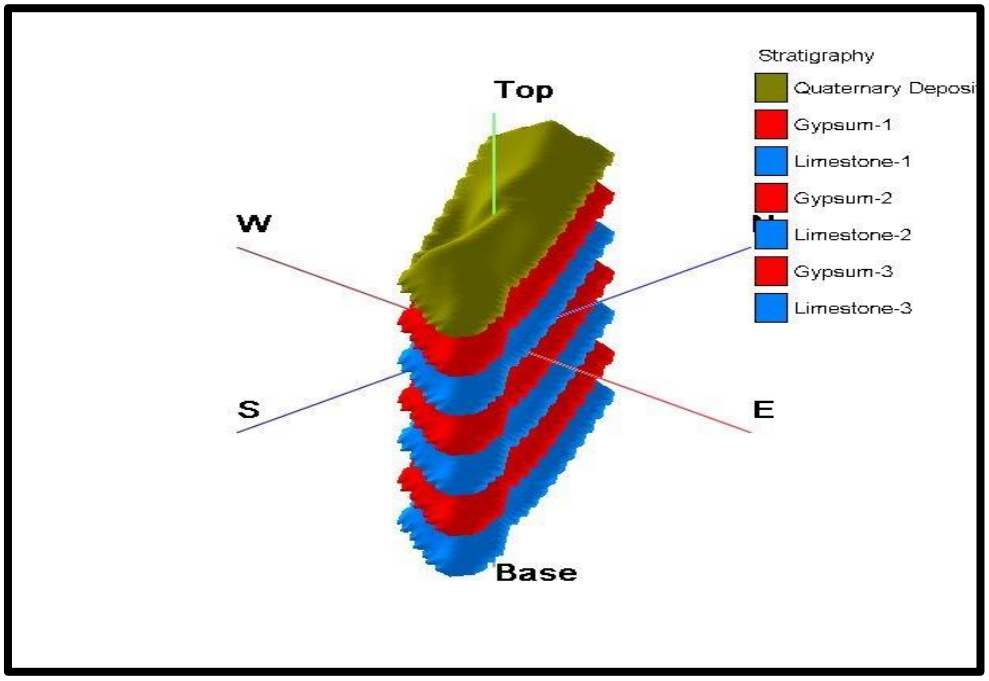

Fig.(14): 3D-Model of the Gypsum and Limestone Horizon in Makhul-Anticline

The RockWorks Utilities Volumetric/EZ Volume calculator is used to compute the volume of thickness for each limestone and gypsum horizons for a column of thickness value in the RockWorks Utilities datasheet, Table (٢). Volumes here in this research are computed using a triangulation method in which the samples are connected together in a network of triangles, a sample at each vertex Fig(15). The volume of each triangle is computed, based on the thickness used as Z-values, and then the total volume added up, and the the total volume are converted to mass in tonnes by multipling by the density value fo each horizon. This method is used because it provide lower estimation of total volume than other griding method based calculation. The calculations are shown in table (2). The Reserve estimation are as shown in Table (3).

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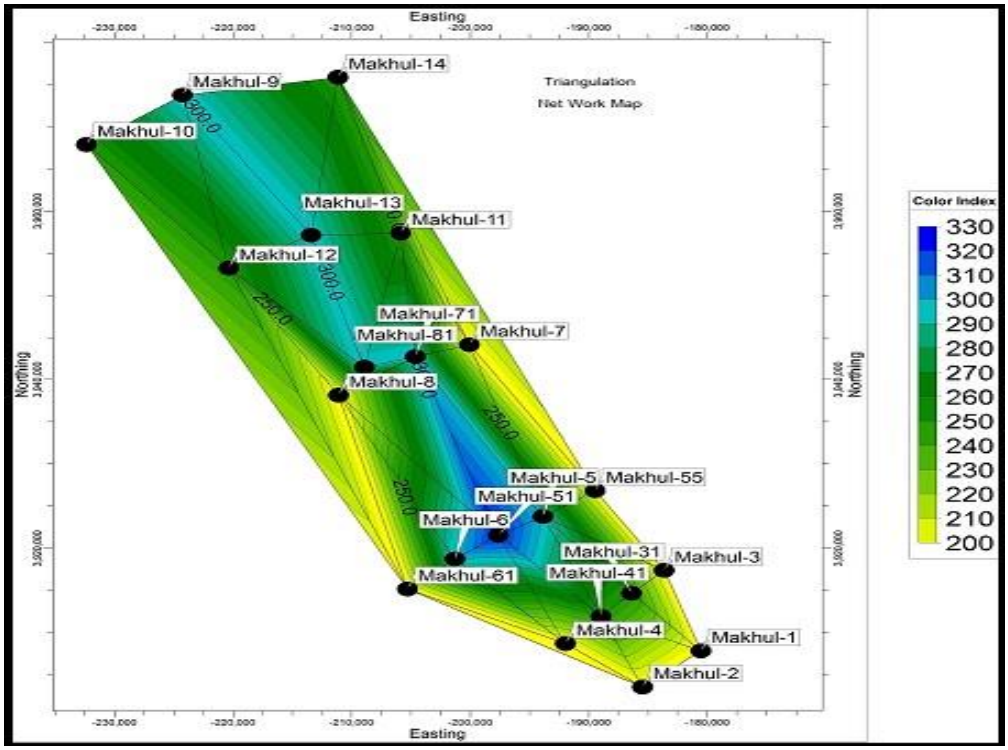

Fig.(15) The Triangulation method of reserve estimation

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Table(2) The datasheet of basic information of Limestone and Gypsum Horizons

Makhul-1	367055	3883257	200	25	3	2	1.5	3	4.5	5	6
Makhul-10	311993	3939717	250	29	1.5	2	1.5	5	5	6	8
Makhul-11	338929	3930911	250	24	1	2	2	3	4	5	7
Makhul-12	324783	3925918	250	25	1.5	2.5	2	3	5	5	6
Makhul-13	331440	3930217	300	21	0	4	3	5	4	6	0
Makhul-14	332550	3948940	250	25	2	1	3	3	5	5	6
Makhul-2	362426	3878704	200	27	4	2	2	3	5	5	6
Makhul-3	363395	3892556	200	27	3	3	2	4	5	5	5
Makhul-31	360837	3889695	250	20	0	6	2	4	4	4	0
Makhul-4	355659	3883431	200	26	2	3	2.5	3	4.5	5	6
Makhul-41	358445	3886816	250	22	0	7	2	4	5	4	0
Makhul-5	352860	3898268	300	17	0	5	1.5	3.5	4	3	0
Makhul-51	349259	3895840	325	20	0	6	2	4	4	4	0
Makhul-55	357048	3901583	200	26	3	2	1.5	3	4.5	6	6
Makhul-6	345812	3892838	300	17	0	5	1.5	3.5	4	3	0
Makhul-61	342050	3889051	200	28	4	3	2	2	5	5	7
Makhul-7	345487	3918135	200	27	3	3	1.5	3.5	5	5	6
Makhul-71	341045	3916459	300	20	0	4	3	4	5	4	0
Makhul-8	334892	3911524	200	27	3	3	1.5	3.5	5	5	6
Makhul-81	336854	3914950	300	22	0	5	2	4	5	6	0
Makhul-9	319675	3946032	300	22	0	5	3	4	5	5	0

Table(3) The Reserve estiamtion of Gypsum and Limestone rocks

Gypsum Reserve Estimation
Gypsum Horizon-1
Volumetric Report
Volume ..... 5,359,464,350.4 Cubic Meters

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Mass..... 11,790,821,570.789 Tonnes
Minimum Thickness ..... 1.0 Meters
Maximum Thickness ..... 7.0 Meters
Total Points Used For Calculation ... 21
Filtering Activated
Minimum User-Defined Thickness ... 0.0 Meters
Maximum User-Defined Thickness ... 10.0 Meters
Points Removed By Filter 0
Volumetric calculations performed by Delaunay Triangulation method
Mass calculated by multiplying volume by density factor (2,200.0 Kilograms Per Cubic Meter).
Gypsum Reserve Estimation
Gypsum Horizon-2
Volumetric Report:
Volume ..... 5,394,306,718.1 Cubic Meters
Mass..... 11,867,474,779.859 Tonnes
Minimum Thickness ..... 2.0 Meters
Maximum Thickness ..... 5.0 Meters
Total Points Used For Calculation ... 21
Filtering Activated:
Minimum User-Defined Thickness ... 0.0 Meters
Maximum User-Defined Thickness ... 10.0 Meters
Points Removed By Filter 0
Volumetric calculations performed by Delaunay Triangulation method.
Mass calculated by multiplying volume by density factor (2,200.0 Kilograms Per Cubic Meter).
Gypsum Reserve Estimation
Gypsum Horizon-3
Volumetric Report:
Volume ..... 7,275,227,897.9 Cubic Meters
Mass..... 16,005,501,375.421 Tonnes
Minimum Thickness ..... 3.0 Meters
Maximum Thickness ..... 6.0 Meters
Total Points Used For Calculation ... 21
Filtering Activated:
Minimum User-Defined Thickness ... 0.0 Meters
Maximum User-Defined Thickness ... 10.0 Meters
Points Removed By Filter 0
Volumetric calculations performed by Delaunay Triangulation method.
Mass calculated by multiplying volume by density factor (2,200.0 Kilograms Per Cubic Meter.(
Limestone Reserve Estimation
Limestone Horizon-1

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Volumetric Report:
Volume ..... 3,195,570,681.0 Cubic Meters
Mass..... 7,988,926,702.602 Tonnes
Minimum Thickness ..... 1.5 Meters
Maximum Thickness ..... 3.0 Meters
Total Points Used For Calculation ... 21
Filtering Activated:
Minimum User-Defined Thickness ... 0.0 Meters
Maximum User-Defined Thickness ... 10.0 Meters
Points Removed By Filter 0
Volumetric calculations performed by Delaunay Triangulation method.
Mass calculated by multiplying volume by density factor (2,500.0 Kilograms Per Cubic Meter).
Limestone Reserve Estimation
Limestone Horizon-2
Volumetric Report:
Volume ..... 6,971,961,754.2 Cubic Meters
Mass..... 17,429,904,385.475 Tonnes
Minimum Thickness ..... 4.0 Meters
Maximum Thickness ..... 5.0 Meters
Total Points Used For Calculation ... 21
Filtering Activated:
Minimum User-Defined Thickness ... 0.0 Meters
Maximum User-Defined Thickness ... 10.0 Meters
Points Removed By Filter 0
Volumetric calculations performed by Delaunay Triangulation method.
Mass calculated by multiplying volume by density factor (2,500.0 Kilograms Per Cubic Meter.(
Limestone Reserve Estimation
Limestone Horizon-3
Volumetric Report:
Volume ..... 5,170,400,752.0 Cubic Meters
Mass..... 12,926,001,880.038 Tonnes
Minimum Thickness ..... 0.0 Meters
Maximum Thickness ..... 8.0 Meters
Total Points Used For Calculation ... 21
Filtering Activated:
Minimum User-Defined Thickness ... 0.0 Meters
Maximum User-Defined Thickness ... 10.0 Meters
Points Removed By Filter 0
Volumetric calculations performed by Delaunay Triangulation method.
Mass calculated by multiplying volume by density factor (2,500.0 Kilograms Per Cubic Meter).

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Total Volume of Gypsum Horizons in Makhul Anticline = (18,028,998,966.4) Cubic Meter
Total Cross Mass of Gypsum Horizons in Makhul Anticline = (39,663,797,725.9) Tonnes
Risk Assessments and eroded area = 10% = (3,966,379,772.59) Tonnes
Total Net Mass of Gypsum Horizons in Makhul Anticline = (35,697,417,953.4) Tonnes
Total Volume of Limestone Horizons in Makhul Anticline = (15,337,933,187.2) Cubic Meter
Total Cross Mass of Limestone Horizons in Makhul Anticline = (38,344,832,968.0) Tonnes
Risk Assessments and eroded area = 10% = (3,834,483,296.8) Tonnes
Total Net Mass of Gypsum Horizons in Makhul Anticline = (34,510,349,671.2) Tonnes

Conclusion:

The conclusion gained from this study is that the entire variety of rock types is of high economic value which can be used for different civil industrial uses. The huge reserves of the all economic rocks make the operation and investment more profitable and economic, so should be exploited and make use of all the rock beds for different types Simultaneously so that the mining operation becomes commercial, productive and more valuable with to environmental concern.

Recommendation:

1) To exploit the limestone and Gypsum rocks we make use of the open pit multi-bench method on one side or the anticline flank simultaneously .

2) All the rocks, limestone, Gypsum, should be exploited at the same time , beginning from the top of the anticline , down to the earth surface, to make the mining operation profitable and easy.

3) No environmental concern during the mining operation, just the dust and noise which is easy to avoid and ignore.

4) The tailing waste must dumped and filled in the pits and dead end valleys which are scatered in the area of interest.

5) The most common environmental concern associated with open pit mine operations is the physical disturbances to the landscape at a mine site, by the actual mine workings, machinery, digging, haulage , etc. and the waste rocks disposal area. These impacts

remain on the landscape until the disturbed area is stabilized and reclaimed for other uses, such as wild life, habitate or recreation areas after mining has ceased.

6) The mining method used is cheap, active , safe and fast which makes the operation system commercial and valuable.

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