Mineral Resources in Jordan

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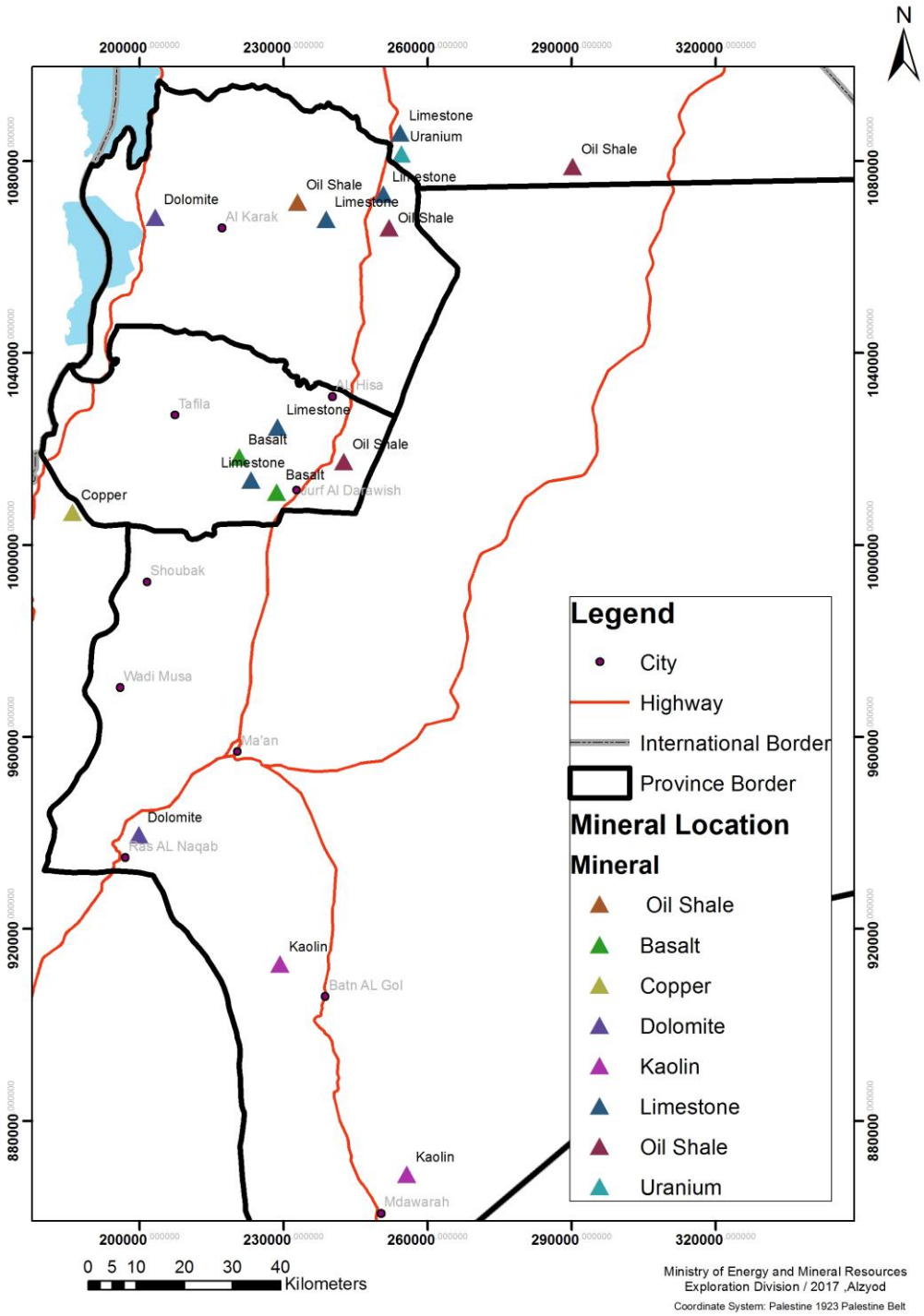
Preface

Mineral resources are necessary in maintaining today's modern life. Mineral wealth a natural asset can stimulate or enhance economic growth potential and social progress. It is expected that mining as an industry will continue to expand over the next 20 to 30 years to satisfy a continuously increasing demand from industrial production, agriculture and high technology sectors.

Jordan is considered rich in mineral resources; some of them were exploited, exported and also consumed in the domestic manufacture of fertilizers such as phosphate and potash. Meanwhile, limestone also exploited and exported. The other mineral resources, such as silica sand, feldspar and kaolin ….etc. were still not exploited in a large scale.

Based on a review of all available studies of mineral exploration studies in Jordan, the following brief describes the known mineral deposits, and their economic potential; the nature of mineral, its immediate geological environment, and its industrial uses along with pertinent specifications for each application and the geological setting and a brief synopsis of the principal known occurrences in Jordan.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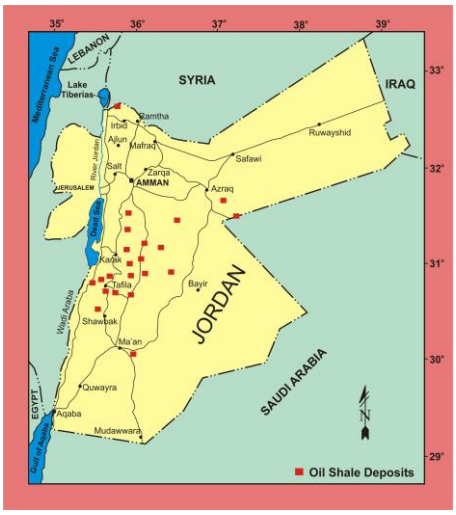
Oil Shale



Introduction

Oil Shale refers to sedimentary rocks mostly carbonates to chalk marl and shale contains immature organic matter that when it is heated to above 500°C, it produces oil and gas.

The Jordanian oil shale is naturally bituminous marls of varying shade of brown, grey or black. The investigation of the potential of bituminous rocks, as a possible source for producing oil by retorting or for generating electricity by direct combustion is of first priority for Jordan.

Geological Setting

Oil shale deposits mostly occur within the lower part of Muwaqqar Chalk Marl Formation (Maastrichtian-Palaeocene). The formation consists of limestone, marls, chalk and phosphates.

Location

There are more than 18 known surfaces and near surface deposits. Eight of which Lajjun, Sultani, Jurf Ed-Darawish, Attarat Umm Ghudran, Wadi Maghar, Siwaqa, Khan El-Zabib and Eth-Thamad areas were investigated at different levels. The major deposits of commercial scale interest are located south of Amman in central Jordan and are easily accessible via Amman and Aqaba Desert Highway.

Area	Location
El-Lajjun	100 km south of Amman
Sultani	115 km south of Amman
Jurf Ed-Darawish	145 km south of Amman
Attarat Umm Ghudran	35 km northeast of Qatrana
Wadi Maghar	40 km east of Qatrana
Eth-Thamad	45 km south of Amman

Reserves

Area	Lajjun	Sultani	Jurf Ed-Darawish	Attarat Umm Ghudran	Wadi Maghar
Area (km^2)	25	19.23	114.5	340	625
Oil shale thickness (m)	1-87	2-65	18-157	21-104	13-108
Overburden thickness (m)	7-78	34-90	33-58	36-150	33-70
Geological reserves (mt)	1200	1180	8000	23100	40800
Indicated reserve (mt)	1170	989	2500	10400	21600

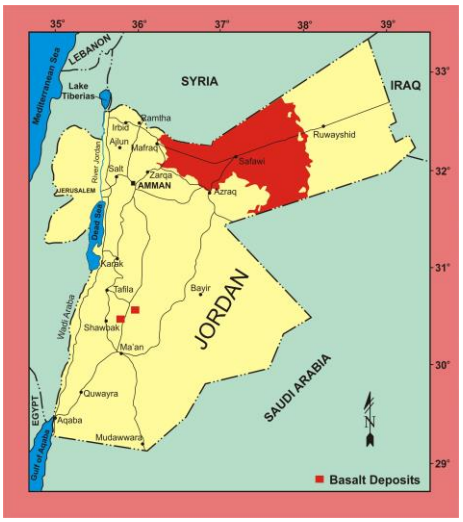
Chemical and Physical Properties

Area	Lajjun	Sultani	Jurf Ed-Darawish	Attarat Umm Ghudran	Wadi Maghar
Av. oil content (wt %)	10.5	9.4	7.8	8.79	7.8
Total organic matter (wt %)	22.1	21.5	18	--	--
Calorific value (kcal/kg)	1590	1210	864	--	--
$CaCO_3$ (wt %)	54.3	46.96	69.11	--	--
SO_3 (wt %)	0.27-4.3	2.6-5.5	3.2-6.5	0.6-2.7	1.2-3.2
Bulk density (g/cm^3)	1.81-2.1	1.8-1.9	1.87-1.99	1.5-1.89	1.34-1.9
Moisture (wt %)	2.43	2.6	2.8	--	--

Investment Opportunities

Oil shale is not exploited so far in Jordan. Investment in oil shale is open on the basis of Production Share Agreement (PSA) and/or any agreement that could be agreed with NRA. Qualified companies in this industry are invited to study, test and analyze samples. All the technical data and support regarding oil shale could be provided. Memorandum of Understanding (MOU) and/ or Concession Agreements are based on negotiations with NRA.

Basalt



Introduction

Basalt in Jordan is part of the North Arabian Basaltic Plateau and covers an area of about 11,000 km^2 in the northeast of Jordan and extends northwest into Syria and southeast into Saudi Arabia. Meanwhile, a group of small continental volcanic rocks are present in Central Jordan. Basalt can be used in many industrial applications such as: rock wool, Pipes, moulds, and as construction materials.

Geological Setting

They were at least two phases of extensive basaltic activity in central Jordan during Neogene to Quaternary. The oldest basaltic flow crops out north of Al Hashimya where it is partly covered by Pleistocene sediments. The youngest flow covered Wadi gravels north and northwest of Jurf Ed-Darawish village. The basaltic flows form aboard plateau area and comprise mostly massive and blocky lava in the study area. Volcaniclastic deposits are up to 15 m thick and exposed in the eastern part of Jabal Uneiza area.

Location

Basalt occurs in different localities in central Jordan, but the most important locations are Tell Burma and Jabal Uneiza, about 170 km south of Amman within Jurf Ed Darawish map sheet area.

Reserve

The proven reserves are calculated from data obtained from boreholes in Tell Burma and estimated about 310 mt.

Mineralogical Properties

X-ray analysis indicates a major content of Augite and Feldspar. Heamatite, calcite and zeolite occur as a minor quantity. The petrographical analysis indicates the presence of following:-

- Olivine: occurs as a major mineral
- Feldspar: occurs as plagioclase
- Pyroxene: Occurs as clinopyroxene
- Calcite and Zeolite: occurs as a secondary minerals

Chemical Properties

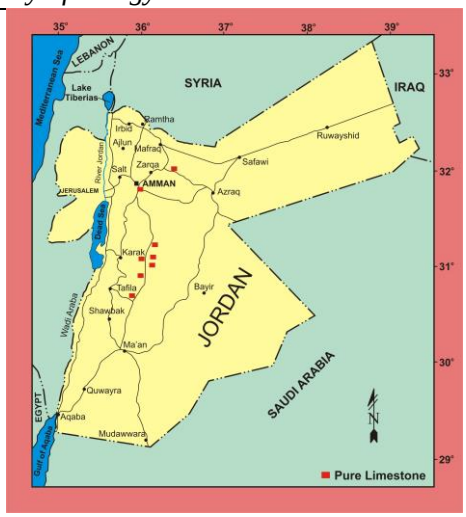
Chemical analysis indicates the following:

Fe_2O_3 %	13.2 – 14.3
MnO %	0.19 – 0.22
TiO_2 %	2.8 – 3.3
CaO%	9.9 – 11.8
K_2O%	0.53 – 1.3
SiO_2%	40 – 43
Na_2O%	0.62 – 2.5
Al_2O_3%	11.8 – 12.7
P_2O_5%	0.57 – 0.65
MgO%	9.8 – 9.15

Investment Opportunities

The basaltic rocks are open for investment and mining. Exploration companies are invited on the basis of detailed exploration, evaluation and exploitation.

Pure Limestone



Introduction

Pure limestone is among the most important non-metallic raw material used for industrial and agricultural purposes. It should have the following criteria:

$CaCO_3$ > 93%, SiO_2 < 3%, MgO < 1.2% (and higher for certain products), Fe_2O_3 < 1.5 (and lower for certain products), S, P_2O_5 and alkaline salts as low as possible.

Pure limestone can be used:

- In the metallurgical industry as a fluxing agent for the smelting and refining of iron, aluminum and copper.
- In the chemical industry in the production of lime, calcium carbonate, alkali compounds, calcium carbide, magnesium oxides and soda ash.
- In industries of white cement, iron and steel, glass, paper, sugar-refining, water purification, sewage and waste treatment, and gas desulphurisation, and
- Agricultural uses in soil conditioning, fertilizers and animal feeds.
- As filler material in paints, rubber, paper, ceramics, floor tiles, tooth paste, medicine.

Geological Setting

Pure limestone exposures can be found within of the Upper Cretaceous Bahiya Coquina Member of Al Hisa Phosphorite Formation (Campanian-early Maastrichtian). Bahiya Member is up to 40m thick.

Location and Reserve

Area	Location	Reserve (mt)	Cut-off grade (CaO %)
Qatrana	85 km south of Amman	31.5	> 54.3
Sultani	100 km south of Amman	460	> 52.2
Al Hasa	140 km south of Amman	69	> 54.19
El-Hallabat	75 km northeast Amman	286	> 52.56
Jurf Ed Darawish	150 km south of Amman	90	> 53.0
Al Abiad	120 km south of Amman	11	> 53.5
Siwaqa-Damekhi	70 km south of Amman	388	> 53.3

Chemical and physical properties

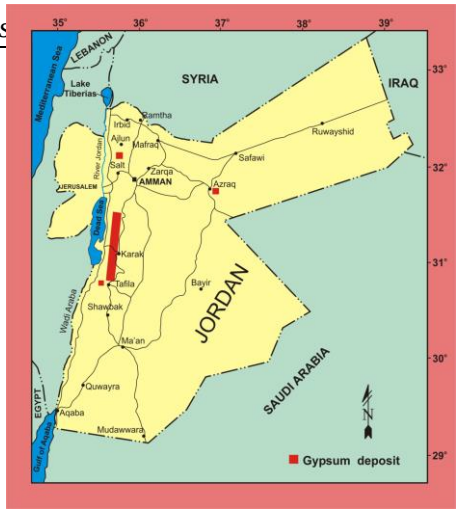
Area	CaO%	Fe_2O_3%	MgO%	Al_2O_3%	SiO_2%	Whiteness%
Qatrana	50.86-54.26	0.09-1.14	0.15-2.08	0.02-0.6	1.5-3.8	75.91-95.68
El-Hallabat	53.0 -53.6	0.18-0.45	0.31-0.76	0.01-0.48	1.7-1.86	----
Al-Hasa	48.16-54.87	0.02-0.52	2.72-0.2	0.13-0.98	0.02-9.94	75.62-97.4
Siwaqa-Damekhi	47.56-53.95	0.1-0.48	0.10-0.51	0.1-0.96	1.5-3.23	82.10-90.3
Sultani	52.56-54.07	0.2-0.34	----	----	0.34-4.0	93.7-95.5
Al Abiad	51.19-53.77	0.08-0.41	0.14-0.21	0.12-1.06	1.27-4.75	64.0-87.8
Jurf Ed Darawish	42.32-53.66	0.11-0.25	0.23-3.52	0.12-0.59	1.67-5.89	70.7-85.9

Investment Opportunities

Currently, pure limestone is being mined, produced and exploited for the use of white cement and calcium carbonate industries.

- Investment is open in pure limestone in different localities in Jordan to produce calcium carbonate and in white cement industry.
- Pure limestone in El-Hallabat area is currently extracted by a Jordanian-Syrian Company for white cement production.

Gypsum



Introduction

Gypsum is one of the non-metallic minerals, composed mainly of hydrated calcium sulfate. It is usually formed by precipitation of $CaSO_4.2H_2O$ due to evaporation of solution with high content of SO_4^{-2} and Ca^{+2} ions. Gypsum occurs associated with varying amount of carbonates, clays and other impurities. Naturally it can be found at many forms such as: selenite, satin spar (fibrous), gypsite and massive gypsum. Gypsum is used mainly for cement industry, building construction, chemical, medical and industries and ceramics.

Location and Geological Setting

Area	Formation (s)	Age
Azraq	Azraq	Quaternary
River Zarqa (Wadi Azab)	Abu Ruweis	Triassic
Central/ Southern Jordan	Fuhays, Hummar, Shu'ayb, Wadi As Sir	Cretaceous (Cenomanian-Turonian)
Wadi Al-Dahel	Shu'ayb	
Jabal Bani-Hamida	Shu'ayb	

Reserves

Area	Geological Reserves (mt)	Gypsum Thickness (m)
Azraq	3	0.25-0.5
River Zarqa (Wadi Azab)	10	60
Central/ Southern Jordan	8	0.2-4
Wadi Al-Dahel	0.284	0.5 -3.9
Jabal Bani-Hamida	Not estimated	0.8-1.2

Chemical Properties

Area	SO_3%	CaO %
Azraq	42-45	32-35
River Zarqa (Wadi Azab)	40-47	31-34
Central and southern Jordan	37-46	25-35
Wadi Al-Dahel	36-52	29-39
Jabal Bani-Hamida	45-60	32-36

Investment Opportunities

The Public Mining Company is currently mining gypsum from River Zarqa (Wadi Azab), Malih and Burbaita (south Jordan) areas for cement industry and the private sector in Jordan. An Arabian company has been established in Jordan to manufacture gypsum products. Due to high demand in the Arab countries and international markets for a quality plaster, the production of this material is highly required.

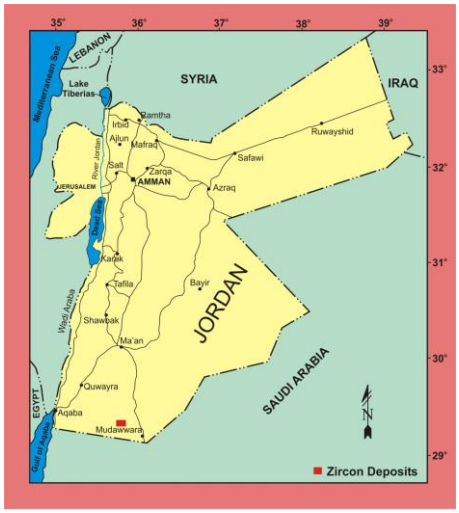
Naturally occurring (non-calcinated) gypsum is being used for the following:

1. Cement industry.
2. Fertilizer.
3. Increasing the permeability of soil.
4. Carrier for insecticides due to its high ability for absorption.
5. Filler material in wood, texture, papers and paint industry.
6. Remove the sulfur from the chimney.
7. Mud oil well drilling.

On the other hand, the calcinated gypsum is used for:

1. Building decoration (wall bound, sheet rock and dry wall construction).
2. Medical and pharmacological industries.
3. Ceramic industries and molds.

Zircon and REE



Introduction

Zircon mineral consists of zirconium silicate ($ZrSiO_4$) and Hafnium in addition to some rare earth elements usually heavy minerals associated with zircon as titanium minerals (Rutile, Ilmenite) monazite and others.

Zircon has a high temperature resistance (melting point of 2500^{o}C), acid corrosion resistance, high heat conductivity and low thermal expansion.

Zircon is used chiefly for facing on foundry moulds to increase the resistance against metal penetration. Milled zircon is used in refractory paint for coating the outside of moulds. It is also used in manufacturing fused cast and in tooth pastes.

Geological Setting

Zircon occurs in the middle member of Dubaydib Sandstone Formation (DB2) of Middle Ordovician age. This member consists of very fine-grained sandstone, brown to dark brown in color. The thickness of the bed bearing zircon ranges from 1.5-4.2m.

Location

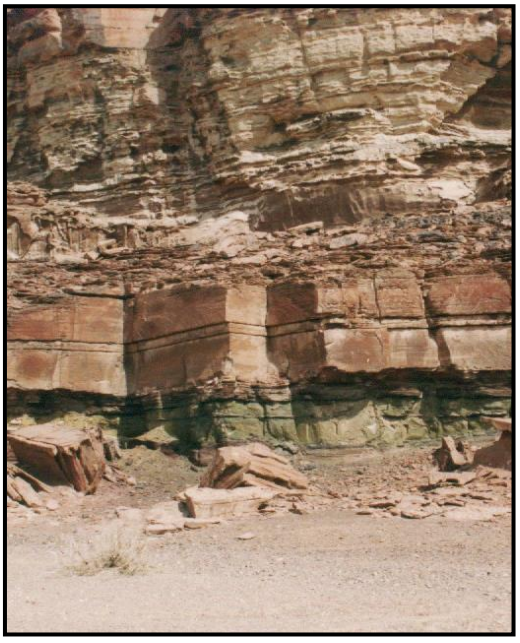
The area is located about 350 km south of Amman and 100 km east-northeast of Aqaba.

Reserves

The estimated reserve in one locality (Wadi Al-Mezrab) area is about 96000 metric tons.

Chemical Properties

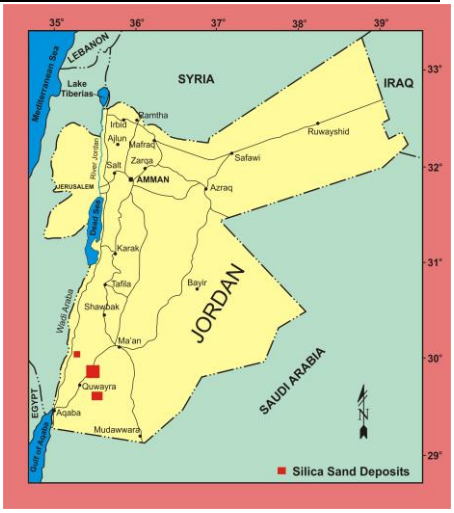
Mineral	Composition	Grade
Zircon	ZrSiO4	0.67-3.75%
Cerilium	Ce	499-2168ppm
Lanthanum	La	224-1065pmm
Titanium	TiO2	1.61-4.91%



Mineralogical Properties

Quartz mineral is the main constituent of the zircon bearing bed, with the presence of small amounts of feldspar, and heavy minerals (zircon, rutile, brookite, epidote and monazite) are present.

Silica Sand



Silica sand is defined as a high purity industrial mineral in which the sand grains are made entirely of quartz. Impurities are very minor and commonly are clay minerals (kaolinite, illite), titaniferous minerals, iron oxides and heavy minerals. The term silica sand is applied to quartz sand that conforms to the specifications of which the main composition is SiO_2 >99%, with very little contaminant contents and heavy minerals of <0.1%.

Location

White silica sand deposits are found exposed on the surface of early Ordovician and Lower Cretaceous sandstone in south Jordan. Deposits are found in the following locations: -

Area	Location	Stratigraphy
Ras En Naqb	70 km northeast of Aqaba	Ordovician sandstone
Qa' Ad Disa	50 km NE of Aqaba	
Ein El Bayda	North of Petra city	
Wadi Es Siq-Wadi Rakiya area	65 km north of Aqaba	Cretaceous sandstone
Al Jayoshia	6 km east-southeast of Aqaba	

Chemical Properties

Major Oxides	Raw %		Wet sieved (%)		Scrubbed for (%)		§ Grade-A, Glass sand *(BS: 2975, 1988)*
					8 minutes	6 minutes	
	Ras En Naqb	W. Es Siq	Ras En Naqb	W. Es Siq	Ras En Naqb	W. Es Siq	
SiO_2	98.7	95.23	99.41	99.36	99.62	99.65	99.70
Al_2O_3	0.52	2.57	0.16	0.22	0.04	0.04	0.20
Fe_2O_3	0.04	0.04	0.03	0.03	0.01	0.01	0.01-0.013
TiO_2	0.09	0.09	0.04	0.04	0.02	0.02	0.02 (*)
CaO+MgO	0.08	0.22	0.02	0.12	0.01	0.01	0.02 (*)
Na_2O+K_2O	0.11	0.17	0.09	0.09	0.02	0.02	0.02 (*)

* Sibelco Company Grade § Grade (A) stands for optical and ophthalmic glass

Area	SiO_2%		Al_2O_3%		Fe_2O_3%		TiO_2%	
	raw	refined	raw	refined	Raw	refined	raw	Refined
Qa' Disi	96.59 -	98.36 -	1.43 -	0.24 -	0.025 -	0.019 -	0.13 -	0.04 -
Jayoshia	95.21 -	98.93 -	2.97 -	0.32 -	0.028 -	0.013 -	0.14 -	0.04 -

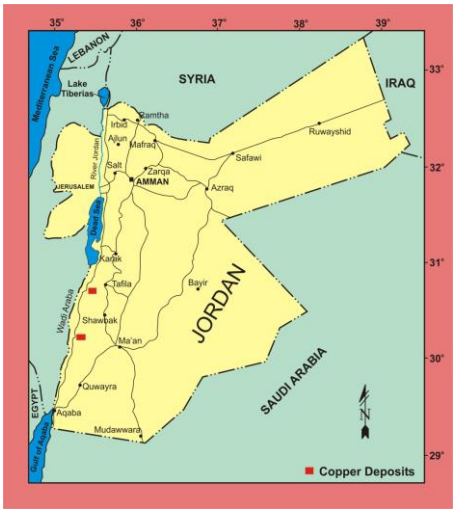
Reserves

Area	Geological Reserves (mt)
Ras En Naqb	>10000
Qa`a Disi	Billions of tones
Wadi Es Siq-Wadi Rakiya	120
Al Jayoshia	Not determined

Investment Opportunities

The easy accessibility, low content of impurities and low content of heavy minerals are advantages for exploitation of silica sand in Jordan. Currently, no glass production in Jordan and only two companies are producing processed silica flour. Deposits are open for investment on the basis of mineral agreement.

Copper



Introduction

The first discovery of copper mineralization in Jordan was in the Fifties of the 20th century in Wadi Dana/ Wadi Araba area. In ancient times, there were many mining activities for extracting copper as indicated by the slags and old mines in Khirbet El-Nahas, Wadi Jaryia and other localities.

Geological Setting

Copper mineralization occurs within the Palaeozoic Cambrian sediments in two formations; Abu-Khushayba sandstone and Burj dolomite Shale formations). Copper mineralization is located, in areas that extend approximately 70 km in length and 15 km wide, along the eastern side of Wadi Araba from the southern end of the Dead Sea to Wadi Abu-Khushayba area. opper minerals are malchite, chrysocolla, atacamite, cuprite, blancheite and others, which are mostly oxides and silicates.

The mineralized areas are characterized by rugged, high and steep topography, up to 1000 m (a.s.l), and traversed by deeply incised valleys with their drainage lines mainly following the fault patterns westward, towards the Rift Valley.

Location and Properties

Khirbet El-Nahas-Jaryia area

The area is located in the northern part of Feinan area and the copper mineralization in both formations covers an area of about 61 km^2. The mineralized shale is 2 m thick and the average copper content is 2.3 %. In addition, another 1 m of mineralized dolomite bed is located directly beneath the mineralized shale with an average copper content of 2 %. Within the area, Jabal Marzuka-Jaryia area, which covers an area of 8-10 km^2, is more promising for future exploration and evaluation.

Feinan area (Wadi Khalid, Dana and Ratyia)

The area is located in the central part of Wadi Araba. The copper mineralization in Feinan area is present in the two formations. An average copper content is 1.37 % in the mineralized zone with an average thickness of 2.06 m.

Abu Khushayba area

The area is located in the southern part of Wadi Araba. The copper mineralization exists in the Abu-Khushayba sandstone formation. The thickness of the mineralization zone is 1–3 m with 0.65% copper content.

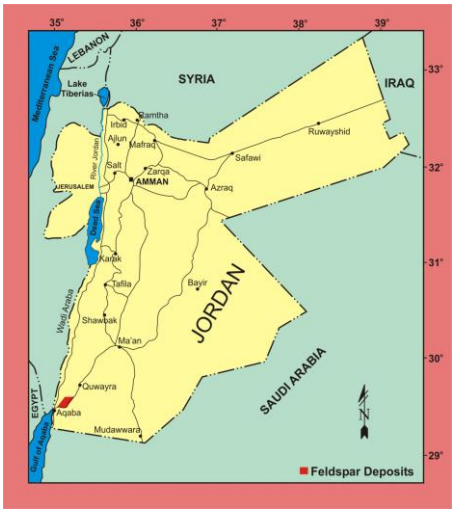
Reserves

Area	Reserves (mt)
Khirbet El-Nahas – Wadi Jaryia	Not determined
Feinan	19.8 (proved)
Abu-Khushayba	8 (proved)

Investment Opportunities

Mining/exploration companies are invited for investment by their own or can joint ventures with Jordanian companies for copper exploration in Wadi Araba. The mineral is open for investment.

Feldspar



Introduction

Feldspar is the most important single group of rock forming silicate minerals. There are four chemically district groups of feldspar; potassium feldspar ($KAlSi_3O_3$), sodium feldspar ($NaAlSi_3O_8$), calcium feldspar ($CaAlSi_3O_8$) and barium feldspar ($BaAl2Si_3O_8$). About 90% of produced feldspar is used for glass and ceramic industries. Soda feldspar is preferred in glass manufacture, but potash feldspar is more popular for ceramics.

Geological Setting

Igneous rocks, which form part of the feldspar ore body, are part of the Yutum Granite Suite from the Aqaba complex. The age of these rocks range from approximately 630–600 Ma. The source of the feldspar is the granitoides of Abu Jadda granite and/or Imran Monozogranite units.

Area	Location	Reserve (mt)
Wadi Al Jayoshia	6 km south of Aqaba	115
Wadi Al-Mahlabah	5 km north east of Aqaba	0.4
Jabal Al-Gufran	18 km NE Aqaba along Aqaba-Maan Highway	0.6
Wadi Sader Mulgan	25km north of Aqaba and 8km to the west	22

Location and Reserve Estimation

Chemical Properties

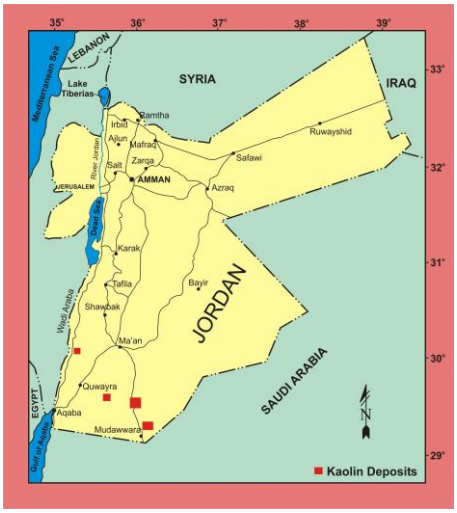
Chemical analysis for feldspar in south Jordan (%).

Area	SiO_2 %	CaO %	MgO %	Fe_2O_3 %	Al_2O_3 %	TiO_2 %	**Na_2O** %	**K_2O** %	MnO %
Wadi Al Jayoshia	71.46	1.05	0.35	1.02	13.98	0.88	5.53	4.29	0.02
Ain Al-Hasheem	70.37	1.29	0.52	2.21	14.95	0.37	2.02	6.27	0.37
Wadi Sader Mulgan	72.99	0.61	0.07	0.65	14.29		4.13	5.64	0.02

Investment Opportunities

The mineral is open for investment and mining/exploration companies are invited on the basis of detailed exploration, evaluation and exploitation.

Kaolin



Introduction

Kaolin is white, soft, plastic clay mainly composed of the fine-grained platy mineral kaolinite; a white hydrous aluminum silicate, $Al_2Si_2O_5$ $(OH)_4$, containing 23.5% alumina, 46.5% silica, and 14% water.

It is used in the manufacturing of white-ware ceramics and in filling and coating of paper. It is also used as filler in paints, rubber, plastics and many other productions.

Geological Setting

Kaolin deposits are exposed in four main localities in south Jordan; Batn El-Ghul, Al Mudawwara, Al-Hiswa and Umm Sahm areas. Both Batn El-Ghul and Hiswa have been exploited in few quantities. Kaolin is still not exploited in Mudawwara and Umm Sahm areas. The four deposits are of Ordovician age. Locally, both Batn El-Ghul and Al-Mudawwara deposits belong to Batra Mudstone Member of Mudawwara Formation and Al-Hiswa deposit belongs to Al-Hiswa Sandstone Formation.

Location and Reserve

Area	Location	Reserve (mt)
Batn El-Ghul	70km SE of Ma'an about 280 km south of Amman	1100
Al Mudawwara	120 km SE of Ma'an, about 10 km east of Al-Mudawwara police station	9700
Al Hiswa	45 km east of Al-Quwayra town, close to Al-Hiswa railway station	54
Um Sahm	40 km southeast of Ad Disa town	1090

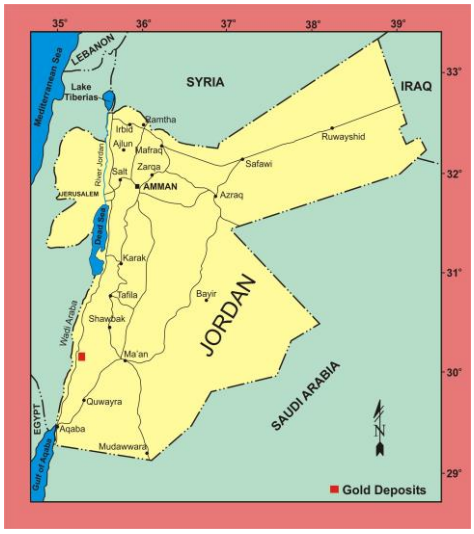
Chemical properties

Area	Al_2O_3 %		SiO_2 %		Fe_2O_3 %	
	max.	min.	max.	min.	max.	min.
Batn El Ghul	25.37	14.01	68.32	47.79	8.37	4.05
Al-Mudawwara	27.54	13.36	70.20	41.87	10.54	4.54
Al-Hiswa	29.27	12.94	78.88	49.04	9.09	1.15
Dubaydib/Um Sahm	24.70	17.0	61.97	49.04	11.04	3.5

Investment Opportunities

- Investment is open in areas, which have huge reserves of kaolin as Batn El Ghul, Mudawwara and Dubaydib/Umm Sahm areas.
- Jordan is one of the less well-known ceramics manufacturing bases in the Middle East. However, the kaolin producers have enhanced their position on the global stage due to a steadily expanding domestic market and a program of product improvement.
- Cement industry is one of the most important factors in the Jordanian mining sector. Thus, it depends solely on the domestic natural minerals as raw materials such as kaolin. There is a rapid growth in local cement market due to the increase of construction industry in Jordan and neighboring countries.

Gold



Introduction

Recent geochemical prospecting in Jordan by the Natural Resources Authority (NRA) detected anomalous gold values over the northern extremity of the Arabian-Nubian Shield in South Jordan. The best anomaly, sited over felsic volcanic rocks in Wadi Abu Khushayba area, returned gold values up to 40g/t in heavy mineral concentrations collected from stream sediments. Visible gold was observed in heavy mineral concentration.

Geological Setting

The Araba Complex is dominated by the Ahaymir Volcanics Suite, which has been identified as the main exploration target in the Pan African Jordanian basement for precious metals. The suite trends north-northeast and crops out in a belt of 2 to 4km wide over some 70km long. The Ahaymir Suite is dominated by alkaline, effusive and extrusive quartz and feldspar-quartz porphyries with subordinate andesite. Volcanic activity is considered to have ceased by 540 Ma.

Location and Properties

- Wadi Abu Khushayba area

Wadi Abu Khushayba area is situated 90 km north-northeast of Aqaba in South Jordan. The prospect located some 4 km east of the Dead Sea-Aqaba highway in Wadi Abu Kushayba of Wadi Araba area. The area is accessible using 4-wheel drive vehicles.

Abu Khushayba gold occurrence is sited within quartz porphyry and quartz feldspar porphyry volcanic rocks of the Ahaymir Volcanic Suites of Wadi Araba Complex. The gold mineralization is hosted in an intensely silicified linear zone up to 1m in width. Hydrothermal breccias are commonly developed in the marginal zone in which recognizable rhyolite fragments are encased in siliceous matrix. The gold rock is being identified as epithermal precious metal deposition and hosted by aplite granite with felsic composition vein. As a result, visible gold was detected in a number of the heavy mineral concentrates up to 40g/t. Values up to 15g/t of gold were obtained from the vein and the highly silicified weathered rock in alteration zones.

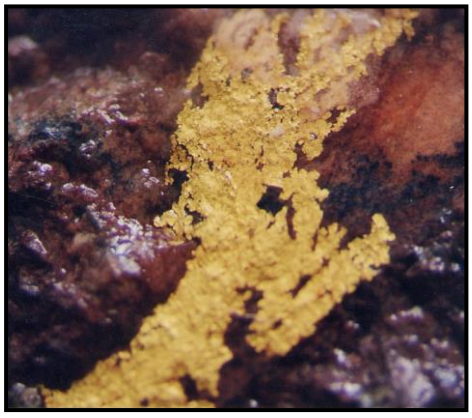
Integrated exploration program over Abu Khushayba gold occurrence have been implemented, geologic map at scaled 1:10000, geochemical, geophysical survey and remote sensing set up.

- Wadi El Huwar and Wadi Sabra areas

The two areas are located south and southeast of Abu Khushayba occurrence. Semi-detailed geochemical exploration was carried in Wadi El Huwar and Wadi Sabra. The two areas were characterized by relatively high gold anomalies.

Reserves

Reserves are not yet determined. Further works is still required in Wadi Abu Khushayba prospect area to ascertain the true surface extent of the gold anomalies and the distribution of gold in width and depth.

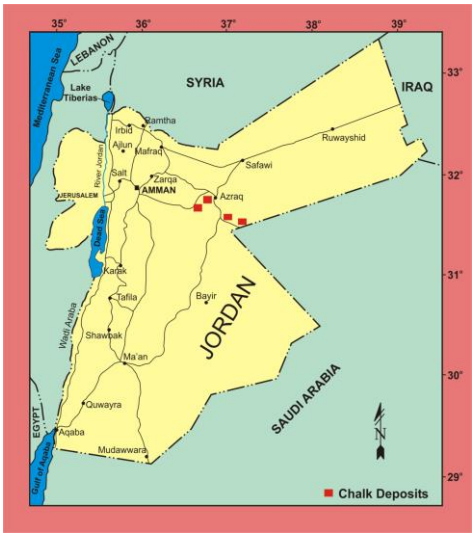


Investment Opportunities

The mineral is open for investment and mining/exploration companies are invited on the basis of detailed exploration, evaluation and exploitation.

Memorandum of Understanding (MOU) and/ or concessions are based on negotiation with NRA under a Mineral Concession Agreement standard or Production Sharing Agreement (PSA).

Chalk



Introduction

Chalk is a fine-grained white limestone or micrite. On average, it consists of 97.5 – 98.5% calcium carbonate. Clay and quartz are the most common impurities. Most chalk is soft friable rock that does not required explosives.

Chalk, typically consists of smooth, rounded weakly bonded coccolith structures that consist of minute individual calcite crystals in the order of 1 micron in size. Chalk as a form of carbonate rocks containing high calcium carbonate can be used in many industrial applications such as paint, cement, agriculture etc.

Geological Setting

Chalk occurs in rocks at different stratigraphic levels and can be found throughout Jordan within the Muwaqqer Chalk Marl Formation (Maastrichtian-Palaeocene) and Wadi Shallala Chalk Formation (Eocene). Wadi Shallala Formation is considered the most important resource of chalk due to the high thickness of chalk and broad distribution.

Locations and Reserves

Area	Location	Reserve (mt)
Al-Umary-Dahikiya	45 km southeast of Al Azraq	1325
Wadi Al-Ghadaf	35 km south of A Azraq	161
Qasr Al-Harrana	50 km east of Amman	976
Wadi Al-Dabi	60 km east of Amman	3364

Chemical and Physical Properties

Important chemical and physical properties of chalk.

Area	CaO %	Brightness %
Al-Umary-Dahikiya	38.9 - 49.6	74.8 - 81.7
Wadi Al-Ghadaf	43.6 - 52.6	79.5 - 81.4
Qasr Al-Harrana	47.9 - 52.6	76.6 - 83.5
Wadi Al-Dabi	51.59 - 53.15	76.6 - 85

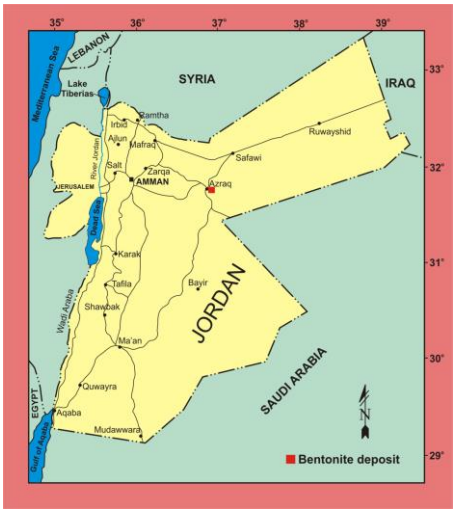
Mineralogical Properties

Calcite is the main mineral; other trace minerals are kaolinite, dolomite, quartz and halite.

Investment Opportunities

The mineral is open for investment and mining / exploration companies are invited on the basis of detailed exploration, evaluation and exploitation.

Bentonite



Introduction

Bentonite is a commercial term for a special type of clay composed essentially of crystalline smectite minerals commonly dominated by montmorillonite. It is formed from alteration of glassy igneous material either tuff or volcanic ash and deposited in shallow water lakes in the Plio-Pleistocene time. Chemically, it is a hydrous aluminium silicates with magnesium and iron that partially substitute (Al) in the structure. Alkalis or alkaline earth elements are also present as essential constituents.

Location and Access

Bentonite deposit occurs in two separate areas; Q'a Al Azraq and Ein Al Bayda that are approximately 120 km northeast of Amman. Q'a Al Azraq represents a closed basin and covers about 150 km^2. Both areas have low relief about 510m above sea level. Smectite,mixed layer illite/smectite and kaolinite forming the major constituents of clay minerals, whereas quartz, feldspar and calcite are present as impurities. The investigated area is crossed by many tracks that can be easily crossed by 4-wheel vehicles in normal weather. In winter, floods and intermittent flows render most of the central part of the study area inaccessible.

- **Reserves**

  Ein al Bayda area: 105 million ton. Q'a Al Azraq: not determined

- **Chemical Properties**

  Chemical comparison between Jordanian bentonite and Wyoming bentonite (%)

Sample/Location	**Na_2O** %	**MgO** %	**Al_2O_3 %**	**SiO_2 %**	**K_2O %**	**CaO** %	**TiO_2 %**	**Fe_2O_3** %
Bentonite/Azraq	0.13	3.47	20.08	55.67	2.45	2.15	2.54	13.47
Bentonite (Wyoming)/ USA	**ND**	1.92	22.84	66.11	0.56	1.32	0.55	6.51

- **Physical Properties**

Specific gravity	2.49-2.72
Specific surface area M^2/g	370-487
CEC Meql100g	53-83
Oil absorption% by wt	73-87
Water absorption% by wt	115-207
Attrition resistance%	80-95
Adsorption of water vapor	17-Jun
Bleaching capacity of edible oil	81-99

Particle Size Distribution

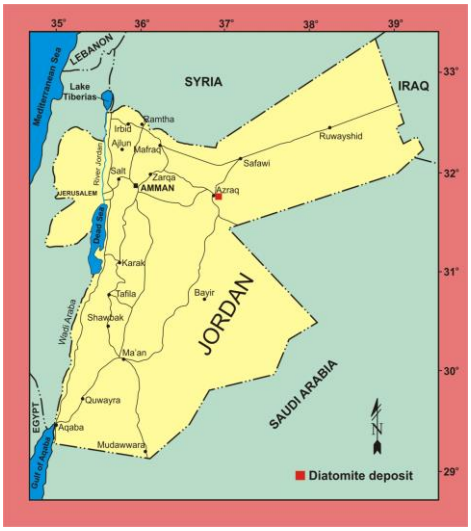
Grain size	**Wt %**
+ 1000 µ	0.13 - 0.41
1000-63µ	2.71 - 4.93
63-2 µ	42.14 - 44.77
- 2 µ	49.89 - 55.02

- **Investment Opportunities**

Bentonite deposits are open for investment mining and exploration companies are invited on the basis of detailed exploration, evaluation and exploitation. Based on the physical and chemical properties the bentonite can be used in the following industries:

- Bleaching of edible oil.
- Oil absorption.
- Odour and liquid absorbent (Cat litter).
- Waste water treatment.
- Cast iron industry.
- Pelletization.
- Filtering and clarification.

Diatomite



Introduction

Diatomite is a sedimentary rock that consists mainly of micro-amorphous silica that is the siliceous remains of microscopic single algae cell called "Diatom".

Referring to the chemical and physical properties, the Jordanian diatomite could be used in the following industrial applications after simple treatments:

- Liquid absorption
- Mild abrasive and polishes
- Purification
- Additive in cement industries

Location

The diatomite is located in Azraq area; 110km northeast of Amman, covered an area more than 150km^2. Qa'a Al Azraq is referred to the whole area where a former lake believed to have been formed in Azraq depression of Miocene time.

Reserves

Horizon	Reserve (mt)	Diatomite thickness (m)	Overburden (m)
First	1040	4.5-31	11-52.5
Second	212	2-20	37-92.5

Chemical Properties

Component	SiO_2	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O	TiO_2, MnO & P_2O_5
%	41-70.7	10-16	2.35-9.9	Traces	2-4	1-2	traces

Comparison between Jordanian diatomite and Danish Diatomite (Moler) as follows:

Components %	**Jordanian Diatomite**	**Moler** (Danish Diatomite)
SiO_2	41-70	68-80
Al_2O_3	10-16	8-10
Fe_2O_3	2.35 - 9.9	5-7

Mineralogical Properties

Azraq diatomite deposit is mainly composed of diatomite mixed with clay minerals. Illite/ smectite and kaolinite are commonly present. Overburden mainly composed of smectite, illite, palygorskite and kaolinite. Few gypsum beds mixed with clay are at top clay layers.

Physical Properties

Oil Absorption	pH	Surface area	Dry density	Specific gravity
47-72gr/100gr	6.2-8.1	23-64m^2 gr.	666-791kg/m^3	2.27-2.63

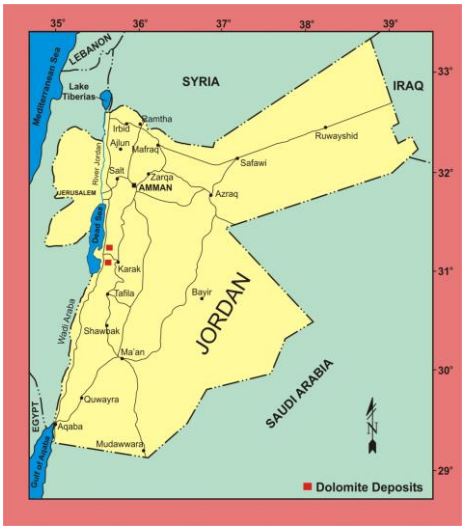
Particle Size Distribution

Grain size	<2μ	<10μ	<20μ
Wt%	9.4 -16.3	82.02-94.5	93.3-99.5

Investment Opportunities

The mineral is open for investment and mining/exploration companies are invited on the basis of detailed exploration, evaluation, and exploitation.

Dolomite



Introduction

Dolomite ($CaMgCO_3$) is a sedimentary rock occurs as a sedimentary deposit similar in nature to limestone. Most dolomite deposits are as a result of replacement of Mg instead of Ca during the recrystallization of limestone, whereas some dolomite precipitates directly from sea water. The dolomite rocks contain more than 50% of both calcite and dolomite minerals in which dolomite is more abundant than calcite.

Theoretically, pure dolomite contains: CaO: 30.4%, MgO: 21.8%, CO_2: 47.8%.

Impurities in dolomite include clay minerals and chert. The uses of dolomite are classified as follows:-

- Direct applications of dolomite (agriculture, cement mortar, and treatment of cracks),
- Uses of selectively calcined dolomite (produce, magnesium oxychloride cement, magnesium oxysulphate cement, inorganic magnesia foams, and silicate bricks)
- Chemicals from dolomite (magnesium oxide, magnesium hydrooxide, magnesium carbonate).

Geological Setting

Dolomite occurs in rocks of all ages, and is generally associated with limestone. In general, dolomite can be found throughout Jordan in the Cambrian Burj Dolomite Shale Formation and the Cretaceous Naur, Hummar and Wadi As-Sir formations. Dolomites that occur in Wadi I'sal and Al-Haditha areas belong to the Wadi As-Sir formation (Turonian).

Location and Reserve

Province	Area	Location	Reserve (mt)
Karak	The area between Wadi I'sal and Ahemir I'sal	30 km west of Karak	62
	Al-Haditha area	25 km west of Karak	20
Ma'an	Ras An Naqab area	70 km NE of Aqaba	80

Chemical properties

	Wadi I'sal and Ahemir I'sal	Al-Haditha area	Ras An Naqab
MgO %	1.77 – 18.98	1.74 – 20.2	19.06
SiO_2 %	0.95 – 6.44	0.45 – 24.2	2.6
CaO %	31.13 – 46.7	21.55 – 50.9	35.06
Fe_2O_3 %	0.12 – 1.36	0.1 – 3.57	0.69

Mineralogical Properties

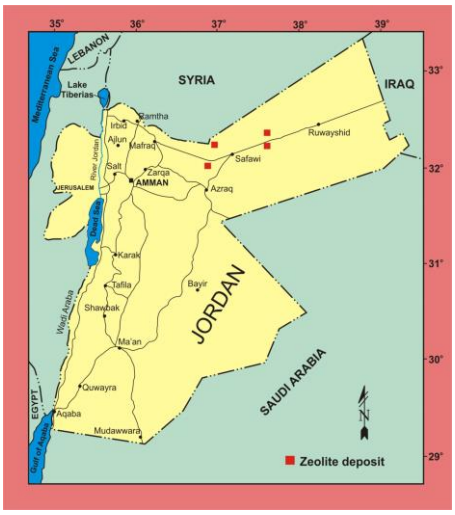
Al-Haditha area:

The dolomites of this area mainly consist of dolomite and calcite with minor amount of Gypsum, Quartz and Kaolinite.

Investment Opportunities

The rock is open for investment and mining / exploration companies are invited on the basis of detailed exploration, evaluation and exploitation.

Zeolite (Zeolitic Tuff)



Introduction

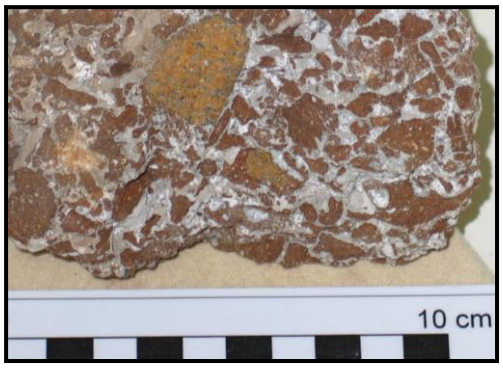
Zeolites are hydrated alumino-silicates of the alkaline and earth metals principally; Na, K, Ca and Mg. Zeolite minerals were generated from alteration of volcanic tuff in northeast and central of Jordan. It occurs as a cementing material to the volcanic tuff granules.

Location

The North Arabian Plateau Basalt covers an area of about 11,000 km^2 in northeast of Jordan and extends northwest into Syria and southeast into Saudi Arabia.

Phillipsite, chabazite and faujasite are the most abundant zeolite minerals found in the Jordanian zeolitic tuff. The zeolite content in these tuffs varies from (20% to 65%). Using simple mineral processing routes, zeolite concentrates with grades up to 90% were achieved.

Zeolitic tuffs are located in Jabal Aritayn (30 km northeast of Azraq), Tlul Al-Shahba (20 km east of Al Safawi), Tal Al-Rimah (35 km northeast of Al Mafraq) and other small deposits in central and south Jordan.



Reserves

Area	Geological Reserves (mt)
Tal Al-Rimah	46
Al-Aritayn	170
Tlul Al-Shahba	9.2
Northeast areas	472
Other areas	1340

Chemical Properties

Area	SiO_2%	Al_2O_3%	Fe_2O_3%	MgO%	CaO%	K_2O%	Na_2O%
Exploited							
Tal-Al Rimah	42.0	12.8	12.1	10.1	8.5	0.8	4.0
Al Aritayn	38.6	12.8	12.1	9.6	9.3	1.5	2.1
Mukawer	42.7	13.9	12.7	9.2	9.8	1.9	2.1
Not exploited							
Shihan	44.0	13.2	8.3	8.6	11.3	1.2	2.0
Tal Juhayra	35.0	10.2	11.3	7.6	20.2	0.7	2.4
Jabal Ata'atah	48.0	10.8	8.1	7.7	10.1	0.5	1.5
Tlul Al-Shahba	41.7	11.8	12.0	10.3	9.4	1.7	2.8
Jabal Unaizah	40.0	7.9	8.8	8.6	15.8	0.9	5.7

Investment Opportunities

Zeolitic tuff production in Jordan started in 1998, and therefore it is a relatively new sector. The total output was 4500 tonnes during 2002, produced by three companies. Total domestic consumption was estimated to be 3500 tonnes, with the balance being exported. It is expected that the majority of this consumption used in agricultural applications.

It could be stated that the major markets for Jordan zeolitic tuff resources are mainly domestic and regional. Given the size of the agricultural sector in the region, it is estimated that the market potential in these application is large. In terms of Jordan's cultivated land, each two percent increase in land treated with zeolitic tuff would result in an increase in zeolitic tuff demand of 100,000 tonnes per annum and 50,000 tonnes per annum in animal feed and odor control. The total expected demand potential is 360,000 tonne per annum depending on previous assumptions.

Investment in zeolite is open. There is a large room for investors to take part in the field of zeolite and zeolitic tuff on many different applications in Jordan.

Proposed project

Potash

Potash is a dissolved salt concentrated in Lisan Peninsula of Dead Sea in Jordan. It is a promised area for investment opportunities where there are no previous studies on it. Potash is the dominant source of fertilizer potassium throughout the world; it can be used also in many industries such as: soap, paints, medicines, papers, fireworks, tooth pastes, etc.

Rare earth Elements Projects

Rare Earth elements project is running now in south of Jordan – Dubadeab area, initial evaluation indicate that we have promised results.