Chapter 2

Minerals in Jordan

The University of Jordan
Chemical Engineering Department
Spring 2022
Prof. Yousef Mubarak

Important Minerals

- Basalt
- Bentonite
- Chalk
- Kaolin
- Diatomite
- Dolomite
- Feldspar
- Gypsum
- Limestone
- Silica Sand
- Zeolitic Tuff
- Heavy Materials
- Granite
- Marble
- Oil Shale
- Gold
- Copper

Basalt

- Basalt is a common gray to black volcanic rock.

- It is usually fine grained due to rapid cooling of lava on the earth's surface.

Uses of Basalt

- The industrial applications of basalt are based on the basic quality properties of basalt such as high abrasion resistance, compressive strength and chemical resistance.
- Basalt can be made into fine, superfine and ultra fine fibers, basalt fibers are considered superior to other fibers in terms of thermal stability, heat and sound insulation properties, vibration resistance and durability.
- Basalt replaces almost all applications of asbestos and has three times heat reinforced plastics.

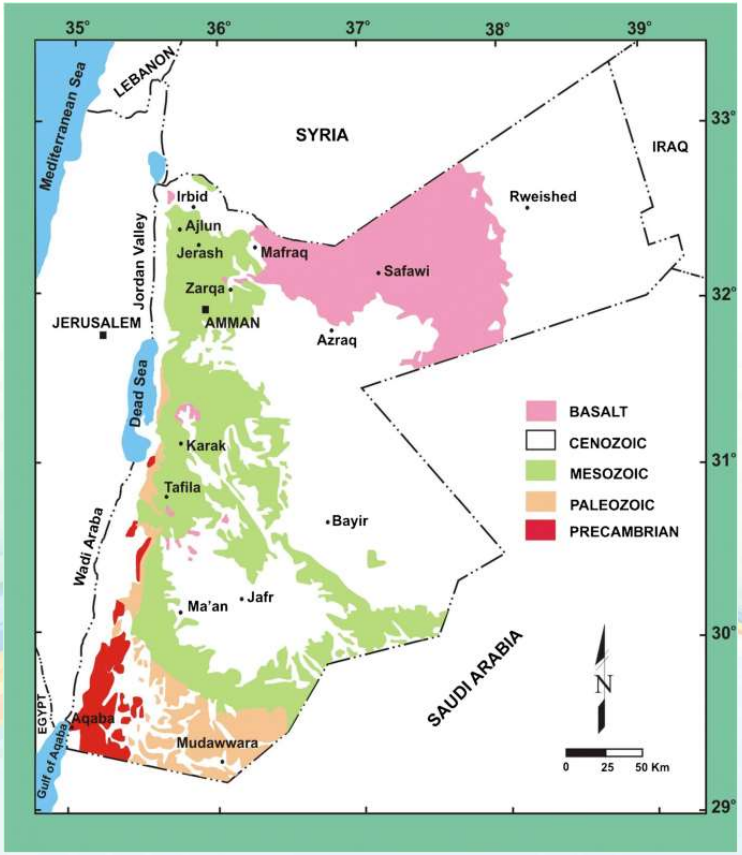
Basalt Typical Applications

- Crushed stone and Concrete aggregates
- Railroad ballast
- Production of high-quality textile fibers and Floor tiles
- Acid-Resistance equipment for heavy industrial use.
- Rock wool
- Basalt plastic pipers and basalt plastic reinforcement bars
- Basalt fibers
- Roofing felt,
- Heat insulating basalt fiber materials and glass wool….etc.

Location of Basalt

- Basalt rocks in Jordan can be roughly divided into three groups:

1. Plateau basalts Harrat ash Shaam in north eastern Jordan.
2. Basalts relating to the Dead Sea rift.
3. Isolated basalt effusions in central Jordan, mostly bound to deep faults.



Bentonite

- Bentonite is a rock term for a clay deposit composed essentially of crystalline clay like mineral formed by alteration of glassy igneous materials either tuff or volcanic ash.
- Grim (1968) considered that bentonite is a clay deposit consisting essentially of smectite minerals usually dominated by montmorillonite which has a very wide range of industrial applications.

- Among the smectite group, Montmorillonite is the most important commercially, with two main types:

  1. Na-Bentonite (Swelling Bentonite): characterized by expansion up to 15 times of original volume when immersed in water.

  2. Ca-Bentonite (Non-Swelling Bentonite): characterized by the adsorption property but do not show expansion when mixed with water. It can disperse in water and has very widespread in nature.

Bentonite location

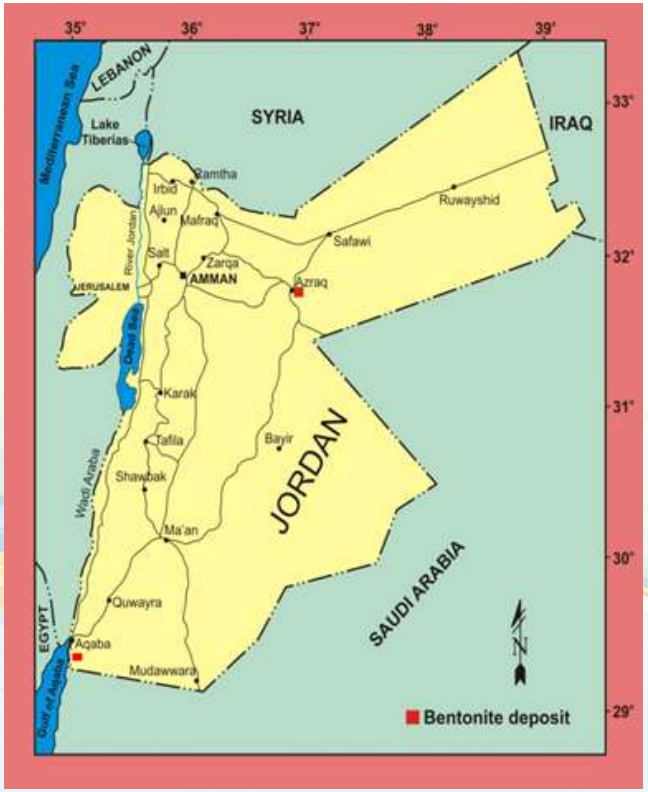
The main two areas containing bentonite deposits are Al Yamaniyya and Al Azraq areas.

- Al Azraq area was divided into two parts:

1. Q'a Al Azraq is located about 110 km northeast of Amman and represents a closed basin and covers about 350 Km^2.
2. Ein Al Bayda areas: The Ein Al Bayda area represents the northern of Azraq depression.

- Al Yamaniyya area:

It is located about 10 km south of Aqaba, extending for 7 km along Aqaba coast with an average width of 6 km.



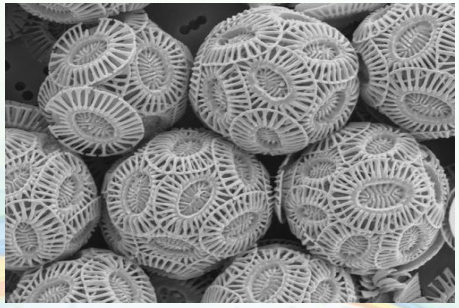
Bentonite Use Reserves

- The reserves in Ein Al Bayda area was 104.6 million ton, while the Q'a Al Azraq and Al Yamaniyya areas are not determined yet.
- There are many applications for bentonite:

1. Absorbents and Pet waste absorbents
2. Adhesives and Ceramics
3. Animal feed
4. Drilling mud
5. Filler
6. Filtering, clarifying, waterproofing and sealing
6. Pelletizing (iron ore)

Chalk

- Chalk is a fine-grained white limestone.
- 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 in mining.
- Chalk, typically consists of smooth, rounded weakly bonded coccolith structures which them selves consist of minute individual calcite crystals in the order of 1 micron in size.

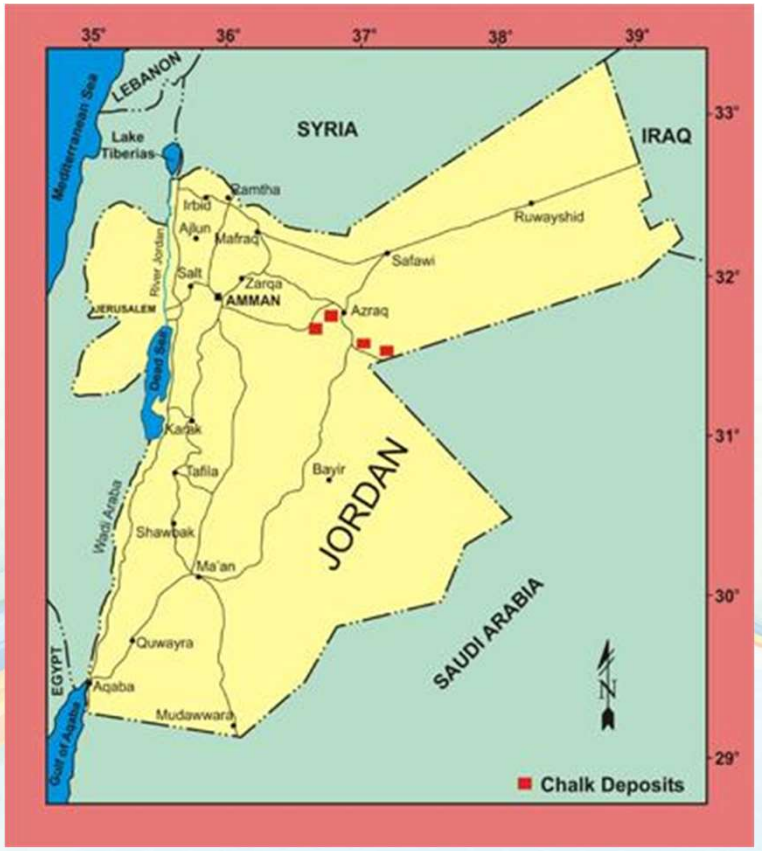


- Chalk as a form of carbonate rocks containing high calcium carbonate can be used in many industrial applications such as:
  1. Chalk can be used as a building stone, and chalk rubble is often used in road construction.
  2. When heated, chalk become lime, which has great many applications.

Lime is used in the production of Steel, Aluminum, Glass, Paper, Sugar, Cement, and Fertilizer.

Chalk Reserves

Area	Reserve (Mt)
Al-Umary - Dahikiya	1325
Wadi Al Ghadaf	161
Qaser Al-Harrana	976
Wadi Al Dha'abi	3364



Chalk Uses

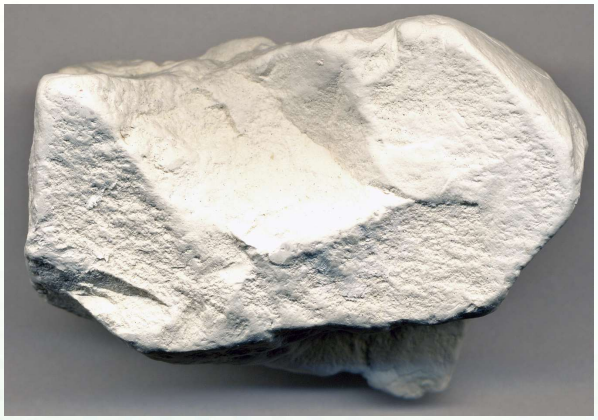
1. Blackboard chalk is a substance used for drawing on rough surfaces.
2. The pavement chalk.
3. In agriculture, It is used to raise pH in soils with high acidity.
4. In field sports, including grass tennis courts, it is used to mark the playing field or field boundaries.
5. In gymnastics, rock climbing, weight lifting and combat traction, chalk – now generally magnesium carbonate – apply to the hands to remove perspiration and reduce slippage.
6. Toothpaste also usually contains a small amount of chalk to function as a mild abrasive.
7. The polishing chalk is a carefully controlled grain-sized chalk for very fine polishing of metals.

Investment Opportunities

- The mineral is open for investment and mining / exploration companies are invited based on detailed exploration, evaluation and exploitation.
- Chalk deposits are soft to medium hard and exposed on the surface, so it is easily removed by open – pit mining and without using explosives.
- The easily accessibility, close to the main roads, and far from the towns, agriculture areas are advantages for the exploitation of chalk.
- Chalk can be used in many industrial applications such as in cement industry, in agriculture and for producing lime which used in many industries.

Kaolin

- Kaolin is white, soft clay mainly composed of the fine grained platy mineral kaolinite; a white hydrous aluminum silicate, $Al_2Si_2O_5(OH)$, containing 23.5% alumina, 46.5% silica, and 14% water.
- It is soft and occurs as extremely small hexagonal- shaped crystals of micron and submicron size.

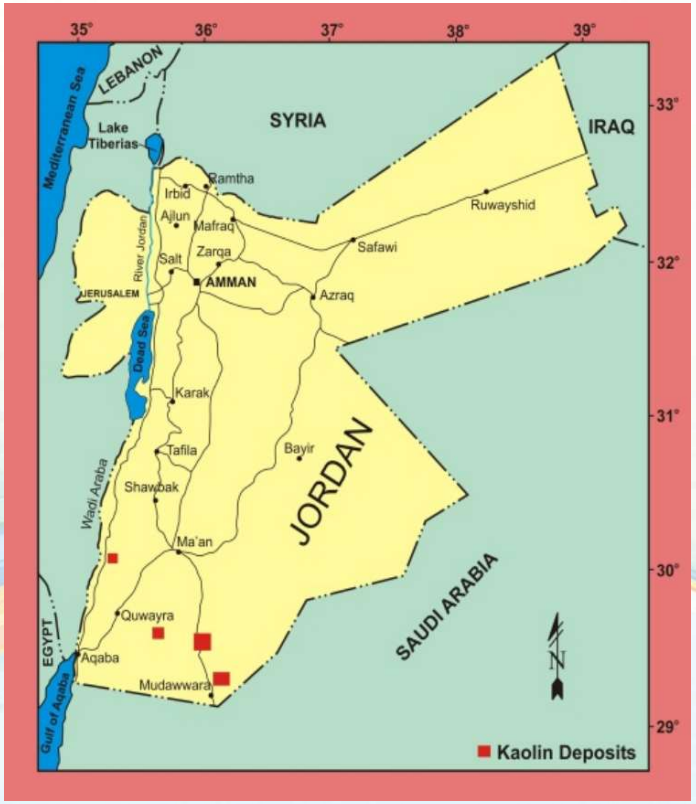


Uses of Kaolin

- It is used in the manufacturing of white-ware ceramics.
- The main use now is in the filling and coating of paper.
- It is also used as filler in paints, rubber, plastics and many other productions.
- Whiteness, fineness and controllable particle size are well known criteria of kaolin.

Location of Kaolin

- The kaolin deposits are almost located in Mahis and Ghour Kabid areas (Central Jordan).
- Other kaolin deposits are exposed in four main locations in south Jordan:
  1. Batn el Ghoul (Jabal al Harad)
  2. Al- Mudawwara (not exploited)
  3. Jabal Umm Sahm
  4. Dubaydib.
- All areas have been exploited to a small extent.

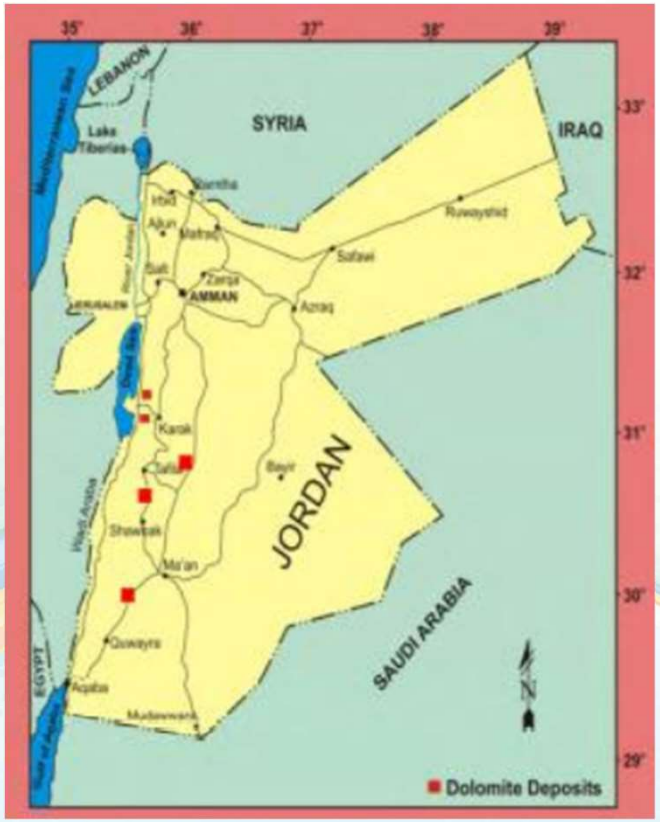


Dolomite

- Dolomite ($CaCO_3MgCO_3$) 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, while some dolomite precipitates directly from seawater.
- 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.
- *Dolomite Location:*

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



Dolomite uses

The uses of dolomite are classified as follows:

1. Direct applications of dolomite (Agriculture, Cement mortar, and treatment of cracks).
2. Uses of selectively calcined dolomite (produce, Magnesium oxychloride cement, Magnesium oxysulphate cement, Inorganic magnesia foams, and silicate bricks)
3. Chemicals from dolomite (Magnesium oxide, magnesium hydroxide, magnesium carbonate)

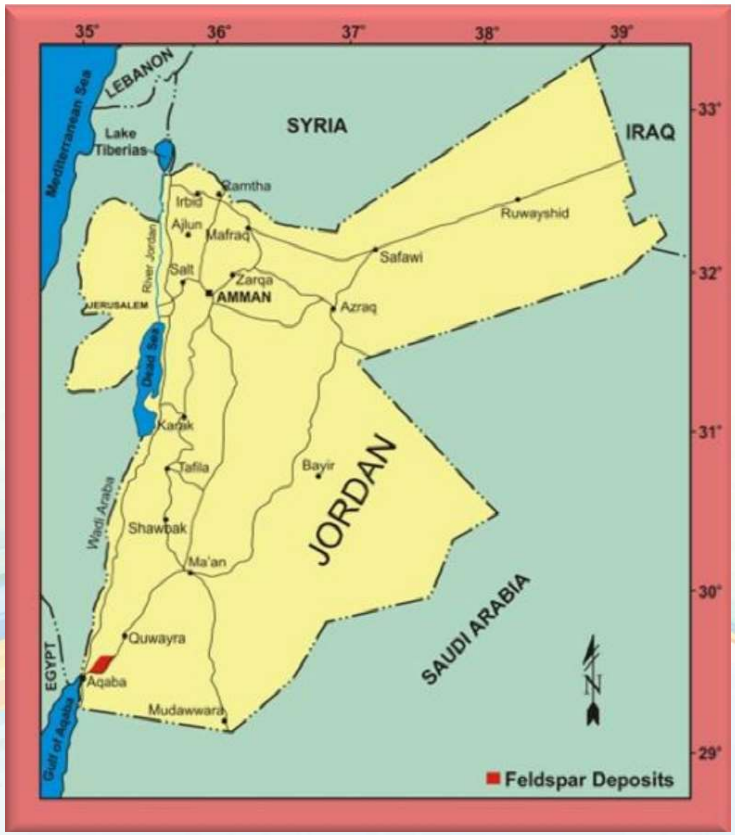
Feldspar

- Feldspar is the most important single group of rock forming silicate minerals.
- The mineral name feldspar is derived from the German words field + spar. The word (feld) is field in German and (spar) is a term for light colored minerals that break with a smooth surface.
- Feldspar minerals are usually white or very light in color, have a hardness of 6 on the Moh` Scale of Hardness.

- There are four chemically district groups of feldspar;
  1. Potassium feldspar ($KAlSi_3O_3$)
  2. Sodium feldspar ($NaAlSi_3O_8$)
  3. Calcium feldspar ($CaAlSi_3O_8$)
  4. Barium feldspar ($BaAl_2Si_3O_8$)
- About 90% of produced feldspar is used by the glass and ceramic industries.
- Soda feldspar is preferred in glass manufacture, but Potash feldspar is more popular for ceramic.
- Feldspar is an important ingredient in the manufacture of glass. The raw material for glass consists of silica sand, soda ash (sodium carbonate) and limestone (calcium carbonate).

Location of Feldspar

- Feldspar adds certain qualities to the process.
- Alumina provides hardness, workability, strength, and makes glass more resistant to chemicals.
- NaO_2 and K_2O from feldspar are fluxes. Fluxes reduce the melting temperature, so less energy is used and decrease the amount of soda ash needed.
- About 110 pounds of feldspar are used to produce one ton of container glass.



Gypsum

- Gypsum is one of the non – metallic minerals, com posed mainly of hydrated calcium sulfate ($CaSO_4.2H_2O$).
- It is usually formed by precipitation of $CaSO_4.2HO$ from solutions over saturated with respect to SO_4^{-2} and Ca^{+2} ions.
- Gypsum is associated with varying amounts of carbonates, clays and other impurities.
- Naturally, it can be found at many forms such as: selenite, satin spar (fibrous), gypsite and massive gypsum.

Uses of Gypsum

- The leading use of gypsum, worldwide, is in the manufacture of cement and concrete, accounting for 50 % to 60 % of all consumption.
- In the developing countries, especially in the Middle East and Asia, most gypsum is used in the production of cement or as a plaster product.

Gold

- During the years 1992-1994, geochemical prospecting in Jordan by the 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 Abu Khushieba area, returned gold values up to 40 g/t in heavy mineral concentrations collected from stream sediments. Visible gold was observed in heavy mineral concentration.
- Enhanced gold concentration were detected at a number of localities, particularly in the felsic volcanic rocks in:
  1. Wadi Abu khushyba,
  2. Wadi Hower
  3. Wadi Sabra areas
  4. In the rocks in Jebel al Mubarak
  5. Enn El-Hasheem

Gold Reserves

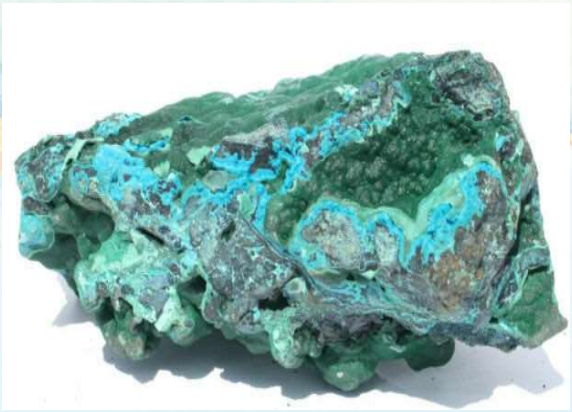
- Reserves are not yet determined.
- Further works is still required in wadi Abu Khushieba prospect area to ascertain the true surface extent of the gold anomalies and the distribution of gold in width and depth.
- The mineral is open for investment and mining/exploration companies invited based on detailed exploration, evaluation and exploitation.

Gold Properties

- Pure gold (Au) is quite soft and readily scratched with a knife.
- It is highly ductile & malleable and can be beaten to form a thin leaf that transmits greenish-blue rays.
- Gold remarkable stability , the unchangeability of its color, its resistance to the action of atmospheric moisture and all strong chemicals have won for its wide application in jewelry.
- Gold usually occurs as grain, scales or nuggets.
- Gold occurs mostly in natural alloys with other metals, usually with silver and copper.

Copper

- Wadi Araba is part of the Jordan Valley, which extends about 175 km from the southern edge of the Dead Sea in the north to the shore of the Gulf of Aqaba.
- It was considered in ancient times a bridge between Asia and Africa because it lies at the crossroads between the two continents.
- The copper deposits in this area are mainly present in the Cambrian rocks and have not been commercially exploited.

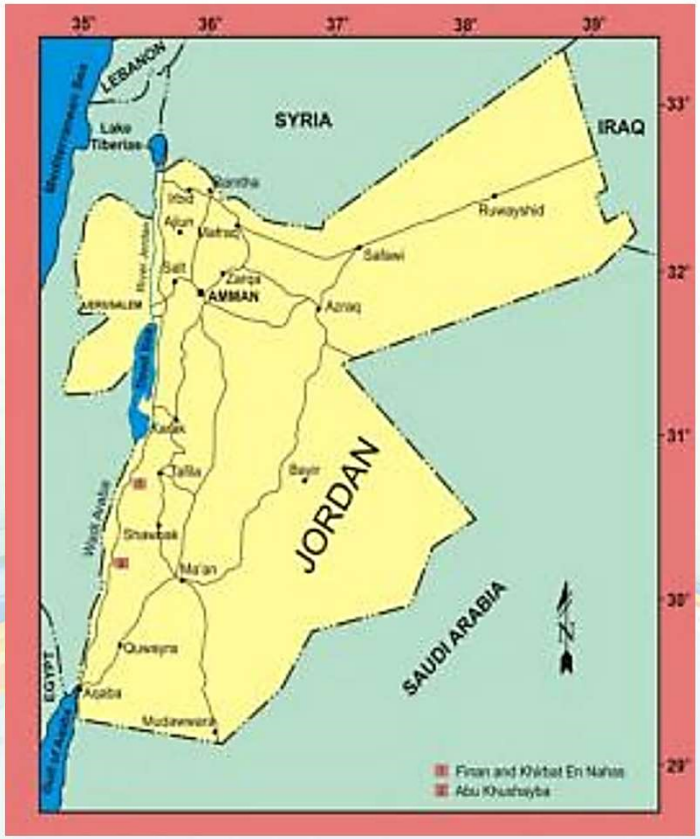


- *Copper ore was mined and smelted extensively in ancient times by Nabatians, Egyptians and Romans.*
- *Archaeological discoveries in Wadi Araba was dated copper production as far back as 3,000 years B.C.*
- *There are three large slag heaps in the Finan district within the Wadi Araba area and fragments of partially smelted copper can be found in it.*

Location of Copper Deposits

- Copper reserves in Wadi Araba area was estimated to be about 52.8 million ton, while the metal reserves of native copper (Cu) were estimated to be 903780 ton.
- The reserves are distributed in four main localities:

1. Wadi Abu Khushayba Area
2. Feinan Area (Wadi Khalid, Wadi Dana)
3. Khirbet EL Nahas
4. Um El Amad



Previous Studies

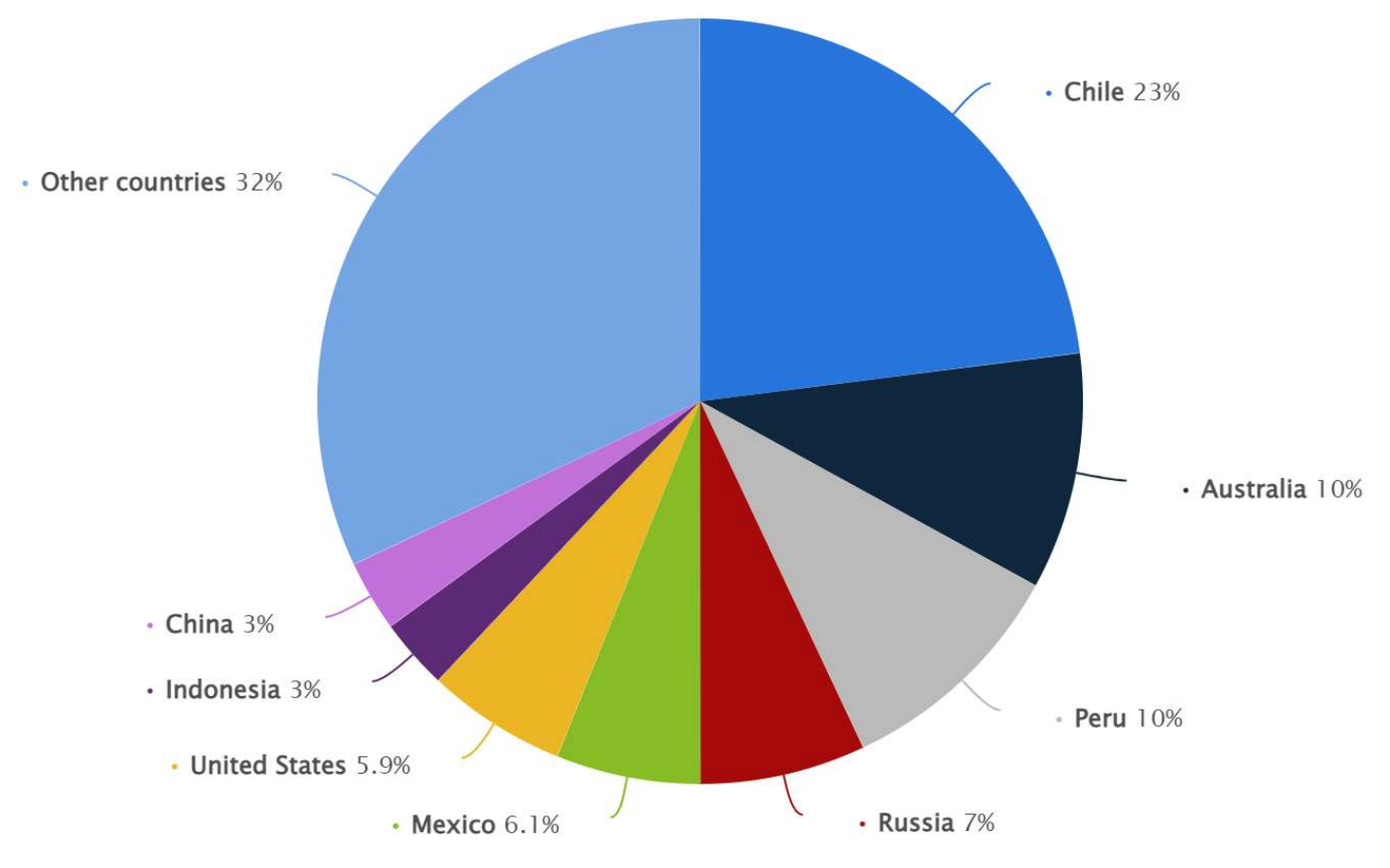
- The most important previous systematic investigations that carried out in the Wadi Araba area which were conducted by the following organizations:

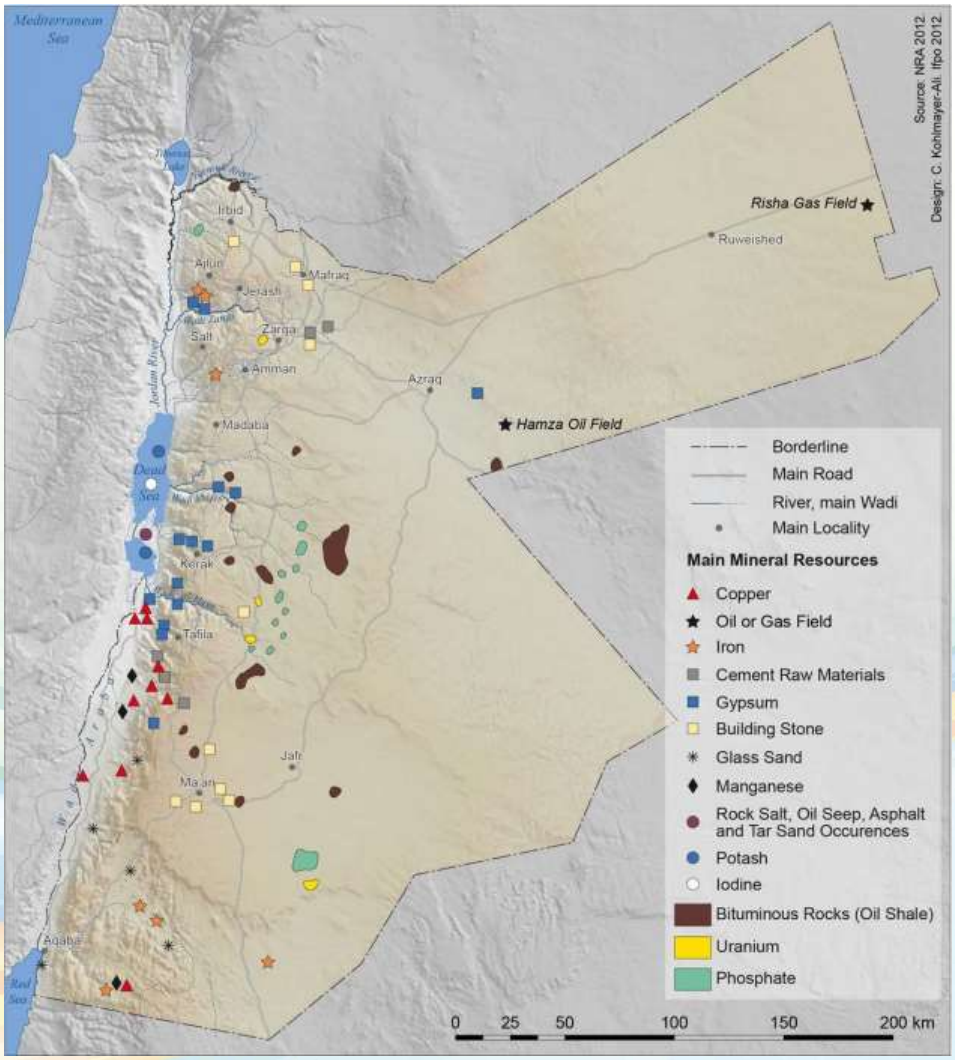
1. German Geological Mission (1961-1964).
2. Natural Resources Authority (1972-1973)
3. Bureau de Recherches Geologiques et Minieres (BRGM) (1974-1975)
4. Seltrust (England) 1985
5. Hanbo Group (South Korea) 1994 6. Phelps Dodge (South Africa) 1999

Conclusions

- The mineralogical studies revealed that it would be very difficult to physically liberate copper minerals from the gangue materials because of the textures and mineralogy.
- As observed from the results of the metallurgical studies, the orthophosphoric acid is efficient as sulphuric acid in its ability to extract copper from sandstone and shale sub members.
- Long wall extraction with back filling is considered to be the ideal mine for extracting the copper ore.

Distribution of copper reserves worldwide in 2019




Mediterranean Sea
Irbid
Ajlun
Mafraq
Jerash
Salt
Zarqa
Amman
Madaba
Azraq
Risha Gas Field
Ruweished
Hamza Oil Field
Dead Sea
Kerak
Tafila
Jafr
Ma'an
Aqaba
Red Sea
Jordan River
Source: NRA 2012.
Design: C. Kohlmaier-Ali. Ifpo 2012.
Borderline
Main Road
River, main Wadi
Main Locality
Main Mineral Resources
Copper
Oil or Gas Field
Iron
Cement Raw Materials
Gypsum
Building Stone
Glass Sand
Manganese
Rock Salt, Oil Seep, Asphalt and Tar Sand Occurences
Potash
Iodine
Bituminous Rocks (Oil Shale)
Uranium
Phosphate
0 25 50 100 150 200 km