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Survey Report on the situation pertaining to the development of mineral resources in the countries of the ECWA region

Prepared by the ECWA Secretariat

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PREFACE

Preparation of this survey report required a lot of travelling in the region with a view to collecting the necessary information to be used as inputs for this study. The meagre information initially available at ECWA in this field prompted such travelling which proved to be useful in collecting data and establishing contacts with the mineral resources authorities of the member countries. It should be indicated, however, that some officials of the member countries were reluctant to release the necessary information which the secretariat required to cover the region in a comprehensive manner. It is important to note that detailed information on all aspects of mineral resources are required for the undertaking of the future mineral resources projects of the Commission. In this connexion, the secretariat of the Commission would highly appreciate a more continuous co-operation of some member countries and would urge others to facilitate the task of ECWA staff by providing them with the required data which will assist them in implementing a work programme already approved by their governments.

Finally, it should be indicated that the present final report was prepared after editing and incorporating in the preliminary report additional information, relevant suggestions and comments received on it from the mineral resources authorities of the member countries and regional and international organizations engaged in the field of mineral resources development. Furthermore, the information contained in this report is based primarily on official country documents and data submitted to ECWA staff by officials of member governments and whenever these data were not available, secondary sources were consulted.

INTRODUCTION

The position of the developing countries in the field of mineral resources development remains unsatisfactory. They possess one half of the world's land area but the known mineral resources located in their territory amount roughly, to only one third of the world total, the remaining known reserves being shared between centrally planned economies (27%) and the developed market economies (35%). These regional differences in ore reserves are generally accepted to reflect differences in imbalances of expenditures which have been devoted to mineral exploration. In spite of the improvement of mineral production in a number of developing countries, 80% of exploration and perhaps two thirds of mining production still take place in industrial countries, and there is hardly any indication of a change in this situation. It could be changed if systematic efforts are made to tap the mineral resources potential of these countries on the basis of their permanent sovereignty over their natural resources.

The natural resources of the ECWA region have, to a large extent, been used in its economic and social development. Many countries in the region depend in their development on a single commodity (oil), the market of which is a function, among other factors, of the international economic and political situation and is, therefore, subject to wide and serious fluctuations. In addition to the oil-producing countries of the region, the Hashemite Kingdom of Jordan depends to a large extent on revenues derived from phosphate production in carrying out its development projects. Other countries in the region are realizing the role of natural resources in the development process and are currently undertaking mineral investigations of their territories.

Economic diversification in many of the ECWA countries is, therefore, needed with a view to broadening the base of economic activity and ensuring a steady and stable growth performance. Development of the mineral resources sector (excluding oil and gas) constitutes one form of economic diversification in addition to being a source of revenue and a stimulus to the economic development of the region.

The share of the mining and quarrying sector in GDP in most member countries is very low. In Saudi Arabia, the mining sector-excluding oil and gas-contributed 58.7 million Saudi riyals to GDP in 1971-1972, rising to 90.4 and 146.4 million riyals in 1972-73 and 1973-74 respectively.

The relative share of this sector to GDP was as low as 0.2 per cent in 1972 and 1973 and declined to 0.1 per cent in 1974. The mining and industry sectors of Jordan experienced a steady growth between 1973 and 1975 with their contribution to GDP rising from 11.1 per cent in 1972 to 14.8 per cent in 1975. Revenue from this sector during the above period rose from 19.8 million J.D. in 1972 to an estimated 45 million J.D. in 1975. The production capacity of the Jordan Phosphate Mines Company increased from one million tons in 1972 to 2.75 million tons in 1975, and a sum of 24 million J.D. has been allocated to a phosphate project aimed at increasing the total production to 7 million in 1980. The mining and manufacturing sector, (including electricity, gas and water) of Syria expanded between 1973 and 1975 with its contribution to GDP rising from 1941.8 to 4638.0 million Syrian pounds.

Although the contribution to GDP of the mining and quarrying sector (excluding oil and gas) of Iraq rose from 7.3 to 12.7 million I.D. between 1972 and 1974, the share of this sector in GDP dropped from 0.52 per cent in 1972 to 0.35 per cent in 1974. In Kuwait, stone quarrying is the main activity under this sector with a value added to industrial production amounting to a low figure of 856,000 and 729,000 K.D. in 1971 and 1972 respectively. In the Yemen Arab Republic, the contribution of the mining and quarrying sector to GDP amounted to 12.7 million Yemeni rials in 1970, as compared to 25.6 million Yemeni rials in 1973 valued at 1972 constant prices. The three year development plan (1973-1976) of YAR allocated 10 per cent of its total development expenditure to the industry sector which includes mining and energy. In the People's Democratic Republic of Yemen, the manufacturing and mining sectors contributed 4.2 million Y.D. in 1970 as compared to 7 million Y.D. valued at factor cost in constant 1974 prices. The authorities in PDRY have allocated 879,000 Y.D. at 1972/73 prices for geological and mineral survey activities in their new five year development plan (1974/75 - 78/79). This modest figure constitutes only 1.2 per cent of the total planned investment over the plan period.

As shown above, the mining and quarrying sector did not yet play an active role in the development performance of most countries in the ECWA region. However, recent development plans in some of the countries have allocated more investment funds to this sector hence enabling it to contribute whenever possible to their economic diversification and development.

The following chapters in this report deal with the following aspects of mineral resources development:

(a) General geological features determining the location of various kinds of mineral deposits and occurences in the region;

(b) Economic assessment of the mineral resources endowment and development of member countries. This part of the study covers the most important metallic and non-metallic mineral raw materials in the region, and deals with the description of their deposits and occurences, their geological features, characteristics of their ores, evaluation of their reserves and an analysis on their present and future utilization;

(c) Administrative and institutional machinery responsible for the development and management of mineral resources in the region;

(d) Mining legislation in the countries of the ECWA region;

(e) Possibilities for regional co-operation in the development of mineral resources in Western Asia;

(f) Recommendations at both the national and regional levels.

CHAPTER I. MINERAL RESOURCES AND DEVELOPMENT OF SOME RELATED INDUSTRIES

The type and origin of mineralization and distribution of mineral deposits and occurences in space and time are closely related to the geological structures created during a long period of geological development.

Particularly, in the ECWA region, location of mineral deposits is closely connected with the development of the Arabian Platform, covering the territory of the Arabian Peninsula and its geosynclinal surroundings.

In the north, the Platform is bordered by the Alpian folded system, extending over the northern parts of Iraq and Syria; to the north-east and east its border is connected with a Mesopotamian Foredeep coinciding with the Mesopotamian Basin and with the eastern part of the Arabian Gulf. It covers particularly the north-western and eastern regions of Iraq and the north-eastern part of Syria. To the south-east, within the Oman Peninsula, the border of the Platform takes the shape of an Alpian folded belt (Oman Mountains), the formation of which was thrusted over it; and at the western and southern peripheral parts, the Platform is bounded by the rift system developed in the Gulf of Aden, Red Sea, Gulf of Aqaba, Dead Sea and Wadi al Araba.

The Platform itself is not structurally homogenous: the western part of it is represented by the Arabian Shield composed of an exposed folded basement, which covers about 27% of the territory of Saudi Arabia. It outcrops also in YAR, PDRY and at some points in Iraq and in the south of Jordan. To the north and east, the basement dips under the Mesozoic and Cenozoic sedimentary formations within the so-called Arabian Shelf, which is divided according to some geologists into the Interior Homocline and the Interior Platform. Within the Arabian Shelf, there are a number of arched uplifts and basins as well as other smaller structures. The most promising area for a wide range of metallic deposits is the Arabian Shield, being composed of metamorphic and igneous rocks with an absolute age of more than 520 mill. years.

Precambrian metallogenic epoch in geological history is one of the most "productive" epochs for some important metals. It has been proven that most of the world reserves of Fe, Ti, Ni, and Au were formed during this period.

Table No. I

Distribution of World Reserves of metals by Metallogenic Epochs (%)

Metallogenic epochs	Fe	Mn	Cr	Ti	Ni	Mo	W	Sn	Cu	Pb-Zn	Au	Hg
1. Precambrian	75	25	20	80	70	?	?	10	25	10	70	-
2. Hercynic and Caledonian	5	-	60	20	10	5	20	20	10	30	5	?
3. Kimmerian	15	5	10	-	2-	5	70	60	5	30	15	5
4. Alpian	5	70	10	-	-	90	10	10	60	30	10	95
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: "Metallogeny", by G. Magakian, 1975.

Within the Arabian Shield, the Precambiran orogenic epoch "produced" the most significant metallic mineralization in the region, located mainly in the territory of Saudi Arabia, and is reflected in the existence of occurences and deposts of iron, titanium, copper, zinc, lead, nickel, gold and silver.

The Alpian metallogenic epoch is characterized by the formation of chromium, nickel, manganese, copper, gold and silver mineralization in the ophiolite belt of the Oman Mountains, extending over the territories of UAE and Oman, and in the Alpian folded system which partly covers the northern parts of Iraq and Syria.

Development of the rift system, followed by disjunctive dislocations and volcanism, resulted in some mineralization, the most important being lead-zinc, barite and magnesite mineralization of Paleogene and Neogen origin and associated mainly with dislocations of NNW-SSE trends. In addition, Fe, Mn, Zn, Pb, Cu and Au mineralizations developed in the ooze in some of the Red Sea deeps.

Within the Arabian Shelf and Mesopotamian Basin, Precambrian basement is covered by Phanerozoic sedimentary formations, which dip gently to the east and to the north-east. The thickness of the sediments in those directions rises to 5500 m and reaches 12000 - 15000 m in the axial parts of the Mesopotamian Basin (Mesopotamian geosyncline zone).

In this part of the Arabian Platform, exogenous mineral deposts are well developed. Oil and gas deposits are, from an economic point of view, the most important ones. In the ECWA region, three oil and gas provinces are developed including: (1) Mesopotamian (MZ - KZ) oil and gas-bearing province covering particularly the northern part of Iraq, and the north-eastern part of Syria; (2) PZ - MZ oil and gas-bearing province, covering the eastern peripheral part of the Arabian Platform and extending to the territories of Saudi Arabia, Qatar, Bahrain, Kuwait, the southern part of Iraq and UAE; (3) MZ-KZ province covering the north-western part of the Arabian Platform which is bounded by the Mediterranian area and extending partly into the territories of Syria, Jordan and Lebanon.

Among the metallic mineral deposits and occurences, iron mineralization of sedimentary origin is found in Iraq (Jurassic), Syria and Lebanon (Cretaceous), and in Syria and Saudi Arabia (Paleogene). Syngenetic manganese ore and copper mineralization occurs in Cambrian rocks in Jordan.

Phosphate deposits of significant economic value are located in Jordan, Iraq, Syria and Saudi Arabia in Upper Cretaceous and Paleogene sediments. Native sulphur mineralization occurs in Syria in the Middle Jurassic and in Iraq and Saudi Arabia in the Neogen formations.

The most important salt and potassium deposits are of Neogen age located in Syria, Jordan, Saudi Arabia and YAR. Less important rock salt deposits and occurences are found in Mesozoic and Cambrian rocks. Gypsum and anhydrite occur in a wide range of geological sequence ranging from Permian to Neogen. Evaporates are located in UAE, Saudi Arabia, Syria, Jordan, Iraq, Qatar, Bahrain and Oman. For some of the countries, these mineral raw materials are of important economic significance. Various kinds of clay deposits associated with Triassic, Jurassic, Cretaceous, Paleogene, Neogen and Quaternary formations are located in Jordan, Kuwait, Syria, Lebanon and Saudi Arabia. Marble, building stone and raw material used in cement industry are found in the upper part of Phanerozoic section and are being exploited in many countries of the ECWA region.

A. Metallic Raw Materials

1. Ferrous metal ores

a) Iron ore:

Inspite of efforts undertaken by some countries of the ECWA region in investigation of their iron ore potential, no exploitable iron ore deposits have been found yet in this region and the problem of securing adequate domestic supply of iron ore for the existing and planned metallurgical industries remains unsolved. At the present time, established enterprises are oriented towards the utilization of imported iron ore or pellets.

The growing process of industrialization in the ECWA countries is followed by an increase in steel consumption per capita, which is expected to reach 75-121 kg by 1985 as compared to 47-59 kg in 1975. Expenditures on imports of iron ore, iron and steel will increase considerably and the self-sufficiency problem in the iron ore is expected to become more acute.

At present, the most promising areas for iron ore deposits and occurences of some economic value are located in various parts of the Arabian Peninsula and primarily in Syria, Iraq, Saudi Arabia, YAR and PDRY. There are also a number of iron ore indications in the other countries of the ECWA region, but their economic value is still not clear.

Iron ore deposits in S a u d i A r a b i a are located in various parts of the country and they vary in their origin and time of their formation. Extensive iron ore manifestations make that territory a promising one. Although exploration and investigation activities are continuing in some of these areas, no iron deposits of commercial value have yet been discovered. The following iron ore deposits in Saudi Arabia are worth mentioning:

- Wadi Fatima oolitic iron ore deposit, located in the wadi bearing the same name and in its subordinate Wadi Shumaysi, occurs in the middle part of the Shumaysi Formation in the form of two oolitic iron ore beds.

The country rocks consist of sandstone, siltstone, shale, pebbly sandstone, chert and volcanic tuff, covering unconformably the crystalline basement, and dipping eastward at an angle between 15° and 30° but with a prevailing dip of 25°E. The thickness of the Shumaysi Formation ranges between 75 and 180 metres. Paleontological and other related examinations of the formation rocks showed that their sedimentation took place along a shore line of an Oligocene transgressing sea, and was changed later to lagoonal fresh water conditions. The oolitic ore is usually underlain and covered by sandstone or shale, and consists mainly of spheroidal or ellipsoidal grains of red goethite, ranging in size from 0.2 to 1.6 mm in the different specimens. They are usually cemented by fine sandy, hematitic and clayey materials. The more consolidated ore has a clayey-gypsiferrous-hematitic cement. Gangue material contains apatite, clay, sometimes feldspar, gypsum, anhydrite, calcite, sidertie, zircon and quartz which is the most common gangue mineral. The Fatima iron ore deposit consists of five ore fields, numbered 1, 2a, 2b, 3 and 4.

In field No. 1, there are two iron ore beds with a thickness ranging from 3.3 m (upper bed) to 4.9 m (lower bed), and with an iron grade of 46.36% and 45.05% respectively. In the south, the thickness is smaller: 1.5 m and 2.9 m, with iron grade 38.5% and 40.2% (for upper and lower beds respectively).

In the field No. 2a, thickness of the ore bodies ranges, for the upper one between 1.2 m and 3.3 m and for the lower bed between 0.3 m and 1.6 m, with iron content of 39.85% - 51.15% and 32.89% - 41.1% respectively.

For the field No. 2b, the respective figures are: 0.52 m - 0.76 m, iron grade 33.9% - 45.2% and o.36 m - 2.3 m with an iron cotnet of 23.5% - 74.4%.

In the field No. 3, preliminary exploration work indicated the existence in some places of two ore bodies with thickness between 0.46 m and 2.8 m and an iron content of 24.7% to 47.5%.

In the field No. 4, only one ore body was found, the investigation of which showed a thickness of 0.38 m - 1.21 m with 28.1% to 36.9% of iron content.

According to some calculations, reserves of the iron ore (indicated and inferred) in the Wadi Fatima deposit only in the fields 1 and 2a amount to 48.5 mill. tons of 46.2% iron, to 200 m vertical depth, including about 15.0 mill. tons of the same grade which can be mineable in an open pit operation.

Exploration work and sample testing have led to the conclusion that the grade of ore is too low and it is very difficult to concentrate (a maximum of 62.4% Fe by magnetic separation) to a level acceptable to the steel industry. Besides, both crude ore and concentrates have high phosphorous contents (0.4% - 0.6% of P in crude ore); and the deposit is not economically exploitable in an open pit operation because of its low reserves and costs of underground mining would be prohibitive due to relatively thin beds, 25^{0} inclination, and extensive small scale faulting. All of these factors prevent further development of this deposit.

It was suggested to continue undertaking feasibility studies of this deposit with a view to assessing it as a source of supply for metallurgical uses. Until now, the iron ore is only used as an iron additive in the manufacturing of portland cement.

- Wadi Sawawin iron ore deposits are located in an area with co-ordinates 27°56'N and 35°53'E, among Pre-Cambrian iron formation which covers the territory of 3 x 23 km. The deposit contains mainly jaspilite with some thermally metamorphosed ores, with total reserves amounting in several deposits approximately 300 mill. tons of 38-42% iron grade and 0.6% phosphate. The deposits are suitable for open pit mining, but preliminary studies revealed some factors which prevented them from being economically exploitable.

The first one relates to the presence of very fine-grained iron and silica, which makes concentration difficult. The highest concentration, that can be achieved on an industrial scale is 58% and 65% with 90% and 65% Fe recovery and with 13% and 16% SiO_2 grade respectively.

The second obstacle is the high phosphorous content, which probably cannot be brought to acceptable limits if metallizing reduction and electric arc furnace processes are used. The content of P_2O_5 in this crude ore and in concentrate averages between 0.6% and 0.2% respectively.

Further steps were undertaken in 1976 when a four-year contract was made with the British Steel Corporation for work leading to full feasibility study.

The first phase was concerned with studies to beneficiate the ore. A possible beneficiation and metallurgical route has been defined and subsequent work can now be directed towards improving upon it.

It has been shown, that a medium grade concentrate of around 57% Fe can be produced by conventional finishing processes, with an overall recovery of 70 to 80%. No specific efforts have been made so far to improve phosphorous rejection.

- Jabal Idsas: It is a segregational iron deposit which contains small packets of high grade magnetite and a much larger quantity of low grade material. The high grade ore does not exist in sufficient quantities to justify mining but the deposit will be examined further, particularly in relation to the possibilities of concentrating the low grade material to supply a possible iron and steel plant in Riyadh. At the present time, reserves of this deposit are estimated at 1.5 million tons of 66.8% and 67 million tons of 16.5% grade iron ores.

Some other iron deposits and occurences have been located in Saudi Arabia, but due to their small reserves, low iron grade and ore quality, they cannot, at the present time, be considered as being of economic value.

According to the new Five-Year Plan, the most promising iron ore deposits, including Wadi Sawawin, are going to be re-assessed by private companies. Furthermore, it was decided to carry out investigations of other known iron ore deposits to assess their commercial potential, in view of the growing import expenditure for iron and steel, which amounted to $ 11,810,000.- in 1974.

Iron ore deposits in S y r i a are found in many areas of the country. They particularly exist in ranges of hills in the northern and western parts of the country: Rajo, Kerri, Alamdar, and in adjacent areas such as Afrine and Kadmous. They also occur in the Zabadani region where iron ores are closely related to the Aptian zone. Most of the iron ore deposits in Syria are of Aptian age, and all of them are of sedimentary origin. Ores are composed of hematite, limonite and goethite. They can be oolitic, pisolitic, nodulous, fragmentary or massive in structure. Pisolitic and nodulous ores are more frequent than others, but massive and oolitic ores contain more Fe.

Prospecting for iron ores in Syria was initiated on a large scale in the middle of 1959 in the region of Rajo which includes the deposit of Rajo itself, Kerry deposit, and iron ore locations in Wadi Al-Nachab. Geological maps covering territories of 12 km^2 and 6 km^2 at a scale of 1:10,000 and 1:2,000 respectively were compiled. As a result of the prospecting activities, reserves were estimated and iron content was determined. Proven reserves of the Rajo deposit are estimated at 26 million tons with 31.8% Fe. Reserves of Alamdar and Kerry deposits amount to 21 million tons with 31% Fe and 14 million tons, with 25% Fe respectively.

Reserves of iron ores in the region of Rajo total about 61 million tons, with an average content of 31-32% Fe. Thickness of the ore layers reaches up to 20 metres, but averages to 7.3 metres.

In 1968, an investigation was carried out of the Kadmous iron ore deposit and reserves were estimated at 20 million tons of iron ores, with grade of 25-30% Fe and thickness of layers ranging from 1 to 2.5 metres. Exploration work was also conducted on one of the most promising deposits in Zabadani. These pisolitic and oolitic ores contain 20-54% Fe. The thickness of ore bodies ranges between 0.5 m and 4.0 m, and reserves amount to a few million tons.

Some other iron ore deposits of less important significance were found in the Palmyrides. All of them belong to the Aptian age, with the exception of one deposit in a clayey formation of Oligocene age. For these deposits, the content of Fe_2O_3 does not exceed 19% in Aptian sediments and 28% in rocks of Oligocene age. Furthermore, black sands containing Ti and Fe were found along the shoreline in the region of Banias. Accordingly, the total iron ore reserves in Syria are in excess of 130 million tons, with 35% Fe content.

Due to the geographical location of iron ore deposits in the country, the high transporation costs involved, the low grade of Fe and the unfavourable composition of ores (limonite-hematite type with no magnetite), mining operations cannot be profitable. According to a report written by a team of West German experts on this subject, this ore can only be used as an additive to richer ores.

In this connexion, it should be indicated that consumption of iron and steel products in Syria increased from 119,346 in 1960 to 191,633 tons (50 kgs per capita) in 1969, with an annual rate of growth of 13%. By 1980, annual consumption may reach around one million tons, i.e., about 100 kg per capita. To meet the increasing demand for iron and steel, Syria imported in 1974 steel and iron at a cost of S.P. 705,691,000.

All iron ore deposts in I r a q are of sedimentary origin. The country rocks are clay, argillite and sandstone of 10 - 24 metres thickness, occuring within calcareous rocks of Upper Triassic - Lower Jurassic age. The main iron ore-forming minerals are represented by goethite and turgite. From structural point of view, iron ores can be divided into oolitic, massive, pisolitic, nodulous, clastic etc., with iron content between 14.6% and 43.74% and with the richest iron grade being in massive and nodulous ores. These iron ores have relatively high concentrations of Al_2O_3, SiO_2, TiO_2, Pb and Zn and low grade of Mn, P and Cr. It is thought, that accumulation of iron hydroxides took place there in the past in a shallow basin, they were derived from zones of deep weathering of the Arabian Shield rocks.

The most significant iron ore deposits in Iraq are :

- Husseinieh deposit, with total estimated reserves of some 25 million tons and an average iron content of 24 per cent; SiO_2 - 32 per cent; Al_2O_5 - 21 per cent; S - 0.03 per cent; P - 0.03 per cent and V_2O_5 - 0.11 per cent. The deposit consists of a small number of lenses with an average thickness of 2.40 m, mostly covered by an overburden, the average thickness of which amounts to 20 m. Country rocks are a mixture of kaolin, red clay and sand. This deposit can be extracted mainly by underground mining and a minor part of it by open pit mining. The magnetite content in the ore, which consists almost exclusively of a pisolitic and oolitic mixture of limonite and hematite, is almost nil. Thus, no magnetic separation from the quartz-bearing gangue is possible. The ore must be crushed to 100 - 150 mesh to free the iron oxide from the cement consisting solely of SiO_2. Furthermore, applying other methods of beneficiation is also a difficult task.

Commercial exploitation of this deposit could not be undertaken because of the transportation required over a distance of 900 km, of which only 550 km are connected by a railroad. The remaining 350 km are connected by highways, the use of which is very costly.

An interregional adviser, who visited Iraq in 1975, estimated that under the given circumstances at least 500 to 600 million tons of ore, with an iron content of 55% or more, are required to undertake an economic exploitation of this deposit.

Other iron ore locations are less significant:

- Isnawa deposit with reserves of 1.3 million tons, iron content 20% - 40%. This ore containing magnetite and limonite is used as an additive in a local cement plant.
- Mishow deposit contains hematitic and limonitic ore, with 20% - 30% Fe and low grade of P and S. After beneficiation, the iron content could be increased up to 60% - 63%. Statistics on reserves are not available.
- Darabandah is low grade iron ore deposit with 16% Fe and high content of Pb, Zn and Cu. Reserves are about 1 million tons.
- Kafrah deposit has 2.5 million tons of limonitic and hematitic ores, 30% of which have 46% Fe content, but with a high content of S (about 2%). Small reserves make this deposit economically unexploitable.

In J o r d a n , iron ore was mined in medieval times in the southern Ajloun district, 7 km west of the village of Burma, and about 35 km north-west of Amman. The ore, dominantly hematite with some limonite, forms an irregular lenslike body of metasomatic origin within the massive limestone of Cenomanian-Turonian age. Test drilling indicated that the ore body is about 300 m long and 200 m wide with a maximum thickness of 9.80 m. The average iron oxide content in 205 samples from 15 boreholes is 67.9%; the proven reserves are 561,000 tons, a quantity too small to be exploited. Some other iron deposits located in the region of Shoeib, between Salt and Jericho, contain hematitic and magnetitic ore, with an average content of iron oxide 63% and a high percentage of SiO_2.

According to the new Five-Year Development Plan 1976-1980, further evaluation and determination of the potential from a technical and economic points of view of iron deposits in the south-eastern part of Ras Naqab, will be carried out.

The absence of economically exploitable iron ore deposits in Jordan led to increasing imports of iron and steel, reaching in 1973 the value of J.D. 8.1 million and thus putting this item among the leading import items of Jordan.

Iron ore deposits and occurences of various origins are located in many parts of L e b a n o n :

- In the Saida region (60 km south-west of Beirut) stratified deposits exist in Jurassic or Cenomanian limestone, which have been exploited locally for the last 50 - 80 years. They contain up to 31% of iron, and the thickness of ore bodies does not exceed 35 cm.

- Oolitic iron ore in Aptian rocks is located in the south of the country in Dahr el Baidar and Fnaidek. The ore bodies there, have a thickness varying from 3 to 9 metres, and contain mainly limonite and hematite, with iron grade up to 48.4%. The minimum ore reserves of the Fnaidek deposit are estimated at 2 to 3 million tons.

- Iron ore occurences are located also on the basalts of Upper Jurassic age where iron grade reaches in some places up to 40% - 50%. Those occurences are located in Hazroun, Becharry, Hadjite, Qunaiwer, Beit Moussa, Laklouk, Tannourine, Mejdal Tarchich.

The most promising area for iron in Lebanon is between Tripoli and Beirut in the Jurassic limestone and in the Aptian rocks containing oolitic iron ores.

In the P e o p l e ' s D e m o c r a t i c R e p u b l i c o f Y e m e n at about 40 km east of the Upper Yaffa, an iron ore occurence was studied by a United Nations mission, and later by Chinese and Soviet missions. Since neither drilling equipment nor means for an airborne geophysical survey were available, no evaluations were carried out. The iron ore consists of over 80% magnetite and the average Fe content is well over 55% reaching 61% in some places. A similar iron ore deposit has been discovered about 100 km west-south-west of the Upper Yaffa area, near the border with the Yemen Arab Republic.

- The other iron ore deposit is located in Wadi Halwal area, 7.5 km west of Al-Majil settlement and 60 km away from the coast. Outcropping formations are principally Pre-Cambrian bonded migmatites and magnetite-bearing quartzites. These have been intruded by diabase dikes, pegmatites and quarts veins. Enrichment has taken place resulting in a high-grade magnetite (67%) outcropping widely over a relatively large area. Exposures have a narrow width of 1 to 6 metres, and it is likely that occurences may exist in larger masses of rich iron ore of economic value. Specialists in PDRY estimated that about 80% of the ore contained magnetite, with an average iron grade of more than 55% and reserves may exceed 100 million tons of ore.

- Beach black sands near the village of Amran and town of Mukalla still need to be studied. These sands cover a zone several kilometres long, partly extending along the sea shore, with a width of several hundred metres, and containing mainly magnetite and minerals of some rare elements.

Further investigations are needed in order to obtain additional information which would enable the authorities to assess the economic value of the iron ore deposits. It should be indicated in this respect that the most promising areas for iron ore can be considered the Pre-Cambrian quartzites and Mesozoic sedimentary rocks.

In the Yemen Arab Republic, there are some indications of iron mineralization at Wadi Ridijan, Al Maazing, Ash Shakhet, An Nopa - with iron grade from 32.2% to 40.6%. These mineral occurences have been identified but their economic potential not yet established.

- Besides the localities mentioned above, in the northern part of the country in Sa'dah area, massive gossans, containing mostly goethite, are spread over many kilometres, extending to N.N.W. along the ranges of calcareous outcrops. The mineralization is of metasomatic type, which is related to a fault and to a number of intrusions developed in this area. Unfortunately, the genesis of the ore was not yet studied, and neither the geology of this region.

Until the beginning of the present century, the goethite ore was mined by the local population and used for iron smelting in metallurgical workshops in the town of Sa'dah. During a few last years, some groups of experts visited the area, including one from USGS which found that gossan in the Sa'dah area is formed as a result of oxidation of a primary sulphide ore similar to the Wassat and Qatan deposits in Saudi Arabia. According to the conclusion of the ECWA experts, the gossan could have been formed as a result of oxidation of primary sideritic ores, closely associated with carbonatites. That kind of iron deposits is well known and they are exploited in some countries. If the analysis of the ECWA experts is confirmed, the Sa'dah area could be considered, as a promising one for the iron ore on the territory of the YAR.

No other iron ore deposit of economic significance exists in the ECWA region. Some occurences of oxide iron ore were discovered in the United Arab Emirates (Sharjah), but no information is available on them.

Table II. Iron Ore Deposits in the ECWA Member Countries

Country, deposits and occurences	RESERVES (million tons of ore)			CHEMICAL COMPOSITION %							Type of ore and ore-forming minerals	Genesis age
	Possible	Proved	Total	Fe (Fe_2O_3)	S	P	Al_2O_3	SiO_2	CaO (Ca)	MgO (Mg)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Saudi Arabia												
1. Jabal Idsas	-	1.5 ~ 80	1.5 ~ 80	66.8 16.5	0.09	0.09	-	2.5	-	-	Segregational, magnetite	Magmatic; Pre-Cambrian.
2. Wadi Fatina	-	48.5*	> 48.5	46.2	0.6- -8.4	0.16- -0.4	8.4	8.2-18	(0.743)	(0.242)	Oolitic; goethite, hematite	Sedimentary; Oligocene
3. Wadi ** Sawawin	> 1000	> 300	> 1300	32-42	-	0.8	-	26-32	3.0-6.0	-	Taconites	Meta-sedimentary; Pre-Cambrian.
Syria												
1. Alandar	-	21.0	21.0	25.24- -46.90	0.05- -0.94	0.23- -1.72	5.16- -22.50	2.6- -30.46	1.8- -9.40	0.51- -3.97	Hematite, goethite, limonite.	Sedimentary; Aptian.
2. Kadmouss	-	20.0	20.0	14.0- -45.0	0.07- -0.02	-	0.1- -14.0	10.4- -62.3	0.2- -65.0	0.0- -2.0	Hematite, goethite, limonite	Sedimentary; Aptian.
3. Kerry	-	14.0	14.0	25.00- -25.72	0.01- -0.23	0.08- -2.75	6.24- -14.72	9.0- -37.9	1.18- -6.39	0.86- -3.15	Hematite, goethite limonite	Sedimentary; Aptian.
4. Rajo	-	26.0	26.0	25.02- -72.81	0.01- -0.22	0.03- -4.14	3.30- -32.06	2.98- -34.56	1.17- -9.17	0.5- -3.22	Hematite, goethite, limonite	Sedimentary; Aptian
5. Zabadani	-	nl.0	nl.0	20-54	0.03- -0.21	0.04- -0.57	1.9- -11.3	10.0- -25.0	3.7- -31.0	12.5- -74.8	Pisolites and oolites; hematite	Sedimentary; Oligocene.
Iraq												
1. Darbandah	-	-	~1.0	16.0	-	-	-	-	-	-	hematite	Sedimentary; Upper-Lower Jurassic

* Only in two main fields, including inferred reserves.
** Several deposits, reserves only for some of them.

Tabble II. (cont'd) Iron Ore Deposits in the ECWA Member Countries

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
2. Husseinieh	-	-	25.0	24.0	0.03	0.03	21.0	32.0	-	-	Pisolites & colites; limonite; hematite	Sedimentary Upper-Lower Jurassic
3. Isnawa	-	-	1.3	20.40	-	-	-	-	-	-	Magnetite, limonite	Sedimentary Upper-Lower Jurassic
4. Kafrah	-	-	2.5	(46.9)*	~2%	-	-	-	-	-	Hematite, limonite	Sedimentary Upper-Lower Jurassic
5. Mishow	-	-	-	low grade	low grade	-	-	-	-	-	Hematite, limonite	Sedimentary Upper-Lower Jurassic
Jordan												
1. Burma	-	-	0.561	67.9	-	-	-	-	-	-	Lenslike bodies of hematite & limonite in limestone	Metasomatic; Cenomanian-Turonian
Lebanon												
1. Saida region	-	-	up to 31.0	-	-	-	-	-	-	-	-	Sedimentary Jurassic or Cenoman
2. Dahr el Baidar 3. Fnaidek	-	-	2-3	up to 48.4	-	-	-	-	-	-	Colites; hematite, limonite	Sedimentary Aptian
PDRY												
2. Wadi Halwal	-	-	>100?	>55.0	-	-	-	-	-	-	Massive, magnetite	Meta-Sedimentary Pre-Cambrian
1. Upper Yaffa	-	-	-	>55.0 up to 61	-	-	-	-	-	-	Massive, magnetite	Meta-Sedinentary pre-Cambrian

Source: Economic Commission for Western Asia, based on data compiled from national and international sources.
* Including inferred reserves

b) Manganese ore:

Manganese is mainly used in ferrous metallurgy, chemical and electrochemical industries, and to a lesser extent in ceramic and paint production.

For industrial use, the following kinds of manganese ore can be identified:

(i) Oxide and oxide-carbonate ore can be considered marketable if the manganese content in crude ore is not less than 17 per cent and if it is possible to obtain the concentrate with a minimum manganese content of 25 per cent. About 90% to 95% of high quality oxide ore ($Mn \geq 40\%$; $P \leq 0.2\%$; $SiO_2 \leq 15\%$) mined in the world is used in the production of ferromanganese or special kind of cast iron (mirror). Chemical industry also uses this kind of ore mainly for the production of dry batteries (MnO_2 content $\geq$ 80-85%).

(ii) Carbonate ore can also be utilized, if it contains not less than 13% and 22% of Mn in crude ore and processed forms respectively. Simultaneously, the maximum SiO_2 content should not exceed 20 per cent.

This kind of ore is frequently used in the production of cast iron (manganese content $>$ 8-12%).

(iii) Siliceous ore is hard to beneficiate and its use is very limited. In some cases, however, it can be used for cast iron production when the sum of Fe and Mn content in the ore exceeds 35% and the SiO_2 content does not amount more than 35%.

World reserves of manganese ore are estimated at 3.3 billion tons. The development of the ferrous metallurgy in the ECWA region will be followed by a growing demand for manganese and, therefore, could be an important area for co-operation.

At the present time, manganese deposits and occurrences are known to exist in Jordan, Syria, Oman, United Arab Emirates, Saudi Arabia and People's Democratic Republic of Yemen.

In J o r d a n , manganese ore has been known for a long time in the eastern side of the Northern Wadi Araba, in the area of the Wadi Dana, about 145 km SSW of Amman. There, a dolomite-limestone-shale formation, correlated with the late Lower Cambrian to Middle Cambrian, contains in its uppermost part a dolomite horizon mineralized with manganese. The compact ore is up to 3m thick and it can grade laterally within a distance of 200m into argillaceous sediments and tends to continue as thin ore interbeds only.

Downwards it passes into individual ore layers, lenses and concretions within reddish shales and argillaceous sandstones.

Manganese ore is also disseminated in the arenaceous dolomite beds below the shales, and appears in a network of joints which intersects the sandstones above the main ore horizon in the Variegated Sandstone Unit (The Upper Nubian time). The ore-bearing rocks cover may square kilometres and they also contain copper mineralization (see item on "copper").

The manganese ore is mainly composed of pyrolusite which is followed by: cryptomelane, ramsdellite, hematite, goethite, calcite, kaolinite and quartz.

The average chemical composition of ore samples collected at Dabbah and Mahjoob is shown below:

	Dabbah	Mahjoob		Dabbah	Mahjoob
SiO_2	3.8%	6.8%	TiO_2	0.1%	0.1
Mn	43.1%	40.7%	V_2O_5	0.01%	0.01%
Fe	10.2%	8.8%	P_2O_5	0.3%	0.1%
Pb	0.8%	0.2%	S	0.1%	0.1%
Ba	2.3%	2.3%	H_2O	0.5%	0.6%
Cu	1.4%	1.5%	H_2O^+	3.5%	3.8%

It was concluded that the ore occurring in certain horizons in the same stratigraphic position is of syngenetic origin and that one filling in the joints of the sandstones above the main ore horizon is thought to be of epigenetic origin.

Although the exploration work conducted by the Natural Resources Authority of Jordan (NRA) proved the existence of 800,000 tons of manganese ore reserves, the economic feasibility of ore production will depend on the results of processing tests for the large-scale separation of Mn - Cu - Fe.

According to the Mining Annual Review (June 1974), total reserves of manganese ore in Jordan are in excess of 5 million tons including 1.5 million tons of ore with 38% Mn and 1.4% Cu. In this connexion it should be mentioned that even these total reserves available in Jordan can be considered as reserves of a small size.

Table No. III Types of Manganese Ore in Bassit Area (Syria)

Types of manganese ore	Shapes of ore bodies	Chemical composition of the ore concentrates (%)							
		Mn	Fe	SiO_2	P	Al_2O_3	CaO	MgO	BaO
I. Micro- and crypto-crystalline, hard, with pyrolusite and relics of manganite psilomelane and wad. Rare nodules and concretions in argillites.	Lenses with a maximum thickness up to 2.5m and length of a few dozens metres	43.64--52.78	0.51--1.33	7.09--16.96	0.005--0.06	0.54--4.54	0.11--3.36	0.16--0.5	0.43--0.83
II. Ore with high SiO_2 content in argillites, radiolarites. Pyrolusite and psilomelane mineralization. (The ore is too hard to be dressed)	Lenticular shape; the size of manganese nodules being 5 x 10 cm.	25.0	-	47.0	-	-	-	-	-
III. The ore bodies are made of radiolarite interrelated with thin, non-persistent streaks, lenses and pockets containing cryptocrystalline manganite, pyrolusite and psilomelane.	Ore bodies of a few metres long and up to 2m thick.	27.0	0.9--3.6	33.4--70.3	0.008--0.015	-	-	-	-

Source: The table is compiled on the data included in "The Geology of Syria", part II, by "Technoexport", Ministry of Geology of the USSR, 1967.

Table No. IV. Manganese Ore Deposits in the ECWA Member Countries

Country, deposits	Reserves million tons ore			Chemical composition (%)								Ore-forming minerals	Shapes of ore bodies	Origin, age.
	probable	proven	total	Mn	Fe	Cu	Pb	Ba	V_2O_5	P_2O_5	S			
Jordan														
Dana	(2.7)*	0.8 (1.5)*	(5.0)*	40.7 -43.1	8.8- -10.2	1.39- -1.50	up to 0.78	2.33	0.01	0.14- -0.30	0.10- -0.12	Pyrolusite, psilomelane ramsdellite	Compact ore; layers, lenses and concretions	Sedimentary, late Lower to Middle Cambrian. Ore occurs mainly on the top of sandy dolomite and clay shale horizon.
Syria				Mn	Fe	SiO_2	Al_2O_3	CaO	MgO	P	BaO			
Bassit area	0.02	-	0.02	29.8	1.33	43.9	3.00	0.61	0.26	0.007	0.32	Pyrolusite, psilomelane, wad, manganite.	Small blocks, and lenticular bodies.	Volcanic-sedimentary series of Mesosoic ophiolite formation.

* Including reserves, probably of Salawan and Khirbet El Nahas areas.

Source: Economic Commission for Western Asia, based on data compiled from national and international sources.

Numerous manganese occurrences and deposits in S y r i a are solely located in Bassit area, where they had been mined in the past and where most of the reserves have, to a large extent or entirely, been depleted. The ore-bearing formation consists of a volcanic-sedimentary series of the Mesozoic Ophiolite formation, including clayey-siliceous and siliceous rocks with which manganese mineralization is related spatially and genetically. The ore bearing bodies are generally of a few metres to a few dozens of metres long and from 2cm to 1.5m thick. In siliceous and clayey-siliceous rocks, mineralized beds may have a thickness of 2 to 2.5m and a length of 50 to 200m. The amount of ore extracted from most of mined pits was extremely small, not exceeding a few tons. The ore bodies are broken into many small blocks and the original structural lenses are extremely hard to be traced and outlined. According to the shape of the deposits and mainly to the characteristics of their structure and quality, the ores may be divided into three grades as shown in Table No. III.

Judging from the average chemical composition of the manganese ore in this area, it can be classified as a poor, silica-manganese ore. Taking into consideration the fact that its geological reserves do not exceed 20,000 tons composing numerous small and very small occurrences, this area cannot be considered as an economically promising one. The self-sufficiency problem in manganese raw materials for the Syrian metallurgical industry remains unsolved.

In O m a n , a manganese deposit which was discovered in Ras-Al-Hadd, was studied and evaluated in 1969, 1973 and 1974 by experts, but results are not yet available.

Several manganese oxide lenses were discovered in metamorphic rocks in the U n i t e d A r a b E m i r a t e s north of Asimah. The largest one forms a ridge, 80 metres long and up to 10.5 metres thick. The strike of the lens is 348° and it dips 40° westwards beneath quartz schists. The main lens pinches out at its northern end and tapers more gradually in the south. Above and below, the lenses become progressively more siliceous and grade into quartzitic schists.

Manganese deposits were also found in Wadi Hatta (Hawasina series). They consists of avoid siliceous black nodules inside a white crystalline silica matrix. Until the present time, the commercial value of those deposits is not clear, but preliminary geological investigations showed that the discovery of manganese deposits of commercial grade is possible.

Manganese oxide mineralization in Saudi Arabia is located in Wadi Bidah. A noteworthy lens of manganese oxides lies on the flank of a quartz-hematite jaspilite reef west of Al Tawilah. This lens is as much as 3m wide and extends over a distance of 500m. Analysis show 9.9% content of Mn and 9.5% - 16.8% of iron.

According to Mining Magazine (June 1976), Hunting Geology and Geophysics Ltd. of the UK undertook exploration work for manganese in Maabir-Chabar area in People's Democratic Republic of Yemen, but no information on this is available yet.

c) Titanium ore*

Titanium, due to its properties: low specific weight, great absolute strength, high degree of hardness, low thermal conductivity, resistance to corrosion and high fusion temperature; is utilized in various industries, including such as metallurgy, which produces titanium alloys with Al, Mg, Cr, Cu, Ni, Co, Fe, Mo, W, As, etc. Metallic titanium and some of its alloys are excellent constructional materials which are used in aircraft, shipbuilding and in a number of other modern industries.

Large quantity of titanium dioxide is utilized for production of titanium white, and as a filler in the manufacture of rubber, paper and plastics.

At present, about 75% of the total of 660 million tons of titanium reserves (in dioxide equivalent) located in the Western and developing countries, are mainly in primary deposits containing ilmenite and titanomagnetite ores. According to the world practice, titanium ore of primary deposits is considered to be of commercial value if TiO_2 content exceeds 10% and the percentage of the ilmenite and rutile concentrates exctracted from the ore after mechanical benificiation is not less than 10 and 15 per cent respectively.

Placer deposits are economically more convenient for exploitation and beneficiation than the primary ones. Cutoff grade of TiO_2 or its equivalent for this kind of deposits is about 20kg per ton of sand. Value of titanium ore could be higher due to the presence of other recoverable useful components contained in it, including cassiterite, staurelite, zicron, monazite, sillimanite (in placer deposits); magnetite, vanadium minerals and to a lower extent - apatite (in primary deposits).

High quality ilmenite concentrate is required to meet the following specifications:

Cr_2O_3, P_2O_5	$< n0.01\%$	SiO_2	$< 1\%$
Al_2O_3	$< 3\%$	MgO	$< 1.5 - 2\%$
S	$< 0.1\%$	$Fe_2O_3 + FeO$	$< 45\%$
V_2O_5, ZrO_2, MnO, CaO	$< n0.1\%$	FeO/Fe_2O_3	~ 0.9

During some last years, the world production of rulite and ilmenite concentrates (calculated in TiO_2 equivalent, with 50-60% content) reached about 3.5 million tons per year.

In the territory of the ECWA region placer deposits located along the seashore were found, but their economic value is not yet known. Some promising occurences for primary titanium ore also exist.

* This item includes description of beach sands containing also other heavy minerals such as zicon, rutile etc.

The People's Democratic Republic of Yemen has some deposits containing titanium ores:

- Makeyras deposit was discovered in 1975 and in 1976 detailed geological and geophysical exploration at 1:20000 - 1:10000 scale has been accomplished. Separate sectors of the deposit were covered with trenching and exploration holes at the scale 1:2000.

Titanomagnetite mineralization is confined to the differential complex of gabbroid rocks, occupying the central part of a large gabbro-diabasic intrusion and in particular to plagiopyroxenites, trachytoid and melanocratic gabbros. Mineralized zone has a shape of elongated body with a size of 400m x 1000m and is identified to 350 m depth. The preliminary laboratory analysis revealed that the deposit contains encouraging rations of titanium and iron oxide and apatite.

- Moura deposit situated at the Wadi Yahar was discovered and studied during 1975-76.

The eastern part of the deposit contains titanium, iron, nickel, vanadium and apatite mineralization, extending to 1500 m. in length and to 200 m. above the Wadi, its thickness is about 94 m.

The western panel has, apart of titanium and iron, a high content of nickel and vanadium and some quantity of chromium. The size of outcropping part of the deposit is 40x50x200m, it is supposed, that the mineralization would be identified at least to 100 m in depth.

The mineralization in both cases is concentrated in diorite and gabbro diorite intursion. Drilling and detailed geological and geophysical investigation are under way.

As a result of reconnaissance work carried out in 1973 by Yemeni and Soviet Geologists and in 1976 by Hunting Geologists (GB) a discovery was made and a preliminary evaluation carried out of placer deposits, located along the Eastern part of the coastline and containing potential sources of ilminite, rutile and monazite.

- Sifal deposit situated at a distance of 10 km south-west of Mukalla, contaings grey-black sands up to 250 in width, extending at the distance of 3km. The highest content of heavy minerals, including zircon, rutile, leucoxene occurs in the upper part of sediments.

- Raydat deposit situated 150km east of Mukalla and extends over 18km in length, covering 50 to 870m width of a seaward margin coastal plane. The forebeach is backed by a yellow dunes about 100-150m wide beyond which there is a zone of grey dune sand, containing the highest concentration of heavy minerals. The most promising area occurs between Wadi Haidh at Al Aiq and Wadi Rhekhnit at the distance of approximately 7 km, where the dunes range between 300 and 800m in width.

- Sayhut deposit lies about 250 km east of Mukalla, has 18 km in length. The setting of the mineralized sand is similar to Raydat.
- Al-Chaydah Beach deposit is extended over 120 km and appears to be accompanied by substantial dune development. The reserves of ilminite, zircon, rutile, leucoxene and monozite of that deposit are small. The same could be said about Kishn deposit located at the same area.

As to the Western part of the coastline, according to the results of the reconnaissance work, considerable heavy minerals concentration in the recent seaside marine terrace and dunes were discovered in the areas Imran, Kharag, Abay, Ahway and Tika-Hawra. Prospecting work on those districts have not been done, but the tentative evaluation of possible reserves could be as much as some million tons.

In S a u d i A r a b i a , titanomagnetite occurs in a gabbro layered intrusion, a complex bowl-shaped pluton, situated at 90 km to the east of Al-Qunfudhah. Pluton (10 km in diameter) has a small pyroxenite core, a layered intermediate zone of diorite and gabbro, and a syenitic peripheral part. Titaniferrous magnetite is concentrated in the pyroxenite core and in several zones of the dioritic and gabbroic units. Some rock samples which were taken from the surface showed 16.7 per cent and 45 per cent of TiO_2 and Fe content respectively. Average content of TiO_2 in drill cores is 16.5 per cent (between 8 and 30 per cent). Furthermore, pyrite, chalcopyrite contents average 1 per cent throughout most of the core. Titanium and iron occur together mainly in a single spinel phase concentrated predominantly in the central pyroxenite core, which is about 500 m wide and 1500 m long, containing lenses of titanomagnetite with size of 5 x 54 metres. The economic value of the deposit is not yetclear..

d) Chromium ore:

Chromium mineral raw material is utilized in metallurgical, refractory and chemical industries. Ferrous and non-ferrous metallurgy uses about 50 per cent of the world chromium ore output in the production of alloys with nickel, cobalt, aluminium, tungsten and molybdenum. Ferrochrome (65-70% Cr) is used in large scale for the production of special kinds of steel, for which 2-3 kg of ferrochrome per ton of steel are required.

As a refractory material, chromite (the only chromium imdustrial mineral) is used as an inside cover to open-hearth furnaces and in furnaces designed for smelting of non-ferrous metals. The proportion of utilization of the world chromium ore production for these purposes is about 40%.

The chemical industry utilizes about 10 per cent of the world production of the chromium ore in the manufacturing of chemical combinations, chromium paints and materials for leather tanning.

At the present time, in the ECWA region, there are no exploitable chromium deposits although, mining operations for chromium ore took place earlier in Syria, Oman and Saudi Arabia; and promising areas and occurences are available in these as well as some other countries of the region.

In O m a n , chromium mineralization is related to the large ophiolite belt and extends over 600 km along the north-eastern coast.

All the chromium occurences and deposits are situated mostly in the northern part of this belt, where the ophiolite units form a great nappe, covering non-metamorphic and some metamorphic series of rocks.

Table No. V.

Main Specifications for Chromium Ore

Utilizing industries	Final products	Main specifications: Cr_2O_3 content (%)	Cr_2O_3/FeO ratio	SiO_2 content (%)	CaO content (%)	Fe_2O_3 content	Percentage of utilization of total world production
Metallurgy*	Alloys	$>40-50$	$>2,5-3$	-	-	-	50%
	Ferrochrome	$>35-40$					
Refractory	Chromite as a natural refractory material	>35	it is possible to use material with ratio <2	$<8-11$	$<1-3$	<14	40%
	-chromite and chrome -magnesite bricks	<35 applicable					
Chemistry	Paints, leather tanning and materials, catalysers, radioactive isotopes, etc.	$>32-44$		$<5-8$	-	<16	10%

* The most valuable chromium ore for metallurgy is Mg-chromite, which can be beneficiated to the grade required, even if Cr_2O_3 content is low ($\sim$12%).

Tectonic dislocations of the ophiolite complex, which led to the present location, took place in Campanian and Late Maestrichtian time. Lower part of the ophiolite sequences is represented by peridotite series and gabbro, which is intruded by dolerite dike swarms and covered by pillow lavas.

The chromium deposits of the northern Oman mountains differ in their mode of occurence, which is very distinctive for the Alpian ultrabasic massives as a whole.

The main morphological types of the chromium ore in Oman can be shown as follows:

(i) Stringers of tabular and pod-like bodies have a length of some hundred metres and contain up to hundred thousand tons of ore, transforming in places into "Schlieren platte" or into high or low grade disseminated ores. As a rule, the ore is of a higher grade in the lower part of the ore bodies.

(ii) Podiform-type deposits are represented by ore bodies, containing some hundred kilos to some thousand tons of chromium ore. As usual, they are of lenticular form with long axes parallel to lineation of the country rocks. Smaller lenses were formed as "ball-bearings" during tectonic movements and are usually limited to shear or fault planes. The size of the transition zone, containing scattered ores can vary within a large scale from a few centimetres to a few metres.

(iii) Isolated crystals or small fragments of chromite scattered in dunite or in serpentinous dunite. The chromite content is not more than 20 per cent of the total volume of the rock, and outcrops do not exceed $20m^2$.

(iv) Dike-like deposits have sharp contacts between massive chromite ores and country rocks. They are, as usual, associated with other types of deposits.

Most of the chromite bodies are located in the upper part of peridotite-serpentinite complex in dunites.

Among many chromite occurences and deposits in Oman, the Farfar area has been investigated in more detail. There, five chromite deposits occur within an area of less than 1 km^2 in a precipitous terrain to the east of Farfar village. These deposits are as follows:

- Farfar I contains stratiform type mineralization, forming an ore body which dips gently to the north. Its thickness averages 10-15 m, but gradual thinning takes place to the west along an estimated strike length of 150 m. The down-dip extent of mineralization cannot be determined owing to thick overburden and lack of a suitable stream section. Contacts between ores and host rocks are sharp and show evidence of shearing and desplacement by faults.

Visual estimations suggest an average content of about 70-90 per cent chromite crystals, usually aggregated, with an average diameter of 4 mm.

Assuming that 20 m of down-dip mineralization is proved, then 160,000 tons of ore may be found enough to make this deposit economically exploitable. However, only further chemical examination could evaluate the ores from their quality and commercial values of view. But, preliminary testing showed that the ore has, on average, a very low content of Cr_2O_3 and a high content of Fe for it to be considered of metallurgical grade. Possibilities to use this kind of ore in other fields of industry are not clear.

- Farfar II consists of thin lenses, stringers and disseminations of chromite in the host peridotite.

- Farfar III occupies a knoll at the crest of a serpentine ridge. It is of padiform type with a maximum thickness of 2 m and a length of about 6 m.

Farfar IV is of podiform type with a maximum width of 1 m and a length of about 10 m.

- Farfar V contains bended chromite bodies ranging in thickness from 2mm to 20cm. The chromite layers alternate with dunite, which also forms the gangue within the ore bands. Zones of incipient concentration of chromite were noticed in the peridotites up to a metre from the main outcrop of banded ore. Chemical analysis showed high silica and magnesia contents and low percentage of chromite.

- The Jinah chromite deposit situated outside of the Farfar area is of podiform type and has a maximum thickness of 10m tapering gradually along a lateral extension of about 50m. Rough visual estimations of chromite content suggest a grade of approximately 80-90 per cent, so in some places, the olivine/serpentine gangue is completely absent. Assuming an underground mineralization of 10m length, rough calculations suggest that about 10 to 20 thousand tons of chromite may be found. This quantity is rather small to justify commercial exploitation unless the grade of ore is particularly high. Chemical analyses of some samples of 80 per cent pure ore taken from this deposit indicate that the refractory grade of the ore contains a high proportion of Fe.

- One more small deposit consisting of three chromite bands was found in the Wadi Ajran. The largest band is 10cm thick and thins laterally to a stringer of chromite grains. All bands are sheared and faulted against a host of chromite poor peridotite.

Table No. VI. Chemical Composition of Chromium Ore Samples from Deposits in the Sultanate of Oman

Deposits	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Moisture	Cr_2O_3	NiO	Kinds of analyzed samples
Wadi Wasit*	2.43	17.20	15.30	16.80	0.20	0.09	47.90	0.20	Float of massive ore; 10-20% gangue
Farfar I									
Top part	9.18	16.90	15.00	20.10	0.42	2.96	34.90	0.19	Massive ore; 10-20% gangue
Middle part	5.57	20.60	14.30	17.60	1.04	0.78	39.60	0.18	Massive ore; 15-20% gangue
Base part	0.25	19.90	14.30	17.70	1.18	3.03	36.70	0.17	Massive ore; 10-20% gangue
Farfar V	14.90	11.20	12.20	28.30	0.28	5.18	25.20	0.27	Banded chromite/dunite sample
Jinah	4.02	22.50	13.60	16.10	2.74	1.93	37.50	0.19	Massive ore; no gangue observed
	2.41	24.00	14.40	15.80	1.67	1.68	38.60	0.20	Massive ore; 10-20% gangue

Source: J.N. Carney and M.J.P. Welland, "Geology and Mineral Resources of the Oman Mountains" 5 Princess Gate, London SW 7 1QN, 1974.

* No other information is available on this deposit.

Among these deposits, Farfar I can be considered as one of economic value. But the complex chemical composition of the ore and the location of the deposit in a particularly inaccessible part of the mountains would pose considerable problems to exploitation.

The Jinah chromite deposit is easily accessible, but is small in size. A preliminary evaluation of this deposit indicated that the ore is rather of low grade. The following table shows the chemical composition of chromium ore in various deposits in Oman. (See Table No. VI).

In the United Arab Emirates the majority of chromite occurrences are associated with the ultrabasic rocks of the Semail Ophiolite Suite, trending to the north, and stretching from Masfut to Manama. Seven localities were reported in this area including: Manama, Siji, Shawkah, Ushail, Namfaria, Masfut 1 and Masfut 2. Chromite mineralization occurs in forms ranging from elongate lensoid, almost tabular bodies, to smaller lenses and pads.

Chromiferrous beach sands were found along the shore lines south of Diba and Ras Al Khaymah. Chromite concentrations form lenses and streaks of variable thickness with a maximum of 10 cm.

Results of chemical analyses of samples containing chromite show that the quality of the chromite ore appears to be rather high and can therefore be utilized by metallurgical, refractory and chemical industries.

Further investigations in this region could lead to the discovery of new commercially exploitable chromite deposits.

Table No. VII Chemical Composition of Chromium Ores from various areas of the United Arab Emirates

Locality	Cr_2O_3%	FeO%	Al_2O_3%	SiO_2%	MgO%
Shawkah	34.11	14.83	10.19	8.44	17.73
Shawkah	41.20	16.26	10.00	6.00	15.71
Shawkah	42.74	15.97	10.47	9.24	18.54
	36.70	14.97	9.91	9.23	17.73
Siji	51.46	16.98	11.58	1.48	14.51
Siji	51.03	16.84	13.61	1.92	16.12
Ramla	41.02	16.84	12.04	1.72	14.51
Ushail	33.51	15.83	13.25	4.68	16.92
Hamfaria	34.54	16.55	10.47	1.92	15.71
Jabal Qamar	55.58	13.81	9.91	4.24	15.71
Beach Sand East Coast	14.54	12.81	3.06	15.24	21.50
Beach Sand West Coast	15.99	30.51	7.97	4.16	8.46
West Coast	11.57	19.86	7.69	8.52	8.46
Manama	44.86	16.84	11.58	1.32	14.89

- Chromite ore has been found in the northern part of Hijaz, in the Kingdom of Saudi Arabia, where its mineralization is associated with ultrabasic intrusive complexes. Ore bodies form lenses, lenticular layers and schlieren in dunite serpentinite of a large (25 km x 50 km) basic and ultrabasic intrusive; and also from conformable layers, impregnations and monocrystalline formations in serpentinized dunite among non-mineralized pyroxenite. This series is identified as Alpian type and its geological position is related to drift movement.

According to chemical analyses made on 144 samples, four groups of chromite have been identified.

Table No. VIII Chemical Composition of Chromium Ores from the Northern Hijaz Occurrences (Saudi Arabia)

Chemical contents	Groups of ores classified according to Cr/Fe ratio			
	Cr/Fe 2.2	Cr/Fe: 2.2-3.2	Cr/Fe: 3.2-4.2	Cr/Fe 4.2
Cr_2O_3	51.65	54.24	56.62	60.19
Al_2O_3	15.00	14.92	12.65	10.03
Fe_2O_3	5.71	4.14	3.83	3.20
MgO	13.05	13.30	13.92	14.63
FeO	14.29	13.80	12.58	10.88

Source: Neary C.R., "Chromite from a serpentinite body in the northern Hijaz of Saudi Arabia". 17th Annual Report, Research Institute, African Geology Department, Earth Science University, Leeds, 1973.

- Earlier, it was reported about chromite segregations which are found in Pre-Cambrian peridotites near Wadi Tulayl situated about 440 km north-northwest of Jeddah. The mineralization is massive or in small aggregates. The massive ores range in size up to tens of metres in length. The total indicated tonnage is small, with one deposit of 10,000 tons, others exceeding 1,000 tons and many others with a negligible aggrotate tonnage. Average grade calculated from 104 analyses was 39.7 per cent Cr_2O_3 with Cr/Fe ratio of 2.1. The deposits are not of economic value.

There are other locations of ultrabsic and basic Pre-Cambrian intrusive rocks (Hijaz mountains, near Al'Ays and near Hamdah - 530 km southeast of Jeddah), which are promising for chromium.

In Syria, chromium mineralization is located in the north-western part of the country in Bassit area where more than 190 other Cr occurences were found. The most significant one is situated in the vicinity of the town of Kurd Dagh, relating to serpentinized peridotite of harzburgite composition.

Ore bodies have a similar shape in all localities: flat veins, lenses and packets. Examination of locations where previous field work was undertaken indicated little mineralization. The bodies are generally 1 to 20 m long, 0.2 to 0.5 m thick with some patches devoid of ore. A distinctive feature of most ore occurences is their association with primary striation in peridotite.

The investigation of the chromium ore occurences shows that most of these had been exploited and only a few workings contain remains of ore bodies, not interesting for explorations and mining. The amount of ore in some bodies is limited and in most occurences, the number of ore bodies does not exceed few dozens with estimated reserves of hundreds of tons. Newly discovered bodies are also small. Only one occurence (north of Zetounjig) may have reserves of several hundred tons. The ore consists of chromite, pyrrhotite, chalcopyrite, pyrite, magnetite, goethite, hydrogoethite and hematite.

The chemical analyses of 112 ore samples have given the following contents:

Cr_2O_3	4.7 to 53.65	CaO	0.48 to 3.91
FeO	4.4 to 23.90	S	0.01 to 0.068
SiO_2	0.5 to 47.78	P	0.00 to 3.02
Al_2O_3	0.76 to 47.78	NiO	0.105 to 3.16
MgO	1.48 to 28.08	TiO_2	0.030 to 0.314

The most usual content of Cr_2O_3 is 30 to 40 per cent and that of FeO - 10 to 15 per cent.

In spite of large amount of prospection work done in Bassit, no commercial chromium deposits have yet been discovered. The amount of ore which has been produced in small pits in the area is not known exactly. Judging from dimensions of all the pits, the amount of ore produced in the area is estimated at 5000 tons. The character of mineralization does not change with depth.

Analysis of the Syrian chromite situation is continuing, but until now no results of any economic value have been obtained.

Preliminary investigations for metallic and industrial minerals in Dubai, Ras al Khaymah, Ajman, Umm al Quawain, Fujairah and Sharjah, were undertaken by Hunting Geology and Geophysica Ltd. of the UK as part of a £ 200,000 contract awarded by the government of the United Arab Emirates. These investigations led to the discovery of rich chromite ores. The new occurrences are probably located in the same ophiolite belt as those of Oman.

Existence of chromite deposits of no economic value have also been proven in Jordan.

2. Development of the ferrous industry

Development of the ferrous industry in the ECWA region faces the problem of keeping enterprises supplied with local mineral raw materials in general and with iron ore in particular.

Since none of the ECWA member countries has economically exploitable iron ore deposits at the present time, establishment of metallurgical plants is mainly oriented towards the utilization of imported iron ore or pellets. For the transportation of these, it is planned to use large tonnage ships (120,000 - 300,000 displacement tons).

One of the important advantages of some countries in the ECWA region is the availability of enormous cheap gas reserves which, when used in a direct reduction process for iron production, would result in saving US$ 10.- per ton of iron produced. This method offers possibilities for establishing profitable "mini-plants" of a relatively small capacity, but which would be enought to meet local demand.

It was also calculated, that the capital expenditure for non-integrated small mills employing direct reduction process approximates US$ 100.- per ton produced annually, which is on par with the related figures for large steel mills of Japan.

As regards small, non-integrated mills, not employing direct reduction of iron ore and with annual production capacity between 300,000 and 400,000 tons, the capital expenditures per ton annually produced can reach $ 150.-

Based on the use of local gas reserves in metallurgical processes, some large metallurgical complexes are being constructed, the production of which is expected to be exported.

In December 1973, the I r a q i government signed a contract worth 600 million francs with the French company "Le Creusot - Loitre" for the construction of a semi-integrated steel mill at Knor El Zubair, 22 km from Umm Kasr, the annual production capacity of which, in the first stage, will reach 400,000 tons of steel. A second contract, of over one billion french francs, was signed in September 1974, with the same company, for the construction of two mills to produce steel wool with a capacity of 400,000 tons and 750,000 tons per year. Part of that production is planned to be exported to France. Contracts to deliver pellets and iron ore have been concluded with different iron ore producing countries including India, Indonesia, Mauritania, Brazil and Sudan. The programme also includes construction of related seaport facilities, including a new deep-water berthage for ships of 100,000 displacement tons. For these purposes, the Iraqi government decided to establish "The General Company for Iron and Steel".

Meanwhile, it is expected that steel and iron imports will increase both in quantity and value as illustrated in the following table:

Table No. IX - Iraqi Imports of Iron and Steel

Years	Import (thousand tons)	Cost per ton (ID)	Total cost (thousand ID)
1975	569	95.5	54,340.-
1980	848	110.7	93,874.-
1985	1354	128.3	173,718.-
1990	2271	148.8	337,925.-

Source: "Al Sinai", published by Iraqi Federation of Industries, No. 3, 1973.

Keeping the iron and steel industry adequately supplied with local iron ores remains a task of first priority.

In Saudi Arabia, the national company "Petromin" and Marcona Corporation recommended, after an economic evaluation of the development and use of iron ore in the country, the importation of iron ore for the operation of future metallurgical complexes in the Kingdom.

At the beginning of 1974, and for this purpose, "Marcona Ground" and "Petromin" signed an agreement concerning the establishment of metallurgical enterprises located at 10km to the north of Al-Jebail in the eastern part of the country with an annual capacity ranging from 1 to 10 million tons of steel. At the beginning, the planned capacity of the complex is to be : 250,000 tons of billets, 150,000 tons of slabs, 300,000 tons of welded spiral pipes; 250,000 tons of plates; and 150,000 tons of concrete rounds.

It was agreed that the planned enterprises would also produce about 3 million tons of pellets, all of which will be exported. Responsibilities of the five companies, members of the Marcona group, are shared among themselves in the following manner:

1. Marcona Corporation: mining, trading and delivering of iron ore from Brazil to the region, east of Ras Tannura, from which oil will also be exported by the same ships.

2. "Nippon Steel": production of steel, concrete rounds and welded spiral pipes.

3. "Nippon Kokan": production of plates and spiral welded pipes.

4. "Gilmore Steel Corporation" (US) steel production in electric furnaces.

5. "Estel" (Western-Germany - Denmark): production of welded spiral pipes.

The ore will be delivered by tankers of 250-300 thousand displacement tons.

For the use of direct reduction method ("Midrex") and steel production, gas from the region east of El-Berry is to be utilized, the annual consumption of which will range between 750,000 to 800,000 cubic metres.

It is expected that about 2000 people will be employed at the complex, after completion of its construction in 1978.

Based on the steel production, construction of a car assembly plant, of a shipyard aimed at producing ships of 350 thousand displacement tons and production of galvanized steel sheets, are being planned.

The Syrian government has planned the construction of an integrated iron mill in Mama, located between Aleppo and Damascus, which will have, in the first stage, an annual capacity of 300,000 tons of iron and steel, including 140,000 tons of cast iron. After the implementation of the second phase of the construction, the complex will produce annually 140,000 tons of billets, 250,000 tons of shapes, 135,000 tons of sheets and 10,000 tons of cast iron.

The project will cost 1,020 million S.P. and will be completed in 1987. It was calculated that the total sales of this complex will reach 356 million S.P., the value of inputs used in the production process totalling 215 million S.P. and the yearly consumption estimated at 48 million S.P. The annual value added will, therefore, be 93 million S.P., and about 4000 people are likely to be employed. It is expected that about 40 to 60 per cent of the country's demostic demand of iron and steel, which will reach 730,000 tons in 1980, will be met by the production of this mill which in turn will be dependent on imported iron ore.

In Kuwait, the Kuwaiti Iron and Steel Co. started the construction of a mill in Suheiba with a capacity ranging from 300,000 tons to 400,000 tons of billets, bars, wires and light sections. The Kuwaiti government has entrusted the French Iron and Steel Research Institute with the task of carrying out studies on the production of one million tons per year of sponge iron for export by using of iron ore pellets which are to be produced in Kuwait also from imported material. For these purposes, hydrogen gas from the petrochemical plants will be used as a reductant.

The number of shareholders of Kuwaiti Iron and Steel Co. exceeds 650, including the government of Kuwait, which contributed 3 million K.D.

of a total of 15 million K.D. (US $ 50 million). Citizens of Kuwait, UAE and Bahrain can only be shareholders in the Company.

In the State of Qatar, Qatar Steel has began the construction of a modern direct reduction steel plant costing $ 140 million in Umm Said with production capacity of about 400,000 tons of billets, bars and shapes per year, 75,000 of which will be locally consumed. The plant was expected to start operation in 1977. Japanese companies "Kobe Steel", and "Tokyo Bocki" are participating in the implementation of this project.

3, Non-ferrous metal ores

a) Copper

Copper plays an important role in world economy, being second in value in world trade to petroleum. In 1976 world copper reserves were estimated at about 450 million tons; 67% of which are in currently producing mines; 13% are in projects under construction and 20% in other deposits for which sufficient information is available to assume with reasonable assurance that exploitation is feasible under present conditions.

Developing countries are endowed with nearly 60% of world copper reserves accounting for more than 1.5 times their share of world output.

During the last 10 years new copper deposits most of which are of the copper porphyric type, containing melibdenium, and sometimes gold or silver, were discovered in more than 30 countries of the world.

The average minimum value of copper ore which permits economic exploitation at the present time is 4.4 and 14.3 in dollar equivalent for open pit and for underground operations respectively. The respective average value of ore for these operations were calculated on the basis of a sample of 81 copper projects to be 9.5 and 27.7 in dollar equivalent. 1/ This implies that the content of copper in the first case would be between 0.35% and 1.1%; and on the basis of the above sample the average copper content for open cost and underground operations is 0.76% and 2.2% respectively.

1/ Calculation was made on the basis of world prices prevailing in 1970-1974, of refined copper and metals (Mo, Au, Ag) with copper porphyric deposits.

The development of copper mineral resources in the Arab countries was given a particular attention by the Second Arab Conference on Mineral Resources held in Jeddah in 1974 and on which the resolution concerned the copper was adopted:

- requested that the Arab States secure scientific and technical co-operation between the Arab Mashriq and the Arab Maghreb in the fields of prospection, exploitation and processing of copper and other metals;

- called the attention of Arab States to the importance of using the most modern scientific and technological methods in prospecting for copper and of assessing their reserves in the soil or seabeds;

- called upon Arab States to provide and encourage the necessary capital with a view to developing existing mines; to provide the necessary capital for exploring, prospecting, exploiting, and processing copper ores, either through bilateral or multilateral co-operation;

- requested the Arab States to co-operate in the extraction of copper ores and other metals by establishing joint industries to meet Arab requirements and to give priority to the needs of Arab industrialists by providing them with their requirements in raw materials from the Arab countries.

The importance and the implementation of this resolution depends on the availability of copper reserves in the Arab World.

In the ECWA region, and until the present time, no copper deposits have yet been developed. However, some countries may in the coming few years start, with the help of western companies, the exploitation of copper.

Other countries will start prospecting for and exploration of copper deposits, leading eventually to copper mining in the near future.

During the last 15-20 years in Saudi Arabia, several hundreds of copper occurrences were discovered in the area of the Arabian Shield. All of them were formed during late Pre-Cambrian time (Hijaz or Bishah orogen cycles), and are represented by metasomatic and vein type mineralization with sulphides. In spite of numerous copper ore manifestations, only some of them can be considered as promising ones and are worthy of further development.

- One of the largest copper deposits, at Jabal Sayid, 300km north-east of Jeddah, was discovered in 1965 by BRGM. It occurs within the Hulayfah

Group (Pre-Cambrian) composed in the area predominantly of basic and felsic pyroclastics, principally of keratophyric to rhyolitic composition, together with volcano-sedimentary clastic rocks, that lie between an ophiolitic complex to the north and a granitic massive to the south.

The rocks in the deposit have been folded into a complex semi-circular anticlinal arc, in which most of the beds dip 70^{0} - 90^{0}. This local anticline is cut by two major faults: one of them trends NE 70^{0} and it displaced eastwards the northern extremity of the Main Gossan for a distance of about 400 m; the other one trending NW 50^{0} displaced north-westwards the hydrothermally altered rocks and the jasper for a distance of about 30m.

Three of the four known mineralized zones are at the same stratigraphic position and mainly comprise massive pyrite-sphalerite ores associated with chert that marks the contacts between the acid tuff and breccia of the footwall and the welded tuffs of the hanging wall. The second one is pyrite-chalcopyrite stringers in the altered footwall. The third zone consists of lenses of pyrite-pyrhotite with accessory chalcopyrite and sphalerite in younger dacitic rocks.

Only two of the three mentioned zones appear to contain economic grades of copper and zinc. Reserves in those zones have been estimated as 8 million tons at 2.2% of Cu, 1.4% Zn., 40g/ton silver, and 0.5g/ton gold. The largest reserves of copper ore have been ascertained in the fourth zone where mineralization grades 1.5% - 2.5% cu.

According to the drilling data, mineralized area reaches up to 200 metres in thickness and contains total reserves, including probable ones, as much as 40 million tons.

Between 1967 and 1964, 55 drillholes were sunk at the deposit, totalling 24,021m, and 9,449 are tested for copper, zinc, gold and silver.

During the 1970-1973 period, a newly developed geophysical method, MELOS, was applied by BRGM.

Insufficient data on the size, grade of ore, metallurgical concentration characteristics, water resources and economic evaluation, prevent immediate development of this deposit. The problem of water supply could be solved as large water reserves have been discovered in alluvial sediments at Ad Dhumariyah.

Thickness of aquifer lying at a depth of 20-30 metres is of about 80 m.

In 1974 an exploration license was granted for five years to Societé d'Etudes et d'Exploitations Minieres and the United States Steel Corporation. Further work will be carried out by the above mining companies, for which about SR 20 million will be needed. But before the mining operation is started, about 7-8 years will be required.1/

If in the course of further work, the deposit's probable reserves are proven, it could be classified as a big one by generally accepted standards.

In such a case, the deposit could be exploited at a rate of 1.6-2.0 million tons of ore per year, depending on the mining method employed (underground or open pit).

For the construction of the mining and processing complex with the necessary infrastructure, more than 90 million dollars of investment capital will be needed and construction of refinery will require about 80-100 million dollars more2/. Eight hundred thousand tons of proven reserves of ore estimated at the present stage of exploration is not enough to undertake economical mining operation.

- Nuqrah (area) is located on the Najd Plateua at a distance of 500km NNE from Jeddah. There are two groups of deposits: North and South Nuqrah lying at a five kilometre distance from each other. Complex sulphide mineralization occurs in the pyroclastic Halaban Formation (Pre-Cambrian)

1/ "Economic Status of Mineral Deposits of Western Saudi Arabia", TR-1974-1, Ministry of Petroleum and Mineral Resources.

2/ Estimation is based on the data published in "Economics of development of copper, lead and zinc ore deposits", V. Zotov, Moscow, 1974.

comprising massive and disseminated interstratified ore bodies with chalcopyrite, pyrite, sphalerite, galena and with a varying content of gold and silver.

- North Nuqrah (Lat 25° 38' 30''N.; Long. 41° 26' 20''E) deposit consists of south and north ore fields with possible reserves 175,000 tons each, containing on average:

	South field	North field
Cu	1.97%	0.66%
Pb	1.74%	3.01%
Zn	16.6%	4.7%
Au	2.1 g/t	1.14 g/t
Ag	89 g/t	260 g/t

- In South Nuqrah, (Lat 25° 35' 45''N; 41° 26' 20''E), the possible reserves, larger than those of Nuqrah North, reach 1 million tons, with the following average grades of metals: Cu - 1.2%, Pb - 3.44%, Zn - 7.6%, Au - 5.86 g/t, Ag - 235 g/t.

Further work will aim at investigation of a possible existence of ore bodies between North and South Nuqrah and in the deeper zones of the known mineralized areas, and at the determination of concentration characteristics and providing feasibility studies. After granting of an exploration licence in 1974 to Nippon Mining Co. Ltd. and Mitsui Co. Ltd., it was surrendered in 1975 because the companies failed to prove extensions to the reserves and considered the known reserves too small to repay mining. Subsequent work by the Ministry has also failed to prove any significant additions to the reserves. In 1977 Granges AB has applied for an exploration licence which is still under consideration. According to an analysis of exploration and development of 85 copper, lead and zinc deposits undertaken in 31 countries of the world during the last 7 to 10 years, it could be deduced that the value of ore in North and South Nuqrah is the richest from among of the above mentioned exceeding them in this respect by 5 and 7 times on average, and in spite of the small reserves, these deposits can be considered by world-wide experience as economically exploitable even if South Nuqrah deposit is considered separately.

The existing reserves in both deposits from that point of view can be economically exploited for a period of 10 to 12 years at a rate of 100 to 140 thousand tons of copper ore per annum. Smelting and refinery operations are not advisable due to small ore reserves. Rough estimation of required capital expenditure, based on world current experience, would reach about $ 15 million, including the establishment of a processing plant, infrastructure and preparations for underground mining.

- Wadi Bidah mining district lies within a large north-trending faulted belt in the southern Hijaz of Western Saudi Arabia, bounded by co-ordinates 20° 22' and 20°48'N and 41° 20' and 41°27'E.

Pre-Cambrian metavolcanic and metasedimentary rocks (Baish Group) are represented in the district by a greenshist derived from a metamorphozed basalt and basaltic tuff, interbedded with graphitic marble, chert and ferruginous chert, which are bounded by a younger andesite to the east and by an amphibolite and quartzite to the west. Within and to the east of the Wadi Bidah fault zone, there are diorite and quartz diorite plutons which are dated at 920 million years by potassium-argon techniques.

Copper mineralization extends over a distance of about 60km occurring in locations and deposits of two genetic types: (1) sulphide metasomatic mineralization found in calcareous schists (Rabathan and Sha'ab Eltera mines), and in propylitically altered acidic intrusive rocks (Gehab mine); (2) quartz vein mineralization (Mulkal mine), usually associated with metasomatic deposits, mentioned above.

- Rabathan deposit is associated with sheared and deformed schistose basaltic metatuffs and major interbeds of siliceous sericitic schists, cherty schists, and graphitic carbonate rocks of the Baish Group. East of the fault zone metabasalts and metatuffs are intruded into by a dioritic batholith.

Some holes intersected a massive sulphide mineralization occurring in limbs of a tightly folded anticline, and which is generally conformable to schistosity and contain chalcopyrite, pyrite, sphalerite with some quantity of silver and gold. The main ore body - tabular in form - has 200m in length and its thickness varies from 19m in central part, to 1-2m in peripheral parts. It plunges to the north and is cut along the axis of the anticline by a steep-dipping fault, which displaced downwards the western side of the deposit. Drilling indicated that the deepest mineralization extends down to 220m. Preliminary calculation showed that the deposit consists of at least 1.5 million tons of ore, with 2.14% copper, 0.148 g/t of gold; 2.45 g/t of silver and a low grade of zinc.

- Sha'ab Eltare deposit is located in the central part of the Wadi Bidah mining district and consists of seven north-trending gossans of a total length of about 600m and as much as 35m wide. The largest one is 90m long and 35m wide.

The massive sulphide mineralization is interbedded in a sheared, calcareous quartz-sericite schist. It occurs also in the form of stringers and veins which cut across the schistosity of the wall rocks. Besides of the main ore body, pyrite mineralization is disseminated throughout the schist, the content of which does not exceed 5 per cent.

Drilling and a study of the deposit showed that it resulted from two stages of mineralization: the first one a disseminated and massive pyrite, with its content, in some places, exceeding 90 per cent; the second stage consists of a superposed chalcopyrite mineralization in between the grains of pyrite and in the form of massive lenses that cut the pyrite as well as the schists.

The ore reserves have been roughly estimated on the basis of data obtained from three holes only spaced at distances of 240 and 110 metres from each other. Assuming a depth of 80m, an average thickness of sulphide ore body of 26 metres and its approximate strike length of 400m, the total ore reserves can be estimated at 4,000,000 tons containing 0.36% copper; 1.09% zinc; 0.55 grams of gold and 3.46 grams of silver per ton of ore.

- Gehab deposit lies in the northern part of Wadi Bidah mining district. Breccia, and basaltic tuff, with interrelated layers of chert and ferruginous chert of Baish Group, metamorphozed into a greenshist facies were disrupted by sills of dacitic porphyry and later by massive, mafic sills, which together with the country rocks were folded into a broad anticline.

Copper replacement mineralization, closely associated with the mylonitized and propylitically-altered quartz porphyry and with sheared contacts with the mafic sills, developed during the second phase, which followed a primary pyrite mineralization. The deposit comprises several outcropping, steeply dipping, tabular or lenticular mineralized bodies.

One of the most promising ore bodies is more than 300m long, extending at least to 130m below the surface, and ranging from 4 to 7m in thickness. On the strength of four drill holes, reserves may be estimated at around 1.038,000 tons, with average content of 0.95% copper, 0.81% zinc, 0.79 g/t of gold and 5.49 g/t of silver. The highest grade of metals consists of 1.54% - 3.67% copper; 1.24 - 1.9 g/t gold; 5.13 - 35 g/t silver. These figures were obtained from two separate drill holes.

Copper ore deposits in the Wadi Bidah mining district are relatively small in size and of low grade. Mining conditions render these deposits exploitable only by underground methods. Further exploration work by diamond drilling, geological mapping, geophysical and geochemical investigations currently undertaken will provide additional information concerning the the economic value and feasibility of exploiting the deposits.

- Wadi Shwas district has been explored since 1970, when the ancient copper works were discovered by a Japanese geological survey team. The significance of this area is not yet clear.

- Jadmah deposit consists of massive sulphide beds and disseminations in the Wadi Damah formation (Pre-Cambrian)represented by dacitic, rhyolitic and andesitic lavas and acidic lapilli tuffs with lenses of limestone.

Mineralization related to north-striking sheared zones nearly parallel to bedding, is indicated by limonitic gossans associated with hydrothermally altered zones with sericitization, silicification, and dissemination of pyrite. It consists of chalcopyrite, sphalerite, pyrite, native copper and secondary minerals of copper and iron.

This deposit has the following ore reserves: 0.2 million tons of 4.8% copper ore, 3.0 million tons of copper ore with 1% copper; and 1.0 million tons 2.3% copper ore plus recoverable amounts of gold, silver and zinc.

At present, because of insufficient reserves of high grade copper ore and the complication of the mineralized zone by various intrusive rocks, additional drilling both in the main and in the western zone of the deposit, geophysical survey and geological mapping have been planned and some are under way aiming at economic evaluation of this deposit.

- Umm ad Damar copper ore occurence is located to the south of Jabal Sayid in the schisted and chloritized rhyolotic tuff cut by diorite and quartz porphyry of the pyroclastic Halaban Formation.Some small gossans are present, and the largest of them, 300m x 2-10m is composed of limonite and hematite containing up to 1% copper. For an economic assessment of the Umm ad Damar occurences, additional geological and geophysical work has been planned.

- As S'afra deposit contains disseminated sulphide mineralization in massive ore and stockworks in fault and shear zones in acid tuffs, sohists and dolomitic marbles of the Precambrian Halaban Formation. The ore occurs in small bodies which would require several underground workings and an extremely careful grade control. Rough estimate of ore reserves indicate the existence of about 2 million tons with 2 % Cu. At the present stage of exploration, it is difficult to assess the economic value of this deposit.

Many other copper occurrences exist in Saudi Arabia, but their economic importance is at present not clear, and will remain so in the near future.

The first mineral reconnaissance of the O m a n was carried out during a regional mapping programme by geologists of Petroleum Development Ltd. (1968). The report notes particularly the locations and geology of several ancient copper workings, possibly of the Early Islamic Age, but new finds of copper mineralization occurrences and a revision of old workings were made later.

One of the most important results of the geological investigations and prospecting in Oman was the discovery of a copper deposit near Sohar (45km), comprising approximately 12 million tons of copper ore, with a 2.1% copper content with additional unexplored reserves of as much as 80 million tons. The deposit consists of four ore bodies: Lasail, Aarja, Bayda, and Rakah. The co-ordinates, reserves and grades of these ore fields are as follows:

Ore fields	Co-ordinates	Reserves (million tons)	Grade Cu	Grade Zn
i) Lasail	Lat. 24°16'N Long. 56°26'E	7.6	2.22 %	-
ii) Aarja	Lat. 24°21'N Long. 56°24'E	3.0	1.59 %	1.02 %
iii) Bayda	Lat. 24°22'N Long. 56°26'E	0.8	3.28 %	1.51 %
iv) Rakah	Lat. 23°40'N Long. 56°35'E	4.1	1.36 %	0.19 %

Massive sulphide mineralization is confined to the basic volcanogenic rocks of the ophiolite formation and mainly contains chalcopyrite, pyrite, malachite and copper oxides. A governmental project envisages the exploitation of the deposit starting in 1978 and construction of a refinery near Sohar, that will produce approximately 20000 t/y of metallic copper.

Saudi Arabia has made a grant of $ 100 million toward the mining enterprise, which will be a joint venture involving the government of Oman (51%) and the Douglas B. Marshall interests of Houston, Texas (49%).

Total capital needs for the joint venture, to be called Oman Mining and Co., are estimated at $ 120 million.

- Some old copper workings were examined in the Wadi Aw'al - Wadi Laqere area and in Tawi Ubaylah.

Mineralization in the wadis area occurs in veins containing sulphides of copper, zinc, lead and traces of Pb. Assaying made across a representative part of the largest Wadi Aw'al vein showed a rather low copper content (0.53%). Rough calculations based on an average copper content of 0.50% indicate the existence of 600 metric tons of copper besides minor amounts of other metals. This quantity alone is too small to justify the exploitation of the deposit unless more veins of similar size occur nearby.

- The mineralized zone in Tawi Ubaylah occurs in a bleached gabbro and on its contact with a sheared serpentinite. The dominant mineral is brochantite, forming veins and coating in both the gabbro and sheared serpentinite.

According to very rough estimates, the copper content ranges between 0.73% and 0.03% and its reserves amount to some 250,000 tons. Because of the low grade, this deposit can only be exploited by the open pit method. For economic underground operations, the copper content in the ore should be in excess of 1.2 %.

- Preliminary evaluation of other areas where old workings (Luzuq Copper Workings, Mizqa Copper Mines) are found, showed in some places a rather high content of copper (up to 6.25%), but no estimation of ore reserves was carried out for them. Further exploration is to be directed to locate and evaluate supergene enrichment zones which have not yet been found.

Recent exploration for copper and other minerals was carried out by some Canadian and American companies according to an agreement which was signed with the Omani government in 1973.

In J o r d a n , copper mineralization of endogenous origin is considered to be uneconomic. It is associated with the Precambrian basic dikes and with the late Upper Proterozoic-Cambrian quartz-porphyry, both located on the eastern side of the central Wadi Arabah, in the area of Wadi Huwar, Wadi Musa and the Upper Wadi Abu Qurdhiya (8-10km west of Taiyiba). The latter type contains oxidized disseminated copper ore restricted to irregularly shaped small parts of the intrusions. These occurrences are rare and only of a few square metres in size, with copper content up to 0.77%. Further investigations, including geochemical surveys have been recommended.

The exogenous copper mineralization in the country could play a significant role in the mining industry of Jordan in the coming years. That kind of occurrences and deposits are spread on the east side of Wadi Arabah, between Gharandal in the south and the Dead Sea in the north, being associated with the Cambrian sediments.

The mineralization is confined to the two following units:

a) The late Middle Cambrian White Fine Sandstones. The maximum content of copper was observed in the region of Wadi Abu Khusheiba, extending over an area of 30 sq. km. The mineralization was observed also in the areas of Wadi Halid - Wadi Ghuweir - Salavan - Umm el Ammad and its traces were also found further towards the southern end of the Dead Sea. So, the total length of the mineralized zone is proved to be extending over 72 km.

Copper minerals (malachite, cuprite, chalcocite, bornite, chalcopyrite) occur in small nodules, less frequently as diffused mineralization in thin-bedded, intensively blue-green coloured fine sandstones. Occasionally nodules are grown together to ore aggregates and flat lenses of up to 40cm thick.

Many indications prove that the copper mineralization and country rocks are syngenetic, but at the same time the process of the deposition was contemporaneous with an extensive quartz-porphyry volcanism, which took place in this area.

The thickness of the copper-bearing rocks reaches in some places up to 45m, but the main bulk of the mineralization is confined to the upper part of the section.

In some publications this unit is called as "the Upper Horizon", which is part of "the"Variegated Sandstone Unit", which, in turn, is a member of the Upper Nubian Sandstone. It means, in this case, that the age of the copper bearing unit should be Cretaceous or at least Mesozoic.

b) According to F. Bender, at the eastern side of the central Wadi Arabah, partly sandy dolomite laterally replaces the lower white fine sandstone. The thickness of this dolomitic intercalation in the Cambrian (or Upper Nubian) sandstones increases from 5-7m in the north to 26m in the Feinan area and to 35m at Seil el Ja'ar.

In Y.E. Nimry's writings, these rocks are called as the Dolomite-Limestone-Shale Unit, whose age is Lower to Middle Cambrian, and which underlines the Nubian Sandstone. The uppermost four metres of the section comprise mainly claystone, shale and red siltstone, sometimes intercalated with dolomites which contain epigenetic copper mineralization. It is referred to as the Lower Horizon.

The type of mineralization in the dolomites is different from the ore-nodule mineralization of the White Fine Sandstones Unit. Here it occurs along joints and fissures, and is observed as an irregular mineralization of the matrix in the coarse sandstones, forming irregularly shaped ore pockets and lenses of copper-manganese ore directly above the dolomites. These and other peculiarities indicate that this mineralization is of secondary type, which is supposed to had formed as a result of downward migration of weathering solutions from the overlying strata (The Upper Horizon).

The main and the most promising deposits in Jordan are:

- Abu Khashabia, located in the district of the same name, with co-ordinates: E 175 000, N 970 000, containing 18 million tons of proven and possible reserves of ore;

- Fenan deposit which is situated in the area with co-ordinates E 186 000, N 005 500. During the period 1972-1974, the Natural Resources Authority of Jordan estimated the proven reserves of copper ore in the Fenan region at about 60 million tons and possible reserves at 50 million tons, with an average copper content of 1.36%.

The total potential ore reserves in the Wadi Arabah area are estimated at 200 million tons which could be enlarged by additional findings, particularly in Wadi Ratya, Khirbet el-Nahas, Wadi el-Hammar and in Helaysia - Salwan areas.

Chemical analyses of the two main types of ore: clayey of the Lower Horizon and sandy, clayey and silty type of the Upper Horizon, exposed a significant difference between them in copper content and chemical composition (see Table No. X).

In 1974/75 the Authority, in co-operation with the French state-run "Bureau of Geological and Mining Research", carried out a technical and economic feasibility study for the development of these deposits. The study showed that owing to the sharp decline in the world prices of copper, the proposed investment will be uneconomic unless a plant with an annual capacity of 40 thousand tons is established.

It is suggested that a pilot plant be constructed during the Five Year Plan period. Its operations will be confined to deposits with reserves estimated at 5 million tons of ore which would be mined by opencast method. Mining operations are to be performed on a selective basis so that the investments will be limited to the costs of treatments and extraction units and associated basic services. Total cost of the project for 1976-1979 is about J.D. 5 million.1/

At the same time, according to the 1976-1980 Development Plan, further exploration and prospecting work is to be conducted in some places of Wadi Arabah area and particularly in Wadi E'isal and in the region of Fifa.

1/ "Five Year Development Plan of Jordan", 1976-1980.

Table No. X   Chemical Composition of Copper Ore from Abu Khashabia and Fainan Deposits in Jordan

Types of ores	Cu	Fe (Fe_2O_3)	Al_2O_3	TiO_2	MnO	CaO	SiO_2	Pb (PbO)	Ag	Au	MgO	K_2O	NaO_2	loss on ignition
Complex ores (sandy, clayey and silty)	0.53	0.03	3.64	0.06	0.005	0.48	91.04	0.02	0.04	0.02	-	-	-	-
Clayey ores	1.364	(3.45)	19.80	-	3.60	0.75	60.74	(0.24)	-	-	2.39	0.45	0.25	4.71

<u>Source</u>: "Copper Deposits in Jordan", The Second Arab Conference on Mineral Resources.

In the Yemen Arab Republic notable copper mineralization occurs in the form of veins confined to fracture zones, trending NWN and cutting Precambrian metamorphic rocks, consisting of feldspatic schist, mica schist, hornblenda gneiss and quartzites. Pegmatites, granitic intrusions and a system of basic, aplitic and granitic dikes are spread widely in the area . Unfortunately, the genetic and structural associations between copper mineralization and tectonic features have not yet been studied. Two copper deposits, both of them situated in the southern part of the country, could be considered as the most promising.

- Al Hamura deposit (Hamura Vein) occurs at the distance of about 50km south of Taiz and 10km west of Rahda (Lat 14°30'N; Long. 44°56'E). It was discovered in 1942, but no systematic investigations were undertaken until recently. Mineralization crops out on the surface as a group of gossans trending N 15°W, with an overall length of about 1200m. The main Hamura vein is cut by faults trending N 40°W with horizontal displacements of the vein in several places, which divided it into separate parts. In the same area, some preliminary geophysical testing was conducted, which also indicated mineralization situated between Wadi Zariba and Rahda - Hifan, having a thickness of 30m and diping at 70° to the north-east direction. It was also indicated, that oxidized zone reaches a thickness of 16m. One more occurrence was found at about 3.5km SE of Hamura in Guwasan area, which is its continuation.

The main copper-bearing minerals in all of those cases are represented by chalcocite, cavellite, malachite, azurite and chrysocolla.
Sometimes noticeable content of nickel and cobalt minerals are also indicated.

Groups of experts who visited the deposit in the last years, made contradictory evaluations of its commercial value, as the results of their investigations were different. This is illustrated particularly in the following table:

Content of metals in samples, collected from the Al-Hamura Copper deposit (YAR)

Expert groups	Samples	Content of metals			Copper equivalent
		Cu	Co	Ni	
I. Development Consultants Association (Ciam)	1.	0.43%-0.58%*	up to 2%	up to 1.3%	up to 11.0%
II. Prospection Limited (Canada)	1.	0.49%	-	-	0.49%
	2.	0.10%	trace	trace	0.10%
	3.	0.16%	0.11%	0.52%	1.8%
	4.	trace	-	trace	trace
	5.	1.77%	0.04%	-	1.9%
III. USGS	1.	0.2%	N.A.	0.02%	0.24%
	2.	0.07	N.A.	0.007%	0.09%
	3.	> 2	N.A.	0.5%	> 3.16%
	4.	> 4	N.A.	0.15%	> 4.3%

* Some samples contain up to 10-14% of Cu.

Considerable contributions to the evaluation of the deposit were made by the Czechoslovak group under Dr. Morkonsky, which conducted geophysical investigations in the Hamura area and found that the mineralized zone is indicated to be at least 100m deep, not less than 1200 metres long, and about 35 metres wide. The fracture zone itself extends over at least 2.5-3 km and can be considered very promising for further copper prospection.

In 1977, the deposit was visited by ECWA experts, who made a rough evaluation of possible reserves and recommended execution of a preliminary investigation.

Those recommendations are based on the results of the previous work which proved the following characteristics as a minimum: length of the mineralized zone - 1000m; width - 30m; and depth - 100m.

It was also assumed that the minimum content of the copper equivalent in the ore required for econo. ic underground operation (1.2%) could be available due to the presence of cobalt and nickel . That assumption seems more certain if we take into account, that all samples were collected from the oxidized zone, and the primary ore as usual is of a higher value in metal content. It was also reasonable to assume that the quantity of the cutoff grade ore is 50 per cent. So according to those figures, ore reserves only in that limited zone could be as much as 5,000,000 tons with content of copper equivalent - 60,000 tons valued at $ 75,360,000 (1973 prices). Such a deposit can be considered economically exploitable, under the following parametres:

The capital expenditure required for the establishment of a mining enterprise, including a dressing plant and infrastructure, ranges between 8 and 10 million US$.

Annual production capacity (in ore) - 500,000 tons;

Annual production capacity (in concentrate) - 20,000 tons;

Annual value of concentrate produced: - $ 5 million;

Total value of concentrate - $ 50 million;

Period of exploitation - 10 years.

In the case of mining, transportation problems could relatively be easy to solve due to the short distance separating the deposit from the main road (about 10-15km) and from the deposit to the seaport of Al-Mokha (about 165km).

At the same time, the following serious difficulties have to be taken into account:

i) Geological and mining conditions could be very complicated due to the post-mineralization tectonics, which may extensively be developed in this area;

ii) Lack of a sufficient amount of water which is required for mining, beneficiation and for consumption pruposes;

iii) Lack of sufficient manpower in general and absence of qualified mining personnel in particular.

- The Mazabi-Shakkat deposit (Al-Bayda - Al-Fatha region) occurs as separate lenticular veins, some of which reach 150m in length, and with an average width of the outcrops being about 20m. The overall length of the exposures reaches about 1300m, with a strike direction of NW 35° and a vertical dip.

A study of the samples taken from the veins showed that the sulphide ore contains pyrrhotite, chalcopyrite, digenite, pyrite, magnetite and that the upper leached zone contains malachite, azurite, covellite, chalcocite, chrysocolla, limonite and goethite.

The X-ray fluorescence analysis of samples taken from the unoxidized ore below the leached zone showed that the grade of Cu is sufficiently high ($< 2.1\%$), and it contains also nickel (1.0% - 1.2%) and cobalt (0.25% - 0.70%). Preliminary examination of the ore indicates that it could be of economic value in which case the location of the mineralized area, 60km away from Aden would take transportation cost of the ore or concentrate relatively low.

In People's Democratic Republic of Yemen the majority of copper mineralization occurs within the Aden Trap series (Q_2-Q_3) (Thalab Volcanic Group) in agglomerate pyroclastic formations and non-segmented lavas of basaltic and andesite-basaltic composition where it forms disseminations in patches and fractures, confined to shear zones; in discreet veins with quartz, calcite or epidote gangue and occasionally in granitic dykes. The mineralization in the shear zones tends to be sporadic.

In 1973 the UN Survey examined indications of copper mineralization in Wadi Chabar and the surrounding areas. A number of occurrences containing malachite, chalcocite, azurite, cuprite and chrysocolla were noted along fault zones cutting the Thalab Group.

In 1976 a systematic field survey has been carried out over Maabir - Ghabar area of approximately 1300 sq. km. which resulted in discovering 28 in-site and 72 float occurrences of copper.

- For more detailed investigations initially the Wadi Al Masaini - Kartery, Wadi Duhi and Maabir occurrences located in the central and south-western parts of the area were selected. From the results obtained it was found that Wadi Duhi is more promising and a further study was recommended.

Most of the attention was paid to the Wadi Ghabar area where wide geological, geochemical and geophysical investigations have been undertaken. In particular 645 geochemical samples were tested, geological and topographic maps at 1:10000 scale were compiled and 4 holes with a total depth of 310 metres have been confined. The investigation was primarily for copper, but important indications of gold and silver were discovered.

Other information concerning the grade and reserves of ore is not available.

associated with post-tectonic granites. Along the NNW fault trend, twenty three mineralized zones have been traced over distances varying between 20 and 300 metres with widths reaching up to 5 metres but averaging about one metre. The principle minerals are sulphides, viz. chalcocite, chalcopyrite, enargite and bornite and the average grade is slightly more than 1 per cent.

This area is considered by far the most promising one in the country, and since 1975, Hunting Geology and Geophysics Ltd. of the UK has been carrying out there a mineral exploration including the assessment of copper deposits. Field surveys are to be carried out over an area of 1300 km^2 and the cost estimate for this work during the first year is about US$1.5 million.

The latest investigations, undertaken in 1975-76, by HGG of the UK in the northern part of the United Arab Emirates, revealed the existence of minor copper occurrences in metamorphic rocks of the lower part of Hawasina Series (Pre-permian - Upper Cretaceous), in complex zones of gabbro and ultrabasic rocks and in the so-called Sheeted Diabase, representing the highest part of ophiolite formation.

All those occurrences are associated with massive quartz veins or with alteration zones in the host rocks. The most important occurrences are located near Manama, in Wadi Ham and near the east coast, north of Fujairah. No commercial deposits have so far been reported.

In the south of the Gollan Heights in Syria, copper hydrothermal mineralization was discovered in conglomerates of the lower part of Neogen formation. The copper grade varies between 1.38 - 2.60%. Copper mineralization was also discovered in Al Bayda (Taffa-Fatha and El-Cheili) and Rahed areas. At present, prospection is under way in some of those areas but no results are yet available.

During the last 20 years estimated reserves of copper in the developing and the Western developed countries doubled, reaching 192 million tons in 1971. This growth took place mostly due to the discovery of huge reserves of low-grade copper-porphyry ores in more than 30 countries of the world. This kind of deposits contains also molibdenum and sometimes silver or gold. Geological position of copper-porphyry deposits in many cases gives possibility to exploit them by the most economic opencast method on a very large scale. All of that creates a competitive situation in the world copper market and a considerable fluctuation of the prices.

Further advantage in extraction of copper from the prophyry-copper fields is expected, when hydrometallurgy techniques are developed to the industrial level, which will make possible production of metallic copper directly on site and eliminate conventional smelting, with its attendant economic and pollution problems.

In view of the existence of environmental protection laws in some copper importing countries with respect to sulphur pollution, demand for copper ore with high content of sulphur is limited. For this reason, the tendency prevails to build smelters and refineries in the territories of the exporting countries.

Table No. XI. Main Copper Occurences and Deposits in the ECWA Member Countries

Country Deposits	Location	Reserves of ore (million tons) probable	proven	total	Contents of metals	Value of* useful recoverable components per ton of ore ($ equivalent)	Mineralogical composition of ore	Type of mineralization
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Saudi-Arabia								
1. Jabal Sayid	Lat. 23°50'40''N Long. 40°56'10''E	(~ 40)	0.8	> 40	Cu-2%(1.7%) Zn-1.4% Au-0.5g/t Ag-40g/t	32.4	Chalcopyrite, sphalerite, pyrrhotite, pyrite, magnetite	Massive and stringer sulphide mineralization in pyroclastic formations (PCm Hulayfah Group)
2. Nuqrah North	Lat. 25°38'30''N Long. 41°26'20''E	-	0.4	>0.4	Cu-1.3% Pb-2.3% Zn-10.6% Au-1.6g/t Ag-175g/t	60.5	Chalcopyrite, sphalerite, galena, pyrite	Massive and disseminated sulphide stratiform mineralization, lenses (PCm).
3. Nuqrah South	Lat. 25°35'45''N Long. 41°26'35''E	-	1.0	>1.0	Cu-1.2% Pb-3.44% Zn-7.6% Au-5.86g/t Ag-235g/t	72.3	Chalcopyrite, sphalerite, galena, pyrite	Massive and disseminated sulphide stratiform mineralization, lenses (Pcm).
Wadi Bidah district								
4. Rabathan	Lat. 20°23'42''N Long. 41°22'59''E	-	1.5	1.5	Cu-2.14% Zn-0.022% Au-0.148g/t Ag-2.45g/t	>27.3	Chalcopyrite, sphalerite, pyrite	Metasomatic type, tabular ore bodies with massive and disseminated sulphide mineralization in calcareous shists of Baish Group (pre-Cambrian) (PCm)
5. Gehab	Lat. 20°40'58''N Long. 41°17'02''E	-	1.038	>1.038	Cu-0.98%(1.56%) Zn-0.81% Au-0.79g/t Ag-5.49g/t	16.6	Chalcopyrite, sphalerite, rhodonite, rhodochrosite barite	The same as above in prophylitically altered acidic intrusive rocks

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Table No. **XI.** Main Copper Occurences and Deposits in the ECWA Member Countries (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6. Sha'ab Eltare	Lat. 20°35'00''N Long. 41°22'00''E	-	4.0	>4.0	Cu-0.36% Zn-1.09% Au-0.55g/t Ag-3.46g/t	8.9	Chalcopyrite, sphalerite, pyrite	Metasomatic, tabular and lenticular sulphide mineralization in calcareous shists of Baish Group (PCm)
Wadi Shwas district								
7. Jahmah	Lat. 20°00'30''N Long. 41°58'30''E	0.2 3.0	-	-	Cu-4.8% Cu-1.0% Cu-2.3% Zn- ?	>12.5	Chalcopyrite, native copper pyrite, sphalorite	Massive sulphite lenses and pods and disseminations in the Wadi Damah formation (PCm) probably during Hijaz Orogenic cycle.
8. Umm ad Damar	Lat. 23°40'40''N Long. 41°03'15''E	-	n0.1	>n0.1	Cu-up to 1% in gossans	> 12.5	Chalcopyrite, pyrite	Lenticular sulphide ore body, veins along shear zones in the shisted and chloritized rhyolitic tuff and in quartz porphyry of the pyroclastic Halaban Formation (PCm)
9. As S'afra	Lat. 24°13'00''N Long. 41°53'30''E	-	-	2.0	Cu-2%	> 25.0	Chalcopyrite, pyrite	Sulphides in pyroclastic rocks: tuffs, rhyolitic welded tuffs; some marbles of Halaban Group (PCm) stock-works, and disseminated ore.
Oman								
1. Sohar	-	-	-	2.0	Cu-2.1%	>25.0	Chalcopyrite, sphalerite	Veins in ophiolite complex of Cretaceous age (Alpian orogen)
2. Wadi Wa'al - Wadi Laqere region	-	-	-	>0.6	Cu-0.53% Pb- ? Zn- ? Rb- ?	>6.0	Chalcopyrite, sphalerite	Veins in ophiolite complex of Cretaceous age (Alpian orogen)

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Table No. XI. (cont'd) Main Copper Occurences and Deposits in the ECWA Member Countries

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3. Tawi Ubaylah	-	-	-	0.25	Cu-0.73-0.935	>9.2	Bronchantite	Veins in gabbro and in sheared serpentinite of ophiolite complex (Alpian orogen)
Jordan *****								
1. Abu Khashabia	175 000E 970 000N	4.0	8.0	18	> Cu-0.53***	>6.6	Cuprite, bornite chalcopyrite, chalcocite	Sedimentary and epigenetic in cavities, fractures disseminated mineralization. Early Cambrian age.
2. Fenan	186 000E 005 000N	35	33	110	Cu-1.36	17.0	Cuprite, bornite, chalcopyrite, chalcocite	Sedimentary and epigenetic in cavities, fractures disseminated mineralization Early Cambrian age
YAR								
1. Al Hamoura	Lat. 14°30'N	-	-	-	Cu->2.1% Ni-1.0%-1.2% Co-0.25%-0.70%	>67.5	Pyrrhotite, chalcopyrite, pyrite, magnetite covellite, chalcocite	Veins in PCm metamorphic formations.
2. Mazabi-Shakat	Long. 44°56'E	-	-	-				
PDRY								
1. Wadi Duhi (Maabiz-Ghabar area)		Further investigations are planned. No data available					Chalcocite, malachite	Veins and disseminations Mineralization in Aden Trap Series of agglomerate pyroclastic formations & non-segmented lavas of basaltic & andesitbasaltic composition
2. Wadi Chabar		-	-	-	Cu->1.0%	>12.6	Chalcocite, chalcopyrite, enargite, gold, silver	Hydrothermal mineralization is associated with granites.

<u>Source:</u> Economic Commission for Western Asia based on data compiled from national, regional and international sources.

* See the Publication referred to in item 111 of the attached Bibliography.

** Mineralization in the main zone.

*** Copper content should be higher than that figure, as the average Cu content in sandy ores is 0.65% and in the clayey ores is 1.364% according to the report "Copper Deposits in Jordan" submitted to the Second Arab Conference for Mineral Resources. It is considered, that general potential of ore reserves in Wadi Araba can amount to 200 million tons of ore.

**** Total potential reserves of Cu ore in Wadi Al Araba can be ammounted to 200 million tons.

b) Lead and zinc ore:

These two metals can compose some types of ores including lead or zinc monomineral ores, bimineral zinc-lead or lead-zinc ores which may contain silver, cadmium, and some other elements. The fifth type is the complex polymetallic ore, which in addition to lead and zinc, can contain gold, silver, copper and some other elements, including cadmium or germanium, indium, gallium, bismuth, antimony, tellurium and selenium.

For commercial utilization, the monomineral ores should contain a minimum of 3% lead or 5% zinc. In bimineral ores, the total grade of zinc and lead should not be less than 3% with a minimum lead content of 1%. In the polymetallic ores content of lead and zinc can be lower, as the other useful components, present in the ore increase its value.

In the ECWA region, the most important lead and zinc mineralization occurs mainly in polymetallic complex ores in association with copper, gold and silver. But until the the present time no lead and zinc deposits have been exploited, although ancient workings with exhausted ore bodies have been found in many places in **Saudi Arabia** and in some other countries of the region. Complex polymetallic ores of Nuqrah North and Nuqrah South deposits 1/ can be considered as a lead-zinc ores as well, since the total lead-zinc grade is much higher than the minimum required for commercial grade. The size of lead and zinc reserves in both of these deposits alone is according to international standards large enough to justify their mining.

- Al-Amar deposit which was exploited for copper, has been shown by diamond drilling to contain 1 to 11% of zinc. The deposit is located at 650km to the east-north-east of Jeddah near the east edge of the Pre-Cambrian Shield. The ore contains sulphides of base metals in quartz veins, silicified zones in acid volcanic tuffs and metasedimantary rocks of the Pre-Cambrian Upper Halaban Formation. Mineralization is represented by massive and disseminated sphalerite-chalcopyrite ores with some content of gold, silver, galena and pyrrhotite.

Proven reserves are estimated at 3.75 million tons with 5% Zn in rich zones; probable reserves amount to 25 million tons with an average of 1.5% Zn in the whole stockwork. The copper and gold values in the drill holes are very scarce and too dispersed to allow an average grade to be calculated.

1/ See item "Copper".

In 1974 the Ministry started underground exploration and sampling. At the present time all activities on Al Amar have been stopped because it was found uneconomical.

- Samrah deposit is located at 600 km to the east-north-east of Jeddah in the Dawadami district, a 1000 km^2 area with scores of ancient prospects. Polymetallic mineralization occurs in quartz and quartz-carbonite veins and silicified breccia associated with andesite dikes, out across a complex of intrusive igneous rocks ranging from gabbro to granite. The deposit is of Pre-Cambrian age.

Exploration drilling confirmed the existence of these sulphide mineralizations. Proven ore reserves are estimated at 300,000 tons with 5% of Zn, 1% of Pb and 446 g/t of silver, potential reserves amount to 800,000 tons. Gold is also present in the ore but its average content was not determined.

- Jabal Dhaylan lies at a distance of 500kms to the north-north-west of Jeddah near the Red Sea Coast. Oxidized lead and zinc stratified mineralization with some copper content was found in Paleogene, Neogene and Quaternary sediments and also in fractures, cavities and faults. The lower part of those deposits is always above the water table and only traces of primary sulphides can be found. Weighted average grade of all drilled intersections is 4.9% zinc and 1.39% lead. Further exploration will assess the feasibility of mining the deposits. This kind of mineralization can be considered as one of the most interesting for the future investigations along the Red Sea Shore, where young volcanic and sedimentary rocks are associated with the development of the Red Sea rift system.

The significance of the area becomes evident, if we take into consideration that on the west shore of the Red Sea in similar geological structures substantive production of lead and zinc is obtained from interbedded ore bodies or veins occurring in the Cretaceous-Middle Miocene sediments covering the Upper Proterozoic basement complex. Less extensive mineralization occurs also in Plio-Pleistocene and in Qaternary.

That kind of deposit is located particularly in the territory of Egypt between Quseir in the north and Ras Banas in the south. According to A.H. Sabat, V.P. Bordonosov, D.P. Shelev though as the majority of the rich mineralizations occur in "calcareous sandstones and breccia-line limestones of Middle Miocene basal series, and also in the Nubian sandstones, there is a reason to consider that the mineralization is closely connected with long life deep faults." Commercial mineralization concentrates mainly within the limits of conjunction of deep faults. The zone of deep faults has a trend NW and ENE and contains arch-line faults.

Some other mineral occurrences and mineralized zones of no economic value at the present time require a lot of investigation and exploration work.

In the other ECWA member countries, lead and zinc mineralization is not of economic value neither lead and zinc mineralization is known in the Western part of S y r i a near Jabbata Az-zet and in Rimeh in the Anti Liban. Zinc is present in the copper-zinc ores in the Sohar deposit, located within the ophiolite belf of the northern O m a n mountains (see item "copper").

c) Nickel Ore:

No nickel ore deposits are known to exist in the ECWA region, although some occurrences of nickel mineralization, the economic value of which is not clear, are located in some areas such as J o r d a n and O m a n, where investigations for Cu and Ni were conducted by American and Canadian companies in the north-eastern part of the country.

In P e o p l e ' s D e m o c r a t i c R e p u b l i c o f Y e m e n, Ataq area has been designated as a promising one for finding of nickel mineralization.

In S a u d i A r a b i a, nickel sulphide mineralization occurs in the Wadi Qatan area at 650kms southeast of Jeddah near the eastern edge of the Pre-Cambrian shield. In this area, massive stratified nickel bearing sulphide deposit has been located in a sequence of basic volcanic and volcano-clastic rocks. The nickel-bearing zone is over a kilometer long with a thickness of up to 35m. Nickel grades range from 0.5% to over 3% (1.5% in average). The ore reserves have been estimated at 2 mill. tons at the present. The deposit is still under study by the Arabian Shield Development Company.

time after additional studies have been completed. Further work is carried out by the Arabian Shield Development Co. which has been granted a licence over the area.

4. Development of non-ferrous industry

Among the non-ferrous mineral raw materials in the ECWA region, only mining of copper is likely to take place in the coming few years. Particularly, a mining operation at the Sohar copper deposit is to be initiated in 1978 in Oman. Plans call for construction of a refinery that will produce approximately 20000 ton per year of metallic copper.

Studies are underway on possible construction of a copper wire plant.

The smelter is expected to employ some 850 salaried and hourly workers at the peak of construction and approximately 500 once production is reached.

Other non-ferrous industry in the ECWA member countries is presently exclusively limited to processing of imported bauxite 1/ to produce aluminium which is mainly used for construction purposes.

The World's production capacities in Western countries are concentrated in a few major transnational aluminium corporations: 1. Aluminium Company of America (Alcoa U.S.); 2. Alcan Aluminium Limited (Alcan, with its headquarters in Canada); 3. Raynolds Metals Company (Raynolds, U.S.); 4. Kaizer Aluminium and Chemical Corporation (Kaizer, with its headquarters in the U.S.); 5. Pechiney Ugine Kuhlmann SA (Pechiney, with its headquaters in the U.S.); 6. Pechiney Ugine Kuhlmann SA (France); Schweizerische Aluminium AG (Alusuisse, with its headquarters in Switzerland). These corporations keep under control about 57% of the market economies' bauxite production capacity, 70% of alumina refining capacity and 60% of their aluminium smelting capacity.

in Bahrain, an aluminium smelter costing $ 150 millions was built and put into operation in 1971 by the "Aluminium Smelter Co." (ALBA), which initially had seven shareholders including the Government of Bahrain (23.4%);British Metal International (17%); Kaiser Aluminium Bahrain (17%); General Cable Corporation (17%); Electro Copper (12%); Breton Investment (5.1%) and Western Metals (8.5%). Recently Amalgamated Metal Corp. Ltd. of UK and some other shareholders agreed to sell their shares to the Bahraini Government, whose share has thus risen to 52.4%.

ALBA imports alumina from Australia and produces ingots and the shareholders are responsible for marketing the aluminium. Part of the smelter's output is used as an input to an aluminium atomizer completed in 1973 and owned in part by the Bahraini Government.

1/ Bauxite mineralization in Lebanon occurs in the region of Laklouk and is formed in the upper part of basalt of Upper Jurassic age. The mineralization is of no practical value.

The annual production capacity of the smelter is about 120,000 tons of high quality aluminium ingots. Once the expansion programme which is likely to cost around B.D. 15 million is realized in 1978, production will reach 185,000 tons per year. The main supplier of alumina is the Australian Aloca of Kwinana Co., which signed a contract guaranteeing an annual supply of 230,000 tons of the raw materials respectively for a period of 20 years.

At present the share of aluminium production of Bahrain in the total value of production in developing countries is about 12.5% (1974).

In I r a q , the State General Company for Manufacture of Aluminium Ingots was established for the construction and management of an aluminium plant costing I.D. 38.5 million, with a capacity of 32,000 tons per annum of aluminium ingots. The construction of the smelter was undertaken by the French Fpeschinary Company.

Q a t a r , according to its industrial development plan, will also establish an aluminium smelter with a capacity of about 75,000 tons per year.

The construction of an aluminium smelter in S a u d i A r a b i a has been undertaken by the Japanese consortium Al Jubaya. After the completion of the project in 1977, the smelter will produce 200,000 tons of aluminium annually.

In May 1975, the ruler of D u b a i and the British Smelter Constructions signed an agreement whereby the company has been granted a right to construct an aluminium plant which is expected to be the second largest one in the Arabian Gulf area. The cost of the plant, which is expected to be operational in 1979, is of about 150 million and its production capacity of 150,000 aluminium tons per year. It was announced also that the US Southwise Company Carlton of Atlanta will participate in the execution of this project.

5. <u>Precious metals</u>

Of the precious metals occurrences in the ECWA region, only gold and silver are at the present time of commercial value. The gold and silver mineralization is located mainly in the Arabian Shield as a component of complex polymetallic ores in association with copper, lead and zinc (Au, Ag); with lead and zinc (Ag); and Au in quartz and quartz-carbonatite veins; and in silicified breccia. Structurally all these deposits and occurrences are associated with faults and fractures followed by intrusive and volcanic activities. Both of these metals were the subject of intensive mining during the ancient times in Saudi Arabia and in other countries of the ECWA region.

It is thought that monomineral deposits of gold or silver can be considered of commercial value if the content of the metals in primary deposits is not less than 3g/t and 100g/t respectively.

a) Gold and silver:

The silver and gold mineralization is concentrated mainly in the Pre-Cambrian shield, which covers about 27 per cent of the territory of Saudi Arabia.

As was previously mentioned, the commercial concentrations of these metals can be associated with copper, lead and zinc ores. In the copper deposits of commercial value, listed above, gold and silver reserves amount to a minimum of 18.5 tons and 410.5 tons respectively, including more than 235 tons of silver in the Nuqrah South deposit alone which classifies it as a medium size silver deposit without even accounting for the metal components, which make the value of this ore unique.

The most promising silver mineralization occurs in association with lead and zinc in numerous veins in Ad-Dawadami district, which was known in ancient times as a silver mining region. It lies at 760 kilometres east-north-east of Jeddah and 320 kilometres west-south-west of Ar-Riyadh, at the extreme east-central border of the Arabian Shield. Geological setting of the deposits can be summarized on the basis of the investigations which were carried out by various geologists between 1963-1971.

About 80% of the district's area is underlain by a granitic batholith; in the northern and southern parts of the territory occur two layered basic intrusions. In the north and in the south-east are also present metamorphic sedimentary rocks which are unconformably overlain by Ordovician sandstones. As a result of Hejaz orogeny (1000-660 million years) the pre-Cambrian rocks were folded and metamorphosed in a green-shist, and the following Jaid orogenic cycle (660-570 million years) produced the important Najd wrench fault system and is represented in the district by postkinematic granitic intrusions, northwesterly wrench faults and secondary extensive fracturing and subsequent dike intrusions.

The zinc-lead-silver mineralization is associated with those secondary fractures, and it formed in them veins as a result of a postkinematic hydrothermal activity. Subsequent tectonical reactivation resulted in shearing, brecciation, mobilization and recrystallization of the deposits.

Two types of mineralization are evident in the region; the latest one consists of vein deposits associated with fracture, shear and brecciation zones of the country rocks; but the earlier generation of quartz vein contains the main bulk mineralization which is composed of sphalerite, galena, pyrite, chalocopyrite and silver minerals including polybasite, argentite, tetrahedrite, phrargyrite, and native silver. Magnetite, hematite, arsenopyrite and pyrrhotite are also present. They occur in lenses of a mainly pyrrhetite-sphalerite assemblage within a calcareous horizon of the Ar-Ridaniyah Formation.

The latest type of mineralization prevails in the Ad-Dawadami district, occuring in the granite batholith within a zone about 10km wide, and lies approximately in its central part.

The total number of ancient workings is about 150, located along fractures dominantly northeasterly and to a leasser extent along these of east-west trend.

The mineralized veins display brown-stained outcrops, easily distinguishable on the surface. The exidized zone contains hematite, limonite, hemimorphite, malachite, cerussite and manganese oxides.

- Ten mines have been investigated recently, but only four of them showed silver mineralization (Smarah, Materah, Sumairah and Pl-44). The most detailed investigation was conducted on the Samrah Mine [1/] by drilling along the 400m mineralized zone, extending to a depth of about 200m. Mineralogical composition of the ore is similar to that described above. The primary sulphide mineral assemblage comprises sphalerite, pyrite, galena and to a lesser extent chalcopyrite. The main silver minerals are polybasite and pyrargyrite plus native silver in subordinate amounts. Magnetite and hematite occur in minor amounts in addition to the sulphides.

According to various estimates, the deposit comprises 230,000 to 330,000 tons of polymetallic ore, which contains 4.5 to 5 per cent Zn, about 1 per cent Pb and 410.5 to 466.5 grams per ton of silver. The

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1/ Detailed description is published in the documents of the Second Arab Conference on Mineral Resources.

grade of metals, particularly of silver is rather high and the value of the useful recoverable components per ton makes up to 40.0 - 44.2 dollar equivalent, while the minimum value for commercial exploitation was determined on a statistical basis to be 14.3 dollar equivalent per ton for undergound operation. To undertake mining operations, the reserves of ore should be 1.5 - 2.0 twice more than the existing ones.

Three other ancient mines located in this district and containing silver mineralization cannot be considered of any economic value because of the low silver grade (not more thant 80g/t on average) and small proven reserves.

As regards other interesting localities in that area, including Jadma and Ash-Shayeb, no positive results have yet been obtained.

The most interesting gold and silver deposits in Saudi Arabia which is going to re-open is an ancient gold and silver mine , Mahd Ad-Dhabab. This deposit is represented by gold-bearing quartz veins in three of six large fault zones that cut a monocline in agglomerate and rhyolite of the Murdama Group (PCm). Native gold and silver occur in sphalerite, pyrite, galena, chalcopyrite. Mahd Ad-Dhabab was productive about 950 B.C. and between 750 and 1200 A.D. Production was resumed by the Saudi Arabian Mining Syndicate from 1939 to 1954, when the mine was closed due to the depletion of reserves and increased costs of operation.

Total past production at Mahd Ad-Dhahab is computed as more than 0.75 million fine ounces of gold and more than 1 million fine ounces silver.

Preliminary estimates of the remaining reserves are 6 million tons at about 7g/ton gold and 25g/ton silver.

Detailed geological mapping in 1972 was followed by geochemical sampling of the mineralized zones at surface; 322 of the 781 samples indicated significant gold mineralization of more than 2.5g/ton.

Exploration drilling undertaken in the north-east and south-east parts of the district in 1973 discovered high-grade mineralization in two of ton holes with as much as 20.8g/ton gold, 140g/ton silver, 2.15% Cu, 12.5% zinc over a drilled length of 1.7m.

In 1976 an exploration licence was issued to Consolidated Gold Field to carry out surface and underground exploration to determine reserves.

In D e m o c r a t i c Y e m e n , as it has already been mentioned above (see item "Copper"), important indications of gold and silver were noted and

and investigated in Gabar area, which is going to be studied in details during 1978.

Gold was also found in Upper Yafeh area by UN experts and was studied in detail, including compiling of geological map at a scale of 1:10000, the final results are not clear yet.

No other gold and silver deposits and occurrences of economic value exist in the ECWA member countries. But the promising areas for locating these metals are the same as the ones for copper, lead and zinc, with which they are often associated and may, therefore, exist in Oman, Yemen Arab Republic and United Arab Emirates.

B. Non-metallic mineral materials

1. Chemical mineral raw materials

a) Phosphate:

Phosphate-bearing units, which are developed in the northern part of Africa extending from Morocco to Egypt, are present also in the northern part of the Arabian Peninsula, with many phosphate deposits and occurrences

in Iraq, Jordan, Syria, and Saudi Arabia. They represent the so-called East Mediterranean Phosphate Basin which is the eastern part of the vast Mediterranean Phosphate Province.

Huge reserves of high quality phosphate ore, favourable mining conditions and location of deposits are the main factors, which put the countries located in the province among the important world suppliers of phosphate raw materials and fertilizers.

The growing world demand for fertilizers on the one hand and the doubling of international phosphate prices during the last seven years on the other hand encourage further development of the mining and processing industry in the phosphate producing countries.

The ECWA member countries endowed with important phosphate deposits have just begun to develop and utilize their phosphate raw materials in a processed form through the establishment of chemical and fertilizer industries and the application of modern techniques and new methods of processing and benefication in their mining operations.

The first phosphate deposit in I r a q was proved in the Western Desert, some 60km west of Rutba town between 1960 and 1962, by a group of Soviet geologists. In 1963, the same team in collaboration with Iraqi geologists discovered the first phosphate occurrence in Akashat area. Exploration and prospecting, including mapping, drilling and radiometric surveys, continued till 1969 and resulted in ascertaining probable reserves amounting to 1,760 million tons of phosphate ore.

- Akashat phosphate deposit forms only the central part of the Western Desert phosphate area and covers 100 sq. km. The total ore reserves proved in this area are as follows:

Category B:	Bed I:	179.5 million tons	average 23.8% P_2O_5
	Bed II:	39.3 million tons	average 16.7% P_2O_5
Category C_1	Bed I:	136.5 million tons	average 23.0% P_2O_5
	Bed II:	76.5 million tons	average 18.0% P_2O_5

Further detailed prospecting was carried out for Quarries I and II representing about 15% of the below mentioned total reserves. Reserves of category A were proved to be 12.3 million tons out of total reserves amounting to 65.6 million tons in both Quarries. Total reserves are estimated at 432 million tons.

The phosphate-bearing sediments in Akashat are of Upper Cretaceous and Lower Paleogene age, similar therefore to the geological sections of the region in both Jordan and Syria. They contain seven horizons of phosphate. The lowest three horizons are of Upper Cretaceous age, extending to Syria, Jordan and Egypt and characterized by a complex composition of cementing material (carbonates and silica).

The first three horizons are of no significant economic value in Iraq. In the Akashat area, the two industrial beds forming the deposit are considered to be equivalent to the fourth phosphate horizon in the Western Desert. The 5th, 6th and 7th horizons are not present in the Akashat deposit.

The lithology of the phosphate-bearing unit is as follows:

Upper Cretaceous (Tayarat Formation)

- Shelly inter clastic dolomitic limestone 9m
- Bone-phosphatic limestone, sometimes gypseous and dolomitic 1-3m.

Paleogene (Paleocene Umm-Er-Radhuma Formation)

- Claystone 1-3m
- Clay, calcareous dolomite and bone phosphatic limestone 0.2-1m
- Bone-oolitic calcareous phosphate 1-2m
- Shelly oolitic phosphate 0-2m
- Oolitic calcareous phosphate 8-10m
- Shelly limestone 3-5m
- Aphano-crystalline (marly) limestone 3-6m
- Pseudo-oolitic (phosphatic) argillaceous limestone 0-0.5m
- Highly calcareous claystone 2-3m

Paleogene (Eocene, Dammam Formation)

- Recrystallized foraminiferal limestone 10m

The deposit is considered generally of a chemical origin, with marine sediments as a complimentary part of the regional chemogenic sedimentation of phosphate.

The ore is proved to contain 48-71% phosphate and 23-45% calcite, in addition to small quantities of other admixtures. A characteristic feature of the ore is a high porosity of phosphate occurring in substantial quantities (50-70%) as a compound with calcite. All the different types of ore comprise crystalline calcite. About 5% of the oolites consist of pure calcite and the rest (93%) of phosphate.

The average of mineral composition of the Akashat phosphate is shown below:

Mineral components	Bed I	Bed II
	Content in %	
1. Phosphate grains forming phosphate	65.3	32.7
included in composition with calcite	(33.9)	(32.2)
2. Weathered phosphate	3.2	19.3
included in composition with calcite	(2.5)	(19.3)
3. Calcite (large crystals)	7.1	2.5
4. Micro-aggregate calcite	18.4	39.1
included in composition with calcite (large crystals)	(4.6)	(10.6)
5. Halite (NaCl)	0.2	1.9
6. Gypsum ($CaSO_4.2H_2O$)	1.2	1.3
7. Alumna-$Al(SO_4)_2.12H_2O$	1.9	1.4
8. Volatile components (organic matter and moisture)	1.7	1.1
9. Silicate and Silica admixtures (illite, opal, quartz etc.)	1.0	1.2

In order to select the most effective method for dressing and benefication of the phosphate ore, various techniques were tested at a laboratory level, including selective grinding, crashing and classification, electrostatic separation, froth-flotation and calcination.

The essential element in the dressing of phosphate ores was to remove and separate the calcite from the phosphate mineral grains. Mineralogical composition indicated clearly that calcination is the most promising and preferred method for upgrading the ore. Using this method makes it possible to obtain a concentrate with a 29 to 30% P_2O_5 content. By increasing the solid ball ratio in the ball mill and doubling the time of the second stage of grinding to 20 minutes, the grade of the concentrate can be increased to 32% P_2O_5, with a recovery rate of 70% for the first industrial bed alone. It is possible to upgrade the concentrate through prolonged scrubbing and finer grinding, but it will entail a substantial loss of phosphate, i.e. a lower P_2O_5 recovery.

Calculations regarding mining, dressing and further chemical processing show that exploiting a mixture of both beds is the most economically viable alternative. When comparing the variants of dry and wet processing, it was also shown that the dry process is more economic than the wet one. This was arrived at by cerrelating the cost of 1 ton of concentrate obtained by both methods, with the sulphuric acid consumption required by the concentrate produced by each process, taking into consideration the economic characteristics of the sulphuric acid plant and the cost of 1 ton of the final product (TSP).

The following table includes some data on the dressing of the Akashat ore using calcination combined with various processes. (Table No. XII)

According to a contract signed on 1 September, 1975, exploitation of the Akashat deposit will require about 85 million dollars of investment and will be carried out by a Western European company. It is expected that further development of the Akashat deposit will take 3 years leading possibly to an increase of producing by 3.4 million tons per annum of phosphate. This deposit will be exploited by the open cast method and by mining the two beds jointly. The projected bench width in the phosphate bed is 30m with a bench slope of about 60°.

Table No. XII. Data on Concentration of Akashat Phosphate Ore Employing various flowsheets on Laboratory Scale.

Industrial beds tested	P_2O_5	CO_2	Process after calcination	Concentrate			Slimes	
				%	B%	E%	B%	E%
First industrial bed	22.5	15.0	Dry processing in one stage	64.6	29.5	85.0	17.0	10.0
			Dry processing in two stages	60.0	30.0	80.0	19.1	15.0
Mixture from 1st and 2nd industrial beds	20.5	18.0	Dry processing in one stage	60.0	28.8	84.0	15.4	9.0
			Dry processing in two stages	51.3	30.0	75.0	17.8	18.0
First industrial bed	22.5	15.0	Wet processing in one stage	65.0	30.0	87.0	14.2	8.0
			Wet processing in two stages	58.5	31.5	82.0	15.3	13.0
			Wet processing in three stages	51.0	33.0	75.0	15.2	12.0
Mixture from 1st and 2nd industrial beds	20.5	18.0	Wet processing in one stage	60.0	29.6	86.6	11.0	6.4
			Wet processing in two stages	53.0	31.4	81.3	12.6	11.7
			Wet processing in three stages	48.0	32.0	70.0	17.8	21.0

Source: The Second Arab Conference for mineral resources. Conference Documents.

Phosphate, being the key mineral raw material for the country, plays an important role in the economy of J o r d a n . Phosphate was discovered at the turn of the present century during the construction of the Hedjaz Railway.

Presently, about 60% of the Jordanian territory is considered to be highly promising for finding new phosphate deposits, possibly of commercial value.

Most of the known phosphate deposits are located mainly in two regions: El-Ruseifa and El-Hasa. In addition, a total of 19 ore bodies have been discovered in Central Jordan in the area between El-Hasa and El-Qatrana.

The phosphate-bearing sediments in Jordan belonging to Maestrichtian, Campanian (Upper Cretaceous) and Oligocene were deposited in a shallow sea. But the main industrial significance is, in the deposits of Maestrichtian age which are exploited in the two above mentioned areas. Phosphates of Oligocene age have been found in the "East-Jordanian Plateau", where phosphate beds up to 2m thick have been located.

The phosphate-bearing unit (named as Phosphorite Unit of Maestrichtian age) is situated between the underlying silicified limestone unit (Campanian) and the overlying chalk marl unit (Danian) and has a thickness ranging between 35 and 65m.

In El-Hasa - El-Qatrana region, the phosphate unit is divided into three parts:

the upper one has a thickness of 10 to 15m and consists of phosphatic chert, limestone, reddish, medium-grained and coarse-grained phosphate, marl and limestone;

- the medium part is 40m thick and contains limestone and marl with light grey phosphate;

- the lower member is represented by two horizons of phosphates with limestone, marl and chert.

The phosphate bodies were deposited in the form of lenticular strata having a thickness varying etween 20cm at their peripheries and 9m in the centre. These lenses are generally dipping towards a south-eastern direction.

In El-Ruseifa-El-Zarqa region, the phosphate unit contains four exploited beds of soft and hard high-grade phosphate, the thickness of which reaches 12m. Country rocks are represented by clay, limestone, cherts and marl. In addition, there are thin unexploitable silicified phosphate layers.

The layers of the deposits were also subject to the process of folding and faulting, and the general dip of the phosphate formation trends to the east. Ore bodies have the form of elongated lenses or lenticular strata.

Table No. XIII. The main morphological characteristics of phosphate ore bodies in the four fields in Jordan

Names of ore fields	Size of ore bodies	Thickness	Shapes of ore bodies	Comment
Wadi El-Bahiya	2900 x 2400m	up to 9m	lenticular	
	3000 x 1800m	up to 9m	lenticular	One of the four segments.
Qa'el Fuheili	5230 x (1250-2900)m	up to 9m	lens	
	2500 x 1400m	N.A.	lens	
Wadi El-Baija (in the first 3 horizons from the bottom)	Segment 1. Southern 3: lenses each 350 x (1500-300)m northern one 2000 x 1400m	N.A.	lenses	The field consists of 3 phosphate horizons. This is the lower and most valuable horizon.
	Segment 2. 2800 x 2500m	N.A.	lenses	
El-Hasa	1200 x 300m	up to 9m	lens	Width can reach 700m.
	3500 x (500-1200)m		lenses	The main ore body. There are small lenses also.
Wadi Buweija	2300 x 1500m	N.A.	lens	

Table No.XIII (cont'd)

Wadi Sah El-Jorbu	1200 x 500m	N.A.	N.A.	Only the upper part is shown.
	300 x 800m	N.A.	lens	Coquina member
Kh. Mudeibi	1400 x 1000m	N.A.	N.A.	Coquina member
Wadi Es-Sultani	1300 x 1400m	N.A.	N.A.	Upper member
	N.A.	up to 5m	lens	
Jebel El-Humur	the western segment			
	55,000 sq. m.	N.A.	N.A.	
	the eastern segment			
	700 x 400m	N.A.	N.A.	
Arabah	800 x 300m	N.A.	N.A.	
	8000 x (3000-5000)m	N.A.	N.A.	consists of 3 horizons
Wadi El-Tawai	Horizon I	N.A.	Lenticular layers	consists of 2 horizons
	2 lenses 2000 x 1400m			
	1 lens 1800 x 1300m			
	Horizon II	N.A.		
	2 lenses 3000 x 3000m			
El-Ruseifa	N.A.	14m in total, including 4 exploitable beds with thickness varying from 1.2 to 3m for each bed.	bedded strata	

Lithologically, seven types of phosphate ores can be distinguished:

- sand-like, matrix-free phosphate, representing the highest grade of commercial phosphate;

- calcareous ore, representing a large group of phosphate rocks, which contain apatite grains cemented by calcite;

- siliceous silicified types, with apatite grains cemented by silica and with hardness and toughness ranging between hard tough and very hard tough;

- mixed calcareous/silicious phosphates, consisting of 50% by weight of calcite and of silica;

- marly phosphates are typical marly looking rocks. They are rich in phosphate (50% by weight apatite), and form soft, friable rocks;

- argillaceous phosphates containing a considerable quantity of clay and fine quartz impurities;

- argillaceous and marly type is a mixture of the two previous types.

The most frequent type of ore is the calcareous one.

Mineralogical analyses showed that the most frequent grade of ore minerals are the fluorapatite and the carbonite fluorapatite. There are also calcium carbonate, silica, and traces of uranium and vanadium. Most of phosphate ores are friable and contain some deleterious components, including sodium chloride which can be washed off by water.

Chemical composition of the three main types of ore shows the high grade of P_2O_5 and TCP in the first two of them. This is illustrated in Table No. XIV.

Until 1973 and for El-Russeifa and El-Zarqa areas only, the value of the total phosphate reserves (proven, possible and probable) were estimated at 224.7 million tons. (See Table No. XV).

According to various sources, Jordan has new exploitable reserves estimated at about 1000 to 1200 million tons and some 2000 million tons of potential reserves which puts this country in the sixth place among the world phosphate-producing countries. Together with low grade phosphate ore, the total reserves in Jordan can be estimated at 44,000 million tons of 15 to 32% P_2O_5 content. 1/ In 1974 Jordan ranked sixth in as far as the value of phosphate production is concerned, among 65 phosphate producing countries in the world.

Exploitation of phosphate deposits is carried out by the Jordan Phosphate Mines Co. Ltd. (a 90% State owned Co.) which has a mining lease for Ruseifa

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1/ "Engineering and Mining Journal", No. 3, 1975.

Table No. XIV. Chemical Composition of Three Types of Phosphate Ore in Jordan

	Sand-like loose friable phosphate El-Hasa - Old concession 25.5 - 31.5m	Calcareous phosphate Ruseifa, Impresite E	Siliceous phosphate, Ruseifa and T_2 bed 1 1.00 - 1.60m
P_2O_5	36.10	31.8	22.40
TCP	78.80	69.3	48.80
CaO	50.40	50.5	32.40
I.A.R.	0.74	-	35.60
SiO_2	-	1.08	-
F_2	4.67	3.42	2.80
Cl_2 total	0.30	0.26	0.04
MgO	0.21	0.27	0.12
L.O.I.	5.67	10.4	4.64
Al_2O_3	0.15	0.34	0.27
V_2O_5	0.03	-	0.05
U (ppm)	-	135.00	-
SO_3	1.18	0.38	1.43
Fe_2O_3	0.13	0.18	0.33
K_2O	0.02	0.01	0.01
Na_2O	0.49	-	0.41
MnO	0.01	-	0.03
CaO	0.003	-	0.004
NiO	0.01	-	0.01
Cr_2O_3	0.01	-	0.02
Sr	0.13	-	0.13
Ba	0.11	-	0.18
CuO	0.003	-	0.01
Organic matter	0.16	-	0.19

Source: The Second Arab Conference for Mineral Resources. Conference Documents, Background Papers.

Table No. XV. Reserves of Phosphate Ore (1973) (El Hasa - El Qatrana Region)

Name of the region and its location	Name of the deposit	Co-ordinates of the deposit		Ore reserves / metric tons			
		East	North	proved	probable	possible	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
El Qatrana: 95 km to the south of Amman	Ore No. 6	253,200 254,300	54,000 54,000	1,020,000		1,000,000	2,020,000
	Ore No. 7	258,500 261,500	62,000 64,500	12,500,000	13,340,000	20,000,000	35,840,000
	Ore No. 8	260,500	55,500	770,000	-	1,000,000	1,770,000
El Hasa region: 135 km to the south of Amman.	Ore No. 1	244,500 245,500	28,300 29,500	1,400,000	-	-	1,400,000
	Ore No. 2	249,500 251,000	27,000 30,200	9,000,000	-	-	9,000,000
	Ore No. 3	248,600 250,500	47,000 48,700	11,110,000	-	-	11,110,000
	Ore No. 4	244,000 244,800	35,700 37,000	7,330,000	-	-	7,330,000
	Ore No. 5	254,700 255,300	37,400 38,100	3,600,000	1,800,000	1,000,000	6,400,000
	Ore No. 9	247,400 250,200	23,000 27,500	28,620,000	-	-	28,620,000
	Ore No.10	252,500 253,300	47,500 48,500	1,110,000	-	500,000	1,610,000
	Ore No.11	250,800 252,800	23,000 27,500	1,700,000	3,400,000	-	5,100,000
	Ore No.12	240,300 242,000	20,000 22,700	-	3,000,000	2,500,000	5,500,000
Total ore reserves in El Hasa - El Qatrana region				78,160,000	21,540,000	26,540,000	125,700,000

/...

Table No. **XV.** (cont'd) Reserves of Phosphate Ore (1972) (El Ruseifa - El Zarqa Region)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
El Ruseifa - El Zarqa area region: 15 km north-east of the city of Amman	El-Ruseifa ore	247,500 249,500	156,200 158,000	9,000,000	-	-	9,000,000
	El-Zarqa ore A	249,500 250,800	156,200 157,700	18,000,000	-	-	18,000,000
	El-Zarqa ore B	250,000 254,000	156,500 160,000	3,000,000	30,000,000	39,000,000	72,000,000
Total ore reserves in El-Ruseifa - El-Zarqa region				30,000,000	30,000,000	39,000,000	99,000,000

Source: The Second Arab Conference for Mineral Resources, Conference Documents, Background Papers.

area extending on both sides of the Hedjaz Railway and an option for obtaining five exploration and two mining leases for an area totalling 288 km^2.

Mining of the phosphate deposits is undertaken by opencast if the stripping ratio is less than 6:1 (El-Hasa) or less than 4:1 (El;Ruseifa). The percentage of recovery in opencast mines is generally between 95 to 97 per cent.

The underground operation is used in El-Ruseifa mine on a limited scale and with the application of semi-mechanical methods. The percentage of recovery is 85 to 90 per cent. There are plans to develop underground operations on one of the deposits of El-Hasa by applying the most modern mechanized equipment. The percentage of recovery in this region is expected to attain 80 to 85 per cent.

Production of the wet-screened phosphate and roasted ore concentrate for the period 1954 to 1973, together with some characteristics of the ore concentrate are shown in Table No. XVI

Mining during that period increased by more than 18 times. Production almost doubled between 1972 and 1975 rising from 709,000 to 1,500,000 tons and is expected to reach 7 million tons in 1980. Expansion of phosphate production requires the opening of new mines, up-grading of its quality, establishment and improvement of infrastructure. These activities are expected to lead to wider markets which in turn would make it possible to use fully the production capacity of the company which was well above the actual ore production in 1975. (Production in 1975 was 1.5 million tons and the production capacity of the Jordan Phosphate Mines Co. was 2.75 million tons).

Most of the Jordanian phosphate is shipped through the port of Aqaba, the export capacity of which has recently been increased to 2 million tons per year. Automatic loading equipment has been installed and two storage depots and a deep-water berth have been constructed.

It is expected that about 90 per cent of the total phosphate exports will be handled through this port in 1980. The share of the phosphate export earnings in the total commodity export earnings during the last five years ranges between 24 and 28 per cent (30% in 1973). Phosphate exports

Table **XVI**-Production in Jordan of Wet Screened Phosphate and The Roasted Ore concentrate (in metric tons)

Year	El-Ruseifa	Mine	El-Hasa	Mine	Total	
	wet screened	roasted concentrate	wet screened	roasted concentrate	wet screened	roasted concentrate
1954	74,848	63,621	-	-	74,848	63,621
1955	163,598	139,058	-	-	163,598	139,058
1956	208,557	178,520	-	-	208,557	178,520
1957	261,896	216,600	-	-	261,896	216,896
1958	293,832	242,328	-	-	293,832	242,328
1959	337,624	318,218	-	-	337,624	318,218
1960	391,640	341,091	-	-	391,640	341,091
1961	439,130	346,227	5,821	4,948	444,957	351,175
1962	622,616	572,981	58,394	49,635	681,010	456,309
1963	561,824	274,773	53,612	45,570	615,436	320,343
1964	557,348	549,753	146,478	82,212	603,802	631,965
1965	709,329	527,669	148,013	86,551	857,342	614,220
1966	619,443	489,247	381,322	307,687	1,000,765	796,394
1967	623,365	426,702	680,022	467,666	130,387	894,368
1968	573,097	411,489	1,017,759	750,392	1,590,856	1,161,881
1969	489,937	361,375	830,673	725,958	1,320,610	1,087,343
1970	461,313	386,741	550,486	504,568	1,011,799	891,309
1971	627,500	334,887	152,271	193,002	779,771	527,889
1972	502,750	385,598	418,167	308,232	920,917	693,830
1973	739,721	650,724	635,098	463,639	1,114,363	1,203,360

Source: The Second Arab Conference for Mineral Resources, Conference Documents, Background Papers.

Table No. XVII

Main characteristics of Phosphate Ore Concentrates Produced from The Main Deposits in Jordan

Some characteristics of the ore concentrates	El Ruseifa mine		El-Hasa mine		
	70/72% TCP type (unwashed)	70/72% TCP type (washed)	70/72% TCP type (unwashed)	73/75% TCP type (washed)	75/76% type (washed)
P_2O_5	32.34	32.36	32.46	33.9	34.6
CaO	52.22	50.32	49.90	52.3	52.7
$Fe_2O_3 + Al_2O_3$	0.52	0.50	0.88	0.47	0.47
Cl	0.07	0.046	0.41	0.04	0.04
F	3.63	3.72	3.70	3.86	3.96
Sandy matter	3.21	5.52	5.13	2.62	2.00
Loss by weight	6.80	7.72	5.75	6.06	5.62
CO_2	5.10	5.89	3.80	4.00	3.60
Organic matter	0.31	0.21	0.34	0.50	0.27
Humidity	1.50	1.2	1.50	1.50	1.50

Source: The Second Arab Conference for Mineral Resources, Conference Documents, Background Papers.

reached in 1973-74 about 1.2 million tons per year, which is about 40% less than the Aqaba export capacity. Annual income generated from marketing of phosphate exceeded four million J.Ds.

About 30 to 40% of the total phosphate export is sold to India and 18% to Japan. Other consumers are: Turkey, Czechoslovakia, Yugoslavia, African countries, Iran, and Lebanon. As of 1976, the great bulk of the Jordanian phosphate export will go to Romania, which bought during that year 300,000 tons and it is estimated that exports of phosphate to this country will reach 500,000 tons by 1980.

The territory of S y r i a is rich in phosphate. Although commercial discoveries of phosphate resulted from the work undertaken during the last 10-15 years, its presence in Syria was reported by L. Dubertret and his colleagues much earlier in the thirties.

The stratigraphic series contains phosphate ranging in age from Campanian to Late Eocene. Cretaceous phosphate is solid in composition and according to the shape of its ore bodies, may be referred to as land phosphate rock. Paleogene phosphate is found in the form of nodules included in glauconite intercalations, both are marine platform formations.

Land phosphate rock contains phosphate material in oolite-like grains, oolites, concretions and organic remains. Concentration of nodular phosphate consists of phosphate nodules plunged into glauconite, carbonate or clay mass with calcite indication, phosphate grains and fish bones and teeth.

The first considerable amounts of phosphate appear in the Campanian sequence, with the greatest number of phosphate beds and their largest thickness prevailing in its upper part. In outcrops, phosphate makes a compact granular rock of grey colour with light concretions and some organic material. The subsurface ore is generally not strong, but brittle. The number of phosphate beds is 12 with the thickness of each exceeding 1m. There are places where phosphate beds are up to a few metres thick. The beds are traceable laterally for several kilometres. The Campanian phosphate is confined to the eastern part of the Palmyrides.

The phosphates of Campanian age differ both by their structure and by the content of TCP. Distinctly recognizable is a granular phosphate in

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BEIRUT

Corrigendum

Survey Report on the Situation Pertaining to the Development of Mineral Resources in the Countries of the ECWA Region

1. Please insert the following sentence on page 176, line 20 to read:

"Following the establishment of a geological documentation centre and a geological data bank, the establishment of these specialized centres could contribute to a better evaluation ...."

2. Please replace the first paragraph on page 184 under item 1, "Pre-investment activities and establishment ....." to read as follows:

Pre-investment activities require heavy expenditure the return on which may not materialize directly. Financial and technical assistance provided by international and regional organizations to the least developed countries of the region becomes therefore a necessity. Furthermore the participation of these organizations in the creation of regional mechanisms aimed at promoting economic, technical and financial co-operation among member States will help these countries solve some of the key problems facing the development of mineral resources in the ECWA region.

which oolite-like bodies make up to 80% of the rock. Most widespread is the phosphate having a mixed structure: nodular-granular, organic-granular and nodular-organic (the poorest type). All types contain a small amount (about 5-10%) of terrigenous quartz grains, the size of which ranges between 0.1 to 0.6mm. Cement can consist of calcareous, siliceous and siliceous-calcareous material. The richest type of ore contains carbonate-phosphate cement. The average content of P_2O_5 is about 22%, with extreme values of 16 and 34.6% for a minimum and maximum contents respectively.

- One of the largest phosphate deposits of Syria is Khneifiss deposit located in Khneifiss region on the western border of Jabal Al-Abtar, south of Palmyra. The explored area of the phosphate formation extends over a distance of 7km to the north-west of the Abtar and Khneifiss anticlines.

The dip angles of the phosphate beds generally range from 6 to 20^o. The anticlines and the entire area of the deposit are separated by a nearly latitudinal fault along which the northern block is upthrown.

The phosphate unit consists of five members (from bottom to top):

1. Flint with rare phosphate intercalations (0.1 to 0.4m thick) and limestone lenses.

2. Phosphate (19.39 to 34.60% P_2O_5), with limestone and flint lenses. The thickness reaches 12.7m but the average is about 3.92m.

3. Limestone and flint, the thickness ranges from 0.1 to 5.8m with an average width of 2.95m.

4. Phosphate (19.84% to 34.82% P_2O_5), with petering out intercalations (5 to 40cm) of limestone. The thickness ranges from 0.7 to 7.1m, but the average is about 3.36m.

5. Various limestones, clays and opokas intercalated by flint and phosphate (0.15 to 1m) of Maestrichtian age.

The average chemical composition of the commercial beds is as follows:

Unsoluble residue - 9.10%
SiO_2 - 8.59%
R_2O_3 - 0.74%
CaO - 48.06%
MgO - 0.34%
FeO, alkalis and SO_3 - n0.1%

P_2O_5 in the lower bed - 27.63%
P_2O_5 in the upper bed - 27.79%

The total estimated phosphate reserves of the deposit are 24,585,530 tons, including about 15.5 million tons of ore containing on average 28.58% P_2O_5.

The thickness ratio of the overburden to the phosphate bed for the entire deposit is 2.05 (the thickness of overburden above the upper bed is not more than 20m).

Two additional phosphate deposits of the same age, Sharkieh A and Sharkieh B, are located 45km south-west of Tudmor. In this area, the phosphate formation is 11 to 19.5m thick and lies on a massive organic limestone. It contains pinching beds (2 or 3m) of limestone and dolomite. These beds are mainly found at the lower part of the formation measuring up to 8.5m and are excluded from the estimation of reserves. In both deposits, the upper part of the formation is composed, in places, of the ore averaging 24.45 per cent P_2O_5 (19 to 33%). The other chemical composition of the ore is showed below:

Unsoluble residue - 8.7% 8.78%
R_2O_3 - 0.5 to 1%
CaO - 48%
MgO - 0.2 to 0.7%

The beds are horizontal. Phosphate rock is outcropping in a large area or is overlain by Maestrichtian clays with subordinate limestone and dolomite and by sediments of Quaternary age.

The proven reserves of the deposits total 139,080,000 tons, with an average thickness of about 11m, average P_2O_5 content of 24.5% and an average thickness of overburden of 3m. The estimated reserves calculated from a rare network of exploratory pits, amount to 266 million tons, with an average thickness of not more than 22m.

The second phosphate series in the stratigraphic sequence of Syria is confined to the lower part of the Maestrichtian beds, the thickness of which varies from 35 to 100m. Land phosphate rocks of this age are also found in the eastern half of the Palmyrides area. The number of phosphate beds amounts to 20 with a thickness ranging from 0.1 to 1m.

The phosphate of Maestrichtian age belong mainly to a mixed type The content of different phosphate elements varies, but generally simple grains prevail. There are phosphates of oolitic texture with clearly seen oolites, teeth, spinyform scales, vertebrae, bone fragments and concretions. The cement is calcareous, argillo-calcareous, argillaceous, with an admixture of phosphate in richest varieties. Siliceous cement is rare, being secondary and disappearing with depth. The P_2O_5 content in these phosphates amounts to 32 per cent.

- Commercial evaluation was carried out on the Maestrichtian phosphate after the exploration of Erkheime deposit. There are three exploitable phosphate beds, which are of Maestrichtian and Campanian age. The thickness of overburden above the top bed is not more than 15m (the thickness ratio of overburden for the whole deposit is 5.9). Available reserves amount to 70,053,920 tons. The average chemical composition of the ore is as follows:

P_2O_5 - 23.3%	MgO - 0.4%
CaO - 42.1%	SiO_2 - 16.8%
R_2O_3 - 1.2%	

- The phosphate is found at the base of the Maestrichtian in Jabal An-Nusseiriyeh, Kurd-Dagh, generally belongs to a nodular type and are associated with glauconite. This type of phosphate presence in the Mzeraa phosphate deposit is located in Jabal An-Nusseiriyeh. Phosphate-bearing beds of this deposit dip at an angle of 5° to 15°, extending over 9km and in some places has a maximum thickness up to 25 metres. Phosphate is present in the form of irregular grains and nodules. The nodules contain 23.2 - 25.7% of phosphate and make up less than half the volume of the rock.

- Younger deposits of phosphate are of inferior quality and do not form any thick and persistent accumulations. In the rocks of Late Banian age, in Chadir El-Kamal, there is an eighteen metre formation of argillaceous, plate limestones containing thin, non-persistent, usually silicified laminae of granular phosphate. At the top of the formation there is one bed containing 17.5% P_2O_5 and having a thickness of 0.7m.

- Phosphate concentrations found at the base of the Lower and Upper Paleocene rocks are developed only locally and are of a low grade (Jabal Ash-Sheikh).

The Lower Eocene phosphates are similar to the Cretaceous ones, but the maximum content of P_2O_5 is 24.8%. Solubility of phosphate in citric acid is not more than 22%. Phosphate of this age is present in many occurrences but occurs in thin poor laminae. Its quality and thickness improve in the extensive desert plain in the south-east of the country.

- According to results of a preliminary prospecting conducted in Taraq el Hbari and Bir Sejri areas, which constitute one phosphate-bearing field, only one or two beds have an exploitable thickness (more than 0.4m). The content of P_2O_5 amounts to 24.78% but often drops down to 16%. Geological reserves of phosphate in the respective areas of 108km^2 and 73km^2 total 431.6 million tons, with 19.06% average content of P_2O_5 and up to 56% content of SiO_2.

Stratigraphically upward "phosphatization" rapidly decreases though the beds of Middle Eocene age contain both solid-granular and nodular-glauconitic phosphate with teeth and bones. The latter is more common and has a larger thickness but a low content of P_2O_5. In the richest localities of this age the rock contains 9 to 12.7% P_2O_5 and pure nodules 22.8 to 26.5%.

- The last phosphate bed in the sequence is confined to the base of the Upper Eocene limestones. This bed occurs in Tell Om Ad-Darrabiyeh where it is 2.7m thick and often filled with fossil shells. Phosphate in the form of grains, micro-concretions, nodules, teeth and bones is concentrated mainly at the bottom of the layer containing 7 to 10% P_2O_5, with negligible amounts of glauconite.

In Syria, therefore, there are three main phosphate deposits of solid granular phosphate belonging to Campanian and Maestrichtian ages viz: Khneifiss, Sharkiya A and Sharkiya B. Exploitation of those and other phosphate deposits is one of the major activities in Syria, to which the government attaches high priority after the oil industry. Necessary steps have been taken to exploit 2 million tons of ore per year. Presently, mining of phosphate at Khneifiss reaches 300,000 tons and is expected to increase up to 600,000 tons per year. After exploitations of the Sharkiya A and Sharkiya B has been effected, the output will increase by 900,000 tons of ore per year (600,000 tons and 300,000 tons per year respectively). In 1976 phosphate production increased to 1,200,000 tons as against 857,000 tons

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Romanian company "Geomin", Polish "Centrozap" and Bulgarian experts took part in studying and mining of phosphate deposits in Syria.

Considerable prospects exist for discovering new phosphate deposits in the Palmyrides and in the central areas of the country. A wide development of granular and nodular phosphate on the adjacent south-eastern territory suggests the presence of commercial phosphate deposits in Paleogene formations of the Syrian desert.

During the last few years, exploration and prospecting was carried out and is planned to be conducted in various parts of the country, including the Abtar area, the regions of Baida (the central part of the Syrian desert) and Hefeh (Kala'a Jandal, Ain Leiloun), where 6.5 million tons of reserves have been estimated with a P_2O_5 content ranging from 16 to 25 per cent.

In the northern part of S a u d i A r a b i a near its border with Jordan, two large phosphate deposits have been located in the Turayf - Thaniyat area.

Phosphorite beds crop out along the south-western rim of the Sirhan-Turayf sedimentary basin.

- The best phosphorite located so far is at West Thaniyat, found in two beds of the Aruma Formation (Upper Cretaceous age). The first one of them is 10cm to 1m and the second one 1 to 2.5m thick. The two beds are separated by a mostly barren material, the thickness of which reaches 1.65m. One of the beds averages 165cm in thickness, covering an area of 50 sq. km. and having an average grade of 23 per cent P_2O_5. The estimated reserves are about 190 million metric tons of phosphate rock. Beneficiation up to 33.5 per cent P_2O_5 (a minimum export grade) would involve calcination and possibly gravity or flotation techniques, which could well prove to be uneconomical. Beneficiation to above 31% proved very difficult and the obtainable final grade may not even be marketable. However, grades above 27-28 P_2O_5 are usually suitable for economic production of phosphoric acid and may be used for manufacturing single or triple super phosphate. Ratio of $CaO:P_2O_5$ is low, and much of the quartz can be screened off, leaving only clay minerals in the phosphate. If fuel is made available at production cost including transportation, and sulphuric acid is supplied at low cost, establishment of a fertilizer industry can be economically viable.

Other factors preventing immediate development of the deposit are: a very thick overburden limestone ranging from 26m to over 100m, hence preventing the use of open-pit mining method; a long distance from the coast (over 400 kilometres) and the uncertainty of water supply.

Further work will provide an estimation of the approximate cost of production and additional drill holes will give more detailed information on mineralogy, grade and reserves of the deposit.

- Turayf depost, occuring in Hibr Formation of Paleocene-Eocene age, contains 3 phosphorite zones, the thickness of which ranges between 0.25 and 8.09m. For an area of 78.5 sq.km, reserves are estimated at 722,200,000 tons of phosphates averaging 18% of P_2O_5 content. The material has virtually no silica and no clay minerals. Beneficiation without calcination does not produce an economic grade dor direct shipment or for phospheric acid - superphosphate conversion.

Prospects for mining depend on the availability of water, results of ore testing and cost of fuel. The deposit is currently under study. Small amounts of phsphate have been reported also from Tertiary beds in the coastal region east of Jeddah which contain shark teeth.

In Lebanon, some unstudied phosphate occurrences of Upper Cretaceous age are located at about 85km from Beirut south Bekaa region, in Ain Fjour area, where a limited exploitation work was carried out during the last few years. Other occurrences associated with a marine glauconite horizon are known in the region of Rachaya and Quaraoun. The probable reserves of phosphate in two deposits of this region amounted to 200,000 tons and 1,675,000 tons with P_2O_5 grade of 20-25%. The phosphate bearing horizon has a thickness of 2 to 5m, dipping 30-35°.

No additional information is available on phosphate in Lebanon. Despite the availability of phosphate deposits, this country imports about 10,000 tons yearly of superphosphate fertilizers from abroad.

People's Democratic Republic of Yemen and Oman are planning to search for phosphate in the areas where Upper Cretaceous rocks from subout crops.

It is probable that phosphate occurrences exist in the Gulf States, however, no information is available on the subject.

It should be mentioned in this case that phosphate ores usually contain low grade of uranium, which could be extracted when the industrial technology is applied. Experiments on the extraction of U_3O_8 on an industrial scale are conducted with phosphate ores.

It should also be indicated that precautionary and safety measures should be taken during phosphate mining since the usual component of the phosphate ores is the product of the uranium radioactive decay-radium 226. During mining and processing operations, the readioactive material may occur in the air and water leading to a contamination of the environment. Pollution control would be desirable and need to be established in the mining and surrounding areas.

Phosphate Reserves in the ECWA Member Countries Table No. XVIII

Countries and Deposits	Reserves million tons proven	probable	total	P_2O_5 Content (%)	Type of ore	Age	Production capacity (in million tons of ore) and method of mining	Industrial enterprises	Production and capacity of chemical enterprises
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Iraq									
Akashat area		1,760	1,760		Porous, oolitic, to pseudo-oolitic, isomorphic mixture of fluorocarbon apatite and sodium sulfo-apatite	Upper Cretaceous Paleocene-Eocene	1 million tons per annum in the first stage; open-cast method; overburden thickness is about 5.5m	Under construction:	
								1. Phosphoric acid plant	130,000 tons of phosphatic acid
Akashat deposit	12.3	419.7	432.0	20.5				2. Triple super phosphate plant	300,000 tons TSP of of 45-46%, P_2O_5
								3. Sodium fluoro-silicate plant	70,000 tons, 95% purity of Na_2SiF_6; (in the 2nd stage, 6,000 aluminium fluoride and 3,000 tons cryolite)
								4. Dressing plant	One million tons of ore per year
Jordan									
El-Ruseifa region	30.0	30.0	99.0	32.0--33.0	Sand-like; calcareous; mixed calcareous/siliceous	Maestrichtian, Campanian Eocene	750,000 of 70/72% TCP open and underground	Under construction:	
								1. Phosphoric acid plant	Phosphate acid, mono-ammonium, di-ammonium
El-Hasa region	78.160	21.54	125.7	32.2--34.8	Siliceous; argillaceous-siliceous; argillaceous; marly		1250,000t. of which 450,000t of 75/77% TCP grade	2. Triple super phosphate plant	600,000 tons of TSP (N.A.)

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Table No. XVIII

(cont'd) Phosphate Reserves in the ECWA Member Countries

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Total in Jordan	108.16	>300	>1115	15-35	Mineralogical composition: fluoroapatite and fluoro-carbon apatite		By 1980, production capacity will be 7.0 million tons including 2.6 million tons in Hasa region	3. Phosphate processing plant	Reduced chlorine content phosphate
Saudi Arabia									
Thaniyat	-	190	>190	23.0	Mixed calcareous/ siliceous	Upper Cretaceous (Aruma Formation)	Not exploited, overburden ranges from 26 to more than 100	Suggestions to build phosphoric acid and fertilizer plants	
Turayf	-	722.2	>722.2	18.0	Calcareous?	Paleocene-Eocene (Hibr Formation)	Not exploited		
Syria									
Khneifiss	-	24.6 including 15.5	>24.6 -	~27.70 28.50%	Land: oolitic oolite-like concretions with organic remains Nodular: phosphate nodules into glauconite, carbonate or clay mass.	Campanian-Maestrichtian	Overburden rock up to 20m thick, overburden thickness ratio is 2.05. Production up to 300,000 ore per year. It is planned to mine 600,000 tons	1. Fertilizer plant at Homs is under construction	450,000 tons per year of triple super phosphate in addition to phosphoric acid and red phosphorous

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(cont'd) Phosphate Reserves in the ECWA Member Countries Table No. XVIII

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sharkieh A) Sharkieh B)	-	130.0	266.0	24.45	Land and nodular with calcareous, siliceous and siliceous-calcareous cement		Overbruden rock has an average thickness of 3m Mining in Sharkieh A up to 600,000 t/y; in Sharkieh B 300,000 t/y		
Erkheiml	-	70.0	70.0	23.3			Overburden up to 15m thick. The ratio of overburden is 5.9		
Taraq el Hebri and Biz Sejri areas	-	-	431.6	19.06 (up to 56% SiO_2)	The same as the Cretaceous one		Lower Eocene	Not exploitable	
Tell Om Ad-Darrabiyeh	-	-	-	7-10	Nodules, grains, micro-concentrations, teeth and bones		Upper Eocene	Not exploitable	
Hefeh (Kala'a Jandaly Ain Leiloun)	-	6.5	>6.5	16-25	-		Under exploration		

Source: Economic Commission for Western Asia, based on data compiled from national, regional and international sources.

b) Sulphur

About 30 per cent of the world sulphur production is extracted from crude oil and gas during the refining process. It is estimated that total sulphur reserves contained in crude oil and gas are about 1.250 billion tons, 70% of which come from the Middle East.

In 1975, the world production of sulphur was 52 million tons, including elementary sulphur - 17.6 million tons; sulphur from pyrite - 15.1 million tons; and 12 million tons of sulphur extracted from the metallurgical gas.

In this item only the first two types of sulphur, namely, elementary sulphur and pyrite deposits are described below. From a geological structure point of view, a large sulphurous basin is located in the large zone of connexion between the Mesopotamian depression and the Arabian Platform.

Some large deposits of native sulphur are located in I r a q , where commercial concentrations of it found in anticlinal structures are associated with gypsum-bearing units of the Miocene Age.

Accumulations of native sulphur intergrown with calcium carbonate are likely to occur where the calcium sulphate of gypsum or anhydrite was reduced by anaerobic bacteria in the presence of gaseous hydrocarbons.

Sulphur ore bodies are usually in the form of layers with thickness ranging from 1 to 46 metres and sulphur content over 30%, lying at a depth of more than 10 metres (at Mishraq deposit between 50-300m).

I r a q ranks first in the world in sulphur reserves, which are estimated at 335 million tons, as compared to a total of 912.5 million tons of its world reserves.

- While studying the geological features of the main Iraqi sulphur deposit of Mishraq, it was found that the Frasch method is the most suitable one for its mining. This method uses hot water (about 165°C) which is forced under high pressure down to the ore beds through the drilling pipes. Melted sulphur is then lifted by the water pressure in the rock formation. Compressed air forced down the smallest pipe (1 inch), lightens the sulphur which would then rise all the way to the surface. This process is continuous during the whole life of the mine.

According to an agreement signed between the National Iraqi Mining Ores Co. and a Polish Company on development of the deposit, production of native sulphur will reach 250,000 tons per year (former production was 60,000 tons per year). At the second stage, production will reach 1 million tons of native sulphur per year. The cost of the project is about ID 16 million. In 1973 Iraq exported 100,000 tons of sulphur to each of India, China, and Poland and 60,000 tons to Lebanon.

- In 1972 Iraq started exploitation of the other sulphur deposit located in the Mosul region with an output of 150,000 tons per year. It is expected that the total native sulphur output will reach in the near future 1 million tons per year. The growth of production depends also on the growth of world demand for sulphur.

In S a u d i A r a b i a native sulphur occurrences have been noticed in gypsum beds of Neogen age along the Red Sea coast.

- Another source of sulphur in the country consists of massive pyrite in some areas, the reserves of which amount to 640 million tons, i.e. about 34% of total world reserves of pyrite ore. The deposits are located in the

Wadi Wassat and Adhbat-Katen districts, about 620 km south-east of Jeddah where they occur in bedded acid pyroclastic and sedimentary rocks and appear to represent a stratabound, syngenetic type of deposit which is marked at the surface by wide iron-rich gossans. Pyrite mineralization has a discontinuous strike length of about 18km at Wadi Wassat and 47km at Adhbat-Katen. Preliminary estimates based on limited drilling indicate the existence of 95 million tons of ore with 78% pyrite at a 100m depth.

Stratiform pyrite mineralization was found in Samran area, where comparatively small ore lenses and disseminated pyrite mineralization are associated with pyroclastics in a synvolcanic form. Hydrothermal vein deposits which also occur in this region are usually of sub-economic value.

In both of these areas, large reserves of iron and sulphur have been identified, but the mineralization does not contain any base or precious metals which would enrich the value of ore and would make the deposits located in remote areas economically exploitable.

Sulphur as a by-product of natural gas has virtually eliminated pyrite as a sulphur source.

Further efforts to discover base and precious metal ores associated with the iron sulphides are planned.

In S y r i a native sulphur mineralization is located in Middle Jurassic black, strong clay and gypsum occurring in Jabal Qalat El-Hirri in Palmyrides. Sulphur forms patches and selvages in cracks, sometimes within gypsum. The grade is too low (0.6% to 29.8%) for the sulphur ore to be considered as an economically exploitable one. Further exploration work is planned in the area of the extent of the Middle Jurassic rocks. The more promising sediments for sulphur are of Neogen age spread in the north-east of the country. During the last 5 to 6 years extensive exploration work was conducted in Ras El-Ain in Jazireh, in the north-west of Palmyrah in Deir-Ezzor, El-Haffe near Kherbet El-Kreik, and Tawwal El-Aba.

c) Rock salt, sodium sulphate, potassium salts:

Total world salt reserves are estimated at about 1.75 million km^3, mostly related to Phanerozoic sequence.

These minerals play an important role in the life of human beings and are used in various branches of industry.

Rock salt ($NaCl$) is known not only as a food product, but is also used as a fodder and for the production of various natrium and chlorine chemical products, including coastic and calcic soda, chlorine gas, chlorates, chlorhydric acid, sal-ammoniac, chlorous calcium etc.

Rock salt is used also in soap and paint production, in nitric, metallurgical, oil and pharmaceutical industries and for other purposes totalling not less than one thousand five hundred uses.

More than 90% of potassium salt is utilized in the production of fertilizers and the remaining 10% is used in the chemical industry. Potash, potassium chlorides and potassium sulphate are used in the production of fertilizers.

Carnallite ($KCl.MgCl_2.6H_2O$) is utilized for the production of potassium and magnesium salts, magnesia and metallic magnesium.

Tenardite (Na_2SO_4) and mirabilite ($Na_2SO_4.10H_2O$) are among the important raw materials used in the production of soda, ammonia soda, potassium sulphate, sodium sulphide, ultramarine etc.

Furthermore, these salts are widely used in glass, paper-making, pharmaceutical industries, photography and for various other purposes.

In the ECWA region, salt deposits are located in many countries, mainly concentrated in the youngest evaporates of the upper parts of Cenozoic. In the Y e m e n A r a b R e p u b l i c , salt is one of the most important natural resources, a leading export item of, and potentially a foreign exchange earner for the country.

A salt deposit occurs near the Gulf of Salif 1/ at a distance of 80km north of Hodeidah. According to a geological survey conducted recently by a Canadian consulting firm, the deposit is spread over an area of 2.5km by 1.5km, with a thickness of about 100 metres and its estimated reserves of 200 million tons. These reserves are sufficient to meet the annual export demand of 1 million tons over a period of 70 years. The survey also points out to the possibility of finding another deposit nearby. Quality of the North Yemeni salt is very high. According to the weighted average values from the analysis of samples from 16 holes drilled in the mining area, the chemical composition of the salt is as follows:

Sodium - 38.64%	Chloride - 59.60%
Potassium - 0.016%	Sulphide - 0.75%

1/ See also item "gypsum and anhydrite".

Calcium - 0.36% Water insolubles - 0.38%

Magnesium - 0.0083% Sodium chloride 98.23%

For the exploitation and marketing of salt deposits, the "Yemen Salt Mining Corporation" (YSMC) was established by law No. 36 promulgated on 4 June 1972. This corporation which has its headquarters at Salif operates under the supervision of the Ministry of Economy.

In 1968 the government signed a contract with Romanian "Geomin" for the modernization of equipment. Another agreement signed on 28 July 1970 with the "Kuwait Fund for Economic Development", aimed at increasing production up to 1 million tons per year and loading capacity up to 1 thousand tons per hour in ships of 50,000 D.W. This project was expected to be implemented by a Canadian company "Swan Wooster Engineering Co. Ltd". Accordingly mining is expected to be initiated in December 1975.

Japan was the only country which imported salt from YAR. Because of high CIF prices, exports of salt to Japan stopped in 1972. This situation can be explained by a weakness in loading capacities.

Although Japan is the largest salt importer in the world (about 50% of total salt imported by developed countries), its salt imports from Yemen did not amount more than 1.2% of its total salt imports. The economic significance of salt exports in YAR is shown in the following table.

Table No. XIX . Proportion of the value of salt export to the value of total export for 1965-1973 (value in thousand Yemeni rials)

Year	Total exports (1)	Salt export (2)	(1) to (2) %
1965	7023	2000	28.4
1966	7283	2000	27.5
1967	-	-	-
1968	-	-	-
1969	17957	1351	7.5
1970	15759	1490	9.5
1971	21571	2384	11.1
1972	20074	661	3.3
1973 1/	36008	31	0.08

1/ According to the Arab Industrial Review, Vol. 11, No. 6, 15 March 1975, salt export in 1973 made up 4 million Yemeni rials or 10% of total export.

Total investment in the salt mining industry during the three year development plan (1973/74 - 1975/76) is expected to reach 20015 YR financed from foreign sources. Before 1973/74, total investment was only 8751 YR. The production capacity of Salif mine at present is 250,000 tons of salt per annum.

In Jordan, the main reserves of salt are contained in the water of the Dead Sea, the salinity of which ranges between 28% and 33%. Estimated reserves of various salts are given below:

1.	Magnesium chloride	23 billion tons;
2.	Sodium chloride	12 billion tons;
3.	Calcium chloride	7 billion tons;
4.	Potassium chloride	2 billion tons;
5.	Potassium bromide	2 billion tons;
6.	Magnesium bromide	975 million tons;
7.	Rubidium chloride	12 million tons.

Until recently a huge solid salt deposit was exploited only for potassium chloride at a production rate of 10,000 tons per year. Because of impurities with magnesium salts, the rock salt in particular cannot be produced by simple seawater evaporation. Following a study conducted in 1974, it was planned to increase production of potassium chloride up to 1 million tons of salt per year.

As a first stage, it was suggested to construct one kilometre experimental dike and to conduct site investigations using the results arrived at in drawing up technical specifications for the production units. Economic, marketing and management aspects of this project will be studied. At later stages, companies will be established which in collaboration with the existing Arab Potash Company will undertake the extraction of other salts from the Dead Sea. It is expected that production will start in early 1982; the financial requirements for the implementation of this project are estimated at JD 45 million. 1/

As a result of the potash project, some industries will spring up in Jordan, including production of medicines, plastics, detergents, insecticides, paints and cosmetics. Fire-resistant bromine and magnesium will also be produced from the Dead Sea brine.

1/ "Five Year Development Plan of Jordan", 1976-1980.

According to responsible officials of the Arab Potash company, the above project will create additional employment opportunities and increase Jordan's export earnings by $200 - 300 million annually. Potash production is expected to start by 1982 with an initial production capacity of 300,000 tons per year. The annual production target of one million tons will be reached for years later.

Rock salt is produced in small quantities in the area of the Al-Azraq Basin where saline groundwater is collected in trenches and brought into evaporation pans.

An unlimited, but not yet utilized 100m thick deposit of rock salt occurs in the Al-Lisan Peninsula where it underlies Upper Pleistocene marls.

Potash layers were discovered in Miocene (?) - Pliocene evaporite sequence in the south-east part of the Al-Lisan Peninsula, but this deposit has not been studied yet.

A large rock salt deposit was discovered in 1969 in the Jizan area in the southern part of S a u d i A r a b i a. A diapir with Miocene salt beneath a shallow cover underlies a hill of 1.5 x 3km. Estimated reserves in the upper parts of the hill total 33.5 million tons within a depth of 40 meters. For each additional depth of 10 meters, an addition of 8.4 million tons of presumably similar grade material can be expected to already estimated reserves. Possible reserves are over 1 billion tons. Average grade for the 400,000 m^2 x 40 m block is:

NaCl - 96.00%

$CaSO_4$ - 1.50%

Undissolved residue: $CaSO_4$, clay, salt and quartz grains - 2.10%

Br - 0.01%

KCl - 0.20%

Moisture - 0.06%

Total - 99.86%

The flanks of the hill consist of rock salt of no economic value. Low grade of salt rock (2% less than the desired quality) and the limited loading facilities at the seaport of Jizan constitute the main obstacles to facing the development of this deposit in the near future. Furthermore, the existence of a Salif deposit in YAR located on the Red Sea shore and containing a high quality raw material may result in an unfavourable marketing situation for the Jizan deposit. Further exploration of this deposit requires providing of geological mapping, beneficiation testing and consultancy and studying possibilities of improving the loading facilities at the Jizan Harbour.

In the same region of Saudi Arabia, in the Miocene sequence, indications of soda were proven also. In addition, it has been found feasible to extract potassium chloride from the water of the Gulf of Garnet.

Salt of Mesozoic or older sedimentary rocks occurs in the south-western part of Ar Rub'al Khali, but these deposits are too far from the markets to be exploitable.

In the Arabian Gulf area, salt occurs along the coastal plain in Sabkhah deposits which were formed as a result of recent evaporation of brines. Sabkhah Al-Hamam deposit, located near Abqaiq, contains about one million tons or rock salt. Near Ras Tannurah the Umm Es-Sahij salt deposit is located. Analyses of two samples of crude salt taken from those two deposits show the following chemical composition:

Table No. XX. Chemical composition of crude salt from Salt Deposits in Saudi Arabia

Chemical components	Umm Es-Sahij deposit	Sabkhah Al-Hamam deposit
Sodium	40.58	37.5
Chlorine	55.80	58.10
Sulphate	0.66	1.40
Magnesium	0.41	0.27
Calcium	0.27	0.28
Bromine	0.022	not determined
Undetermined	2.25	1.63
Total	99.99	99.18

Table No. XX (cont'd)

Sodium chloride	94.40	95.38
Calcium sulphate	0.97	0.95
Magnesium chloride	1.68	0.31
Magnesium sulphate	0.00	0.91
Insoluble	0.00	0.82
Total	97.05	98.37

Source: "Mineral Resources of Saudi Arabia" Bulletin No. 1, 1968.

Because of small tonnage and low quality of the salt, these deposits are of limited economic value.

No information is available about salt reserves in the other countries of the ECWA region. Considering their geological background, salt deposits of economic value may be found in O m a n in the Upper Miocene sequence as well as in Upper and Middle Cambrian. In the United Arab Emirates salt is an important constituent of coastal and, to a lesser extent, inland sabkha deposits of Pleistocene **Miocene** age. Promising areas for possible commercial exploitation include Sir Abu Nu'Air and Jabal Ali, where the existance of salt plug (Jurasic ?) in the depth has been identified from surface geology. In I r a q there are some exploited salt deposits probably related to the Farce Formation.

Rock salt-bearing formations in S y r i a are associated with Lower and Middle Miocene (Tortonian and Burdigalian) sediments struck by wells at various depths. Burdigalian salt-bearing formation in the Al-Furatian trough lies at a depth ranging between 560.4m and 970m and its thickness varies between 120m and 200m. Lithologically, this formation is mainly made of rock salt, with thin gypsum interbeds at the bottom and limestone intercalactions at the top. Due to their depth, these deposits are not considered commercial. The most promising salt-bearing rocks which lie at small depths, belong to the Tortonian age. They are composed of alternating rock salt, limestone, gypsum and marl. The salt is white, in places pinkish, pure and translucent. In Harmoshia area rock salt was struck by a hole at a depth of 100 metres. This deposit is located on both banks of the Al-Furat river. Tortonian beds on the left bank of the river are 350 to 550m thick and on the right bank 290m to 400m thick. They are composed of anhydrite, gypsum, calcareous clay with marl and intercalactions of limestone and dolomite.

In the middle part of the sequence there are four lenticular interbeds, and two beds of salt. The upper bed was traced only on the left bank of the river while the lower one was traced on both banks. The salt beds are separated by a clay and anhydrite formation, 33 to 35m thick. Thickness of the upper bed varies from 4.1m to 10.5m, which has been proved to extend to over $16.35km^2$ at an average depth of 175m. The lower bed on the left bank is 5.5 to 12.3m thick, and it extends over $29.2km^2$ at an average depth of 219m. On the right bank, the thickness of the bed varies from 0 to 6.15m, with an average thickness and depth of 4.41m and 145m respectively.

Both beds are composed of white, coarse-crystalline, solid rock salt, with pockets and rare thin laminae of anhydrite. On the right bank, anhydrite lies in amounts which make it possible to obtain first grade salt (NaCl - 96%). On the left bank, high-grade beds alternate with low-grade ones. Reserves of this deposit are estimated for categories $B+C_1$(in preparation to mining project) at 95847.19 thousand tons and C_2 (for planning further exploration) at 812051 thousand tons.

In 1971, a project concerning development of salt deposits in Deir-Ezzor and Tabni was carried out, according to which the salt output would reach 140,000 tons per year in 1974. The cost of this project was estimated at 12 million Syrian pounds. An increase of the production of sodium solutions and chlore elements in the new plant was also planned.

- Salt production from the Tabni deposit, the reserves of which amount to 10 million tons with NaCl content of 98% to 99%, was 36,000 tons in 1975 and is expected to reach 114,000 tons per year. The deposit is exploited by underground method.

- The Ishmah salt deposit has 30 million tons of reserves and the value of production in 1975 amounted to 11 million Syrian pounds.

Further development of the rock salt mine is planned during the five-year plan period. For this purpose, the Syrian Government is to invest about 2730 thousand Syrian pounds. Part of this programme consists of UNIDO project concerning the evaluation and feasibility study of salt production either from lakes or the sea. (SYR/70/936)

At present the total possible rock salt reserves in Syria are estimated at 1 billion tons.

In PDRY a project on the technico-economic and market study for solar salt production in the Aden area were planned to be executed with UNIDO assistance. (project SOY/71/807)

2. Development of fertilizer and chemical industries based on phosphate and sulphur

In Jordan, the Jordan Fertilizer Company was established in 1975 with a capital of 20 million J.D. (about $ 63 million) to participate in the development of the fertilizer industry in Jordan. Shares of the company are distributed in the following manner:

- The Jordanian Government - 51.1 per cent;
- Jordan Phosphate Mines Co. - 25.0%; and
- The International Finance Corporation - 5.0 per cent.

The balance which is 18.9 per cent of the shares can be bought by Jordanian or Arab individuals and institutions.

According to the Five Year Development Plan (1976-1980), a fertilizer and chemical complex will be constructed by the company including: two sulphuric acid units with a total production capacity of 4000 tons per day, a phosphoric acid unit with a production capacity of 1.100 tons per day, a fertilizer unit aimed at producing triple super phosphate, mono and diammomium phosphate unit with a production capacity of 2.000 tons per day.

Low-grade phosphate (57 - 60 per cent TCP) will be used in the production of phosphoric acid. Internal requirements of ammonia (80,000 tons) and sulphur (350,000 tons) will be met by imports. The complex is being established on the southern tip of the Aqaba coast, and it is expected to become operational in 1979. The cost of the project is estimated at U.S.$ 313.5 million. Implementation of this project may result in an annual export earnings of 100 million dollar worth of fertilizer products, i.e. about 10 per cent of Jordan's GNP. In order to promote the export of phosphate in a competitive world market, the Jordan Phosphate Mines Co. announced in 1974 the decision to construct a phosphate processing pilot plant at a cost of $ 1.25 million with a UNDP 5% financial contribution.

This pilot plant will help to work out flow-sheets for improving the beneficiation process up to the optimum conditions practicable for the local ore.

The investments required for the beneficiation of presently non-exported phosphates range between \$ 130 to \$ 150 million.

Construction of two production lines of phosphoric acid is planned in I r a q , at Akashat. These production lines will concentrate the acid from a 30 per cent P_2O_5 content in order to satisfy the requirements of the triple super phosphate (TSP) plant. The production capacity of these lines is expected to be 130,000 tons per annum of P_2O_5.

A sulphuric acid plant will also be constructed in Al-Qain to supply the phosphoric acid plant with about 460,000 tpa of sulphuric acid (about 3.5 tons H_2SO_4 is required per ton of P_2O_5).

Due to the high ratio of fluorine in the above compared to silicon dioxide, about 30,000 tpa of silica will be added. The units are designed to absorb most of the fluorosilicic acid, to convert it into sodium fluorosilicate and thus to minimize the fluorine pollution of the atmosphere.

In the first stage, the fluorine (fluorosilicic acid) will be used in the production of about 10,000 tpa of sodium fluorosilicate (95 per cent purity) on the basis of utilization of the rock salt. In the second stage of production, the fluorisilicic acid will be used in the production of aluminium fluoride (about 6000 ton/year) and cryolite (about 3000 ton/year) which will depend on imported alumina and locally produced sodium carbonate. These compounds will be used in the aluminium project, the construction of which is planned in south of Iraq prior to 1980.

In addition to the above mentioned plants, a triple super phosphate (TSP) plant with a capacity of 300,000 tpa of TSP will also be constructed too. The granulated TSP containing 45 to 46 per cent P_2O_5 will be partly exported and about a third of the product will be consumed in Iraq. The main requirements for water and energy to supply the Akashat industrial site were determined to be 50,000 m^3/day (including 5000 m^3/day for mining operation) and 370 kw/hr per year respectively.

The phosphate project will require around 80,000 tpa of liquid fuel (apart from the need for a power station) most of which will be needed for calcination and drying. All burners will be designed to use fuel gas as well as fuel oil.

There will be three slime storages: the first one is for phosphogypsum from phosphoric acid (about 750,000 tpa); the second one is for the slimes from the dressing plant (about 450,000 tpa); and the third one for slimes containing mainly fluorosilicic acid as well as sulphuric and phosphoric acids. In later stages, water will be recycled. All necessary precautions are to be taken to protect the environment.

The construction of two townships is planned for 3500 people at Al-Qain and another one at Akashat, to accomodate about 800 workers and staff.

The S y r i a n government is promoting the development of chemical and fertilizer industry based on phosphate exploitation. In 1975 "Industrialexport" of Rumania was awarded a contract for the construction of a fertilizer plant at Homs. It will be a triple super phosphate plant with a capacity of 800,000 tons of phosphate ore (processing) and 450,000 tons of fertilizer (producing) per year. In addition, about 200,000 tons of sulphur and chemical materials will be produced including phosphoric acid and red phosphorous used in the production of detergent and in other industries. In order to promote exports, the construction of new warehouses with a capacity of 50,000 tons is planned in Tartous.

Besides, Syria has undertaken development of the existing phosphate factories and planned the establishment of some new ones, particularly at Ain Leiloun. The total estimated cost of these projects is of about 1 million Syrian pounds.

Projects concerning the development of phosphate deposits and phosphate-based industry will contribute an estimated increase of 20 million S.P. per year to the national income of Syria. These earnings will be reflected in the improvement of the balance of payment of Syria through higher exports and foreign exchange savings.

In 1974, the income generated from the export of 638,000 tons of phosphate reached 127 million S.P. (about $ 35 million).

Full realization of the phosphate expansion programme will provide additional jobs for some 1500 workers, technicians and engineers.

3. Industrial Minerals

a) Magnesite:

Magnesite mineralization is associated with dolomites and serpentinites as a result of their hydrothermal alteration and replacement and also as a product of weathering of ultrabasits.

Magnesite occurs in a crystalline or cryptocrystalline form, which is used as one of the criteria in determining its industrial utilization.

Magnesite powder, usually produced from crystalline magnesite, is used as a refractory material in metallurgical, cement and sulphuric acid industries. For this purpose, the raw magnesite with more than 43% MgO content and not more than 2.5% CaO and 2% SiO_2 contents can be used.

Magnesite cement which can be produced from both crystalline and cryptocrystalline magnesite, possesses the property of cementing organic and non-organic materials. Raw magnesite which is used for the production of this kind of cement should contain less than 4.5% CaO and not more than 20% of SiO_2. Small quantity of magnesite is used for the production of metallic magnesium and its salts.

The annual world production of magnesite is about 7 million tons.

No magnesite deposits have yet been exploited in the ECWA region. It is possible, however, that during the next few years, mining may start and discoveries of new magnesite occurrences and deposits of economic value may be made.

Some deposits of high quality magnesite have been located in S a u d i A r a b i a .

- Jabal Rukham is represented by Pre-Cambrian dolomite beds dipping steeply to vertically in isoclinal folds. Magnesite, which replaced the dolomite forms massive and blocky bodies. The deposit contains 8-20 million tons of low grade concentrating ore including 1 million tons of good refractory-grade material with $MgCO_3 \geqslant 95\%$, $SiO_2 \leqslant 2\%$, CaO $\leqslant 2\%$ and 1.5 - 2.5 million tons of a marginal-grade material (44.3% MgO, 2.2% SiO_2, 2.43% CaO).

- Zarghat deposit is situated 250km north-east of Al-Madinah. Magnesite outcrops extend over an area of 68,000m^2 within a small elongated basin of J'Balah in Halaban Formation, 400 x 1300m in size. Geological mapping indicated that lenses of magnesite have a synclinal structure and bottom short distances below plain level. The deposit contains reserves over 1 million tons of a good-grade magnesite ($MgCO_3 \geqslant$ 95% and $SiO_2 \leqslant 2\%$). Since 1977 the deposit is under study by the Ministry. It was assumed that the total reserves of the deposit is about 3 mill. tons of which 650000 are of exceptional quality.

In addition to what was mentioned above, bitterns of mixed Sabkhas brines and of other natural brines are available in the Arabian Gulf region and constitute an excellent source of magnesia. Other raw materials and fuel needed for the production of magnesium hydroxide by the Dew process are also available near the sabkhas.

In S y r i a there are occurrences of magnesite mineralization which is not any commercial value. One of them occurs near the Zetounjig village, where schistose serpentinite contains spherical kidney-shaped and sinter-like nodules of white strong magnesite. Though nodules are rather frequent, they do not form significant concentration but are scattered in the serpentinized rock. Formation of magnesite is associated with serpentine weathering in zones of crush.

In O m a n , magnesite occurs in the form of white massive vein deposits in the serpentinite. Chemical analysis of some specimen of the magnesite show a content of 87.4% $MgCO_3$. Until the present time no magnesite deposits of commercial value have been found. It should be indicated that new magnesite mineralization in the Oman mountains was reported in 1974 by the Canadian company "Prospection Limited".

Thin veinlets of magnesite are found in sheared and serpentinized zones within the ultrabasic rocks, particularly, in the western foothills of the mountains in the territory of the U A E . With antigorite and chrysotile, they form a net of veins. The larger ones containing white amorphous, or percellaneous magnesite occur in more massive ultrabasites in the interior of the mountainous zone, north of Wadi Ham. The largest veins several metres long and up to 3 metres wide. The vein magnesite also contains intergrowths of silica, fragments of antigorite and serpentinite. Because of the low quality of material, limited reserves and difficulties in mining, exploitation of these deposits are not, at the present, economically feasible.

b) Barite

Barite is mainly used in petroleum exploration as a material for increasing gravity of drilling muds. For such an application, barite should have a density of 4.0 - 4.2 g/cm^2 and a salinity of not more than 0.35%.

In the chemical industry barite is used as a raw material in the production of paints and coloured enamels.

As a filler it is used in the production of hard rubber and of high quality paper and cardboard. The raw material used for this purpose should contain 98 to 99% $BaSO_4$, up to 0.36% CaO, small content of R_2O_3 and SiO_2, be devoid of Mn, Cu, Pb, and Fe. Barite is also used as one of the components in the production of special kinds of plasters and concretes where the protection from X-ray is necessary. World production of this mineral amounts to 4 million tons per year.

Among some known barite occurrences in Saudi Arabia only one can presently be considered of economic value. It is situated at 150km north of Jeddah near Rabigh. The barite mineralization is probably of Tertiary age, occurring in veins filling faults and fractures up to 2m wide which are associated with the Red Sea rifting. The faults and fractures cut rocks of the Precambrian basement in a north-south rectangular area of a size 20km in length and 3km in width.

The deposit was investigated on different occasions since 1936 and it was concluded that it is of hypogene origin, in which the barite might be part of large-scale zones with hydrothermal ore deposits.

Detailed mapping and sampling (including six shafts of 15 metres depth) indicated the presence of about 100,000 tons with over 90% $BaSO_4$, a minimum vein width of 0.5m and a depth of 30m.

In the northern section of the deposit, the veins occur in younger pink granites. In the middle part of the area occurrences of granodiorite, diorite and albitic granite were noted. These rocks are cut by numerous dark green basic dikes of east-west direction. Only a smaller number of barite veins have been located in this part.

The southern part of the deposit is covered by old metavolcanic flow-rocks of andesitic composition. A great number of basic dikes have intruded the country rock in which only a few barite veins outcrop.

The northern part is thus to be considered as a better mineralized section of the deposit.

The barite veins trend NW and N and in some place NE. They are subvertical. The width of the veins ranges from a few centimetres to more than 2 meters. The barite is white to pink and is contaminated with brown jazperoid, black manganese exide, galena and Cu-stains.

Due to the concentration of barite reserves in veins, which are too narrow for underground mining and in view of the small size of these reserves for supplying a local grinding mill, it was concluded that no large scale mining operation should be carried out on this deposit, and that further exploration should be postponed until a market for barite develops in western Saudi Arabia when opencast mining of near surface material could become feasible.

Elsewhere in the Arabian shield, barite was also found as a gangue mineral in sulphide-bearing veins. At one such cecurrence, about 60km south-east of Al Quwag'iyah, the barite gangue makes up as much as 90% of the veins

There is a barite occurrence in Mahawiyah district, where a barite vein in limestone has been reported at a locality 150km norht-east of the Red Sea village of Al-Qunfudhah.

Small barite veins have been reported in the Jabal Sumran area and in the south of Al'Aqiq in the Bilad Ghamid.

Since no other barite deposits exist in Saudi Arabia, most of the raw material is imported from abroad mainly from USA. "Petromin", the government agency responsible for the exploitation of mineral resources, estimated that for the next 15 to 20 years, about 65,000 tons per year of barite for oil drilling will be required which implied that for the above mentioned period total requirement of barite will amount between 1 and 1.5 million tons; the previously mentioned reserves are therefore hardly sufficient to meet those requirements.

Some barite vein mineralization which cut Tertiary sedimentary rocks have been located in Y e m e n   A r a b   R e p u b l i c.

c) Asbestos

Asbestos is used in many branches of industries. Depending on the length of fibre and the way of utilization, three groups of chrysotile-asbestos can be distinguished:

(i) Textile material with a fibre length of more than 8mm is used in the manufacturing of asbestos fabric and yarn as insulation, fibre-resistent and catalyst materials etc.;

(ii) The second group comprises material with fibre length between 2 to 8mm is used in the production of light fire-resistent asbestos-cement, imitation for oil and gas pipelines, and asbestos papers and cartons;

(iii) The 3rd group with a fibre length varying between 0.2 and 2mm is used for building purposes; (production of fire-resistent and heat insulation materials).

Amphibole asbestos is used for the same purposes as the chrysotile-asbestos but mostly in the production of acid and alkali resistent materials.

Annual world production of asbestos during the last years reached 5 million tons per year, and reserves amounted to 300 million tons.

Asbestos occurrences in the ECWA region are known in some countries, but there are no deposits of economic value.

In S y r i a , asbestos occurrences are confined to ultrabasic rocks of Bassit area. The large localities of chrysotile asbestos occupy areas of few dozen and rarely a few hundred square metres. The largest of these localities are found on the coast, south of Ras El-Bassit cape in Jabal El-Khirbe. The veinlets are 1 to 3mm thick and 7 or 8cm long with asbestos pertaining to the building grade. But due to their small sizes, these chrysotile-asbestos occurrences are non-commercial.

- The amphibole asbestos mineralization is widely spread. It occurs in the area of Bouz Oghlan in which a serpentinized peridotite is cut by gabbro intrusions and veins of diorite, gabbro-pegmatite, plagioclasite and aplite. Tremolite asbestos is confined to fractured zones, the length and width of which do not exceed 70 and 30 metres respectively. Within the zones occur tremolite-serpentine rocks. Asbestos veinlets are 2 to 3cm thick, reaching 10 to 25cm in some places. This deposit is exploited, and the ore is sorted by hand. The content of ore mass in the rock varies between 0.1 to 1-2 per cent, reaching rarely 4.6 per cent. The output of the fibre from the ore mass amounts to 10%. The reserves of the ore mass in the deposit amount to 2,135 tons and those of the fibre total 214 tons. Tremolite asbestos is more brittle, hard and friable than the chrysotile variety. The fibre length ranges from 0.5 to 3mm, reaching rarely 10cm. The quality of the fibre varies tremendously, but on average it can be considered of a building grade. The content of HCL soluble admixtures is 4.51 to 11.04%, i.e. meets the requirements of an acid-resistent asbestos.

- In Qara-Tat occurrence, located 2km west of the village of the same name, the asbestos is confined to a serpentinized peridotite, close to its contact with a coarse-granular gabbro. The asbestos is associated with serpentine and tremolite-serpentine zones which are confined to fractures in the peridotite. The morphology of the zones and the character of mineralization are the same as that in the Bouz Oghlan locality. A small scale mining operation is conducted, but the fibre content is extremely poor.

Both of these asbestos occurrences are not likely to be of commercial value.

Some localities of asbestos mineralization within serpentinized rocks, in sheared zones in ophiolites were discovered in 1973 in O m a n. These areas are under detailed geological and geophysical investigations. Results of these investigations are not yet available.

In the U n i t e d A r a b E m i r a t e s, asbestos occurrences are also confined to the ophiolite complex. They occur in zones of more intensive shearing and serpentinization of ultrabasic rocks. The most intensive mineralization was found in the area east of Jabal Faiyah, and south of Masafi near Wadi Ghadf. In the latter, reserves are estimated to vary between 800,000 and 1 million tons. The asbestos fibres being short or brittle with high carbonate content are like those of similar zones examined elsewhere, of poor quality.

The existence of chrysotile asbestos was reported in many localities in serpentinized ultrabasic rocks in Precambrian in S a u d i A r a b i a. A small outcrop of chrysotile asbestos lies a few kilometres east of Turabah in a zone of talc-chlorite schist. Asbestos fills a few-millimetre wide fractures in serpentinite at Jabal Tharwah, south-east of Rabigh, and in Bi'ir 'Umq area. A more detailed research in these areas might reveal larger deposits of asbestos of commercial grade and quantities.

Other localities include: Hijera Mine near Handah (18° 55'N, 43° 41'E), Lahaja (25° 15'N, 38° 15'E); Wadi Madhar (25° 44'N, 37° 30'E); Wadi Osman (25° 23'N, 37° 58'E). It was reported that a fair to good-quality asbestos is found in these localities.

4. Building mineral raw materials

This group of mineral raw materials includes a large number of rocks of varying composition which can be used as building or decorative stones, or for production of cement, concrete, glass, ceramics and in some other branches of industry.

Unlike the case with the metal ores, the ECWA region has practically unlimited reserves of marble, sandstone, limestone, igneous and metamorphic building materials; sand, gravel, gypsum and anhydrite. Some of the countries also have reserves of clay, kaolin, opoka and many other natural materials which can be used for construction purposes. Most of these deposits are located in the Phanerozoic sedimentary sequence which is spread over the territories of all ECWA member countries.

In spite of the availability of large potential reserves of building mineral raw materials in the region, and their economic importance, inventorization and evaluation of these deposits remain a problem of first priority. This Survey cannot cover all mineral building materials, but will deal with these minerals which play an important role in the economy of member countries and the utilization of which offers possibilities for regional co-operation.

Furthermore, due to lack of detailed information about these deposits, and the limited availability of statistical data concerning production and utilization of building materials in general, the coverage of these minerals in this Survey is rather limited.

a) Marble, limestone, igneous rocks

Stone is a primary commodity found in most countries. The various types of it are used as structural, ornamental, monumental, flooring and roofing materials as well as for decorative and economic housing purposes. Commercial classification of this kind of raw materials is considerably different from that which is applied in petrography. Below is given a commercial classification of stones which are commonly utilized.

Marble

Metamorphic limestone/dolomite

Sedimentary limestone/dolomite

Onyx

Travertine

Serpentine

Verde antique (a veined serpentine)

Limestone,

Same as marble but excluding serpentine, Verde antique or fairly pure dolomite.

Dolomite

Granite

Granite

Syenite (labradorite)

Diorite

Gabbro

Gneiss (often marketed as quartzites, e.g., Alta Quartzite, Offardal Quartzites)

Schist

Basalt

Diabase (e.g. Swedish Black)

Dolerite

Sandstone

Bluestone

Brownstone

Arkose

Greywacke

Quartzite

Slate

Tuffs

Reconstituted marble and stone.

Commercial stocklists are, however, much more extensive. For example, a recent selective list from the United Kingdom contains 125 available domestic varieties; New South Wales in Australia produces over 50 separate varieties and a selective export price list from Italy offers not less than 18 domestic granites and some 220 grades and varieties of marble.

The Marble Institute of America has classified stone, with special emphasis on marble, into four groups according to the characteristics encountered in finishing.

Group A: Sound marbles and stones, with uniform and favourable working qualities;

Group B: Marbles and other stones similar in character to group A, but with working qualities somewhat less favourable due to occasional natural joints. A limited amount of waxing and sticking is necessary;

Group C: Marbles and other stones of uncertain variation in working qualities due to petrological flows, voids, veins and lines of separation. It is a standard shop practice to repair natural defects by sticking, waxing and filling; liners and other forms of reinforcement are freely employed when necessary;

Group D: Marbles and other stones similar to group C and subject to the same methods of processing and finishing, but which contain a larger proportion of natural joints and display a maximum variation in working qualities. This group comprises many of the highly coloured marbles prized for their decorative qualities.

Pricing of stone depends upon the grading, demand, availability and other factors. Indicative prices for stones, which prevailed in the world market in 1973 are as follows:

Table No. XXI Indicative Prices for Stones

Groups		Range of prices per m^3 of block. $*	Range of prices per rough-sown slabs. 2 cm thick per m^2 $**
Stones	Special	up to 850	5.50 - 12.5-
	A	150 - 400	4.50 - 6.00
	B	100 - 150	3.0 - 5.50
Travertine types		50 - 100	-
Industrial fillers and extenders (the highest-grade)		33 - 117 per ton	-

* Blocks exceeding 3m in length can command up to 30% premium.

** Additional thickness costs about 40% more per cm.

The usual minimum requirements for size of blocks are from 2 to 3 metres in length and 1 to 2 metres in width. The thickness should be between 0.5 metres and 1 metre. Blocks below a certain size command a lower unit price than large blocks.

The standard stock thickness for sawn marble slabs is 2cm, whereas building stone, depending on local practice, may be sawn into thickness of 8 to 15cm, and even to 18cm for monumental purposes. To reduce breakage, export slabs are usually thicker than 2cm.

The use of stone is constantly growing; thousands of millions of tons of stone in various forms are used annually. With limestone now heading the list, as far as the bulk is concerned, of the "big six" mineral commodities, the others being salt, sulphur, iron ore, petroleum and coal. An increasing interest in the use of stone has been evident in the developing countries in recent years. Countries with little or no tradition in stone working are paying increasing attention to these possibilities. Stone can be utilized practically without waste, in all sizes, shapes and colours; from expensive marble varieties to low-cost "fill" in excavations.

In S a u d i A r a b i a BRGM inventored and made geological investigations of occurrences of marble and "granite" in the broad sense in the Arabian Shield. The inventory issued in 1971 listed about 180 occurrences that had been examined.

The most important marble occurrences and deposits which have been investigated until now are situated around Jeddah, in the Afif area west of Ar-Riyadh, and in the Wadi Bidah area. They contain mainly five grained or medium-grained (less common) marble. Other features such as the degree of fracturing composition etc. vary from place to place.

- Jabal Khanugah is located about 100km east of Afif. The marble is dark grey, granding into black, with a whiter, mottled and veined marble at the northern nd of the 6km length outcrop. The marble belongs to the Farida Formation in the Murdama Group. Reserves could be as large as 40 million m^3.

- Jabal Al-Khawar which is situated in the same area as above contains dark grey to black fine grained materials with estimated reserves at more than 10 mill. m^3, but the presence of conglomeratic layers could be a hindrance to quarrying.

- Jabal Farasan, 135 km north-northeast of Jeddah. The marble varies from white, whitish to very light grey, with some dark grey to black and is partly sacharoidal, siliceous and fractured.

Because of its accessibility from Jeddah, this occurrence has been quarried by a number of local enterprises.

- Madrakah located north of Mekkah is being quarried now. The marble is crystalline, takes a good polish and is essentially white but attratively veined with various colours.

- Wadi Turabah (the Wadi Bidah district) has grey marble, partly mottled, in beige, white, and rose. The deposit crops out for only about 400m, with an average thickness of 200m. Reserves are estimated at 4 million m^3.

- The marble at Wadi Bidah itself is homogeneous and fine grained, with hanging walls and footwalls of chlorite shist. The average thickness of the bed is about 20m. The colour varies from beige to creamy white, and the texture from pure to mottled. Large blocks are obtainable, and reserves are estimated at about $350000m^3$.

Except for the marble deposits, the wide variety of igneous rocks are available in the country, which could be used as ornamental or structural stones. The most interesting among them are anorthosite in an accessible area near Yanbu' al Bahr and a fine-grained pink granite at Al-Jumum, 70km north-northeast of Jeddah.

Pilot-scale quarrying has been instituted in marble at Jabal Khanugah and another site at Yanbu' al Bahr, to test potential yields, check optimum directions for development and cutting and demonstrate modern quarrying techniques that could greatly increase the efficiency of the many quarries already in operation in Saudi Arabia.

Recently, the Saudi Marble Company in Jeddah has been established. This company developed additional quarry sites at Jabal Farasan and in the Afif area and constructed a modern processing plant in Jeddah.

A wide variety of building stones are quarried near the major cities and towns of the country, including granite, granodiorite, gabbro and andesite, roofing slate, limestone, coquina and sandstone. Some steps have been taken to develop granite deposits near Taif, Yanbu' and in various other parts of the Western Province. Saudi Arabian marble is extensively used in public and private construction and occasionally exported to neighbouring countries. At the same time, Saudi Arabia is continuing to import considerable quantities of marble, travertine, onyx and other decorative stones.

All building material plants in Saudi Arabia are privately owned. Custom duties have been reduced in recent years or abolished completely for certain products, but the building materials industry does not receive enough subsidies. According to the Five Year Development Plan of Saudi Arabia, studies are planned for developing the economic potentials of marble and other ornamental stones.

In the United Arab Emirates, deposits and occurrences of some kind of dimension stone are located in the northern part of the country. Deposits of white limestone ("white marble") are available near Tawi Khadra, further south at Wadi Halah and west of Idhn (Boulder Beds - K_2). Black, fine grained limestone with white calcite veins was found in the upper Wadi Khabb (Musandan Group - J_1 - K_1); brown limestone occurs in the Faiyah mountainous range and grey brown calcareous conglomerate was located in the south of Qara Nazwa. On the east coast, particularly near Khowr Fakkan there are some occurrences of gabbro, which can be used as a decorative stone.

The marble deposit situated at 120km from the city of Ajman is probably exploited. The material has 6 colours with 34 tints.*

Unfortunately, all these deposits contain highly fractured materials, which are suitable for assembling mosaic flooring tiles, and for producing gravel paths or rough casting on buildings.

A small plant, situated between Dubai and Sharjah, uses a mixture of imported and local materials in the production of small dimensional stones, facings and mosaic floorings tiles. All the large blocks of high quality marble are imported. The capacity of the plant is $50m^2$ per day. Production is expected to double in the future.

Oman is planning to produce about 1 million tons of marble blocks. No other information about marble resources is available.

In Iraq, production of marble in 1974 totalled $100,000m^2$. No other information is available about this and other sources of building raw materials in this country.

In the Yemen Arab Republic there are some deposits of marble which could be used as an excellent building and decorative stone. It belongs to the Precambrian "metamorphic limestone".

- One of the most promising is Wadi Maksab deposit with reserves of 10 million m^3 of light to dark grey in colour and medium to fine crystalline

* "Mineral Trade Notes". 1973. No.9.

marble. It is located at the distance about 71km to the east from the seaport of Mokha, and about 10km from the main road Mokha-Taiz. The deposit was discovered by a Russian geological team in 1965, later was studied by a German group which prepared a geological map and calculated its reserves. ECWA mission (1977) visited the deposit and found that it is undoubtedly of economic value due to the size of its reserves, good quality of marble, favourable location and absence of water problem. It was recommended to initiate a detailed investigation of this deposit together with a market survey for marble, and in particular, to study possibilities of exporting it to other countries of the region.

- Al-Shaiban marble deposit is located at 148km to the WNW from the possible port of export (Mokha). It contains about 34 million tons of marble approximately of the same quality and colour as that of Wadi Maksab, but visibly more fractured. Because of the water supply problem which could arise if the deposit was developed, and transportation cost it should be considered as of a second priority, in comparison to the other marble localities.

- Wadi Sokhna marble deposit is composed of two small hills, about 35-40km from the mouth of the Wadi. Its estimated small reserves (about 1.2 million m^3), which consist of a highly fractured and coarsely crystalline material, are intruded by some diabase dikes, which put this deposit out of commercial value for construction purposes. But according to the conclusion of the Russian team, the marble of this deposit could be used as a raw material in the production of chemicals.

Limestone of Jurassic, Cenomanian and Eocene ages is exploited and used for building purposes in many areas in L e b a n o n..

In S y r i a , the most important building rock is limestone which has been mined since ancient times. Limestones of all ages from Jurassic to Quaternary are used. Large quarries of limestone are located in Jabal Qasyoun near Halab and Douna, Arika, Idlib and M'arret An-No'man villages.

Middle Miocene limestone is mined from a large quarry which is located near the village of Berj Istan on the Mediterranian coast and was used as ballast in building the port of Al-Latakia.

Limestone of Cenomanian age is quarried in the area of Hama and Tartous.

"Al-Latakia stone", a limestone of Quaternary age, has been quarried since the ancient times. At the present time, this easily worked shell limestone is the main building material and is used in Al-Latakia, Banyas and a number of other villages. Limestone of late Eocene age was mined 10km north-east of Palmyra (Tudmor) and used in the construction of buildings, the style of which dates back to the Roman epoch.

Results of a mechanical analysis of the Middle and Upper Eocene limestone that was used for the construction of a dam on the Al-Furat river, near the Sharet Sheikh Arodeh village, are as follows:1/

1. Moisture - 11 to 28%
2. Bulk density - 1.94 to 2.3 g/cm^3
3. Specific gravity - 2.77 to 2.85 g/cm^3
4. Porosity - 32 to 49%
5. Porosity coefficient - 0.57 to 0.97
6. Yield limit - 23 to 31%
7. Plastic limit - 17 to 24%
8. Plastic number - 4 to 8%
9. Crushing strength, with natural moisture - 36 to 68 kg/cm^2
10. Shearing strength:

	with natural moisture	saturated with water
Friction coefficient	0.72 - 0.79	0.63 - 0.69
Shearing coefficient	0.72 - 0.79	0.65 - 0.69

Chemical analyses of the limestones of Cretaceous and Paleogene ages indicated that they are suitable raw materials for production of Portland cement. Because of high P and S content, they cannot be used in chemical industry and as a flux.

Basalt has been used in Syria as a building material since a long time. It is of Quaternary, Pliocene and Miocene ages and overlies many areas in Syria. The Quaternary and Pliocene basalts possess the best

1/ The Geology of Syria, explanatory notes on the geological map of Syria, scale 1:500,000, part II. Mineral deposits and underground water resources.

mechanical properties which ensure long life of constructions made from them, such as house and road construction. They are also used as a correcting additive in cement production at the plant near Halab. Miocene basalt is limited to construction purposes due to its significant weathering.

The most important occurrences of the basalts are located in areas of Halab, Aafrin, Al-Bishri, Salamiyeh plateau, in the Homs depression and in some regions of the Al-Furat river etc.

Currently in Syria a project on prospection of building and industrial minerals is under way. The estimated total cost of the project is S.P. 36,580.- out of which S.P. 11,800 will be invested during the Five Year Plan (1976-1980).

The Jordan territory is endowed with a large number of building stones which have been known and used since ancient times. Among these stones the following can be listed:

(i) oolitic limestone of Pleistocene age is found on the western part of the Jordan river, near Khirbet As-Samra;

(ii) thick and hard caliche (Nari) of Quaternary age was found in the area of Jarash;

(iii) massive oyster-shell limestones member series of the phosphorite of Campanian-Maestrichtian age was located in the area between Amman and Al-Qatranah;

(iv) greenish, reddish, light-pink, and white limestones of different units of Turonian to Maestrichtian age were reported in the west of the Jordan river, particularly in the vicinity of Jerusalem and Bethlehem;

(v) reddish, pink, beige and light-grey limestones are present in the upper part of the echinoid limestone member and in the massive limestone member of Turonian-Santonian age, which are extensively quarried at and near Amman and at many other localities in northern Jordan.

On the eastern side of Wadi Al-Arabah and in the area of Al-Quwaynah in southern Jordan, there are outcrops of decorative stones of hornblende gabbro, quartz diorite, granodiorite, and in places of quartz porphyry.

Limestones for building purposes are quarried from latest Cretaceous to Early Tertiary age series east and west of the desert highway between Al-Jizah and Al-Qatranah, particularly in the area of Qasr El-Hamman.

These limestones vary in colour depending on the content of various components such as iron, bituminous matter, apatite and traces of chromium, nickel, vanadium and uranium.

In some places along the eastern side of the Jordan river valley, travertine outcrops can be utilized as a building and decorative material. One of these localities is 10km south of Dayr Alla, where parallel-bedded travertines of 10m thick were observed.1/

D e m o c r a t i c Y e m e n and O m a n have a wide range of building stones, including volcanic glass, marble facing stones and others. These stones have not been examined and their economic value was not assessed.

In particular considerable amounts of exploitable limestone can be expected in the Jurassic and Createcious rocks in the eastern part of Democratic Yemen as well as in Pre-Cambrian formations in the west (Mahfid Nisab), where possible reserves can be evaluated as not less than 700-800 million tons. The limestone can be used in cement production.

K u w a i t has a limited amount of medium-to-poor quality building stone which is quarried at times from the Miocene strata of the Az-Zor escarpment. Small deposits of freshwater limestone and chert, occurring at Sulibiyyah and south of Burgan, have been worked by local operators. The supply of these rocks is very limited. Similar deposits are situated south-west and south of Wafra in the Neutral Zone but because of their distant locations, they cannot be economically exploited.

The Middle Eocene limestone and chert in Ahmadi ridge are quarried and used for construction purposes, but economic workable reserves of this rock are very limited and their quality is not high.

Due to this situation, Kuwait imports a large quantity of marble from abroad, the volume of which is 1974 reached about 13.8 thousand tons (value - KD 644,891); 34% of the imported marble is unworked. In the same year, Kuwait re-exported 557,817 tons of this material (see Table No. XXII).

B a h r a i n has large reserves of dolomite in Khobar. It is the most commonly used and is quarried regularly at several sites on the east central side of Bahrain Island. Limestone from Rus outcrops, within the rimrock, are used extensively in the production of lime.

1/ Friedrick Bender, Geology of the Arabian Peninsula, Jordan, 1975.

CaO	34.13%
SiO_2	3.25%
MgO	0.73%
Al_2O_3	0.58%
Fe_2O_3	0.49%

The outcrop of gyprock at 1km to the east of Salif extends over an area of 1.3 x 0.7 km, with thickness of the gyprock layer of 35m and overburden up to 15m. This deposit is divided into three blocks.

The first one has approximately 2 million tons of economically exploitable gyprock reserves mixed with anhydrite (7.72%) and is considered as the most feasible deposit for mining.

The second block has about 2.5 million tons of economically exploitable gyprock mixed with anhydrite and probably anhydrock. Content of gypsum and anhydrite varies between 84.6% and 92.5% and between 5.82% and 11.3% respectively.

The third block has the thickest overburden, and the thickness of the gyprock amounts to 12m; reserves of gyprock together with anhydrock are estimated at 10 million tons.

The out put of gyprock in Salif area does not exceed 30 tons per day and is used for cement production.

- In Jabal Maarab area there is a light grey to brown and partly reddish gyprock containing approximately 8 million tons of economically exploitable reserves, with some anhydrock. The content of gypsum and anhydrite in two random samples varied between 93.4% and 79.3% and between 4.55% - 12.0% respectively.

- Jabal Quma deposit occurs in a north-south striking evaporite structure having a length of approximately 6km, a width of about 500m and a thickness of 70m. These gyprock beds, of up to 1m length, are interbedded by halite rocks, marlstone and occasionally by dolomite. The content of gypsum in five random samples taken from different spots of the deposit varies from 34.7% to 90.6%. The deposit is considered of low economic value.

- Gyprock deposits located north-east of Sana'a. In this area four gyprock and one alabaster deposit can be identified.

All of them were formed during the Upper Jurassic (Upper Malm) in a basin which covered the west territories, including areas in Saudi Arabia, North Yemen, Ethiopia and probably in Syria as well.

The geological sequence of gypsum and anhydrite-bearing unit is represented by alternating beds of marlstone, sandstone, limestone, gyprock, anhydrock, alabaster and in some places shale. The Jurassic sediments **underline a sandstone of the Cretaceous age.**

- Gyprock bed at Al Gheras locality, north-east of Sanaa, varies in thickness from 10m to 12m strikes 100° ESE-WNW and dips 20° to NNE. Three random samples of gyprock contain 96.1% - 97.8% of gypsum and 1.32% - 1.77% of anhydrite; the content of anhydrite in two anhydrock random samples is between 75.8% - 87.1%, and of gypsum 7.3% - 22.0%.

The economically exploitable reserves of the Al Gheras deposit amount to about 80,000 tons. At the present time, four small-scale mining operations are undertaken by private individuals employing a primitive randomly effected room-and-pillar system without ventilation. The largest mining activity yields about 15 tons of daily rock production valued at around 540 riyals.

- Al Harre-Thuma deposit has the same geological features as that at Al Gheras. In this deposit, the gypsum bed strikes 80° WSW - ENE and dips about 15° SSE. The workings are still at a developing stage and have started in several places along a length of about 250m. The method of mining is the same as in the Al-Gheras deposit.

The output of this mining operation varies between 150 and 200 tons per day. The economically exploitable reserves are likely to amount to about 300,000 tons of gyprock with a gypsum content varying according to a random sample analysis between 72.3% and 97.8%. The gyprock in some cases contains small amounts of anhydrite and calcite.

- Large commercial quantities of gyprock also occur in Khulagah region, where the gyprock bed is 10m thick extends over a length of 4km eastwards of its 100m long outcrop. This deposit has not been studied yet.

- Another deposit in the Sana'a area, located near Shirah village, is only of limited importance with at least 3,500 tons of gyprock reserves.

Import and export of marble stone
Kuwait, 1974

Table No. XXII

Unworked

	Import		Export	
Countries	Value KD	Weight (tons)	Value KD	Weight (
Jordan	1847	140,000	-	-
Lebanon	289	18,000	572	11,000
Oman	-	-	125	27,340
Syria	10,199	194,400	-	-
UAE	-	-	2,857	228,296
Iran	54,732	3,871,781	-	-
Pakistan	947	20,363	-	-
Italy	9,837	449,400	-	-
Greece	2,964	62,000	-	-
Bulgaria	1,646	21,146	-	-
Total	82,461	4,777,090	3,554	266,636

Worked

Total	562,430	9,063,031	26,192	291,181

Source: Yearly Bulletin of Foreign Trade Statistics, Planning Board, State of Kuwait, 1974.

b) Gypsum and anhydrite

Extensive uses of gypsum and anhydrite result from the expansion of the building industry which utilizes them as an astringent material, and a mineral component used in the production of Portland, parian, gypsum and anhydrite cement.

Chemical industry uses gypsum and anhydrite to produce ammonium sulphate, sulphuric acid and fertilizer for some kind of soil. Clear snow-white or even coloured gypsum is used as a decorative stone.

In addition, gypsum is used in pottery, for orthopedic and dental plasters and as a filler.

Total annual world production of gypsum varies between 50 and 55 million tons, the annual world production of anhydrite is much less than these figures.

In countries of the ECWA region, the gypsum-anhydrite deposits are widely spread and are of significant economic value. Geologically, they are concentrated in the upper part of Phanerozoic sedimentary sequence (from Upper Jurassic to Neogen).

In Yemen Arab Republic, geological investigations and evaluation have been conducted by a German geological advisory group in 1974 in three main gypsum-bearing areas: Salif, north-east of Sana'a and north-west of Taiz which contains about 20 million tons of estimated economically exploitable gyprock.

- Gypsum deposits in Salif area are located along the coast of the southern Red Sea in Miocene evaporite sequences which also contain halite, anhydrite, clay and siltstone. At 1 km to the east of Salif outcrops of gyprock and halite build up a 20m high terrace. East and north of the area gyprock crops out sporadically. Other occurrences are located at 9km south of the Jabal Maarab, covering an area of 2 x 7km, and also near Al-Quna 20km to the east of Salif.

Chemical analyses of three samples taken from this area showed the following composition:

$CaSO_4.2H_2O$ (gypsum)	80.50%
SO_3	37.57%

- Gyprock deposits in the north-western Taiz area belong to Upper Jurassic (Upper Malm) age. The area is mostly covered by rocks of the Trap series, and gyprock beds of varying thickness are interstratified with fine-clastic sediments. Three deposits are located in this region, viz: Sharok, Al Gubyl and Al Rawna.

- In Sharok, shale and marlstone alternate with four gyprock beds, having a thickness of 1m, 2.5m, 2m and 3m respectively; the thickness of the alternating beds is 35m. The gyprock also comprises quantities of anhydrite, and up to 18% of calcite, which limits the material's applications for building purposes. At the present time, only the thickest gyprock beds are exploited by open-cast mining, the winnings are delivered by trucks to a place near Taiz where they are calcinated.

- At Gubyl, the deposit is divided tectonically into three staggered blocks of 20m to 30m in length, with the beds dipping from 10° to 50° NE and the strike trending 175° NW-SE. The underlying beds are not exposed.

The mining of the gyprock is still in its early stages and production is low because the gyprock is worked only at times to supplement the production from the Sharck gyprock deposit.

The economically mineable reserves amount to 20,000 tons of gyprock, with small quantities of anhydrite (up to 1.74%) and a high content of calcite (up to 12.4%); limiting therefore the use of this gyprock to building applications. At the present level and methods of operation, only about 6,000 to 7,000 tons per year can be mined. Due to the steeply dipping strata, an optimal operation would require employment of extremely difficult underground mining methods.

- Al Rawna deposit is made up of a bedding sequence approximately 30m to 50m thick. It is composed mainly of 30m thick gyprock layers alternating with thin-bedded shales and marlstone. Only one isolated 2m thick block of calcinated gyprock is mined in a small open-cast on a limited scale.

In order to undertake a comprehensive evaluation of the economic potentiality of gyprock deposits in the Salif area, a programme for further investigation was prepared. It includes surveying, drilling, chemical and mineralogical analyses as well as technological testing. These activities will be carried out by consultants or mining companies.

Other areas were suggested for investigation by the Yemen Minerals and Petroleum Authority.

Table No.XXIII - Gypsum and Anhydrite Rock Reserves in YAR

Area	Deposit	Reserves
Salif	Salif spit	
	Block I	2.000.000
	Block II	2.500.000
	Block III	10.000.000 ?
	Jabal Maarab	8.000.000
Sana'a	Al Gheras	80.000
	Al Marre-Thuma	300.000
	Shirah	3.500
	Khulagah	?
Taiz	Sharok	16.500
	Al Gubyl	7.000
		(20.000)
Total		23.000.000 (out of which 13.000.000 tons are proven reserves)

Source: Geological Report on gyprock deposits in the Yemen Arab Republic (Salif, Sana'a, Taiz area), K.H. Schulze, A. Kaid, M. Mukzed Sana'a 1975.

In Syria, gypsum is found in Pliocene, Miocene and less frequently in Upper Cretaceous and Jurassic formations. Representative chemical analyses of gypsum deposits and localities of different ages are given in Table No. XXIV

The results show a high degree of purity of the raw material and the content in the rock of gypsum mineral calculated from fixed water amounts to 80.6 to 96.9%. Calculated from sulphur trioxide, the content is higher: 83.8 to 98.9%.

- Pliocene gypsum in the El-Barghouth area which consists of 12 beds, 6-8 metres thick each is used by local people for building purposes.

Table No. **XXIV** - Results of Chemical Analyses of Gypsum (Syria)

Locality	Age	CaO	SO_3	Content % R_2O_3	Acid Unsoluble	H_2O
Beida	Middle Miocene Tortonian	32.26	45.26	0.14	-	20
El-Khafsa	Middle Miocene Tortonian	32.09	45.02	0.26	-	20
Tuwal El-Aba	Middle Miocene Tortonian	32.37	45.68	0.26	-	20
Valley of N. El-Kabir, Ash-Shenali, east of Latakia	Upper Miocene	32.37	45.92	0.072	0.5	21
Valley Surret Abou Ad-Duhour	Upper Cretaceous Coniacian	32.86	45.15	0.70	-	21
J. Tyas	Tortonian	32.08	43.15	0.23	1.02	18
J. An-Naqhaqiyeh	Middle Jurassic Bajocian	32.02	44.12	0.55	0.8	18
J. El-Abtar	Middle Jurassic Bajocian	32.39	45.79	0.44	0.59	19
Sahil and Ratich areas (Raqa dist.)	Neogen	32.2	45.5-48.0	0.7	0.3	19

Source: Explanatory notes to the geological map of Syria, Scale 1:500,000, 1963.

- Upper Miocene gypsum is available only in the area west of Latakia, where the occurrence of two beds of gypsum with 8 to 10 metres length each, have been noted. They are fine-grained, microlaminated (alabaster) and coarse-crystalline(gypsum spar) varieties. The outcrops north of the Fadreh village near the motor way are mined by small quarries and used for building purposes in Al-Latakia. Total reserves in the Latakia area may be estimated at tens of million tons.

- Tortonian gypsum is known in the north-eastern part of the country, particularly in the area of the Al-Furatian trough. Thickness of the gypsum layers in the lower part of the sequence is 20-40 metres each, and they are separated by 1 to 3 metre thick beds of limestone and marl. In this case, the gypsum is snow-white, pure, with sugar-like fracture (alabaster). In the upper part, the unit also contains gypsum spar and light-green gypsum contaminated with limestone and clay material. In this case, the thickness of gypsum layers is reduced to 10-20 metres while separating carbonate and terrigene beds become thicker (7 to 15m).

- The largest outcrops of Tortonian gypsum are known in Beida, Tuwal El-Aba, El-Khafsa heights and in the vicinity of Ar -Rasafeh.

- **Coniacian and Bajocian gypsum are known only in Palmyrides,** consisting of beds 10 to 15m thick. They have various colours and are of varying qualities: light-grey, grey, white, dark grey; compact, porous, fine grained, inequigranular, coarse grained etc.

During the last years, further studies were undertaken on building materials including gypsum.**Now** a five year plan in this field was prepared.

One of the areas which was explored is situated on the right bank of the Euphrates river between lat. Line 36° 45' and 39° 15'. It extends over 50km east west and 70km north south. Investigations confirmed the existence of high quality gypsum and anhydrite in Neogen sediments in Sahil and Ratich areas (Raqa District), the reserves of which **partically are not** depleted, **and could be** suitable for exploitation by the opencast method. Gypsum and anhydrite of these deposits **can be used for the pro**duction of sheets, roofing tiles and cement, for utilization as a filler in paper and paint making, in the production of H_2SO_4, ammonium sulphates and in some other branches of chemical industry.

Some gyprum deposits were also investigated near Palmyran, Salamiyah, Qaryatain, Latakia, Damascus and in other areas. Some of these deposits comprise 30 to 40m thick gypsum beds, with reserves estimated at millions of tons of high grade gypsum (Salamiyeh, Damascus and Latakia areas); and mining of some of them can be conducted using the open-**cast** method.

The deposit located near Latakia is presently being mined and the gypsum supplied to a cement plant in Hasaka. Total gypsum production in Syria reached 20,000 m^3 in 1972.

Adequate gypsum for domestic needs and export is available in western Saudi Arabia along the Red Sea coastal plain, in the Gulf of Aqaba area in Miocene sequence, in Central Arabia near Ar-Riyadh, and along the Arabian Gulf coastal plain.

- The most known, largest gypsum deposits in the country occur in its western part where the evaporates crop out in the Red Sea coastal plain from the area north of Yanbu to the opening to the Gulf of Aqaba, along hundreds of kilometres of strike length. They are located north of Jeddah, and in the vicinity of Jizan, where gypsum is associated with a salt plug. An almost unlimited supply of very pure gypsum in beds of several hundred metres thick is exposed at Jabal Al-Kibrit, 100km north of Al-Muwaylih and 15 kilometres from the Red Sea. At Magna, near the mouth of Gulf of Aqaba, the gyprock outcrops with thickness of 30m or more are exposed along a long distance.

These deposits have not been studied enough yet, but preliminary evaluation showed that some of them are not of a sufficiently high grade to be marketed, but they could be used in superphosphate production.

- In the central part of Saudi Arabia, several gypsum deposits occur near Al-Kharj. One of them is exposed along a railroad and contains 3 million tons of gyprock with 83% to 92% gypsum grade. Another deposit in the same region has reserves estimated at 10 to 15 million tons and consists of 10 to 15 metre thick beds, and is likely to be of economic value.

- An anhydrite deposit is located in the Hith escarpment between Ar-Riyadh and Al-Kharj, and it is suitable for use as an interior ornamental stone.

All deposits of the central part of Saudi Arabia, are probably of Permian age.

- Some of the most important gypsum deposits of the country are located near the Ar-Riyadh - Arabian Gulf railroad; others are scattered in many localities of the Arabian Gulf area.

The National Gypsum Company constructed in the early 1960s a modern plant in Riyadh for the processing of gypsum using rotary calciners to produce 200 tons of plaster per day. It uses gypsum supplied from deposits located 50km south of Riyadh on both sides of Al-Kharj road. The plant produces a wide range of plasters and plaster products for construction and as a decorative material. Part of the production is exported to other Arab countries.

The company intends also to manufacture sound-insulating plasters, using the gypsum and perlite deposits recently found in the Western Province.

A market study is planned to determine the competitiveness of Saudi gypsum in the world market in the Mediterranean and east African countries before dediding on the expansion of its production.

Table No.XXV Gypsum Deposits in Saudi Arabia

Deposits	Location	Gypsum content	Reserves	Age
	The Red Sea Area			
1. Jabal El-Kibrit	100km north of Al Muwaylih	Not determined	Very large not evaluated	MIOCENE
2. Maqna	Mouth of Gulf of Aqaba	Not determined	Not evaluated	
	The Central Area			
3.) Al Khay 4.)	Near El-Khay, along the railroad	83% - 92% Not determined	3 million tons 10-15 million tons	PERMIAN
5. Hith (anhydrite)	Between Ar-Riyadh and Al-Kharj	Not determined	Not calculated	
	The Arabian Gulf Area			
6. Khashm Umm Huwayd	165 kms south of Dhahran	96%	5 million tons	
7. Ayn Dar	39km west of Abqaiq	75%	0.3 million tons	
8. Al-Hufuf	26km east of Al-Hufuf	94%	3 million tons	MIOCENE

Source: Economic Commission for Western Asia, based on data collected from national and international sources.

In J o r d a n , in the Wadi Al Karak, gypsum forms beds of 1 to 4m thick in the middle part of the Cenomanian nodular limestone member and in the Wadi Al-Mawjib in the lower third of the echinoid limestone member of Cenomanian-Turonian age. Gypsum is also found about 35km north-west of Amman at the confluence of Wadi Al-Munah in the Nahr Az-Zarqa River, in a 25m thick bed within a Triassic rock sequence. While all these occurrences are of economic value, the Maestrichtian-Danian gyprock, which consists of thin layers, is not considered as an exploitable deposit.

Anhydrite was penetrated in some places by exploration oil wells in the Dead Sea region where it occurs in Triassic, Jurassic, Lower Cretaceous (?) and Miocene - Pliocene evaporate sequences.

A deposit of gyprock is known to be situated along the Amman-Karak road, but no detailed information on it is available.

Gypsum and anhydrite rocks in I r a q are associated with evaporates widely spread in Triassic, Jurassic, Cretaceous (Cenon), Paleogen (Oligocene, Miocene) and in Neogen (Eocene) sequences. According to "Mining Annual Review" (July 1973) total commercial reserves of gypsum in Iraq reach 50 million tons.

Information on the quantity produced is not available, but gypsum is used mainly in cement and building material industries.

Occurrences of gypsum in the U. A. E. are located at Jabal Ali, south-west of Dubai, consisting in part of the Lower Fars Formation (Oligocene - Pliocene). It includes limestone, marl and shale which are exposed owing to salt diapirism. Drilling is being carried out at Jabal Ali, and it was found that the gypsum bodies are too thin to be economically exploitable. Further prospecting for gypsum was suggested to be conducted in the lower part of the sequence in the same area. Commercial deposits of gypsum and anhydrite could be found in large valleys (Hadramaut, Masila and others) and on the sea coast, which may turn out to be suitable for cement manufacturing. The probable reserves of those mineral raw materials are evaluated at approximately 500 - 600 million tons. A large deposit of gypsum and anhydrite was discovered near Batis (the 3rd Governorate).

Gypsum occurs in B a h r a i n at varying depths. The thickness of separate beds does not exceed 60 to 70 cm. The gypsum is often intermixed with thin beds of dolomite and marl. For some decades gypsum was mined and used for making building blocks.

Gypsum and anhydrite are also found in Q a t a r , and in K u w a i t (Jurassic (?), Neogen), the latter being of no commercial value.

c) <u>Clay, Kaolin, argillous rocks:</u>

These raw materials are widely used for multivarious purposes in many branches of the industry owing to their specific physical properties.

Unlike for many other mineral raw materials, there are generally no accepted technological standards and specifications for clay rocks. This would be explained mainly by the fact that the strict dependency between quality of final product and mineral raw material used does not exist. So far, technological testing of clays in the process of exploration and development of deposits is one of the main elements for the qualitative evaluation.

Below, only some general considerations concerning utilization of various kinds of clay rocks, are described.

In the case of ceramic production the main specifications are shown in **table No.** XXVI.

For the production of the refractory materials employed in the ferrous, non-ferrous, glass, cement, chemical and some other industries, fire **clay and flint are used.** They possess high refractoriness (1580°C) and are classified depending on the contents of Al_2O_3+TiO_2, Al_2O_3, Fe_2O_3+TiO_2, the grade and temperature of their vitrification, plasticity and rate of dispersion.

Bentonitic clays, loams, clay shales, coaly-clay shales, argillites and some other similar rocks, which possess low fusion temperature, are widely used, after processing, as fillers for the production of Haydite concrete. The most suitable material for this purpose is montmorillonite and hydromica clays.

Alkaline and alkaline-earth bentonitic clays are in use since the last 15-20 years in increasing quantity in the production of iron-ore pellets from iron-ore concentrates. Bentonitic kaolin and kaolin-montmorillonite plastic bond and high refractory clays are utilized in the foundry. Up to 30-35% of feeds in the production of Portland cement consist of clay, loam, clay shale, which have low fusion temperature, not high Al_2O_3 content and a total sum of magnesia and sulphur trioxide not exceeding 4.5-6%.

A very important application of some clays, particularly for the oil-producing countries, is in drilling muds. The best material for this purpose is the fine-dispersive alkaline bentonitic clay and alkaline-earch bentonite (after addition of some soda ash) or polygorskite kinds of bentonite if drilling is conducted in evaporate rocks.

In the chemical and petrochemical industries some kinds of clay are used as sorbents, coagulants and catalyzers.

Consumption of bentonitic clays is continuously increasing and new lines of production and branches of industries, including medicine, agriculture, pharmacalogy etc., make use of this material.

The main specifications for clay materials in ceramic production

Table No. XXVI

Final products	Kind of raw material	Specifications				Remarks
		* Refractoriness temperature C°	Vitrification temperature C°	Vitrification Farge	Plasticity	
Building ceramics (bricks, tiles, ceramic blocks, etc.)	Clay, loam	$< 1350^{\circ}$	$900^{\circ}-1000^{\circ}$	$\sim 100^{\circ}-120^{\circ}$	Plastic	Sand content should not be more than 10%-15%, impurity of sulphates, calcareous particles is not favourable.
Crude ceramics (acid resistant products, drainage and sewage pipes, Flemish bricks, plates, etc.)	Clay	$< 1580^{\circ}$	$< 1200^{\circ}$	$\sim 200^{\circ}$	Plastic	Harmful inclusions, dolomite, gypsum, iron sulphides, calcareous concretions, plant residuals.
Porcelain and faience products.	Kaolin, as a main component, white-burning clay as a bonding material.	$> 1600^{\circ}-1700^{\circ}$	$1550^{\circ}-1500^{\circ}$	$150^{\circ}-200^{\circ}$	Bonding	High content of Al_2O_3 is useful. There should be a minimal content of iron and titanium oxides. Mineral inclusions as pyrite, siderite, marcasite are not admissible.

* In the western countries in the refractories industry - the **pyrometric** core equivalent is a comparative value used to determine the refractoriness of a material; here, is the temperature of the clay-softening.

Another very important application of clays is as fillers in paper, rubber, plastic and perfumary production, **particularly about 40% of the total output of Kaolin in the USSR is utilized in the paper industry.**

Usually, the clay and argillous rocks are exploited by opencast method and only refractory material and kaolin can be economically mined using underground method. Exploitation of the most important deposits by the opencast method is possible if the clay layer is not less than 1m thick and the stripping ratio is not more than 10:1. For poorer types of clay, this ratio should be at least 1:1.

In spite of the existence of sedimentary formations covering most of the ECWA region, no important and notable deposits of bentonitic clay exist in the region which would help to meet the increasing domestic demand and could reduce the large imports of this material.

The following table shows the distribution of re-exports of bentonite from Kuwait to the countries of the region. Originally, the bentonite was imported by Kuwait from USA, India and Iran.

Table No. XXVII. Kuwait's Imports and Exports of Bentonite in 1974

Country	Imports		Exports	
	KD value	Weight	KD value	Weight
Iraq	-	-	419,615	14,607,660
Jordan	-	-	7,460	195,000
Qatar	-	-	31,403	135,250
Saudi Arabia	-	-	139,667	4,509,750
Syria	-	-	10,400	200,000
UAE	-	-	323,983	12,000,000
PDRY	-	-	6,224	172,000
USA	90,986	1,356,868	-	-
India	243,155	45,083,875	-	-
Iran	52,778	3,735.000	16,156	700,000
Total	386,919	50,175,743	936,908	32,519,660

In S y r i a , clay was found in the **Aptian** and Maestrichtian, Oligocene, Middle Miocene and Quaternary formations.

- In 1970 investigations of building raw materials were conducted in the vicinity of Raqa City, where the most important findings were recorded in Wadi Al-Faid and Riquit Al-Samra areas. In the latter area, 32 boreholes with an average depth of 8.7m and a total depth of 279m were drilled. In this location, Upper Quaternary clay layers with an average thickness of 5.6m contain 1,683,880m^3 of "B" category reserves. Chemical and mineralogical analyses as well as preliminary technological tests show that the discovered clay can be used for brick production. It is estimated that this deposit could supply a brick plant with a production capacity of 20 million standard bricks per year for a period of 46 years.

Further semi-industrial tests of clay were recommended for studying the feasibility of constructing such a plant.

- Prospecting conducted in Qamishly area (Hilaliyah deposit) by drilling of 20 boreholes to an average depth of 20 metres led to the discovery of two clay beds. The upper one consists of a loam bed 6.6m thick (Middle Quaternary) followed by a limestone derived clay having a thickness of 11.2m (Pliocene). Reserves of the loam bed are estimated at 1.45 million m^3 of C_2, C_1 and B categories, which are enough to supply a plant with a capacity of 20 million bricks of standard size. Furthermore, reserves of the limestone clay of C_1 and B categories amounting to 3.1m^3 are available in the lower bed.

Working conditions of this deposit are very favourable since no overburden overlies the loam bed. Geological conditions of the deposit and technological properties of the material are uniform and its quality ranges between average to good.

- The Hasakah loam deposit is situated 10km north of Hasakah by the main road between this town and Qamishly. It extends over an area of 3 x 3km. Prospecting aimed at ensuring enough loams for the brick industry. This Upper Quaternary deposit consists of brown loams of good plasticity and with a high content of fine, dispersed calcium sulphate. They are overlain by gravel and sand.

For a proper evaluation of C_2 reserves, 9 drill holes spaced by 200 to 300m were drilled and the samples tested. The material has been found suitable for production of good quality-building bricks the dimensions of which are 71 x 240 x 215mm.

The loam bed is not covered by any overburden and therefore can be mined by open pit. Reserves of the loam with category C_2 are estimated at 501,942m^3. An increase in the amount of these reserves is also possible.

- An investigation was carried out of the Sfaya (Hasakah) deposit with estimated reserves of 501,942m^3. The possibility of utilizing the loam of this deposit seems to be more favourable than the one offered by the Hilaliyah deposit. Reserves will be enough to supply a medium-size brick plant for a period of 30 years.

- A clay of Upper Aptian age is widely known in the Anti Liban and in Jabal Ash-Shaikh where it takes the shape of beds and lenticular interbeds (up to 2 or 3m thick) occurring in a formation of red sandstones. Samples collected near the Beit Jahn showed that the clay is moderately plastic, semiacidic, with a high content of staining oxides, and containing calcareous inclusions. After special treatment for removing the inclusions, the material may be used in ceramic and brick production as well as a raw material for pottery.

- A clay and clayer marl of Maestrichtian age were studied in the El-Bayad valley and on the sides of Wadi Hsayyeh. They consist of two members, 80 and 165m thick respectively. Clays are calcareous, grading into clayer marl, grey, thin bedded and platy. They belong to high-carbonate and low-alumina varieties and can only be used in cement and drilling mud production. Cement production requires a reduction of alumina modulus possibly through an addition of iron ore.

- Clayer marl of Middle Eocene age was tested in a laboratory and the results showed that after special preliminary treatment, it can be used for preparing a satisfactory mud suitable for drilling under both normal and complicated conditions.

- Clays of Oligocene age which are found in Palmyrides are confined to the Middle and Upper Oligocene formations (the southern slope of Jabal El-Haet, in Wadi Jhar, Jabal At-Tyas). In Jabal At-Tyas, the clay member is 29m thick with some beds measuring 2 or 3m, alternating with marls, quartz sandstones and ferruginous siltstones. The clay is bluish, greenish and slightly carbonate.

- The Upper Oligocene sequence contains grey clay, in layers with thickness of 50m. As a rule, clays are alternating with carbonate and terrigene rocks.

These clays can be used in cement production and in the preparation of muds for drilling under nor‑al geological conditions. The use of high concentrations of carbonyl-methyl-cellulose is necessary for preparation of fine quality muds.

- The Miocene clay is worked in the area of Dimashq and used as an alumia additive to Eocene marl in cement production. After simple chemical treatment, the clay may also be used for the preparation of mud suitable for drilling under both normal and complicated geological conditions.

Investigations showed that in Syria, are available practically unlimited reserves of clay and argillites that can be used for brick-making and for preparing drilling mud. The latter application is very important in view of the numerous drilling activities for water and oil.

- The two exploited bentenitic clay deposits, the raw material of which is used for drilling purposes, are Tel-Hadjar and Ragadan (Pliocene, Upper Miocene). Both of them were formed at the peripheral parts of the Arabian Platform. The use of this clay for pottery is relatively difficult.

Besides the clay deposits mentioned above, some deposits of laterite are also found in Syria and are used for brick production (Raqqa, Hasaqi, Deer). Further investivation on laterites in Deer-Homs area is planned.

In J o r d a n , the most significant clay deposit is located at 19km WNW of Amman in the vicinity of the village of Mahis. Layers and lenses of the clay, with a thickness up to 4.2m, are associated with the upper part of the massive white sandstones of the Lower Cretaceous (the Kurnub Sandstone Formation), which lays on delomitic limestones of Jurassic age and is overlain by Cenomanian limestones. The clays of the Mahis deposits contain, besides caolinite as the main constituent, mascovite, illite and quartz. The Mahis deposit contains two productive horizons: the Upper Mahis Clay (K4) containing fine ceramic clays (class A" and class B") with reserves of 1477 thousand tons, and the Lower one with 420, 340 tons of heavy ceramic clay (class C"), which occurs near the surface and is suitable for the production of fleer titles, sanitary wave pipes, bricks, etc. As to the Upper Mahis Clay, about 7% of these reserves have a stripping ratio of 1:4 or less; and it could be mined partly by underground method. It was calculated that the underground mining cost per ton of clay delivered to the stockpile on the surface could be J.D. 2.166, annual production could be as much as 30,000 tons.

A total of about 100 employees could be engaged in the mining operation and administration.

In the eastern side of the Jordan Valley, approximately 25km north of the northern end of the Dead Sea near Ghor Kabid, there is another clay deposit, occurring in a similar sequence as the previous one. It contains yellowish, reddish, light-bluish-grey material, which forms three beds of 0,25m to 1,2m thickness each. The proven reserves of this deposit are rather small, as they do not exceed 47000 tons. The results of quantitative chemical analyses of clays from Mahis and Ghor Kabid deposit, carried out by the Geological Survey of the Federal Republic of Germany (H. Gundlack, 1965) are quoted in the following:

Quantitative Chemical Analyses of Clays from MAHIS and GHOR KABID (JORDAN)

Table No.XXVIII

	M A H I S		
	50cm. light-grey clay above the main clay bed and 80cm. from the upper part of the main Clay bed (in %)	140cm. from the middle part of the main Clay bed (in %)	150cm. from the lower part of the main Clay bed (in %)
SiO_2	60.7	60.8	66.8
Al_2O_3	25.6	24.2	19.8
Fe_2O_3	1.78	1.76	1.66
FeO	$<$0.10	$<$0.10	$<$0.10
TiO_2	1.44	1.99	2.24
MnO	$<$0.02	$<$0.02	$<$0.02
CaO	~ 0.10	~ 0.10	0.36
MgO	0.28	0.22	0.25
Na_2O	0.24	0.24	0.21
K_2O	0.78	0.86	0.85
P_2O_5	0.07	0.07	0.07
H_2O^+	0.66	0.70	0.54
H_2O	8.24	8.30	6.83

Table No. XXVIII (Cont'd.)

	GHOR KABID		
	upper yellow clay bed, 25 cm. (in %)	middle red clay bed, 70 cm. (in %)	lower (main) clay bed, 120 cm. (in %)
SiO_2	43.0	42.4	48.8
Al_2O_3	36.5	37.6	32.8
Fe_2O_3	1.86	3.30	1.09
FeO	$<$0.10	$<$0.10	$<$ 0.10
TiO_2	4.69	2.52	2.24
MnO	$<$0.02	$<$0.02	$<$0.02
CaO	$\sim$ 0.10	$\sim$ 0.10	$\sim$ 0.10
MgO	0.15	0.03	0.24
Na_2O	0.21	0.27	0.37
K_2O	0.33	0.29	0.47
P_2O_5	0.09	0.06	0.15
H_2O^-	0.88	1.51	1.85
H_2O^+	12.0	12.2	11.9

Source: F. **Bender**, Geology of Jordan, Gebrüder Borntraeger, Berlin, Stuttgard 1974.

According to the "Mining Annual Review" (July 1973), the total reserves of Kaolin in Jordan amount to more than 5 million tons, but until now only a small scale operation is conducted in the Mahis area to supply the local cement plant.

It was also reported about Pleistocene bentonites in El-Azrak Area , which are confined to the northern Wadi Sirhan Depression and are exposed on the surface. Thickness of the clay layer varies between 1 and 4 metres, calculated data on expandabilities are between 30% to 85%. Reserves and any other more detailed information on the deposit are not available.

In I r a q kaolin is exploited for ceramic and paper production; a deposit of bentonitic clay is also mined. Some deposits of Triassic and Miocene age which are exploited for cement manufacturing in Al-Gaara and Nayar are located to the west and to south of Baghdad.

A scientific and laboratory research was carried out on various kinds of clay deposits aimed at finding new utilizations for the available resources. Among these is a bantonitic clay of Qara-Tappa deposit which was studied with the view of determining the possibility of using this clay for the preparation of oil well drilling muds. A suitable method to this end has been worked out.

Another scientific research was conducted at the request of the state Organization of Design and Industry on the feasibility of producing refactory clay bricks using the clay available in Rutba. At present, Iraq imports large quantities of refractories from abroad. Testing of clay samples from the Rutba district indicated that composition of the material is suitable for this purpose. It is thought that the kaolinite clay of the deposit could be used for production of refactory bricks, characterized by a high softening temperature and a high heat shock resistance. Other properties of the refractories such as density and porosity are also within a suitable range. Production will start at a ceramic plant which is presently being established by the Ministry of Industry.

For this purpose, the Government of Iraq has signed in 1975 a contract with the British William Bolton concerning the supply of plant **with equipments** The value of the contract is £ 100,000.

An application of the Iraqi kaolin as a raw material for the manufacture of aluminium silicate pigment (water-paints and oil paints) was suggested.

In K u w a i t , the problem of locating clay deposits is of significant importance in view of the intention of setting up a local cement producing plant. Until the present time no clays even suitable for good bricks or pottery have been found due to the clay being thin, mostly sandy or silty and irregularly developed. Layers of clay and shale within the **Mescene sequence are exposed at the Tal Az-Zewreescarpment** and have hardly any economic significance.

Two samples taken from Warba Island were tested. Differential thermal analysis showed that the main constituent of the material is a clay mineral of the illite group. The plasticity is good and the fusion point between 1140 and 1350 Centigrades. Although not refractory, these results should encourage further studies. One of the main problems is a certain degree of salinity which is always present in the rocks, because of the constant influence of the high marine groundwater table and occasional floodings.

In B a h r a i n deposits of the Middle Eocene (Dammam Formation) clay are located near Buri village and in the area of west rimrock. The thickness of two clay learning units does exceed 15 metres each, and the quantity of reasonably clean clay is only about 25%. According to some chemical analysis, clay from both deposits contains very high percentage of calcium and carbonate and cannot therefore be used as a raw material for the ceramics industry. Preliminary testing has been conducted to evaluate the suitability of the material for brick and pottery manufacturing.

The other clay deposit, situated in Wadi near A'Abli is mined and material is used for production pottery at the local factory

RESULTS OF CHEMICAL ANALYSES OF CLAY (BAHRAIN)

Table No. XXIX

Chemical Companents	Chemical Composition in % %		
	Sharks Tooth Shale Unit	Orange Marl Unit	A'Ali deposit
SiO_2	23.7	9.9	34.0
Fe_2O_3	1.6	1.1	5.2
Al_2O_3	6.3	2.1	9.3
TiO_2	-	-	1.4
Ca	8.0	17.1	11.6
Mg	4.7	10.7	6.0
Co_3	16.6	49.5	25.9
Cl	4.7	0.3	0.1
SO_4	1.7	0.5	0.1
PO_4	2.0	Nil	0.3
Less at 500°C	30.1	7.7	8.2

Source: "Report on the Geology of Bahrain with Hydrology and Economic Aspects" BAPCO.

Clay as a raw material for cement has been discovered at 300km northwest of Riyadh (Buraydah) and in some other regions along the Red Sea shore in Saudi Arabia. One of the deposits contains about 56 million tons of the material (Khushaym Radi). Brick-making clays are worked in the Jeddah area, and promising clays for making bricks, tiles and possibly sanitary ware occur near Ar-Riyad. Kaolin occurs at As Sarat, in association with alunite.

Lebanon has unaccounted reserves of clays ranging from Jurassic to Quaternary, some of which are worked.

Democratic Yemen has some deposits of loam loesses and clay shales in Hadramaut, Masila and in some other valleys and on the sea coast, which could be suitable for cement manufacturing. Good quality clays (mainly of montmorillonitic and beidellitic compositions) can be expected in areas of development of basaltoid and spilite-diabasic volcanics of Cretaceous - Paleogene and Pre-Cambrian age in the 2nd and 5th Governorates. Promising areas for kaolinite are situated in the 4th, 5th and 6th Governorates.

5. Development of the cement industry

During the last 15 to 20 years, the demand for, and production of cement in the ECWA member countries increased considerably. This increase was not only due to the growing rate of industrial and housing constructions in these countries, but also due to the prospects for exporting it to other countries within and outside the ECWA region. Rough calculations show that by 1980, countries of the ECWA region will be producing at least 20 million tons per year of cement using the large and practically unlimited reserves of mineral raw materials which are available in many of these countries.

In Saudi Arabia three cement plants with a total annual production of 1.452 million tons are under operation. After the implementation of the planned expansion programme which will cost 385.5 million dollars, cement production will increase by 2.970 million tons per year in 1980. Furthermore, the Saudi authorities are planning to construct additional cement plants which will produce annually 4.950 million tons of cement. The total annual production capacity of the cement industry in Saudi Arabia is therefore estimated at 9,372 million tons in 1980. For the implementation of both programmes, the government is planning to invest about 906.2 million dollars.

Table No. XXX Cement industry in Saudi Arabia

Plants	Annual production (Thousand tons)	
	1975	1980
Hufuf	429	1,419
Riyadh	363	1,353
Jeddah	660	1,650
Jubail area	-	990
Buraydah	-	990
Tabuk	-	990
Yanbu	-	990
Southwestern area	-	990
Total annual capacity	1,452	9,372*

Source: Second National Development Plan (1394-95 - 1399-1400)

In Iraq the cement industry is more developed than in any other ECWA member country with a production capacity of 2.1 million tons per year, an annual production cost of $ 40.5 million (estimated at 1972/73 prices); about 500,000 tons of cement production is exported, hence making cement one of the leading export items in Iraq. In 1974 six cement plants were operating in the country as shown by the following table:

Table No. XXXI Cement plants operating in Iraq as in 1974.

Company	Location	Annual capacity
Iraq Cement Co.	Baghdad	400,000
Iraq Cement Co.	Sadet Al-Hindiyeh	200,000
Iraq Cement Co.	Sammawa	400,000
Rafidain Cement Co.	Badouch	200,000
Haman Al-Alil Co.	Haman Al-Alil	100,000
Haman Al-Alil Co.	Surchinar	100,000
Total		1,400,000

Source: Annual Abstract of Statistics, 1975. Central Statistical Organization, Republic of Iraq, Ministry of Planning.

* According to recently obtained information from the Ministry of Petroleum and Mineral Resources, the annual production of cement will reach in 1980 4.4 million tons.

An expansion of cement production is envisaged by the Iraqi government. Annual cement production is expected to reach 6 million tons in 1978, 50 per cent of which will be exported to three main regions: the Arabian Gulf States (2.5 million tons); Europe and the Mediterranean States (250,000 tons); and Africa and Asia (100,000 tons).

In order to execute this expansion programme, a contract was signed in August 1974 with the French company Five Cail-Babock, whereby the company will construct a cement factory at Hamam Al-Alil near Mosul of a production capacity of 500,000 tons per year. The plant is expected to start operating during the second quarter of 1977.

A second contract was signed with Techno-Export Agency (USSR) for the establishment of a cement plant at Sammawa. The cost of this plant is estimated at 42 million and its annual production capacity will be of 500,000 tons. Completion of this project is expected **during** the second quarter of 1977.

Another cement plant is planned at Fallujah with an initial production capacity of 240,000 tons and a possible maximum capacity of 750,000 tons per year.

Six cement plants producing more than one million tons of cement per year are operating in S y r i a . Five of these plants were constructed between 1952 and 1966.

Table No. XXXII Cement plants operating in Syria

Company	Location	Annual production, 1972 (tons)
National Cement	Damascus	285,000
Al-Chahba Cement	Aleppo	200,000
Al-Chahba Cement	Aleppo	110,000
Al-Chahba Cement	Latakia	100,000
Syrian Cement	Homs	100,000
Syrian Cement	Hama	110,000
Total		905,000

<u>Source:</u> Fourth Five-Year Economic and Social Development Plan of the Syrian Arab Republic (1976-1980).

The Syrian government prepared a development programme for the cement industry until 1980, the year in which output is expected to reach 6 million tons per year. This development programme in which Romanian and West German state agencies are involved, includes the construction of cement plants in Tartous, Aleppo, Hama and Adra. It is expected that all these plants are to be put into operation between 1976 and 1978. In addition, a contact valued at 250 million Syrian pounds was signed in 1974 with the Lebanese company CAT for the construction of two cement plants in Latakia and Homs. The General Cement Organization of Syria has planned to complete during the Five Year plan period (1976-1980) the construction of one more cement factory in Sheikh-Said (S.P. 425 million) and to start building the other cement plants of Tartous, Musilimieh, Adra and Aleppo. Construction of new cement plan will be also started at Raston. The total estimated cost of the new projects and of the ongoing projects S.P. 2794 million. An expansion programme of the cement industry was also carried out in the United Arab Emirates. In 1974, at least five cement plants were under construction.

1. In Dubai - by the Richard Costain Co. Ltd. (Great Britain); the cost of the project is Sterling Pounds 27 million, and production is estimated to be between 500,000 and 1 million tons per year.

2. In Ras Al-Khaimah - by the Mothercat (Lebanon); the cost of the project at Sterling Pounds 3.5 million and the equipment is to be delivered by IHI (Japan).

3. In Al-Ain, the cost of the plant is estimated at Sterling Pounds 19.6 million with an annual production of 200,000 tons of cement.

4. In Sharjah, the cement plant was built by the Five Cail-Babock Co. (France) and the Belgium company Siv Construct.

5. In Abu-Dhabi, the plant was built by one of the Japanese firms, and the cost is estimated at Sterling Pounds 7.8 million. The final capacity of the plant is expected to be 250.000 tons per year.

When all these plants would become operational, total cement production in UAE will be at least over 1.5 million tons per year most of which will be exported.

In 1974 a cement project was initiated in Lebanon. Cement is also produced in Yemen Arab Republic and Jordan, cement production where amounts to around 500,000 tons per year.

K u w a i t has one cement plant in Shuaiba owned by the Kuwait Cement Company which was established in 1972. This company uses mineral raw materials imported from the Neutral Territory to produce 300,000 tons of cement per year. Besides, clinker is also delivered from Iraq in bulk and is ground locally.

An expansion programme is envisaged to increase cement production up to 750,000 tons per year. For this purpose, a new cement plant will be built in 1977 in Shuabba. At present, Kuwaiti imports of cement total around 800,000 tons per year.

In Q a t a r , a cement plant managed by the Qatar Cement Company (40 per cent government participation) was constructed in Umm Bab on the western shore. Production which started in 1968 with 100,000 tons per year, increased in 1973 to 250,000 tons per year. A further production increase is expected.

For supplying this plant with mineral raw materials, the company imports gypsum and ferruginous materials, and uses domestic limestone and clay which are mined nearby.

In spite of relatively large cement production, Qatar is still an importer of cement. In 1974, total cement import reached 200,000 tons.

O m a n has also initiated the construction of a cement plant with a production capacity varying between 100,000 and 130,000 tons per year. The cost of the project is 5,500 .000 Omani rials.

Feasibility of establishing a cement plant with a capacity of 250 tons per day is being considered in P e o p l e ' s D e m o c r a t i c R e p u b l i c o f Y e m e n . It was estimated that available reserves of local mineral raw materials will be sufficient to supply the cement plant for a period of 50 years.

According to the UNDP project (PDY/75/004/11/371) it planned to undertake a study of the available documents and a survey of various raw material deposits in the country suitable for the manufacture of building materials, and also to work out recommendations, concerning suitable manufacturing units with an indication of their economics. Cost of this project is about $ 28,000 and it was to be started in December 1975.

C. Mineralization in the Red Sea [1/]

The Red Sea extends in a northwesterly direction from the narrow strait of Bab El-Mandeb at its southern end and to the southern tip of Sinai Peninsula, a distance of about 1.930 kms covering about 438,000 km^2. It cuts across a huge dome of pre-Cambrian basement rocks, flanked by epicontinental and marine sediments.

At its southern end, the Red Sea is connected to the Gulf of Aden which trends ENE-WSW, opening into the Indian Ocean and separating the southern part of the Arabian Peninsula from the Somali Plateau. At the northern end, the Red Sea bifurcates into the Gulfs of Suez and Aqaba creating the triangular Sinai Peninsula.

The main Red Sea graben was formed about 26 million years ago following a period of basaltic volcanity. This was followed by a relatively quiet period of about 14 million years in which time large quantities of clastics and evaporites were deposited. A further phase of activity began about 8 million years ago when movements connected the Red Sea to the Gulf of Aden and Indian Ocean. After a short quiet period there have been further rift movements continuing to the present day. The last phase of rifting covers the last 3 million years. Now the centre of the Red Sea and especially its southern part, are seismically active.

The Red Sea has been the subject of geophysical and geological investigations since the last decade of the 19th Century and the early part of this century. Recently, the most intensive investigations were undertaken by research vessels "Vema", "Atlantis", "Atlantis II", "Chain" (Lamont Geological Observatory and Woods Hale Oceanographic Institution, USA), "Discovery" (of the National Institute of Oceanography, Gr. B.) and by R.V. "Aragonese" (of the NATO SACLANT ASW Research Centre).

The first indication of anomalously high temperature near the Red Sea bottom was discovered in 1948 by Swedish vessel "Albatross". Further investigations in the 1960s resulted in discoveries of deeps with geothermal brine deposits containing a high grade of metals.

1/ Written mainly on the materials published in "Hot Brines and Recent Heavy Metal Deposits in the Red Sea". It was edited by Egon T. Degens and David A. Ross, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 1969.

Chemical and mineralogical analyses performed on samples from ten specially selected cores from the Red Sea bottom in the hot brine areas, show the existence of seven bedded and laterally correlative facies as follows:

1. Detrital
2. Iron-montmorillonite
3. Goethite-amorphous
4. Sulphide
5. Manganosiderite
6. Anhydrite
7. Manganite

Distribution of the facies, their unconsolidated nature and age relationship indicate that the solids were precipitated out of the overlying brine column, that the area of brine discharge is local limited almost to the Atlantis II Deep.

Mechanisme of precipitation include simple cooling of subterranean brine as it discharges into the bottom of the Atlantis II Deep and mining of the brine with the overlying seawater.

The source of heat is assumed to be subjacent bodies of igneous rocks. Origin of the brine is not known for certain, but a reasonable hypothesis is that its salt content is derived by circulation through the underlying or adjacent evaporite deposits.

During investigations, the three facies delineated in a composite cross section were assumed to be continuous layers across the Atlantis II Deep. Average thickness values of 4, $3\frac{1}{2}$ and 1m for the " Iron-Montmorillonite", "Goethite" and "Sulphide" facies respectively were used. Average compositions were calculated from chemical analyses for these facies in each core and these values were subsequently used to calculate average compositions for the whole of each facies, as presented in table No.XXXIII.

Table No. XXXIII

Average weighted concentrations of metals in each facies a the Atlantis II Deep

Chemical Composition	Atlantis II Deep			Discovery Deep
	"Goethite" facies	"Fe-Montmorillonite" facies	"Sulphide" facies	"Goethite-Detrital" facies
Fe_2O_3 (tot)	49 (8.7)	35 (2)	33 (10)	20
Mn_3O_4 (tot)	2.9 (2.1)	2 (2)	1.3 (0.8)	1
ZnO	1.0 (0.9)	4.7 (3)	11.1 (4)	0.15
CuO	0.5 (0.5)	0.7 (0.4)	4.6 (3)	0.05
PbO	0.1 (0.1)	0.1 (0.1)	0.2 (0.2)	0.03
AgO	.0033(0.0015)	0.0062(0.005)	0.013(0.008)	0.001
Au	0.00003	0.00006	0.00013	-
Per cent brine	84 (4)	92 (2)	75 (15)	68
Area (m^2)	56×10^6	56×10^6	56×10^6	11×10^6
Thickness (m)	3.5	4	1	(10)
Volume (m^3)	196×10^6	224×10^6	56×10^6	110×10^6
Sp. G. Sed (wet)	1.33	1.26	1.39	1.49
Brine-free tonnage	42×10^6	22×10^6	19×10^6	52×10^6

Total Atlantis II Deep (brine-free)- tonnage: 83×10^6

Total Atlantis II Deep volume (m^3): 48×10^7

Tonnages for individual metals in the three facies in the Atlantis II Deep were calculated from the above data.

Source: Hote Brine and Recent Heavy Metal Deposits in the Read Sea, 1969.

Table No. XXXIV

Gross Values of Metals in Upper 10m of the Atlantis II Deep

(metal prices from Engineering and Mining Journal, Dec. 1967;
Value per ton brine-free material = $ 30;
per m^3 in-place sediment = $ 5.2)

Metals	Price (dollars per ton)	"Goethite"		"Fe Silicate"		"Sulphide"		Total		
		Tons	Value $ x 10^7	Tons	Value $ x 10^7	Tons	Value $ x 10^7	Averaged assay (%)	Tons	Value $ x 10^7
Fe	-	143 x 10^5	-	55 x 10^5	-	45 x 10^5	-	29	243 x 10^5	-
Zn	300	3.3 x 10^5	9.9	8.4 x 10^5	25.2	16.9 x 10^5	50.7	3.4	29 x 10^5	86
Cu	1200	2.1 x 10^5	25.2	1.3 x 10^5	15.6	7.2 x 10^5	85.3	1.3	10.6 x 10^5	127
Pb	300	0.3 x 10^5	0.9	0.2 x 10^5	0.6	0.3 x 10^5	0.9	0.1	0.8 x 10^5	2
Ag	62.400	12 x 10^2	7.5	11.9 x 10^2	7.4	21 x 10^2	13.1	0.0034	45 x 10^2	28
Au	1.2 x 10^6	12	1.3	11.9	1.4	21	2.3	0.5ppm	45	5
Total			44.8		50.2		152.3			248

Source: Hote Brine and Recent Heavy Metal Deposits in the Red Sea. 1969.

The main conclusion from the data in Table No. XXXIV is that the sulphide zone, although only **in** thick, contains more valuable metals than the other facies combined. In order of value, the metals are: Cu, Zn, Ag, Au and Pb. The value of other minor elements would probably add only slightly to the total. Semi-quantitative and quantitative analyses have shown about 0.005% tin, 0.03% cadmium, 0.03% cobalt and nickel, between 0.01% and 0.05% arsenic, less than 0.005% germanium, and less than 0.001% bismuth, indium and mercury.

Seismic reflection studies suggest that deposits in the brine deeps may, in places, extend to about 20m depth and in isolated places may extend to 100m.

According to the rough calculation of the potential tonnage of metal-rich oozes, the Atlantis II Deep contains about 2 billion tons of the material (assuming 6.12×10^8 square feet area, the volume is about 4×10^{10} cubic feet, thickness of 20 to 30m, ooze density about 1.6), with the average dry weight assays as follows:

Iron - 12.00%

Copper - 0.19%

Zinc - 0.93%

Silver - 0.60 oz/ton

Gold - 0.01 oz/ton

Other results were obtained from assessments of 34 other samples, which were taken from the same area and average contents calculated.

Copper - 0.2%

Zinc - 0.7%

Silver - 0.3 oz/ton

Gold - 0.005 oz/ton

Based on the world prices that existed in the world market for these metals in 1967, each ton in situ contains approximately $ 4.15 value of metals which amounts to 8 billion dollars in the Atlantis II Deep. Taking into consideration growth in metal prices for past **some** years, these average grades in the Atlantis II Deep could be considerdd commercial as compared with those exploited on the land. But these metals have no real value unless they can be recovered and enter the market place profitably.

To exploit that deposit, a number of engineering problems have to be solved including pumping of very fluid ooze from the depth of about 2000m, transportation and processing. Assuming that such venture would be profitable, its optimum handling facilities should be for at least 5,000 tons per day (1.5 million tons per year) of dry ooze, or 15,000 tons per day of wet ooze. Production of 5,000 tons per day of dry material requires handling 2,500,000 ft^3 of ooze per day.

Although the sediments of the Atlantis II Deep contain a large value of metals, their value versus the costs of mining and extraction will determine whether the sediments are to be considered an ore body (capable of being mined at a profit) or a mineral curiosity. The programme of their economic evaluation is a complicated and expensive one and it includes: taking of new spaced much more closely and deeper than the present ones, ensuring that the sediment can easily be pumped to the surface, undertaking metallurgical investigations to show whether the metals can be economically concentrated by one of the methods, carrying out related studies of whether the sediment must first be leached, dried, or treated in bulk. On the method of treatment also depends whether the sediment can be processed aboard ship or must be processed ashore; cost analysis of the operation to determine what should be the minimum economic rate of mining in order to offset the large capital investment required for the final evaluation and initiation of the operation, plus the regular operating costs.

In 1973, a new metalliferrous ooze with Fe, Mn, Zn, Pb, Cu, Ni, Co, Cr and Hg was discovered in deep of Nerego which has 40km in length, 12 km in width and a maximum depth of 500 metres. In places, at the bottom of the deep a hot brine with temperature up to 30.2°.occurs. Metalliferrous sediments - black muds - were struck at the depth of 50cm.

Investigations were continued later in 1975 in the area with co-ordinates of approximately 21°N and 38°E which aimed at sampling and testing of metalliferrous oozes and studying of hot brine.

At present, the problem of the economic value of the Red Sea deposits remains open and there is no sufficient data which can confirm that the [illegible]oitation may be profitable.

The international legisltative aspects of mineral exploration and exploitation activities in the Red Sea are not covered by this survey. However, it is clear that co-operation among coastal countries of Western Asia and Africa is necessary.

The first steps on this way were undertaken in May 1974 when the joint Saudi-Sudan Commission for the exploration of Red Sea resources was established. Saudi Arabia agreed to finance projects and will be repaid from any income generated.1/ In 1978 some SR 55 million ($16,4 million) will be spent on mineral prospecting by the Commission. Earlier, the Commission said it will spend $45 million on mineral exploration, and has commissioned Preussag of West Germany to do feasibility studies for Red Sea mineral deposits.2/

At the same time in the field of ocean mining it was reported that several systems for dredging the nodules are now operational or will become so within the next few years. There seems to be little doubt that the developed countries would begin ocean nodule mining on a significant scale in the near future.

Technological progress may result in new uses for metals such as manganese, nickel and cobalt which may be obtained from nodules in excess of their projected requirements and at prices lower than those from Inland Deposits.

1/ Meed, Vol. 19:20, 16 May 1975.

2/ Meed, Vol. 4:3, 1977.

CHAPTER II. MANAGERIAL AND LEGISLATIVE ASPECTS OF MINERAL RESOURCES DEVELOPMENT

A. Mineral Resources Administration and Institutions

The development of mineral resources in the ECWA region has been dealt with by independent authorities in some countries and by various ministries in others. The first group of countries with relatively well developed and independent mineral resources authorities consist of the Syrian Arab Republic, the Hashemite Kingdom of Jordan, the Republic of Iraq, and the Kingdom of Saudi Arabia. In these countries, the authorities concerned have the necessary substantive departments that deal with the different stages of mineral resources development. In Syria and under the Directorate of Geologic and Mineral Research, in the Ministry of Petroleum and Mineral Resources, departments concerned with phosphate exploration, geology, mineralogy, radio-active material, geophysics, laboratories and a geological library for geologic research have been established. The experts working in the Directorate totalled 42 engineers and geologists and 9 chemists in 1975, all of Syrian nationality. Assistance is sometimes extended to them by a team of foreign experts.

The organizational setup in J o r d a n consists of the Natural Resources Authority (NRA), under which the Geological Survey and Bureau of Mines operates. This department consists of a mining division, laboratory division serving the entire work of NRA and a geophysical division. The mining division has also four sections dealing respectively with economic geology, geochemistry, drilling and licensing in the field of mineral resources. The number of experts working at NRA in the fields of petroleum, water and minerals exceeds 85. Only six mining engineers work at NRA as compared to 37 who work at the Jordan Phosphate Co. The Public Mining Company Ltd., a newly established company, is working closely with NRA and is concerned mainly with mining, processing and marketing of industrial minerals. Three mining engineers, one mechanical engineer and a geologist were working in this company in early 1976.

In I r a q the mineral resources authority consists of an independent "State Minerals Co." which is responsible for all the activities in the mineral resources field from geological, geophysical, hydrological and mineral surveys to exploration, exploitation, refining, storing and marketing of minerals.

The Iraqi State Minerals Co. was established in 1969 with a capital of 5 million I.D. and its staff at that time totalled 205. Up to the middle of 1975 and due to an increase in its operations, the capital of the company was increased to 25 million I.D. and the staff working in the company increased ten fold to 2150 staff members.

A board of directors manages the company which is independent administratively and financially. Directly under the board, comes the president and vice-president of the company. Working under the supervision of the vice-president are the substantive departments dealing with accountancy, research and marketing, personnel and administration, legal matters, quarries, mineral research and geological surveys. The legal office consists of two sections: one concerned with contracts and the other with wrights and lands. Under the mineral research and geological survey department, there are sections concerned respectively with documentation (library), mineral exploration, geologic, topographic and geophysical surveys. While laboratories are attached to the geological survey section, drawing unit is attached to the topographic survey section. Safety of workers and amployees, maintenance of equipment, drilling department and transport, all come under the services section. Other sections dealing with accounting and administration were also established.

In the case of S a u d i A r a b i a , the Directorate General of Mineral Resources in the Ministry of Petroleum and Mineral Resources is the main responsible body for the development of mineral resources in the Kingdom. Working directly under the minister of petroleum and mineral resources is the deputy minister for mineral resources who is assisted by consultants in supervising the work in the cost control unit, department of planning and budgeting and the legal department. Attached also to the deputy minister for mineral resources are the Concessions Department dealing with the activities of mining companies, the Projects and Control Unit and the Atomic Energy Department. The Concessions Department includes mining inspection, issuance of concession for quarring and exploration licensing. The Projects and Control Unit consists of a section dealing with geological missions, administration, financial and technical control. The Atomic Energy Department is composed of sections dealing with health physics, electronic engineering, nuclear engineering, nuclear chemistry, exploration for radio-active materials and reactors physics. Reporting directly to the deputy minister for mineral resources is the assistant deputy minister for mining who is assisted by the director for technical affairs and the director general of mineral resources. The director for technical affairs is responsible for two departments: the geological department and the technical services department. The geological department includes sections on petrology and mineralogy, geological mapping, geophysics, geochemistry and economic geology. The technical services department consists of chemical laboratories, computers, a library, telecommunication and transportation services. As to the director general, he assumes the responsibility of two main departments: the finance department and the general affairs department. The former department consists of sections dealing with tenders and purchases, warehouses for field equipment, chemicals and stationaries, accounting and auditing. The general affairs department consists of administrative and personnel matters.

Another independent institution which is directly contributing to the development of mineral resources in the Kingdom is the Centre for Applied Geology, a UNESCO/UNDP/Saudi government project, completed in 1970. It is mainly a post-graduate institution granting an M.Sc. degree in mineral exploration, hydrogeology and engineering geology. In addition to the Master's programme, the Centre for Applied Geology has 2 year geology technician training programme leading to a diploma.

The second group of countries consists of Kuwait, Bahrain, United Arab Emirates, and Lebanon. In these countries, the responsibility for mineral resources development is either spread between different ministries or is being dealt with by one ministry usually the ministry of industry and commerce. Until recently, the development of mineral resources in the United Arab Emirates was the individual responsibility of each Emirate separately. But after its independence in 1971 and the unity which was achieved between the Emirates with the formation of a central government, a Federal Ministry of Petroleum and Mineral Resources was established and a department concerned with mineral resources was founded in this ministry. While in the People's Democratic Republic of Yemen, a petroleum and mineral resources authority is assuming the responsibility of planning and undertaking mineral resources projects, no such authority yet exists in the Yemen Arab Republic.

However, work is underway in this country to establish a mineral resources authority and a draft organizational chart of the authority was already prepared and is being finalized. In O m a n , the Directorate General of Petroleum and Minerals in the Ministry of Agriculture, Fisheries, Petroleum and Minerals deals with mineral activities in the country. Up to January 1976, Oman did not have a geological and mineral survey department.

In general, it could be said that member countries have not until recently given enough importance to mineral resources development in the ECWA region. This situation is reflected sometimes in the lack of independent institutional and administrative machineries to manage, implement and follow up on mineral activities in the region. Although S a u d i A r a b i a , J o r d a n , S y r i a and I r a q are better equipped than the other member countries, they still need to improve on their existing authorities. The fields in which work and improvement are still needed are: establishment of new laboratories and acquisition of modern laboratory equipments, strengthening the geological survey department and existing geological libraries, expansion and organization of training programmes for nationals in geology, geophysics, mineral economics and other related fields. As to Kuwait and Bahrain, which are relatively less endowed with mineral resources, their governments did not find any real justification for the establishment of such administrative machineries to carry out mineral activities in these countries. In UAE, Oman and YAR, the problem is even more acute. The whole institutional setup needs to be established and in the case of YAR, both expertise and financing are needed to build up the required machinery, to plan, implement and supervise activities in the field of mineral resources.

Although PDRY has established an authority to deal with mineral resources, it still needs significant improvements from the administrative aspect, namely, the creation of specialized departments in the field of geology and mineral survey as well as the establishment of specialized laboratories. For both Yemens, financing comes up as a major obstacle to the development of mineral resources.

From some of the development plans of member countries, it is possible to depict the needs in the field of mineral resources and the direction in which mineral resources development in the ECWA region will be conducted in the coming five years.

The mineral resources activities in the new five year (1976-1980) development plan of Jordan are mainly directed towards the general prospecting of minerals, expansion of phosphate production from 1,200 million tons in 1975 to 7 million tons in 1980, the expansion of the cement production capacity at Fuheis from 1,700 tons per day to 3,700 tons per day over the plan period, the extraction of potash at a production capacity level of one million tons per year of potassium chloride (62% oxide), the production of copper through the construction of a pilot plant with an annual capacity of 3,000 tons per year and finally the construction of a sulphuric and phosphoric acid units and a fertilizer unit to produce triple super phosphate.

The ambitious five year (1976-1980) development plan of Saudi Arabia includes mineral resources projects concerned mainly with basic geology, mineral exploration, geophysics, strengthening of supporting services such as establishment of new and improvement of existing labs, drilling services, geochemical prospection, underground exploration, reorganization and strengthening of the Directorate General for Mineral Resources, and expansion of training programmes for new technical staff. While the part on basic geology mainly consists of geologic studies, the section of mineral exploration will deal with detailed investigations and evaluation on mineral prospects including uranium and iron ore, assessment of the **economic potentials** of phosphorite resources and preparation of studies to develop the economic potentials of marble and other ornamental stones.

In the People's Democratic Republic of Yemen, the projects in the field of mineral resources concentrate on geologic surveys of the country, establishment and acquisition of laboratories and laboratory equipment, aerial geophysical survey of the south-western region of the country and a training programme for locals. In Iraq, work in the field of mineral resources centers on geologic, geophysical and mineral surveys, preparation and classification of geological information, production of building material, glass sand for domestic industries, marble, sulphur and sulphuric acid, implementation of projects dealing with the production of phosphate and phosphate fertilizers, production of kaolin for the cement and paper industries and finally, the expansion of the production capacity of the sulphur mines. In both Kuwait and Bahrain, work is underway to increase the production of building material. In the United Arab Emirates, the department of mineral resources in the Ministry of Petroleum and Mineral Resources should have by now completed the mineral survey of the country.

A general evaluation of the mineral resources projects that are likely to be undertaken in the near future shows that the countries of the region are initiating mineral surveys of their territories. Furthermore, countries of the region have during the last five years made some progress in trying to identify their potential endowment of mineral resources. It is expected that work will continue at a faster rate in order to determine the availability of minerals and to start whenever economically feasible, the exploitation, production and processing of these minerals.

B. Mining Legislation

During the last decade, member countries of the ECWA region have to some extent recognized the need and importance of mining legislation for the development of their mineral resources. Countries like Saudi Arabia, Syria, Jordan, Oman, Lebanon and Iraq have comprehensive mining laws. Mining legislation in Bahrain, UAE and Kuwait is governed by contracts or agreements between the government on the one hand and individuals or mining companies on the other. New mining laws have recently been prepared for the two Yemens and were submitted to their respective governments. Under the Saudi mining code, reconnaissance permits, exploration licences, mining leases, treatment plants and transportation leases, permits for small scale mining quarrying leases or permits, materials permits are granted to individuals or bodies possessing corporate personality. With respect to the reconnaissance permits, the permit holder may take samples, use scientific devices and undertake any other work in the preliminary examination of potential mining lands. The reconnaissance permits is usually the first step before requesting an exploration licence or a mining lease, The permit holder is required to submit to the Ministry of Petroleum and Minerals a report on the results of the reconnaissance period which may last two years subject to extension if necessary. The Saudi law concerned with exploration licences, gives the licencee the right to use any practical exploration method within the area specified in the licence. However, the representative of the ministry can enter these areas and take any action he sees fit provided he does not hamper the licencee's operation. If the holder of an exploration licence discovers any exploitable mineral, he can, within the areas specified to him in the licence, be granted a mining lease. It should be noted that an exploration licence can be granted for an area not larger than 10,000 km^2 and for an initial duration of 5 years renewable for a maximum period of 4 years. The ministry reserves the right to ask for an initial deposit from the holder of an exploration permit specially when the areas in which the licencee is interested have already been studied by the government. The licencee will also have to abide by the conditions of the licence and in this respect, the government has the right to withdraw the licence if these conditions are not met. The holder of a mining lease has the right to exploit all or some of the minerals within the leased area. His financial obligations would be the payment of an income tax or the acceptance of a profit sharing agreement with the government. In this case, the government may ask the permit holder not less than 10 per cent and not more than 50 per cent of the net profits in addition to a surface rental estimated at not less than one thousand riyals and not more than ten thousand riyals per square kilometre. The state under one article of the mining code, has the right to participate in any exploration or mining company.

In I r a q , minerals are classified into four categories consisting of (1) radioactive material like uranium, radium etc., (2) precious minerals consisting of gold and silver and precious stones such as diamonds, (3) metallic minerals like iron and copper, and (4) non-metallic minerals like phosphate, sulphur, salt etc. The Iraqi mining laws specify the cases and places where mining is prohibited unless a permission is granted by some of the concerned ministries in the country. The President of the State Minerals Company issues the licence which specifies the territory covered by it and the obligations of the permit holder vis-a-vis the government. Furthermore, the mining company is expected to submit to the government a copy of its organizational chart and the names of its board of directors. The President of the State Minerals Company has the right, after securing the approval of the Council of Ministers, to issue a licence for limited areas for a period not exceeding 15 years renewable provided the extraction of minerals requires heavy investment amounting not less than 50 thousand Iraqi dinars, the exploitation of this mineral is of economic benefit to the country, the project is undertaken by a shareholding company in which the government can participate, and which is expected to be involved in related industries as well, and provided the surface rental agreed upon does not amount less than 25 I.D. per dunum per year. In other circumstances, the lease is usually granted for a period of 5 years renewable. It must be mentioned that the companies are exempted from the surface rental for an initial period of two years starting from the day of operation.

In addition to the surface rental, the obligations of the mining companies consist of a payment of 20 per cent of the value of the mineral extracted in the first two categories, valued at current prices and of a payment of 10 per cent of the value of the mineral extracted in the other two categories if the mineral is discovered at the surface and 5 per cent if the mineral is found underground. Other items in the Iraqi mining law set the conditions for which the permit holder needs to qualify when asking for a licence, describe the procedure to be followed in applying for a lease, regulate and limit the number of permits that one person or company can hold in a specific area, describe the conditions for renewing the permit, transfer of right or permit etc.

The Natural Resources Authority (NRA) of J o r d a n , an autonomous government body is responsible for devising policies to develop mineral resources, concluding contracts and applying the law governing the development of mineral resources in the Kingdom. Exploration and exploitation of minerals and rock materials are concluded through exploration permits, prospection licences and mining rights. These permits are granted to Jordanian citizens and companies. However, foreign companies can still apply for such permits and obtain them through special agreements with the Natural Resources Authority and upon the approval of the Council of Ministers. Like other mining laws, the Jordanian mining law prohibits exploration, prospection and mining activities in antiquity sites, holy places, forest, municipal and other similar areas etc. Exploration permits are granted upon the payment of appropriate fees and the approval of the Authority. The applicant is required to prove his technical qualification in geology or mining engineering and to reveal financial resources sufficient to carry out the project. The applicant should be over 25 years and possess no criminal record. If the holder of an exploration permit discovers minerals in commercially exploitable quantities, he will inform and register this discovery with the Vice-President of the Authority and will receive in return a certificate of discovery giving him priority over other interested parties for a 2 year mining permit.

The prospecting licences like exploration permits are awarded subject to some restrictions. However, the prospector licencee is allowed to make a more complete examination of the land than the holder of an exploration permit. In this connexion, the holder of a prospecting licence has the exclusive right to explore the area defined in his licence, to undertake topographical and geological surveys, to introduce equipment and open roads for prospection purposes. Finally, the licencee who holds a certificate of discovery may on application, receive an exploitation permit with the approval of the Council of Ministers of Jordan. The land covered by the exploitation permit should not be larger than 25 square kms. The duration of the permit is for 30 years renewable upon the approval of the Natural Resources Authority and the Council of Ministers. Application for the exploration permit should include topographical and geological maps of the area and estimates of the total amount of ore in the deposit and reports on the feasibility of extracting the mineral using the applicant's technical and financial capacities. Furthermore, the Natural Resources Authority requests field inspections, plans of prospective mining operations, financial and statistical reports. The Jordanian mining law has also a section devoted to safeguarding the environment, protecting the health and ensuring the safety of workers and engineers.

Legislative aspects of mineral resources development are governed by a mining and petroleum law in the Sultanate of Oman. The mining law consists of 5 chapters which cover the procedures and requirements for exploration and exploitation permits, for the conduct of mining operations in the Sultanate and the protection of labourers and environment. In order to avoid any ambiguity in defining the terms used in this law, the first chapter is mainly concerned with giving the accurate or government definitions of terms used. The second chapter consists of 6 articles all of which specify the entitlements of mining companies in undertaking exploration or mining activities in the Sultanate.

It should be mentioned that no person or company can undertake any exploration, exploitation, storage or trade activity before obtaining a permit from the Directorate of Petroleum and Mineral Resources. For those who have such a permit, they cannot build roads, bridges and houses, use water or any other natural resources for their mining activities unless they secure the prior approval of the Directorate. Applicants should submit to the Directorate copy of the agreement granted to them by other Sultani authorities, their names, addresses, date and place of birth and nationality, as well as guarantees which are deemed satisfactory to the Omani government as a compensation for any damage caused by operations undertaken by this company and for any sum of money which the applicant may pay the government under the Omani law. Furthermore, the Omani law like other mining laws prevents mining activities close to holy places, villages, and towns. Moreover, the permit holder cannot transfer or sell any of his right to others without securing the prior approval of the Sultan. All persons working for the operator or mining company shall be subject to all laws and regulations of the Sultanate applicable to that operator or mining company. The permit holders are required to maintain and preserve all books, records, documents and samples regarding their operations in the Sultanate. The government has the right to enter all territories within the Sultanate in order to inspect documents, records, samples of minerals and to test the facilities and equipments used in exploration, exploitation and storage activities. The permit holder is expected under a different article of the same law to inform the Directorate of Petroleum and Minerals within three days of its occurence of matters relating to the discovery of any mineral, injury to workers or property, abandonment or supervision of any operation, and the reasons behind such acts. The mining law of Oman has few articles (5) for the protection of labourers working for the operator. These articles touch upon the training, housing, education and health situation of labourers. The operator is responsible for all the operations of his labourers when these are doing the work requested by him. The same law devoted a chapter on protection of the environment and required the operator to take all the necessary measures to minimize the pollution of the air, water and lands of the Sultanate. If an operator is found to have caused any form of pollution as a result of lack of due diligence in the conduct of operations, he will be fined a maximum of three times the cost of restoration or three times the damage caused by his operations whichever is greater. Finally, it is the Directorate of Petroleum and Mineral Resources which is the responsible body to see that all the above mentioned rules and regulations governing the activities in the field of mineral resources development are observed and applied.

In S y r i a , legislative decree No. 133 of December 22, 1959, prohibits the granting of any concession for the development of mineral resources to any private individual or company, Syrian or foreign. All natural resources in Syria are the property of the people, and the State is the sole legal owner of these resources. Prior to 1964, and according to decree No. 133, Syrian resources were governed by mining law No. 7 of December 21, 1953, which regulated all metallic and non-metallic ores and all hydrocarbons. According to this law, three types of rights could be granted to Syrian nationals or to companies having offices in Syria. The first right consists of obtaining information on mineral resources without undertaking any drilling activity. The second right deals with the investigation of the land in detail using drilling and digging facilities with a view to determining the availability of mineral deposits and evaluating their reserves. The third right was granted in connexion with exploitation, storage and treatment of the minerals discovered.

At the present time, private individuals or companies can assist or undertake exploration and exploitation activities on the Syrian territory by signing an agreement with the Syrian government, the sole legal owner of all mineral resources of Syria, specifying the obligations and entitlements of the permit holder vis-a-vis the government.

The exploration and exploitation of solid minerals in L e b a n o n are regulated by decree No. 113/LR of 1936. Since then, licence fee have been revised upward by decree No. 7281 of August 7, 1961. The Chief of the Bureau of Mines in the Ministry of Planning regulates the granting of applications for exploration permits. Decree No. 113/LR classifies all minerals in seven categories: (1) precious metals, (2) metals and their ores, (3) nitrates, phosphates, borates and similar compounds, (4) coal, lignite, and other similar minerals, (5) asphalt and bitumen, (6) petroleum and gaseous hydrocarbons, and (7) all other minerals. The permits given by the Mines Section are of three types: exploration, exploitation and concession permits. The exploration licence is a transferable personal right limited only to the minerals specified in the licence. The duration of this licence is one year renewable for one year the first time and for 2 years the second time. The permit holder is permitted to do the necessary work for examining deposits but cannot sell the product of his prospecting without the approval of the Lebanese authorities. At this stage, the financial obligations of the permit holder consists of paying a 5 per cent tax of the total value of minerals extracted. The exploitation licence is granted prior to a concession licence where locations of deposits previously covered by the exploration licence need to be studied more carefully and where it is still too early to grant a concession licence. The exploitation licence is also a transferable right and can be extended twice, each time for 5 years. Extension of the licence can go beyond 10 years provided the duration of the licence does not exceed 25 years. In each period, the permit holder is expected to extract a certain quantity of the minerals. The concession permit is valid for 75 years and can be renewed for an additional period of 25 years. The obligations of the permit holders of exploitation licences and concessions consist of an annual area tax of 5 L.P. ($ 1.70) per hectar, with an annual minimum of 225 L.P. ($ 75) and a royalty of 5 per cent of the value of the extracted product valued at the place of extraction.

In People's Democratic Republic of Yemen, mining law No. 17 of 1968 asserts that all minerals and quarry materials in the republic are owned by the State. Exploration and search permits as well as exploitation deeds are granted by the government. The holder of an exploration permit is expected to put in writing any discovery of minerals raw material and report it to the Oil and Mineral Resources Authority. Search permits are granted to the discoverer if he applies within three months of writing his report on the discovery of minerals in a specific area. This permit would allow him to investigate the mineral deposits in order to evaluate their reserves and the feasibility of exploiting them. The duration of this permit is for one year renewable. When the search permit holder proves the existence of a particular mineral in a specific area, the President of the Republic can, if he so wishes, grant exploitation deeds for a period not exceeding 30 years. The exploitation deed will contain the conditions under which this right is granted: limitation of area, payment of rent, taxes in kind, cash or both, and other obligations of the permit holder. The operator may use any mineral material such as stones, gravel etc.

in connexion with his mining activities but cannot sell or give these materials to other persons without the approval of the authorities.

In the case of radioactive materials, the operator is expected to inform the Yemeni authorities within 14 days of the discovery of such materials and to refrain from undertaking any activity in connexion with these minerals until he is notified by the government to resume his work. He may, however, resume work if the authorities do not notify him within 60 days from his written notice. The Y e m e n A r a b R e p u b l i c does not have classified petroleum and mining laws. Some of the activities undertaken in this field are usually carried out through bilateral agreements between the Yemen Arab Republic and other countries, such as the agreement which was signed in 1969 between the Algerian State Agencies Sonatrach and Sonarem, and the Yemeni government on a 50-50 exploratory oil concession covering an area of 15,000 square kilometres. It should be mentioned in this connexion that a new petroleum and mining law was prepared for the two Yemens by a consultant in August 1975. The new mining law consists of 58 articles covering and regulating all stages and aspects of mineral resources development.

K u w a i t , B a h r a i n , Q a t a r and the U n i t e d A r a b E m i r a t e s do not have comprehensive laws regulating mining activities in these countries. Concessions to explore and exploit the mineral deposits in these countries are granted after direct negotiations between applicants and the governments of these countries. In Kuwait, for instance, an application form for the exploitation of building materials including sand and gravel is accompanied by an attachment specifying the rules, obligations and entitlements of exploiters. These applications have to be completed and submitted to the Ministry of Commerce and Industry for approval. After securing the approval of the Kuwaiti authorities, the permit holder will exploit the minerals subject to the articles and conditions attached to the application form.

It is clear from all the above that mining legislation needs to be developed and improved in the countries of the ECWA region. Legislation including environment control and safety measures is a necessary condition for the development of mineral resources in the region. Due to the importance of this subject, it is expected that a detailed and comprehensive report on appraisal of existing mining codes will be prepared before the end of 1978 and sent to member countries for their consideration. In addition, the ECWA secretariat is seriously considering the possibility of appointing a regional adviser in the field of mining and oil legislation to respond to requests of member countries in this important and vital area of mineral resources development.

CHAPTER III. REGIONAL CO-OPERATION IN THE DEVELOPMENT OF MINERAL RESOURCES

Countries of the ECWA region have realized the need for a regional approach to mineral resources development. In some cases, work in this field becomes only feasible or easier if concrete and well defined means of c-operation between the countries of the region are worked out and applied. The modalities of co-operation would have to be clear, realistic and concerned directly with the needs of member countries in this field. In this respect, exchange of technical and economic information on mineral resources development, existing and planned mineral exploration activities, deposits, reserves, available technical and economic data, mining, marketing and processing of minerals needs to be conducted and encouraged for a better assessment of the mineral potential of the ECWA region. In addition, exchange of experience between member countries on the development of specific minerals is extremely useful in view of the similarity in the characteristics of some mineral ores and deposits in these countries as well as in their methods of exploration and exploitation. This exchange of information and experience would have to take place through institutional setups which can only be established with the full co-operation of member countries in the ECWA region. It should be mentioned in this nonnexion that no machinery yet exists in the Arab worl whcih can facilitate the exchange of information on mineral resources. However, this subject was recently raised and discussed in a number of meetings and conferences on mineral resources in the Arab countries.

The conference of Ministers of Arab States responsible for the application of science and technology to development, CASTARAB meeting, (16-25 August 1976), recommended to the organizers of the third Arab Conference on Mineral Resources the creation of an Arab centre for geological documentation and information. This centre is expected to provide Arab countries with information and documentation on mineral resources in the Arab World and establish a network of centres and points of contact in the Arab countries to facilitate the exchange of such information between the centre and these countries. The centre will operate according to the most modern and up-to-date electronic processes. Establishment of this centre will be the first and basic regional activity that the Arab region, as a whole, and the countries of Western Asia in particular, will find useful and helpful in the assessment and development, of their mineral resources. Closely related to this centre is the support received from several delegates in this Conference concerning the establishment of a geological data bank for the Arab world. This project will provide Arab countries with a mechanism through which collection and updating of information on a wide range of subjects including geological investigation processing, trade, and utilization of metallic and non-metallic minerals can be carried out. The operation of this bank is expected to contribute to a better assessment of mineral resources in the region, and to facilitate the implementation of regional and sub-regional projects in this field. Furthermore, the proposed Arab Data Bank which is entrusted with the task of collecting, storing and processing information on mineral resources in the Arab world, will supply Member States with up-to-date information in this field and provide regional organizations with some guidelines on the ways and areas in which regional co-operation should be conducted and promoted. The work of this bank will be accomplished through regular extraction of data from geological surveys, technical and economic reports, through compilation of obtained data, evaluation of reserves and quality of their mineral ores, studying possibilities for additional exploration in some areas and identifying areas for field surveys.

Finally, ECWA is in the process of studying the feasibility of establishing a documentation centre for the Arab world to cover many fields including the field of mineral resources. This centre will deal with various fields including mineral resources, and will accordingly be of a multidisciplinary nature. The documentation centre at ECWA will constitute a regional mechanism through which information on minerals and other subjects in the ECWA region can be located and exchanged for a better understanding of the mineral and economic situation in Western Asia.

Another regional activity which is very demanding in terms of professional skill and financing but which is expected to contribute to a better assessment of the mineral resources of the region is the compilation of a geological map for the Arab region. Due to the importance of this project and its regional nature, preparation of this map will require the co-operation of all countries concerned.

The geological map of the Arab world is an important and much needed instrument for the preparation of exploration programmes in the region. It is, therefore, a project of first priority which was previously recommended by the first and second Arab conferences on mineral resources, the Conference of the Union of Arab Geologists and the CASTARAB meeting. The machinery which was suggested by UNESCO at this meeting, for undertaking this activity consists of a secretariat which will be entrusted with the task of collecting the information from national geologic surveys and maps and of compiling it in a regional geological map for the Arab World.

The co-operation of participating countries would be reflected in their submissions to the secretariat of all requested geological maps, survey reports, and other statistical and technical data as deemed necessary. These submissions would have to be continuous and regular in order to facilitate the up-dating of geological information on the region.

The suggested scale of the geological map for the Arab region would be 1/1,000,000 or 1/1,500,000. Co-operation will be ensured between the secretariat of the geological map for the Arab world on the one hand, and the International Union of Geological Sciences, the Federation of Arab Geologists and ALECSO on the other. The CASTARAB meeting has also recommended to the Arab States to study the feasibility of establishing <u>regional specialized centres</u> to undertake applied studies with the co-operation of universities, United Nations agencies, ALECSO and other regional Arab organizations. Following the establishment of a geological documentation centres could contribute to a better evaluation of the mineral resources endowment of the region through concrete and applied studies and research in the field of mineral resources, using up-to-date information supplied by the documentation centre and the geological data bank. These pre-investment activitires would provide member countries with guidance and information on prospecting, exploration and mining activities in the region.

For the proper undertaking of pre-investment and investment activities in the field of mineral resources, member countries expressed on different occasions and meetings and, in particular, in the Second Arab Conference on Mineral Resources (Jeddah, November 1974) and in the CASTARAB meeting, Rabat, (16-25 August 1976) their desire, need and support for the formation of <u>adequate cadres</u> able to undertake and cnduct geologic and mining activities in the region. These cadres would also train specialists and technical assistants in various branches of geology. Establishment of new training centres was, therefore, recommended and strengthening of existing ones such as the Centre for Applied Geology in Jeddah was stressed and supported.

The CASTARAB meeting encouraged also Arab universities and research institutions to develop programmes for field work and training to give the students a background of and some practical field experience in the geology of the Arab world. Establishment of regional training centres is one solution to the problems of many Arab countries deficient in skilled and semi-skilled manpower in the field of mineral resources.

The Second Arab Conference on Mineral Resources recommended the establishment of a mineral centre for intermediate and technical training in the processing of phosphates, showed importance and interest in having two vocational training centres, in addition to field training in the Arab world, recommended the enlargement of the specialized centre for intermediate vocational training in Morocco with a view to making it a regional centre and finally supported the establishment of a specialized centre for intermediate technical training in one of the states in the Arab Peninsula for the various mineral activities of the region.

Furthermore, the secretariat of ECWA will be undertaking a study on short and long-term requirements for skilled manpower in the mineral resources sector in the ECWA region. Upon the completion of this study and after exploring the need of member countries for an institution of research and training in the field of minerals, and taking into consideration present and planned training centres and institutions in the region, ECWA may, if the need still exists, consider establishing such an institute to fulfil the manpower requirements of the region in the field of mineral resources. Co-ordination and co-operation with the Arab Labour Organization (ALO), UNESCO, ALECSO, IDCAS, the Centre for Applied Geology in Jeddah and other training centres will be sought in order to avoid any duplication of work in this field.

In anticipation of various mineral activities in the Arab world, and in view of the importance and priority given to mineral resources development by the participating countries at the Second Arab Conference on Mineral Resources, the Conference recommended the establishment of an organization within IDCAS whose task would be to co-ordinate and follow up Arab activities in the field of mineral resources development, issue periodicals and prepare seminars.

The proper functioning of this organization will help to avoid overlapping of mineral activities in the Arab region, ensure some sort of co-ordination between these activities in the region, hence contributing to a better planning and policy formulation of mineral resources development in the Arab countries.

There is no doubt that the development of mineral resources in the ECWA region requires huge financing which is sometimes beyond the financial means of some countries in the region. Geological survey and exploration are very much demanding in terms of financing and professional skill and may or may not result in any mineral discovery. Yet these activities are necessary in order to locate new mineral deposits. Some countries of the region can afford this huge financing and others are not in a position to allocate large funds for the development of this sector. Furthermore, some deposits with proven reserves in the region have been located and further studies need to be done to find out whether they are economically exploitable. In addition, some countries may in the near future discover exploitable deposits but cannot undertake any mining activity due to shortage of funds. From this perspective, regional co-operation is viewed as a means to assist the needy countries of the region in developing their mineral resources which may result in additiona mineral discoveries with direct benefit to these countries and beneficial spill-over effects to the other countries of the region. Financing, in this connexion can, at this stage, be directed mainly to activities pertaining to geological surveys of the region prospecting exploration, and exploitation of minerals. In some cases, however, financing is and may also be needed in the processing of some kinds of minerals. The Second Arab Conference on Mineral Resources recommended for this purpose to increase the capital of the Arab Fund forEconomic and Social Development and that part of this increase be used for financing mining activities in the Arab countries and the other part to assist the least developed countries of the region in financing exploration works and feasibility studies.

Besides the Arab Fund for Economic and Social Development, the Arab Mining Company which was established in Jordan following the decision of the Council of Arab Economic Unity during its ordinary twenty third session in June 1974, is expected to play an important role in and contribute to the exchange of studies, participation in meetings and conferences and consultation on various aspects of mineral resources development.

The Natural Resources, Science and Technology Division of the ECWA secretariat is responsible for implementing regional projects in the field of mineral resources. The (1976-1977) work programme and the draft (1978-1979) programme budget in mineral resources consist of projects aimed at promoting regional co-operation in this field. Activities of the secretariat in this field cover all aspects of mineral resources development including the geological, economic, legislative, manpower and technical aspects. The projects concerned with mineral supply and demand projections, economic aspects of mineral resources exploration and processing in the region, identification and promotion of investment in mineral resources development at the national and regional levels, regional and interregional co-operation in the development of mineral resources, appraisal of existing mining codes, strengthening organizational and administrative institutions in the field of mineral resources, and economic analyses of the development and uses of non-metallic raw materials in the region, will be implemented with the co-operation of member countries and regional organizations. The ECWA secretariat is also organizing a meeting in 1979 on regional policies and co-operation in the field of mineral resources development.

The implementation and completion of these activities are expected to contribute to and widen the scope of regional economic and technical co-operation in the field of mineral resources.

As was outlined above, for regional co-operation to be effective and for it to contribute to the development of mineral resources in the region, a willingness and readiness of all countries to co-operate and implement procedures agreed upon need to be stressed. As to the modalities of such co-operation, they consist first of the specific areas where such co-operation is needed or desirable and second of the mechanisms through which regional and interregional co-operation will be conducted, maintained and furthered. It is hoped that the various machineries that are operating, and are likely to be established in the future will contribute effectively to the development of mineral resources in the region and will assist, in particular, the least developed countries in undertaking some vital activities in this field.

CHAPTER IV. CONCLUSIONS AND RECOMMENDATIONS

A. Summary

The report reviewed in a concise manner some development aspects of mineral resources and its related industries, in the countries of the ECWA region. The findings of this survey partly explain the economic significance and importance of developing the mineral resources (other than oil and gas) of the region taking into consideration the following factors:

(1) For some countries of the region with a limited development potential in the industrial and agricultural sectors, exploitation and development of mineral resources could play a major role in their economic development;

(2) For most of the oil-producing countries of the region, the economy of which is mainly dependent on oil and gas, exploitation of other mineral resources constitutes an important means of economic diversification and an important factor in establishing a solid economic structure;

(3) Most of the demand for mineral raw materials for construction and industrial purposes, is met by imports, the resulting import bill draws heavily on the foreign exchange reserves of member countries and contributes to a deterioration in their balance of payments. The self-sufficiency problem in this field would be less acute and the economic cost less important if the mineral resources sector of these countries were adequately developed;

(4) The development and utilization of mineral resources in the ECWA countries offer possibilities for strengthening economic and technical co-operation among member states and between them and other countries. Unfortunately, the present situation in the field of mineral resources (other than oil and gas) in the ECWA region is not encouraging. Among all kinds of metallic mineral raw materials, only copper is going to be mined in some coming years in Oman and Jordan. Despite the existence of ferrous industry in a number of countries in the region, all metallurgical plants still depend in their production on imported iron ore concentrates. Furthermore, the aluminium industry established in some countries of the Arabian Gulf is completely dependent on imported bauxite. The demand for all kinds of metals is therefore met by imports of mineral raw materials, semi-manufactured and manufactured products.

financing and undertaking of mineral activities pertaining to exploration, extraction, processing, transportation and manufacturing in the Arab region.

The head office of this company is in Amman, and it will operate like any other commercial firm. Shareholders of this company consist of 12 members: the Hashemite Kingdom of Jordan, the United Arab Emirates, the Kingdom of Saudi Arabia, the Syrian Arab Republic, the Republic of Iraq, the Kuwaiti Foreign Trading and Contracting Investment Company S.A.K. in the state of Kuwait, the Yemen Arab Republic, the People's Democratic Republic of Yemen (all ECWA countries); the Democratic Republic of Somalia, the Arab Republic of Egypt and the Socialist People's Libyan Arab Jamahiriya.

The capital of this company is one hundred and twenty million K.D. divided into twelve thousand shares and distributed unequally among its members. The Company is managed by a board of directors (10-12 members), out of which a chairman and a deputy chairman are elected. Whenever the need arises, or exigencies of work require, the company is authorized to open branches or sub-offices, and establish or participate in the establishment of other companies in different countries. The term of this company has been fixed for an initial period of 50 years renewable.

This company is expected to undertake all operations related to exploration for minerals, to conduct technical studies on mineral deposits with a view to determining the feasibility of exploiting them; to carry out all the work necessary for mining operations such as construction of roads, bridges and railways; to undertake treatment of exploited deposits including concentration, refining, and melting; to perform operations concerned with transportation and marketing of minerals; and to establish training and mining research centres. The Company has recently started its operations by contributing 40 per cent to the Arab Potash Company's capital of 40 million J.D. which will enable the Potash Company to implement the Dead Sea Potash Project. Furthermore, the General Assembly of the Arab Mining Company is expected to enter into negotiation with the Omani authorities to decide on the company's share in a copper project in Oman.

The Arab Mining Company can be a useful instrument for accelerating the development of mineral resources in the region and for assisting the Arba countries in undertaking projects in this field.

On the other hand, and in order to further technical and economic co-operation among member c untries of the ECWA region, the ECWA secretariat has been studying for the last two years the need for an possibility of establishing a mineral resources development council which will be entrusted with the task of identifying priorities, selecting projects, formulating policies and discussing technical and economic problems in the field of mineral resources. This mechanism could bring together policy makers and technical experts fr m member countries in this field to discuss and evaluate the mineral activities and situation in the region and to take whatever action is needed in this respect.

Furthermore, the council would organize technical seminars on specific minerals with a view to giving member contries the possibility of exchanging among themselves information, experience, and views on some technical problems related to some minerals. In addition, the council may invite experts from different regions to meet with experts from the ECWA region to exchange ideas and experience on problems concerning the different stages of mineral resources development. It is hoped that this council would further technical and economic co-operation in the region and would contribute to a better assessment of, and policy formulation for the development of mineral resources.[1/]

Co-operation between ECWA and regional organizations concerned with mineral resources development will continue and expand. The Natural Resources Science and Technology Division of ECWA established contacts with the Council of Arab Economic Unity, IDCAS, the Centre for Applied Geology with a view to co-ordinating activities in the field of mineral resources, exchanging ideas and discussing projects in this field. Co-operation would also be maintained and enhanced with United Nations regional and international organizations such as UNESCO, the Office for Technical Co-operation, the United Nations Development Programme and the other regional commissions. In addition to the major activities previously mentioned, co-operation between ECWA on the one hand, UN and Arab regional organizations on the other will also include joint undertaking and programming of projects,

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1/ For further details on this council, see part C of Chapter IV.

A much more favourable situation prevails in the field of non-metallic mineral raw materials. The most important of them is phosphate located in Iraq, Syria, Jordan and Saudi Arabia, constituting with varying degrees an important export item of most of these countries. The most important chemical raw materials in the region are represented by sulphur (Iraq), soda, potassium, rock salts currently and/or expected to be mined in many countries of the region. The largest deposits of salts are in the Dead Sea (Jordan) and in Salif (Y.A.R.).

The availability of some mineral raw materials in most countries of the region contributed to the intensive development of the cement industry during the last few years.

Furthermore, building stones, marble and gypsum are unevenly spread in the region and a number of countries are suffering from acute shortages of these minerals most of which are imported.

B. Policy Options

The formulation of ECWA's policy in mineral resources development stems from the situation prevailing in that field in the region and is based on the following main facts:

(i) The acute shortage or absence of economically important sources of solid mineral materials on the one hand and the existence of a number of promising areas for mineral resources on the other hand.

(ii) Lack of adequate and comprehensive study on the mineral resources of the ECWA region and the absence of unified world technical documentation required for undertaking such a study and carrying regional projections as well as planning in the mineral resources field.

(iii) Absence or acute shortage of techniques and equipment for geological exploration and investigation in most countries of the ECWA region.

(iv) Lack of qualified and trained personnel in national authorities responsible for the development of mineral resources.

(v) Slow progress in equipping the concerned authorities with modern techniques, transferring advanced know-how and applying scientific achievements in the mineral resources area.

(vi) Lack of technological, economic and statistical information on various aspects of mineral resources in the world in general and the ECWA region in particular, resulted in adverse effects on the activities of the national geological surveys and prevented an improvement in the staff's career development.

(vii) Weak technical and economic co-operation among member countries emanating from the sensitive nature of the mineral resources field and the strong feeling of these countries on the issue of national sovereignity and therefore on the strict confidentiality of information in this field.

Accordingly, priority should be given to pre-investment activities and together with the creation of the regional machineries as opposed to the work which is related to investments.

1. Pre-investment activities and establishment of the regional machineries for development of mineral resources

This field of work requires great expenditures and cannot be directly profitable. Financial and technical assistance provided by international and regional organizations to the least developed countries of the region as well as their contributions in the creation of the regional network which could provide economic, technical, financial and other co-operation to meet the key problems related to development of mineral resources in the ECWA region.

The work mentioned above should be shared between various United Nations agencies particularly ECWA and UNDP in the United Nations system and other concerned regional Arab organizations.

One of the important aspects of pre-investment activities are the organization of, and advisory services to regional geological investigations in the region. These activities include the following items:

(i) regional geological, geophysical and other investigations for mineral resources in the promising areas of Western Asia;

(ii) compilation of geological, structural, tectonic, paleogeological and other specialized maps;

(iii) inventorization of mineral resources in the region;

(iv) depending on the results of the work achieved under (i), (ii) and (iii), and using the results of previous studies and analysis, compilation of regional metallogenic prognostic maps should be carried out. These activities will make regional exploration work on a regular and scientific basis possible and efficient.

The idea of compiling a regional (Arab region) geological map was a subject of many resolutions, recommendations and decisions taken by competent bodies at various meetings such as the Arab Conference on Mineral Resources, the Conference of Ministers of Arab States responsible for the Application of Science and Technology to Development (CASTARAB), the meeting of the Union of Arab Geologists. In October last year the Technical Committee on the geological map for Arab region was established under ALECSO.

It should be mentioned also, that the Economic and Social Commission for Asia and the Pacific provides and supervises geological and geophysical investigations in the ESCAP region in co-operation with UNESCO and member states.

ECWA's initiative in this field consists of studying the possibility of establishing specialized bodies that can assist in removing some of the obstacles facing the development of mineral resources in the ECWA region.

In this connection, the Secretariat of ECWA investigated, through field missions, late in 1975 the possibility of establishing a regional mineral resources development council. The council was then thought of as a policy making organ for the ECWA region in the field of mineral resources development. The idea will not be pursued further by the Secretariat in view of the resolution of the third Arab Conference on Mineral Resources (Rabat, 15-20 April 1977) to establish an Arab Organization for

Mineral Resources Development. The responsibilities, functions and activities of this organization are to a large extent similar to those of the above-mentioned council. In view of this fact and noticing that the territorial coverage of the Arab organization is wider than ECWA's proposed council and in order to avoid duplication of efforts between two organizations serving the same region in the field of mineral resources, the ECWA Secretariat, as mentioned above, will not, at the present time, take any further steps towards the establishment of the council. However, close co-operation and co-ordination between the ECWA Secretariat and the recently established Arab Organizations would have to be clearly spelled out and regular contacts and exchange of views on various activities in this field would have to be initiated, maintained and strengthened.

Furthermore, ECWA will continue to study the possibility of establishing the following bodies:

(a) Systems of information exchange in mineral resources

Preparation of this report faced serious difficulties because of lack of information on mineral resources in the region. The establishment of a system for the exchange of technical, economic and statistical information among member countries and between them and ECWA, is urgently needed. In addition to facilitating the implementation of ECWA's work programme, the system of information exchange will serve the following main tasks:

- to inform authorities of member countries and specialists involved in various fields of mineral resources development about aspects pertaining to the situation in mineral resources at the national, regional and international levels, including exploration, mining, processing, manufacturing and trade of minerals;
- to promote the use and application of new methods and up-to-date technology regarding the development of mineral resources in the ECWA region.
- to contribute substantively and regularly to the education, knowledge and experience of local mining engineers, geologists and other technicians of member countries through their easy access to recent periodicals, papers and documents in the field of mineral resources.

Promoting the exchange of information was the subject matter of General Assembly's resolution 3507 (XXX) and following resolutions. Furthermore, the CASTARAB meeting recommended the creation of an Arab Centre for geological documentation and information. In this connection, mentioned should be made of the survey of information facilities in the Arab countries, completed by the ECWA Secretariat in preparation for the establishment of a documentation centre for the Arab world - the feasibility study for establishing this centre is expected to be completed in 1978. In the event the Arab documentation centre will be established, a suggestion can be made to have the proposed Arab Centre for geological documentation and information as part of ECWA's documentation centre. ECWA's initiative in this respect would avoid duplication and ensure co-ordination of work between ECWA, UNESCO and other concerned regional Arab bodies.

Prior to the establishment and operation of this Centre, the creation of an information section on mineral resources within the ECWA library can deal with the exchange of information on mineral resources in the ECWA region.

(b) Regional Training Centre

The first step in this direction consists of assessing the regional requirements of specialists in various occupations and levels in the field of mineral resources up to year 1990. Close co-operation between ECWA and the mineral resources authorities of member countries will be necessary for the implementation of this project.

ECWA has initiated the study through collection of information on the subject. The key information is expected to be supplied by the national authorities concerned. For this purpose a detailed questionnaire was worked out and sent to the member countries. Following the completion of that report and depending on its findings, a feasibility study concerning the establishment of training facilities or Centre may be initiated in co-operation with relevant UN and Arab organizations, in particular UNESCO and the Arab Labour Organization.

(c) Regional Laboratory

The proposed laboratory services are designed to serve mineral and also water exploration and development activities on the regional and sub-regional levels. They should comprise laboratory facilities which require highly specialized expertise and instrumental outfit. Such facilities are very expensive and therefore can only be afforded by rich and developed countries; also the amount of analytical work required has to be large enough to make the establishment and running of such a laboratory economically feasible. It should be mentioned at the same time that a larger scale of operation makes the analytical work cheaper. These are the reasons that put such a laboratory beyond the reach of most developing countries and which make this proposal attractive as a regional project. The other functions of the laboratory activity, in which the member countries are likely to be vitally interested, are expert services, on-the-job training of the national laboratory staff, occasional supervision as requested of those laboratories, calibration and maintenance of equipment. In addition, laboratory work could be equipped with a workshop for precision and electronic repairs of geophysical and geochemical tools from the national geological surveys.

The financial responsibility for setting up and operating of the regional laboratory would formally be of the governments being parties to the agreement. It can, however, be reasonably accepted that considerable donations would be granted, initially and extended in a longer run by various international, Arab and national organizations and agencies.

It should be pointed out that the establishment of the regional laboratory will be initiated by ECWA but will eventually be independent from it. Contacts with the new Arab Organizations for mineral resources will be made with a view to investigating the possibility of delegating the responsibility of the management and functioning of this institution to the afore-mentioned Arab Organization.

2. Investment activities:

ECWA should support in close co-operation and co-ordination with the Arab Mining Company, development and exploitation of primary mineral deposits in the member countries and in the region as a whole.

Shortage of mineral raw materials in some countries of the region on the one hand and the existence of unexploited primary deposits in some other countries on the other hand, create a favourable situation for economic and technical co-operation among member countries leading possibly to the establishment of joint mining enterprises. As a first step, such co-operation could be envisaged in the mining of marble and other building stones with a view to supplying countries situated in the northern part of the Arabian Gulf with these minerals. If this co-operative effort turns out to be successful, it could be enlarged to include other minerals, hence widening the scope of co-operation.

APPENDIX I

Mineral deposits and the most valuable occurrences in the ECWA region

(Metallic Raw Materials)

Countries, mineral deposits and occurrences	Deposits of commercial value				Non-Commercial value	Mineralization with no clear economic value	Note
	except-	large	medium	small			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IRON ORE						
Saudi Arabia*							
(i) Jabal Idsas				////// //?///		//////// ////////	In process of exploration
(ii) Wadi Fatimah							Low-grade, difficult for concentration
(iii) Wadi Sawawin				///// //?///		//////// ////////	High phosphorous conte & difficult to concent ate, under exploration
Syria							
(i) Alamdar					////// //////		Deposits are not of commercial value because of low grade of Fe, small reserves and transporatation for a long distance.
(ii) Kadmous					////// //////		
(iii) Kerry					////// //////		
(iv) Rajou					/////// ///////		
(v) Zabadani					////// //////		
Iraq							
(i) Darabandah					/////// //////		Low grade and small reserves
(ii) Husseinieh					////// //////		Low grade, high cost of underground mining transportation proble
(iii) Isnawa					////// //////		Small reserves
(iv) Kafrah					////// //////		High grade
(v) Mishow						//////// ////////	

* There are about 25 more iron ore occurrences, some of them are under exploration.

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Mineral deposits and the most valuable occurrences in the ECWA region (cont'd)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Jordan							
(i) Burma (Ajloun Distr.)					//////		Small reserves
(ii) Shoeib region					//////		Too high SiO_2 content, small reserves
Lebanon*							
(i) Dahr el Baidar					//////		Locally used
(ii) Fnaidek					//////		small reserves
(iii) Saida region					//////		
PDRY							
(i) Upper Yaffa						///////	High iron grade reserves are not accounted
(ii) Wadi Halwal			////// ????			///////	Promising deposit, has not been studied yet
YAR							
(i) Sa'dah						///////	The deposit has not been studied yet
MANGANESE ORE							
Jordan							
(i) Wadi Dana				////// ??		///////	
Syria							
(i) Bassit Area					//////		Old workings, deposits largely or entirely worked out.
Oman							
(i) Ras Al Hadd						///////	No information available
UAE							
(i) Asimah						///////	Further studying is required
(ii) Wadi Hatta						///////	
Saudi Arabia							
(i) Wadi Bidah						///////	Deposit has not been studied yet.

* About 10 more other occurrences with no economic value.

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PDRY	T I T A	N I U	M	O R E			
(i) Mukeyras						//////////	Titanomagnetite. Under study
(ii) Moura						////////////	Under study, ore contains also Ni, Cr Va
(iii) Sifal						///////////	Beach sand, containing Zr, Rutile, Under study.
(iv) Raydat						////////////	Beach sand, containing Zr, Rutile, Under study.
(v) Sayhut						//////////////	Beach sand, containing Zr, Rutile, Under study.
(vi) Al Chaydah						//////////////	Small reserves
(vii) Kishn						/////////////	Small reserves
(viii) Western sea shore area						/////////////	Small reserves
Oman	C H R	O M	I U	M	O R	E	
Farfar Area (i) Farfar I				////////////		////////////	May be worked after additional exploitation
(ii) Farfar II					//////////////		Low grade
(iii) Farfar III					//////////////		Small reserves
(iv) Farfar IV					/////////////		Small reserves
(v) Farfar V					//////////////		Low grade Cr_2O_3, high grade of Silica and magnesium
(vi) Jinah					//////////////		High grade ore, too little reserves.
(vii) Wadi Ajran					//////////////		Small reserves
UAE							
(i) Masfut-Manama area						//////////////	Number of occurrences ha not been evaluated yet.
(ii) East & west beach coast sands						//////////////	
Saudi Arabia							
(i) Northern Hijaz area						//////////////	Small reserves
Syria							
(i) Zetounjig (Bassit area)						//////////////	Small reserves

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	C O P	P E R	O R	E			
Saudi Arabia							
(i) Jabal Sayid				/////// ////////			Not exploited. It was supposed that total reserves can be more than 40 million.
(ii) Nuqrah North				///???// //////////		//////// ////////	Very high value of ore, reserves are limited
(iii) Nuqrah South				///???// //////////		//////// ////////	
(iv) Rabathan (Wadi Bidah district)						//////// ////////	Limited reserves.
(v) Gehab (W. Bidah district)						//////// ////////	Limited reserves.
(vi) Sha'ab Eltara W. Bidah district)						//////// ///////	Low-grade ore & limited reserves
(vii) As S'afra						//////// ///////	Further exploration needed.
(viii) Jadmah						//////// ////////	Middle-grade ore reserves are limited.
(ix) Umm ad Damar						//////// ////////	Further exploratic. needed.
Oman							
(i) Sohar			///// /////				Mining in 1978 & later smelting will be initiated with rate of 20,000 of copper p/y .
(ii) Tawi Ubaylah					////// //////		Small reserves, low grade.
(iii) Wadi Aw'al-Wadi Laqere area					/////// ///////		Small reserves, low grade.
(iv) Luzuq						//////// ///////	Reserves are not clear, Cu content is rather high.
(v) Mizqa						//////// ////////	
Jordan							
(i) Abu Khashabia			///// /////				Both those deposits are planned to be put under mining during Five-Year Plan period.
(ii) Fenan			////// //////				

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	C O	P P	E R	O	R E	(CONT'D)	
YAR (i) Al-Hamoura						////// //////	Further studying is required
(ii) Mazabi-Shakat						////// //////	Further studying is required
PDRY (i) Wadi Dahi						////// //////	Further investigations are planned
(ii) Wadi Ghabar						////// //////	Under investigation
Syria (i) Al-Bayda						////// //////	Under exploration
(ii) Rahed						////// //////	Under exploration
(iii) Gollan Heights						////// //////	Occupied territory
		LEAD	AND	ZINC	ORES		
Saudi Arabia * (i) Al Amar					////// //////		Small reserves and low grade
(ii) Jabal Dhaylan					////// //////		Very promising area for Pb-Zn
(iii) Samrah				///// /////		///// /////	Small reserves semi-commercial.
		N I	C K E	L	O R	E	
Saudi Arabia (i) Wadi Qatan				??? ///// ????		////// /////	Under investigation, may be of economic value.
		GOLD	AND	SILVER	ORES		
Saudi Arabia (i) Nuqrah South (Ag)[a]				///// ?????		///// //////	High value complex ore, limited reserves.
(ii) Samrah				////// ?????		////// //////	Semi-commercial deposit, small reserves
(iii) Mahd adh Dhahad				//// ????		////// //////	Under exploration

[a] See also South and North Nuqrah deposits in "Copper".

? High probability to be of commercial value.

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Mineral deposits and the most valuable occurrences in the ECWA region (cont'd)

(Non-metallic Raw Materials)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PHOSPHATE						
Iraq							
Akashat area	//////						Evaluation is based on total reserves in the area
(i) Akashat deposit		//////					Under mining
Jordan							
(i) El Hasa-El-Qatrana			//////				Under mining
(ii) El Ruseifa-El Zarqa			//////				Under mining
Syria							
(i) Kneifiss				//////			
(ii) Sharkieh "A"			//////				Under mining?
(iii) Sharkieh "B"			//////				Under mining?
(iv) Erkheime			//////				
(v) Mezeraa						//////	
(vi) Chadir El-Kamal						//////	
(vii) Taraq el Hibri and Bir Sejri areas		///??///					In the process of geological research
(viii) Tell Om Ad-Darrabiyeh						//////	
(ix) Abtar area						//////	
(x) Baida area						//////	Areas under exploration
(xi) Hefeh area						//////	
Saudi Arabia							
(i) Thaniyat			///??///			//////	Beneficiation problem, too thick overburden, water problem. Deposits are under study.
(ii) Turayf		///??///				//////	

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lebanon							
(i) Ain Fjour					///////		High grade of P_2O_5, reserves are limited.
(ii) Rachaya					///////		
(iii) Qaraoun					///////		
	SULPHUR						
Iraq							
(i) Mishraq (native S)	///////						Under operation
(ii) Mosul region (native S)	///////						Under operation
Saudi Arabia							
(i) Wadi Wassat						///////	Pyrite ores, located in remote areas
(ii) Adhbat-Katan						///////	
(iii) Samran area					///////		
Syria							
(i) Jabal Qalat El-Hirri						///////	Further exploration is planned.
(ii) Ras El Ain						///////	Results of exploration work are not available.
(iii) Deir-Ezzor						///////	
(iv) El Hafee						///////	
(v) Tauwal El-Aba						///////	
	SALTS						
YAR							
(i) Salif (rock salt)	///////						Under exploitation
Jordan							
(i) Dead Sea (Potassium)	///////						Only potassium is extracted. It is planne to extract other salts also.
(ii) Al Lisan Peninsula(rock salt)	/////// ???					///////	Reserves are very large deposits have not yet been studied.

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	SALTS		(CONT'D)				
Saudi Arabia							
(i) Jizan area (rock salt)	////??////					//////	Large reserves, not studied yet.
(ii) Sabkhah Al Hamam (rock salt)						//////	Limited reserves, not studied yet.
(iii) Umm Es-Sahij						//////	Limited reserves, not studied yet.
Syria							
(i) Deir Ezzor	COMMERCIAL						
(ii) Ishmah		NO	INFORMATION				
(iii) Tabni							Under operation, Underground mining.
(iv) Al-Furatian trough					//////		Salt occurs at the depth of 560-970m.
(v) Wadi Al-Furat	COMMERCIAL						It is not exploited.
	MAGNESITE						
Saudi Arabia							
(i) Jabal Rakham				////??////		//////	Small reserves
(ii) Zarghat				//////			Under exploration
Syria							
(i) Zetounjig					//////		Occurrence is not of economic value.
UAE							
(i) Wadi Ham					//////		Low quality and limited reserves.
	BARITE						
Saudi Arabia							
(i) Rabigh						//////	Small reserves, the grade is commercial.

/...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A	S B	E S	T O S			
Syria (i) Bouz Oghlan				////// //////			Small size operation, building grade asbestos.
(ii) Qara-Tat				////// //////			Small size operation.
(iii) Jabal El-Khirbe					////// //////		Building grade asbestos, Small reserves.
UAE (i) Wadi Ghadf						///// /////	Poor quality, reserves 0.8 .. 1.0 million tons.
Saudi Arabia (i) Bi'r Umq area						///// /////	Not yet studied
(ii) Jabal Tharwah						///// /////	enough
(iii) Hijera Mine						///// /////	Occurrences with
(iv) Lahaja							fair to good
(v) Wadi Madhar							quality of asbestos,
(vi) Wadi Osman						///// /////	not yet studied.
	M A	R B	L E	AND	OTHER	BUILDING	STONES *
Saudi Arabia (i) Jabal Khanugah	C	O M	M E	R C	I A	L	Dark grey marble > 40 mill m^3.
(ii) Jabal Al Khawar	C	O M	M E	R C	I A	L	Dark grey marble > 10 mill m^3.
(iii) Jabal Farasan	C	O M	M E	R C	I A	L	White to grey marble under mining.
(iv) Madrakah	C	O M	M E	R C	I A	L	White marble under minin
(v) Wadi Turabah	C	O M	M E	R C	I A	L	Beige-rose marble under mining
(vi) Wadi Bidah	C	O M	M E	R C	I A	L	Beige - white marble.
(vii) Yanbu Al Bahr	C	O M	M E	R C	I A	L	Anorthosite.
(viii) Al Jumum	C	O M	M E	R C	I A	L	Pink granite.

* Besides deposits listed, many other marble and other building and ornamental stone deposits are available in the countries of the ECWA region, particularly in Oman, Iraq, Lebanon, PDRY and Qatar, but we haven't any information about them.

/...

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)
UAE								
(i)	Ajman area	C	O M	M E	R C	I A	L		Under exploitation
(ii)	Faiyah						///// /////	
(iii)	Idhn						////// /////	
(iv)	Tawi Khadra						///// /////	
(v)	Wadi Halah						///// /////	
YAR								
(i)	Wadi Maksab C	O M	M E	R C	I A	L		Further exploration is required.
(ii)	Al-Shaiban C	O M	M E	R C	I A	L		
(iii)	Sokhna					////// /////		Can be used for the production of chemicals
Syria								
(i)	Arika C	O M	M E	R C	I A	L		Limestone which was exploited since ancient time.
(ii)	Berj Astam C	O M	M E	R C	I A	L		
(iii)	Halab C	O M	M E	R C	I A	L		
(iv)	Hama C	O M	M E	R C	I A	L		
(v)	Idlib, Maaret An-Noaman Area C	O M	M E	R C	I A	L		
(iv)	Palmyra area C	O M	M E	R C	I A	L		
(vii)	Tartous C	O M	M E	R C	I A	L		

/...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	M A R B L E			(CONT'D)			
Jordan							Limestone of Upper Cretaceous to Quaternar age is used widely for building purposes.
(i) Amman-Al-Qatranah area	C O M M E R C I A L						
(ii) Bethlehem	C O M M E R C I A L						
(iii) Dayr Alla						//////	Travertine
(iv) Jarash	C O M M E R C I A L						Limestone of Upper Cretaceous to Quaternary age is used widely for building purposes.
(v) Khirbet As-Samra	C O M M E R C I A L						
(vi) Qasr El-Hamam	C O M M E R C I A L						
Kuwait							
(i) Ahmadi	Low commercial value						Low quality limestone; for local use.
(ii) Burgan	Low commercial value						
(iii) Subibiyyah	Low commercial value						
(iv) Wafra	Low commercial value						
Bahrain							
(i) Khobar	C O M M E R C I A L						Dolomite, under operation
	G Y P S U M		A N D		A N H Y D R I T E		
YAR							
(i) Salif spot	C O M M E R C I A L						Small scale production
(ii) Jabal Maarab	C O M M E R C I A L						Not operated
(iii) Jabal Quma	C O M M E R C I A L						Not operated
Sana'a area							
(iv) Al Gheras	C O M M E R C I A L						Small scale production
(v) Al Harre-Thuma	C O M M E R C I A L						Under operation
(vi) Khulagah						//////	Not yet studied. Reserve could be large.
(vii) Shirah					//////		Small reserves used for local needs.
Taiz area							
(viii) Sharok	C O M M E R C I A L						Under operation
(ix) Al-Gubyl	Low commercial value						Early stage of operatio
(x) Ar Rawna	Low commercial value						Only for local use.

/...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GYPSUM	AND	ANHYDRITE	(CONT'D)			
Syria (i) El-Barghouth area						////// /////	For local use only.
(ii) Lattakia	C O M	M E R	C I A L				Some deposits are under operation
(iii) Shahil area	C O M	M E R	C I A L				Very large
(iv) Ratich area	C O M	M E R	C I A L				reserves
(v) Salamiyeh	C O M	M E R	C I A L				High gypsum grade, large reserves.
(vi) Damascus area	C O M	M E R	C I A L				High quality rocks.
(vii) Al Furatian trough area						////// //////	
Saudi Arabia Red sea area (i) Jabal Al Kibrit	C O M	M E R	C I A L				Very large reserves, deposits have not yet been studies
(ii) Maqna	C O M	M E R	C I A L				
Central area (iii) Al Khay region	C O M	M E R	C I A L				Deposit has not been studied.
(iv) Hith						/////// //////	Can be used as ornamental stone.
Arabian Gulf area (v) Al Hufuf						////// //////	
(vi)Ayn Dar						////// //////	
(viii)Chashm Umm Huwayd						////// //////	
Jordan (i) Wadi al Karak	May	be	of	commercial	value		Under
(ii)Wadi al Mawjib	May	be	of	commercial	value		study
(iii)Wadi al Munah	May	be	oc	commercial	value		
(iv) Amman-Karak road area						////// /////	
PDRY Batis area						////// /////	Large deposit of gypsum and anhydrite.
	CLAY,	KAOLIN	AND ARGILLOUS		ROCKS*		
Syria Raqa City area (i) Riquit Al-Smara	Commercial		value				For brick production
(ii)Wadi-Al-Faid						/////// ///////	

* Because of lack of information about clay deposits in the region, this list of deposits cannot be considered as a complete one.

/...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Syria (cont'd)	CLAY, KEOLIN AND ARGILLOUS ROCKS (CONT'D)						
Qamishly area							
(iii) Hilaliyeh	C O M M E R C I A L						Can be used for brick production.
Hasakah area							
(iv) Hasakah	C O M M E R C I A L						Suitable for brick Ind.
(v) Sfaya	C O M M E R C I A L						Suitable for brick Ind.
(vi) Beit Jahn	May be of commercial value					///////	Can be used for ceramic and brick pottery prod.
(vii) Deer	C O M M E R C I A L						Used for brick producti
(viii) Dimashq area	C O M M E R C I A L						Used for cement Product can be used for prep. o drilling mud.
(ix) El Bayad valley	May be of commercial value					///////	For cement industry & f preparing of drilling m
(x) Hasaqi	C O M M E R C I A L						used for brick producti
(xi) Jabal at Tyas						///////	
(xii) Jabal el Haet						///////	
(xiii) Ragadan	May be of commercial value					///////	Bentonitic clay may be used for pottery.
(xiv) Raqqa	C O M M E R C I A L						Used for brick producti
(xv) Tel Hadjar	May be of commercial value					///////	Bentonitic clay, may be used for pottery.
(xvi) Wadi Hsayyeh	May be of commercial value					///////	For cement industry & f preparing drilling muds
(xvii) Wadi Jhar						///////	
Jordan							
(i) Mahiss			///////				Mainly kaolin for ceramic & cement prod. Under limited operation
(ii) El-Azrak						///////	
(iii) Ghaw Kabid						///////	Small reserves
Iraq							
(i) Al Gara	C O M M E R C I A L						Exploited for
(ii) Nayar	C O M M E R C I A L						cement production
(iii) Rutba district	C O M M E R C I A L						Refractory material
(iv) Qara-Tappa						///////	Under study, Bentonitic deposit, clay can be used for drilling muds
Kuwait							
(i) Warba Island						///////	
Bahrain							
(i) A'Abli	C O M M E R C I A L						Under mine for pottery production
(ii) Buri						///////	
Saudi Arabia							
(i) Khashm Rida						///////	Large deposit under investigation

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Corrigendum

Survey Report
on the Situation Pertaining to the Development of
Mineral Resources in the Countries of the ECWA Region

1. Please insert the following sentence on page 176, line 20 to read:

"Following the establishment of a geological documentation centre and a geological data bank, the establishment of these specialized centres could contribute to a better evaluation ...."

2. Please replace the first paragraph on page 184 under item 1, "Pre-investment activities and establishment ....." to read as follows:

Pre-investment activities require heavy expenditure the return on which may not materialize directly. Financial and technical assistance provided by international and regional organizations to the least developed countries of the region becomes therefore a necessity. Furthermore the participation of these organizations in the creation of regional mechanisms aimed at promoting economic, technical and financial co-operation among member States will help these countries solve some of the key problems facing the development of mineral resources in the ECWA region.