

*A REPORT ON*

**FIELD EXAMINATIONS  
OF MINERAL DEPOSITS  
IN  
KASSALA PROVINCE, SUDAN**

**DMJM**



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PLANNING § ARCHITECTURE § ENGINEERING § SYSTEMS

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A. REPORT ON  
FIELD EXAMINATIONS OF MINERAL DEPOSITS  
IN KASSALA PROVINCE, SUDAN

GOLD	VERMICULITE
IRON	MANGANESE
COPPER	ASBESTOS
QUARTZ	GYPSUM

CONTRACT ICAC -- 1846

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Planning \* Architecture \* Engineering \* Systems  
Khartoum, Sudan

## PREFACE

This revised report includes the information contained in the April, 1962 report developed in Khartoum and such supplemental information as it has been possible to develop in Los Angeles since the return of the Field Staff from the Sudan.

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## I. RECOMMENDATIONS FOR IMPLEMENTATION

### Asbestos

This deposit appears to be commercially exploitable. The fibers should be graded and tested, the reserves determined, and a feasibility study undertaken.

### Manganese

This deposit is commercially exploitable; ore is being mined and sold at present on a very small scale. The reserves should be determined and a feasibility study undertaken.

### Iron

The magnitude of the estimated reserves is such that a formal examination should be undertaken at a later date.

### Gold

Expansion of the present operation does not appear to be warranted.

### Quartz

Present mining operations can be made more efficient. Greater production rates are not warranted by the present market.

### Vermiculite

These deposits do not appear to be commercially exploitable.

### Gypsum

This deposit may be commercially exploitable. Chemical analysis of the gypsum needs to be determined, reserves determined, and a market study undertaken.

### Copper

These deposits do not appear to be commercially exploitable at this time.

## II. AUTHORITY AND SCOPE

### Authority

Authority for this study is contained in Work Order No. 5 issued to Daniel, Mann, Johnson, & Mendenhall by United States Agency for International Development/Sudan on 22 September 1961.

### Scope

The scope of work for this study "is to investigate briefly the advisability of making additional feasibility studies in connection with asbestos and copper mining".

This scope was increased to include manganese, iron, gold, quartz, vermiculite and gypsum at the request of the Director, Geological Survey Department, Government of Sudan, and with the approval of the Chief, Mining and Industry Division, USAID/S.

### III. INTRODUCTION

The Geological Survey Department, over a great number of years dating back to the early days of the Anglo-Egyptian Condominium, has conducted extensive prospecting and limited exploratory work in various parts of the Sudan in an attempt to discover exploitable mineral resources. They have published reports on a number of the more important deposits discovered.

During the latter part of 1961, the Government of Sudan, through the Geological Survey Department, requested USAID assistance in the evaluation of certain iron mines already in operation in the Red Sea Hills. This study of the Sufaya Iron Deposits is the subject of a separate report. A secondary purpose of this request was to investigate briefly the advisability of making additional feasibility studies in connection with asbestos and copper mining. This was subsequently expanded to include manganese, other iron deposits, gold, quartz, vermiculite, and gypsum.

Accordingly, two field examination trips were made. The first trip, from 14 January 1962 to 17 January 1962, was to examine the asbestos deposit and the exploratory trenching operations at Gala En Nahl. The second trip, extending from 29 January to 11 February 1962, covered seven different mineral deposits in the Red Sea Hills area.

Inasmuch as Mr. John P. Lowe, E.M., A.I.M.E. came to the Sudan primarily to explore the Sufaya iron deposits, very little time could be spent in the examination of the deposits herein reported on. All sites visited were as selected by the Department of Geological Survey, Government of Sudan, and all inspections made under their direct supervision. Only a few hours of time were available at some of the sites for direct examination of the deposits. There was no time available or authorization to develop this report to any greater detail than as presented. This report is also to be considered as only preliminary in nature and to serve merely as a basis for future more detailed studies, as warranted and authorized.

Since Sudan is primarily an agricultural country, substantially all of its foreign exchange earnings being derived from cotton and other crops, any development of mineral resources will create wealth and improve the economy of the country. Such development will tend to stabilize the economy by reducing its dependence on the vagaries of nature and the world cotton prices.

It is, therefore, considered to be highly important to develop any natural mineral resources, consistent with demand and cost to develop and market, which is commercially exploitable. As a parallel activity, prospecting for new sources of mineral wealth should continue, but not to the detriment of exploitation within a limited budget.

This report describes the mineral deposits and recommends the further course of action which will ultimately lead to development and production of these reserves which are feasible to exploit. All mineral reserves and production figures where applicable are expressed in metric tons.

#### IV. ASBESTOS

There are a number of asbestos deposits, serpentine chrysotile, in the Qala En Nahl area of southeast Kassala Province, approximately 45 miles south of Gedaref. Of these deposits, three have been explored by surface trenching and shallow shafts, and a fourth deposit is being explored at the present time. Qala En Nahl is approximately 270 miles by rail or road from Khartoum and about 500 miles from Port Sudan.

##### No. 1 Deposit (Qala En Nahl - West range)

This ore, located at approximately 13° - 30' N. latitude and 34° - 45' E. longitude, is exposed on the side of a hill having a slope of about 40° and which rises approximately 100' above the flat country plains. Many outcroppings of ore may be seen on the hill, covering an area of approximately 50' x 200'. Some talus and weathered rock covers much of the deposit.

Two trenches, which extend into the hillside for about 20', have a maximum depth of 12'. They are located 100' apart, and the ore exposed by these cuts is fractured serpentine with asbestos filling the fissures. Fibre lengths of 1/16" to 3/8" of good clean grade were noted.

Mining of this deposit could easily be accomplished by open cut methods. There are apparently only a few feet of weathered waste rock overlying the ore. Access to the mine would require only simple repair of the road from Qala En Nahl, a distance of about 5 miles in a northwesterly direction.

Ore reserves cannot be calculated at this time as the thickness is not known. There is a possible 10,000 tons or more of ore with an asbestos content of 5% to 10%. Shafts should be sunk to establish the depth of ore.

##### No. 2 Deposit (Qala En Nahl - West range)

This deposit is located within 2 miles south of the No. 1 deposit and has had the most development work done on it. The work done consists of 5 hillside cuts and one 15' deep shaft. The ore is exposed on the surface on two hillsides which are about 300' apart and separated by a flat area covered with soil. The hillside cuts were driven into the slopes on a downward grade. The deepest cuts had a depth of about 15' below the surface. All of the cuts showed a weathered zone of a

few feet on top of the asbestos bearing serpentine. A shaft 15' deep was sunk in the flat area halfway between the hills. This showed about 5' of soil and boulders and another 5' of the altered, weathered serpentine on top of the ore.

The asbestos is deposited in many fractures cutting through the serpentine. Lengths of good clean fibre were seen up to  $3/4$ ". The exploratory work showed ore in place of 5 to 12% asbestos content. An attempt was being made to core drill the flat area but the results were unsatisfactory. Any asbestos encountered was ground up and could not be seen. Another shaft is to be sunk and the surface cuts will be deepened so as to determine some thickness of the ore.

The surface area under which the ore lies apparently is approximately 300' x 500'. The ore on the hillsides and in the flat area could easily be mined by open cut methods.

The thickness of the ore will not be known until a greater depth is reached, but it appears possible that there is in excess of 100,000 tons of ore.

The road conditions are the same as at the No. 1 deposit with a shorter distance to the railroad.

#### No. 3 Deposit (Qala En Nahl - East)

This is located about 5 miles south of the railroad at Qala En Nahl, approximately  $13^{\circ}$  -  $20'$  N. latitude and  $35^{\circ}$  E. longitude. The ore is exposed by outcroppings on the surface and by 5 trenches into a  $45^{\circ}$  hillside. The trenches are located about 50' apart and have a maximum depth of 15' below the surface. Four of the trenches cut into the ore. One end cut was barren and appeared to just beyond a fault zone which ended the ore zone. Each cut showed a barren altered serpentine of up to 8' in thickness overlying the ore.

The asbestos occurs in the many fracture planes in the serpentine. Fibre lengths of up to  $3/4$ " were noted with a content of 5% to 10% asbestos in the ore. An area of about 100' x 300' is indicated as being mineralized.

This deposit could easily be mined by open cut methods. The road to the property is in fair condition and would not require much additional repair work.

It is indicated that there is a possible 30,000 tons or more of asbestos ore here.

#### No. 4 Deposit (Jebel Umm Sagata)

This deposit is located approximately 31 miles south of the village of Qala En Nahl, approximately 13° N. latitude and 35° E. longitude. Trenching has been started, and the ore is exposed by surface showings on one side of a 45° hillside.- This hill is one of the highest in the area and rises abruptly from the flat surrounding plain to a height of about 200'. The exploration trenches were cut to a maximum depth of 12' below the surface.

This deposit appears to be the largest and has the best grade of fibre. Many veins of asbestos having fibre lengths of over 1/2" were seen with up to 20% asbestos in some exposed ore. The mineralized zone extends for about 800' in length and 400' wide.

It is entirely possible that there may be 200,000 tons of ore in this deposit.

The road from Qala En Nahl is a fair desert track for 20 miles. The last eleven miles is in very poor condition, but would not require much work to make it serviceable.

#### General

The mineral deposition in the various deposits is identical as it always occurs as chrysotile filling fractures in serpentine. All are suitable for open cut mining.

Water is a problem as none has been developed near the deposits. All water is now hauled from Qala En Nahl, which is short of water.

The deposits near Qala En Nahl are located on or about low hills. The country is mostly flat, covered with high grass and there are many Acacia trees. The deposit at Jebel Umm Sagata, to the south, is in the gum tree area with much grass and also mostly flat.

It was noted that all of the deposits examined showed the presence of a dark mineral in the float. However, shafting and trenching proved the sub-surface ore to be entirely different. Visual and microscopic examination also proved this ore to be very clean with no iron content apparent. The regional geology is mainly sand mixed with various debris and numerous small jebels or hills protruding, which are either granite or diorite. The asbestos bearing serpentine is usually on one side of a jebel only. This was true of all deposits visited. It is not known how far the serpentine extends under the sand and debris, but the shaft sunk between the two hills at No. 2 deposit indicated a continuation.

Samples from the shaft at No. 2 deposit and the freshly broken ore from trenches at the other deposits were taken to the laboratory of the Geological Survey Department in Khartoum, where they were to be tested for grade and impurities. Additional samples were also to be sent into the laboratory as work progressed. No test work had been done at the writing of this report as the laboratory was inoperative due to lack of personnel. It may be that these tests have now been completed and that the results could be obtained from the Department of Geological Survey by inquiry through proper USAID/Sudan channels.

Labor is available at 20 piasters a day.

### Conclusions

There are apparently several hundred thousand tons of asbestos ore in the area which could be mined with grade of 5% or better.

While a considerable amount of the asbestos is short fibre which could only be used for cement-asbestos products, there should be an appreciable amount of the higher value long fibres used in spinning. When the deposits are more fully developed large samples should be tested to determine the resulting grades and thereby enable a value to be given the ore.

### Beneficiation

The usual process is to crush the ore with crushers and hammermills to free the fibres. Air separators are used to separate the asbestos and waste rock. The product is then screened for sizing. This can all be done dry so water is not a great problem.

### Prices

Current prices range from about \$40 per ton for the shortest fibres to \$1800 per ton for plus 1/2" long fibres.

### Recommendations

1. The current program of exploratory trenching and shafting should be completed. The extent of this work should be such that an accurate calculation of Class A, measured ore, reserves can be made.

2. Representative samples from each of the deposits should be crushed and the asbestos fibres separated so as to determine the percentage of fibre in each deposit.

3. The planned program of grading the asbestos should be consummated. This requires the use of a Quebec Standard Asbestos Testing Machine to determine the percentage of the different fibre lengths in the asbestos recovered from representative samples. This classification of fibres should be accomplished for each of the four deposits. It is understood that the required equipment is being obtained by the Geological Survey Department, and that upon completion of these tests, a report on these deposits will be published.

4. Upon completion of the Government of Sudan report, copies should be sent to all asbestos producers who have expressed interest in the development of these deposits. A sample, 10 to 20 pounds of representative ore, should accompany the report. Four producers who have shown interest to date are:

H. K. Conn, Exploration Manager  
Canadian Johns-Manville Co., Ltd.  
Asbestos Fibre Division  
P. O. Box 1500  
Asbestos, Quebec Province  
Canada

Lake Asbestos of Quebec, Ltd.  
120 Broadway  
New York 5, New York  
U. S. A.

Nicolet Industries, Inc.  
Nicolet Avenue  
Florham Park, New Jersey  
U. S. A.

Attn: E. T. Duke, Director of Product Development  
Dr. Wallace Emo, Manager of Mineral Exploration  
Dept.

Raw Asbestos Distributors, Ltd.  
Asbestos House, Fountain Street  
Manchester  
England

5. If the current program (1 above) indicates the expense would be justified, a formal examination involving complete technical and economic feasibility study should be undertaken to enable evaluation of the commercial exploitability of these deposits.

## V. MANGANESE DEPOSITS

There are several manganese deposits in Kassala Province, four of which were examined. Other deposits were defined as being mined out of minor importance.

### A. Gebeit Mine

This mine is located 53 miles northwest of the railroad town of Gebeit. Access to the property is mainly by a very poor desert track. The area is fairly flat with scattered hills rising above the wadis to a few hundred feet in height. Location is approximately 19° N. latitude and 36° - 30' E. longitude. Gebeit is approximately 80 miles by rail from Port Sudan.

The mine is being operated by the National Mining Co. of which Sayed Omer Abu Amna, of Gebeit, is the Director. Approximately 600 tons of ore have been mined, of this 200 tons have been hauled to Port Sudan and 300 tons have been trucked to the railroad at Gebeit. The ore averages plus 50% Mn.

The ore (see Figure I) occurs along the side of a hill with numerous outcroppings and with little overburden. It is in a series of lenses which have a strike of about WSW. The lenses are nearly vertical, have thicknesses from 2 to 12 feet and lengths up to 40 feet where exposed. About 10 of the lenses have been mined to depths of from 15 to 30 feet.

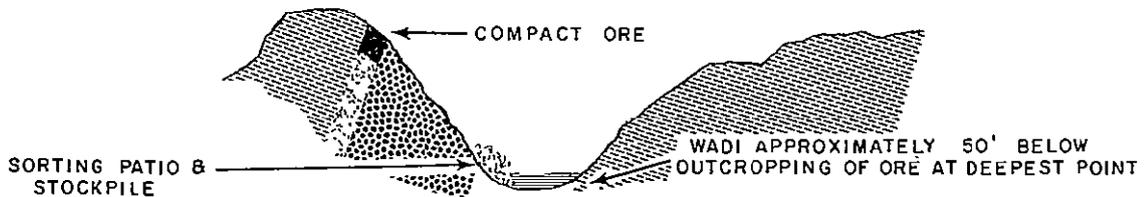
The surrounding area is principally typical sandy desert with numerous jebels or hills protruding. These jebels are granite or granite gneiss with very few rising more than 50 feet above the wadis. Quartz stringers were noted in the ore only near the surface and it is assumed that this came from the quartz in evidence on the ridge above. No quartz was seen in ore at depth nor were any unaltered manganese garnets seen. The ore is psilomelane and pyrolusite.

The ore is mined by use of pneumatic rock drills and dynamite. The broken ore is hand transported to a sorting level in a draw below. Much of the ore requires no hand cobbing, but some is mixed with quartz and this is broken off. The pits invariably show a high content of quartz stringers crisscrossing the ore near the surface and gradually diminishing with depth. The deepest workings, approximately 30' show this change very clearly. The lower 10 feet or so shows no quartz. The lenses which are exposed are very nearly on the same strike with only minor offsets. Outcroppings are found along this strike for well over 1,000 feet and exploration would probably show a further continuation. The lenses occur at irregular intervals, but the average spacing

# SKETCH OF GEBEIT MANGANESE MINE (NO SCALE)



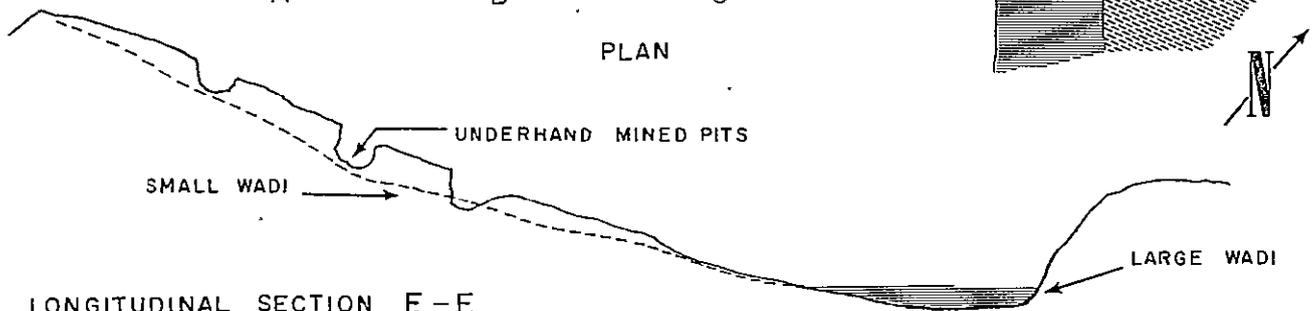
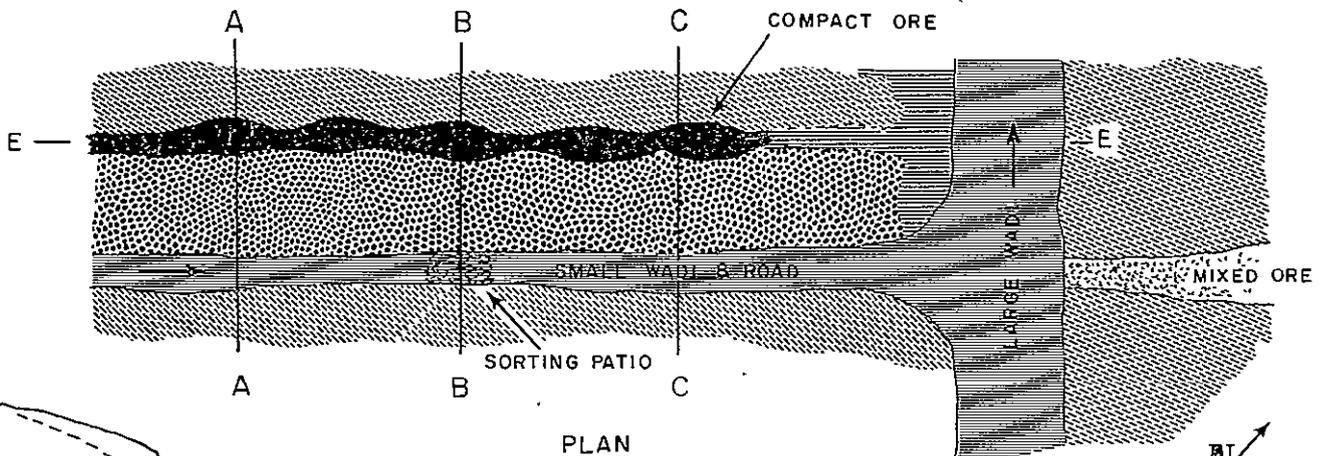
CROSS SECTION A-A



CROSS SECTION B-B



CROSS SECTION C-C



- SAND & DEBRIS
- GNEISS WITH QUARTZ STRINGERS
- SCHISTOUS ROCK
- COMPACT ORE

FIG. 1

would be about 40 feet. Small veins of ore appear to be continuous between. Some of the present pits indicate a pinching at depth, but the deepest pit shows a very uniform width the full 30 feet.

The present workings are mined to about the deepest they can be as now being worked. If this deposit extends to quite a depth, as it appears likely to, the ore should be mined by overhead stopping from underground. This would necessitate a shaft being sunk in the ore or in the waste rock paralleling the ore.

Diamond core drilling could be used to determine the downward extension to some extent, but, due to the topography, locations would be far from ideal. The only possible place to drill would be in a narrow draw, which is about 50 feet to one side of the vein and at an elevation approximately 50' lower than the outcropping.

If it is definitely known that the ore has a downward extension of at least 100' below the present pit bottoms, a shaft should be sunk in the draw below the present workings. This shaft should be about 80' deep plus ore pocket space at the bottom. A cross cut would be made to the vein and then drifting would be done, following the ore for a working level. This would allow for 100' of ore to be mined by mining to the bottom of the present underhand stopes.

If it is not definitely determined that the ore extends to a substantial depth, a shaft should be sunk in the ore. This would give some returns in ore while sinking and serve to explore the deposit. It is, of course, possible that considerable ore would be tied up in the shaft area which could not be mined. This shaft should be sunk on the last lens, to the east-north-east, which is toward the road. Very little timber would be required in mining this ore, as the walls are a hard schist and vertical, or nearly so. This work would have to be done under the supervision of an expatriate mining engineer familiar with underground mining methods.

Driving a cross cut from the draw to intersect the ore below the present pits was discussed with the operators, but they were not in favor of doing any work in waste rock even though this would be a reasonable approach. The reason given was the necessity of financing this operation from their own limited capital. Sinking a shaft in the ore body is the desire of the mine operators, but, as has been said previously, this will require the services of someone knowledgeable with underground mining methods. Drifting on the vein from the lower exposure of the strike near the large wadi is also possible, but the grade of the ore seems lower here.

Chemical analysis of this ore as determined by the Geological Survey Department shows the following:

Mn	-	47.00	-	55.00%
Fe	-	0.87	-	0.30%
P	-	0.01	-	0.57%
SiO	-	3.5	-	6.0%
S	-	0	-	0.12%

This analysis was made from samples previously taken by geologists of the Geological Survey Department. It could not positively be determined just where these samples were taken from, but it was thought that the high phosphorous sample came from the offset ore showing on the northeast side of the large wadi. Further samples were taken from newly broken ore in the pits and from the stockpiled ore in Gebeit, but again, due to lack of laboratory personnel, no analysis had been made as of this writing.

#### Price

The latest quoted price for metallurgical grade plus 48% Mn ore is \$0.90-\$0.95 per contained long ton unit; 44% to 48% Mn ore is quoted at \$0.85 to \$0.90 per long ton unit. Therefore, a 50% Mn ore would be worth \$45 or more a long ton delivered in the U. S.

No sales have been made from this mine as of April, 1962, due to insufficient tonnage mined. However, Sayed Mahmoud Abdulla, Director of the Geological Survey Department, and Lowe were advised by Sayed Omer Abu Amna, principal owner and director of National Mining Company, that he had an offer from a Yugoslav company for purchase just as soon as 1000 tons of ore were ready for shipment and full chemical analysis of the stock piled ore completed and approved. The Geological Survey Department plans to sample and make complete analysis on all ores prior to approving any contracts for exportation as a protection to the owner and the Government of Sudan.

#### Conclusions

It is Mr. Lowe's opinion that this deposit has exceptionally good ore which should command a substantial price in world markets. All indications are favorable for the ore to continue downward to a considerable depth and additional length of the vein is possible.

It is certainly warranted to continue the surface exploration, explore the underground ore and prepare for underground mining.

If the ore continues downward similar to what is seen on the surface there should be at least 200 tons of ore for each vertical foot mined.

#### Recommendations

1. Exploratory work should continue to determine depth of ore. The nature of the deposit is such that ore can be mined as a product of the exploration.

A shaft should be sunk to at least 100' depth, provided that the ore body continues to this depth. At depth a drift would be driven laterally and ore mined by overhand stoping. The depth of the shaft and the length of the drift will prove the reserves in that area. Further shafting, drifting and mining would be dependent on the results obtained. All ore obtained in this exploration will be marketable.

2. A complete technical and economic feasibility study should be undertaken at such time as reserves are determined as herein recommended.

#### B. Al Amar Mine

This deposit is leased and operated by Sayed Abdel Monim Samkart of Port Sudan. It is located approximately at 22° N. latitude and 36° - 30' E. longitude, approximately two miles west of the Port Sudan-Halaib Road and 175 miles north of Port Sudan. Ore shipments could be made from Port Abu Imama, which is approximately 36 miles distant and the port from which the Sufaya iron ore is being shipped.

The manganese ore is apparently a hard psilomelane and occurs usually as a cementing material around rounded boulders and angular pieces of conglomerate. The thickness varies from a thin coating up to 6" or more. The ore is normally quite clean when broken from the waste rock, but considerable veinlets of calcite were noted in some. Numerous pits are scattered at random over an area of about 150' x 1000'. These show overburden of from 0 to 8'. The deepest pit has a depth of about 15'. The deposition of the mineral is very erratic with shoots of high grade ore going in all directions and ending abruptly in waste conglomerate. The pits are of variable sizes and show some of the enriched zones have produced from a few tons up to about 50 tons of ore.

Spotty ore is still showing at the bottom of the present pits. This ore occurs as a sedimentary deposit as it is in loose and cemented sands and debris. It could not definitely be determined if this manganeseiferous debris was from the immediate zone or had travelled from some distance. However, as no manganese could be found in any of the surrounding hills area, it could be assumed that the original deposit was local and had weathered to its present condition and then covered by sands.

Al Amar mine has been operated in a small way over a number of years at irregular intervals. All mining is being done by hand. No drilling is done, nor any dynamite used. Picks are used to break loose the ore, which is carried to the surface in bags, hand cobbled to remove the waste rock and then stockpiled. The mineral usually breaks clean quite easily. Approximately 200 tons of ore is stockpiled at present and the grade was said to be about 53% Mn. This deposit will apparently always require hand or mechanical separation of waste from ore unless it alters completely at depth.

There is nothing to indicate the depth of this deposit and, due to the irregular deposition, it is impossible to estimate reserves. Many sample pits or drill holes would be required to ever prove any large tonnage. It is believed that if the overburden were to be stripped off, considerably more enriched zones would be exposed for the only areas being mined at present are those wherein the ore is exposed on the surface, or very nearly so.

This deposit, if there is sufficient ore, could be readily beneficiated by use of jigs and heavy media separation methods. As it is only a few miles from the Red Sea this water could be utilized. A bulldozer, compressor and rock drills will be necessary to put this mine into significant production.

#### Recommendations

1. Magnitude of reserves should be determined by exploratory drilling or sample pits.
2. If the results of the market study made in connection with the Gebeit Mine feasibility study are encouraging, a complete technical and economic feasibility study should be undertaken. Complete chemical analysis and development of markets would be primary steps prior to recommending any heavy equipment investment for increased production.

### C. Kalabeit Deposit

This deposit is located approximately 10 miles west of Halaib in low rolling hills extending above the coastal plain. The manganese ore occurs as a filling in fissures in the granitic country rock. The mineral varies in thickness from small veinlets to 2 or 3 inches. A large amount of calcite is distributed throughout the ore and it is doubtful if a saleable grade could be made. The deposit appears to be small, but no definite outlines can be seen by the few shallow pits now there. More trenching and some deep shafts will have to be dug before this deposit would warrant much work being done or money spent for equipment.

#### Recommendations

The nature of this deposit is such that no action is deemed warranted at this time. If the market is sufficiently large to support greater production than could be provided by the Gebeit and Al Amar Mines, if developed, then exploratory drilling followed by a feasibility study would be warranted.

### D. Sarara Deposit

This deposit of manganese ore is located about 10 miles northwest of Halaib-Adaldeib Road. Only a few shallow cuts have been dug here and they show a poor grade of ore in cemented sands. It appears to be high in iron, but due to the small thickness of the mineral it would be difficult to sort it from the waste rock.

This deposit does not appear to be economic, but if prospected to a greater depth it may show a better grade of ore. More trenching should be done to define the deposit.

#### Recommendations

No action is recommended at this time. After development of markets and the more exploitable deposits, this deposit may be re-examined to determine whether or not exploratory drilling and feasibility study are warranted.

## VI. IRON DEPOSITS

The Fodikwan group of deposits is located approximately 21° - 45' N. latitude and 36°-45' E. longitude in the northern Red Sea Hills area, nine miles inland from the Port Sudan-Halaib Road at a distance of 167 miles from Port Sudan. The nearest harbor is at Marob, a distance of 12 miles. A jetty would be necessary for ship loading.

### Ore Occurrence

The ore occurs in a metamorphic rock that is predominant in the area and is exposed in two main locations within 400 feet of each other with various small deposits in the immediate area. The two large ore bodies are divided by a fault which is located between them and occupy the crests of hills which rise to about 175' above the surrounding country.

The deposit is made up of two types of ore: (1) solid massive ore and (2) mixed ore composed of veinlets and disseminated iron oxides in the country rock. The mixed ore usually surrounds the solid ore and apparently underlies it.

### Previous Studies

A. The Sudan Geological Department published a bulletin in 1958 entitled "Fodikwan Iron Deposits". This publication covers the results obtained from an extensive geological examination, trenching and core drilling.

The report classifies the ore as containing magnetite as the primary constituent and hematite the secondary. The deposits are divided into solid and mixed ore with reserves estimated as follows:

147,000 metric tons of solid accessible ore of plus 60% Fe.

95,000 metric tons of mixed accessible ore of plus 50% - 60% Fe.

Numerous samples showed the sulphur and phosphorous content was negligible.

The report concludes that this deposit is in the form of a sheet resting on the country rock and, therefore, that the possibility of any vertical extension of ore is remote. Drilling was done on a hillside where ore was exposed.

B. Another geological and geophysical report on the Fedikwan iron ore deposit was made in 1960 by Dr. Branislav Milovanovic, Professor of University, Institute for Geological and Geophysical Research, Belgrade. This firm was hired by the owners of the deposit, Central Desert Mining Co., Port Sudan, to do this work. Sayed Abu Bakrasaeed Baasher is the principal stockholder and operator.

This report differs considerably from that of the Sudan Geological Survey Department. The geologists do not believe the deposit to be a flat sheet resting on the country rock, but that it really is a dyke. They also show reserves of much larger tonnage, as follows:

Ore over 50% Fe	1,923,176 tons
Ore 20 - 50% Fe	420,811 tons

Much of the lower grade ore would have to be ground and separated.

The above figures are based on geological, geophysical and geomagnetic surveys, surface sampling and results from 6 bore holes. The report itself was not available and notes from Geological Survey files gave no more detail than as given above.

A study of the maps and bore hole logs confirms the estimated tonnage of reserves. Logs of the bore holes are as follows, with inclined holes calculated to vertical:

- B-1 - 11' waste, 12' hard ore (plus 50% Fe), 5' waste, 28' hard ore, 12' mixed ore (20-50% Fe).
- B-2 - 6' waste, 5' hard ore, 18' waste, 8' hard ore, 6' mixed ore.
- B-3 - 9' waste, 6' mixed ore, 5' waste, 8' mixed ore, 8' waste, 5' hard ore.
- B-3a - 12' waste, 1-1/2' hard ore.
- B-4 - 3' waste, 2' mixed ore, 7' hard ore, 1-1/2' mixed ore, 3' hard ore, 8' mixed ore.
- B-4a - 18' waste, 6' mixed ore, 9' waste, 12' hard ore, 10' mixed ore.

NOTE: B-3a and B-4a were vertical holes with the others being inclined downwards at 45° and drilled into the ore from the wadi below the exposure. The holes were all collared in waste a short distance from the exposed surface ore so that which is shown as waste at the starting of the bore hole logs would not necessarily have to be mined. Of course, all of the waste in between the ore zones would have to be removed, as would any overburden.

## Conclusions

Based on bore holes made by the Yugoslavs, it is apparent that there are more ore reserves than that given by the Sudan Geological Survey Report. Mr. Lowe is inclined to agree with Geological Survey Department geologists that this deposit is a sheet and not a dyke with evidences of deeper ore being the erosional remains of a fairly thin sheet.

Due to the deposition of hard ore, mixed ore, and waste rock, the mining would have to be done selectively, which would increase costs. It is doubtful if it would be economically possible to upgrade the mixed ore. This would involve grinding, separation by magnetic or other means, and sintering or nodulizing the concentrate.

Development of this deposit should be a low cost open pit operation. Size and type of equipment would have to be determined by the tonnage of ore to be mined, as developed by a feasibility study.

It is understood that the Central Desert Mining Co. Ltd. is negotiating with an American contracting firm for the development of this deposit.

## Recommendations

1. If the negotiations for development are successful, the deposit will be exploited and no recommendations are required.
2. If the negotiations should fail, it is recommended that formal examination involving technical and economic feasibility study be undertaken, for at best low cost open pit operation with selective mining would show marginal profitability unless even greater reserves than 2,000,000 tons could be proven.

## VII. GOLD DEPOSIT

### History

This mine was originally worked by the Egyptians to the 60' level, and is probably one of the oldest active gold mines in the world. It was reactivated again by a British company about 1916 under the name of Gebeit Mining and Milling Company, with a Mr. Percy Tarbut as principal owner and manager. They installed a 15 stamp (650#) mill and amalgam tables. These stamps are still in evidence at the old workings. They are, of course, in very poor condition. A good shaft was sunk, which eventually went to an inclined depth of over 700 feet with ore being mined above to the surface leaving pillars for support. At a later date a cyanide plant was installed and operated until the closing down of the operation in 1932, upon Mr. Tarbut's death. The gold bearing quartz vein has a granite foot and hanging walls. The upper part of the deposit was irregular in dip, varying from 20° to 45° which below the 60' level became a fairly uniform dip of about 45° N. The vein had a uniform strike level of about 700' to the full depth of the shaft with the vein pinching, widening, and varying in grade both on the strike and on the dip. A sorting patio on the surface was used to remove waste rock and they were able to mill between 35 and 50 tons per 24 hour day. Ores were mined with grades as high as \$200 per ton, but no ores were mined that assayed less than \$10 per ton.

NOTE: The above historical information was received by Mr. Lowe in a personal interview on April 22, 1963 with Mr. Henry J. Jory, E.M., retired and living in South Pasadena, California. He was General Superintendent at the Gebeit Mine from 1918 until 1928. The Geological Survey Department supposedly had records of production and maps of the mine in the Khartoum office, but these were never found.

### Operations

The gold mine located at Gebeit is now being operated on a small scale by local natives, as a cooperative, producing 3 to 5 tons of ore per day. The gold recovery averages approximately one ounce per day. It was reported that this gold sells for L\$19 an ounce. Therefore, the average recovery would be about \$55 a day with the ore thus having a value of from \$11 to \$18 per ton. The location is approximately 21° N. latitude and 36° - 30' E. longitude. Gebeit is approximately 150 miles from Port Sudan by desert trail.

The mining methods are very crude, as the ore is hand drilled for blasting, and hand carried through torturous passage ways in baskets to a small shaft. The ore is dumped into a bucket which is hoisted to the surface by a hand operated windlass. All work at present is being done in an old working above the 60' level.

Due to caving, backfilling, and water, it is now impossible to go down the shaft sunk by the British company. The local operators dump their waste rock into any opening available into the lower stope areas and have blocked access. Present operators are only mining the pillars that were left from the old workings, so no large scale production is possible at present. Ventilation, of course, is non-existent and the air in the mine workings is very bad.

The ore removed from the mine is hand crushed with hammers to minus one inch for the mill feed. The mill consists of the original British company 15 stamps, of which only 3 are used. The ore is crushed and allowed to flow over an amalgam table. The amalgam is retorted on the property. The only power at the mine is a small diesel engine to operate the stamps and a gas engine to pump water from a nearby well.

The gold in the ore is very fine and is seldom visible to the naked eye. The quartz vein which contains the metallic gold also has pyrites which are gold bearing. This gold would not be recovered in the amalgamation process used. The gold bearing pyrites would have to be concentrated from the amalgam table's reject and then cyanided. With increased depth in the ore body the amount of metallic gold will decrease and the gold bearing pyrites will increase.

#### Ore Occurrence

The metallic gold and auriferous pyrites are in quartz veins of various thicknesses. It was possible to go underground to the 60 foot level only and in this area the veins were all quite flat, about 20 to 30 degrees. The veins which had been mined and are being mined are from 2" to 2' in thickness. Usually there is but one vein, but occasionally there will be 2 or more veins in a 4 foot section.

#### Conclusions

This mine would require extensive investigation before it could be determined if installation of a metallurgical plant would be warranted. A feasibility study, including market survey, would have to be undertaken prior to making any recommendations as to additional capital investment.

Prior to making any recommendations, maps as developed by the British company, if they can be located, should be studied. If not available, it would then be necessary to clean out the original shaft so that the lower levels could be examined and mapped with the alternative of sinking a new vertical shaft to intersect the ore vein in a shorter distance. Justification of a custom cyanidization plant in the Gebeit area would probably require the full evaluation of the ores at several nearby existing mines and the possibility of treating their production at the one plant.

### Recommendations

1. A market study could be undertaken to determine if increased production can be sold at current prices.

It is understood that the Omdurman jewelry trade is the major market for gold from this and other local gold mines. Since the current price of \$55 per ounce is well above the world market price of \$35 per ounce, the market would appear to be limited to the present buyers. As far as it is known, all gold mines use the amalgamation process, and all mines would like to have the capital to obtain a cyanidization plant to increase their gold recovery. However, it appears that such increased production might exceed the demand, increase the competition and force a price decline. For this reason, a very careful market study and analysis needs to be made, for it might be detrimental to the total economy if one operator with a cyanidization plant could either depress the market or drive the competitors out of business.

2. If warranted by the results of the market study, a complete technical and economic feasibility study should be undertaken.

## VIII. QUARTZ DEPOSIT

A quartz deposit, approximately 18° - 45' N. latitude and 36° - 45' E. longitude, is located about 15 miles southwest of Tohamiyam, with access by a poor road. Tohamiyam is approximately 110 miles by rail from Port Sudan and 380 miles from Khartoum. A conical shaped mound of high grade quartz rises for about 35' above the surrounding plains. It has a base diameter of about 150'.

The quartz is being mined at present at the rate of 450 tons per month, and an increase in production has been requested. Sale is to the Khartoum Bottle Company, which pays LS3.100 per ton delivered in Khartoum on a present five year contract.

The rock is drilled, blasted and the broken pieces are carried to a sloping side and rolled to the bottom. Any piece too large for one man to handle is broken down with sledge hammers. Trucks are loaded by hand. Mining at present is being done by sinking down through the center of the hill and so making a hole, through which the rock is removed with difficulty. It was suggested that surface benching methods should be used. The equipment now used is satisfactory for any immediate requirements. If larger production is required, further study should be made to determine equipment requirements for mechanization. In general, a larger compressor, rock drills, loading equipment, crusher, and trucks would be required.

This is a very profitable operation, as the labor costs are low and mining conditions are excellent. Records of the National Mining Company were examined and showed that cost of mining and truck haul to Tohamiyam was LS0.90 per ton including all supplies, maintenance, supervision, labor, etc., and that shipment by rail from Tohamiyam to Khartoum was LS0.77 per ton for a total cost of LSl.67 delivered in Khartoum. The contract with Sudan Railways was also examined and rail transport costs verified. With selling price established by contract at LS3.10, this leaves a net profit before taxes of LSl.43, or \$4.14 per ton. It should also be pointed out here that the Khartoum Bottle Works have tested quartz from other areas, but find this deposit to be the best available for their use.

The present operators are the National Mining Company, Sayed Omer Abu Amna, Gebeit. Improvements in mining procedures have been suggested to the owner, which he has taken under advisement. However, they seem well satisfied with present operations and do not require any financial assistance.

### Recommendations

1. The owner can increase production and/or reduce costs if the techniques suggested are applied.
2. At such time as the presently limited market might expand, a study should be made of the feasibility of mechanizing the operation, which of course would require further exploration below the base of the cone to prove out reserves.

## IX. VERMICULITE DEPOSITS

The vermiculite deposit, approximately 18° N. latitude and 36° - 45' E. longitude, is located 20 miles southeast of the railroad town of Tohamiyam. Considerable trenching has been done on numerous exposures scattered over an area of about 200' x 1000'. National Mining Company of Gebeit holds the lease on this property, but have done nothing beyond trenching to date.

The ore exposed by the trenches showed only small widths of vermiculite from 1' to 3'. It is mixed with a soft schistose rock with both foot and hanging walls being a granite-gneiss, which is typical of the area wherever an exposure may be seen. A large proportion of waste rock would have to be moved in order to recover a small amount of ore and in most cases it would be necessary to hand sort.

It is extremely doubtful that this deposit could be mined profitably to any extent. Crushed samples showed a very high proportion of fine flakes with little of the higher value coarse flakes. This deposit, however, readily exfoliates.

Another deposit located about 10 miles south of Tohamiyam shows the same conditions as the first one.

Roads to both deposits are very poor.

### Recommendations

It does not appear advisable at this time to consider exploitation of these deposits. At such time as a demand may develop for a low grade, impure vermiculite, further consideration may be warranted.

X. GYPSUM DEPOSIT

This gypsum deposit, approximately 20° - 30' N. latitude and 37° E. longitude, is located about 2½ miles northeast of the village of Eit, which is 50 miles north of Port Sudan on the road to Mohamed Qol. This property is under lease to Sayed Abdel Monim Samkart of Port Sudan.

The gypsum is exposed on the surface over an area of probably half a square mile and appears to be at least 15 feet thick. The color is grayish.

Sayed Samkart blasted some steep faces of ore exposed by water erosion up to depths of 15 feet and gypsum rock still showed continuation at that depth. The area surrounding the deposit is entirely sand with no other exposures nearby. The deposit extends to the west within a few hundred yards of the Red Sea.

Due to the low price of gypsum, this ore would have to be used for local consumption. Samples were taken for analysis to determine the grade and the CaSO<sub>4</sub> purity; the work to be done by the Geological Survey Department. However, these tests had not been performed at the writing of this report due to lack of technical personnel in the laboratory.

If developed, production would be an open pit mining operation consisting of drilling, blasting, power shovel, and trucks. Crushing and grinding would be dependent on market requirements.

Recommendations

1. Laboratory tests to determine quality and purity should be completed.
2. A market study should be undertaken to determine the country requirements for such industries as Portland cement, building blocks, wall board, ceiling board, plaster of Paris, mortar, fertilizer, etc. It must be noted that run-of-mine gypsum sells for approximately \$2 - 3 per ton.
3. A complete feasibility study would not be warranted unless an adequate market existed in the greater Khartoum area.

## XI. COPPER DEPOSITS

Two copper deposits, approximately 18° - 15' N. latitude and 36° - 45' E. longitude, located within 5 miles of Tohamiyam were examined. Very little exploration work had been done. This property is under lease to National Mining Company of Gebeit.

Where the rock had been blasted to 2 or 3 feet deep there was only a light malachite stain showing. The copper content of the rock would be very low.

It is possible that a better grade may be found at depth but a beneficiation plant to treat a copper ore would be impossible owing to present water shortage in the area. The Geological Survey Department has been drilling in the area so as to locate enough water for human consumption, but has had little success to date even for this basic requirement.

Surface showings do not indicate an extensive deposit and, therefore, the deposit does not appear to have any commercial possibilities.

### Recommendations

Natural copper ores cannot be economically shipped any great distance. The common practice is to install a concentration plant at the mine to up-grade the ore from the normal 1% - 5% copper content to 20% - 30% content. Large capital investment and large quantities of water and power are required for concentration.

Since this would be an export product, it is not considered feasible to consider development of any marginal copper deposits at this time, particularly poor ones such as these.

## XII. CONCLUSIONS AND RECOMMENDATIONS

### A. Promising Deposits

The asbestos, manganese, and gypsum deposits appear to be the most promising. In each case the reserves need to be determined and a market study accomplished. Subsequently, a complete feasibility study should be undertaken if the magnitude of reserves and the indicated market are satisfactory.

### B. Deposits for Which Market Studies Should be Made

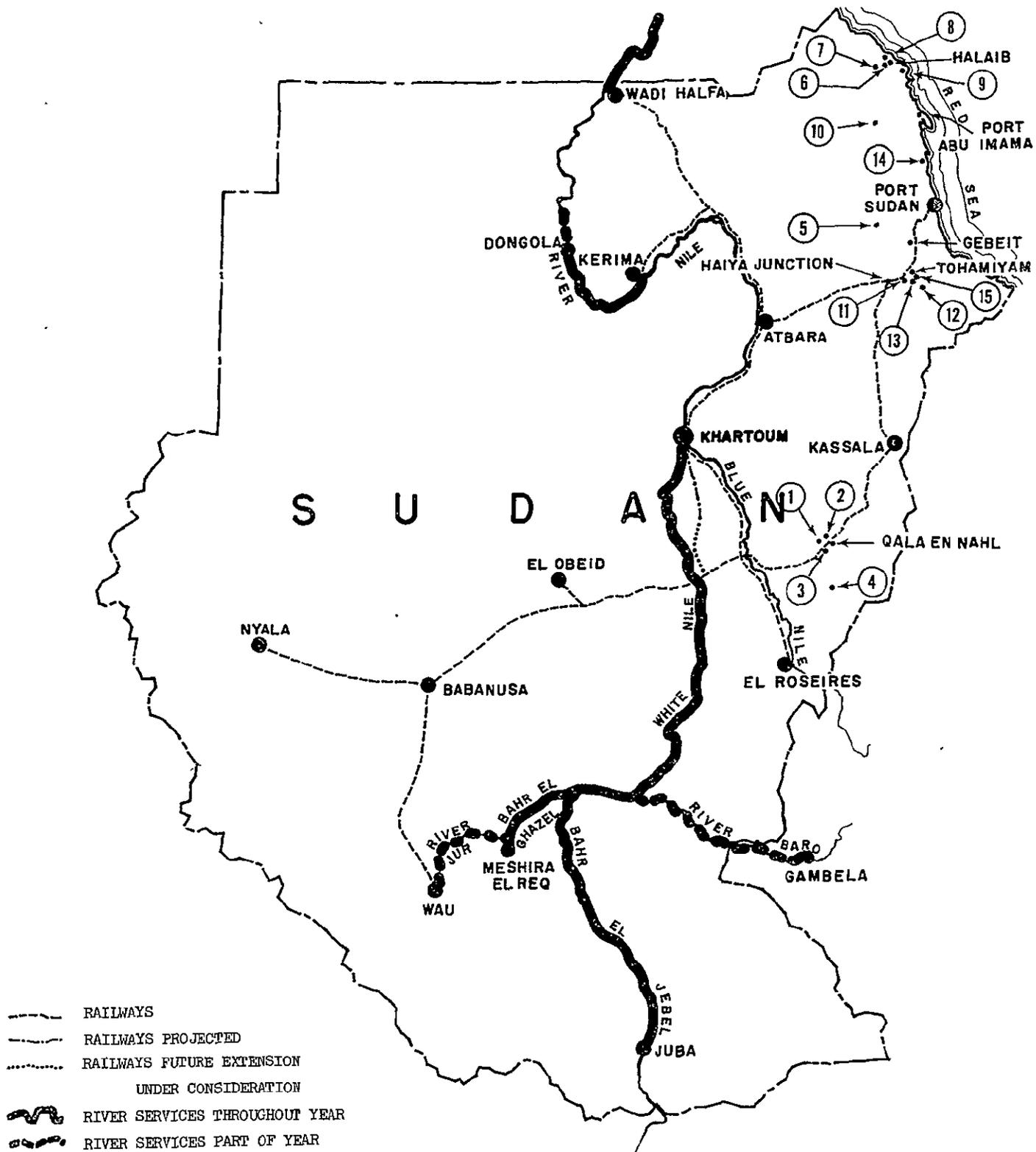
The further development of the gold and quartz mining operations does not appear to be warranted at this time. However, a careful market study is needed to verify this conclusion.

### C. Deposits for Which Further Studies Should be Deferred

The Fedikwan iron deposit study should be deferred until the outcome of the current negotiations is known.

### D. Deposits of Doubtful Value

The vermiculite and copper deposits do not appear at all exploitable, and no further study is advised.



- ① ASBESTOS - NO. 1 DEPOSIT
- ② ASBESTOS - NO. 2 DEPOSIT
- ③ ASBESTOS - NO. 3 DEPOSIT
- ④ ASBESTOS - NO. 4 DEPOSIT
- ⑤ MANGANESE - GEBEIT MINE
- ⑥ MANGANESE - AL AMAR MINE
- ⑦ MANGANESE - KALABEIT DEPOSIT
- ⑧ MANGANESE - SARARA DEPOSIT

- ⑨ IRON - FODIKWAN DEPOSITS
- ⑩ GOLD MINE - GEBEIT
- ⑪ QUARTZ MINE
- ⑫ VERMICULITE DEPOSIT
- ⑬ VERMICULITE DEPOSIT
- ⑭ GYPSUM DEPOSIT
- ⑮ COPPER DEPOSITS

FIG. 2

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#### XIV. ACKNOWLEDGMENTS

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