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# REVIEW OF GEOLOGICAL INVESTIGATION
# PROPOSED LIMESTONE QUARRY AND CEMENT PLANT
# OKHEIDER - RAMLIA AREA, EGYPT
# FOR UNITED STATES AGENCY
# FOR INTERNATIONAL DEVELOPMENT

**DAMES & MOORE**

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February 2, 1976

Department of State
Agency for International Development
Washington, D.C. 20523

Attention: Mr. L. E. Stanfield

Gentlemen:

We are pleased to submit herewith our report entitled "Review of Geological Investigation, Proposed Limestone Quarry and Cement Plant, Okheider -- Ramlia Area, Egypt for United States Agency for International Development". These reports are submitted in compliance with the requirements of Work Order No. 1, Contract AID/otr-C-1304, dated January 14, 1976.

From our evaluation we have found that the investigations performed by the Arab-Swiss Engineering Company have been properly conducted, that the limestone and clay raw materials are present in the required amounts and qualities and that there is reason to believe these materials are adequate to support the proposed Portland cement plant. Mining methods and equipment specifications are not sufficiently developed that we can comment on these.

We will be pleased to assist you in the future if there are further questions related to the deposit, the mining method or the proposed mining equipment. Additionally, if there are questions regarding this report, please call at your convenience.

Yours very truly,

DAMES & MOORE

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Principal-in-Charge

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Project Geologist

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# REVEIW OF GEOLOGICAL INVESTIGATION

# PROPOSED LIMESTONE QUARRY AND CEMENT PLANT

# OKHEIDER - RAMLYA AREA, EGYPT

# FOR UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

DAMES & MOORE

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## TABLE OF CONTENTS


| | Page |
|---|---|
| INTRODUCTION | 1 |
| Study Objectives | 1 |
| Scope of Work | 1 |
| Consultants' Activities | 2 |
| Summary and Conclusions | 4 |
| PROJECT DESCRIPTION | 5 |
| Proposed Project | 5 |
| Geology | 7 |
| Proposed Mining Methods and Crushing Facilities | 10 |
| LIMESTONE AND CLAY EVALUATION | 11 |
| Sampling Methods | 11 |
| Analytical Methods | 12 |
| Limestone and Clay Quantities | 13 |
| Limestone and Clay Quality | 14 |
| CONCLUSIONS | 16 |
| RECOMMENDATIONS | 18 |

# REVEIW OF GEOLOGICAL INVESTIGATION
# PROPOSED LIMESTONE QUARRY AND CEMENT PLANT
# OKHEIDER - RAMLIA AREA, EGYPT
# FOR UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

## INTRODUCTION

### Study Objective

This study was undertaken in order to assist the United States A.I.D. Mission in Egypt in evaluating the quantities and quality of limestone and clay deposits proposed for use as raw materials for a million tons per year Portland cement plant to be constructed in Egypt near the Suez Gulf. In addition, the proposed mining and limestone crushing methods were to be reviewed on a preliminary basis.

### Scope of Work

As outlined in our letter of proposal dated January 9, 1976, under the provisions of contract no. AID/otr - C-1304, Dames & Moore was to provide a geologist experienced in limestone evaluation to review the proposed Portland cement plant project near the Suez Gulf. Specifically, Dames & Moore was to provide the following services as detailed in A.I.D. Work Order No. 1, dated January 13, 1976:

1. Review and evaluate the exploration and investigation programs being conducted by the Arab Swiss Engineering Company to evaluate the quality and quantities of limestone and clays for a million tons per year Portland cement plant.
2. Review the information already compiled by the Arab Swiss Engineering Company regarding the reserves and their physical and chemical properties as raw materials for a million tons per year Portland cement plant.
3. Review and evaluate the proposed schemes and plans for mining and quarry operations with special attention to overburden removal and disposal from an environmental point of view. Review and evaluate the proposed preliminary crushing and grinding facilities.

## Consultants' Activities

In order to obtain a better perspective and more detailed background information on the proposed cement manufacturing project, interviews were held with a number of persons familiar with various aspects of the study to date. On January 17, 1976, a meeting was held at the Offices of the Arab

Swiss Engineering Company in Cairo. Present at this meeting were Messers. Omar Guemei, Managing director; Peter Maier, Technical Manager; Nabil El Hariri, Engineer; and Mohamed Osman Khalil, Geologist, all of the Arab Swiss Engineering Company; Philip Lewis, of the Agency for International Development/Cairo; and James Furlow, of Dames & Moore. Discussions at this meeting were mainly centered about the geology of the prospective quarry site and other items related to development of the limestone and clay deposits.

On January 18, 1976, Mr. Hariri and Dr. Mourad Ibrahim Youssef, Chairman of the Department of Geology at Ain Shams University and consultant to ASEC, escorted Mr. Furlow to the prospective limestone/clay quarry for an examination of the geology at the site. Mr. Furlow examined the limestone outcrops exposed in the face of Gamal Okheider (or Gabal El-Ramlia), the method of channel sampling the limestone, the drill rig engaged in clay core drilling, and cores taken in previous drilling.

On January 21, Mr. Hariri and Mr. Furlow met with Dr. Rushdi Said, Director of the Geological Survey of Egypt. After some discussion regarding the quantity and quality of limestone present in the Gabal Okheider/El-Ramlia area, and a tour through the Offices of the Survey, Mr. Hariri and Mr. Furlow met with Dr. Abdel-Aal Amer, Director of the Geological Survey Laboratories. At this meeting the procedures and

quality control measures used in chemical analysis of the limestones and clays were covered in some detail, followed by a complete tour through the analytical laboratories of the Survey.

## Summary and Conclusions

After reviewing the limestone and clay evaluation being conducted by the Arab Swiss Engineering Company, we have reached the following conclusions:

1. The sampling methods being used on both limestone and clay deposits are suitable for the preliminary investigation phase.
2. The chemical analysis methods being used are suitable for this and future phases of the investigation, provided present quality control measures are followed. The quality of analytical standards in use is excellent.
3. Both limestone and clay tonnages present substantially exceed desired reserve requirements.
4. On the basis of the preliminary evaluation, the quality of both limestone and clay deposits is suitable for the manufacture of Portland cement.
5. At this time, sufficient information is not available for a review of preliminary mining and

quarry operations or crushing and grinding facilities.

6. Project management and technical expertise in the exploration and preliminary evaluation phases of this investigation appear to be excellent.

In summary, we are of the opinion that the project is being well run, the raw materials are probably present in the required tonnages and quality, and there is an excellent probability that a successful Portland cement plant can be built using these raw materials as a source.

## PROJECT DESCRIPTION

### Proposed Project

The Portland cement industry in Egypt began production in 1900 with a 60,000 ton per year plant south of Cairo. At the present time there are four companies producing cement in Egypt, with a combined annual output of approximately 3.5 million tons per year.

Until recently, cement production in Egypt was adequate to satisfy domestic needs, and in addition, to provide substantial exports. However, following the 1973 war, plans were made to reconstruct damaged portions of the Suez Canal and facilities on the Sinai Peninsula. As a result, cement

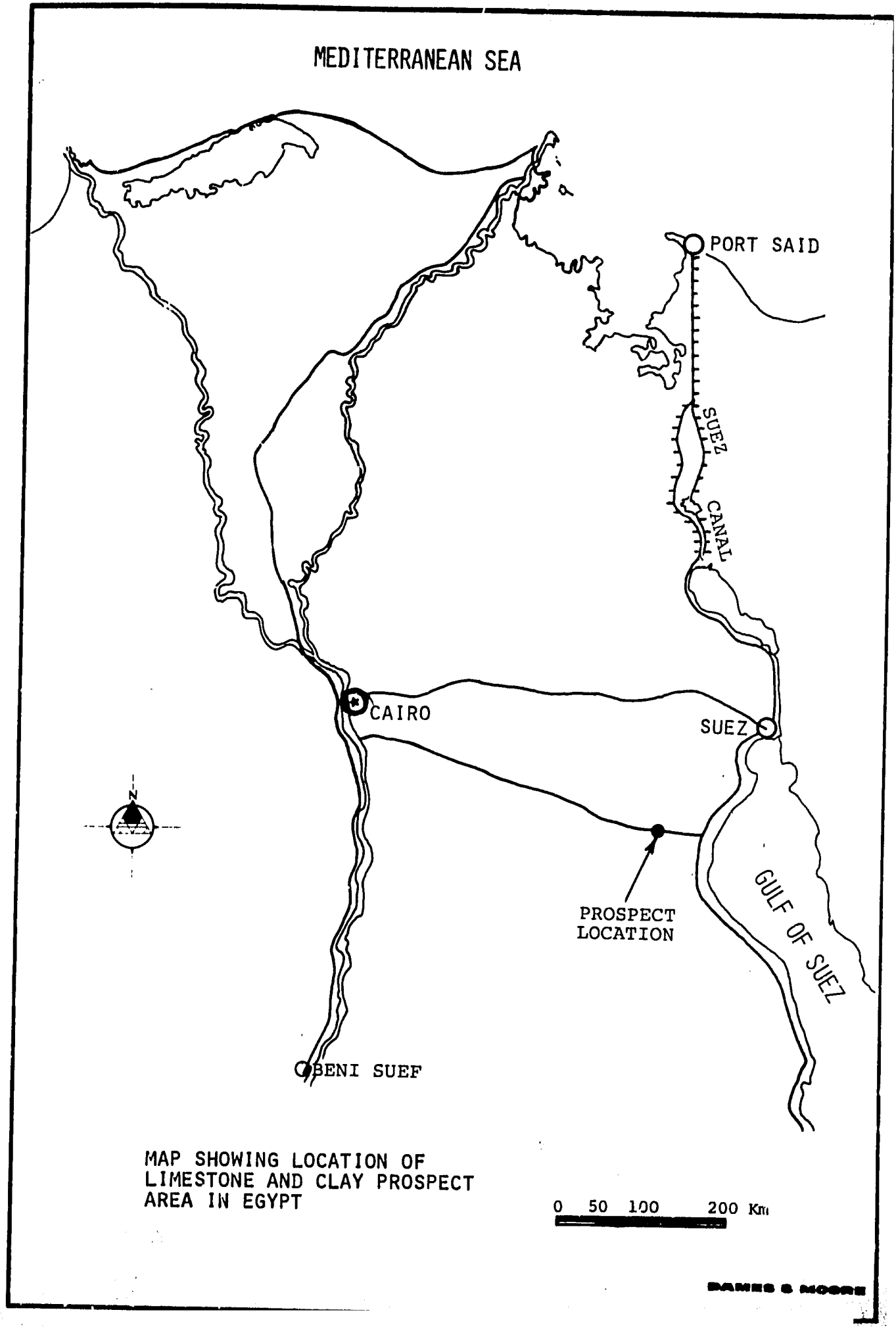
requirements in Egypt will exceed production rates for some years to come.

Due to the increased domestic cement requirements, the Egyptian Ministry of Housing and Reconstruction is attempting to increase production either by building new cement plants or by expanding existing plants, rather than import large quantities of cement. After some study, it was found to be more feasible to build a new plant rather than to expand existing plants to the required production.

It is estimated that in 1980 the cement requirements in the Suez Canal and Sinai Zone will be approximately one million tons per year, and will reach a maximum of 1.5 million tons in the year 1984. Accordingly, the desired capacity of the proposed plant was set at one million tons of cement per year to meet the regional reconstruction needs.

The Gabal Okheider area (or Gabal El-Ramlia area, as shown on more recent maps) (See Plate 1) was selected for a limestone exploration program for three main reasons:

1. Extremely large quantities of raw materials, i.e., limestone and clay, are known to exist in the area. In addition to Portland cement, there is a possibility of quicklime and white cement production from these materials.
2. The area, which is about 50 kilometers southwest of the City of Suez, is close to the Suez Gulf




MAP SHOWING LOCATION OF
LIMESTONE AND CLAY PROSPECT
AREA IN EGYPT

and the Red Sea, with paved access roads and a port at Adabiya. At the present time, other limestone deposits closer to Suez are not available for evaluation or mining due to national security restrictions.

3. Limestone reserves in the required amount of 200 million tons are not available in any one locality near Suez due to either excessive overburden or occupation by military forces.

The Okheider-Ramlia area is located about 40 kilometers by road southwest of the City of Suez, and 12 kilometers by road west of the Suez Gulf.

## Geology

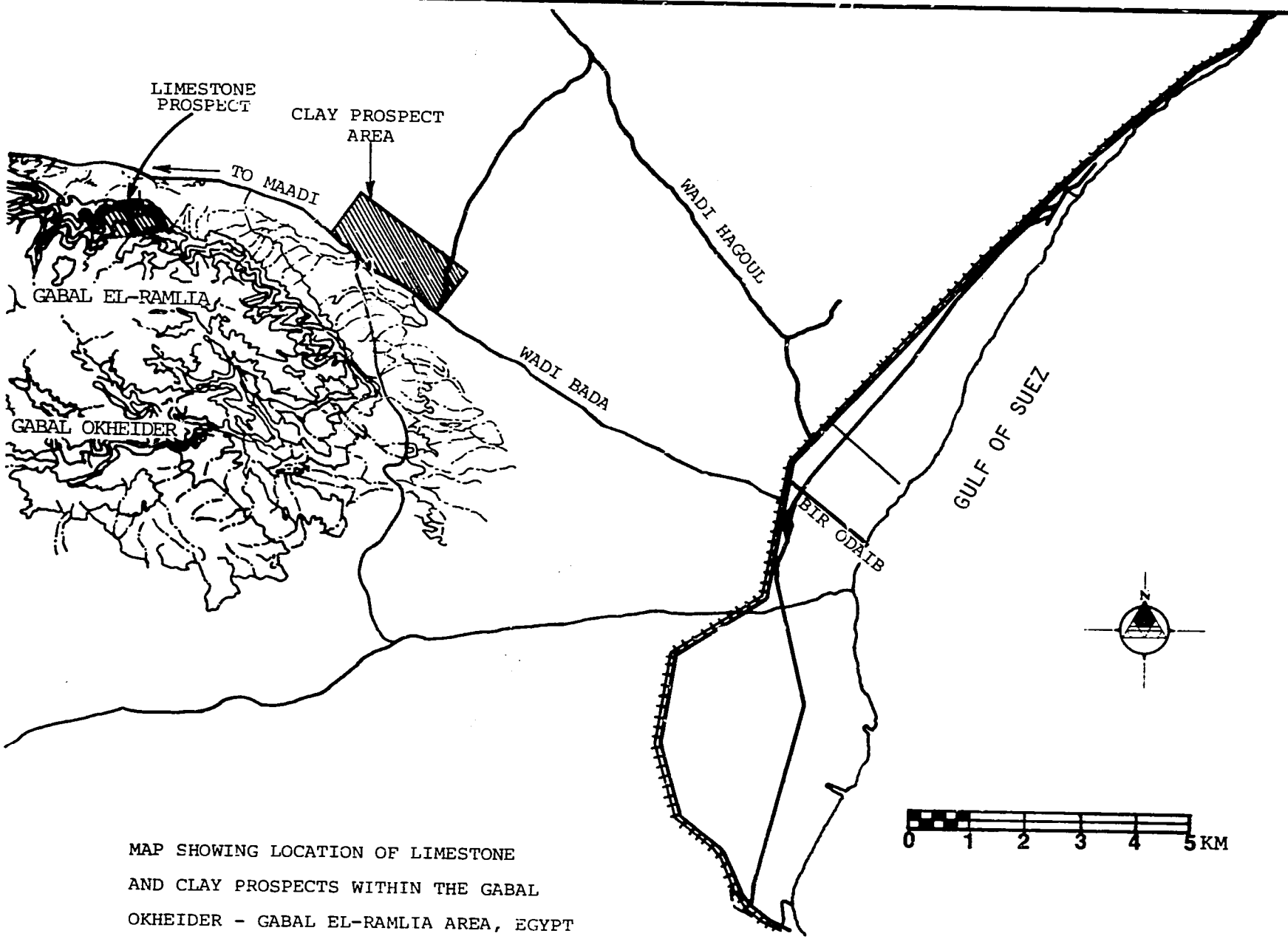
The Gabal Okheider (or Gabal El-Ramlia) mountains consist of a large uplifted fault block, in which most exposed rocks consist of limestone of Eocene age. The northeastern face of the mountain range is a fault scarp that rises as much as several hundred meters above the plans of Wadi Bada and Wadi Hagoul.

Various clays and limestones of Miocene age underly the surface of the plains to the north and east of the mountains. Near the base of the mountains, alluvial material overlies the clays and fills dry washes cut down into the Miocene sediments.

Faulting and uplift of large blocks into mountain ranges probably began in late Miocene time and may have continued into the Pliocene; softer Miocene clays and less resistant sediments were eroded from underlying Eocene limestones as the fault blocks moved upward and are no longer present in the mountain areas. Within the larger uplifted fault blocks there are numerous smaller faults that may locally show vertical displacement on the order of tens of meters.

The original area selected for exploration within the Gabal Okheider - Ramlia area lay at the eastern edge of the mountain range. An extremely thick sequence of limestone exposed here appeared at first to present an excellent prospect. After further investigation, however, it was found that a bed of limestone some 11 meters thick near the top of the sequence contained large quantities of chert nodules. Selective mining and removal of this bed would be not only physically difficult but also expensive. In addition, utilization of the chert-bearing limestone for cement manufacture would be expensive in terms of excessive wear and increased maintenance on crushing and grinding equipment.

For this reason, therefore, an effort was made to locate a block of limestone within the range that did not contain the chert-bearing bed. Such an area was located about 3 kilometers from the southeastern edge of the range, on the northeast face (See Plate 2 ). Within this area the chert-




MAP SHOWING LOCATION OF LIMESTONE AND CLAY PROSPECTS WITHIN THE GABAL OKHEIDER - GABAL EL-RAMLIA AREA, EGYPT

DAMES & MOORE

bearing limestone has apparently been removed by erosion. The thickness of potentially suitable limestone exposed above the plain in this block ranges from 112 to 170 meters. As a result of successfully locating the block of limestone devoid of the chert-bearing horizon, further evaluation efforts were concentrated on this one area.

The limestone exposed at the potential quarry site is Eocene in age, lithologically uniform, massively bedded, and contains no interbedded shales or sandstones within at least the upper 150 meters. The limestone is white in color on fresh surfaces, moderately friable, and relatively unleached.

The block of limestone tentatively selected for mining is bounded on the north by the eroded fault scarp along which the range was uplifted, and on the east and west by deeply entrenched drainage gorges. The block is connected on the south to the main portion of the range by the uneroded continuation of the near flat-lying limestone beds.

Slopes on the three free sides of the block are steep, in some areas nearly vertical. The steep slopes, combined with a vertical difference in elevation of about 200 meters from bottom to top, make access difficult.

To the north and east of the prospective quarry site Miocene sediments have been preserved over a large area of the Plains of Wadi Bada and Wadi Hagoul, which lie only a few feet above sea level. These sediments consist mostly of various

clays, although there are some interbedded limestones and sandstones present. Dips in these sediments are near-flat. The Miocene sediments are underlain at depth by Eocene limestones similar to those exposed in the mountains nearby.

Lithologically, the Miocene clays range from sandy clay to silty clay to clay containing little or no sand or silt. The silty clays appear to be most predominant in the area.

Exposures of Miocene sediments occur locally in dry washes and on the flanks of low hills, but for the most part are covered by a thin overburden of sand, which may range in thickness from a few centimeters to several meters.

## Proposed Mining Methods and Crushing Facilities

At this stage of the project, neither specific nor general information on proposed mining methods or limestone crushing equipment is available for review. A preliminary mining plan will be drawn up in the near future, however, and once phyisical testing of limestone samples is completed, the size, type and number of stages of crushing equipment required can be determined. Such testing will be completed soon, and equipment selection will then begin.

## LIMESTONE AND CLAY EVALUATION

### Sampling Methods

The large block of limestone selected for a potential quarry site is inaccessible to wheeled vehicles due to the steep slopes involved. Although a substantial attempt was made to locate an access route across the connecting extension of limestone beds, it was not possible at this time to get a vehicle up to that area either. Therefore, as an alternative to core drilling, it was necessary to devise a different method of sampling that would provide reliable preliminary evaluation results. The method selected was that of channel sampling the limestone beds from bottom to top at a number of localities. Due to the presence of deep erosional gorges, it was possible to sample the limestone block on three sides. A total of seven channels are presently being hand-dug to unweathered rock at a spacing of about 400 meters. Continuous samples are being taken along the entire length of each channel for chemical analysis. Channel sampling for analysis by the method used is, in general, considered an acceptable technique for preliminary geological evaluation.

Clays in the area were initially sampled by digging trenches and test pits by hand. More recently, however, two

drill rigs have been brought on site. At the present time, only one rig is operating because of the lack of a second crew. The operating drill rig is currently taking 135-millimeter diameter cores of the underlying Miocene sediments to a depth of approximately 40 meters. Drilling is presently proceeding on a 200-meter grid, and will go to a 100-meter grid in the more promising areas. Cores are placed in labeled boxes in a central storage area and sampled for chemical analysis.

## Analytical Methods

Limestone and clay samples are presently being processed and analyzed by the Egyptian Geological Survey in Cairo. Duplicate analyses of randomly selected samples are performed at the laboratories of the affiliated Holderbank Management and Consulting Company in Aargau, Switzerland, as a means of quality control. Analyses are all done by the wet chemical method, which is generally considered standard for limestone analysis. The quality of analysis performed by the Egyptian Geological Survey appears to be excellent, with a good system of internal quality control checks.

## Limestone and Clay Quantities

In order for the proposed cement plant to have an output of one million tons of cement per year, it must have an input of approximately 1.7 million tons of raw materials per year, of which approximately 80 percent will be limestone and 20 percent will be clay.

The Arab Swiss Engineering Company has assumed a 50-year operating life for the cement plant, with the possibility of double the original desired capacity for that 50-year period Therefore, the required reserve tonnage of limestone for cement production is about 135-150 million tons over the life of the plant, allowing for some wastage.

In addition, there is a strong possibility that the plant may also produce quicklime. Should this occur, an additional reserve of 50 million tons will be required. Total limestone reserve requirements, therefore, are approximately 200 million tons.

Assuming an average length of the limestone block selected as a quarry site of 1.5 kilometers, an average width of 800 meters, and an average mineable limestone thickness of 150 meters, the estimated limestone reserves are approximately 320,000,000 metric tons. Such a reserve tonnage is more than adequate to meet the needs of the proposed Portland cement plant.

Required clay reserves for cement manufacture will be approximately 35 million tons for a 50-year operation at double capacity. Although delineation of suitable clay sources and tonnages has not been completed at this time, there appears to be no reason to doubt that adequate reserves of acceptable clay materials can be obtained from the extensive Miocene sediments present in the area.

## Limestone and Clay Quality

The quality of limestone exposed in outcrop at the proposed quarry site is excellent. For example, in one section averaging about 145 meters thick, the average values of seven composite samples are as follows:

| Constituent | Average Percent |
|---|---|
| $SiO_2$ | 0.65 |
| $Al_2O_3$ | 0.09 |
| $Fe_2O_3$ | 0.09 |
| CaO | 53.03 |
| MgO | 1.59 |
| $SO_3$ | 0.13 |
| $Na_2O$ | 0.07 |
| $K_2O$ | 0.01 |
| Cl | 0.06 |
| L.O.I. ($CO_2$) | 43.67 |
| Total | 99.39 |

Mathematically converting CaO to $CaCO_3$ yields a theoretical calcium carbonate content of 94.7 percent, which is a chemical or metallurgical grade limestone, significantly better than required for the manufacture of cement. The ratio of $SiO_2$ to $Al_2O_3 + Fe_2O_3$ is in the desired vicinity of 3:1; $SO_3$, $Na_2O$, $K_2O$ and Cl percentages are all relatively low. The only constituent that becomes somewhat undesirably high is MgO, mainly in the lower portion of the limestone sequence. If mining methods are used that will allow mixing of the upper and lower limestones to some extent, the MgO content of the lower portion will not be high enough to cause quality control problems in the manufacture of cement. Other than this one consideration, which can be dealt with, the quality of limestone at this locality appears to be quite suitable for Portland cement manufacture.

The quality of clays present in the area is more variable than that of the limestone. The main variable in the clays is the proportion of silica present in greater or lesser degree both horizontally and vertically. These sediments may range lithologically from a clayey sand or silt to a clay containing practically no sand or silt.

An effort to better delineate the more suitable clay horizons and localities is currently in progress. Based on the results of test pit and core drill sampling to date, there appears to be a good potential for locating adequate reserves

of the more desirable type of clay, which should contain not more than about 65 percent $SiO_2$ and not less than about 12 percent $Al_2O_3$.

An interim report on recent analysis of limestone and clay samples should be forthcoming from the Arab Swiss Engineering Company by the middle of February. This report will detail the results of the limestone channel sampling and clay core drilling programs up to the present time.

## CONCLUSIONS

Based on our review of progress and findings of the Arab Swiss Engineering Company study to date, we have reached the following conclusions:

1. Access to the top of the limestone ridge by wheeled vehicles is not possible at this time. Future access for purposes of core drilling must be either by helicopter or construction of a road to the top.
2. The sampling methods being used on both the limestone and clay deposits are suitable for the preliminary evaluation phase of this project.
3. Chemical analysis methods used to analyze limestone and clay samples are suitable for this and future phases of the investigation, provided

quality control measures presently being used are maintained. The quality of chemical analysis standards being used by the Egyptian Geological Survey is excellent.

4. Project management and technical expertise in the exploration and preliminary evaluation phases of this project appear to be excellent.
5. Limestone tonnages present are more than adequate for the possible required maximum reserve of 200 million tons.
6. Limestone quality, on the basis of preliminary data, is excellent. The lower portion of the limestone is somewhat high in MgO content, but blending of this material with that from higher up will result in an acceptable raw material product for cement manufacture.
7. Adequate reserve tonnages of suitable quality clay are most likely available in the area presently being investigated, but have not yet been proven out.
8. At the present time, sufficient data does not yet exist to allow a review of proposed mining methods or crushing and grinding facilities. When physical testing of the limestone is completed in the near future, such information

will be developed by the Arab Swiss Engineering Company.

## RECOMMENDATIONS

The following recommendations are intended to ensure that the limestone and clay evaluations, quarry planning and crushing and grinding equipment selection processes are carried out in an orderly sequence of events. In most cases the Arab Swiss Engineering Company has previously planned to follow this general line of approach. Our recommendations serve to specify what we believe to be necessary for the next phase of investigation.

1. Representative raw materials consisting of both limestone and various available clays should be submitted for physical analysis and processing in a pilot plant. Until this is done, little can be accomplished towards equipment selection and design of crushing and grinding facilities.
2. The next phase of more detailed limestone evaluation should consist of core drilling on top of the limestone ridge at the prospective quarry site. In order to core drill, it will be necessary to either carry a drill rig to the top of the ridge by helicopter or blast and cut a road

to the top. Of the two choices, cutting a road would be preferable, if time permits.

3. Delineation of various clay types and reserve tonnages should be completed as soon as possible. At the present time, although two drill rigs are at the site, only one is operating, due to lack of a second crew. If possible, a second crew should be obtained to man this rig for clay exploration drilling.

4. A preliminary mining plan, including transportation of limestone to the crusher and tenative selection of mining and crushing equipment, should begin as soon as physical testing of raw materials in a pilot plant is completed. Since most equipment used in this project will be purchased in the United States, it is strongly recommended that an American mining engineer familiar with available American equipment and current prices be made available for consultation with the Arab Swiss Engineering Company during a portion of the mine planning and equipment selection processes.

5. In order to facilitate making a final judgement on the overall suitability and acceptability of raw material reserves and mining/crushing methods,

the above-cited actions, which constitute the next phase of investigation, should be accomplished. As this information becomes available, it should be forwarded to the geological consultant for review and comment.

6. Immediately prior to making a decision on funding for this project, both the geological consultant and mining engineering consultant should return to Cairo for a review of findings, proposed methods of operation, and equipment selection.