وزارة الطاقة والثروة المعدنية

الجرانيت-شرق العقبة-بركات-1988

THE HASHEMITE KINGDOM OF JORDAN

MINISTRY OF ENERGY AND MINERAL RESOURCES

NATURAL RESOURCES AUTHORITY

MINING DIRECTORATE

MINES DIVISION

FIELD STUDY OF MEDIUM TO COARSE-GRAINED CRUSHED ALKALI GRANITE DEPOSIT OF EAST AQABA AREA

PART I

PREPARED BY :

GEOL. HAZEM BARAKAT

September 1988

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PROJECT STAFF :- ENG. M. HADDAD.

ENG. S. ABU ALIM.

GEOL. H. BARAKAT.

ENG. M. HAMMORI.

I. ACKNOWLEDGEMENT

The authors wish to express their deep gratitude to His Excellency, The Minister Of Energy and Mineral Resources Dr. Hisham El Khatib, The Director General Of N.R.A., Eng. Kamal Jreisat and to the Deputy Director General, Eng. Muhammed Abu Ajamieh. For the apportunity they gave us to undertake this work and for their continuous support during the implementation of this project.

Thanks are due to the Head Of Mining Directorate, Eng. Kasim Omari for his supervision of the work and reviewing this report.

Thanks are also due to the Head Of Mineral Laboratory Division and to the Head Of Geological Mapping Division and to their collegues in the Chemical Analysis and Petrographic Sections.

II. SUMMARY

The area of medium-grained crushed alkali granite, is located 8km. East Of Aqaba. It is enclosed within the following coordinates:

152.0 - 157.0 E

878.0 - 887.0 N (Palestine Grid).

This area which was previously recommended by Rashdan and Mortimer, 1985 has been studied in details in order to see the possibility of utilizing the medium grained crushed alkali granite as a source of feldspar for industrial uses especially for glass and ceramic industries.

During field work, 232 sample locations were dug in the investigated area for the extraction of samples.

179 fresh samples were collected representing the whole studied area, they have been chemically analysed at the NRA, Laboratories for the following minerals:

L.O.I., SiO_2, Fe_2O_3, TiO_2, MgO, CaO, MnO, Al_2O_3, Na_2O and K_2O .

Average assays for the northern-central part and southern part were calculated.

Five hand specimens were mineralogically studied by the Petrographic Section Of Geological Directorate.

Three composite samples were collected from the studied areas for laboratory beneficiation studies.

Results of mineralogical and chemical analysis studies indicated that the alkali-granite rocks of the investigated area are more or less, homogenous and regular in chemical and mineralogical composition.

The chemical assay results of the medium to coarse-grained alkali granite, showed that can be a source of medium grade feldspar without treatment.

The utilization of this raw material after the process of micronization only should be regarded. This fact is due to the uniform distribution of the dark minerals in the mixture.

This raw materials may be utilized as it comes from the quarry is in the coloured glass and medium quality ceramics. However to meet the required specifications for white transparent glass, fine ceramics and other industrial uses beneficiation of the raw materials (heavy liquid

separation, differential floatation, and high intensity electro-magnetic separation) will be necessary. Beneficiation will increase the alkali content (K_2O and Na_2O) and considerably decrease the content of mafic minerals.

This project started on 15th December, 1987 and was completed at the end of May, 1988.

Part II of this report covers a comprehensive beneficiation studies carried out by NRA at the Research Center in Ruseifa of Jordan Phosphate Mines Company.

III. INTRODUCTION

Feldspar is the most important single group of rock forming silicate minerals. There are four chemically district groups of feldspar : Potassium feldspar ($KAl\ Si_3O_3$), Sodium feldspar ($Na\ Al\ Si_3O_8$), Calcium feldspar ($CaAl_2$, Si_3O_8) and Barium feldspar ($Ba\ Al_2\ Si_3O_8$).

Sodium and Calcium feldspars form a continuous series of solid solution which are termed plagioclase feldspar.

About 90% of produced feldspar is used by the glass and ceramic industries. Soda feldspar is preferred in glass manufacture, but potash feldspar is more popular for ceramic.

In Jordan, the feldspars deposits are found in the alkali granite rocks, Leucogranite, feldspar pegmatites, and alkali-rich granites, which occurring as medium and coarse-grained, light-coloured igneous rocks such as aplites and alaskite respectively which have a granite composition but are characterised by low levels of mafic (iron-bearing) minerals.

Purpose Of Study.

The project aims to study the crushed feldspar occurrences in the Aqaba region in order to see the possibility if utilizing the feldspar raw materials to produce potassium feldspar, sodium feldspar, or combined feldspar for different

IV. LOCATION AND ACCESS

The studied area is located in South Jordan (fig.1), it can be reached from Amman by the Desert Highway, 8km. east of Aqaba City.

The studied area extends northwards from Wadi El - Jashieh in the south to Wadi Al-Yutum in the north, which is enclosed within the following coordinates:

152.0 - 157.0 E
878.0 - 887.0 N (Palestine Grid).

The northern and southern parts of the area are easily accessible by standard four-wheel drive vehicles, while the central part of the area can only be traversed on foot.

There are no settlements within the boundaries of the study area, however, only some nomadic Bedouins are inhabiting the area especially during winter time.

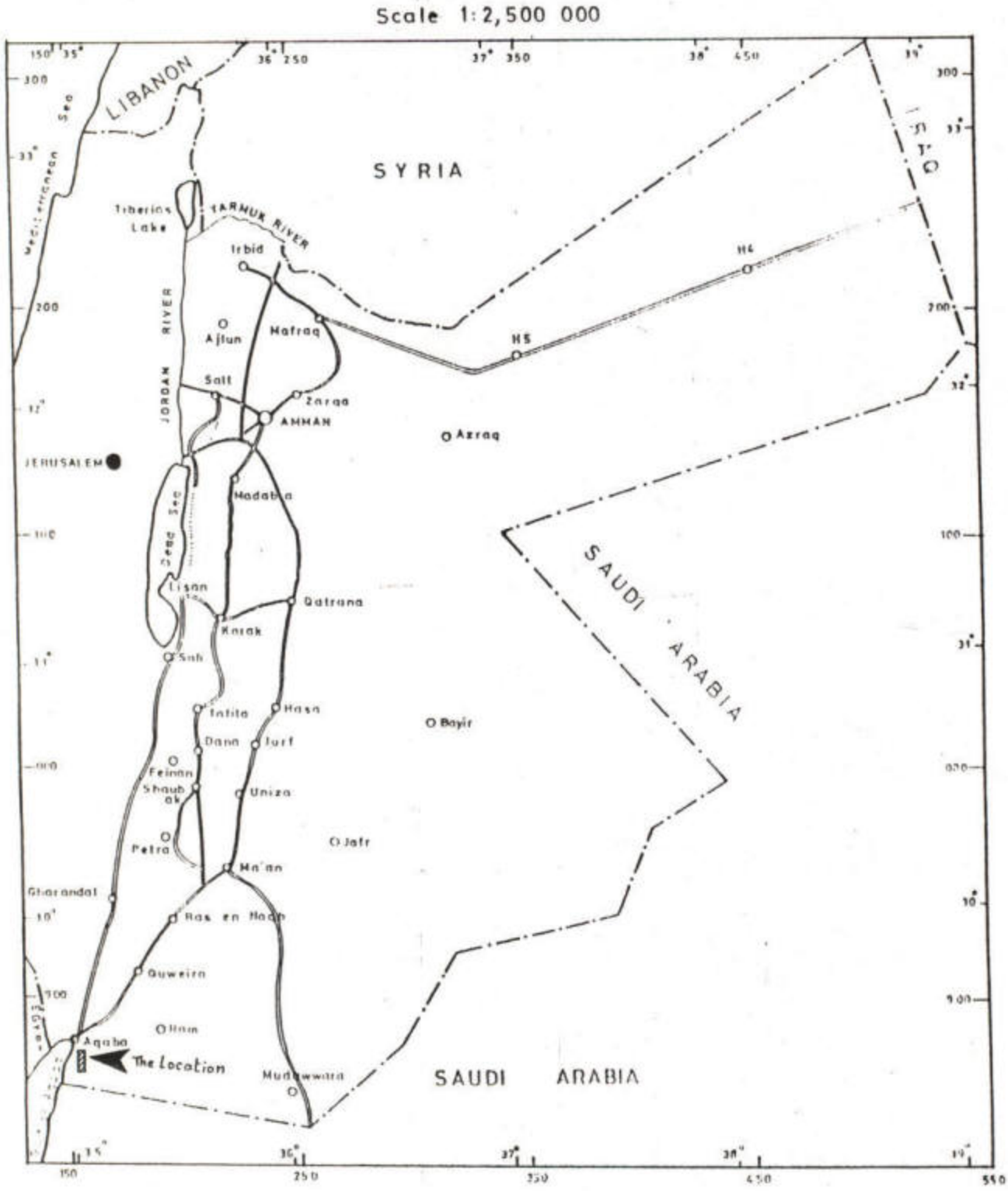


Fig. 1 : LOCATION MAP

V. TOPOGRAPHY-CLIMATE AND VEGETATION.

Topography.

The area varies in elevation from 200m. to 500m. Relief is highly intensive with rugged mountains and flat bottomed wadis. Those wadis are dry during summer-times and occasionally flood in winter seasons depending on the amount of rainfall.

Climate and Vegetation.

The average annual rainfall in the area is less than 50mm. in winter months from September until April. Summers are hot and dry and the evaporation is high.

VI. PREVIOUS STUDIES.

Research on the feldspar in South Jordan started on October, 1968. And a preliminary report was prepared by Pacal Z. and Gharaibeh R. 1968.

Based on a request from the Ministry of Industry and Trade, the research continued in the granitic complex which has a very large extent in South Jordan. A report on the results of the studies was presented in 1969, by Pacal Z. and Gharaibeh R. the report indicates the presence of good quantities of leucogranite as a source rock favourable for feldspar mining and production. It has found also that some other types of granite, especially the medium-grained alkali granite, can be considered as a good source for feldspar, this report as well as the report of Walid Hakki (1976) recommended to carring out detailed studies in some localities in South Jordan.

Up grading research, on some of the samples taken from different localities, was carried out in the NRA Laboratory. A report on these researches was prepared by M. Haddad 1972.

Swindell-Dressler Company carried out a feasibility study to extract the feldspar on a pilot plant level (1972).

A study for the exploitation of feldspar deposit in the El Quweira Area was done by Technostone S.P.A. Carrara Italy for the Public Mining Company Ltd. in 1984.

A preliminary study by Rashdan and Mortimer, 1985 indicated that analysis of material from crushed granite were favourable for commercial feldspars, and recommended to carryout a detailed studies in the area 8km. east of Aqaba.

VII. GEOLOGY-STRUCTURE AND MINERALOGICAL STUDIES.

A) Geology And Structure.

In general the rocks outcropping in Aqaba area are predominantly igneous in origin, specifically plutonic granitoids, and are late proterozoicin age. These granitoids, along with minor, older metamorphic rocks and abundant post-plutonic dykes comprise the Aqaba complex (Rashdan, 1988).

The investigated area consists of the Yutum granites suite, which is the youngest and volumetrically the most important plutonic phase recognized.

It varies in composition from monzogranite to alkali-feldspar granite and is coarse-grained equigranular to aplitic in texture. The dominant unite is the medium to coarse-grained, massive equigranular, biotitic Abu Jedda Granite which varies from monzogranite to syeno-granite and is distinguished from the Imran Monzogranite on colour index and the presence of spars hornblende.

Major faults are oriented in four directions NNE-SSW parallel to the Wadi Araba Rift, NE-SW approximately E-W and NW-SE, faults are vertical to sub-vertical.

The geologic map fig.(2) of the studied area, shows the relationship between the structure and feldspar mineralization, feldspar occurs in a fault zone (0.5-1.5km. wide), trending NS to NNE. The fault zone consists of three more or less parallel normall faults.

The feldspar mineralization was affected by faults trending EW to NW.

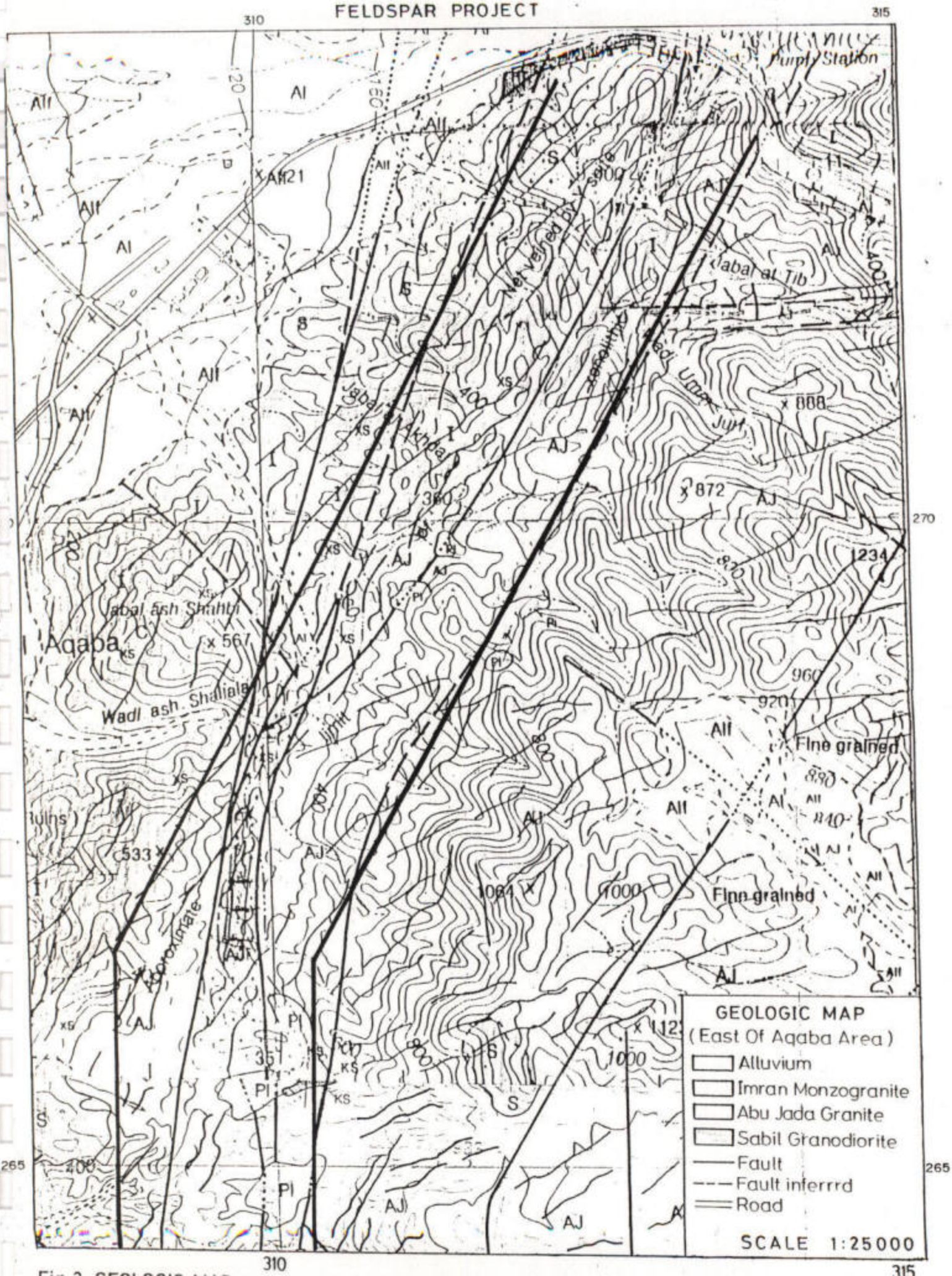


Fig 2 GEOLOGIC MAP

B) Mineralogy.

Sample No. M1, M2, and M3.

1) Nomenclature.

Syenogranite to monzogranite.

2) Magascopic Characteristics.

The samples are medium to coarse-grained, phaneritic and pinkish-coloured hololeucocratic granite, with wormy clusters of subhedral, smoky to milky quartz crystals. The rock is almost not fresh.

3) Microscopic Characteristics.

The rock is holocrystalline and medium to coarse-grained. The most dominant texture is the perthitic intergrowth of orthoclase and albite plagioclase, intergrowths between microcline and orthoclase are less common. There is also a granophyric texture seen as radiating intergrowths of quartz arranged about euhedral equant plagioclase crystals.

4) Mineralogic Constituents.

According to the results obtained from the automatic point counter, the average percentage of perthite is 4.0. It occurs as anhedral crystals, very commonly with Carisbad twinning and hosts biotite, opaques and small crystals of plagioclase. Grain size average is between 1.2 mm-7.5mm. A bleb-like intergrowth occurs between quartz and perthite, and there are small isolated crystals of quartz between perthite crystals. The Lamellae of albite in perthite are altered to clay minerals. Microclinewas also recorded.

The average amount of quartz is 27.0 percent. A few crystals of quartz are ambayed in perthite, at the boundary of the crystals as an interfingering. It occurs as

clusters with sutured boundaries. Grain size is between 0.8mm. - 3.6mm., the quartz hots small fresh crystals of muscovite.

The average plagioclase content is 26.0 percent of the rock, myrmekitic texture is very common, in which crystals of plagioclase contain irregular, rod like inclusions of quartz. Kaolinitization and sericitization has taken place, and increases towards the crystal centers. There are remnants or frames of plagioclase crystals still found with the original crystals changes to perthite. Grain size is between 0.4mm.-3.6mm. zoning is common, and there are inclusions of biotite.

The average amount of biotite is 7.0 percent. It occurs as anhedral tabular crystals, partially altered to chlorite especially along the cleavaege, and hematite. It contains euhedral prismatic crystals of apatite, zircon and magnetite. Grain size is between 0.3mm.-1.9mm. Hornblende has not been noticed in the samples. Secondary minerals are chlorite, epidote and hematite which occur predominantly in sample no. M1.

5) Comments.

The petrographic affinities of the samples are very similar to those for Abu Jadda Lethodeme.

Slide No.: C 45-8

Rock Name: According to the strekeisen triangular, the name of the rock is monzogranite.

Texture:

1) Perthitic texture.
2) Poikilitic texture.
3) Consertal texture.

Mineralogy:

1) Quartz: It is the major mineral, medium-grained (grain size varies from 1.20-3.20mm.), anhedral grains it is about 35.9 percent of the rock, highly fractured.

2) Alkali-feldspar: Orthoclase and perthite are the most common of k-feldspar, occurs as an anhedral, medium-grained (grain size range between 0.95-2.95mm.) fractured and weathered showing carlsbad twinning. It is about 42.6 percent.

3) Plagio-clase: It is about 20.6 percent, medium-grained (grain size range between 0.5-2.5mm.), subhedral grains, showing polysynthitic according to albite law.

4) Biotite: It is about 0.80 percent of the rock, dark brown color, and also there is chlorite found as alteration product of biotite.

Accessory Minerals:

1) Apatite:

2) Zircon: Both minerals are found as an inclusion in biotite.

3) Opaque Minerals: Spreaded in the rock.

Slide No. : C 43-4

Rock Name: According to the strekeisen triangular the name of the rock is monzogranite.

Textures:

1) Consertal texture.
2) Microperthitic texture.
3) Poikilitic texture.
4) Micrographic texture.

Mineralogy:

1) Quartz: Found in medium-grained (grain size range between 0.90-1.60mm.), anhedral, nearly fresh, the average percent is 25.5.

2) Alkali feldspar: Orthoclase and perthite are the most common type of alkali feldspar, anhedral grains, medium-grained (grain size range between 1.70-400mm.). It is make up 48.9 percent, showing carlsbad twinning.

3) Plagioclase: Found in subhedral grains, medium-grained (grain size range between 1.20-2.70mm.), showing albite twinning, highly weathered altered to sericite.

4) Biotite: It is found in percent 4.5, dark brown color, partially altered to chlorite.

Accessory Minerals:

- Apatite:

- Zircon: The both minerals are found as an inclusion in biotite.

- Opaque Minerals: Spreaded in the rock.

VIII. FIELD WORK

A) Reconnaissance Studies .

Reconnaissance studies have been carried out for the studied area and included the followings :

- Field abservations
- Study of the aerial photographs and topographical maps.
- Mapping the crushed feldspar zone on scale of 1:25000 fig.No. 2

The crushed granite zone covers an area of approcimately 8 sq.kms. It has a length ranging between 8-10 kms and a width ranging between e.s-1km.

The investigated zone is restricted between two major faults , almost parallel to each other . This area is largely affected by the tectonic movements and caused of many minor faults on the intersection zone (crushed-zone) . The grinding action of relative block movements has locally crushed and pulverized the granite to coarse-medium and fine grained.

The studied area was divided along the crushed zone strike to three parts (sub-areas) , northern , central and southern part , due to their accessibility and the nature of the alkali granite rocks as follows :

1- Northern Part .

The northern part is located between Wadi Um Nuseila and Wadi Yutum , about 5 km . length .

2- Central Part.

The central part is located between Wadi Al-Jashiah and Wadi Ash Shaliala , about 2 km. length.

3- Southern Part.

The southern part is located between Wadi Al-Jashiah and the new high way , about 1-1.5 km. length .

B) FIELD WORK.

1) Northern Part : (ore Body II).

The occurrences of the crushed alkali granite in this part is characterized by the intensive green dykes (doleritic dykes) joints and to a lesser extent by crushed rocks. It is favorable for selective mining. This part is not largely affected by the tectonic movements which took place in the studied area.

78 samples were taken from different locations depending upon the distribution of the crushed alkali depending upon the distribution of the crushed alkali rocks. All samples were analysed at NRA Laboratories for the following minerals SiO_2 , CaO , MgO , Al_2O_3 , Fe_2O_3 , K_2O , Na_2O and TiO_2. The results of chemical analyses of the northern part showed that the average is as follows :

Minerals	Average Assay %	
Na2O	4.99	
K2O	4.17	9.16 Total Alkali
Al2O3	13.63	
SiO2	71.36	
Fe2O3	1.41	Impurities
MgO	0.43	
TiO2	0.56	Mafic Minerals
Mn	0.03	

Following the classification given in the attached memorandum these crushed alkali - granite could be considered as raw materials for medium grade feldspar

Table (2)

The best part of the northern area is the adjacent part to the central area due to the total alkali in the first twenty samples taken from this part as shown in table 2 . This part equel to one quarter of the northern area .

2) Central Part : (Ore Body I).

It is the most important part of the studied zone for less intensive dykes and joints. This part is largely affected by the tectonic movements . The grinding action of

relative block movements has locally crushed and pulverized the granite to coarse-medium and fine grains.

69 samples were collected from different locations in this part . Chemical analysis results of the 69 samples showed that the average assay in percentage of the different minerals of this part is as follows :

Minerals	Average Assay %	
Na2O	5.85	Total Alkali
K2O	4.35	10.20%
Al2O3	13.95	
SiO2	67.37	
Fe2O3	2.32	
Mgo	0.65	
TiO2	0.60	
Mn	0.005	
CaO	1.35	

Table (1) shows that the results of the chemical analyses of the mineral content of the central part are homogenous average total alkali is 10.2 and silica centent is 64.4 .

The central part is more favorable for exploitation for the feldspar raw materials for the following reasons :

1- More accessable .
2- More crushed and ground friable deposits.
3- Less dykes .
4- Less explosives consumption.
5- Easier explosives consumption.
6- Alkali content is high.
7- Mining + beneficiation costs are low.

3) Southern Part : Ore Body III

This is the smallest part of the studied areas and looks like the central part from the point of dykes and joints. Tectonic movement gently affected this part.

33 sample locations were dug in this part.

Equipment used during fied work :

The following equipments were used during field work in order to enable the field staff to take fresh samples from the crushed granite zone.

- Chisels
- Hand hammers.
- Comprssor
- Jack - hammers

All samples locations were marked in numbers.

Project Staff.

1) Three Mining Engineers.
2) One Geologist.
3) Ten Labours.
4) Two Drivers.
5) One Communications Man.

C) Composite Samples Preparations.

Three composite samples were collected and prepared in the field. The three composite samples represent the northern , central , and southern parts .

Composite sample number (1) represented the central part : Ore Body No. I.

Composite sample number (2) represented the norhtern part Ore Body No. II.

Composite sample number (3) represented the southern part Ore Body No. III.

Way of Preparing The Three Composite Samples.

1- Composite sample No. (1).

69 fresh samples (10-15 kg.) each were collected from different locations . These samples were all mixed together thoroughly several times , A head sample represents the heap was taken by coning and quartering for chemical analysis (H1), the heap again was divided

to two half (500 kg. each) by coning and quartering . One half was sent to The Research Center In Ruseifa (JPMC), the other half was sent to the NRA Labs as a reference.

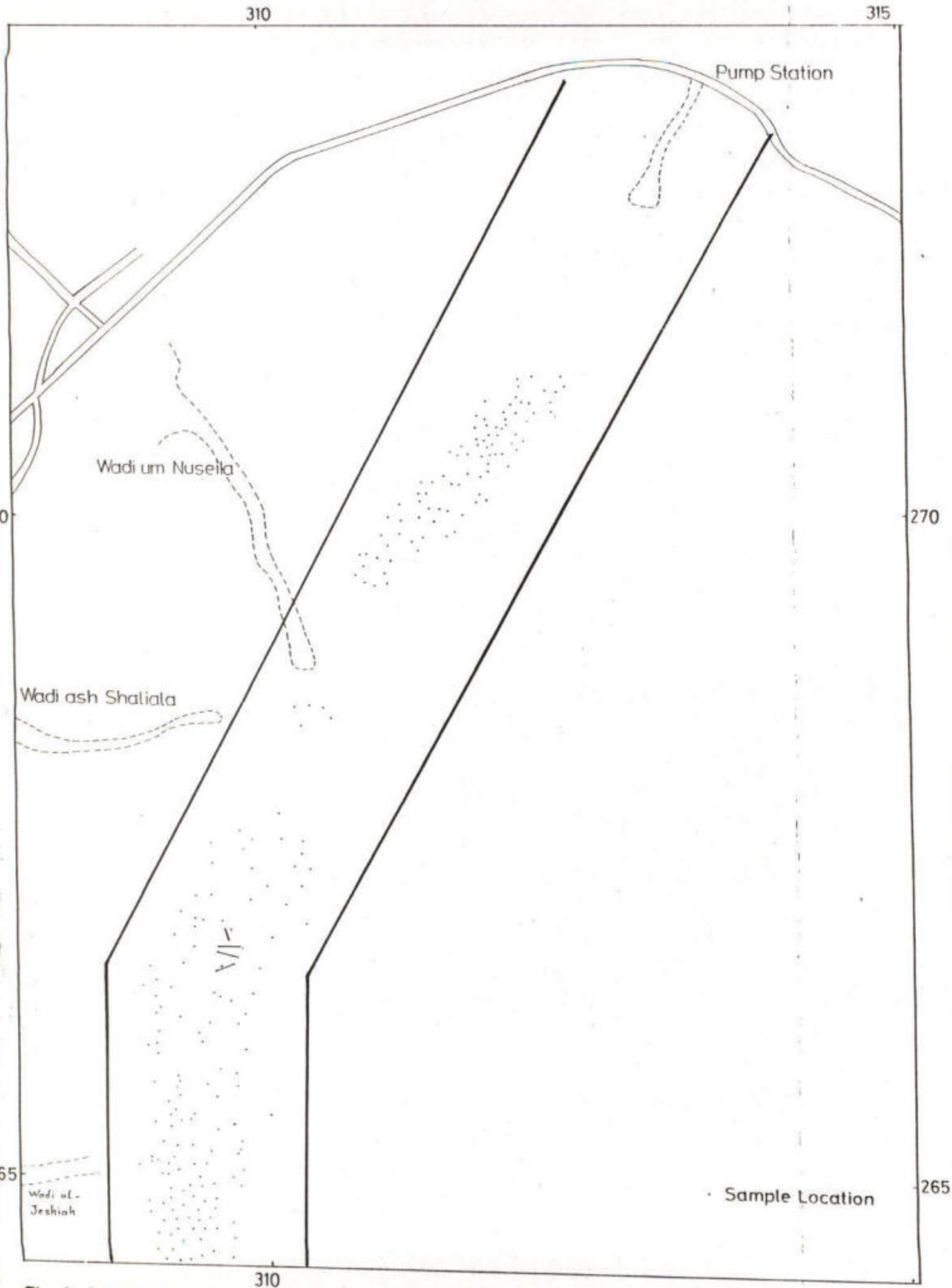
2- Composite sample No. (2 and 3).

The same proceedure mentioned for composite sample I was applied for composite samples II and III.

The aim of collecting the three composite samples is to study the possibility of up grading the crushed alkali granite rocks by different beneficiation methods for the production of commercial feldspar.

CHEMICAL ANALYSES OF THE THREE COMPOSITE SAMPLES (H1,H2,H3)

S.No.	L.O.I. %	SiO2 %	CaO %	MgO %	Fe2O3 %	Al2O3 %	TiO2 %	Na2O %	K2O %	MnO %
H1	1.04	71.46	1.05	0.35	1.02	13.98	0.88	5.53	4.29	0.02
H2	1.31	71.72	1.04	0.50	1.37	13.63	0.92	5.34	4.34	0.03
H3	1.78	71.33	3.22	0.42	0.81	12.90	0.32	5.54	2.30	0.03


310
315
Pump Station
Wadi um Nuseila
70
270
Wadi ash Shaliala
265
Wadi al-Jeshiah
Sample Location
265
310

IX. RESERVE ESTIMATION

Since no boreholes were drilled in any of the studied three parts of the medium - grained alkali granite , the reserve was roughly calculated as follow :

The reserves calculation is based on the unit density . Unit measures = 250 X 250 = 62500 M2

1) Northern Part Calculated Reserve.

Square measure = 250m X 250m = 62500m2

rock density = 2.57 gr/cm3 .

Average thickness of the rock = 10m

The northern part contains about twentytwo units see fig. 4, (reserve map).

Calculated Reserve = 62500 X 22 X 10 X 2.57

= 35 million ton .

2) Central And Southern Parts Calculated Reserve.

The central and southern parts contains fifty units.

Calculated Reserve = 62500 X 50 X 10 X 2.57

= 80 million ton

The total calculated reserve of the studied area is (115) million metric ton.