資料 10

REPORT
ON
THE SURVEY OF GYPSUM IN KILIMANJARO REGION
IN
TANZANIA

MARCH 1987

（註　資料８及び９の和文報告書の英訳版）

REPORT

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IN

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MARCH, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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ANNEXTURE

PHOTO 1

CHART (Fig.1)

I. REPORT ON THE SURVEY OF GYPSUM

GENERAL

Production facilities for ceramic tableware (stoneware) in Ceramic Research Development Center (CRDC) at Same in Kilimanjaro Region have been operated since its establishment in October, 1984.

The monthly production capacity in CRDC is approx. 5,000 pieces of stoneware. As day goes by, the sales volume goes on increasing gradually.

Gypsum mold is indispensable for mass production of ceramic tableware, sanitary ware, insulators, etc. It is present circumstances that gypsum mold now relies upon imports from Japan.

Finding gypsum ore locally, we conducted gypsum mold-making test after firing and grinding with use of the existing facilities in CRDC. The practical use resulted in 1/3 life as compared with Japanese-made one. The extension of durability will depend on procurement of high grade gypsum and production process from firing to gypsum plaster.

In Morogoro approx. 200 KM west of Dar Es Salaam, there is a ceramic tableware and sanitary ware manufacturing plant to be the biggest plant in Tanzania who imports and consumes several hundreds tons of gypsum per annum.

With the purpose of making feasibility study for exploitation of gypsum and development of gypsum industry, we have prosecuted survey for the probable quality, probable ore reserve of gypsum and gypsum plaster manufacturing project plan.

1. SURVEY PERIOD

July 3, 1986 to August 17, 1986

2. SURVEY REPORT

2.1 Nyumba Ya Nungu

2.2 Lengurmo

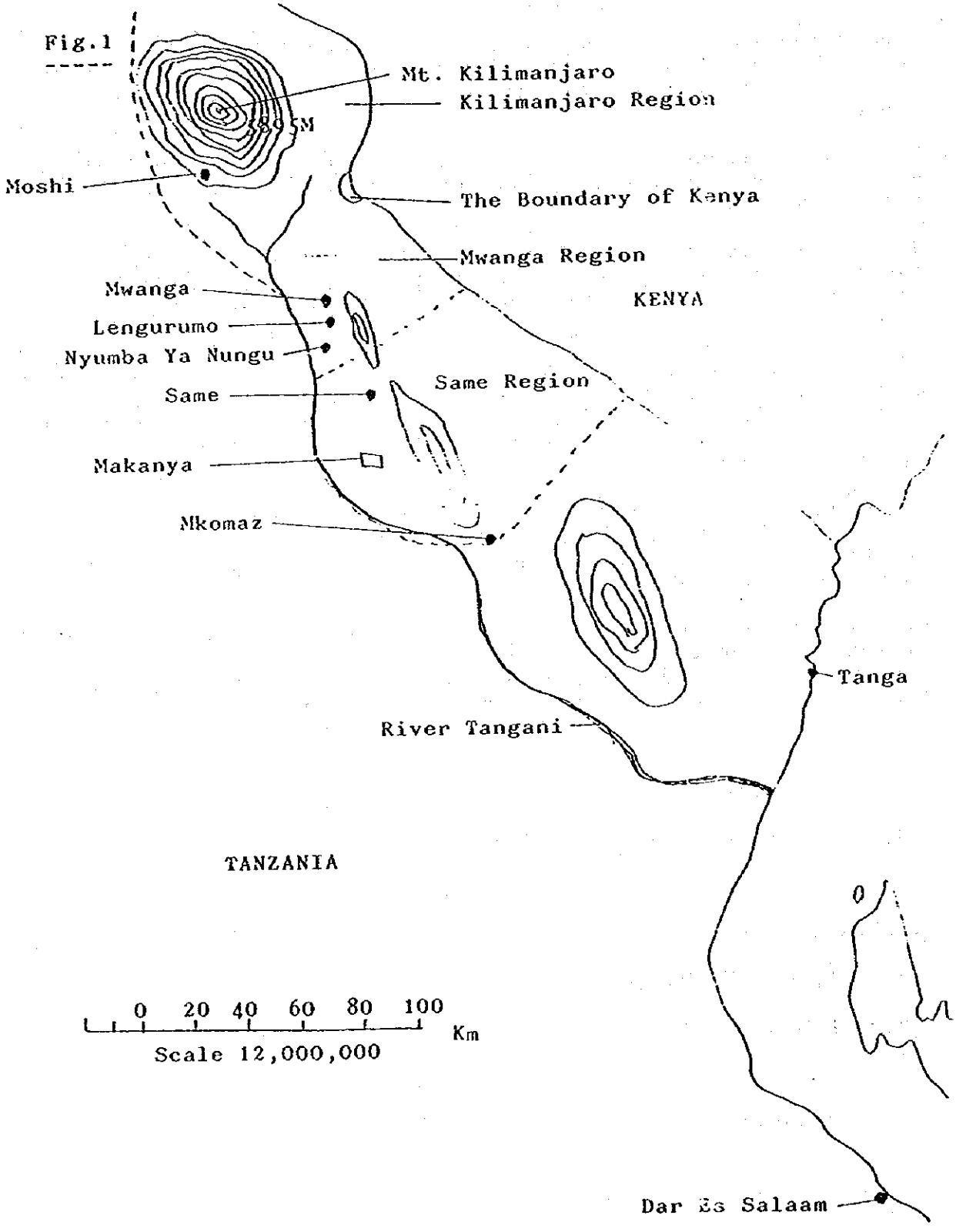
2.3 Mkomaz

2.4 Makanya

2.5 The Boundary of Kenya

Fig.1 shows the location of gypsum survey site.

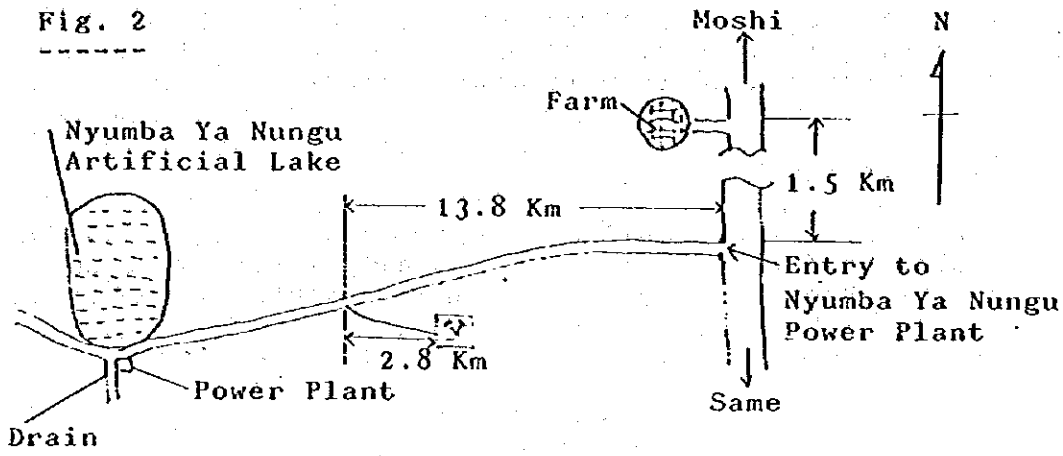
Fig.1



2.1 Nyumba Ya Nungu

1). Location of Gypsum Survey Site

Fig. 2



The area lies in approx. 2.8 KM southeast by east after turning left at the point 13.8 KM of indication board showing entry to Nyumba Ya Nungu Power Plant diverging from trunk road between Moshi and Same.

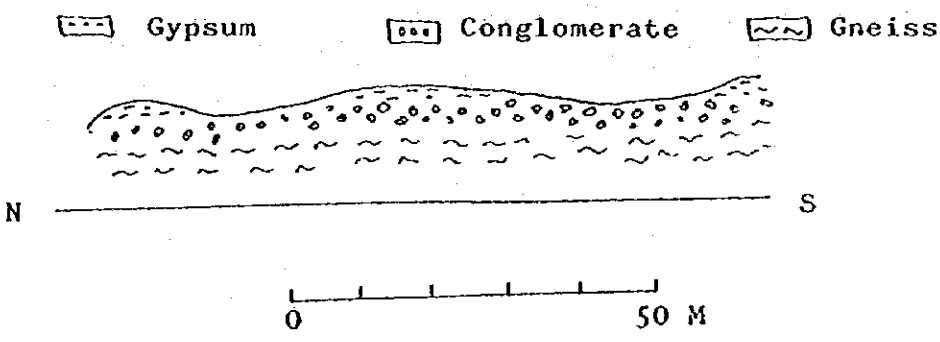
2). Topography

Gently sloping hilly area approx. 750 M above the sea level. There are no human habitations. It is thorny shrubbery (a kind of acacia) zone in 1 - 5 M height to be so-called savannah where deer and squirrel live. In the area of 13.8 KM to 2.8 KM, there is no landmark. So, we have cut trees or painted trees as a guide.

3). Geology

In the Cambrian period, gneiss exists as base rock. On the upper portion, limestone and conglomerate including magnesite are recognized, and on the top portion, gypsum is supposed to have piled almost horizontally. Fig.3 shows geological section.

Fig.3



4). Gypsum

4)-1 Ore Body

The outcrop and ore of gypsum could be confirmed in the area extending to approx. 1,000 M in east and west, and approx. 100 M in north and south with depth approx. 0.5 M.

4)-2 Boring

Fig.4 shows the result of boring by Hand Auger and Table 1 shows the depth of strata confirmed by boring, condition by strata from outer appearance and probable gypsum content.

Fig.4 Section Figure of Ore Body Based on Boring

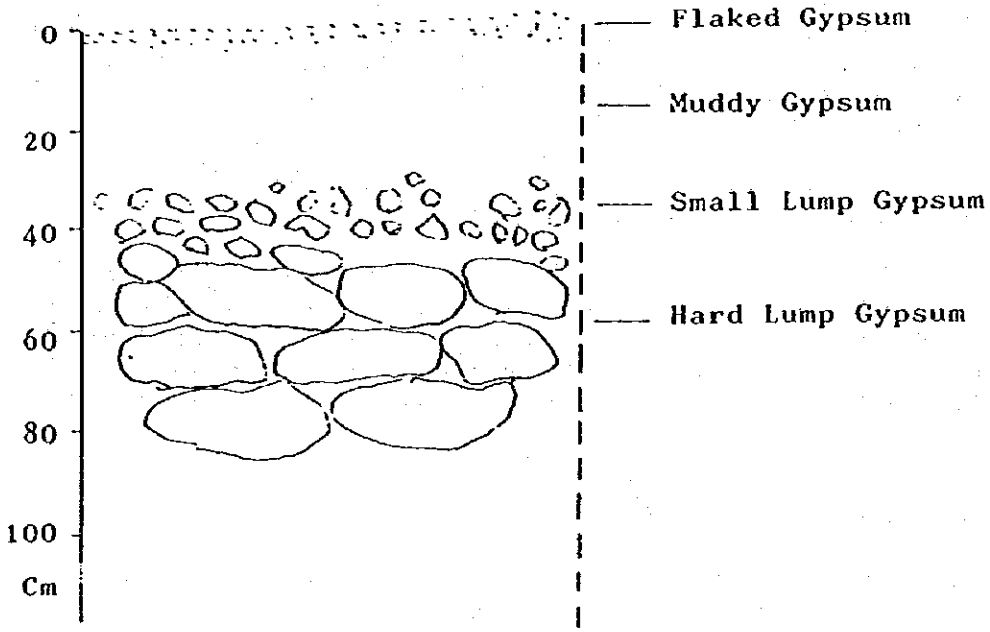


Table 1 Observation of Gypsum Based on Boring

Strata	Depth	Outer Appearance	Probable Content of Gypsum
Flaked Gypsum	0-5 CM	Piling of flaked due to weathering	Min. 98 %
Muddy Gypsum	30-40 CM	Scattering in irregular form in the ground	Min. 60 %
Small Lump Gypsum	20-40 CM	Grayish white. Smaller than clenched fist size. Less mixing of muddy gypsum and getting slightly harder.	Min. 90 %
Hard Lump Gypsum	20-50 CM	Grayish white to white. Larger than clenched fist size. Hard. Digging with spalling by gad.	Min. 95 %

4)-3 Ore Reserve

Gypsum near the ground surface suffers from weathering to get muddy and contain clay or sand much. Once washing is made, accordingly, gypsum degrades to decrease yield ratio and low gypsum content. Such gypsum is therefore considered to be useful for cement setting retarder rather than raw materials for gypsum mold.

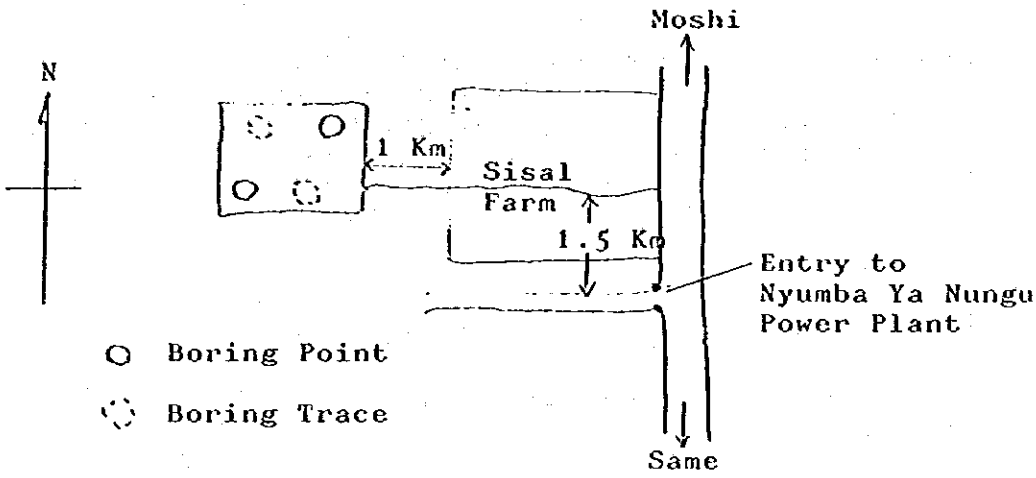
Meanwhile, small lump or hard lump gypsum scarcely suffering from weathering will be the object of mining, dressing, washing, concentration and manufacture of gypsum plaster. The probable reserve of hard lump gypsum has been calculated as 12,000 MT (Calculation basis = Length x Width x Depth x Gypsum Bulk Density 2.0)

2.2 Lengurumo

1). Location

The deposit lies in area approx. 1.0 KM west of sisal farm after turning left at the point approx. 1.5 KM toward Moshi from Indication Board showing entry to Nyumba Ya Nungu Power Plant diverging from trunk road between Moshi and Same.

Fig.5



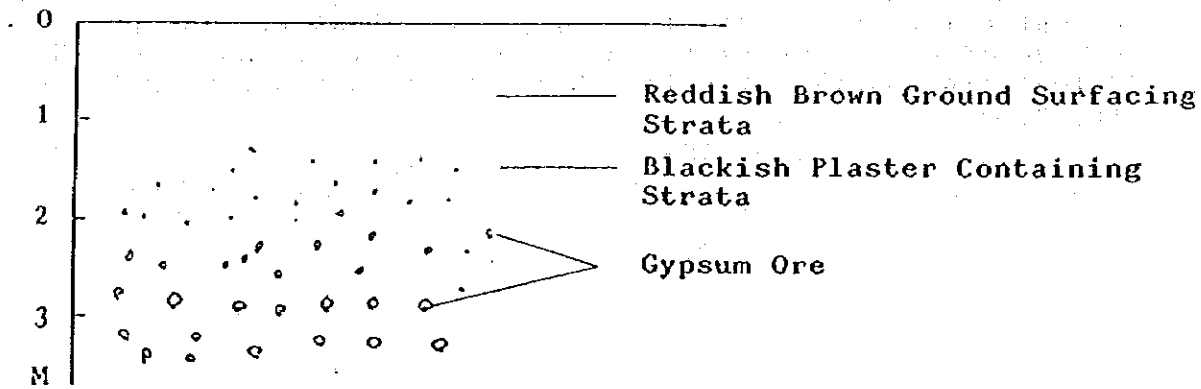
2). Topography

Flat grassland 900 M above sea level commanding a view of Mr. Luami on the north, Nyumba Ya Nungu Road on the south, mountain system of the North Pare on the east and Lengurumo settlement on the west. Extending approx. 3 KM east and west and approx. 2.5 KM north and south.

3). Boring

Fig.6 shows the result of boring by Handy Auger.

Fig.6 Section Figure Based on Boring



As the result of observation of gypsum based on boring, the existence of irregular shaped gypsum below 30 MM diameter was recognized, but ore body of gypsum couldn't be recognized. The soil was so hard beyond our expectation that the boring work was indeed painful. That is to say, the progress of boring to 3 M depth at 2 pits was no more than approx. 0.7 - 0.8 M a day per pit by 2 workers.

On the occasion of executing boring next time, power sources such as motor, generator, etc. and pulley with tripod for lifting of drill are considered necessary. To recognize gypsum ore body, full-scale boring is expected. On the assumption that strata 0.2 M in thickness at the relatively shallow place from the ground surfacing was recognized, the probable ore reserve amounts to 3,000,000 MT.

2.3 Mkomaz

1). Sampling of gypsum was made from the stock on the premises of National Railways "Mkomaz Station" approx. 80 KM south of trunk road between Moshi and Same. Mkomaz gypsum is now used for cement. For comparison study with Nyumba Ya Nungu gypsum, survey was made.

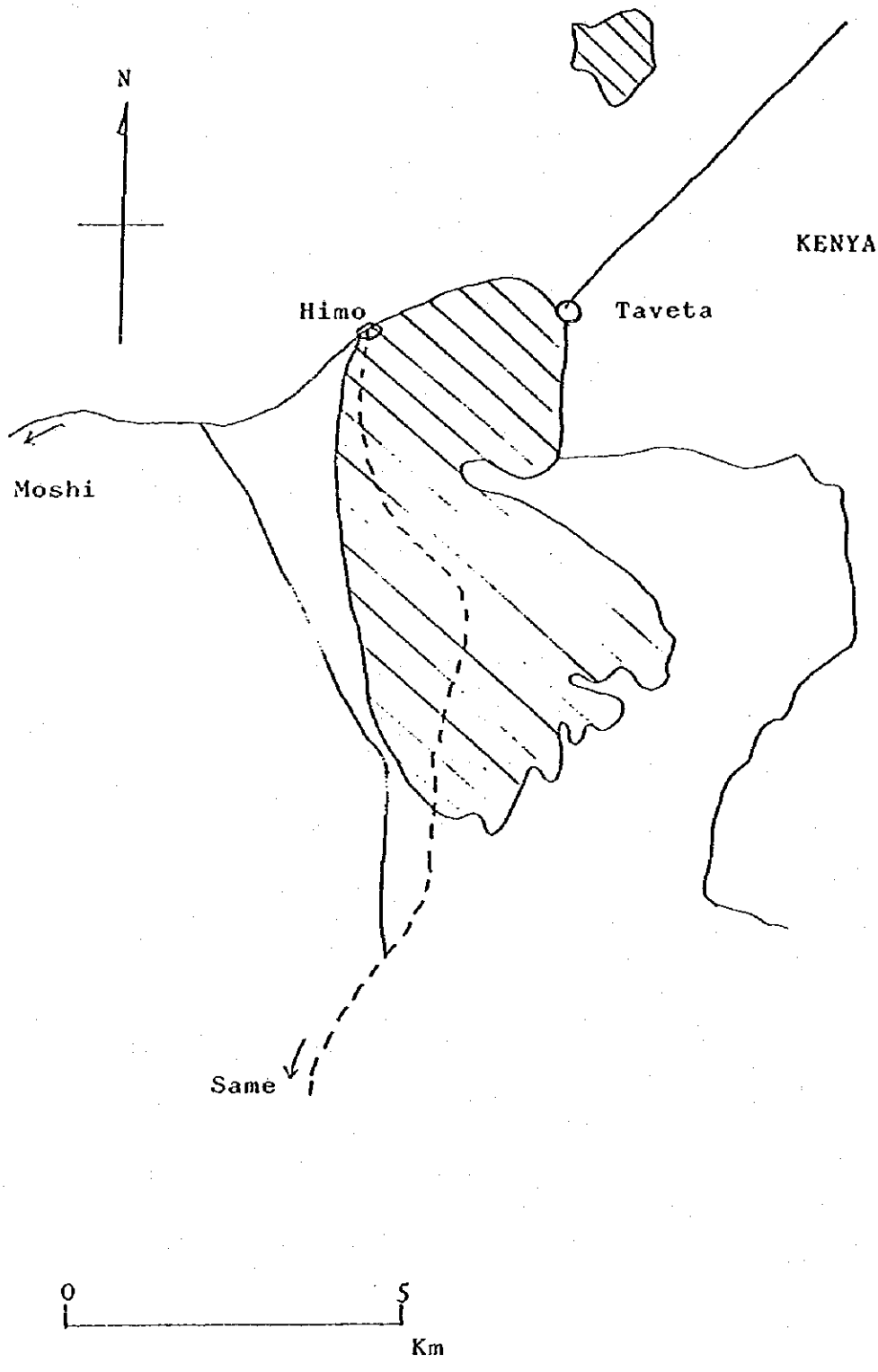
2). Observation of Outer Appearance

Size is of clenched grip size to man's head size and shape of irregularity. Presenting gray to grayish brown. Hard gypsum ore. The quality containing much clay and sand is recognized. The probable content of gypsum is less to be 50 %. Unsuitable for raw materials for gypsum mold.

2.4 Makanya

1). The area approx. 14 KM west of National Railway "Makanya Station" approx. 35 KM south of trunk road between Moshi and Same. This area is divided into small mine-lots of more than 100 places where open-cut mining is conducted. Area of approx. 5 square kilo-meters is dotted with mining traces. The over-burden has the thickness of approx. 1 M and the depth of gypsum strata Makanya gypsum is also used for cement in the same way as Mkomaz gypsum. For comparison study, survey was made.

Fig.7



2). Observation of Outer Appearance

Almost man's head-sized one. Shape of irregularity. Presenting light brown to grayish brown and partially gray. Hard gypsum. Containing much clay and sand. The probable content of gypsum is less to be 50 - 60 %. Unsuitable for raw materials for gypsum mould.

3). Possible Ore Reserve

The possible ore reserve in this area is 50,000,000 MT.

2.5 The Boundary of Kenya

From the data of analysis of water soluble basicity (MG/100 G) in soil, SO_4 is remarkably high to be 980.22 MG/100G. The possible reserve of gypsum exists at the area approx. 3 KM east and west and approx. 7 KM north and west from Himo 25 KM east of Moshi to Taveta in the boundary of Kenya.

The owner of gypsum mine-lot at Nyumba Ya Nungu gets gypsum sample from the area. The site survey was once planned but not realized because of bad traffic facilities, bad road condition and long distance on foot. We expect that taking an opportunity, Kilimanjaro Industrial Development Center (KIDC) and/or CRDC will investigate the site.

3. CONCLUSION

3.1 Site survey was prosecuted at various places for approx. 1 month. As the result, gypsum ore in the place other than Nyumba Ya Nungu is unsuitable for raw materials for gypsum mold for ceramic industries as shown in the forthcoming "Test Result of Gypsum". Described hereunder are the conditions of Nyumba Ya Nungu area and others.

3.2 The condition of gypsum at Nyumba Ya Nungu can be geologically summarized as follows:

1). Geology

The formation of gypsum goes back to the Cenozoic tertiary period. The environment of sedimentation is considered full of variety and complication.

2). Ore Deposit

Sedimentation ore deposit due to vaporization of lake. The scale is middle to small.

3). Mining Condition

Mud or lump which is sedimentated almost horizontally at the top of hilly area. The deeper the ore deposit is, the harder the ore body becomes.

4). Mineral

Mainly composed of crystallization of Selenite presenting laminar, flaky or emarginated transparence or semi-transparence or light brown, and gypsum presenting monolithic or powder-like and light white or light yellow.

Impurities: Sand and clay are recognized mainly on the ground surface.

5). Ore Reserve and Demand Quantity

In our survey at 5 places in Kilimanjaro Region, probable reserve of approx. 12,000 MT could be confirmed at near the Lake Nyumba Ya Nungu.

The ceramic plants using gypsum mold for ceramic tableware are as follows:

a). CRDC

b). Ceramics Wares Ltd. in Morogoro

c). Ceramic Plant in Arusha (Owned by Mr. Sheriff)

In consideration of demand quantity and others (Mbeya Sido Ceramic Tableware Plant and Dodoma Tile Plant) besides the above, if annual demand quantity is estimated as 400 MT per year, the life of ore reserve will be 30 years (= 12,000/400).

The present total demand quantity of gypsum plastic for ceramic industries and the other industries in Tanzania is approx. 800 MT per year, so that the probable reserve of 12,000 MT corresponds to the life of 15 years.

6). Quality

Presenting white in appearance but containing fairly much impurities in comparison with Morocco gypsum being imported into Japan for gypsum mold.

So, if treated to gypsum plaster, the quality is equivalent to or somewhat inferior to JIS B. Even though the quality is inferior, Nyumba Ya Nungu gypsum plaster can be used with mixing imports from Japan or West Germany, to contribute to the cost down of raw materials.

3.3 Other conditions of gypsum in Tanzania are as follows:

1). Tanzania is an agricultural country producing coffee, tea, sisal, etc., but underdeveloped in industry. Accordingly, it is impossible to expect by-products (chemical gypsum) produced in chemical industry.

2). Gypsum plaster of Morogoro Ceramic Wares Co., Ltd.

The Company is using gypsum mold for the manufacture of sanitary ware and tableware. Above all, old gypsum mold for sanitary ware is excessively used since imports for supplement from Czechoslovakia have been suspended. Accordingly, gypsum plaster is promptly needed.

3). Gypsum Plaster in CRDC

The use quantity of gypsum plaster in CRDC is less than that of Morogoro Ceramic Wares Co., Ltd. (Approx. 1/40). Needed in CRDC is gypsum mold for casting such as pot, creamer, sugar pot, etc., as well as gypsum mold for jigger.

4). Ceramic Plant in Arusha (Owned by Mr. Sheriff)

If the quality and quantity of gypsum mold being used in CRDC are ensured, it will be sufficient enough. The production items are coarse tableware (cup and saucer), vase,

flowerpot, etc.

5). Ensuring of Gypsum Area in Nyumba Ya Nungu and Lengurumo

According to an information from reliable source, a big sugar corporation called as TPC (Tanzania Plant Company) has begun to investigate limestone and gypsum as neutralization agent. KIDC and CRDC had better ensure raw material site promptly.

II. GYPSUM PLANT MANUFACTURING PROJECT PLAN

1. RESERVE

Provable Reserve : 12,000 MT

Possible Reserve in Lengurumo : 3,000,000 MT

2. QUALITY

Corresponding to JIS B

3. DEMAND ESTIMATE

Table 1

Description	Usage	Annual Demand Estimate (MT)
1). For Ceramic Industries		
Morogoro	Sanitary Ware & Tableware	320 MT
Mwanga	Tableware	8 MT
Arusha	Tableware	8 MT
Mbeya	Tableware	Probable 10 MT
Dodoma	Tile	Probable 5 MT
Dar Es Salaam	Tile	Probable 5 MT
Iringa	Tile	Probable 10 MT
Various Places	Artistic Handicraft	Probable 5 MT
Sub Total		371 MT/Year

2). For Building Materials		
Gypsum Board, Gypsum Plaster and Plaster	Probable	100 - 200 MT/Year
3). For Medical Treatment		
Gyps and Dental Medicine	Probable	5 - 10 MT/Year
4). For Chemical Industries		
Rubber, Paper, Sugar, Etc.	Probable	100 - 200 MT/Year
Total		576 - 781 MT/Year

4. PLANT

4.1 Capacity

Table 2

Description	Production Capacity
1). To cope with the total demand in Tanzania	800 MT/Year
2). To cope with the total demand in ceramic industries	400 MT/Year
3). To cope with the demand of Morogoro Ceramic Wares Co., Ltd.	320 MT/Year
4). To cope with the demand of CRDC (Same)	8 MT/Year

4.2 Process and Rough Estimate of Production Facilities

1). In Case of 8 MT/Year Capacity (For CRDC Only)

A). Process Flow

Gypsum ore → Rough Crushing → Belt Conveyer → Firing → Finish Crushing

a). Charge the selected gypsum ore of clenched grip size into Crusher.

b). Charge the powder of gypsum ore which was discharged by Belt Conveyor into Kettle.

c). Conduct firing.

d). Discharge fired products and charge it into Fine Crusher.

e). Put the products thus made fine crushing, into bag for ageing and then use them for gypsum mold.

B). Main Equipment

Crusher

Hopper for Crusher

Motor for Crusher

Belt Conveyor

Kettle

Fine Crusher

Water, electricity, concrete, etc. are locally procurable.

C). Rough Estimate

FOB Japan ¥19,600,000.-

2). In Case of 320 MT/Year Capacity (For Morogoro Ceramic Wares Co., Ltd. Only)

A). Process Flow

Gypsum Ore → Crushing → Belt Conveyor → Bucket Conveyor → Firing → Hopper → Bucket Conveyor → Fine Crushing

a). Charge clenched fist size of selected gypsum ore into Crusher.

b). Charge gypsum powder which was discharged by Belt Conveyor, into Kettle by Bucket Conveyor.

c). Charge the fired products once into Hopper for storage.

d). Charge them from Hopper to Fine Crusher by Bucket Conveyor.

e). Put the products thus made fine crushing into bag for ageing and then use them for gypsum mold.

B). Main Equipment

Crusher

Hopper for Crusher

Motor for Crusher

Belt Conveyor

Kettle

Hopper

Bucket Conveyor

Fine Crusher

C). Rough Estimate

FOB Japan ¥90,000,000.-

3). In Case of 800 MT/Year Capacity (For the Total Demand in Tanzania)

A). Main Equipment

Crusher

Hopper for Crusher

Motor for Crusher

Kettle

Hopper

Dust Collector

Bucket Elevator

Screen

Fine Crusher

Magnetic Ferro-filter

Hopper

B). Rough Estimate

FOB Japan ¥212,000,000.-

4.3 Plant Site

In the event that gypsum plaster manufacturing plant project is decided in Kilimanjaro Region in Tanzania, there are Moshi, Same, Nyumba Ya Nungu and Mwanga as the proposed plant site. Table 3 shows the result of our study.

Table 3

Description	Moshi	Same	Nyumba Ya Nungu	Mwanga
Electricity	OK	OK	OK	OK
Water	OK	OK	OK	OK
Concrete	OK	OK	OK	OK
Transportation	OK	OK	OK	OK
Worker's attractiveness	More convenient on account of city	OK	OK	OK
Making of gypsum mold (Making gypsum plaster to gypsum mold)	New plant	Expansion	New plant	New plant
Public peace and order	Slightly questionable in safety	Safe	Safe	Safe

Same in the proposed plant lies within 50 KM from gypsum ore mining site where road condition and railways are available. CRDC is now performing its activity there, so that Same is advantageous.

Nyumba Ya Nungu in the proposed plant is capable of using drainage from Power Plant, but inconvenient as compared with Same. Worker may get discomfort in various ways.

Moshi in the proposed plant is blessed with abundant electricity and water, where labour power is easily procurable and traffic is convenient.

In Mwanga locating in the center of the mountain system of the north Pare, there is a regional main office, and municipal construction is in steady progress as a rising town, where ceramic center to produce ceramic tableware locally is now being projected. It is therefore well suited for the essential condition of plant site, where future development can be expected. The realization of the ceramic center will contribute as main industry in the town.

From the above, we recommend Mwanga as the best plant site among four(4) proposed plant sites.

III. TEST RESULT OF GYPSUM

1. This Report covers the result of the test conducted by us, of gypsum ore in Tanzania.

2. Sample

Nyumba Ya Nungu Gypsum Ore	20 Kg
Makanya Gypsum Ore	1 Kg
Mkomaz Gypsum Ore	1 Kg
West Germany Gypsum Plaster	2 Kg

3. Test Result

3.1 Test for Gypsum Ore

1). Content of Crystal Water

A). Purpose : To know the content of the impurities being contained in gypsum ore.

B). Method : After crushing gypsum ore, quartering reduction, mill-crushing and drying, test was made in accordance with JIS R 9101 Chemical Analysis of Gypsum.

C). Result : Table 1 shows the test result.

Table 1

	Nyumba Ya Nungu Ore	Makanya Ore	Mkomaz Ore
Crystal Water	19.38 %	18.10 %	14.46 %

The theoretical value of crystal water is 20.9 %, but the standard for qualitative recognition of natural gypsum ore is specified as 20.02 %. Accordingly, the purity of the aforesaid samples is calculated as per Table 2.

Table 2

	Nyumba Ya Nungu Ore	Makanya Ore	Mkomaz Ore
Purity	96.8 %	90.4 %	72.2 %

d). Discussion

Nyumba Ya Nungu ore among three(3) samples contains less impurities but Makanya and Mkomaz ores much impurities, while gypsum ore for gypsum mold needs the purity of more than 95 %. Accordingly, Nyumba Ya Nungu ore can be judged as suitable one but Makanya and Mkomaz ores as unsuitable ones.

B). X-ray Analysis

a). Purpose : Determination of impurities and estimate of their content.

b). Sample : Nyumba Ya Nungu ore and Makanya ore Containing much impurities, Mkomaz ore was excluded from the object of test.

c). Method : After drying samples and fine crushing to 200 mesh pass, x-ray analysis was conducted under the terms and conditions as shown in Table 3.

Table 3

Target	Cu
Filter	Ni
Scanning Speed	2 °C / Min.
Voltage	30 KV
Current	20 mA
Chart Speed	20 mm/Min.
Full Scale	10^3 x 1 C.P.S

d). Result

As shown in the Chart (Fig.1) attached hereto, quartz (Alpha-SiO_2) and limestone ($CaCO_3$) of impurities were recognized in Nyumba Ya Nungu ore, while quartz, limestone and a little feldspar in Makanya ore.

e). Discussion

Quartz and limestone of impurities were recognized in both Nyumba Ya Nungu ore and Makanya ore.

In Nyumba Ya Nungu ore, the intensity of quartz is small to be estimated as several percents and below in the content, while in Makanya ore, the intensity is large to be approx. 4 times of the former and estimated as approx. 20 %. The ore is accompanied by a small quantity of limestone. Even after the ore is heat-treated to turn into gypsum plaster, limestone is stable without decomposition. So, it is judged that the existence will not render bad influence upon gypsum plaster.

C). Observation by Scanning Electron Microscope

a). Purpose

Comparison with Morocco gypsum to be worldwidely famous for the form of crystal and the size of crystal grain.

b). Nyumba Ya Nungu ore and Morocco ore

Both Makanya ore and Mkomaz ore were excluded from the object of test.

c). Test

Photo 1 shows scanning electron micrograph (x 3000). Recognized is laminar gypsum of well-developed crystal.

d). Result

The shape and size of crystal were nearly same as those of imports from Morocco for gypsum mold.

3.2 Gypsum Plaster-Making Test

a). Purpose

To know whether usable or not for mold materials.

b), Sample

Both Nyumba Ya Nungu ore from which favorable result is expected by ore test in the preceding item 2.1 and imports of gypsum plaster from West Germany which are now being used at Morogoro Ceramic Wares Co., Ltd., for comparison study.

c). Test Item

Mixing Water Content

Initial Setting Time

Final Setting Time

Wet Tensible Strength

Wet Compressive Strength

Particle Size

d). Test Method

In accordance with JIS R 9112 Test Method of Physical Properties of Gypsum for Mold Materials for Porcelain Ware

e). Test Result

Table 4 shows the result of test for Nyumba Ya Nungu sample and imports of gypsum plaster from West Germany together with quality standard (Super Grade, A Grade and B Grade) of gypsum for mold materials for porcelain ware based on JIS R 9111.

Table 4

	Nyumba Ya Nungu Sample	West Germany Sample	JIS Super Grade	JIS A Grade	JIS B Grade
Mixing Water Content (%)	72	70	Max. 75	Max. 78	Max. 82
Initial Setting Time (Minute)	9	11.5	Min. 8	Min. 8	Min. 8
Final Setting Time (Minute)	24	26	Max. 35	Max. 35	Max. 35
Wet Tensible Strength (Kg)	7.5	9.6	Min. 9.5	Min. 8.5	Min. 7.5
Wet Compressive Strength (Kg)	65	93	-	-	-
Particle Size 420 Micron	0	0	0	0	0
149 Micron	2.9	-	Max. 7	Max. 7	Max. 10
Remarks: Water Temp.	21.9	21.2			

4. CONCLUSION

4.1 Gypsum plaster from Nyumba Ya Nungu was recognized to be inferior to the imports from West Germany but similar to JIS B Grade.

4.2 Nyumba Ya Nungu sample is sufficiently usable as gypsum plaster for Mechanical Jigger now being needed by CRDC and for mold materials now being planned for the manufacturing project.

4.3 The usage of gypsum plaster for mold materials can be classified as follows:

1). For Jiggering Mold

A). For Mechanical Jigger

B). For Roller Head Type Jiggering Machine

2). For Casting Mold

A). For Ordinary Casting

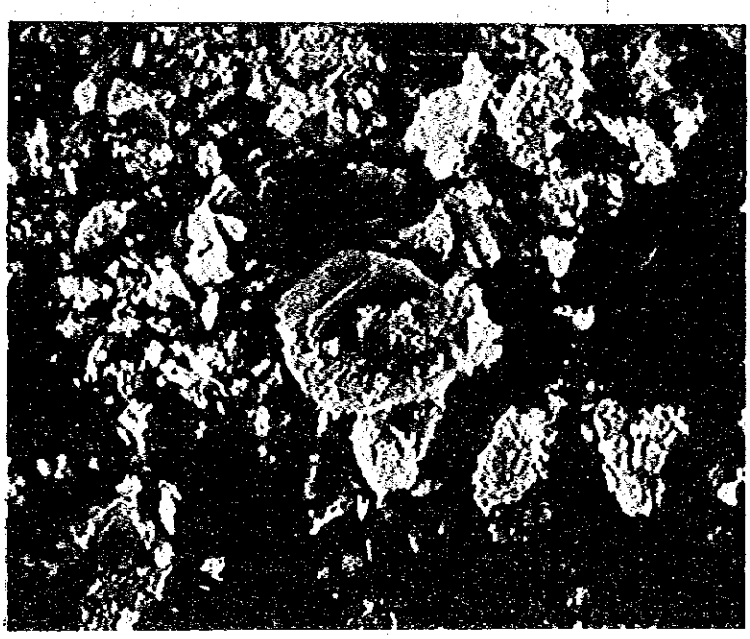
B). For Pressure Casting

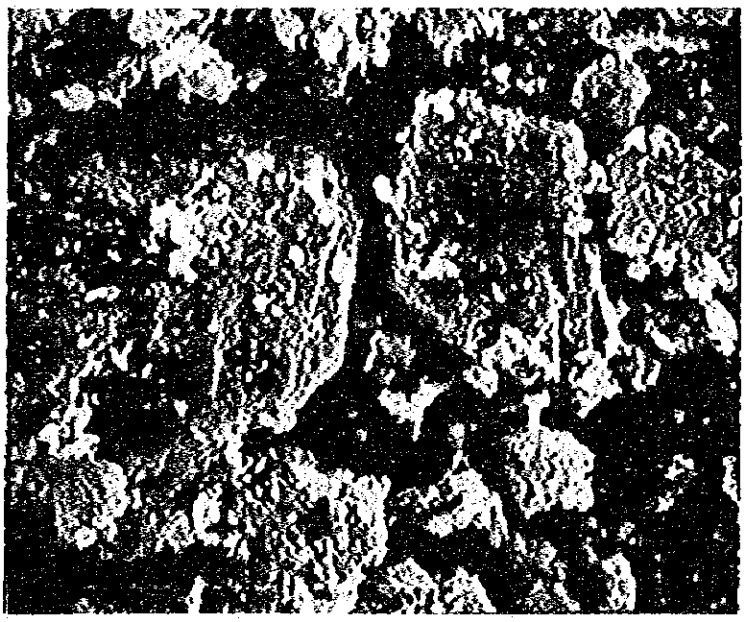
4.4 In the event that CRDC installs Roller Head Jiggering Machine in future, gypsum mold which doesn't need much mixing water content and is equipped with the character of strong mechanical strength after hardening and strong abrasion resistance, will be indispensable.

In order to meet the requirement of such quality, it is necessary to change crystal form of ore. Gypsum plaster for Mechanical Jigger and casting mold does need mixed component of Alpha crystal and Beta crystal.

For the purpose of forming Alpha crystal component, Autoclave is separately needed. The installation of Autoclave will make it possible to manufacture gypsum plaster capable of coping with all kinds of request for ceramics and mold materials.

PHOTO 1

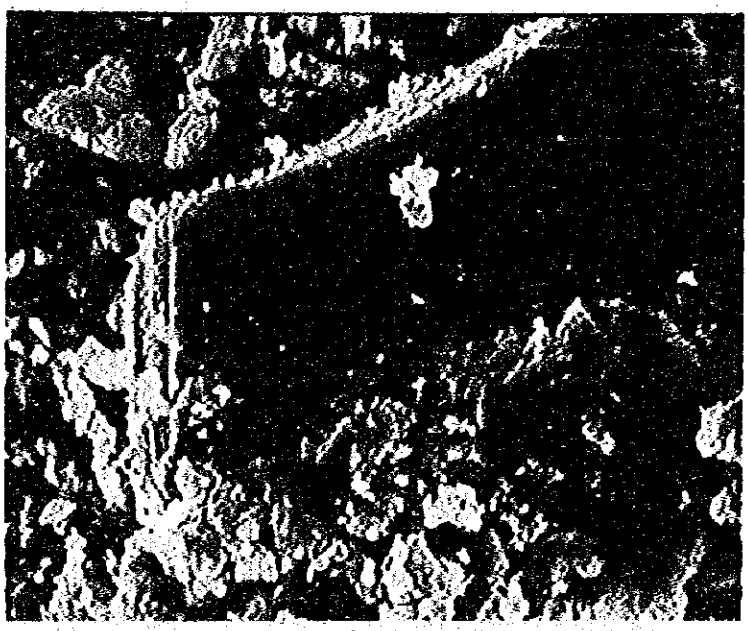




モロッコ産　石膏　原鉱

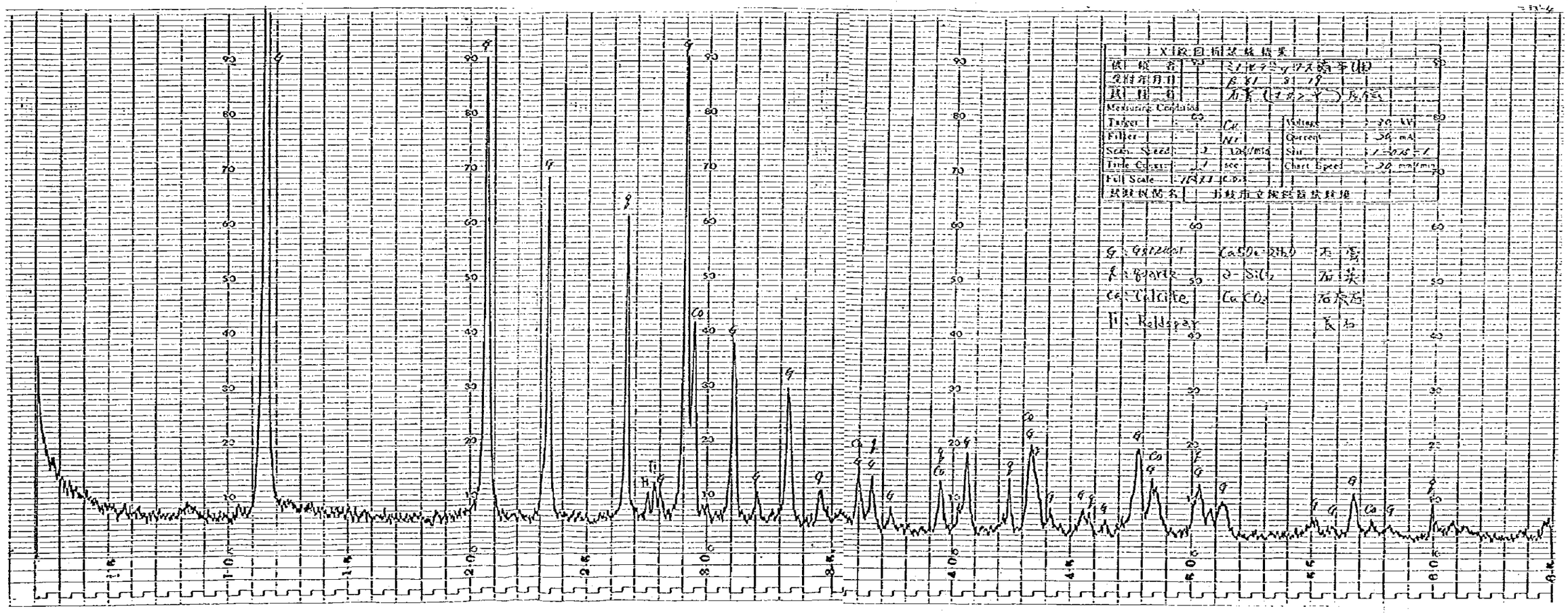
MOROCCO Gypsum Ore

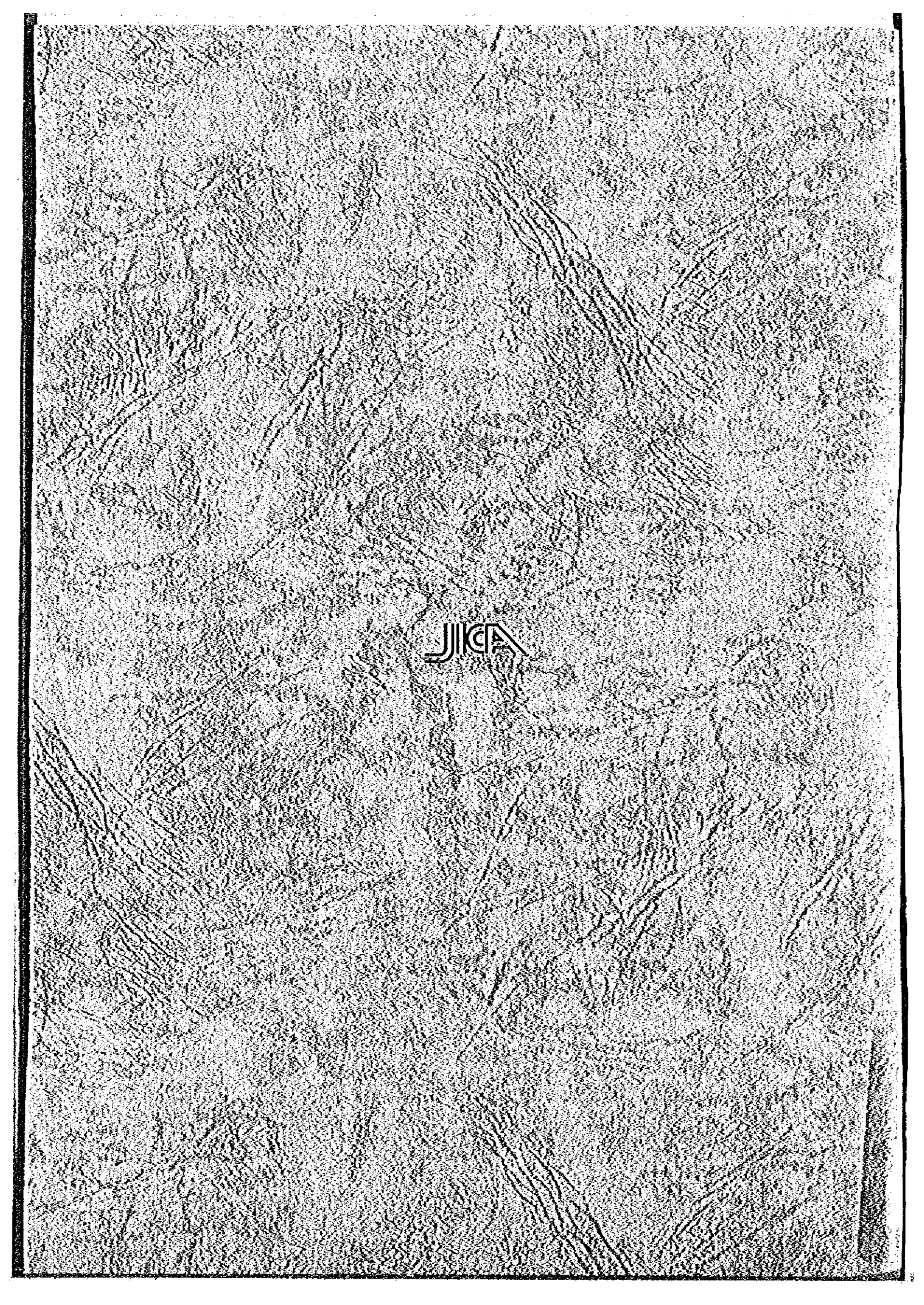
(×3000)



ヌンバヤムング産　石膏　原鉱

（ ×3000）


X線回折線描写
供試験者
受付年月日
其他一般
Measuring Condition
Target
Filter
Scan. Speed
Time Constant
Full Scale
其他試験条件
Gypsum
Quartz
Calcite
Feldspar
Chart Speed
1.0 K
1.5 K
2.0 K
2.5 K
3.0 K
3.5 K
4.0 K
4.5 K
5.0 K
5.5 K
6.0 K
6.5 K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