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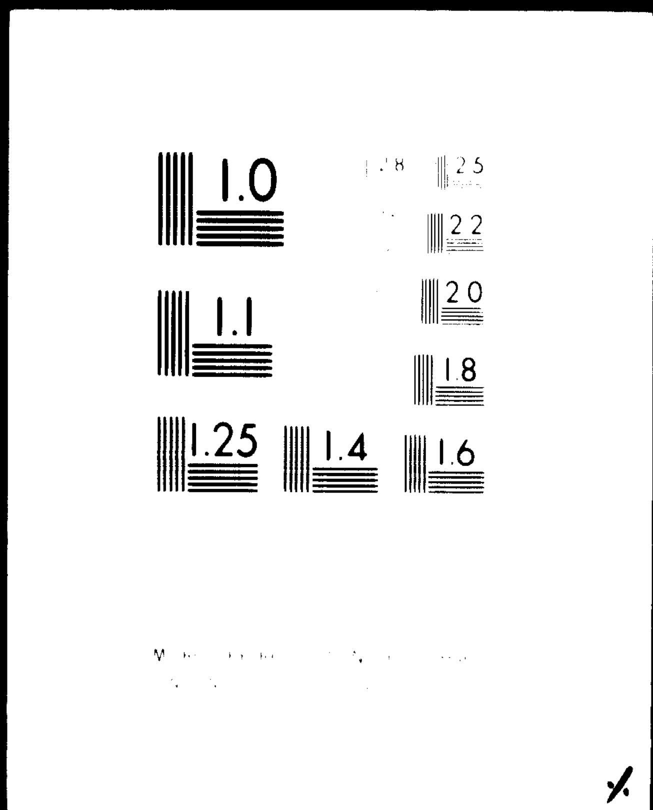

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FINAL REPORT

FEASIBILITY STUDY FOR THE COMMERCIAL EXPLOITATION OF KAOLIN DEPOSITS IN GAMBIA

(DP/GAM/72/004)

INSTITUTE FOR CERAMICS
REFRACTORIES AND RAW MATERIALS
HORNÍ BŘÍZA,
CZECHOSLOVAKIA

1974

INTRODUCTION

UNIDO concluded Contract No. 73/3 - Project No. DP/GAM/72/004 - for a Feasibility Study for the Commercial Exploitation of Kaolin Deposits in Gambia with Polytechna.
All the field activities, testing of raw materials, technical and technological evaluation, as well as market and economic study were implemented by the Institute for Ceramics, Refractories and Raw Materials as subcontractor to Polytechna.

The main duty of the contract was to evaluate a secondary kaolin in order to improve the possibilities of industrialisation of The Gambia. However, the team of experts in the field found that no kaolin but kaolinitic claystone was available in the upper part of the country. In respect to this situation it was necessary to accommodate the technical part of the contract in such a way that large scale trials connected with the utilisation of kaolin were eliminated. Because the main utilisation of kaolinitic claystone was in the field of ceramics, the above mentioned trials were replaced by trials of fire bricks, façade tiles and cement production which were not included in the Contract.

The presented Final Report discusses the problems according to the Contract with regard do the above mentioned changes in the following chapters.

C O N T E N T S

Conclusions and recommendations

UNIDO Contract No. 73/3 was fulfilled as described in details in this report. As result are the following conclusions and recommendations:

1. It has been found that kaolin is not suitable for paper, rubber and cosmetic industry. It is actually kaolinitic claystone which is suitable in combination with other raw materials for ceramic industry.

2. Other raw materials sampled in The Gambia such as clay Fatoto, clay Basse, sea shells, quartz sand and laterite are also suitable for the production of different ceramic items. Only laterite is too rich in iron and may be used only for the production of dark coloured products.

3. Gambian raw materials were found suitable namely for the production of wall tiles, floor tiles (mozaics), sewerage pipes and refractories.

4. The body composition consists of the above mentioned raw materials in various ratios. The reserves of kaolinitic claystone were stated in a quantity of 576 000 tons what means they are sufficient for more than 20 years. However, the reserves of the other ceramic raw materials are not perfectly known and should be stated before any industrial activity is started. For at least twenty years production of items mentioned in this report the following quantities of raw materials should be geologically and technologically tested:

Clay Fatoto	30 000 t
Clay Basse	24 000 t
Seashells	15 000 t
Quarzsand	18 000 t

5. Before any decision to build a factory is taken it would be necessary to make large scale trials in a quantity of about 100 - 200 m^2 or two tons of every item. It is to be mentioned that the remaining stock of kaolinitic claystone is deposited in Czechoslovakia and will be sufficient for the above mentioned large scale trials.

6. The Gambia has no experience with any industrial ceramic production and therefore it is advisable to build in the first step a ceramic pilot plant. Also economic and market views support this assumption. After a possible erection of a factory for production of mosaics and wall tiles, this pilot plant may be used as a factory shop producing gift items.

7. The market study shows that wall tiles and mozaics in quantities of 1000 tons each and gift items in quantity of 50 tons per year are saleable in The Gambia and the neighbouring countries provided that 75 % can be exported.

8. The economic study confirms acceptable production rentability of the above assortment. However the total economic effect is based predominantly on the profitability of gift items.

9. With regard to points 1. - 8. it is recommendable to start the ceramic production in The Gambia by erection of a pilot plant which would be the first step towards industrial application of the local ceramic raw materials. UNIDO should support this activity with experienced experts and in this way promote the industrial development of the country.

i) **Field activity**

The following team of experts left Czechoslovakia for The Gambia on 8 March 1973 to fulfill the tasks in the field.

Ing. Jan Dřevo	team leader (economist)
Dr. Jiří Babůrek	geologist
Ing. Josef Franče	mining engineer
Bořivoj Haták	technologist

Duration of the trip: 8.3.1973 - 7.4.1973

Officers contacted during the field trip:

Senegal:
- Mr. Tilot, Senior UNDP Field Adviser for West Africa UNDP Office, Dakar
- Mr. M. Myslil, UNDP expert, hydrogeologist in Senegal
- Mr. Pattinson, Institut de Technologie Alimentaire, Dakar
- Mr. Schwob, Institut de Technologie Alimentaire, Dakar
- Mr. Depuylort, Director of the firm Prochimat, Dakar

Gambia:
- Mr.W.F.Harper, Resident Representative UNDP in Bathurst
- Mr.John Jonas, Administrative Officer UNDP, Bathurst
- Mr.Klumm, Officer for technical projects, UNDP Bathurst
- Mr.A.A.N'Jai, Lands Commissioner
- Mr. Ireton, Development Secretary, President Office
- Mr. Bol, Planning Officer, Ministry of Local Government
- Mr. N'Sowe, Permanent Secretary, Ministry of Local Government
- Mr. N'Dow, Permanent Secretary, Ministry of Finance, Industry
- Mr. Blaine, Division Commissioner, Basse
- Mr. Abus Suud, Development Bank
- Mr. T.B.Foon, Commissioner of Labour, Bathurst
- Mr. Ignacio de Guzman Noguera, Development Bank
- Mr. Gibril, Central Statistics Division
- Mr. Roberts, Central Statistics Division
- Mr. Chelleram, Chief of Chellerams Company
- Mr. Jobe, Customs Office
- Mr. Van De Poll, Ministry of Agriculture
- Mr. Christensen, Permanent Secretary, Presdident Office

The experts arrived at the Dakar Airport Yoff on 9 March 1973 at 07.30 GMT. The same day, few hours later, the team of experts contacted Mr. Tilot, Senior Industrial Development Field Adviser and discussed with him the tasks to be fulfilled in the field. During that day Mr. Tilot arranged also the necesary Gambian visas for the experts.

The first official meeting with Mr. W. F. Harper, UNDP Resident Representative took place on Sunday 11.3.1973 because Mr. Harper had to leave on Monday 12.3.1973 the Gambia for Senegal. During this meeting the experts explained their ideas for implementation of the project tasks.

Monday morning on 12.3.1973 the experts visited the UNDP Office and had a meeting with Mr. J. Jonas and Mr. Klumm. Later on the same day they visited the Lands Office and had a discussion with Mr. A. A. N´Jai, Lands Commissioner, who was responsible as a Gambian representative for the project. Such problems as room for administrative work of experts, room for laboratory and samples, procuring cars and trucks, transport of collected samples etc. were succesfully solved during this meeting and during meeting on 13.3.1973.

Mr. Babůrek and Mr. Franče left Bathurst for Basse on 14.3.1973 morning while Mr. Dřevo and Mr. Haták continued in the official discussions. Together with Mr. N´Jai they have visited Mr. N´Dow, Permanent Secretary, Ministry of Finance, Industry, Commerce. Mr. Sehou N´Jie accompanied Mr. Babůrek and Mr. Franče to Basse in order to help them with the organization in the field namely with hiring of labourers.
Immediately after arrival to the minig area it was started with cleaning of previous geological test pits and test trenches that had been opened by Mr. Veltheim.

In order to cover completely the field of kaolin few more pits and trenches were recommended and dug. Togethar 20 pits and trenches were cleaned and dug but only 16 were used for sampling because the remaining four were negative on kaolin. All the pits were dug down to the base - red sandstone.

The depth of the pits was from cca 80 cm to 6 m according to the composition of the kaolin deposit. Two main areas were sampled: Kundam area (Kusa Burey, Kundam Demba, Tiri Konko and Kebe Konko) - 14 samples and Mane Kunda area - 2 samples.

All samples were prepared in such a way that the raw material was collected through the whole depth as well as through the diameter of the pit. Origin of all 16 samples was marked on simple maps (see Fig. No 1, 2 [illegible]).

Except kaolin other raw materials suitable for the ceramic production available locally were also sampled.

All 16 samples were prepared in a quantity of 60 - 120 kg each. Every sample was carefully packed and inserted into steel drum and so prepared for shipment to Europe. The total weight of 16 samples of kaolinitic clay is approximately 1800 kg.

To speed up testing of the clay and other sampled raw-materials, it was decided to send by air via Dakar average samples to Prague. The total weight of all samples was 50 kg.

While Mr. Babůrek, Mr. Haták and Mr. Franče organized the activity with digging, sampling and transport of samples of kaolinitic clay and other collected raw materials including packing and putting aside to the steel drums, Mr. Dřevo continued the discussions with local authorities.

A discussion with Mr. Christensen, Permanent Secretary, President Office, with Mr. Gibril and Roberts from Central Statistics Division of the Presidents Office, with Mr. I. B. M. Jobe, Customs officer etc. took place.

On 2.4.1973 a meeting with Mr. Tilot who came from Dakar to Bathurst was arranged. Mr. Tilot was informed by the team of experts about the situation in the field activity as well as about the future programme in shipment of samples, testing of collected raw materials in ČSSR. Mr. Tilot evaluated positively the activity of the team and recommended utilization of raw materials namely for a ceramic production.

The same day afternoon a meeting with the Resident Representative Mr. W. F. Harper was arranged. That was actually the conclusion and recapitulation of the field activity in Gambia. Mr. Harper stressed his satisfaction with the job of all members of the team and expressed his hope to help the Government of Gambia with utilisation of local raw materials.

Because the ship to Hamburg was delayed it was necessary to arrange loading after experts´ departure from Gambia. The Lands Office, namely Mr. N´Jai, Lands Commissioner, promissed to be in contact with Elder Dampster Lines and to ensure the shipment of 13 steel drums. The team leader already received his cable indicating 12 drums having been shipped from Bathurst on 24 April via Hamburg.

The last meeting in Gambia was with Mr. N´Sowe, Permanent Secretary, Ministry of Local Government. This meeting was actually the official conclussion with local authorities of the field activity in Gambia.

On 3.4.1973 at 21,00 GMT the team of experts´ left The Gambia for Daker. The team returned to Prague on 6.4.1973 at 21.30 GET.

ii) Geology, mineralogy and petrography of the Gambian ceramic raw materials

1/ Summary of the results and recommendation of further arrangements

In spite of the fact that previous research done by Mr. [illegible] heim in this area indicated kaolin, it has been found that these layers are actually layers of kaolinitic claystone with a relatively high content of fine silica. In the surroundings of Bassé and Fatoto on the river Gambia a number of deposits of this raw material has been found. Only deposits at Sanka Pari, Sanka Bari II, Tiri Konko and Kebe Konko are of industrial signi-ficance. In this area the kaolinitic claystone is minable from the surface because the ratio overburden: raw material is appro-ximately 2:1. It means, that on 1 ton of mined raw material it may be counted with less than one cubic meter of idle earth which is built almost from dark red laterites and sandstones containing iron. The expected extent of kaolinitic claystone with deposits in hundreds of millions tons was not confirmed. In sur-roundings of Kundem and in the Bassé area geological reserves of little more then 500 000 tons were found. According to the research made in the field and in conformity with the laboratory testing it was certified that horizontal as well as vertical vari-ability of chemical and mineralogical composition of kaolinitic claystone is not too high and therefore homogenization of the mined raw material will be rather easy. The raw material may be used not only in the body mix of different ceramic products but also in the production of refractories (fireclay bricks).

Except the kaolinitic claystone deposits of other two highly plastic clays have been found in the Basse and Fatoto area. Both of them are kaolinitic clays with a higher content of quartz. In spite of the fact that it was not possible to verify the quan-tity of the clays, it was possible to test their quality for the production of various ceramic items. One of them, clay Bassé, is also suitable for the production of cement as correction clay.

In the delta of the river Gambia there are deposits of quality quarts sand and sea shells built of aragonite, which may be suitable for the production of various ceramic items as well as for the cement production.

All raw materials are minable from the surface with a relatively low expenses. Minig may be done either by labourers only or by using machines such as scrapers, buldosers etc. A short distance of the clay deposits from the river Gambia assumes also low transport costs of mined clays to the factory.

Before any final decision about industrial exploitation of the kaolinitic claystone deposit for local ceramic production is taken it is recommendable to ascertain geological reserves of other two plastic clays in Bassé and Fatoto area as well as of white or off white quartz sands and aragonite sea shells. For such an assessment it will be necessary to dig a certain number of pits and trenches, take samples which will be evaluated on their technological and mineralogical properties; according to the obtained results it will be necessary to calculate geological reserves of the above mentioned raw materials. Further it may be recommended to find the primary rocks from which our kaolinitic claystone was developed by erosion and sedimentation. Here is the hope to find the primary kaolins somewhere in the upcountry.

2/ General geological situation

The researched area is as far as geological situation is concerned a part of Senegal-Mauretanian basin. The basic rocks which do not appear in Gambia on the surface are actually different types of granites and gabbers with other metamorphic rocks of Paleozoic and Gambrian age.

The thickness of overburden Proterozoic and Tertiary Rocks is not perfectly known. The search for crude oil and gas in The Gambia has shown that their thickness is more than 4000 meters. The territory of The Gambia is built by sedimentary rocks of Tertiary and Quarternary ages.

<u>The Maestrichtian</u> - (the end of the Upper Cretaceous) is developed on a rather big territory of Senegal and The Gambia and is built from layers of sands, sandy clays and clays. In some places hardened sandstones (with calcareous or clayey cementation) are developed. The petrographic variation of the sediments is in horizontal as well as in vertical direction very high. The thickness of sediments increases from east to west.

<u>The Plaeocene</u> - is developed predominantly in the form of limestones and transitions into marlstones. The thickness of these layers is approximately 50 to 80 metres. These rocks represent the main water bearing horizon in this area.

<u>The Lower Eocene (Lutetian)</u> - appears namely in the west part of Senegal and is built almost entirely from clay sediments.

<u>The Middle Eocene</u> - is composed of two stages:

I) the Lower Lutetian - marls and limestones

II) the Upper Lutetian - mostly limestones

<u>The Oligocene-Miocene</u> - sediments are represented by marls and clayey limestone. These sediments are known namely from Casamance area. In the upper part of river Gambia this formation is developed as sands, sandy clays and clays of various colours.

The latest Tertiary sedimentary cycle is represented by so - called Terminal continental series resting discordantly on the preceding sediments. This cyclus of sedimentation was accompanied by tectonic processes. The Terminal continental series is developed in a whole range of facies from sands to sandy clays. The series is developed almost on the whole territory of Senegal and on a considerable part of gambian territory. In the alluvial plain of the Gambia River these beds are mostly denuded. In the direction towards the interior of the country a higher thickness of the Terminal continental series can be observed. The basal detrital kaolinite has been known in major thickness (up to 10 m) from the Kundam area near Basse.

The Quaternary - is developed in several facies.
In the alluvial plain of the Gambia River and its tributaries, these facies are grey mud clays or variously coloured clayey sands to sandy clays. On the Atlantic coast, they are mostly blown sands of different ages. At the lower course of the river Gambia, near Cape Mary, rather extensive layers of lacustrine laterite occur; these are accumulations of material coming from eroded lateritic soils and laterites.

In the area of brackish development next to the mouth of the river Gambia, layers of shells occur along the whole coast.

3/ Kaolinitic clays in the Bassé area

3.1. Geology of the deposits

As mentioned above, in the Continental Terminal series also layers of kaolinitic clays and sands have developed. After subsequent chemical processes during lateritic weathering the deposition of detrital kaolinite is regarded as the beginning of the sedimentation of the Terminal continental series which was deposited discordantly on the preceding Miocene sediments. The layer of detrital kaolinite filled the unevenesses of the ground and, therefore, the total thickness of the originally deposited detrital kaolinite may vary considerably as well as its areal distribution in which especially filling of earlier water courses etc. can be expected. The layers of the kaolinitic raw materials were exposed to the lateritic weathering. Namely in the upper parts of these layers it is possible to find a higher content of iron compounds and therefore a characteristic red calour.

In the Kundam area the following lateritic development can be observed:

I) On the surface there are visible parts with characteristic red colour indicating enrichment in iron compounds; there are abundant iron brecktios, and sandstones with a spongy texture.

II) A buff - coloured horison, purple, orange, violet etc., gradually passing, from above downwards into a sandy kaolinitic claystone, with irony coatings on joint planes. The total thickness of this layer varies between about 4 - 8 m.

III) Compact "kaolin" (kaolinitic claystone) of white or slightly purple tint with purple coatings on joint planes. Its thickness varies around 2 - 3 m.

In the course of erosion caused by the development of the valley of the Gambia River a very dissected margin of the beds of the Terminal Continental series developed, and the border of the "kaolin" layers was shifted by several metres downwards due to the solifluction processes. These shifted layers usually display a geological setting favourable for exploitation.

In the large surroudings of Bassé all up to now known and economically significant deposits of kaolinitic claystones are concentrated, specified by Mr. Veltheim as "sedimentary kaolin". For this territory Mr. J. Franke made a geological map 1:5000 which is also enclosed. Deposits of kaolinitic claystone were found very close to Bassé, Sanka Bari and Sanka Bari II, Kebe Konko and Tiri Konko.

A characteristic geological profile through the deposit in this area is as follows:

- the underlaying beds - red, weakly consolidated sandstones
- the lower layer of the kaolin claystone - compact claystone disintegrating into coarse lumps, coating of iron compounds on joint planes. The kaolinitic claystone is tough, non-sandy, whitish, light gray or slightly purplish; it cannot be worn away by water; it can be dressed into a plastic tough by fine grinding only. The richness of this lower layer is 1 - 3 m, usually 1,8- 2 m.
- the upper layer of the kaolin claystone - transition from the lower layer is unconspicious, manifesting itself by an increased content of fine quarts and a higher amount of iron compounds; in the upward direction it looses the liability to disintegrate into lumps and passes gradually into the buff-coloured horizon. The workable thickness of the sandy claystone is about 1,5 - 3 m.

- the overlying beds - buff coloured horizon of variable thickness 3 - 8 m, bearing on its surface a layer of irony sandstone of about 1 m thickness is developed.

Geological reserves of kaolinitic claystone in the large surroundings area of Bassé are according to our existing knowledge approximately as folows:

Kebe Konko	.....	68 200 t
Sanka Bari	.....	403 000 t
Sanka Bari II	....	16 500 t
Tiri Konko	.....	35 200 t
T o t a l		522 900 t

The occurrence of kaolinitic claystone was also tested in the close surroundings of Bassé. This raw material is also here developed in thin layers of 0,3 to 0,6 m thickness and is strongly pigmented with iron compounds.
Therefore this part was not calculated as geological reserves.

3.2. Mineralogical and petrographical composition of kaolinitic claystones

From industrial exploitation point of view of every raw material it is very important to know except its geological reserves also mineralogical composition indicating useful compounds and impurities. Further it is very important to know its variability in quality in vertical and horizontal direction of the deposit.
For this reason the kaolinitic claystone was sampled in short distances in the pit No 8 and trench No 4. These samples were tested by chemical and mineralogical analysis.

Table No 1a : Chemical composition of samples of kaolinitic claystone in the pit No 8

metres	ignition loss %	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MgO	CaO	Na_2O	K_2O
0,0 - 0,5 m	12,04	50,22	31,34	2,23	2,54	0,06	0,13	0,02	0,02
0,5 - 1,0 m	11,8[illegible]	50,12	32,06	2,06	2,45	0,06	0,16	0,02	0,04
1,0 - 1,5 m	12,65	48,70	33,43	2,18	2,53	0,05	0,15	0,01	0,04
1,5 - 2,0 m	12,30	50,17	32,10	2,16	2,49	0,05	0,10	0,01	0,02
2,0 - 2,5 m	12,19	50,23	32,32	2,18	2,46	0,05	0,14	0,02	0,04
2,5 - 3,0 m	11,98	51,28	31,26	2,04	2,43	0,05	0,09	0,02	0,04

Table No 1b: Chemical composition of samples of kaolinitic claystone from trench No 4

metres	ignition loss %	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MgO	CaO	Na_2O	K_2O
0 - 2 m	10,66	52,73	30,17	2,86	2,42	0,03	0,04	0,02	0,06
2 - 4 m	11,75	51,20	31,24	2,66	2,35	0,04	0,03	0,02	0,06
4 - 6 m	9,86	57,78	27,02	2,60	2,42	0,05	0,02	0,02	0,06
6 - 8 m	9,57	59,70	25,56	2,14	2,23	0,04	0,04	0,02	0,06
8 - 10 m	8,[illegible]9	65,40	22,07	1,87	1,60	0,04	0,02	0,02	0,05
10 - 12 m	8,20	67,22	20,94	1,68	1,59	0,03	0,04	0,01	0,05
12 - 14 m	10,85	54,20	29,61	2,14	2,38	0,05	0,04	0,02	0,06
14 - 16 m	9,44	61,04	21,84	1,76	2,09	0,05	0,07	0,01	0,06
16 - 18 m	10,94	55,67	28,56	2,01	2,19	0,04	0,03	0,02	0,05
18 - 20 m	10,48	59,06	25,99	2,04	2,04	0,04	0,03	0,02	0,04

Table No 1a shows chemical composition of kaolinitic claystone from test pit No 8, which was located close to Kundam, approximately 15 km far from Bassé. The content of Al_2O_3 (Alumina) varies in vertical direction very little and irregularly in dependence on the deepness of the pit. The same is valid for variation of iron oxide and TiO_2. The content of alkalis is very low. It may be said that chemical composition does not show any dependence on the deepness of the tested pit as far as vertical direction is concerned.

Slightly different is the situation with the trench No 4 (approximately 300 m to the south from the pit No 8). Content of silica increases and content of alumina simultaneously decreases to the base of the deposit.

Also iron oxide decreases in this direction. The variation of alumina content is visible also macroscopically, it means that content of very fine quartz sand increases in vertical direction.

The DTA (Differencial Thermal Analysis) curves show only characteristical endo- and exothermic reactions (maximum with 610 ^{0}C and 905 ^{0}C) and do not show any other peaks indicating presence of minerals. Also the base of the deposit which is built from red coloured sandstones contains a small amount of clay which has the same mineralogical composition.

The X-ray difraction analysis does not show presence of other minerals except kaolinite and quartz in spite of the fact that other minerals such as alumina hydrates may be expected there.

Microscopic study of thin sections of these rocks (kaolinitic claystone and red coloured sandstone from the base) has shown that particles of present quartz are milky coloured, sometimes also pellucid and round. The particles of kaolinite are of submicroscopic size and build irregular agregates. The claystone is very compact. However, presence of amorphous silica which may explain such a good compactibility has not been found.

4/ Deposits of clay Basse and Fatoto

When prospected the area of the upper part of the river Gambia a gray plastic clay has been found very close to Bassé on the left side of river Gambia. A very similar type of clay, slightly darker, was found also on other places very close to the river. The layer of this clay is 0,5 - 1,5 m thick and is covered with 1 m thick over burden which is built from sandy clay. Because of limited time for the field work it was not possible to make further search of this clay.

In surroundings of Fatoto (village with higher sea level than Bassé in the upper part of the river Gambia) compact kaolinitic claystones appear a few metres above the water level of the river. They are covered with a rather thick layer of red coloured lateritic horizon. Mining of these claystones does not seem in such conditions economical.

In the Fatoto area a dark gray clay probably of quarternary age has been found. The layer of the clay comes up to the surface in the immediate proximity of Fatoto close to the road to Bassé. This layer is approximately 1 m thick. This clay is highly plastic and suitable not only for the production of red bricks and tiles but also for the ceramic production.

Geological reserves of both types of clays which seem to be very hopeful for the ceramic production must be tested and verified by further geological investigation. Simultaneously total geological reserves of both clays should be calculated. Also decision for the best minig method should be made after having good knowledge about geological situation of both raw materials.

5/ Deposits of sea shells and quartz sand

The shells from the sediments of the brackish facies in the mouth of the river Gambia are commonly worked and further dressed by crushing and sorting into fractions of an asphalt mixture for roads. Their chemical composition (a high content of calcium oxide and a low content of impurities) shows that they are suitable for the ceramic production and also for the cement production.

Along the middle part of the river Gambia and namely in its delta (near the Cape Mary) layers of light and white quartz sand appear. This quartz sand is relatively pure and may serve as one of the components of the cramic bodies. A simple geological research which will verify geological reserves and mining conditions is recommended.

6/ Mining conditions for particular raw materials

All tested raw materials, in spite of the fact that further geological research will be necessary in order to ascertain geological reserves, are minable from the surface, what means in the open mine.

a) Kaolinitic claystone - the most suitable place for the opening of the mine according to the existing knowledge seems to be the locality Sanka Bari. Ratio idle earth:raw material will be approximately 2 : 1 what means that to extract 1 ton of mined kaolinitic claystone approximately 1 m^3 of idle earth must be removed (correct figure is 0,908 m^3). This idle earth is possible to be used for building of roads and ways. The overburden layer of iron sandstone may be disintegrated by explosives and removed either with scraper or by labourers using shovels and trucks. The deposit of kaolinitic claystone may be also discharged by explosives (partly homogenization will take place during this operation) and loaded by labourers with the use of a conveyor. When machine will be used then feeders of the type Caterpillar (USA), Alpine (Austria), Volvo (Sweden) with the bucket 1 - 2 m^3. These machines are suitable also for difficult climatic conditions.

b) Plastic clays from Baegé and Fetoto have similarly as quarts sands better minig conditions in comparison with the kaolinitic claystone. The ratio overburden: raw material will be most probably 1 : 1 to 3 : 1 according to the point where the deposit will be open. In this case it is not necessary to disintegrate the raw materials by explosives.

c) Sea shells in the delta of the river appear in thin layers very often covered with sand. Further geological research as mentioned above will be necessary. However, according to the existing knowledge collected during preliminary visits in the field, it seems that the minig conditions will also be simple. The upper layer of the sand may be removed by scraper and sea shells loaded to the trucks.

It is an acceptable presumption that in the first stage after construction of the factory the consumption of all raw materials will be about 3000 tons/year and the amount of each particular raw material will not be higher than 1000 tons per year. From this point of view two possible ways how to solve the raw material problem may be recommended.

1. Recommendation with the use of machines

This recommendation presumes minig of particular raw materials in such amounts which will cover the factory consumption for one whole eventually for two whole years. In this case light storage buildings for a large amount of raw materials should also be built.

For this way the following machines will be necessary:

- One scraper. This machine will be necessary for approximately 3 months. In this time also time necessary for moving of the machine from one deposit to the another is calculated.
  Tender: 2 people.

- One drilling machine to prepare bores up to the deepness 2,5 m which are necessary for stockblasting.
  Tender: 2 people.
- One digger loeder to excavate the disintegrated material and load it on a lorry.
  Tender: 1 man.

Except these m[illegible]es 2 workers for blasting and 5 labourers - helpers for mining and loading will be necessary.

2. Recommendation without use of machines

This recommendation pressumes mining of all necessary raw materials simultaneously each on its deposit through the whole year (except rainy season) and transporting them to the storage buildings of the factory. In this case factory storage buildings may be smaller.

As mentioned above 3000 tons of raw materials will be necessary for the first stage of production. 200 working days may be counted per year. It means that 15 tons of raw materials must be mined daily. Because overburden is approximately twice so thick then also 30 tons of idle earth must be removed. However, in this recommendation the overburden layer of iron sandstone may be discharged by blasting as well as useful raw materials. In such a case only further discharging and loading of 45 tons on trucks will be necessary. For this operation 22 - 30 labourers and 2 - 3 trucks may be used.

This recommendation is without any mechanisation and seems to be sufficiant for the first stage. If the first recommendation is accepted the following process (procedure) should be used:

On the deposit Sanka Bari the overburden will be shooted and removed by scraper when overburden on the deposits Fatoto and Basse was already removed. Then the scraper will be transported (e.g. on the ship) to the deposits of quartz sand and sea shells where also upper layers of idle earth will be removed.

Immediately after scraper and loader will load raw materials on the Fatoto, Basse, Sanka Bari deposits on trucks or streight on a ship. Than it will be also transferred on the ship to sand and sea shells deposits in order to load them on trucks.

The raw materials will be located in stores with a light roof. A good homogenization of the raw materials will be reached by this recommendation while the other recommendation does not guarantee such a mixing of the raw materials.

7/ The possibilities of dressing of the raw materials

For the ceramic production such as production of floor tiles, wall tiles, façade tiles, sanitary ware, sewerage pipes and cement the raw materials need not be dressed.

In the deposit of kaolinitic claystone from Kundam it will probably be necessary to remove by hand pieces which are strongly pigmented with iron compounds.

It may also be necessary to wash sea shells in order to remove present sand and clay. Higher purity of sea shells will be reached by using of vibrating screen.

8/ Recommendation for further activity

The reserves of kaolinitic claystone which is expected to be used for the ceramic production in The Gambia seem to be sufficient. By further detailed geological prospection in Upper River Division probably other deposits of this raw material may be found. However it is sure, that the ratio overburden : raw material will not be so advantageous, as it is on the Sanka Bari, Tiri Konko and Kebe Konko deposits. On the other hand if the deposit is sufficiently large it may serve as the base for the production of refractory grog. From geological point of view it will be useful to find the deposit of kaolinitic claystones' mother rock because then also deposits of primary kaolins may be found and genesis of secondary deposits of clays and claystones would be perfectly explained.

Further geological research of the deposits of clays at Basse and Fatoto, quartz sands and sea shells in the delta of the river Gambia should be done before any steps in decisions to build a factory are made. Such a research is necessary in order to find sufficient reserves of these raw materials for the event of the ceramic production or cement production.

iii) **Testing and evaluation of sampled raw materials**

The geological part shows that actually three different clays are interesting from industrial point of view. These are:

a) kaolinitic claystone which was declared by Mr. Veltheim
b) plastic clay of gray colour from the Fatoto area
c) plastic clay of yellow-puff colour from the Basse area.

Except these three clays also quartz, sea shells and laterite were sampled. All samples were tested and the results are given below.

a) Kaolinitic claystone

16 samples (1 - 9 and 11 - 17) from trenches and pits were tested for chemical analysis, each separately. Sample No 10 was lost during the sea transport. Fortunately this sample is not very important for the complete evaluation of the kaolinitic claystone. The chemical analyses are given in table No 2a and 2b. The variation of the SiO_2, Al_2O_3, Loss on Ignition, Fe_2O_3 and TiO_2 in specific samples is shown on the diagram No 1.
It is evident that sample No 13 is quite different in comparison with other fifteen samples and that it contains more silica. Also Loss in Ignition is lower. The remaining fifteen samples are more or less similar and were mixed therefore together to one everage sample which was tested again and the following properties have been found.

Kaolinitic claystone - chemical analysis

Table No 2a

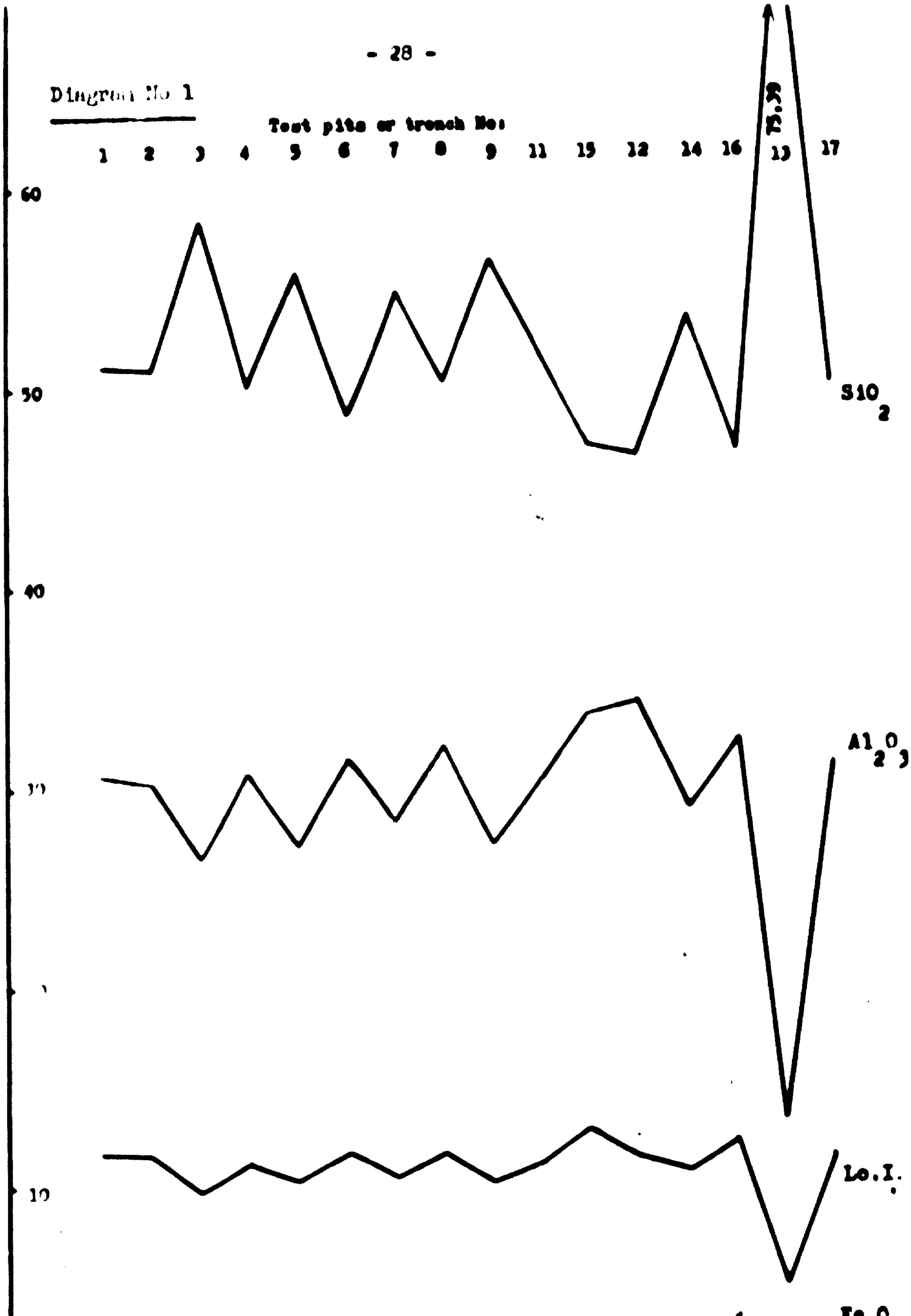
Sample No		% L.o.I.	% SiO_2	% Al_2O_3	% Fe_2O_3	% TiO_2	% MgO	% CaO	% Na_2O	% K_2O		Total
Gambie	Pit No 1	11,70	51,21	30,62	2,80	2,42	Traces	0,25	0,07	0,06		99,13
	Pit No 2	11,70	51,09	30,24	2,73	2,39	0,02	0,17	0,05	0,06		98,45
	Pit No 3	9,93	58,53	26,60	2,33	2,12	Traces	0,17	0,04	0,04		99,76
	Trench No 4	11,27	52,74	30,83	2,46	2,34	Traces	0,13	0,05	0,04		99,86
	Trench No 5	10,47	55,31	27,28	2,55	2,35	0,07	0,17	0,06	0,04		98,90
	Pit No 6	11,95	48,90	31,62	3,43	2,56	0,04	0,13	0,05	0,04		98,72
	Pit No 7	10,71	55,06	28,49	2,18	2,23	0,10	0,10	0,05	0,04		98,96
	Pit No 8	11,93	50,53	32,19	2,54	2,51	0,05	0,10	0,03	0,03		99,91
	Trench No 9	10,50	56,68	27,41	2,09	2,20	0,12	0,03	0,16	0,28		99,47
	Pit No 11	11,44	51,33	30,70	2,63	2,42	0,09	0,09	0,21	0,32		99,63
	ø 1 - 9	11,1	53,41	29,48	2,57	2,35	0,04	0,14	0,06	0,07		99,25

Table No 2b

Kaolinitic claystone and other components - chemical analysis

Sample No		% L.o.I.	% SiO_2	% Al_2O_3	% Fe_2O_3	% TiO_2	% MgO	% CaO	% Na_2O	% K_2O		Total
Gambie	Pit No 12	12,75	[illegible]	[illegible]	[illegible]	4,53	0,08	[illegible]	0,17	0,26		99,74
	Pit No 13	5,25	73,33	13,74	2.30	0,65	0.03	0.07	0,45	0,63		99,37
	Trench No 14	11,04	53,36	23,25	[illegible]	2,45	Traces	0,15	0,18	0.27		99,39
	Trench No 15	13,10	47.44	33,36	2.74	2,49	Traces	Traces	0,15	0.24		100,12
	Trench No 16	12,51	47,35	[illegible]	[illegible]	[illegible]	[illegible]	0.03	0,20	0,30		99,45
	Pit No 17	11,77	50,71	[illegible]	2,73	[illegible]	0.03	[illegible]	[illegible]	0,34		99,56
	Clay Fatoto	8,98	64.61	20,33	2.00	1,53	0.45	0,13	0,25	0.70		99,73
	Clay Basse	7,78	61,52	22,34	[illegible]	1,61	[illegible]	0,04	0,72	1,61		100,32
	Quartz	0,45	[illegible]	0,35	0,17	0.47	0.03	0,08	Traces	0.03		99,23
	Sea shells	42,55	0,86	0,43	0.47	Traces	Traces	52,41	1.47	0,16		98,36

Diagram No 1



Test pits or trench No:
1 2 3 4 5 6 7 8 9 11 15 12 14 16 13 17
60
50
40
10
SiO_2
Al_2O_3
Lo.I.
Fe_2O_3
TiO_2

Kaolinitic claystone
- technological properties

Table No 3

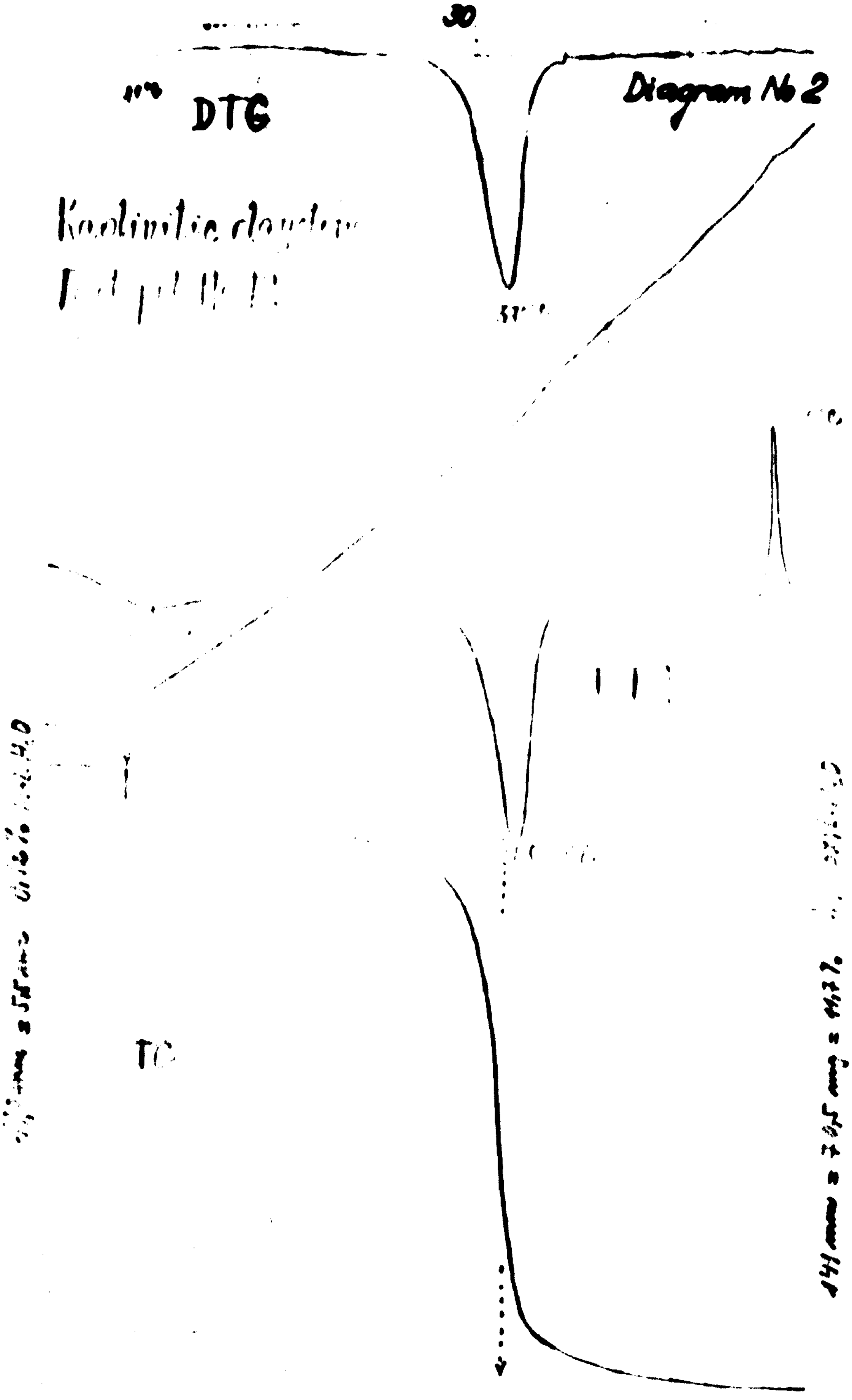
	green	fired to the temperature		
		1040 °C	1080 °C	1250 °C
Loss on drying	25,3 %	-	-	-
Loss on Ignition	-	11,0 %	11,4 %	11,5 %
Waterabsorption		27,0 %	26,0 %	7,8 %
Wet-dry shrinkage	5,[illegible] %	-	-	-
Dry-fired shrinkage	-	1,[illegible] %	2,2 %	11,3 %
Wet-fired shrinkage	-	7,5 %	7,8 %	16,8 %
Brightness (MgO standard)	50,7%	-	-	-

	pits No				trench No
	1	3	8	12	15
Content of Mn in HNO_3 solution	0,0002 %	0,0002 %	0,0002 %	0,0002 %	0,0002 %
Content of Cu in HCl solution	0,0002 %	0,0002 %	0,0002 %	0,0002 %	0,0002 %
Content of Fe in HCl solution	0,022 %	0,025 %	0,052 %	0,017 %	0,085 %

Also differencial thermal analysis (DTA) and X-ray difraction analysis was tested. They show that the raw material is actually kaolinite mixed with quartz. The curves of DTA and X-ray analysis are shown on diagrams No 2 and 3. It resulte that this raw material is suitable for the ceramic production including production of refractories.

b) Plastic clay from the Fatoto

This clay is of gray colour and has a high content (65 % and more) of particles below 1 micron. The residue on the screen 10 000 op/cm^2 is nearly 6 % and it is built by fired quartz sand without higher content of impurities. X-ray difraction analysis indicates the presence of kaolinite, quartz and small amount of micaceous clay mineral. The diagrams No 4 and 5 show the curves of DTA and X-ray difraction analysis. The chemical composition is given in table No 2b. The following table No 4 indicates some technological properties.


30
DTG
Diagram No 2
TG

Test pit No 12

Diagram No 3

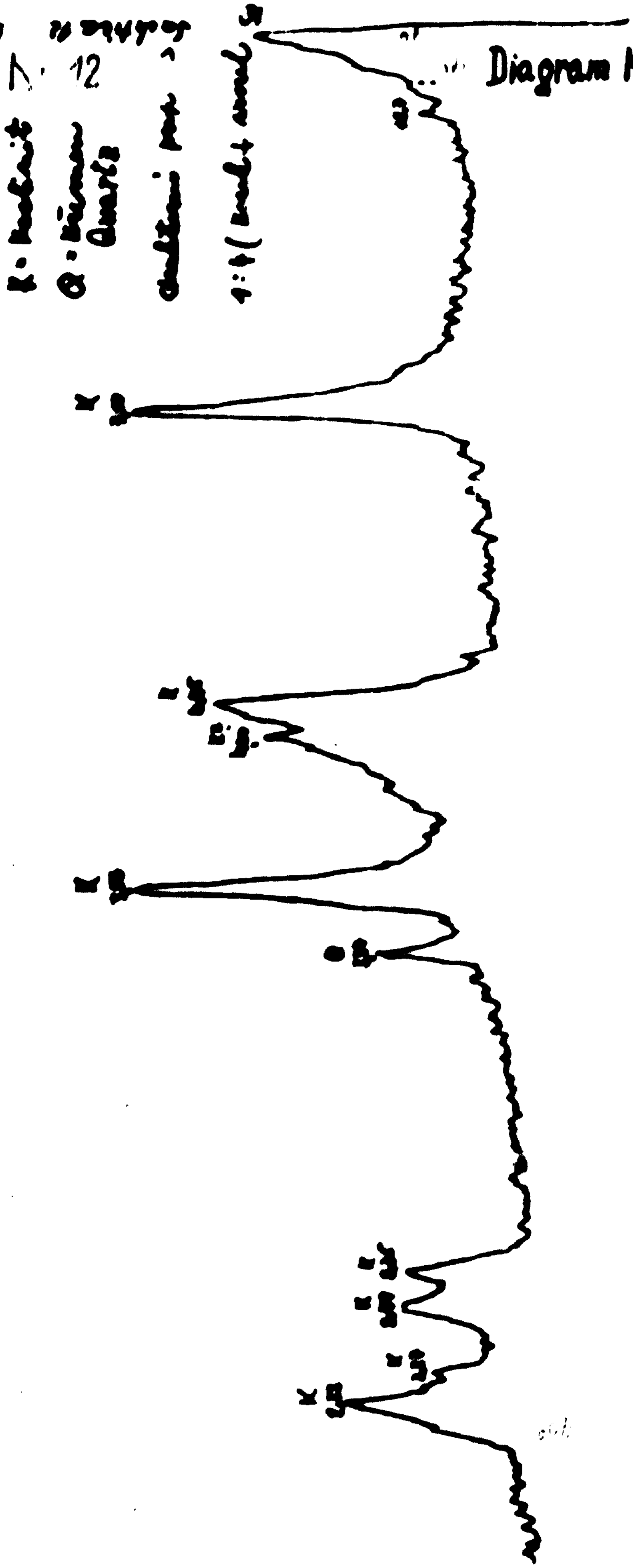


Diagram no 4

Faloto

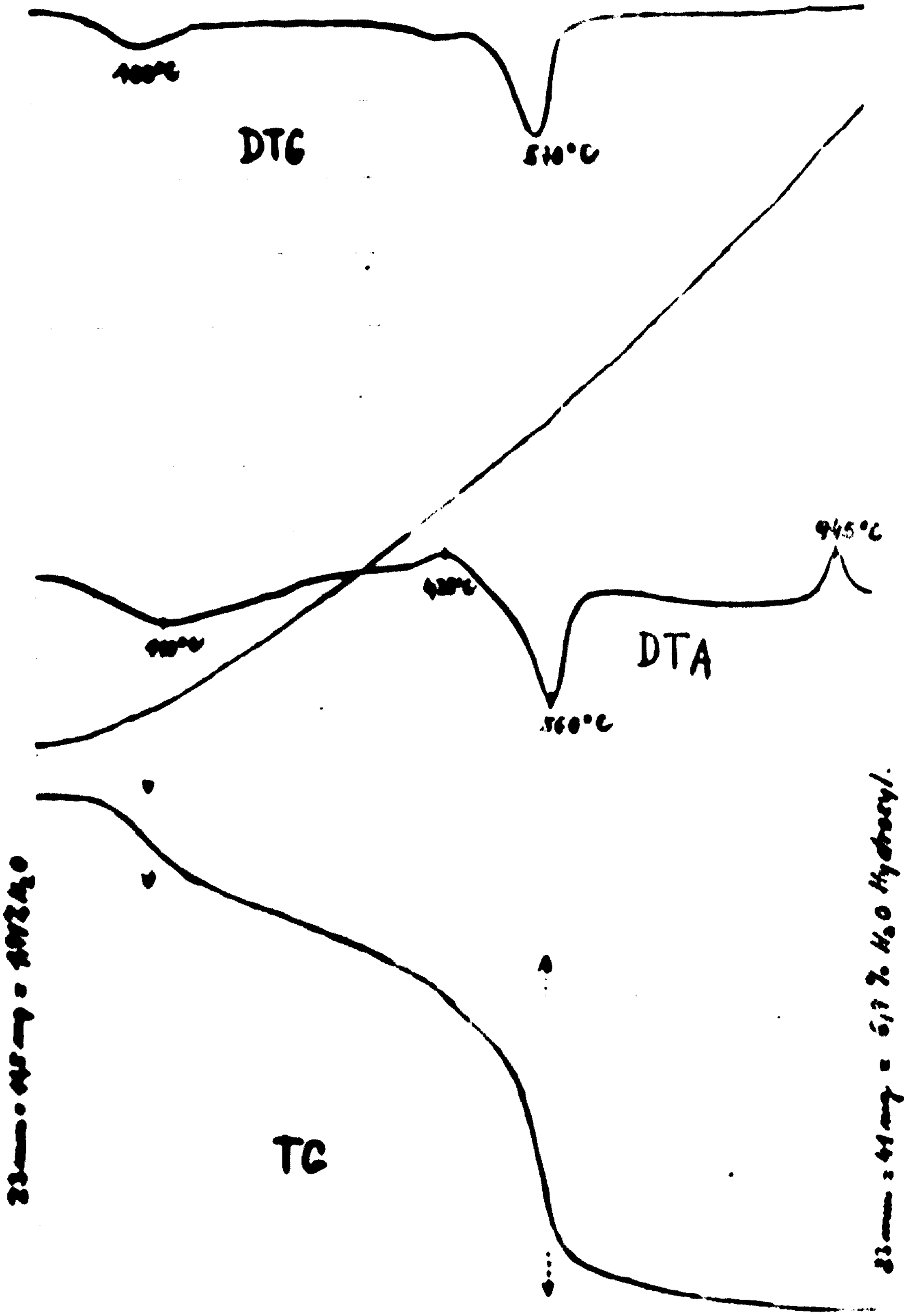
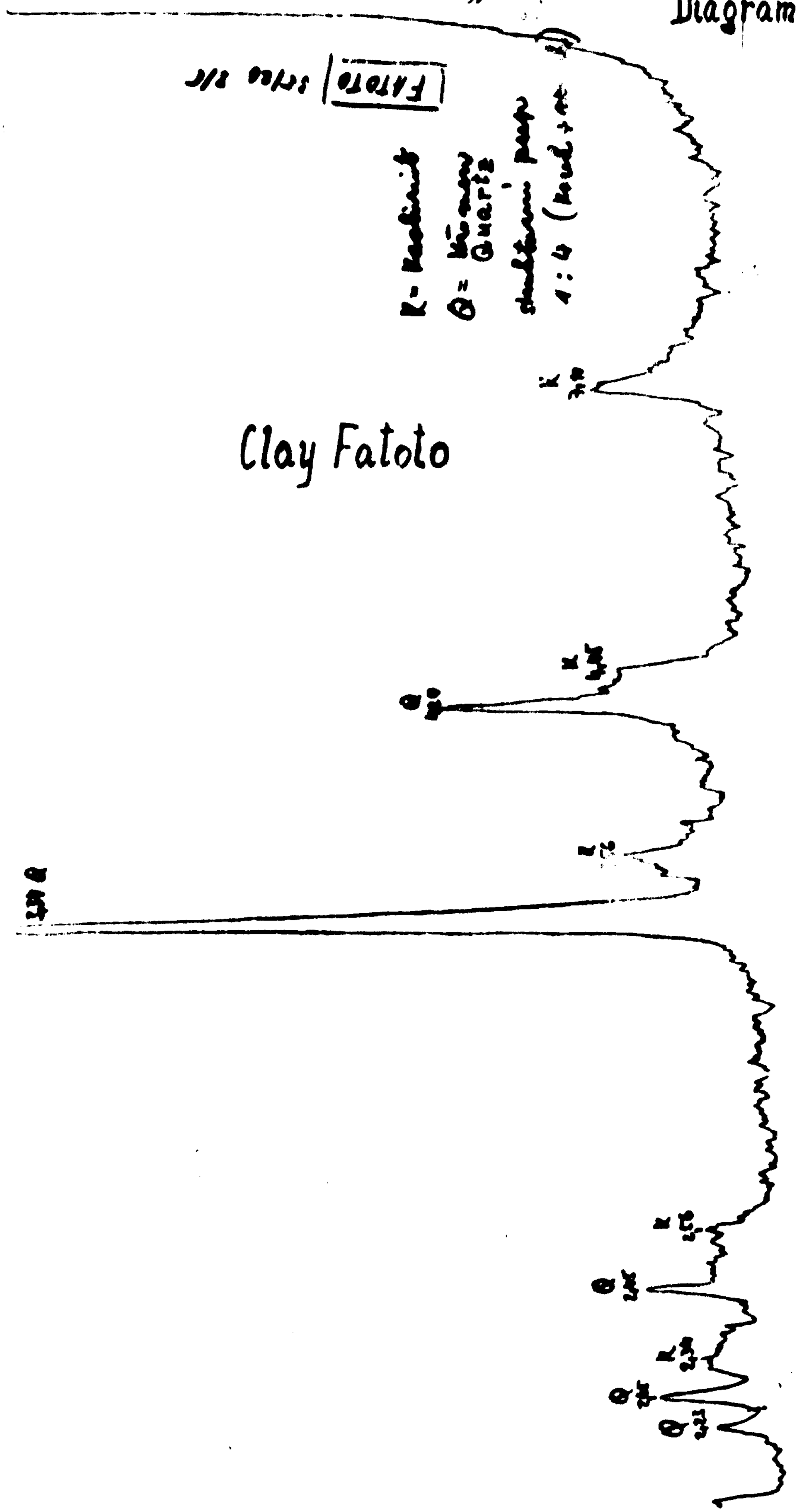


Diagram No 5



Plastic clay Fatoto
- technological properties

Table No 4

	green	fired to the temperature 1090 °C	1120 °C	1250 °C
Loss on drying	22,8 %	-	-	-
Loss on firing	-	9,5 %	10,1 %	10,3 %
Waterabsorption	-	19,1 %	19,1 %	12,2 %
Wet-dry shrinkage	7,1 %	-	-	-
Dry-fired shrinkage	-	2,0 %	2,5 %	5,1 %
Wet-fired shrinkage	-	8,9 %	9,4 %	11,9 %
Strength of rupture (dryed)	2,97 kp.cm^{-2}	-	-	-

As far as physical, chemical and technological properties given above are concerned it may be said that the clay from Fatoto is suitable for the industrial use, especially for the ceramic industry.

c) <u>Plastic clay from the Basse</u>

Plastic clay from the Basse has yellow-puff colour with lower plasticity in comparison with the clay from the Fatoto. The content of particles below 1 micron is about 50 %. Clastic impurities are present in a small amount and are built from round grains of quartz. The X-ray difraction analysis indicates except kaolinite a higher amount of fine quartz. Diagram No 6 and 7 show the curves of DTA and X-ray difraction analysis. Chemical analysis of this clay is given in Table No 2b. The technological properties are given in table No 5.

Plastic clay Basse
- technological properties

Table No 5

	green	fired to the temperature 1100 °C	1250 °C
Loss on drying	22,1 %	-	-
Loss on firing	-	8,02 %	8,16 %
Waterabsorption	-	10,2 %	7,0 %
Wet-dry shrinkage	6,95 %	-	-
Dry-fired shrinkage	-	5,6 %	6,5 %
Wet-fired shrinkage	-	12,2 %	13,0 %
Strength of rupture (dryed)	5,25 kp.cm^{-2}		

Clay Basse Diagram No 6

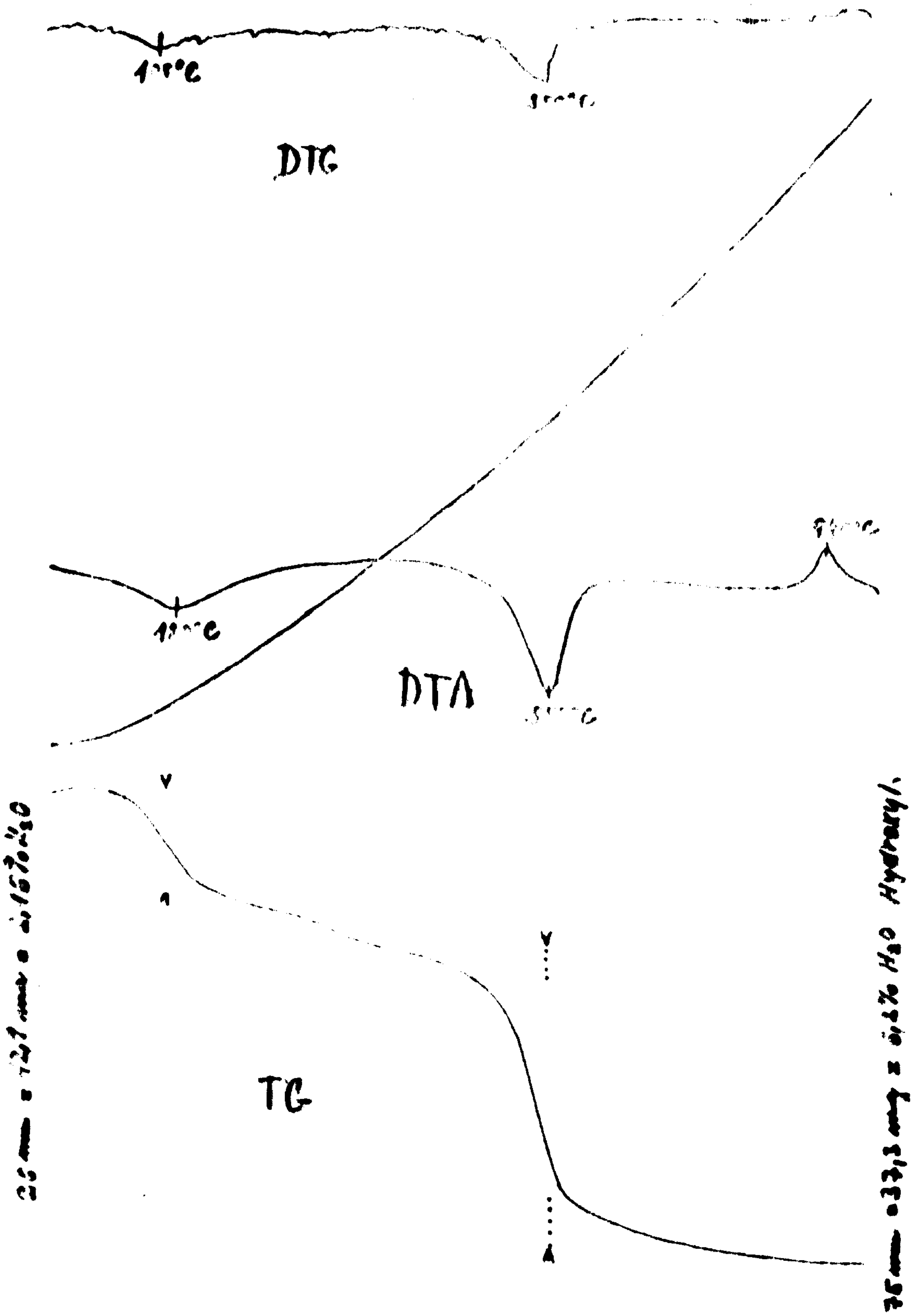
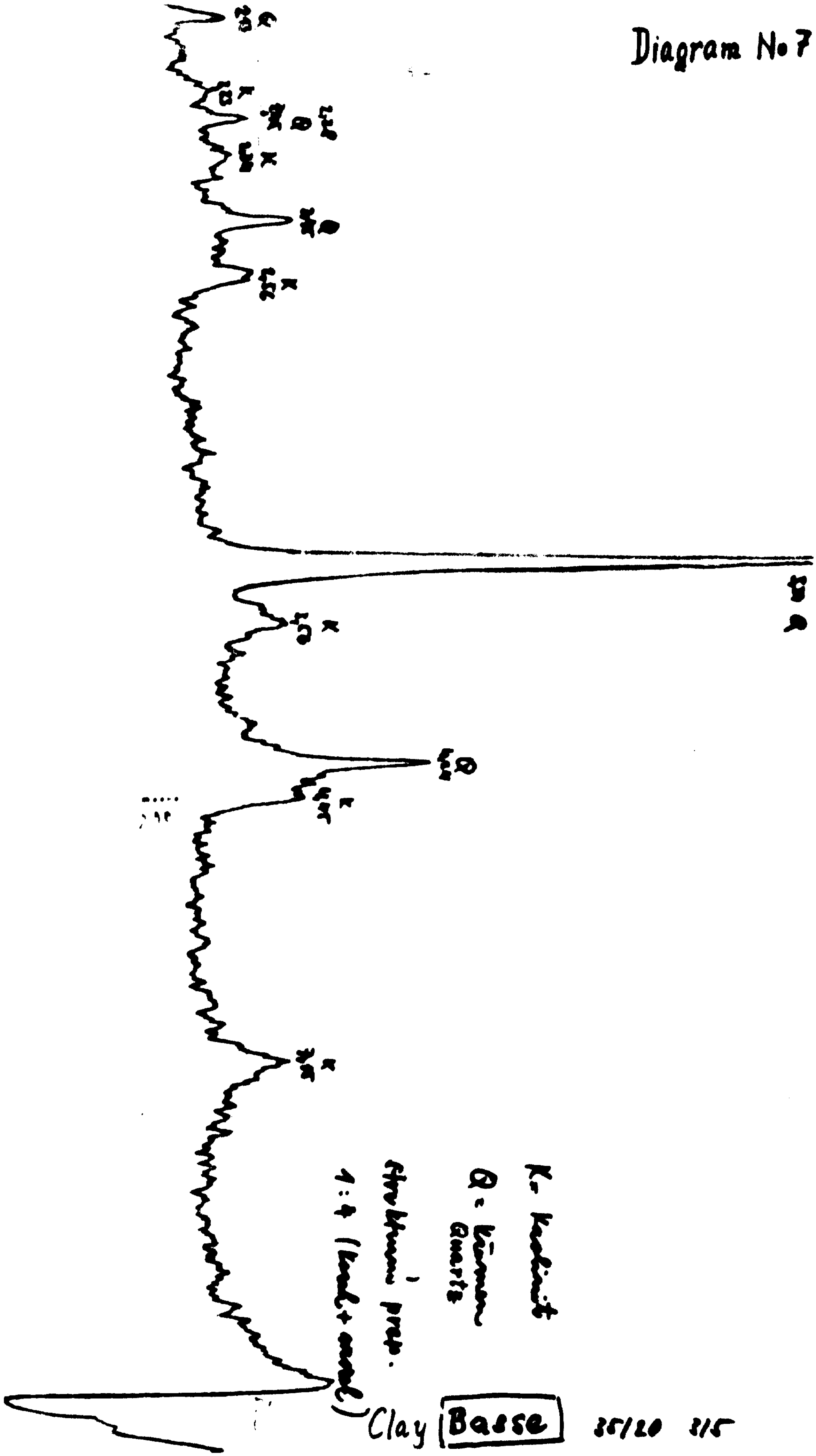


Diagram No 7



The physical, chemical and technological properties indicate that clay from the Basse will be suitable for industrial use namely for the ceramic industry as well as additive in cement production.

d) Quartz sand from the Serre Kunda

This raw-material is of white colour and the only impurities which are present are pieces of wood and leaves. Therefore also Loss on Ignition is 0,46 %. The chemical composition of quartz sand is given in Table No 2 and the particle sizes of quartz sand are as follows.

above 1 mm	0,12 %
0,5 mm - 1 mm	2,63 %
0,345 mm - 0,5 mm	7,36 %
0,2 mm - 0,345 mm	14,66 %
0,09 mm - 0,2 mm	39,45 %
0,063 mm - 0,9 mm	11,57 %
below 0,063 mm	24,21 %
	Total 100,00 %

In spite of the fact that the Al_2O_3 content is nearly 1 %, content of Fe_2O_3 is only 0,17 % and therefore the sand is suitable for the ceramic production and may be also used as additins for the cement production.

e) Sea shells

The Sea shells were sampled as a source of $CaCO_3$ which is necessary for some of the ceramic productions. The chemical composition is given again in Table No 2b and indicates that this raw material is pure enough to be suitable for industrial use.

f) Laterite

The laterite was sampled in Basse area close to a water tank and shows the following properties:

Chemical composition:

Loss on Ignition	6,39 %
SiO_2	68,82 %
Al_2O_3	13,46 %
TiO_2	1,01 %
Fe_2O_3	9,10 %
CaO	0,52 %
MgO	0,81 %
K_2O	0,16 %
Na_2O	0,04 %
Total	100,31 %

The raw material is not plastic and seems to be suitable only for the production of red floor tiles because it contains nearly 10 % of Fe_2O_3. On the other hand content of TiO_2 is rather low to reach a strong red colour.

iv) Technological evaluation of Gambian raw materials

1/ Evaluation of kaolin for use in paper industry

From the geological part it is evident that there is actually not a deposit of kaolin in the Gambia but the deposit of kaolinitic claystone which is rather hard and nonplastic. The layer of this raw material in the deposit has many finer or coarser fractures which were fullfilled with ferritic components. Therefore also the white colour changes after fine grinding to a light pink one.

The main properties for a filler in paper industry are the brightness and residue on the screen 10 000 op/cm^{-2}. The brightness of the kaolinitic claystone in only 50,7 % (MgO standard) and as mentioned above, the material is available only in lumps.

For these reasons the kaolinitic claystone cannot be recommended for use in the paper industry.

2/ Evaluation of kaolin for use in rubber industry

For a filler in the rubber industry namely the content of Mn, Cu and Fe is important and of course grainsize (residue on the screen 4900 op.cm^{-2}). The content of the above mentioned metals should not be higher than:

Mn	maximum 0,002 %
Cu	maximum 0,001 %
Fe	maximum 0,05 %

The kaolinitic claystone is from this point of view acceptable only in the content of Mn and Cu. The content of Fe is in some cases above the limit of 0,05 %.

For this reason the kaolinitic claystone cannot be recommended for the rubber industry.

3/ Evaluation of kaolin for use in ceramic industry

The physical, chemical and technological properties of kaolinitic clay indicate that this raw material is built on kaolinite slightly mixed with fine silica sand. It is also non plastic but after fine milling it shows little plasticity. The content of Fe_2O_3, TiO_2 and other coloured impurities is from ceramic point of view reasonable. All these facts indicate that this raw material may be recommended for testing in the production of wall tiles, façade tiles, floor tiles, sanitary ware, utility ware, stoneware and refractories as a part of their body compositions.

As mentioned above the kaolinitic stone-clay is non-plastic and it will not definitely cover all the requirements expected from the ceramic body. To increase the plasticity of the ceramic body as well as to increase its cold crushing strength and strength of rupture it will be necessary to add other types of plastic clays. Therefore actually the term of experts sampled during their stay in Gambia other two plastic clays which should also be used for the composition of different ceramic bodies.

According to the Contract specification the main duty of the team of experts in the field was investigation of Gambian kaolin and therefore sampling of other raw materials as plastic clays, sea shells, quartz etc was done only in small quantities.

3a/ Floor tiles

Floor tiles are ceramic products with low porosity used for covering floors of corridors, bathrooms, kitchens, department stores and other places like halls, terraces etc.

The following table shows the properties prescribed for floor tiles in different countries:

	German Federal Republic DIN 18 155	Great Britain BS 1286-1945	Austria ÖNORM B 3232	CSSR CSN 72 4820
Water absorption	1,5 - 2,5 %	0,3 - 5,0 %	2,5 - 6,0 %	2,0 - 4,5 %
Acid resistance	with 70 % H_2SO_4 - 20 °C - 28 days no changes	-	with 10 % HCl - 7 days no changes	92 %
Strength of rupture	250 kp/cm^{-2}	ø 250 kp/cm^{-2} individual 200 $kp.cm^{-2}$	individual 200 $kp.cm^{-2}$	200 kp/cm^{-2}
Tolerance in sizes:				
Length & width	± 1 %	± 1 %	± 0,5 - ± 1 %	± 0,5 mm
Thickness	± 10 %	± 10 %	± 5 - ± 10 %	± 10 %

The table shows that the main problem is water absorption, strength of rupture and sizes.

From this point of view 28 various body compositions were prepared. Because the body of floor tiles should be vitrified and because the Gambian raw materials (clay) give high porosity after firing to the temperature of 1250 °C (usual temperature for the production of floor tiles) feldspar should be added to the body composition. In spite of the fact that Gambia is rich in clays of different qualities, feldspar or similar raw materials like pegmatite or fonolite are not available. Therefore feldspar of the following composition (Czechoslovac provenance) was used.

Feldspar from CSSR:		
	LOSS on ignition:	0,28 %
	SiO_2	66,71 %
	Al_2O_3	18,24 %
	TiO_2	traces
	Fe_2O	0,12 %
	CaO	0,27 %
	MgO	0,07 %
	K2O	9,20 %
	Na_2O	4,03 %
	Total	**98,92 %**

Of course any other feldspar or pegmatite may be used for the production. The question is only to recalculate the body composition in case that the chemical composition of the feldspar most suitable from economic point of view will be different in its properties.

Properties of further Gambian raw materials used for the production of floor tiles are given in para iii) of this report. According to these properties the most suitable local raw material for floor tiles production seems to be "Clay Basse" which gives more vitrified body than other Gambian clays. It means that the body needs very low addition of feldspar (10 - 15 %) which will be probably imported to the factory. Unfortunately this clay gives after firing to 1250 °C dark brown colour and may be used only for the production of brown, red and black floor tiles.

On the other hand "Clay Fatoto" does not vitrify so much as "Clay Basse" and therefore needs higher addition of feldspar (25 - 30 %). However body composition with "Clay Fatoto" gives after firing light yellow brown colour which may be used for the production of yellow and blue floor tiles as well as for the production of different porfyr floor tiles.

Local quartz was used in some cases to decrease firing shrinkage in the production and to decrease therefore the tolerances of floor tiles.

In three body compositions "laterite" was used to reach red colour of floor tiles because its chemical composition shows a high content of Fe_2O_3. After firing of these bodies only dark red-brown colour was reached and the colour of floor tiles was not uniform.

As mentioned before, 28 different body compositions were prepared from local raw materials and from feldspar from Czechoslovakia. To reach a wide scale of colours different stains were added.

All 28 body compositions were prepared on laboratory scale only and the specimens were tested on their properties.
From all 28 compositions only 7 were recommended for large scale trial. These are compositions prepared on a larger scale No 5a, 7a, 20a, 22a, 23a, 25a and 27a. Details about all 28 body compositions are given in II. Interim report.

The above mentioned seven selected compositions about 20 kgs mixture of each were prepared for large scale tests. It is true that 20 kgs mixtures is not too much for large scale production but the sampled quantities of plastic clays from Gambia were limited. These trials were pressed and fired in factory conditions and passed through the floor tiles production line.
The following table shows body composition and properties of fired products of above mentioned large scale trials.

Body No		5a	7a	20a	22a	23a	25a	27a
Clay Basse	%	84,-	-	65,-	-	-	84,-	
Clay Patoto	%	-	64,-	-	50,-	55,-	-	53,-
Feldspar	%	10,-	30,-	15,-	25,-	25,-	12,-	25,-
Quartz	%				15,-	17,-	-	16,-
Laterite	%	-	-	20,-	-	-	-	-
Black-stain	%	6,-	-	-	-	-	-	-
Blue-stain	%	-	6,-	-	--	-	-	-
Anatas TiO_2	%	-	-	-	10,-	3,-	-	-
Red-stain	%	-	-	-	-	-	4,-	4,-
Cobalt-green-stain	%	-	-	-	--	-	-	6,-
Moisture before pressing	%	7,9	7,4	7,7	7,0	7,2	8,0	7,3
Wet-dry shrinkage	%	0,2	0,1	0,1	0,1	0,1	0,2	0,1
Dry-fired shrinkage	%	8,2	9,6	8,1	7,1	7,5	8,1	8,5
Total-shrinkage	%	8,4	9,7	8,2	7,2	7,6	8,3	8,6
Water absorption	%	0,27	0,12	1,11	0,83	1,69	1,57	0,98
Strength of rupture	$kp.cm^{-2}$	473	483	391	425	347	479	442
Acid resistance	%	97,1	98,0	97,1	97,9	97,2	97,3	97,5
Colour		black	blue	brown	light yellow	yellow	red	light blue

The body compositions were prepared by milling in ball mill with the ratio : raw materials : pebbles : water = 1 : 1 : 1 Laboratory filter press was used to remove excess water. The pressing powder was prepared on a small scale roller mill with openings of 2 mm. The moisture before pressing was 7 - 8 % and it is precisely marked in the above table for each body composi-ti...

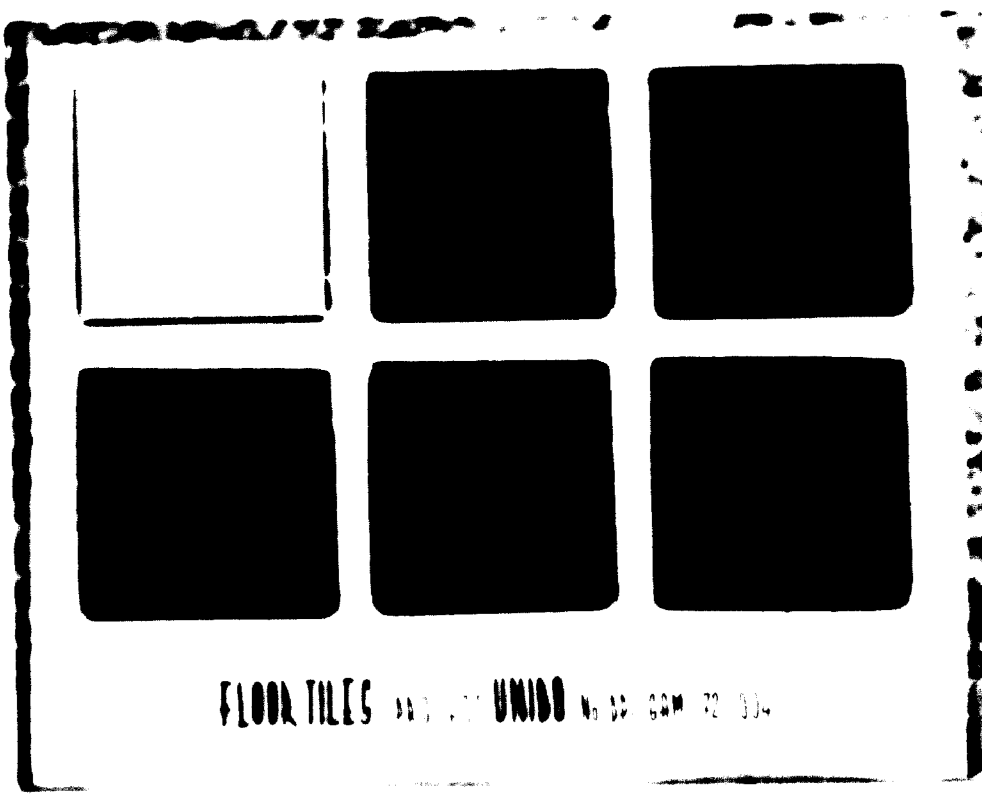
The products from all 7 large scale trials were pressed on hydraulic press with the pressure of 300 kp/cm^2 and dried in factory dryer with ordinary production. The floor tiles were fired in the tunnel kiln to the temperature of 1250 °C with the generator gas.

Except seven different basic colours tested in large scale trials few samples of floor tiles were prepared with porfyr design. It is evident that number of different combinations of colour may be extended and also marble design may be prepared. The final decision of different combinations should be done after discussions with Gambian authorities.

When comparing properties in different national standards with properties of floor tiles of seven basic colours we may say that all of them are suitable for the industrial production. The water absorption varies from 0,12 % in blue floor tiles to a maximum of 1,69 % in light yellow tiles. Strength of rupture is suitable in all cases as well as acid resistance.

From some of produced floor tiles two sample charts were prepared. These sample charts were handed over to UNIDO representative during the discussion of the II. Interim report. A fotocopy of one of them is shown for the documentation on the following page.

It seems to be unlogical that the title of the contract is Commercial utilisation of "Kaolin of Gambia" and that for the production of floor tiles kaolin was not used. The reason is in the fact that kaolin is after firing to 1250 °C very porous (21,3 %) and will therefore need a very high addition of feldspar which should be imported from abroad. Usually kaolin is used as a part of [illegible] composition to increase the whiteness (brightness) of t[illegible]y. However in [illegible] the gambian kaolin itself gives a mustard yellow to pink colour and therefore it will not increase the brightness after being added. We also understand that every percentage in imported feldspar will make the economy of the production worse.



3b/ W a l l t i l e s

Wall tiles are ceramic products with higher porosity and glazed surface used for lining of interior walls which are not exposed to the variations of weather. They are applied in bathrooms, kitchens, corridors, stores etc.

The following table gives the properties prescribed for wall tiles in different countries.

	German Federal Republic DIN 18 155	Great Britain BS 1281-1966	Austria ÖNORM B 3231	CSSR CSN 72 4812
Water absorption		max. 18 %	max. 18 %	14 - 22 %
Strength of rupture	ø 200 kp.cm^{-2}		min.120 kp.cm^{-2}	ø100 kp.cm^{-2}
Harkort test	10x80 ± 5 °C	-	160 °C	white 150 °C colour 125 °C
Autoclave test		7kp.cm^{-2} 2H		

After testing of all Gambian raw materials we understood that the following raw materials are suitable for the production of wall tiles:

Kaolin Kundam
Clay Fatoto
Quartz
Sea shells

We have calculated according to our experience the composition of three wall tiles bodies which were prepared for the first orientation in this problem on laboratory scale.

After firing and testing of these three bodies we come to the conclusion that either firing shrinkage or coefficient of thermal expansion (CTE) is too high, what means that the production of wall tiles will partly be out of tolerances, partly warped after glazing with ordinary glaze.

Having this knowledge we have prepared other three body com[illegible]ons on laboratory scale in order to improve the quality of tested wall [illegible]es.

The conclusions about these resulting three bodies may be summarized as follows: Coefficient of thermal expansion decreased in comparison with the previous bodies but it is still too high and the wall tiles show slight warpage. It indicates that the SiO_2 content is still very high and CaO which should react with SiO_2 still too low.

According to our experience with these results we have prepared on laboratory scale other two mixtures which should remove all above mentioned problems. We understood that addition of quartz should be lower and percentage of sea shells in the body compositions should be higher.

Therefore the following body compositions were prepared.

Body composition No		7	8
Clay Mtoto	%	30,-	28,-
Kaolin Kundam	%	18,-	20,-
Sea schells	%	19,-	21,-
Quarts	%	25,-	23,-
Pitches	%	8,-	8,-
Chemical composition: SiO_2	%	67,79	65,81
Al_2O_3	%	14,99	15,42
Fe_2O_3	%	1,73	1,54
TiO_2	%	1,29	1,29
MgO	%	0,21	0,21
CaO	%	12,55	14,05
Na_2O	%	0,46	0,50
K_2O	%	0,34	0,53
Total	%	99,36	99,35
Residue on sieve with 10 000 op/cm^2	%	1,3	1,5
Moisture before pressing	%	6,0	5,9
Strength of rupture after pressing	$kp.cm^{-2}$	15,1	14,1
Wet-dry shrinkage	%	0,-	0,-
Dry-fired shrinkage	%	0,6	0,6
Total shrinkage	%	0,6	0,6
Water absorption	%	15,1	16,7
Strength of rupture	$kp.cm^{-2}$	194,-	202,-
CTE ⌀ 20 - 500 °C . 10^{-7}		78,9	76,2
Harkort test white glaze		> 200	200
Harkort test coloured glaze		> 200	200

Both of tested body compositions gave good results. Body No 8 seems to be slightly better in comparison with used glazes. CTE corresponds and firing shrinkage is acceptable. Also Harkort test is good.

Because the laboratory test of bodies No 7 and 8 gave good results, we have prepared the same bodies in large scale trials. Therefore we have prepared about 50 kg of these body compositions in a ball mill where the ratio raw materials : pebbles : : water was 1 : 1 : 1. The residue on the screen 10 000 op/cm^2 was between 1 - 2 %. Laboratory filter press was used to remove excess water. The cakes were dried in the electric dryer and were milled on a small scale roller mill with openings of 2 mm. The moisture of the pressing powder was 60 - 65 % and is marked in the above table for each body composition.

The products from both body mixtures were pressed on a friction press (80 tons). Both sizes - 100 x 100 mm and 150 x 150 mm were pressed. The pressed tiles were dried in factory drier and fired with ordinary products in a factory tunnel kiln. The biscuit was fired to the temperature of 1100 °C. The biscuit firing did not show any rejections from cracks or warpage point of view.

The biscuit bodies were glazed in the factory glaze machine with factory glazes which were those days used in the factory. Few different plain colour and some marble designs were also prepared.

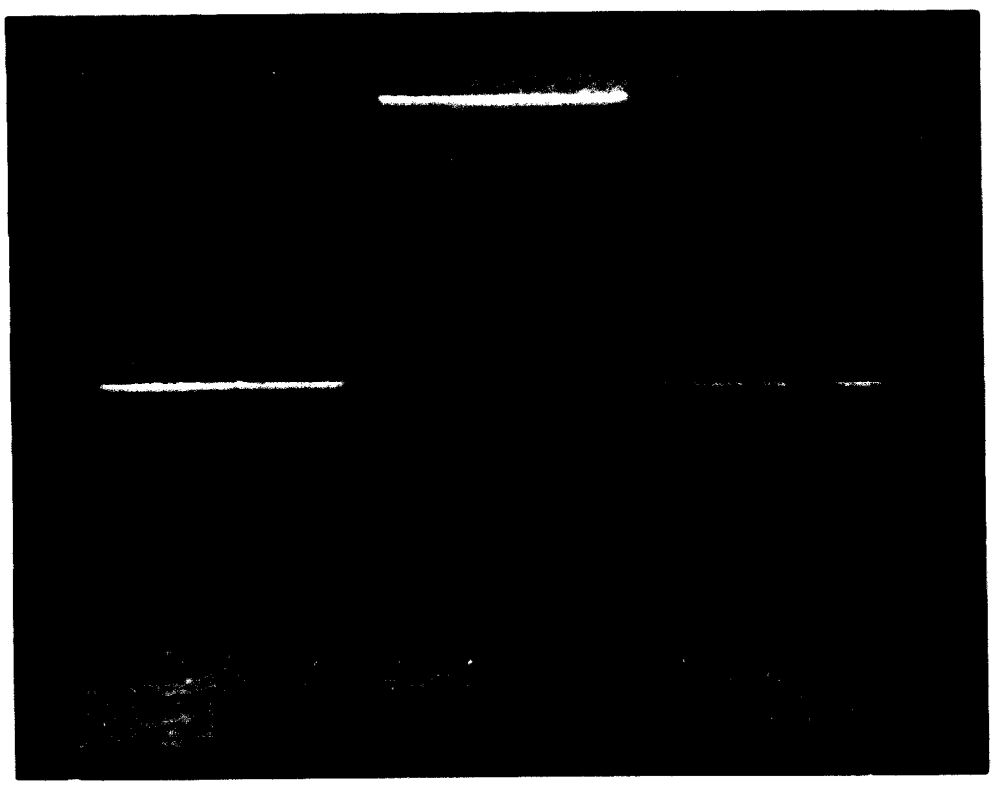
The glost firing was done by 1000 °C in 3 hours time in a electric glost kiln.

It is to be mentioned that body compositions No 1 - 6 are discussed in details in II. Interim Report. From some of produced wall tiles two sample charts were prepared.
A fotocopy of one of them is shown bellow for the documentation. The two mentioned sample charts were given to UNIDO representatives during the discussions about the II. Interim Report.

Tha bodiea used for large scale production are composed only from Gambian raw materials and gave good results. Of course ordinary glazes were used for the large scale production and we do not expect that Gambia will in future produce its own glazes. Tha production of glazes is technically very intricated and therefore it is recommendad to import glazes for the production. For information we may give few names of world known producers of glazes:

Ferro-enamels, Rotterdam Netherlands
Degussa, Frankfurt/Main, German Federal Republic
Reimbolt-Stricke, Köln/Rhein, German Federal Republic
Johnston-Mathews, Stoke-on Trent, Great Britain
Hommel O., Pittsburg, USA

Czechoslovakia also produces its own glazes in "Glazura" Roudnica which were actually used for large scale production. It is not necessary to stress that the colour or design of wall tiles may be changed according to a final decision and analyses of marketing and economic situation in the Gambia.
It is evident that the production of wall tiles from Gambian raw materials is possible. The analysis of marketing and economic situation in the Gambia will give the final answer to this question.



3c/ Façade tiles

Façade tiles are ceramic products which are very dense, often also vitreous with white or other coloured body which is very hard in order to resist the weather conditions and mechanical abrasion. They are used for exterior lining of any kind of buildings.

The following table gives the properties prescribed for façade tiles in different countries.

	German Federal Republic DIN 18 155	United States of America USAS A 137.1	Czechoslovakia ČSN 72 4813
Water absorption	max. 6 %	-	1,5 - 6 %
Strength of rupture	min. 200 kp/cm²	min. 50 psi	100 - 180 kp/cm²
Frost resistance	without damage	-	-25 °C 30 cy[illegible]
Tolerances in sizes:			
Length and width	± 2 %	± 1/16"	±0,5% - ±2,5 %
Thickness	± 10 %	± 1/16"	± 10 %

Because the main property is waterabsorption it was necessary to add feldspar to the body composition in order to decrease its porosity. Having in mind the properties of Gambian raw materials the following body mixture was recommended for the first orientation:

Clay Basse	....	70 %
Kaolin Kundam	....	20 %
Feldspar	....	10 %

With this body composition a laboratory trial was done and the samples showed the following properties:

Residue on the sieve 10 000 op/cm^2	4,8 %
Moisture before pressing	6,9 %
Wet-dry shrinkage	0,3 %
Dry-fired shrinkage	8,3 %
Wet-fired shrinkage	8,6 %
Water absorption	4,15 %
Strength of rupture	295 kp.cm^{-2}

The body mixture was milled in a small scale laboratory ball-mill and the samples were pressed on a hydraulic press with the pressure 300 kp.cm^{-2} and fired in a factory tunnel kiln to the temperature of 1220 ^{0}C.

In spite of the fact that waterabsorption, strength of rupture and other properties correspond to the requirments of the above given standards, the pressed samples of this body were sensitive for cracking during the drying and firing period. The reason of it is in the content of plastic clays and therefore their percentage was decreased in body mixture No 2 and the difference to 100 % was covered with non plastic quartz.

Body mixture No 2 was composed as follows:

Clay Besse	65 %
Kundam kaolin	15 %
Feldspar	10 %
Quartz	10 %

This body mixture was prepared in a semi-large scale (20 kg) in a laboratory ball-mill. The ratio raw materials : pebbles : : water in the ball mill was 1 : 1 : 1. To remove excess water from milled slurry, filterpress was used. The rasidue of milled powder on sieve 10 000 op/cm^2 was 4,2 %. Moisture of the pressing powder has been found 6,6 %. The tiles of sizes 65 x 250 mm were pressed on a hydraulic press with the pressure of 300 kp.cm^{-2}. After drying one part of the tiles was fired without any decoration or glazing in the factory tunnel kiln to the temperature of 1220 ^{0}C. It was evident that the sensitivity to cracking disappeared. Body mixture No 2 showed the following properties:

Residue on sieve 10 000 op/cm^2	4,2 %
Moisture before pressing	6,6 %
Wet-dry shrinkage	0,2 %
Dry-fired shrinkage	8,0 %
Wet-fired shrinkage	8,2 %
Waterabsorption (fired to 1220 °C)	3,5 %
Strength of rupture	318 kp.cm^{-2}

To increase the palette of façade tiles namely as far as porosity is concerned sewerage pipes'body (body No 3) was also used. This body is composed from 85 % cley Base and therefore its colour will be darker and its porosity will be lower. Because this body is enough plastic the tiles may be produced through the pugging in a pug mill. The tiles prepared in this way end dried were fired in the factory tunnel kiln to the temperature of 1220 °C. Of course the surfacewas covered during the firing period with a salt glaze in the same way as ordinary goods fired in the same kiln.

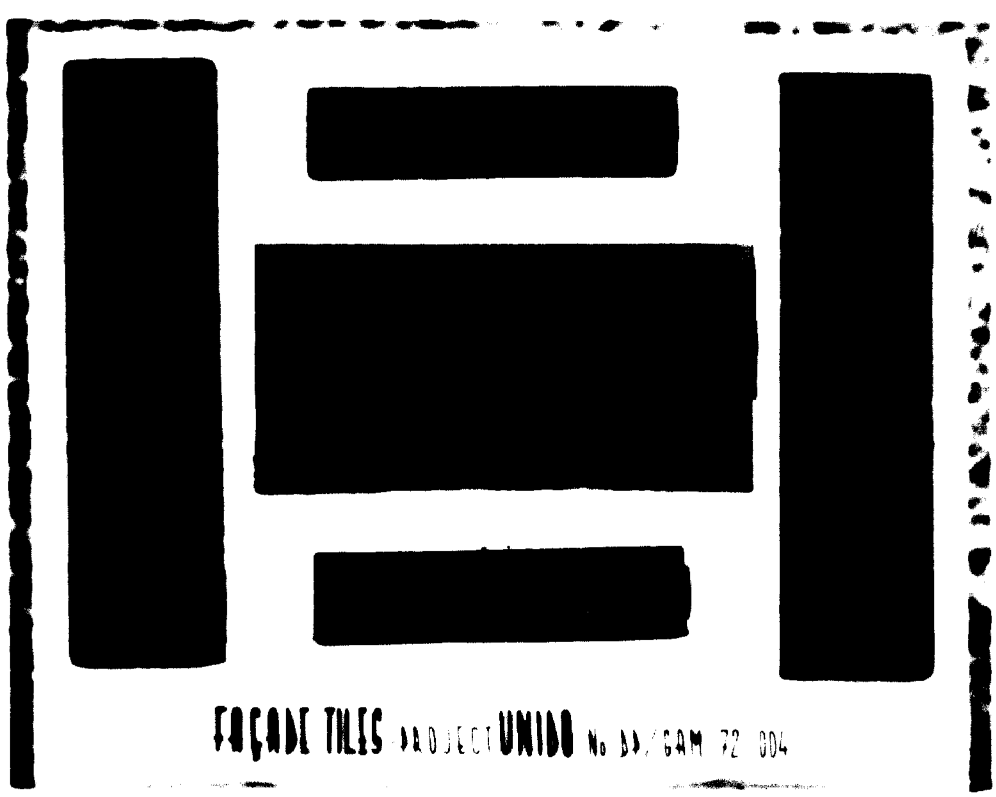
The façade tiles show the following properties:

Moisture before pugging	18,1 %
Waterabsorption	0,75 %
Wet-dry shrinkage	7,1 %
Dry-fired shrinkage	4,6 %
Wet-fired shrinkage	11,4 %
Strength of rupture	523 kp/cm^{-2}

From the products of Body No 2 and 3 sample charts were prepared and handed over during the discussion of II. Interim Report to the UNIDO representative in Vienna. A fotocopy of one of them is shown below for the documentation.

After comparison of the properties of body mixture No 2 and No 3 with some above mentioned standards of different countries it is evident that the quality of façade tiles is excellent. Frost resistance was not tested because the weather in The Gambia need not such a test and because this test is time consuming. In our opinion the excellent quality of façade tiles is supported with the quality of Basse clays. This clay is very plastic and accepts enough water and gives after firing very fine smooth surface. It is very useful for all ceramic production where the colour of the body is not important.

From all above mentioned technical points of view it may be recommended to produce the façade tiles in The Gambia. The disadvantage of this recommendation is that the body mixture is composed not only from local raw materials, but also 15 % of feldspar should be added to reach tho low porosity.



3d/ Sanitary ware

Three types of sanitary ware are known as far as its quality is concerned.

1. Porous sanitary ware
2. Semivitreous sanitary ware
3. Vitreous sanitary ware

The following properties correspond to the above mentioned qualities:

Properties		Porous sanitary ware	Semivitreous sanit. ware	Vitreous sanitary ware
Water absorption	%	10 - 12	3 - 5	0,2 - 1,0
Specific gravity	g/cm^3	1,92 - 1,96	2,00 - 2,20	2,23 - 2,30
Cold crushing strength	kp/cm^2	1000	1500 - 2000	3000 - 5000
Strength of rupture	kp/cm^2	150 - 300	380 - 450	600 - 900
CTE 20 - 760 °C		$47,58 \cdot 10^{-7}$	-	$38 \cdot 10^{-7}$

In the world mostly vitreous quality has been produced for last few years. Only in such cases when the raw materials for vitreous quality are not available locally, porous or semivitreous quality is produced but only for local use. This is actually also the situation in Gambia.

Clay Fatoto, Kundam kaolin and quartz were used from local raw materials for the body compositions. To decrease the porosity of the body after firing, feldspar of Czechoslovak provenience was used. The quality of added feldspar was described in part 3a/. Floor tiles of this Report.
Two different body mixtures were prepared on laboratory scale. The first one using clay Fatoto and Kundam kaolin was recommended in order to amend utilization of local kaolin. The second one was prepared only with clay Fatoto in order to improve brightness of the fired body and eventually to improve its porosity.

The composition of two above mentioned body mixtures and their quality after drying and firing is given in table below.

Body mixture No		1	2
[illegible] Fatato	%	20,-	52,-
Kaolin Kundam	%	30,-	-
Feldspar	%	25,-	30,-
Quartz	%	25,-	18,-
Total		100,-	100,-
Soda ash	+ %	+ 0,6	-
Natrium pyrophosphate	+ %	-	+ 0,[illegible]
Water	+ %	+ 26,-	+ 26,-
Specific gravity	$g.cm^{-3}$	1,76	1,75
Percentage of solid in slurry	%	72,2	72,1
Wet-dry shrinkage	%	3,1	4,8
Dry-fired shrinkage	%	7,1	5,9
Wet-fired (total) shrinkage	%	10,2	10,4
Water absorption	%	6,1	0,7

From the vitreous body point of view body mixture No 2 gives better results. It shows waterabsorption only 0,7 % while body mixture No 1 gives rather high porosity (6,1 %). No difference in colour has been found between these two bodies. However, it is necessary to stress that body mixture No 2 had not acceptable casting properties. It was because the body was very plastic and showed thixotrophy and therefore period of drying was uncontrollable and the produced shapes deformed or cracked.
As result of these two laboratory trials was the conclusion that Kundam kaolin should be included in the body mixture. However the percentage of its addition should be lower in comparison with body mixture No 1.

According to his knowledge body mixture No 3 was prepared on laboratory sc le. The composition of body mixture No 3 was as follows:

Body mixture No		3
Clay Fatoto	%	36,4
Kaolin Kundam	%	12,6
Feldsp	%	28,-
Quartz	%	23,-
Total		100,-
Natrium pyrophosphate	%	0,3
Water	%	+ 40,-
Specific gravity	$g.cm^{-2}$	1,77
Percentage of solid in slurry	%	71,3
Wet-dry shrinkage	%	3,2
Dry-fired shrinkage	%	7,1
Wet-fired (total) shrinkage	%	10,0
Water ab orption	%	0,9

It seemed that this body mixture fulfilled all properties expected from a sanitary ware quality except colour. The colour after firing was lihgt yellow-brown. All other properties like waterabsorption drying and firing shrinkage as well as casting properties are in agreement with the vitreous quality of sanitary ware.

Because of the fact, that properties of body mixture No 3 were suitable, the same body mixture was prepared on a large scale. Fifty kilograms of body composition in the same ratio as mentioned above were prepared in a ball mill with addition of 0,3 % of natrium pyrophosphate and 40 % (20 litres) of water calculated on dry weight of raw materials. The raw materials were milled to the sieve residue of 0,85 % on sieve with 10 000 openings/cm^2. The slurry prepared in such a way was used for casting little shapes of commodes and washbasins.

It is, of course, also possible to mill the raw materials in the ball mill without addition of natrium pyrophosphate with ratio raw materials : peebbles : water = 1 : 1 : 1. In this case the fine milled slip should be filterpressed and the cakes should be transformed to the casting slurry in a mixer with addition of water and 0,3 % of natrium pyrophosphate. The total amount of water in the slurry will be again 40 % when its content is calculated on the weight of dry raw materials. This way has the advantage that the casting slurry may be prepared only in such a quantity which is necessary for the production. The storage of cakes is also easier if compared with storage of casting slurry.

The casted samples of wash basins and commodes were dried to the body moisture of 1 % and glazed with the raw glaze of the following Seger formula:

$$\begin{matrix} 0,2\ Na_2O + K_2O \\ 0,3\ CaO \\ 0,1\ MgO \\ 0,4\ ZnO \end{matrix} \quad 0,325\ Al_2O_3 \cdot 2,8\ SiO_2$$

to which 8 % of $Zr\ SiO_4$ were added to improve the opacity and colour of the glaze. Also the same glaze with addition of 3 % vanadium yellow stain was tested.

After glazing the samples were dried and fired together with ordinary factory products to the temperature of 1250 °C in the factory tunnel kiln fired with generator gas.

Few products were tested and gave following properties:

Residue on sive 10 000 op/cm^2	0,85 %
Wet-dry shrinkage	3,3
Dry-fired shrinkage	7,1
Wet-fired shrinkage	10,1
Water absorption	0,8
Strength of rupture	630 kp.cm^{-2}
[illegible] crushing strength	3620 kp.cm^{-2}

[illegible] of little [illegible] were handed [illegible] 3 [illegible] discussion about [illegible] is shown [illegible]

[illegible] trial [illegible] mixture No 3 is acceptable for [illegible] production of sanitary [illegible]. All properties are [illegible] and cold crushing strength as well as strength of [illegible] give good results. Only colour of the body is not white but light yellow-brown. Therefore the edges of [illegible] show slightly different colour [illegible] with flat parts of the products. Of course, the [illegible] of [illegible] and other sanitary ware products will not [illegible] like small samples. To overcome this problem it [illegible] either yellow or pink colour of the [illegible] of two different colours what has become a fashion in the last few years. In such cases these two different colours will contact just on the edges and the problem of body colour may [illegible].

In any case the quality of sanitary ware product based on body mixture No 3 may serve for the production of goods for local use in [illegible].

3e/ U t i l i t y w a r e

The utility ware are ceramic products of various qualities as porcelain, semivitreous goods or crockery. Usually in Europe under this term is meant body fired to higher porosity (waterabsorption 6 - 12 %) which is as biscuit body fired to higher temperature (1220 - 1280 °C) in comparison with the glost firing (1050 - 1150 °C). Fritted glazes are used for [illegible] production.

The properties [illegible]pulated in different national standards are aimed to the aesthetic quality of the goods. From physical properties only water permeability and strength of fired biscuit are very important.

For the first orientation and having in mind the chemical and physical properties of Gambian raw materials the following body composition was recommended:

Clay Fatoto	36 %
Kundam kaolinitic clay-stone	24 %
Feldspar (CSSR provenience)	20 %
Quartz sand	20 %

This body mixture was prepared in a quantity of 20 kg in a laboratory ball mill. The ratio raw materials : pebbles : water was 1 : 1 : 1 . The excess water was removed through filterpressing and the cakes were pugged on a laboratory pug mill. An automatic shaping machine was used for shaping of cups and saucers. No suitable products were reached because the body mixture was not enough plastic. Therefore a part of plastic body mixture was used for hand shaping on a jigger head. In such a way few little vases, jars and bowles were produced. These products were after drying fired to the temperature of 800 °C, glazed with the earthenglaze and fired again in a glost kiln to the temperature of 1300 °C.

A few products produced in such a way are shown on the picture.

Because the body was not suitable for shaping body mixture No 2 was prepared. Its composition is as follows:

Clay Basse	13,5 %
Clay Fatoto	16,5 %
Kundam kaolin	20,0 %
Quartssand	35,0 %
Feldspar	5,0 %
Pitches	7,0 %
Dolomite (CSSR)	3,0 %

Chemical composition:

Loss on Ignition	6,19 %
SiO_2	71,55 %
Al_2O_3	14,71 %
Fe_2O_3	1,60 %
TiO_2	1,20 %
MgO	0,88 %
CaO	1,98 %
Alkalies	1,22 %
Total	99,33 %

This body mixture was prepared in a quantity of 20 kg in the laboratory ball mill, filterpressed and pugged. Part of the body was used for shaping of cups and saucers. Shaping of cups was done without any problems and difficulties while shaping of saucers on the automatic shaping machine was not possible. The body seems to be not enough plastic and in case if more water added it was mudy while if little water removed the body does not paste sufficiently to the plaster of Paris mould.

Part of body mixture No 2 was transferred to the casting slip through addition of water and 0,03 % of Sodiumpyrophosphate. The casting slip contains 70,0 % of solids. Teapots and milkjars were casted. Casting of these shapes passed without any difficulties.

The products were after drying fired in a factory tunnel kiln to the temperature of 1250 °C to the biscuit body and after glazing with the factory fritted glazes they were fired to the temperature 1100 °C. After glost firing all the goods cracked to small pieces. It is necessary to say that the used glazes had their CTE 68,0 . 10^{-7}.

The reason for cracking of the goods is enormous difference in the thermal expansion of the body in comparison with the used glaze. To overcome this problem it means either to change again the body composition or to change the glaze. Both ways are possible.

Unfortunately we have had no more clays (especially clay Fatoto) in the Institute and therefore we may only recommend body composition No 3 which should have lower content of SiO_2 and higher plasticity. Probably it will be also useful to add to the body composition another good clay of type like English ball clay, e.g. BWS or AK or any other suitable clay. However, the body mixture No 3 should be composed approximately as follows:

Clay Basse	15 %
Clay Fatoto	30 %
Kundam kaolin raw	20 %
calcined	5 %
Quartz sand	15 %
Feldspar	5 %
Pitches	7 %
Dolomite	3 %
Total	100 %

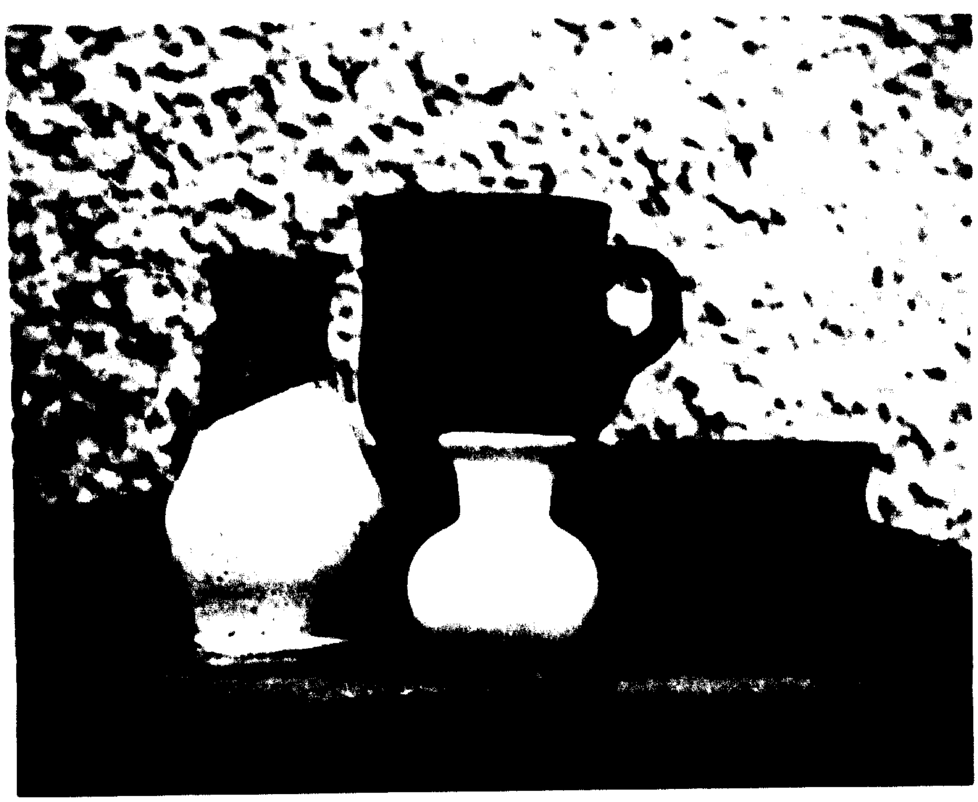
Chemical composition:

Loss on Ignition	7,51 %
SiO_2	65,63 %
Al_2O_3	18,90 %
Fe_2O_3	1,97 %
TiO_2	1,34 %
MgO	0,95 %
CaO	2,02 %
Alkalies	1,26 %
Total	99,58 %

It is evident that the Body mixture No 3 has only 65 % of SiO_2 in green or 71 % SiO_2 in fired stage. In such a way it may be expected to decrease the CTE of the body to be suitable for the glazes used for Body mixture No 2. Unfortunately it is not possible to certify practically this recommendation because clays Basse and Fatoto were out of stock.

Products from body composition No 1 were handed over to the UNIDO representative during the discussion about II Interim Report. The following picture shows these products.

Coming to the conclusions in this part we may say that few more laboratory tests will be necessary to certify clearly the possibility to produce smoothly utility ware in the Gambia only from local raw materials. Body composition No 3 seems to be promiseing but was not tested practically. Because both plastic clays (Basse and Fatoto) contain too much SiO_2 and Kundam kaolin is not enough plastic, it may be also useful to start the production of utility ware in the Gambia with imported ball clays which will definitely give a good result and than slowly accomodate the Body composition to the local raw materials.



3f/ Sewerage pipes

The sewerage pipes are ceramic products produced of stoneware quality in different lengths which are covered with salt, earthen or feldspar glaze. Also fittings of different shapes are produced. The following table shows the properties stipulated for sewerage pipes in some countries:

	United States of America ASTM C261-60T	German Federal Republic DIN 1230-62	Great Britain BS 65 & 540 / 1966	Czechoslovakia CSN 72 5110
Waterabsorption	below 8 %	-	-	9 %
Crushing strength	100-3900 lb per sq ft	2400-3000 kp/m	1350-1450 lb per ft	1500-2000 kp/bm
Tolerances in sizes:				
length	1/4-3/8 in per	± 2 %	± 1/8 in per ft of length	± 2,5 %
inside diametr	-	- 2% + 5%	1/8 - 1,0 in	± 2,5 + 3 %

According to the properties of plastic clays stipulated in Chapter No 1 clay Basse was used for the production. Because this clay itself had the waterabsorption of 7 % after firing to the temperature 1250 °C, feldspar was added to the body mixture to reach a low porosity as stipulated in other national standards. Therefore the first body composition was as follows:

clay Basse .... 85 %
feldspar (CSSR) ... 15 %

This body composition was mixed in a quantity of 30 kg in the laboratory pan mixer and pugged in a laboratory pug mill. Small pipes of inner diameter of 20 mm and fittings of inner diameter of 20 mm were produced. After drying all the products were fired in the factory tunnel kiln to the temperature of 1250 °C and tested. The salt glaze was applied to the body during the firing process in the same way as in ordinary production. The following table shows the properties in green and fired stage:

wet-dry shrinkage	7,1 %
dry-fired shrinkage	4,6 %
wet-fired shrinkage	11,4 %
waterabsorption	0,75 %

It is evident that the waterabsorption is very low and was so decreased becsuse 15 % feldspar was added. Addition of feldspar means increase problems with production in The Gambia because feldspar should be imported. The porosity of 0,75 % is really too low and therefore other two body compositions were recommended in order to decrease the percentage of feldspar and simultaneously to increase slighly the porosity of the body.

The body mixtures No 2 and 3 were composed from this point of view as follows:

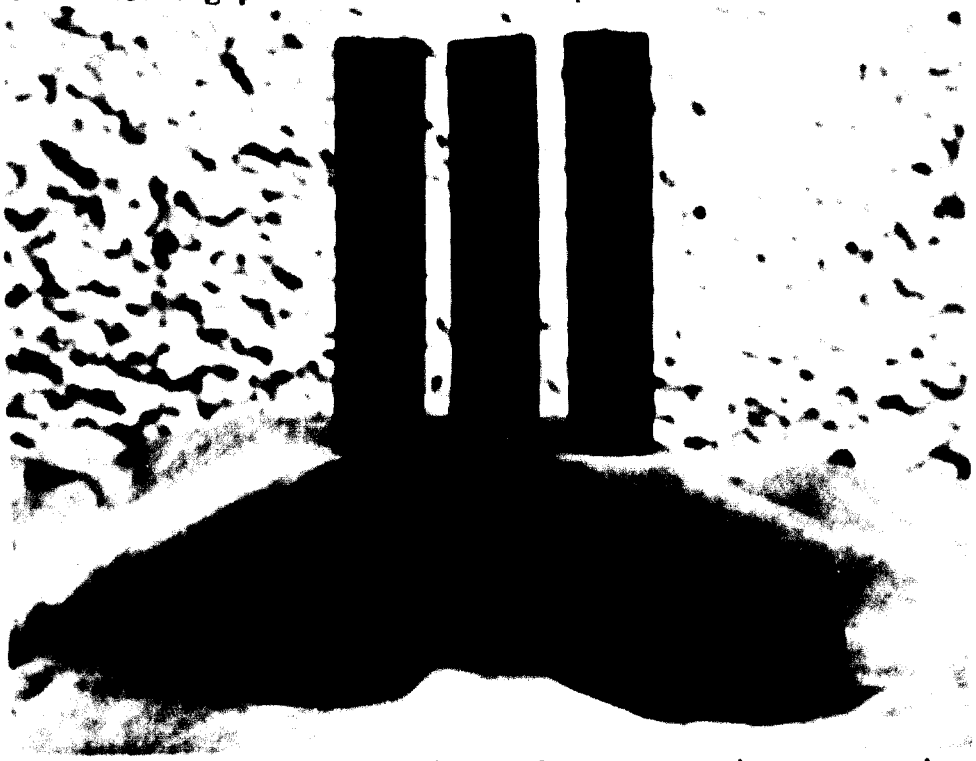
body mixture	No 2	No 3
clay Basse	85 %	85 %
feldspar	5 %	-
quartz	10 %	5 %
pitchee	-	10 %

Both above mentioned body mixtures were prepared in the same way and quantity as body mixture No 1 and also the same shapes were produced. Firing was also done in a factory tunnel kiln with ordinary pipes and therefore the pipes were glazed with salt glaze during the firing process. The properties in green and fired stage of body mixtures No 2 and 3 are given in the table:

wet-dry shrinkage	7,0 %	6,9 %
dry-fired shrinkage	4,4 %	4,5 %
wet-fired shrinkage	11,1 %	11,1 %
water absorption	4,7 %	7,3 %

Local quartz used in Body mixtures No 2 and 3 was added without any dressing. Pitches were milled on a pan mill under 2 mm.

In comparison with different mentioned national standards it may be said that all three mixtures give suitable results. Some of the produced samples were handed over to the UNIDO representative during the discussion about II Interim Report and the following picture shows these products.



Generally speaking the production of sewerage pipes seems to be possible either with a small addition of feldspar or also only from the Gambian raw-materials. The final decision will give a large trial production of about 300 kg when pipes of diameter at least 100 mm will be produced and tested on the crushing strength and leakage under pressure. Also the market study should certify if sewerage pipes should be produced in The Gambia.

It is evident that a laboratory trial of 30 kg cannot give any final decision. However, physical properties of laboratory products are very promissing in spite of the fact that crushing strength was not possible to be tested.

3e/ Firebricks

Firebricks are products of different shapes which withstand the temperature of minimum SK 26 and are used for building of different furnaces and kilns in the steel and metalurgical industry as well as in the cement, glass and ceramic industry. Many different qualities are known in the world. The following table shows the properties of high quality firebricks produced in some countries.

		[illegible]		[illegible] 73 361	Czechoslovakia CSN 72 6106	
		quality			quality	
		[illegible]		[illegible]	[illegible]	[illegible]
P.C.E.	SK	33	[illegible]	33	33/34	32/33
Al_2O_3 content	[illegible]	[illegible]	[illegible]	-	min. 40 %	min. 37 %
Fe_2O_3 content	%	[illegible]	[illegible]	-	below 2,4%	below 2,8%
Water absorption	%	-	-	-	below 10 %	below 13 %
Porosity		[illegible]	[illegible]	-	-	-
Refractoriness under load	[illegible]	[illegible] °C ([illegible])	[illegible]	1520 (5%)	[illegible] °C (0,3 %)	1370 °C
Cold crushing strength		[illegible]	[illegible]	[illegible]	min 300 kp	min 100kp
Specific density g/cm^3		1,8-2,0	1,8-2,0	-	min 2,00	min 1,90

It is evident that one of the mai properties of firebricks is their refractoriness (Pyrometric Cone Equivalent). Therefore only kaolin Kundam and clay Fatoto were used.

Three different body mixtures were prepared. The table below shows the compositions:

	No 1	2	3
Kaolin Kundam fired to 1400 °C 0-0,5 mm	35 %	35 %	45 %
Kaolin Kundam fired to 1400 °C 1- 4 mm	45 %	45 %	35 %
Kaolin Kundam green, finely milled	20 %	-	10 %
Clay Fatoto	-	20 %	10 %

Every mixture was prepared in a quantity of approx. 20 kg in a semilarge scale equipment in such a way that fired grog was crushed in a jaw crusher and milled in a pan mill. Plastic part was prepared through fine milling in a pan mill and Kundam kaolin was added as fine milled slip. The moisture of the body mixtures fluctuated in range of 6 - 7 % and the mixtures were prepared in a pan mixer and further pressed on a hydraulic press with the pressure of 400 kp/cm^2. The pressed bricks were fired after drying in the factory tunnel kiln to the temperature of 1400 °C. When tested the following properties have been found:

No	1	2	3
P.C.E. ... SK	33	32	32/33
Specific gravity g/cm^3	2,002	2,041	2,084
Waterabsorption	12,5	11,2	10,3
Porosity app.	25,1	22,8	21,5
Refractoriness under load (RUL) t_a	-	-	1465
t_e	-	-	1575
Cold crushing strength (CCS)	137	147	241
Al_2O_3 content	33,20	31,54	32,39
Fe_2O_3 content	2,89	2,77	2,83

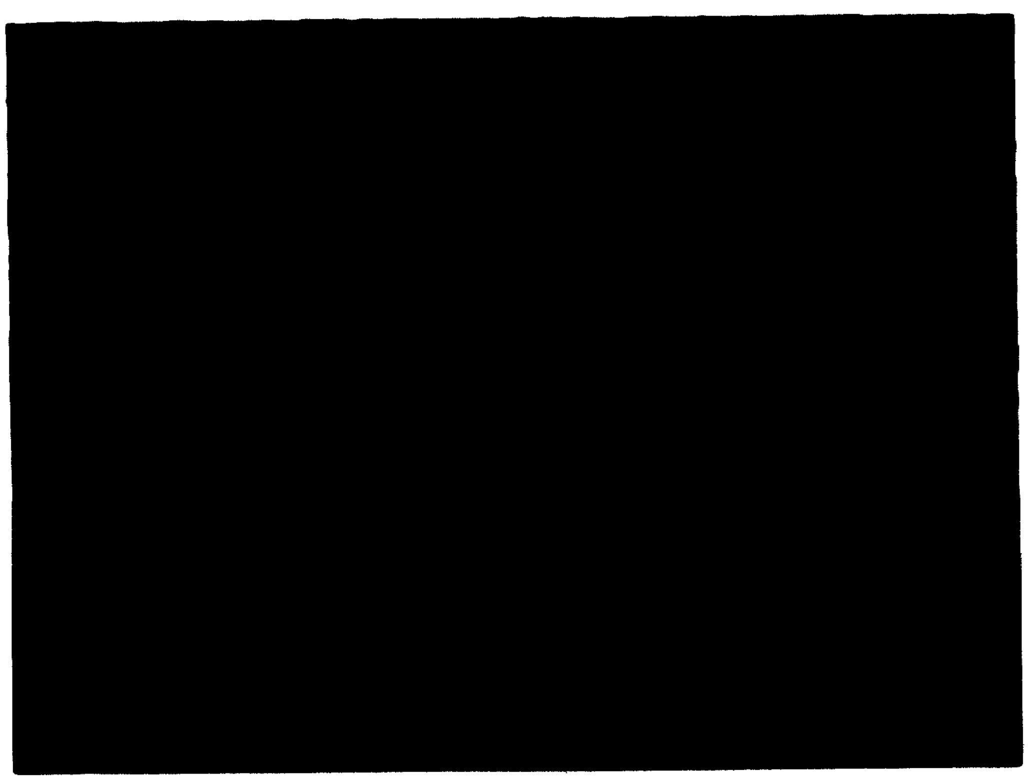
According to the above given results each body mixture may be evaluated as follows:

a) Body No 1 shows good PCE and the highest porosity because only Kundam kaolin was used. It shows also the lowest CCS and the lowest specific gravity. This all indicates that the firing temperature of 1400 °C is not enough high for this raw material. Because the plasticity of Kundam kaolin is not sufficient this body mixture will not be suitable for hand moulded shapes and in spite of the fact that the technological properties are very good it must not be recommended for the ordinary production.

b) Body No 2 uses clay Fatoto as the plastic part. Clay Fatoto itself has a low PCE and therefore the PCE of this body mixture is lower. The body is also enough plastic for hand moulding. This body seems to be suitable for ordinary production and probably it may be improved through the combination of clay Fatoto with Kundam kaolin as the plastic part of the body. This was actually tested in body mixture No 3.

c) Body mixture No 3 uses combination of clay Fatoto and Kundam kaolin as a plastic part. It was also slightly changed in the grainsize of grog. The properties of this body lie between the properties of bodies No 1 and 2 except CCS and porosity which are higher or lower. This body as the final body was also tested on RUL and the result was excellent.
It is evident that the firing temperature 1400 °C is suitable for this body. Also plasticity of the body is sufficient: Therefore Body No 3 may be recommended also for the ordinary production.

The following picture shows the fired bricks of Body No 2 and 3. This samples were handed over to the UNIDO representative during the discussions of II. Interim Report.



Coming to the conclusions in this part we may say that also firebricks may be produced in The Gambia from local raw materials. It is only question if the local market will indicate sufficient consumption of these products. Comparing the properties of body No 2 and 3 with the properties of different national standards given in the above table it is evident that the quality of firebricks produced from Gambian raw materials may be compared at least with the Quality A II of German Federal Republic Standard or with grade 3 of BS 1758:61 or with the quality S II of Czechoslovak standard except Al_2O_3 content. Some properties correspond to the quality AI and SI. Of course large scale trial should be recommended to prove this evaluation.

3h) Cement

The technological testing of Gambian raw materials for the cement production was done like a laboratory trial for information except infrared spectral analysis. The following raw materials were used:

a) Chemical composition:

	Sea shells	Clay Basse
humidity	0,57 %	3,09 %
Loss on Ignition	43,76 %	7,57 %
SiO_2	0,24 %	60,36 %
Al_2O_3	0,11 %	21,57 %
Fe_2O_3	0,24 %	3,63 %
TiO_2	0,02 %	1,60 %
CaO	53,78 %	0,73 %
MgO	0,25 %	0,70 %
K_2O	0,09 %	1,01 %
Na_2O	0,47 %	0,17 %
SO_3	0,22 %	0,05 %
Total	99,75 %	100,48 %

b) Qualitative spectral analysis:

The qualitative spectral analysis was tested on the spectrograph of the Company "Applited Research Laboratories". The analysis gave the following results:

	B	Pb	Zu	Sr	Cu	Ni
Sea shells	-	-	-	0,1 %	0,01 %	-
Clay Basse	traces	under 0,01%	0,01%	under 0,01%	under 0,01%	traces

c) Structural analysis

The raw materials were tested with the RTG type Müller Miliro 111. Difference coal thermal and differential gravimetric analysis was also performed with the Desivatograph of Orion-Pawlik Company.

Sea shells are built practically from pure aragonite. Basse clay has a kaolinitic base with a content of higher amount of quartz. Except quartz a small amount of illite, montmorillonite and probably also hematite is present.

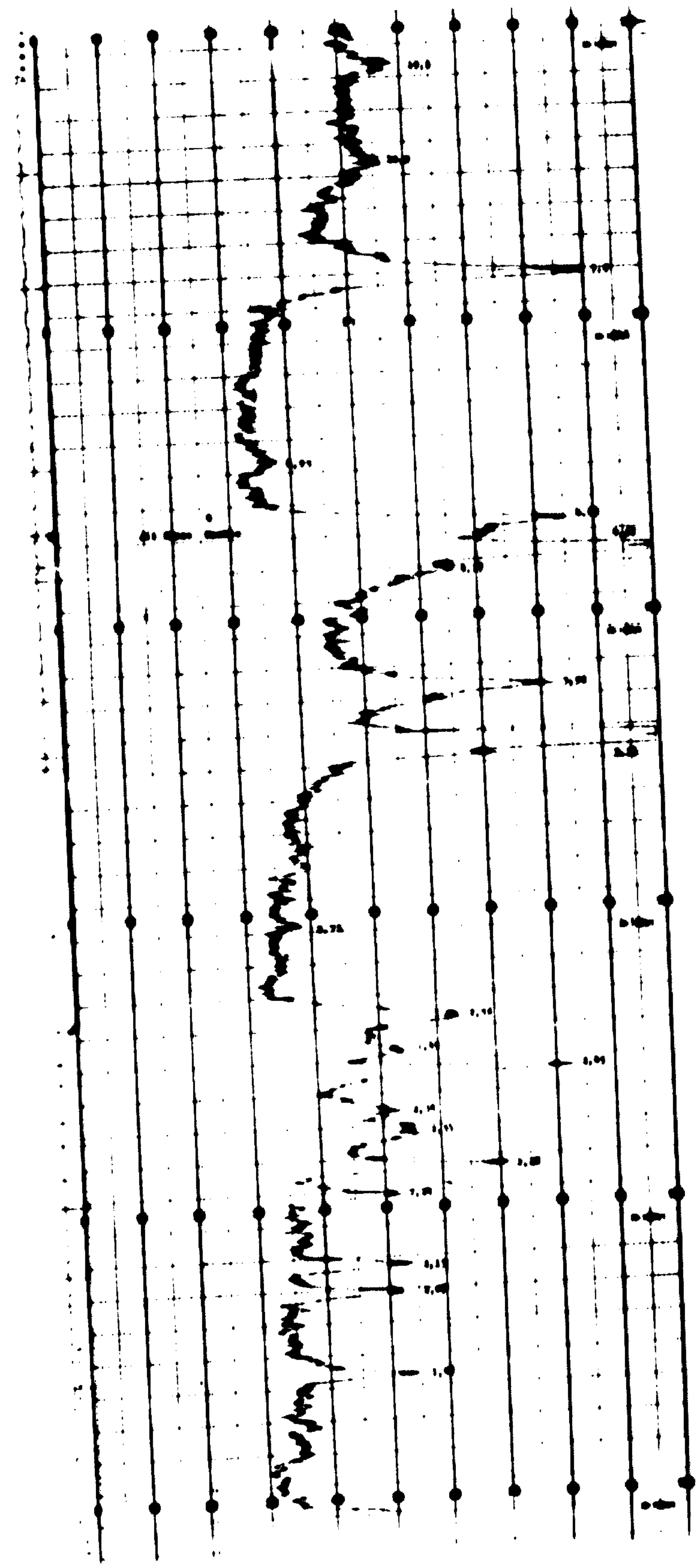
d) The calculation of the composition:

According to the chemical analysis of both raw materials the body composition was calculated to reach suitable modulus for firing in the laboratory rotary kiln. Two body compositions were calculated; the first one with the modulus S_{LP} 95,00, M_S 2,50 and M_A 2,00 and the second one with the modulus S_{LP} 96,00, M_S 2,70 and M_A 2,20. For the calculation other two raw materials had to be added: quartz sand and calcined pyrites in order to increase Fe_2O_3. The composition prepared only from above mentioned Gambian raw materials was not suitable because the composition had higher alumina modulus than silica modulus, S_{LP} 95,00 M_S 2,32 and M_A 4,21.
For this reason it was necessary to add the above correction raw materials in order to reach the above calculated modulus.

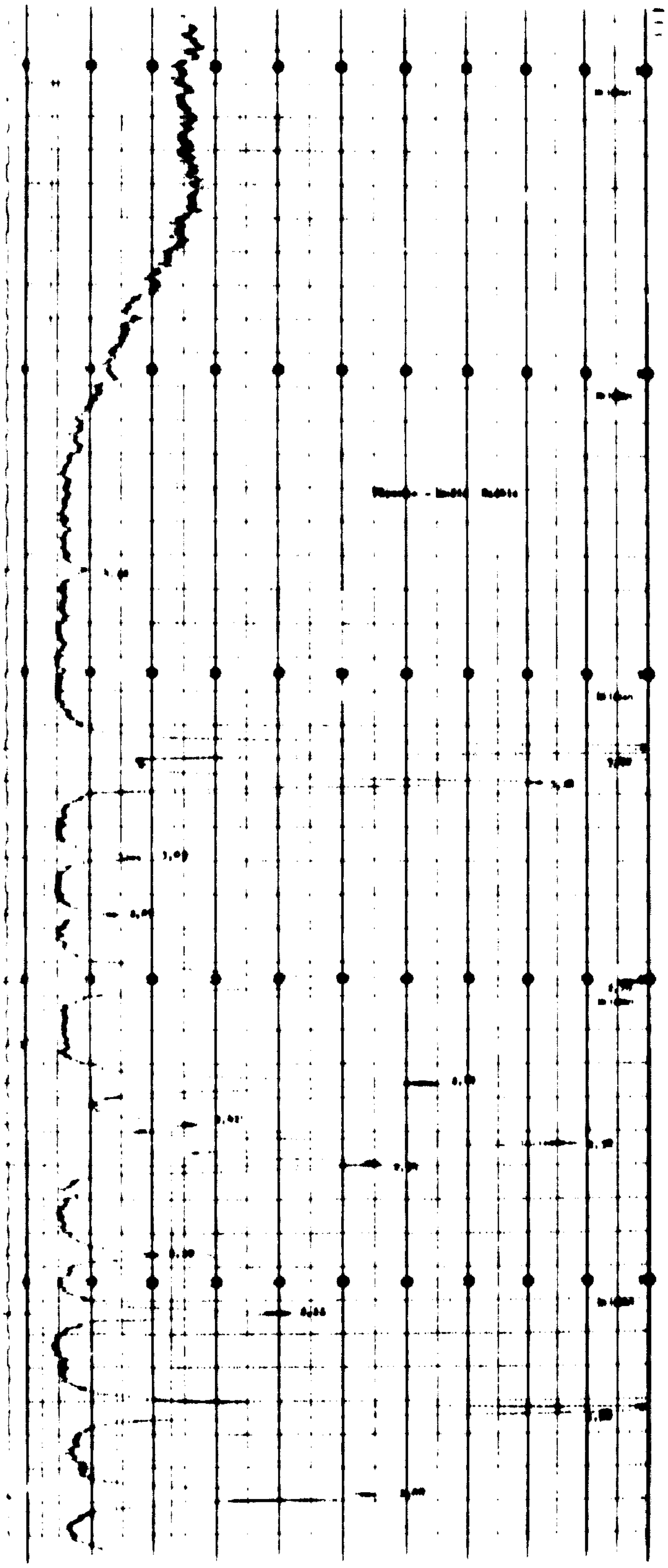
The following correction raw materials have been used:

	Quartz sand	Calcined pyrites
Loss on Ignition	1,52 %	4,09 %
SiO_2	91,41 %	14,08 %
Al_2O_3	2,00 %	5,41 %
Fe_2O_3	2,70 %	62,43 %
CaC	0,35 %	2,87 %
MgO	0,89 %	4,34 %
SO_3	0,02 %	3,22 %

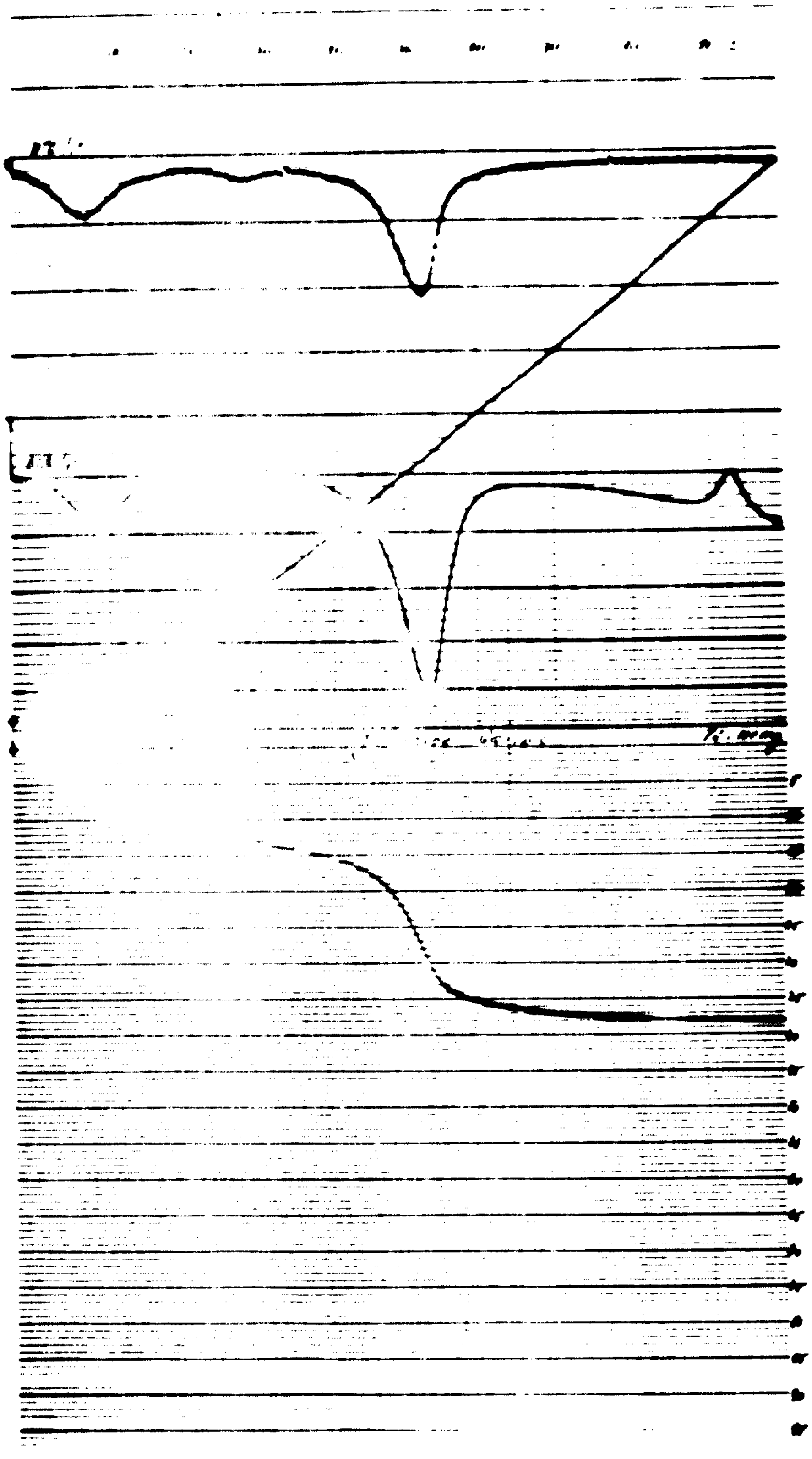
Clay Basse - X-ray analysis



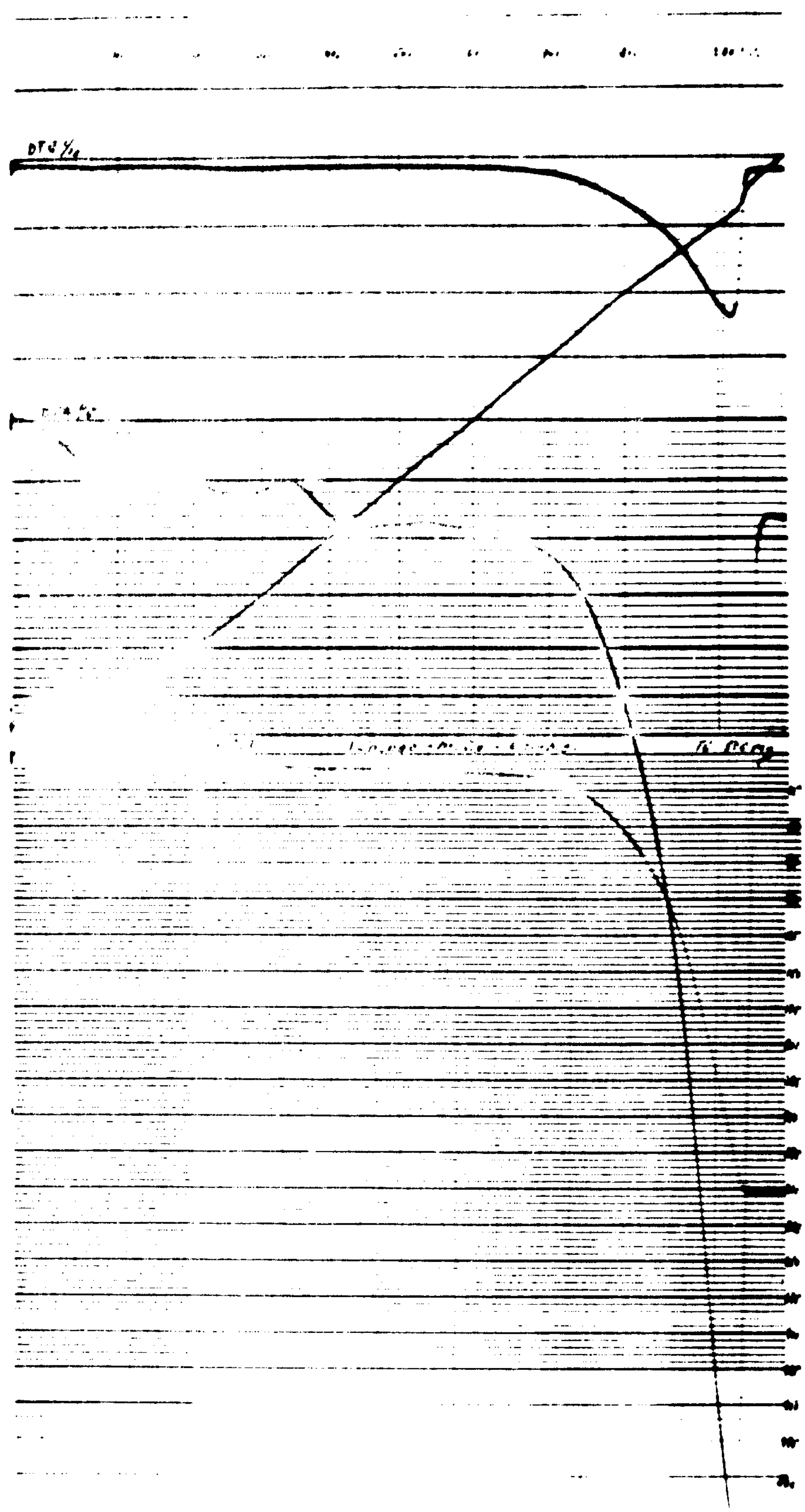
Sea shells - X-ray analysis



Clay Basse [illegible] and [illegible] ana[illegible]is



ea shells - and TA analysis



To reach the above required moduli the following mixing ratios of the raw materials must be applied:

	mixture No 1	mixtute No 2
sea shells	78,55 %	79,02 %
clay Basse	15,65 %	14,99 %
quartz sand	4,23 %	4,79 %
calcined pyrites	1,57 %	1,20 %

These two body mixtures have the following properties:

Loss on Ignition	35,92 %	36,07 %
SiO_2	14,03 %	14,07 %
Al_2O_3	3,74 %	3,58 %
Fe_2O_3	1,87 %	1,63 %
CaO	42,66 %	42,91 %
MgO	0,42 %	0,40 %
SO_3	0,23 %	0,22 %
S_{LP}	95,00 %	96,00 %
M_S	2,50 %	2,70 %
M_A	2,00 %	2,20 %

Clinker fired from these compositions has the following properties:

SiO_2	21,84 %	21,96 %
Al_2O_3	5,82 %	5,59 %
Fe_2O_3	2,91 %	2,54 %
CaO	66,43 %	66,96 %
MgO	0,65 %	0,63 %
SO_3	0,36 %	0,35 %

Mineralogical composition by Bogne is following:

C_3S	60	63
C_2S	17	15
C_3A	11	11
C_4AF	9	8

e) Reactivity of the body mixture tested according to Jirku test:

reactivity: 6,7 ml/g 6,9 ml/g

These figures show that both compositions are of good reactivity.

f) High temperature thermal analysis:

High temperature thermal analysis was tested with the Netzsch apparatus.

The curve, which has been found for both body compositions is practically identical. In the area of low temperature there are two endothermic peaks indicating loosing of water and the presence of clay minerals. The decomposition of $CaCO_3$ starts with the temperature of endothermic peak equalling 935 °C. The ractions in solid phase show only one exothermic peak with the temperature 1240 °C and higher this exothermic reaction changes slowly to the endothermic one which indicates building of liquid.

This reaction ends with 1360 °C, it has a minimum with 1310 °C for body composition No 1 and 1305 °C for body composition No 2.

Firing in gradient laboratory kiln

The testing slabs are after firing in both compositione practically the same.

In range of temperatures 1000 °C - 1160 °C the fired slabs are without any destructions, the light puff colour slowly changes to a darker one.

In range of temperatures 1160 °C - 1240 °C sets out the decomposition of this part of the testing slab due to the development of gama C_2S modification from dicalciumsilicate during its cooling in exicator.

In range of temperatures 1240 - 1295 °C the testing slab is again without any destruction with darker gray-puff colour.

The temperature 1295 °C - "T" - changes the light colour of body composition to dark colour of clinker. The clinker is dark grey, dense with visible shrinkage. From the temperature 1400 °C starts building of liquid phase. The temparature - "T" - for body composition No 2 is 1290 °C.

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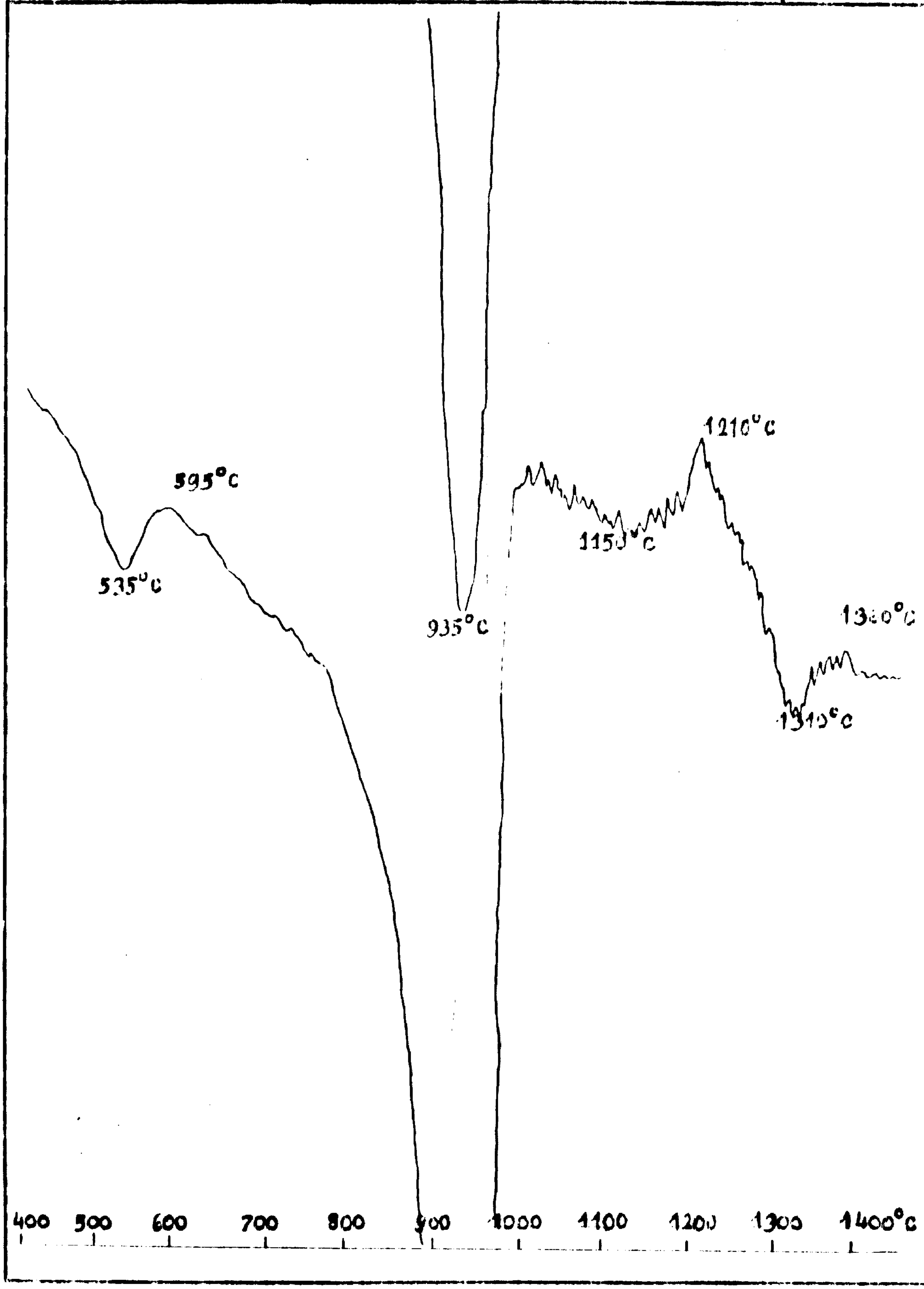
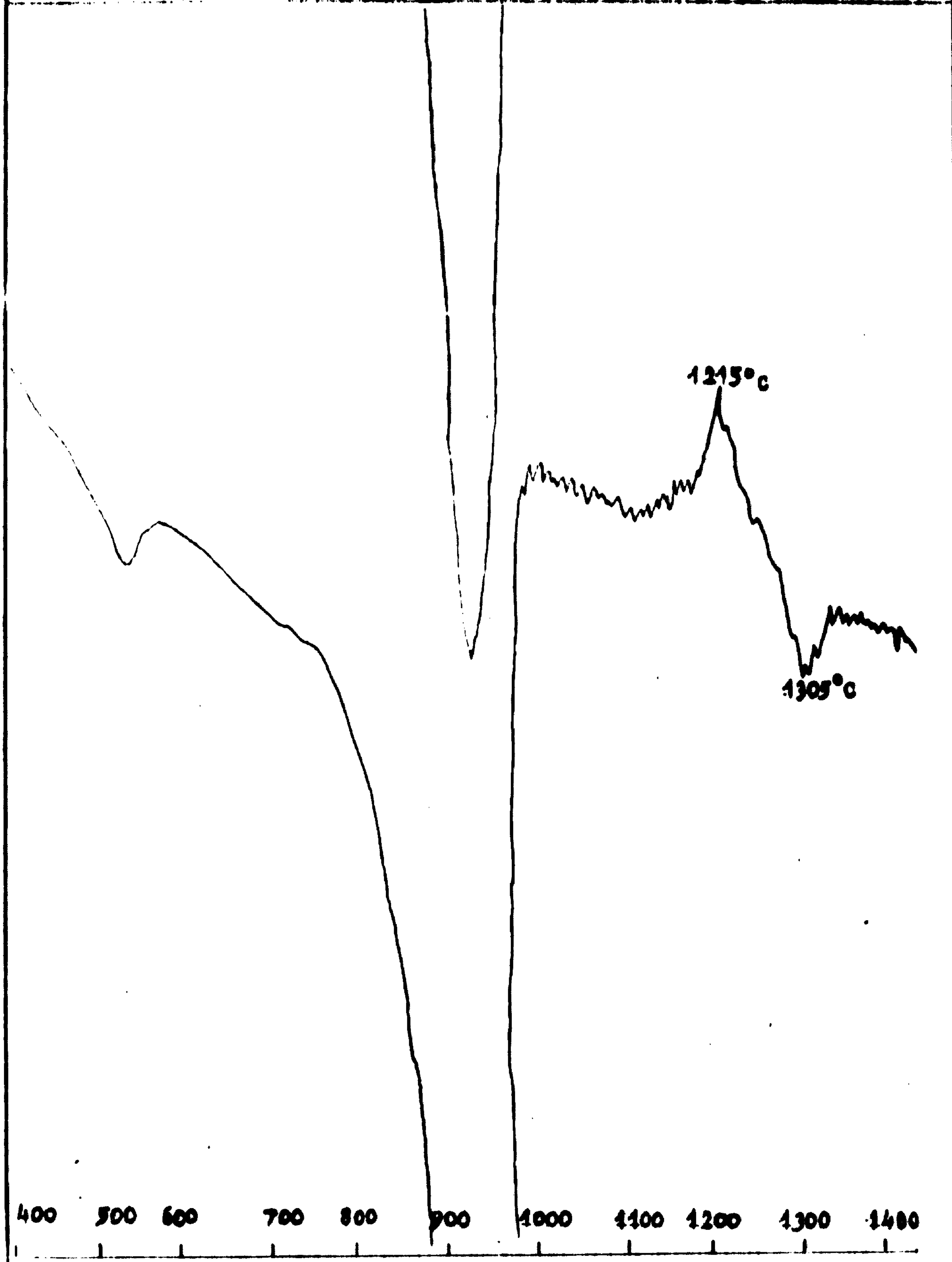
VÝZKUMNÝ ÚSTAV STAVEBNÍCH HMOT V BRNĚ oddělení cementu	GDTA Composition No 1	



VÝZKUMNÝ ÚSTAV
STAVEBNÍCH HMOT
V BRNĚ

GDTA Composition No 2



[illegible] 1

[illegible] 2

Test specimens after firing in a gradient laboratory kiln

Both body mixtures according to their "T" temperature may be evaluated as being good reactive and may be filed to the II Category of reactivity.

Conclusion

The Gambian raw materials - sea shells and clay Basse - may be evaluated as suitable for the cement production. Both of them are without any harmful substances. In both cases it is necessary to add correction raw materiels with SiO_2 and Fe_2O_3 content to obtain the required body composition.

The body composition prepared from approx 78 % of sea shells and 15 % of clay Basse, when sand and Fe_2O_3 rich correction raw materials added, is possible to be classified within the II Category of reactivity. It means that in the production of Portland clinker good firing process and good output of the rotary kiln is to be expected.

4/ **Evaluation of kaolin for use in agriculture**

In agriculture kaolins of lower whiteness and quality or different types of clays are used as base for insecticides and pesticides in order to protect the fields against various pests and to increase the production in such a way.

The basic material should be very finely ground in order to increase the covering capacity in use.

Also kaolinitic clay-stone may be used for this purpose and of course it should be finely ground. Because this raw material is non plastic and does not give with water a plastic mass, insecticides and pesticides soluble in water may be used.
The non-plastic raw material will absorb soluble chemicals and after drying may be used as powder for powdering of fields.

5/ **Evaluation of kaolin for use in cosmetic industry**

Kaolin for the cosmetic industry has in its specification a low content of Fe_2O_3 (maximum 0,7 %), a high brightness (70 - 79 % MgO) and should be very fine (percentage of grains under 1 micron should be at least 80 %).

The Kundam kaolin from the Gambia shows the content of Fe_2O_3 2,57 %, brightness of 50,7 % to the MgO standard and is mined in lumps and should be ground to reach the expected finess. From all these points of view the Kundam kaolin from the Gambia cannot be recommended for use in the cosmetic industry.

v) Conclusions of technical part of the Report

The technical results described in details in paragraphs iv)1-5 may be summarized in the following points:

1. The Gambian kaolin which was the subject of the Contract with UNIDO is actually not a kaolin according to European classification but a kaolinitic claystone which is very hard, nonplastic and without bigger quartz grains.

2. The clays which were sampled according to the Contract in small quantites to receive a broader view on ceramic raw materials in the Gambia are built on the kaolinitic base which is mixed with fine quartz. They are enough plastic but they have unfortunatelly a higher content of iron oxides. Therefore their colour after firing is yellow to dark brown.

3. The quartz sand which was sampled close to Serre Kunda is of a good quality and may be used for the ceramic production. It was sampled also in a small quantity from the same reason as mentioned under para 2.

4. The sea shells sampled on the sea shore are actually a pure aragonite and the content of CaO shows that the sea shells are a good material and enough pure for the ceramic production as well as for the cement production.

5. The laterite which was also sampled in small quantity shows a very low plasticity. The percentage of Fe_2O_3 is about 8 % and therefore it may be used only in a small quantity for the production of floor tiles of dark colours. Therefore laterite is not recommended for the ceramic production in the Gambia.

6. As far as floor tiles are concerned it may be said that good results were reached. Different plain colour floor tiles as well as different marble and porphyr designs were successfully produced. The production of floor tiles seems to be the most promissing one with regard to the Gambian r... materials. The only disadvantage is that feldspar which ... ...

be imported to the Gambia must be added to the body composition in a quantity of approximately 10 - 30 %. White coloured floor tiles were not possible to be produced because the content of impurities in local Gambian raw materials is too high.

7. Body compositions of wall tiles were composed fully from Gambian raw materials. Quartz-lime bodies with low shrinkage were recommended and especially body No 7 and 8 give good results. CTE of body No 8 corresponds with CTE of the used glaze and the surface of wall tiles is very smooth and aesthetic. It's possible to say that wall tiles may be produced smoothly from local Gambian raw materials.

8. Façade tiles were also tested to be produced from Gambian raw materials. The production is possible with addition of feldspar, it means, with the same disadvantage as mentioned under para No 6.

9. In spite of the fact that the physical properties of the produced sanitary ware were excellent the colour of the sanitary ware body was not enough white because of coloured impurities in the raw materials. However, the aesthetic quality may be improved by using coloured raw glazes. Production may be recommended for local use only.

10. The utility ware was not tested with a full success. The reason is probably in the quality of plastic clays from Gambia.

11. Sewerage pipes did not show any problems during the laboratory trials. The physical properties of produced samples correspond to the world production. Mechanical properties of the samples as crushing strength and leakage under pressure were not tested because of the size of samples.

12. Also cement production from sea shells and correction materials is promising. Clay Basse and quartz sand should be used in small quantities to reach suitable silicate and alumina modulus. This testing was done on the wishes of the Gambian representatives and is not mentioned in the Contract specification with UNIDO.

13. Kaolin respectively kaolinitic clay-stone seems to be suitable for use in agriculture after absorption of chemicals and fine milling.

14. The Gambian kaolin is not suitable for the use in cosmetic industry because of very high content of Fe_2O_3 and a very low brightness.

From the 14 above mentioned points it is evident that from technical point of view the following ceramic products may be recommended for the production in the Gambia:

floor tiles
wall tiles
façade tiles
sewerage pipes and
fireclay bricks

Sanitary ware and utility ware does not give such a good results and the products cannot compete with the world production. Specificly the colour of sanitary ware and difficulties in shaping of utility ware are the reasons for this decision.

The properties of kaolin which is actually kaolinitic claystone show that this raw material may serve from the point of commercial exploitation only in the ceramic industry as a part of various body compositions. However for successfull productions also plastic clays from Basse and Fatoto, sea shells and quartz sand should be used.

This situation was not known in the very beginning and therefore the UNIDO Contract stressed its interest mainly on the kaolin. In this new situation it will be very recommendable to make the technological and geological investigation of the remaining raw materials in order to find geological reserves and variation properties of these raw materials. Only with this knowledge a complete view on the possibility to start the ceramic industry in the Gambia may be known.

III. PHASE B:

iii) Economic study

1/ Main characteristics

The Techno-economic Feasibility Analysis is based both on the conclusions of Phase A of the Contract - Collection and Testing of Kaolin Samples - and on the conclusions of the second part of Phase B of the Contract - the Market Study.

The technical report ascertained the absence of kaolin in the investigated area and stated the possibility of successful utilization of other investigated raw materials in the production of wall tiles, floor tiles (mozaics), facade tiles, sewerage pipes and fireclay bricks.

The market report restricted the above range of products with regard to potential home consumption and export possibilities to wall tiles and mozaics and recommended the production of gift items (souvenirs). The recommended production of earthenware cannot be taken into account at present because of unsatisfactory results of technological trials. The production of sewerage pipes could be recommended in later years in dependence on the feasibility of sewerage programme in The Gambia. The production of a small quantity of firebricks can be recommended for later consideration too.

In preliminary calculation the maximum production programme of 1000 t wall tiles and 1000 t mozaics was calculated and found unprofitable. To achieve acceptable profitabality this programme was extended by 50 tons of gift items (maximum production according to market study without potential export to Europe) and it is presented in this study as industrial scale production.
As alternative a pilot plant scale production programme is submitted comprising the manufacture of 25 tons of gift items per year and experimental production of 10 tons of wall tiles and 10 tons of mozaics.

An important problem to be decided was the location of the plant either in Banjul in the centre of local market, within easy reach of the port or at Basse in the area of main raw materials d.posits. A simple calculation has decided in favour of Banjul as it appeared that only 1700 tons of clays per year will be delivered from the Upper River Division for the ceramic plant. In case of location of the plant at Basse some 800 tons per year of quarzsand, seashells, feldspar, glazes and stains in addition to operating supplies would have to be transported up the river and 2000tons of products would be transported back to Banjul. In case of pilot plant the situation would be similar.

All calculations in this study are made in local currency (Dalasis). For conversion the following rates of exchange applied in The Gambia in November 1973 were used. The main characteristics are given in US dollars too.

1 US $ = 1,6 Dalasis

The results of the presented sudy give the following main characteristics:

	Industrial plant		Pilot plant	
Annual production:	tons		tons	
Wall tiles	1000		10	
Mosaics	1000		10	
Gift items	50		25	
	000 D	000 US$	000 D	000 US$
Total investment	2390	1494	392	244
Credits	1302	814	-	-
Annual sales	1326	829	210	131
	%		%	
Return to total capital	11		12,5	
Return to equity capital	24		12,5	
Break even point	48		49,5	
	000 D	000 US$	000 D	000 US$
Direct value added	464	290	136	85
Active balance of payments				
Annual average 1st-4th year	500	313	129	81
Annual average in further years	1067	667	147	92
	persons employed		persons employed	
Labour opportunites: in the plant	84		31	
miners and domestic workers	47		20	

2/ Industrial plant

2.1. Investment

	000 D
Fixed assets	
Buildings and other ivil engineering works	188
Technological equipment	1 473
Fixtures, furniture, transportation	70
Fixed assets - total	1 731
Other investment	
Preinvestment costs	181
Start-up expenses	152
Other investment - total	333
Working capital	
Inventories	181
Accounts receivable	145
	326
Summary	
Fixed assets	1 731
Other investment	333
Working capital	326
Total investment	2 390

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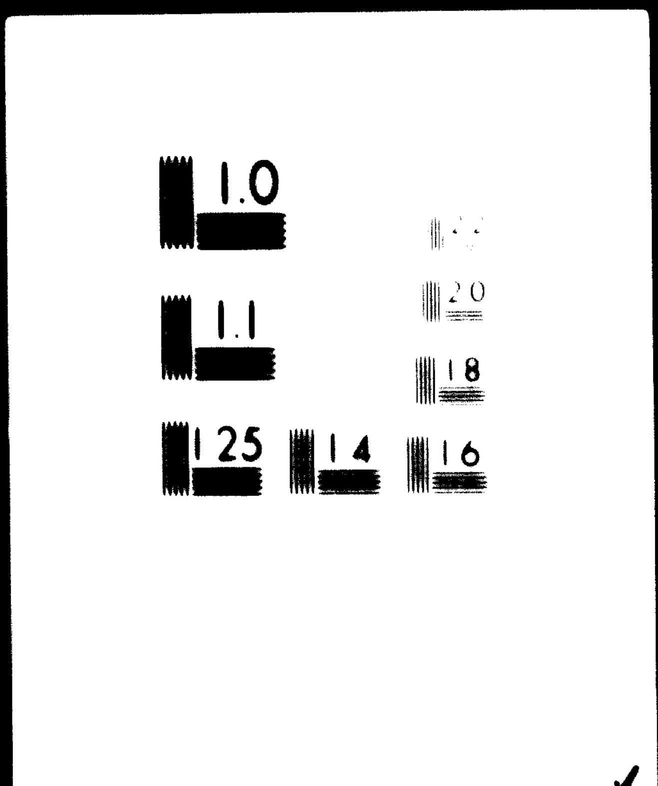

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2.2. Development of operation costs and profits

Sales, production costs, profits (000 Dalasis)

Year of production	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A. Sales - total	563	1326	1326	1326	1326	1331	1326	1326	1326	1326	1331	1326	1326	1326
B. Production costs														
Raw materials, stains, glazes	159	318	318	318	318	318	318	318	318	318	318	318	318	318
Energy	52	104	104	104	104	104	104	104	104	104	104	104	104	104
Operating and gen. supplies	46	85	85	85	85	105	85	85	85	85	105	85	85	85
Depreciation	766	122	110	99	89	84	75	67	61	55	53	47	42	38
Personnel costs	73	102	102	102	102	102	102	102	102	102	102	102	102	102
Administrative costs	17	17	17	17	17	17	17	17	17	17	17	17	17	17
Interest	117	105	63	17	-	-	-	-	-	-	-	-	-	-
Sales costs	64	124	124	124	124	124	124	124	124	124	124	124	124	124
	1294	977	923	866	859	954	825	817	811	805	823	797	792	788
C. Profit														
Profit before tax	-631	349	403	460	467	477	501	509	515	521	508	529	534	538
Tax 45 %	-	-	-	-	-	-	225	229	232	234	229	238	240	242
Net profit	-631	349	403	460	467	477	276	280	283	287	279	291	294	296
Net profit accumulated	-631	-282	+121	+581	+1048	+1545	+1821	+2101	+2384	+2671	+2950	+3241	+3535	+3831
D. Supplier's credit repayment														
Profit applied for repayments	-631	349	403	84										
Depreciation applied for repayments	766	122	110	99										
Repayments	135	471	513	183										
E. Balance of credit 1 302 000 D	1167	696	183	-										

Cas[illegible]w (000 Dalasis)

	Construction year 1st	Construction year 2nd	Production year 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
A. Source of cash:												
1. Equity	1088											
2. Supplier's credit		1302										
3. Sales revenue			663	1326	1326	1326	1326	1331	1326	1326	1326	1326
Source of cash - total	1088	1302	663	1326	1326	1326	1326	1331	1326	1326	1326	1326
B. Uses of cash:												
1. Fixed capital expenditure:												
1.1. Buildings	188											
1.2. New machinery and equipment	130	1343										
1.3. Fixtures, transportation		70										
1.4. Replacement								20				
Fixed capital expenditure - total	318	1413	-	-	-	-	-	20	-	-	-	-
2. Net working capital:												
2.1. Inventories		30	60	91								
2.2. Accounts receivable			60	85								
Net working capital - total	-	30	120	176	-	-	-	-	-	-	-	-
3. Pre-investment and start-up expenses:												
3.1. Pre-investment costs	61	120										
3.2. Start-up expenses			152									
Preinvestment and start-up exp. -total	61	120	152	-	-	-	-	-	-	-	-	-
4. Production expenditure:												
4.1. Materials			159	318	318	318	318	318	318	318	318	318
4.2. Energy			52	104	104	104	104	104	104	104	104	104
4.3. Supplies			46	85	85	85	85	105	85	85	85	85
4.4. Personnel costs			73	102	102	102	102	102	102	102	102	102
4.5. Administrative costs			17	17	17	17	17	17	17	17	17	17
4.6. Sales costs			64	124	124	124	124	124	124	124	124	124
Production expenditure - total	-	-	411	750	750	750	750	770	750	750	750	750
5. Debt service:												
5.1. Interest on credit			117	105	63	17						
5.2. Repayment of credit			135	471	513	183						
Debt service - total	-	-	252	576	576	200	-	-	-	-	-	-
6. Profit tax paid - total	-	-	-	-	-	-	-	-	225	229	232	234
Uses of cash - total	379	1563	935	1502	1326	950	750	790	975	979	982	984
C. Surplus/Deficit	+709	-261	-272	-176	0	+376	+576	+541	+351	+347	+344	+342
Surplus/Deficit accumulated	+709	+448	+176	0	0	+376	+952	+1493	+1844	+2191	+2535	[illegible]

2.4. Data for evaluation

Average net profit		Return to total capital	Return to equity capital
1st-5th year	214	8,90 %	19,70 %
1st-6th year	257	10,75 %	23,60 %
1st-10th year	267	11,17 %	
1st-14th year	273		

Break-even point

48,3 % - 991 tons (see table IV)

Direct value added and employment effects

Direct value added consisting of wages and salaries, average profit during first six years of production and average interest for the same period amount to 409 000 Dalasis per year. If we add the wages of workers mining raw materials and the wages of domestic workers knitting straw boxes for gift items the direct value added would reach 464 000 Dalasis.

The total of employees of the plant would be 84, eventually 131 emploees inclusive miners and domestic workers.

Balance of payment effect

The total sales - 1 326 000 Dalasis would provide for The Gambia 861 000 Dalasis in currencies of West African countries and would save 464 000 Dalasis paid mainly in European currencies for imported ceramics. From these sums 259 000 Dalasis are to be subtracted for imported feldspar, stains, glazes, fuel oil, operating supplies and spare parts so that the active balance 1 067 000 Dalasis is left for purchases in African and European countries. In the first four years of production this balance would be 500 000 Dalasis per annum only due to repayment and interest of supplier's credit.

Social marginal productivity of capital

Each 100 Dalasis of capital investment would create 19,4 Dalasis of direct value added.

2.5. Evaluation of the industrial plant

The production programme consisting of 100 000 m^2 of wall tiles, 100 000 m^2 of mosaics and 50 tons of gift items is given by limitations of market and does not represent the optimum solution from the viewpoint of rational exploitation of machinery, such production lines being usually dimensioned for 300 000 m^2 of wall tiles or floor tiles. Even if effort has been made to eliminate this disadvantage by utilizing one production line for both wall tiles and mozaics manufacture and to apply the prepared wall tiles body for moulding of gift items as well, some problems arose due to this combination that are reflected in the economy.

The analytical part shows that the total profit of 347 000 D in the first year of full production (compare annual sales and annual operating costs) consists of 269 000 D produced by gift items, 108 000 D from mozaics and a loss of 30 000 D shown by wall tiles. It means that the profitability and rentability rests predominantly on gift items production. Although this production is being recommended by shrewed businessmen, the risk connected with introduction of a new article cannot be neglected. Another unfavourable fact is that the percentage of exports in total sales is 65 % by value and 79 % by weight (see analytical part - sales of industrial plant). This phenomenon being perhaps advantageous for promotion of interafrican business is - another risk for time of possible economic depression. Further on it should be stressed that the presented economy is based on booming prices of ceramic products as well as of investment. In this situation no reliable forecasts concerning future trends could be made and the economic assessement has consequently a static character based on relations as they were in November 1973.

The data for evaluation given in the preceeding chapter show the rentability which would cover repayment of credits, leaving no profit for the investor for 9 years. The last three data (National priority test) show the benefits brought by investment to the country.

With regard to this analysis the establishment of the ceramic industrial plant is not recommended at present.

[illegible] Pilot plant

[illegible] Investment of the pilot plant

	000 $
Fixed assets	
Buildings and other civil engineering works	[illegible]
Technological equipment incl. transport and erection	[illegible]
Fixtures and furniture	10
Transportation	[illegible]
Fixed assets [illegible]	[illegible]
Other investment	
Preinvestment costs	[illegible]
Start-up expenses	[illegible]
	[illegible]
Working capital	[illegible]

Summary

Fixed assets	[illegible]
Other investment	[illegible]
Working capital	30
Total investment	[illegible]

3.2. Development of production costs and profits of the pilot plant
Sales, production costs, profits (000 Dalasis)

Year of production	1	2	3	4	5	6	7	8
A. Sales - total	100	200	210	210	210	210	210	210
B. Production costs								
Raw materials, stains, glazes	1	10	10	10	10	10	10	10
Energy	4	6	6	6	6	6	6	6
Operating and gen. supplies	8	15	15	15	15	15	15	15
Depreciation	102	23	21	19	18	16	14	13
Wages	20	20	20	20	20	20	20	20
Salaries	18	50	50	50	50	50	50	50
Administrative costs	2	2	2	2	2	2	2	2
Sales costs	6	13	13	13	13	13	13	13
Total	161	139	137	135	134	132	130	129
C. Profit								
Profit before tax	-61	61	73	75	76	78	80	81
Tax 45 %	-	-	-	-	-	-	36	36
Net profit	-61	61	73	75	76	78	44	45
Net profit accumulated	-61	0	+73	-148	+224	+302	+346	+391

Note: No credit is taken into account

3.3. Cash flow of the pilot plant (000 [illegible])

	Construction year	Production year							
	1st	1st	2nd	3rd	4th	5th	6th	7th	8th
A. Source of cash									
1. Equity	392								
2. Supplier's credit	-								
3. Sales revenue		100	200	210	210	210	210	210	210
Source of cash - total	392	100	200	210	210	210	210	210	210
B. Uses of cash									
1. Fixed capital expenditure									
1.1. Buildings	67								
1.2. New machinery and equipment	205								
1.3. Fixtures, transportation	30								
Fixed capital expenditure - total	302								
2. Net working capital - total	30								
3. Pre-investment and start-up expenses									
3.1. Pre-investment costs	20								
3.2. Start-up expenses	40								
Pre-investment and start-up expenses - total	60								
4. Production expenditure									
4.1. Materials		1	10	10	10	10	10	10	10
4.2. Energy		4	6	6	6	6	6	6	6
4.3. Supplies		8	15	15	15	15	15	15	15
4.4. Personnel costs		38	70	70	70	70	70	70	70
4.5. Administrative costs		2	2	2	2	2	2	2	2
4.6. Sales costs		6	13	13	13	13	13	13	13
Production expenditure - total		59	116	116	116	116	116	116	116
5. Debt service									
5.1. Interest on credit	-	-	-	-					
5.2. Repayment of credit	-	-	-	-					
Debt service - total	-	-	-	-	-	-	-	-	-
6. Profit tax paid - total	-	-	-	-	-	-	-	36	36
Uses of cash - total	392	59	116	116	116	116	116	152	152
C. Surplus / Deficit	0	+41	+84	+94	+94	+94	+94	+58	+58
Surplus / Deficit accumulated	0	+41	+125	+219	+313	+407	+501	+559	+617

9.4. Data for evaluation of the pilot plant

Average net profit		Return to equity capital
1st - 6th year	49 000 D	12,5 %

Break-even point

49,5 % - 22,25 tons (see table IV b)

Direct value added and employment effects

Direct value added consisting of wages, salaries and average profit amounts to 119 000 Dalasis per year, eventually 136 000 D inclusive wages of domestic workers (knitters of straw boxes) and the wages of workers mining raw materials. The total of employees of the pilot plant would be 31, the total number of emloyees employed in connection with this investment would reach the number 51.

Balance of payment effect

It is presumed that 20 tons of gift items worth 160 000 D can be sold to tourists visiting Gambia, 5 tons worth 40 000 D to neighbouring countries. The imports included in the production costs (felspar, glazes, stains, spare parts) amount to 13 000 D only so that the active balance of 147 000 D is left fore purchases in European and African countries.

Social marginal productivity of capital

Each 100 Dalasis of investment would create 34,6 Dalasis of direct value added.

9.5. Evaluation of the pilot plant

The pilot plant should be evaluated with regard to its objectives to be fullfilled:

1. Training of local workers in the manufacture of ceramic products

2. Training of future ceramic technicians
3. Training of local gifted students in application of native art in manufacture of gift items (souvenirs)
4. Production of 25 tons of gift items per year
5. Experimental production of wall tiles, mosaics, eventually of other ceramic products.
6. Market testing

In this way the foundations for local artistic ceramic manufacture would be laid and premises for potential future production of ceramics on industrial scale would be created.
The economic results of the plant should be sufficient to ensure its functioning without subsidies.
The invested capital of 392 000 D could be repaid in 8 years, the dependence on direct exports is 19 % only, the risk of introducing a new article (gift items) is analogous as in the case of industrial plant. The other parameters are self-explanatory.
With regard to the above facts it is recommended to establish the ceramic pilot plant in Banjul.

4/ Conclusions

4.1. Recommendations

The economic study examined the feasibility of exploitation of local ceramic raw materials in two alternatives - on industrial scale production and in pilot plant conditions. The erection of the pilot plant is recommended as the first step in exploitation of local ceramic raw materials.

In this connection the further recommendations are given:

The UNIDO should ensure the evaluation of reserves of local ceramic raw materials (contracting of Amendment is in progress already).

The Government of The Gambia should provide in the framework of Development Act:

- dutyfree import of machinery for the pilot plant
- dutyfree import of imported materials, spare parts and other supplies for the first six years of production
- exemption from profit tax for the first six years of production

The Government of the Gambia should request UNIDO for technical, marketing and artistic assistance in the first years of production.

4.2. Implementation

The implementation consists of the final stage projects, the erection stage and the production start-up period.

Time schedule:

Evaluation of raw materials	1974
Final projects	1975
Contracting	1975
Erection	1976
Start-up production	1977
Full production	1978

4.3. Fulfilment of services [illegible]

In conformity with Responsibilities of the contractor, Phase B, para 1 through -1 the Market study was carried out, the establishment of a ceramic pilot plant was recommended estimates of operating costs, sales profits, investment costs and capital requirements of the proposed pilot plant were submitted, time schedule for pilot plant erection and start up production was recommended.

Appropriate changes in infrastructure are planned by development programmes of The Gambia and are not necessary for the first step of industrial development (the pilot plant).

No changes in handling port facilities are requested as the proposed packing of exported products does not require special loading equipment.

9/ Analytical part

9.1. Capacity of the proposed industrial plant

	Total	Wall tiles	Mosaics	Gift items
	tons	tons	tons	tons
1st year of production	1 025	500	500	25
2nd and further years	2 050	1000	1000	50

The selection of these three ceramic products to be produced has been already explained. As far as the quantities are concerned the market study proposed to achieve the full capacity production after four years from the start of production. Such a long period is planned owing to the fact that the predominant part of sales will depend on export and there is no organisation in the country with experience and contacts in export of ceramics.

On the other hand no investor can afford to exploit the capacity of a new-built plant to approximately 30 % in average for four and half a year. He will have to get the staff experienced in ceramics business and a recommendation for an expert to organise the export of the future plant will be included in this study. With regard to this consideration a steeper grow of production was established (1).

(1) See tables I, II, III

5.2. Technology and technological equipment

5.2.1. Technology (1)

With regard to the manufacture of three different ceramic products in one factory the technology and the equipment had to be applied in such a way as to achieve the maximum exploitation of the technological equipment. Therefore the following principles were agreed before detailed specification of the equipment:

a) The production line from the preparation of raw materials should be used alternately for all three products, the body for wall tiles and gift items being identical.

b) The pressing of wall tiles and mozaics should be done alternately on the same press with exchangeable dies. The shaping of gift items should be done separately.

c) For the firing of all three products one flexible kiln should be applied.

The raw materials are delivered to the plant by lorries from the port or directly from the mines. Raw materials delivered in lumps will pass through the crusher and crushed materiel will be transported by means of elevator and conveyors to store boxes. In the boxes the raw materials will be loaded manually on travelling balance and will be delivered by the skip elevator on the platform over the ball mills, which will be charged manually. Here also the water will be metered. The body is finely milled to achieve the screen residue 2 - 3 % (openings 0,063 mm). After milling the slurry is discharged, passed through a vibrating screen into a cistern provided with a propeller mixer. From the cistern the slurry is pumped through a vibrating screen and over a magnetic separator into a storage cistern from which the atomiser drier is feeded.

The pressing powder prepared in the atomizer drier has a humidity of 4 %. It is transported by conveyors to the storage hopper of the pressing powder from which it is discharged by turnslate feeders into the hopper over the press. By the described method the pressing powder for both mosaics and wall tiles will be processed periodically

(1) Tables V, VI

With regard to the pressed semiproducts the press is provided with corresponding dies and either wall tiles 150x150x6 mm or mozaics are pressed.

The wall tiles are stacked, the stacks loaded on kiln cars, dried in the channel drier and fired in the kiln to the temperature of 1100 °C. After biscuit firing the damaged semiproducts are rejected and the sorted biscuits are inserted onto the feeder of the glazing machine. The glazed walltiles are inserted into saggers on the kiln cars and fired to the temperature of 1000 °C. The fired ware is sorted, packed into crates and transported to the store.

The pressed mozaics are laid down on slabs, these are stacked on kiln cars, dried in the channel dryer and fired to 1250 °C. The fired mozaics are filled in bags and transported to the store.

For the moulding of gift items the wall tiles slurry is taken from the blunger and stored in a storage container provided with propeller mixer. The moulding methods are described in the para 6. Supplement - Pilot plant.

5.2.2. Technological equipment (1)

Item	pcs	Denomination
		01 - Raw materials store and preparation
01-1	1	Box type feeder
01-2	1	Jaw clay crusher
01-3	1	Bucket elevator; Length 8 m
01-4	7	Belt conveyor; Length 4 m
01-5	10	Concrete boxeswith light roofing Note: The investments cost of concrete boxes for raw materials are included in the specification of buildings and civil engineering works.
		02 - Raw materials weighing and charging
02-1	1	Travelling balance
02-2	1	Skip elevator Useful capacity 0,5 cu.m.
02-3	1	Charging platform above the ball mills
02-4	1	Volumetric flow meter
		03 - Body preparation
03-1	2	Ball mill for wet grinding Capacity: 4600 kg of charge
03-2	1	Vibrating screen 236 meshes/cm^2
03-3	1	Propeller mixer
03-4	1	Diaphragm pump
03-5	1	Vibrating screen 2500 meshes/cm2
03-6	1	Electromagnetic seperator
03-7	1	Propeller mixer

(1) Table V

Item	pcs	Denomination
		04 - Dressing of pressing material
04-1	1	Complete atomizer drier Capacity 1000 kg of dried powder per hour
04-2	1	Belt conveyor Width 400 mm Length 8 m
04-3	1	Bucket elevator Length 10 m
04-4	1	Shuttle belt conveyor Width 400 mm Length 7 m
04-5	1	Steel hopper Useful capacity: 10 cum.
04-6	1	Turnstile feeder ø 200 mm
04-7	1	Vibrating screen
04-8	1	Belt conveyor Width 400 mm Length 8 m
		05 - Pressing shop
05-1	1	Press feeding hopper
05-2	1	Complete fully automatic hydraulic press, including drive, press control system, stacking and edge cleaning attachment
05-3	2	Pressing tools for wall tiles
05-4	2	Pressing tools for mozaics
05-5		Auxiliary structures Weight approx. 800 kg

Item	pcs	Denomination
		06 - Channel Drier
06-1	1	Fan, output 2,4 m^3/sec
06-2	1	Fan for exhaust of air from the drier
06-3	1	Circulation fan type
06-4	1set	Circulation air distribution piping
06-5	2	Insulating door for closing of drier
06-6	2	Thermometer Range 0 - 200 °C for measuring of inlet and outlet temperature
06-7	1	Hot air distributing piping from the tunnel kiln into the drier
06-8		Insulation of piping with cement overcoat
06-9	1	Hydraulic pusher incl. base frame and driving station
06-10	1	Chain conveyor consisting of path truck and connecting material
		07 - Glaze preparation shop
07-1	1	Low lift truck
07-2	1	Travelling pulley block
07-3	1	Ball mill for wet grinding
07-4	1	Electromagnetic reparator
07-5	1	Vibrating screen
07-6	1	Propeller mixer
07-7	1	Diaphragm pump - two chambers system
07-8		Tubing for glaze 300 kg
		08 - Firing
08-1	1	Complete shuttle kiln incl. kiln cars, steel accessories, air conditioning, oil heating system, measuring and control system, electric installation
08-2	5	Hand operated crossing transfer table
08-3	2	Hydraulic jacks

Item	pcs	Denomination
		09 - Glazing
09-1	2	Fedder incl. disintegrating equipment
09-2	4	Travelling container for pitches Capacity 0,25 cu. m.
09-3	2	Glazing line - waterfall system
		10 - Sorting and packing
10-1	1	Portable sorting conveyor belt
10-2	6	Table for packing
10-3	4	Travelling container for pitches Capacity 0,25 cu.m.
10-4	2	Platform truck on bantam wheels for carrying crates with wall tiles and bags with mozaics into store room
		11 - Rail transportation system
11-1		Trackage for the handling of trucks in the works, complete, consisting of the following: Rails, supporting sleepers, anchoring and connecting material
11-2	2	Hand operated pusher
		12 - Kiln car repair shop
12-2	1	Hydraulic jack
12-2	1	Wooden table with a vice on swivel base
12-3	1	Mortar mixer
		13 - Oil handling
13-1	1	Oil storage tank incl. accessories
13-2	2	Working pump for pumping of oil from the storage tanks into working tanks
13-3	2	Working tank of 1 cum. capacity

Item	pcs	Denomination
13-4	2	Horisontal gear pump
13-5		Supporting structures
13-6		Fuel oil distribution system consisting of piping, fittings, float-type equipment, slide valves, flanges and measuring fittings
		14 - Water house
14-1	1	Submersible pump
14-2	1	Pressure pumping station
14-3	1	Hand operated wing pump
14-4	1	Air compressor
14-5	1	Deoiler
14-6	1	Pressure tank
14-5		Piping and fittings
		15 - Machine workshop
15-1	1	Universal lathe including standard accessories
15-2	1	Pillar drilling machine
15-3	1	Electric hand drilling machine
15-4	1	Double wheel grinding and polishing machine
15-5	1	Frame saw
15-6	1	Kneetype universal milling machine
15-7	1	Hand grinder with flexible shaft
15-8	1	Rotary welding machine
15-9	1	Gas welding set
15-10	1	Stationary forge hearth
15-11	1	Anvil
15-12	6	Vice on swivel base

Item	pcs	Denomination
		16 - Laboratory
16-1	1	Technical balance including set of weights
16-2	1	Technical balance
16-3	1	Autoclave for the testing of tile crack incidence
16-4	1	Apparatus for tensile bending stress testing
16-5	1	Electric water bath with automatic control to the temperature of 100 °C
16-6	1	Automatic sieving apparatus
16-7	1	set of screens for the sieving apparatus
16-8	1	Electric crucible furnace Input: 700 W Working temperature: 1200 °C
16-9	1	Brabec electric furnace Max. consumption 25 kW Max. temperature 1750 °C
16-9a	1	Transformer
16-10a	1	Analytical balance
16-11	1	Electric sand bath Max. temperature: 600 °C
16-12	1	Laboratory oven Input: 2 kW Temperature range: 60 - 200 °C
16-13	1	Pot mill Input: 0,75 kW
16-14	1	Excicator
16-15	2	Platinum crucible with cap dia. 30 mm,h = 40 mm
16-16	1	Platinum dish, dia. 30
16-17		Chemicals
16-18	5	sets of glassware, porcelain ware
16-18a		and small equipment

Item	pcs	Denomination
		17 - Gift items moulding
17-13	1	Filter press
17-14	1	Belt conveyor
17-15	1	Horizontal vacuum press
17-16		Manual moulding
17-17		Natural drying
		18 - Electric wiring system
18		Comprising main panel and sub-switch boards, transition, terminal and deblocking boxes, control racks and desks, socket boxes, power cables from the sub-switch board to the appliances.

5.3. Investment

5.3.1. Fixed assets

	Dalasie
Site development and buildings (1)	
Site development	5 000
Production hall 2000 m^2 at 60 D/m^2	120 000
Concrete bins (10 boxes at 60 cu.m of useful capacity) 110 m^3 of concrete at 75 D/m^3 incl. light roofing	8 250
Cisterns for blungers and mixers in the production hall - 20 m^3 of concrete at 60 D/m^3	1 200
Ground floor buildings for offices, laboratory and social conveniences - 400 m^2 at 30 D/m^2	12 000
Standard septics incl. piping - 4 pcs at 360 D/pc	1 440
Fencing 420 running metres at 6 D/r.m	2 520
Water supply connection	590
Transformer and power line connection	20 000
	171 000
Unforseen	17 000
Site development and buildings - total	188 000
Machinery and equipment (2)	
(specified in the preceding chapter) - FOB prices	1 030 000
Freight, insurence, wharfage, handling, transport costs - 15 %	154 500
Erection costs - 15 %	154 500
	1 339 000
Unforseen	134 000
Machinery and equipment - total	1 473 000
Fixtures and furniture - total	50 000
Transportation (1 lorry, 1 car) - total	20 000
Fixed assets - total	1 731 000

(1) Prices see references 43,44,56,57,61,63,64
(2) Prices references 12,14,15,56,57

5.3.2. Other investment

Pre-investment costs

Preliminary expenditure and projects	50 440
Interest during construction	106 560
Engineering during construction	24 000
Total	181 000
Start up expenses	
Consultants fees	100 000
Costs of trial run	52 000
Total	152 000
Other investment - total	333 000

5.3.3. Working capital

Inventories

Clays (4 months)	16 000
The other raw materials, glazes, stains (1,5 months)	33 000
Fuel oil (18 days)	2 000
Auxiliary materials and spare parts (1,5 months)	8 000
Work-in-process incl. pitches	30 000
Finished products (1 month)	80 000
Packing material (1 month)	12 000
Total	181 000

Accounts receivable

Domestic customers (15 days)	20 000
Foreign customers (18 days)	125 000
Total	145 000
Working capital - total	326 000

5.3.4. Summary:

1.	Fixed assets	1 731 000
2.	Other investment	333 000
3.	Working capital	326 000
	Total investment	2 390 000

The prices applied for appreciation of investment were quoted in November and December 1973 in a period of steady grow of prices. Also the prices referring to production costs and the prices of products were collected during the same period so that a certain ratio between production costs and investment costs resulting from this study should be preserved for future projects.

9.4. Annual Production

Annual sales - 1st year of full production

Commodities	Total Dalasis	Wall tiles Dalasis	Mosaics Dalasis	Gift items Dalasis
Domestic sales				
White wall tiles 210 t at 460 D/t	[illegible]	96 [illegible]		
Coloured wall tiles 90 t at 850 D/t	76 500	76 500		
Mosaics 100 t at 910 D/t	91 [illegible]		91 000	
Gift items 30 t at 8000 D/t	240 000			240 000
Total	[illegible]	173 100	91 000	240 000
Foreign sales				
White wall tiles 490 t at 360 D/t	176 400	176 400		
Coloured wall tiles 210 t at 460 D/t	96 600	96 600		
Mosaics 900 t at 476 D/t	428 400		428 400	
Gift items 20 t at 8000 D/t	160 000			160 000
Total	861 400	273 000	428 400	160 000
Domestic and foreign sales total	1 325 500	446 100	479 400	400 000
Average price per ton	646,58	446,10	479,00	8000,00

All prices are quoted Ex Plant.
The prices of domestic sales are stated on the level of C.i.f. Banjul prices plus import duty.
The prices of foreign sales will not after adding the transport costs reach the Cif prices of competition in respective countries.
The average transport costs including port charges in Banjul, freight and insurance make 33,40 D/ton for wall tiles and 37,36 D/ton for mosaics.

The mosaics for both domestic and foreign market are delivered and quoted unsheeted, packed in sisal bags. The wall tiles are delivered and quoted in crates. The gift items are packed in straw boxes of different shapes knitted from local material. These packing costs are included in the price too.

9.5. Annual operating costs

Annual production costs - 1st year of full production

	Total Dalasis	Wall tiles Dalasis	Mosaics Dalasis	Gift items Dalasis
Raw materials, stains, glazes	317 595	103 424	209 002	5 169
Energy	104 412	62 463	40 013	1 936
Operating and general supplies	84 804	42 612	24 510	17 682
Depreciation	121 910	63 393	30 478	28 039
Wages	53 990	28 393	13 201	12 396
Salaries	48 410	25 171	12 105	11 134
Administrative costs	17 479	9 089	4 370	4 020
Interest	105 090	54 615	26 298	24 177
Sales costs	124 000	86 500	11 000	26 500
Total	977 990	475 660	370 977	130 993
Tons	2 050	1 000	1 000	50
Costs D/ton	476,87	475,66	370,94	2619,86

Further on the specification of particular costs is given.

9.5.1. Raw materials, glases and stains, consumption (1st year of full production)

	Unit	Total	Wall tiles	Mosaics	Gift items
Clay Fatoto	ton	818,80	437	360	21,80
Clay Basse	ton	560,00	-	560	-
Claystone Kundam	ton	326,60	311	-	15,60
Seashells	ton	342,30	326	-	16,30
Quarzsand	ton	424,80	357	50	17,80
Pitches	ton	125,00	119	-	6,00
Laterite	ton	60,00	-	60	-
Felspar	ton	270,00	-	270	-
Glases	ton	105,00	100	-	5,00
Stains	ton	30,000	-	30	-
Total	ton	3062,50	1650	1330	82,50

Raw materials, stains and glases costs (1st year of full production)

	D/ton	Total Dalasis	Wall tiles Dalasis	Mosaics Dalasis	Gift items Dalasis
Clay Fatoto	29,08	23 816	12 713	10 469	634
Clay Busse	26,08	14 605	-	14 605	-
Claystone Kundam	28,23	9 220	8 780	-	440
Seashells (1)	12,77	4 371	4 163	-	208
Quarzsand (1)	21,76	9 243	7 768	1 088	387
Pitches	-	-	-	-	-
Laterite	3,30	198	-	198	-
Felspar	143,12	38 642	-	38 642	-
Glases	700,00	73 500	70 000	-	3 500
Stains	4800,00	144 000	-	144 000	-
Total		317 595	103 424	209 002	5 169

Prices of local raw materials and other direct materials

The technical part of this report recommends both mechanized and manual methods of mining raw materials. The recommendation is based on the supposition that 3000 tons of materials have to be mined.

After collecting all necessary information regarding the raw materials it must be stated that felspar will be imported, seashells, quarzsand and laterite are extracted and delivered by Public Works Department at reasonable prices (1) and only 820 tons of clay Fatoto, 560 tons of clay Basse and about [illegible] tons of claystone Kundam have to be extracted by the factory.

The calculation for these small quantites of raw materials is established on the following application of manpower and equipment. The machine work-removing of the overburden and piling of the disintegrated raw material onto piles prepared for loading -will be done by a dozer. Also the disintegrating of the overburden and of the raw materiel will be performed by the dozer provided with a ripper. Only very hard materials should be discharged by means of explosives. The work of the dozer will be ordered and paid 80 Dalasis per day (8 hours). It should be done within two months.

All three deposits (Kundam, Basse, Fatoto) will be serviced by 8 labourers and 1 technician (forman) who will be skilled also in handling explosives. The labourers will mainly load the lorries or ships and drill the holes for explosives. Their equipment will consist of shovels, hammers, hoes, two transportable motorconveyors, one motor drilling machine and a few chutes through which the material will be skipped from lorries into ships. The lorries will be hired. The distance between the deposits being 8 miles (Basse-Kundam) and 42 miles Kundam-Fatoto will enable economic circulation of machinary, manpower and equipment between the mines.

This arrangement has been proposed for purpose of calculation of raw materials and current rates of costs applied in the country were taken into calculation. The investor in agreement with government will have to decide whether the mining in this Upper river area should be run by Public Work Department or by himself in future.

(1) Reference No. 65

5.5.2. Energy

Energy consumption (1st year of full production)

	Unit	Total	Wall tiles	Mozaics	Gift items
Electricity	KWH	548 000	385 000	155 000	8 000
Fuel oil	ton	725	390	320	15
Water	cum	2 430	1 250	1 100	80

Consumption of electricity:

- wall tiles 385 KWH per fon of net products
- mozaics 155 KWH per ton of net products
- gift items 160 KWH per ton of net products

Consumption of fuel oil:

- wall tiles 0,39 t per ton of net products
- mozaics 0,32 t per ton of net products
- gift items 0,30 t per ton of net products

Water consumption:

- wall tiles 1,25 m^3 per ton of net products
- mozaics 1,10 m^3 per ton of net products
- gift items 1,60 m^3 per ton of net products

Energy costs (1st year of full production)

	Price per unit D	Total Dalasis	Wall tiles Dalasis	Mozaics Dalasis	Gift items Dalasis
Electricity (1)	0,07	38 360	26 950	10 850	560
Fuel oil (2) *	90,-	65 250	35 100	28 800	1 350
Water (3)	0,33	802	413	363	26
		104 412	62 463	40 013	1 936

* Only Diesel oil is imported and distributed with regard to undeveloped industry.

(1) Reference No. 9
(2) Reference No.60
(3) Reference No149

5.5.3. Operating and general supplies (1st year of full production)

	Total Dalasis	Wall tiles Dalasis	Mozaics Dalasis	Gift items Dalasis
Operating supplies:				
Linings for ball mills 3000 kg	5832	2845	2845	142
Pebbles 20 t	2880	1400	1400	80
Kiln furniture: saggars 2000 kg	2304	2304	-	-
plates 800 kg	346	346		
containers 3000 kg	2592	-	2470	122
Plaster of Paris 10 t	1470			1470
Petrol 9000 l	3000	1200	1200	600
Total	18 424	8 095	7 915	2 414
Maintenance incl. spare parts				
Buildings 2% of 171 000 D	3420	1778	855	787
Production equipment 4% of 1 339 000 D incl. spare parts	53560	27851	13390	12319
Maintenance of 2 cars	2400	1248	600	552
Total	59 380	30 877	14 845	13 658
Office supplies - total	3 000	1 560	750	690
Miscellaneous - total	4 000	2 080	1 000	920
Grand total	84 804	42 612	24 510	17 682

5.5.4. Depreciation

Depreciation - 1st year of full production

	Dalasis
Buildings	6 800
Machinery and equipment	88 380
Fixtures and furniture	3 000
Transportation	3 750
Other investment	19 980
T o t a l	121 910

Depreciation allowances are regulated by the Income Tax Act (1). Decreasing depreciation is applied. Below the annual wear and tear rates applied are given:

	Initial allowance	Subsequent years
Buildings, structures, furnises	10 %	4 %
Plant equipment machinery	40 %	10 %
Fixtures and furniture	40 %	10 %
Transportation	25 %	25 %
Other investment	40 %	10 %

5.5.5. Wages

Workers - manning table	1st shift	2nd shift	3rd shift	4th shift	Total
Raw materials store	2				2
Charging of ball mills	1				1
Attendance of mixers and atomizer	1	1	1		3
Press regulation and lubrication	1	1			2
Attendance of presses	1	1			2
Pressed pieces loading on kiln cars	1	1			2
Car delivery to drier and kiln	1	1	1	1	4
Attendance of kiln	1	1	1	1	4
Unloading and sorting of bisque fired ware	1				1
Stacking and cleaning of kiln furniture	1				1
Attendance, regulation of glazing machines	1				1
Insertion of glazed ware into saggars	10				10
Delivery of loaded cars to kiln	1	1			2
Glazed ware sorting	5				5
Ware packing	2				2
Ware transport into store	1				1
Products store	2				2
Kiln car repair shop	1				1
Machine workshop and maintenance	6				6
Oil handling plant	1				1
Off-site transport	2				2
Guards, cleaners, etc.	3	1	1	1	6
	46	8	4	3	61
Gift items shop (constant workers)	10				10
Total	56	8	4	3	71

Wages (1) (1st year of full production)

	Total Dalasis	Wall tiles Dalasis	Mozaics Dalasis	Gift items Dalasis
Raw materials store	1 300	676	585	39
Charging of ball mills	650	338	293	19
Attendance of mixers and atomizer	1 950	1 015	876	59
[illegible]ction and lubrication	1 948	779	1 169	-
Attendance of press	1 300	520	780	-
Loading on kiln cars	1 300	650	520	130
Car delivery to drier and kiln	2 600	1 300	1 040	260
Attendance of kiln	3 896	2 340	1 170	386
Unloading of bisque	650	325	260	65
Stacking and cleaning kiln furniture	650	325	260	65
Attendence of glazing machine	974	974	-	-
Insertion into saggars	6 500	6 500	-	-
Delivery of loaded cars to kilns	1 300	1 300	-	-
Glazed ware sorting	3 250	3 250	-	-
Ware packing	1 300	780	390	130
Ware transport into store	650	325	260	65
Products store	974	487	390	97
Kiln car repair shop	974	487	390	97
Machine workshop and maint.	5 844	2 922	2 338	584
Oil handling plant	844	422	338	84
Off site transport	1 948	974	779	195
Guards, cleaners, etc.	3 408	1 704	1 363	341
Gift items shop constant workers	9 740			9 740
T o t a l	53 950	28 393	13 201	12 356

The wages are calculated on 280 working days (300 working days per year minus holiday and ilness days). On this basis 16 % are added including paid holiday, paid public holidays, sick-pay and medical treatment.

(1) References Nos. 7,8

5.5.6. Salaries (1) (local personnel)

		Dalasis
1	Assistant manager	8 000
1	Laboratory technician	3 000
4	Foremen	14 000
1	Bookkeeper	4 000
2	Assistant and typist	6 000
4	Sales staff	12 000
		47 000
	+ 3% medical treatment	1 410
	T o t a l	48 410

Besides the Government will request a director and a sales expert in the framework of the United Nations Development programme.

5.5.7. Administrative costs

	Dalasis
Insurance (2)	
Buildings 0,3 % of 171 000 D=	513
Production equipment 0,5 % of 1 440 000 D =	7 200
1 Lorry	400
1 Car	300
T o t a l	8 413
Local rates (3)	
Commercial rate 4,8 % of acq. value of buildings i.e of 132 000 D =	6 336
Water rate	10
Service charge	200
Total	6 546
Rents for site 5 D/100 m^2 (4) (10 400 m^2)	520
Miscellaneous (5) (mining lease, compensation for damages etc)	2 000
Administative cost - total	17 479

(1) Reference No. 40,41
(2) Reference No. 59
(3) Reference No. 39
(4) Reference No. 36
(5) Reference No. 5

5.5.8. Interest - 1st year of full production

	Dalasis	Dalasis
Interest on credit granted by supplier of machinery		
1st year of production - 9% of 1 302 000 D	117 180	
2nd year of production - 9% of 1 167 000 D (full production)		105 030

5.5.9. Sales costs - 1st year of full production

	Total Dalasis	Wall tiles Dalasis	Mozaics Dalasis	Gift items Dalasis
Crates for wall tiles * 68 000 pcs at 1,25 D/pc.	85 000	85 000		
Bags for mozaics * 20 000 pcs at 0,5 D/pc.	10 000		10 000	
Straw boxes for gift items * 50 000 pcs at 0,5 D/pc.	25 000			25 000
Travel expenses and publicity	4 000	1 500	1 000	1 500
T o t a l	124 000	86 500	11 000	26 500

Personnel costs of sales are included in the item "Salaries".

* 1 crate contains 72 wall tiles
1 bag contains 50 kg of mozaics
1 knitted strowbox contains 1 kg of gift items in average

5.6. Financing

The supplier's credit should be 80 % of Cif value of delivered machinery, the remaining 10 % should be paid after signing the order a 10 % upon delivery

Rate of interest: 9 % per year

Repayment: over five years

Cif value of delivered machinery:		1 302 000 D
Granted credit	80 %	1 042 000 D
1st advance	10 %	130 000 D
2nd advance	10 %	130 000 D

During the field investigation in Gambia the potential sources of capital could not be discussed. Only this report is expected to give the first estimates of required capital to the Government of Gambia.

The total volume of loans and credits proposed in this study is about 1 300 000 D (54 % of total investment). As with regard to information received from the Development Bank (1) in Gambia the interest on loan within the Development programme would be 9 % as well, the financing in the study is calculated in such a way as if the whole Cif value of machinery - 1 302 000 D - were credited.

Capital requirement:	2 390 000 D
Capital distribution in the study	
Total investment	2 390 000 D
Supplier's credit (70-80 % of Cif value of machinery)	1 042 000 D
Loan or equity capital	260 000 D
Equity capital	1 088 000 D

(1) Reference No. 54

5.7. Pilot plant

5.7.1. Objectives of the pilot plant

1. Training of local workers in the manufacture of ceramic products
2. Training of future ceramic technicians
3. Training of local students endowed with artistic gift in application of local art in the industrial art
4. Production of 25 tons of gift items per year
5. Experimental production of [illegible]
6. Experimental production of mozaics
7. Market testing

5.7.2. Technology (1)

Raw materials are delivered to the pilot plant by lorries.

Small grain-sized raw materials are discharged directly into roofed boxes. Raw materials delivered in lumps are tipped in front of the jaw crusher which is feeded manually. The crushed raw material is transported by a conveyor into a box. According to recipe the particular raw materials are charged into the hopper of the travelling balance. The hopper is transported by means of the travelling pulley block onto the platform over the ball mill. The slurry is discharged from the mill through vibrating screens into a propeller mixer from where it is pumped either for casting into plaster moulds or it is pumped into the filterpress. (for plastic moulding), from which the body is passed through the pug mill, manually shaped and turned on the potter's wheel.

The semiproducts are dried naturally and fired in the electrical chamber kiln. With regard to the character of products these may be glazed after firing and glost fired in the same kiln.

The glaze is delivered to the plant ready made and packed in sacks. It is hoisted by the travelling pulley block on the platform over the ball mill into which it is charged together with water. The blunged glaze is discharged from the ball mill through the vibrating screens and the electromagnetic separator into the propeller mixer. The products are glazed manually.

(1) Tables VII, VIII

Experimental production of wall tiles and mozaics:
The filterpressed cakes are cut to pieces, naturally dried and ground in the pan mill. The pressing powder is charged into the hopper of the press. The pressed walltiles are dried in stacks naturally, fired in the electric kiln, glazed and glostfired in the same kiln.
The mozaics are produced in a similar way.

5.7.3. Technological equipment

Item	pcs	Denomination
1	1	Jaw crusher
2	1	Bucket elevator
3	1	Belt conveyor
4	8	Boxes for raw materials
5	1	Travelling balance
6	2	Travelling balance
7	1	Ball mill
8	1	Charging platform
9	1	Vibrating screen 236 op/cm^2
10	1	Vibrating screen 2500 op./cm^2
11	1	Propeller mixer
12	1	Diaphragm pump
13	1	Filterpress
14	1	Belt conveyor
15	1	Horizontal vacuum press
16		Manual moulding
17		Natural drying
18	1	Electric chamber kiln
19	2	Flow water meter
20		
21		
22	1	Ball mill
23	1	Charging platform
24	1	Vibrating screen
25	1	Electromagnetic seperator

(1) Table VII

Item	pcs	Denomination
26	1	Propeller mixer
27		Glazing
28		Natural drying
29		
30		Pan mill
31		Press with exchangeable pressing dies

5.7.4. Investment costs

1/ Fixed assets

	Dalasis
Site development	5 000
Production hall 500 m^2	50 000
Standard septics 2 pcs	720
Water supply connection	280
Transformer and power line connection	5 000
	61 000
Unforseen	6 000
Total	67 000
Machinery and equipment as per specification	144 000
Transport and erection	43 000
	187 000
Unforseen	18 000
Total	205 000
Fixtures and furniture - total	10 000
Transportation (1 lorry, 1 car)	20 000
Fixed assets total	302 000

2/ Other investment — Dalasis

Preinvestment costs:

	Dalasis
Preliminary expenditure and projects	15 000
Engineering during construction	5 000
Start-up expenses:	
Consultant fees	40 000
Other investment - total	60 000

3/ Working capital 15 % of sales — 30 000

Summary

1/ Fixed assets	302 000
2/ Other investment	60 000
3/ Working capital	30 000
Investment costs - total	392 000

5.7.5. Production costs, sales, profits

Production costs	1st year Dalasis	2nd year Dalasis
Raw materials, stains, glazes	4 950	9 900
Energy 80 000 KWh/year	4 000	6 000
Operating and gen. supplies	8 000	15 000
Depreciation	101 700	22 700
Wages	20 000	20 000
Salaries	18 000	50 000
Administrative costs	2 000	2 000
Sales costs	6 350	13 400
Total	185 000	139 000
Sales	100 000	200 000
Profit	-85 000	+61 000

Data on which the production costs are based:

Consumption of raw materials, stains, glazes

Clay Fatoto	20 t
Clay Basse	6 t
Claystone Kundam	11 t
Seashells	11 t
Quarzsand	14 t
Pitches	4 t
Laterite	1 t
Feldspar	3 t
Glazes	4 t
Stains	0,4 t
	74,4 t

These materials are needed for the production of 25 tons of gift items and for experimental production of 1000 m^2 of wall tiles and 1000 m^2 of mozaics.
Decreasing depreciation is applied.
Wages for 25 workers are calculated. In the first year of production only salaries of local personnel are calculated. Fees of foreign experts are included in the start-up costs.
In the second year of production salaries of two foreign experts are calculated.

Sales are calculated for 12 500 kg of gift items in the first year of production at 8 D/kg and for 25 000 kg of gift items in the second year. Eventual sales of 1000 m^2 of experimental production of wall tiles and 1000 m^2 of mozaics are not included.

The loss in the first year of production is due to decreasing depreciation with a great allowance in the first year applied in the country (40 % machinery, 10 % buildings).
If the linear depreciation were applied the costs in the first year of production would equal the sales.

A N N E X E S :

References, tables, map

List of Referencies

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   Sessional Paper No 2 of 1971.

2. Seventh Quarterly Report issued by Ministry of Local Government, Planning Office, 15/3/1973.

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4. The Republic of The Gambia - Country programme proposal for UNDP Assistance for the period 1974 - 1976 (Issued 10/10/1973).

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6. Annual wear & tear rates on plant etc. for 1973 and subsequent assessment years.
   File No. ITB/9C/73 (1) Income Tax Office, Bathurst The Gambia, 25th January 1973.

7. Terms and Conditions of Employment for Commercial Workers. The Gambia Gazette, No 13, Vol. 81, 24th April 1964.

8. Minimum Wages - Conversion Table. Joint Industrial Council for Commerce. 1972.

9. The Gambia Utilities Corporation Act (Electricity Regulations), 1972. Supplement "A" to The Gambia Gazette No. 57 of 29th December, 1972.

10. Port (Dries and Rates) Regulations 1972.
    Gambia Ports Authority.

11. Customs Act - Chapter No-69.

12. Pragoinvest, Foreign Trade Corporation for the Export and Import of Equipment and Complete Plants, Českomoravská 23, Praha 9, Czechoslovakia

13. Bickley GMBH, Hochtemperatur - Brennöfen, Postfach 2, 475 UNNA/WESTF., West Germany

14. GIBBONS BROTHERS LTD, P.O.B. 20, Lenches Bridge, Brierley Hill/Staffordshire, England

15. SACMI, Via Provinciale Selice, 17a
    40 026 - IMOLA , Italia

THE LIST OF AUTHORITIES AND COMMERCIAL ORGANISATIONS VISITED AND INTERVIEWED IN GAMBIA IN NOVEMBER 1973 IN CONNECTION WITH UNIDO CONTRACT 73/3 PROJECT NO. DP GAM/72/004

21.	President's Office	Mr. M. M. Sosseh	Deputy Secretary General
22.	President's Office	Mr. S. M. B. Fye	Senior Economist
23.	President's Office	Mr. Armstrong	Chief Economist
24.	President's Office	Mr. D. Belt	Physical Planning Officer
25.	President's Office	Mr. S. K. Sagnia	Economist
26.	President's Office	Mr. H. A. Gibril	Government Demographer
27.	President's Office	Mr. D. Roberts	Government Statistician
28.	Ministry for Local Government	Mr. N. Dodalbhai	Financing Adviser (WHO Expert) Sewage project
29.	" " "	Mr. E. C. Sowe	Permanent Secretary
30.	" " "	Mr. A. Jammeh	Physical Planning Officer
31.	Ministry of Finance	Mr. D. A. N'Dow	Permanent Secretary
32.	Ministry of Finance	Mr. M. L. Aubor	Acting Deputy Permanent Secretary
33.	Ministry of Finance	Mr. M. B. X. Jobe	Chief Price Controller
34.	Income Tax Office	Mr. H. K. Nair	Commissioner of Income Tax
35.	Lands Office	Mr. A. A. N'Jai	Lands Officer
36.	Lands Office	Mr. S. S. N'Jie	Deputy Lands Officer
37.	Customs Office	Mr. I. B. M. Jobe	Deputy Controller of Customs
38.	Customs Office	Mr. A. Savage	Assistant Collector of Customs
39.	Banjul City Council	Mr. C. I. Jagne	Town Clerk
40.	Labour Department	Mr. T. B. Foon	Commissioner of Labour
41.	Labour Department	Mr. D. F. Q. Owens	Labour Inspector
42.	Public Works Department	Mr. J. Moran	Director
43.	" " "	Mr. O. Jammeh	Architect
44.	" " "	Mr. Hyron	Quantity Surveyor
45.	" " "	Mr. A. Carrol	Transport Manager
46.	" " "	Mr. Pugh	Store Consultant
47.	" " "	Mr. A. Batchilly	Chief Building Control Officer
48.	The Gambia Utilities Corporation	Mr. F. Batty	Managing Director
49.	" " "	Mr. C. Bawoda	Water Supply Manager

N. 2

50.	Gambia Ports Authority	Mr. B. M. Sallah	Manager
51.	Central Bank	Mr. A. A. Faal	Chief Accountant
52.	Central Bank	Mr. Bossy	Chief Economist
53.	Gambia Commercial and Development Bank	Mr. H. M. M. N'Jai	Managing Director
54.	Gambia Commercial and Development Bank	Mr. Su'ud	UNIDO Expert
55.	Transport River Division	Mr. King	Manager
56.	Gambia Produce Marketing Board	Mr. V. Brown	Secretary Accountant
57.	Gambia Produce Marketing Board	Mr. Papp	Chief Engineer
58.	Elder Dempster Lines	Mr. Joiner	Manager
59.	Northern Insurance Co.	Mr. F. Cherry	Manager
60.	Texaco Limited	Mr. M. D. A. Senghore	Manager
61.	National Contractors Ltd.	Mr. A. Jacobs	Director
62.	Ministry of Agriculture Forest Division	Mr. F. [illegible]	Forest Officer Yundum
63.	Building Contractor	Mr. M. [illegible]	
64.	Se[illegible], Construction Co. Ltd.	Mr. D. Johnson	Manager

16. NOV 1973

The UNDP Resident Representative in Banjul confirms hereby that the names and authorities in the list are closely concerned about kaolin project in Gambia and have been intervi[illegible]d by Mr. Drovo and Mr. Rataj during their stay in Banjul to complete market and economic report of the above mentioned project.

Seen and confirmed

Williard F. Harper
Resident Representative
16 November 1973

UNITED NATIONS DEVELOPMENT PROGRAMME

Supplement:

65.	PWD	Mr. H. Seng	Senior Executive Engineer

WALL TILES–PROPOSED CAPACITY OF THE INDUSTRIAL PLANT (TONS)

A– Registered and estimated imports in Senegal, Ghana, Liberia, Sierra Leone, Nigeria and Gambia (Market Study)

B– Proposed production of the industrial plant (Economic Study)

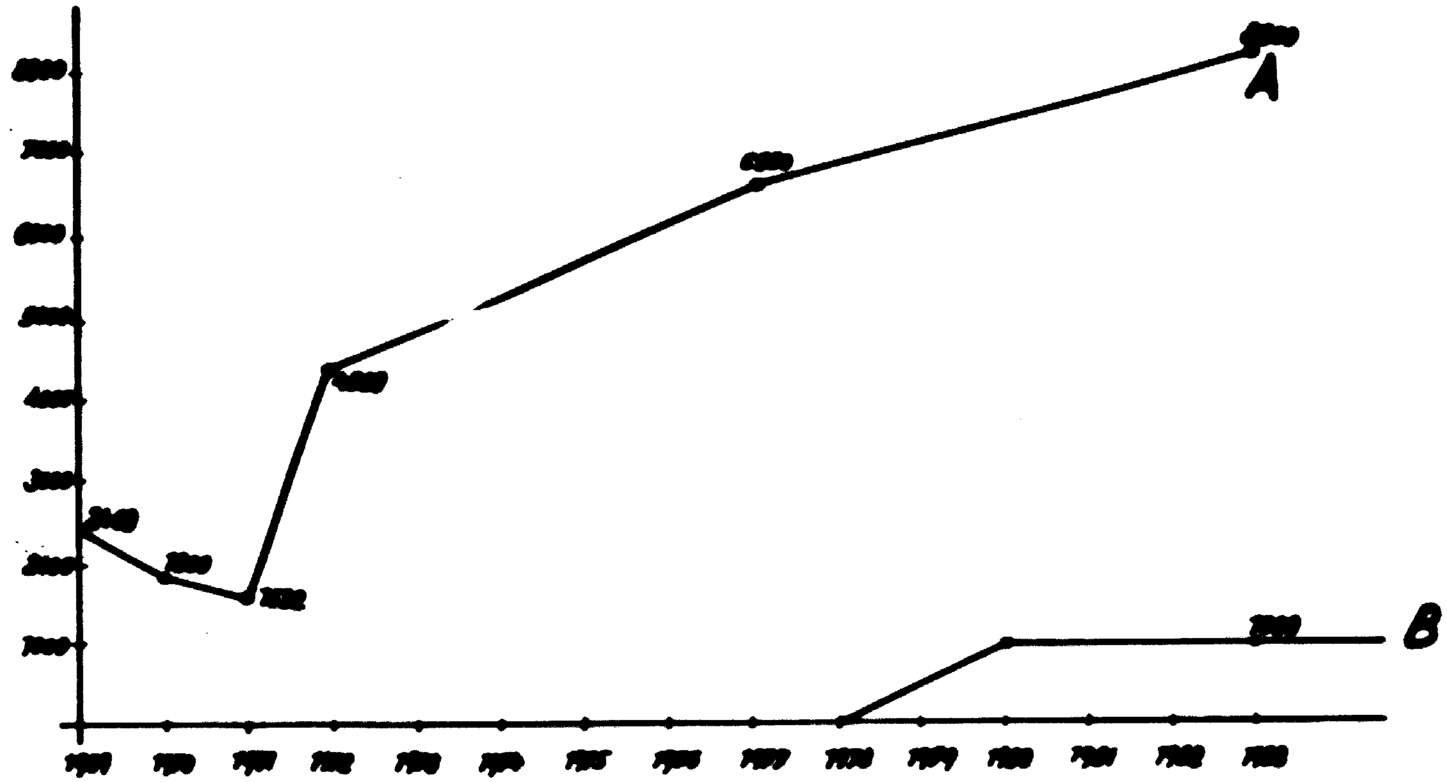


TABLE I.

MOZAICS - PROPOSED CAPACITY OF THE INDUSTRIAL PLANT (TONS)

A - Registered and estimated imports in Senegal, Ghana, Liberia, Sierra Leone, Nigeria, Ivory Coust and Gambia (Market Study)

B - Proposed production of the industrial plant (Economic Study)

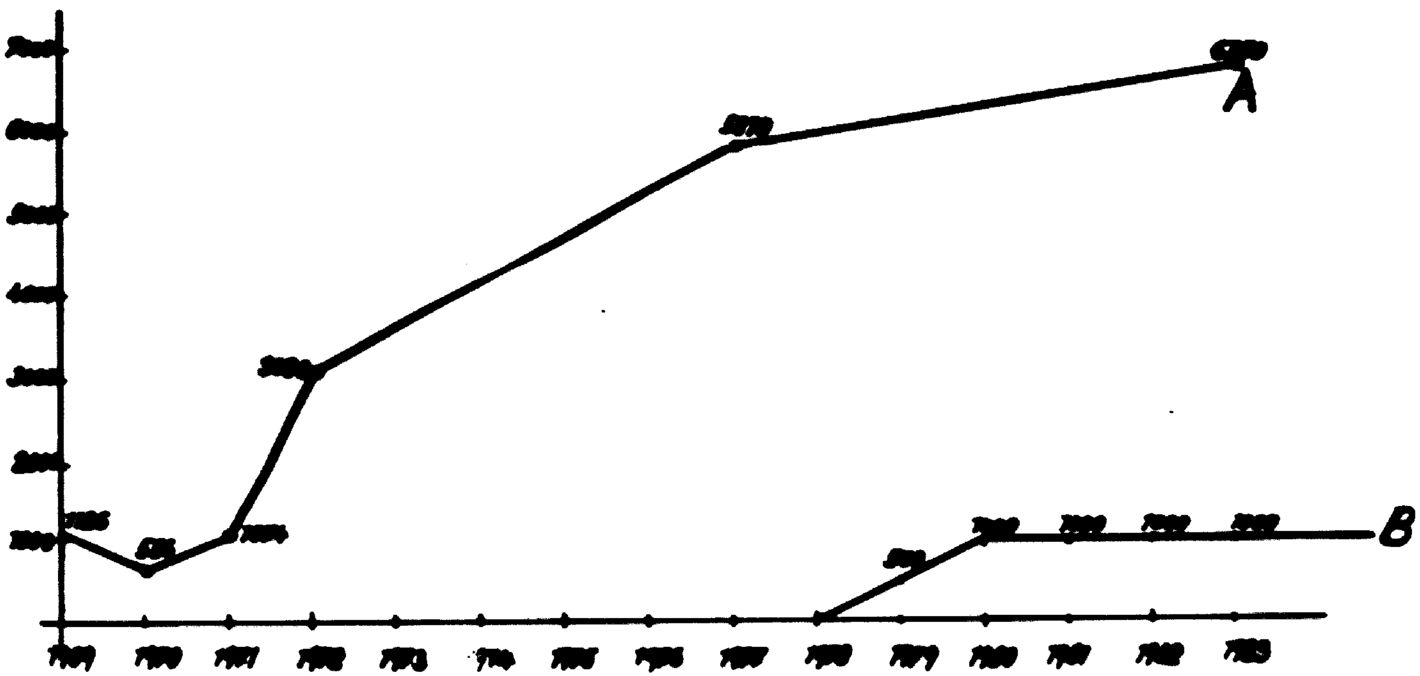


TABLE I.

GIFT ITEMS – PROPOSED CAPACITY OF THE INDUSTRIAL AND PILOT PLANT (TONS)

A – Potential production of gift items in Gambia (Market Study)

B – Proposed production of the industrial plant (Economic Study)

C – Proposed production of the pilot plant (Economic Study)

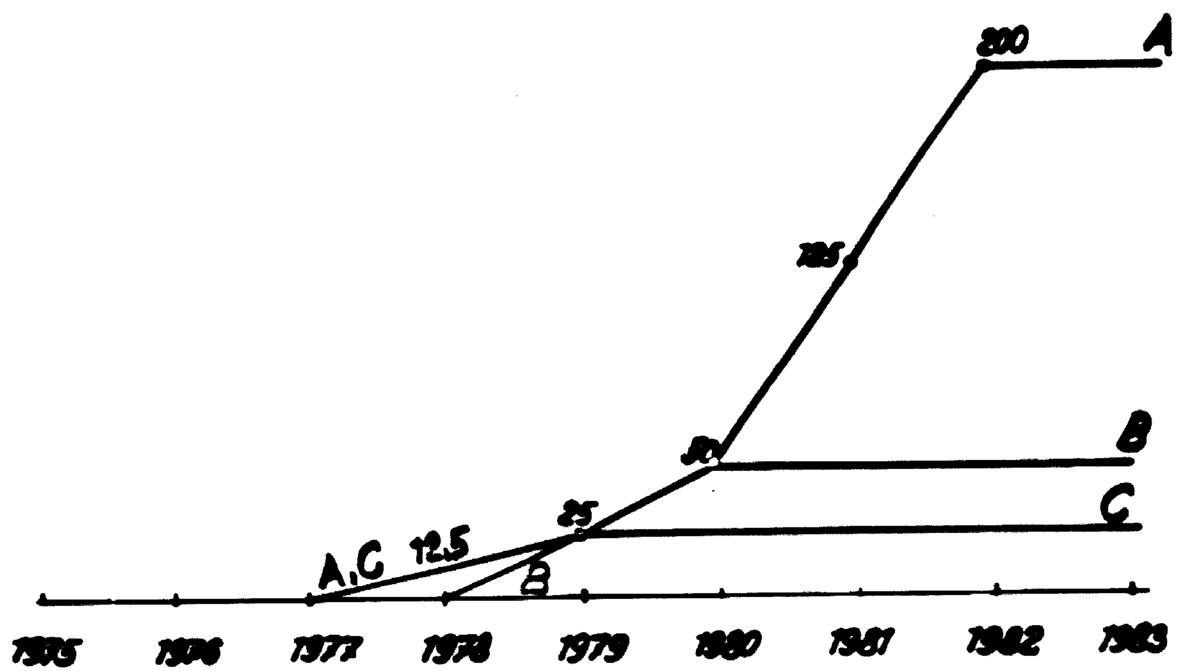


TABLE III.

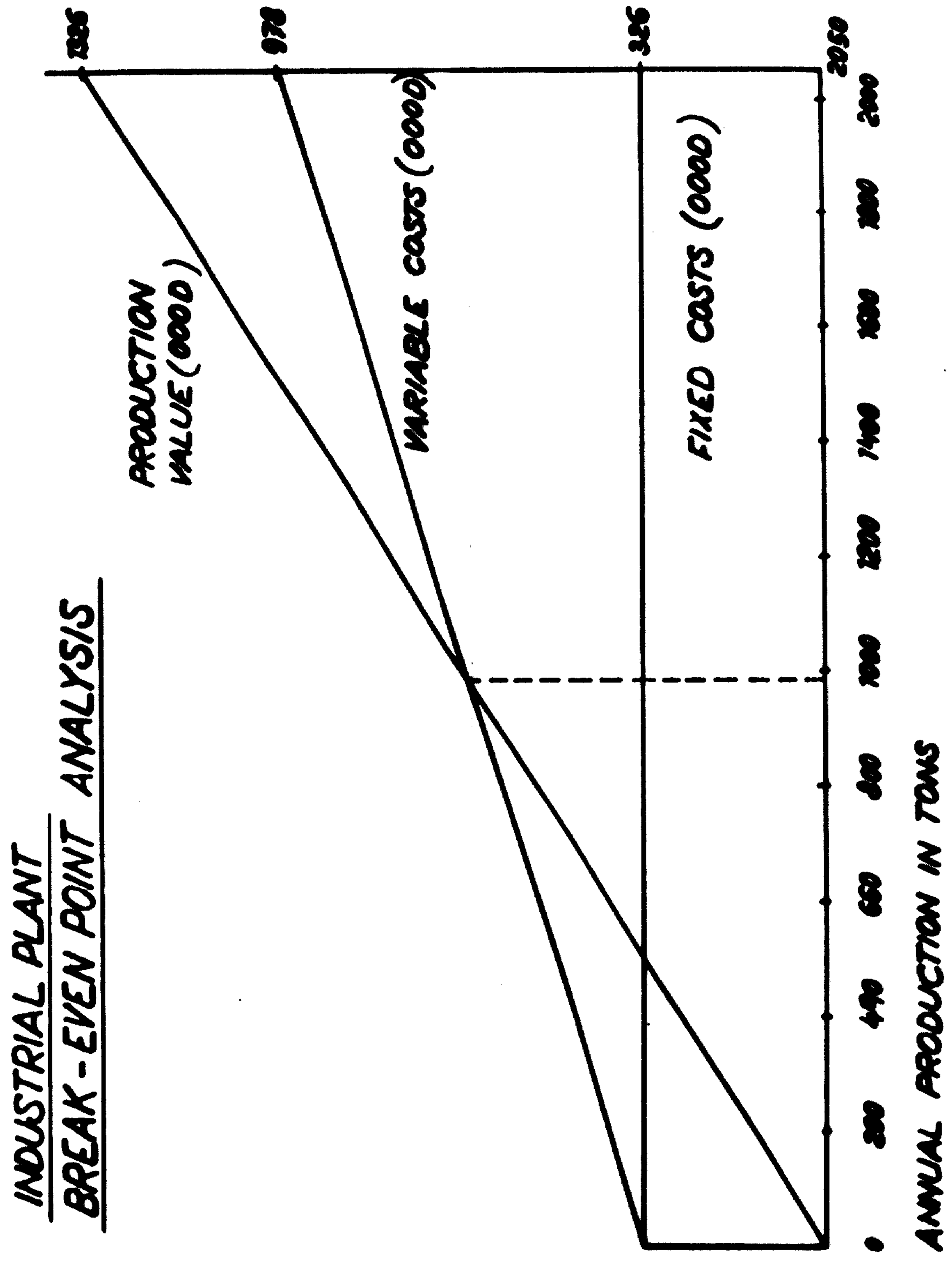

INDUSTRIAL PLANT
BREAK - EVEN POINT ANALYSIS
PRODUCTION VALUE (0000)
VARIABLE COSTS (0000)
FIXED COSTS (0000)
978
2050
ANNUAL PRODUCTION IN TONS

TABLE IV.a

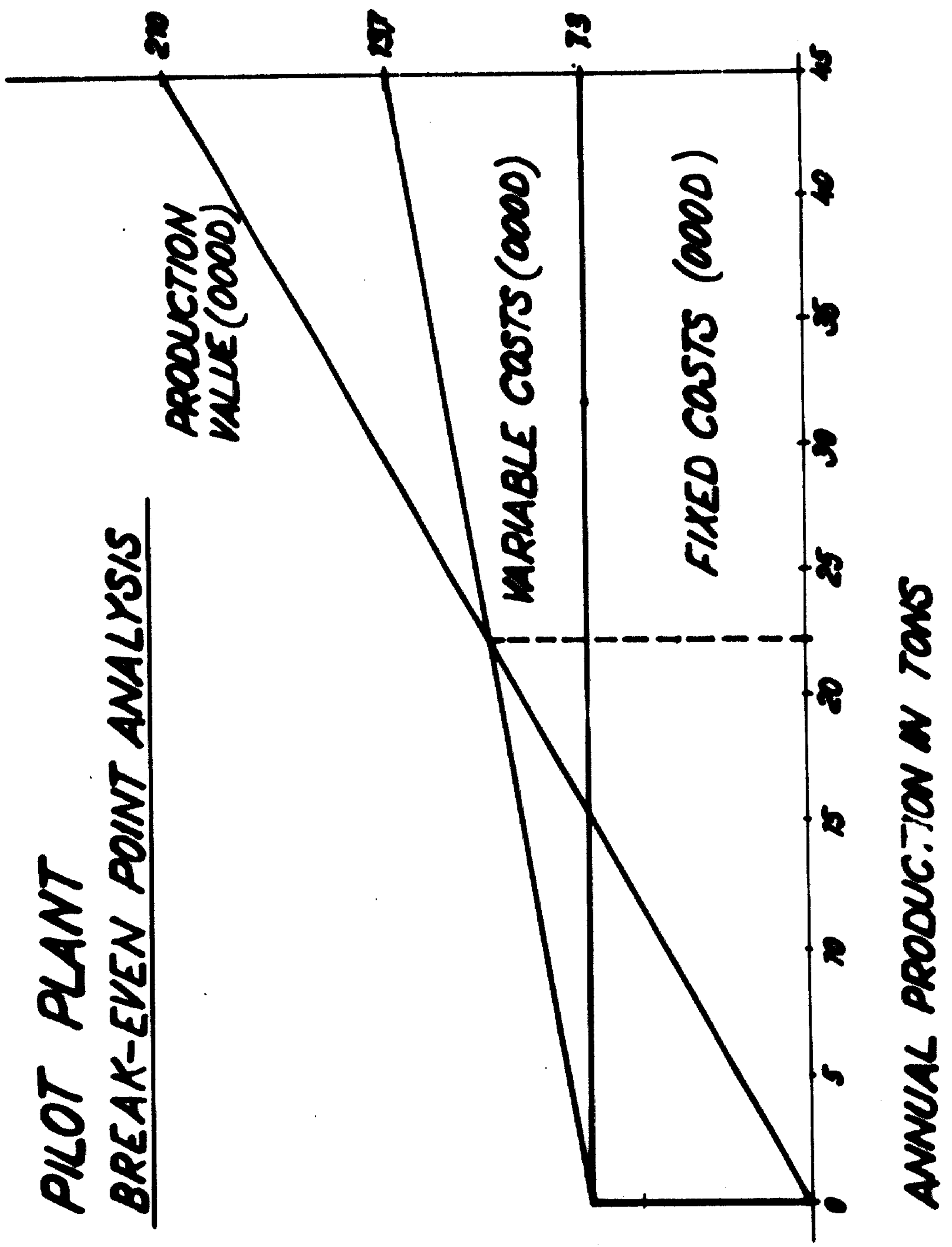

PILOT PLANT
BREAK-EVEN POINT ANALYSIS
PRODUCTION VALUE (000D)
VARIABLE COSTS (000D)
FIXED COSTS (000D)
270
73
0
5
10
15
20
25
30
35
40
45
ANNUAL PRODUCTION IN TONS

TABLE IV. 6

FLOW CHART OF COMBINED MANUFACTURE

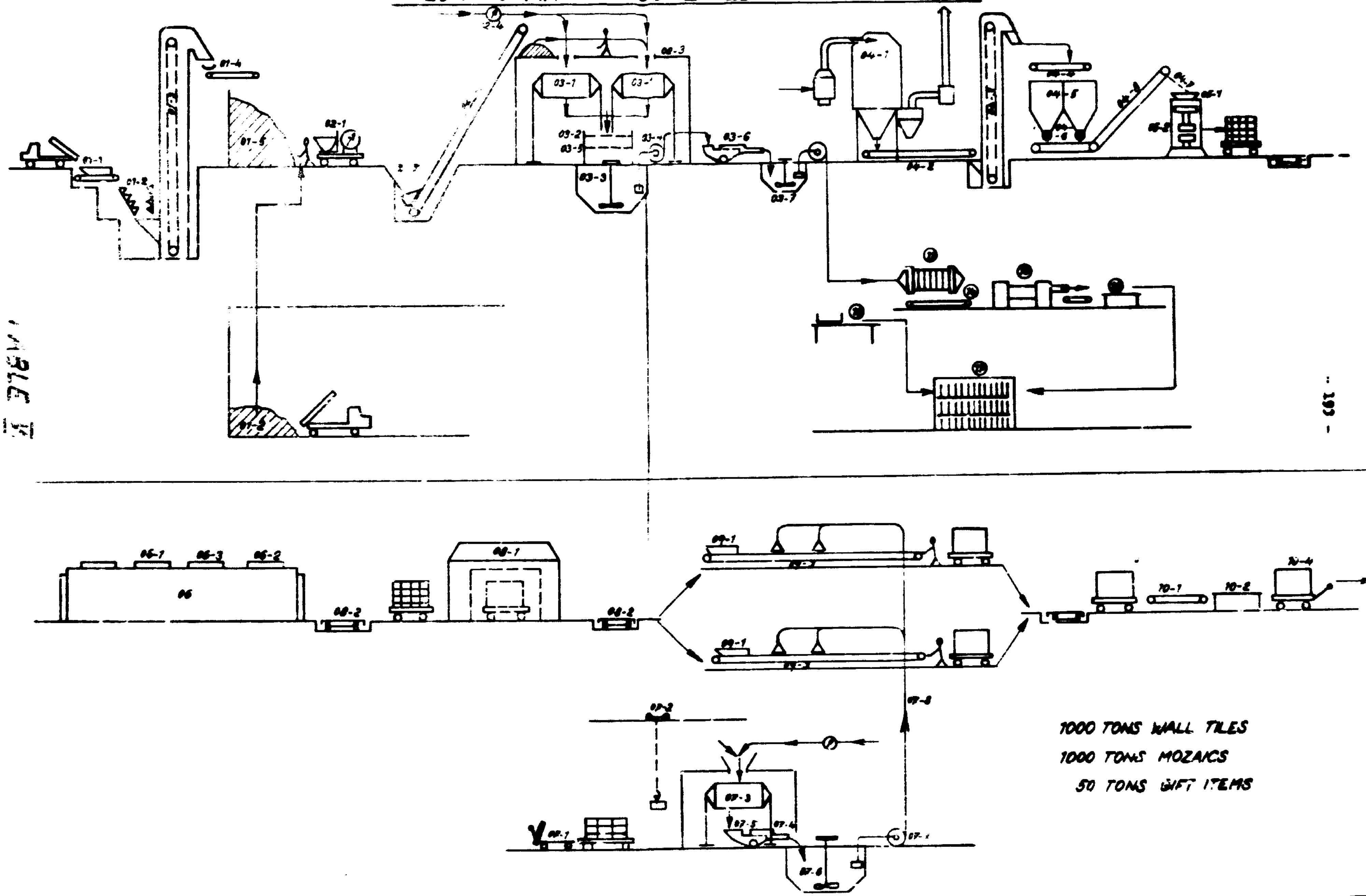


TABLE V

LAYOUT OF COMBINED MANUFACTURE PLANT

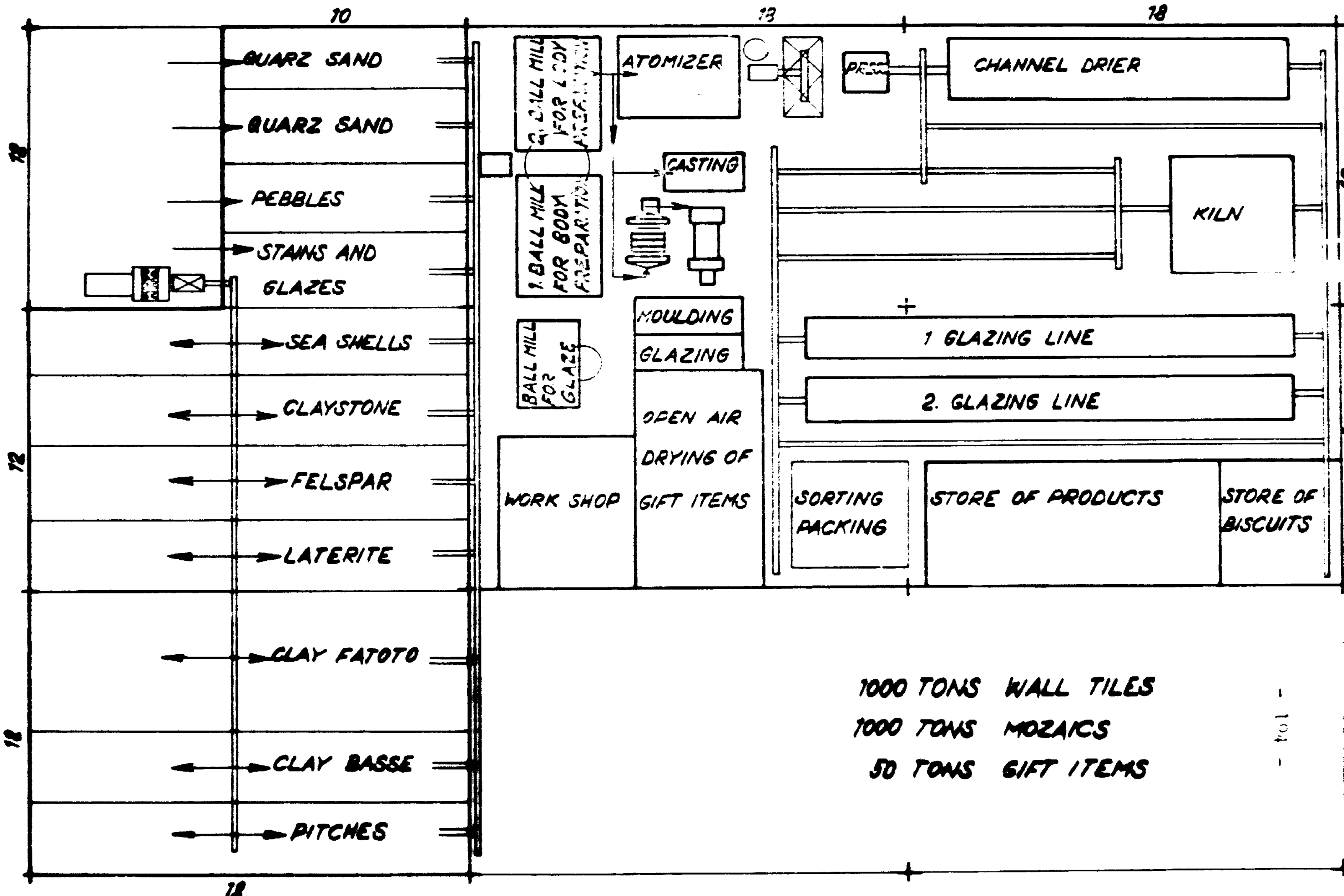


TABLE VI.

FLOW CHART OF PILOT PLANT

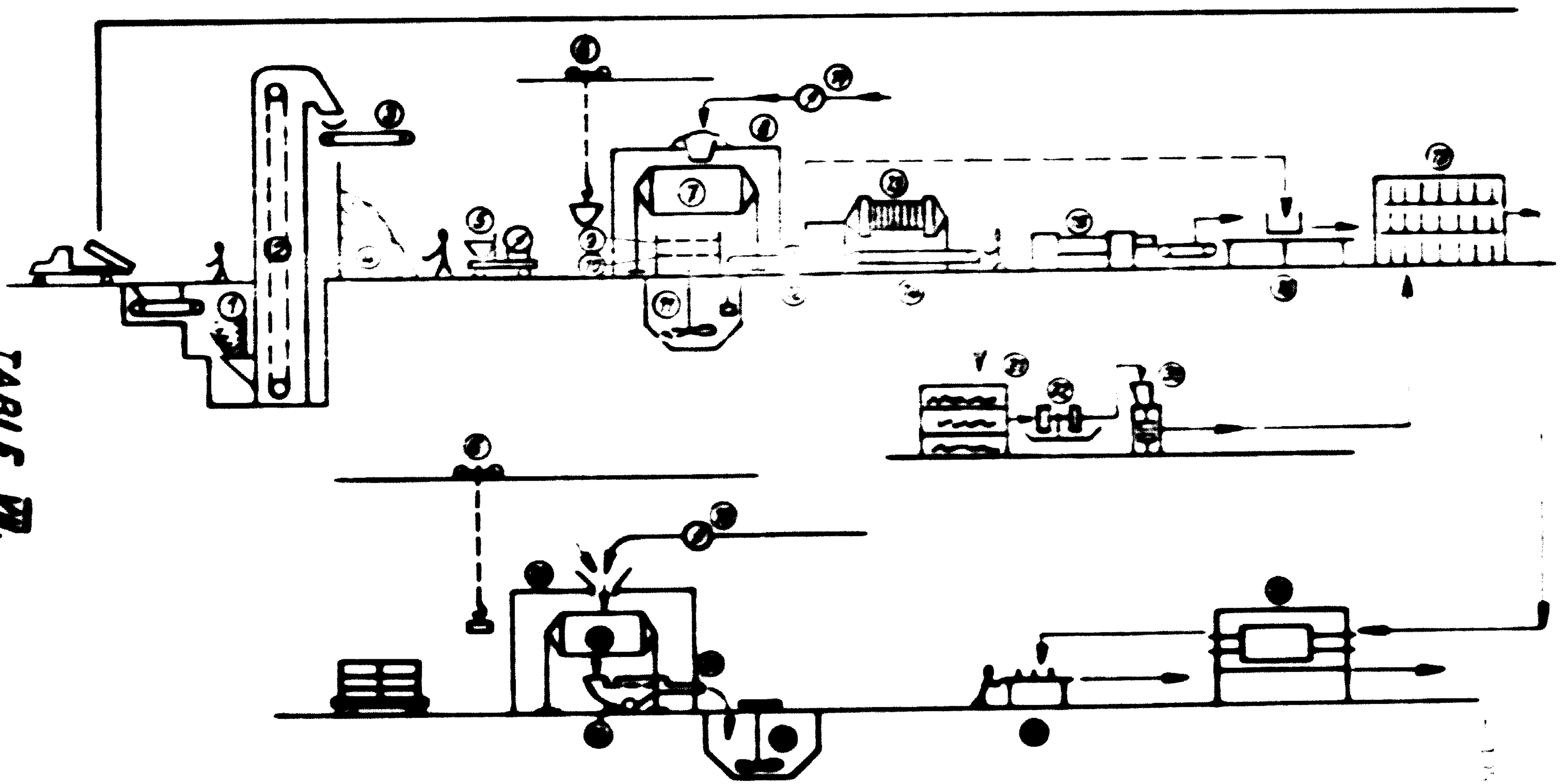


TABLE VII.

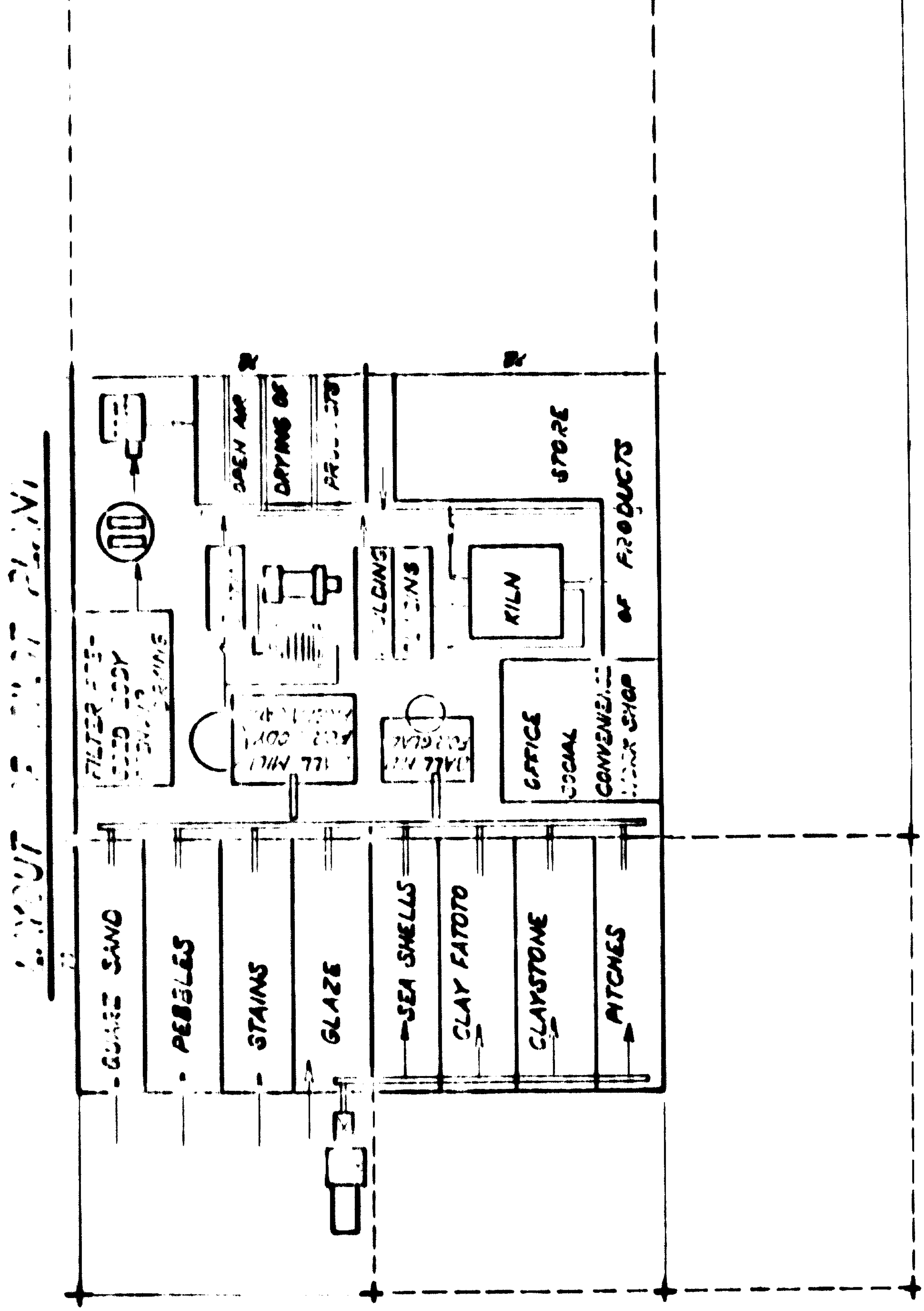
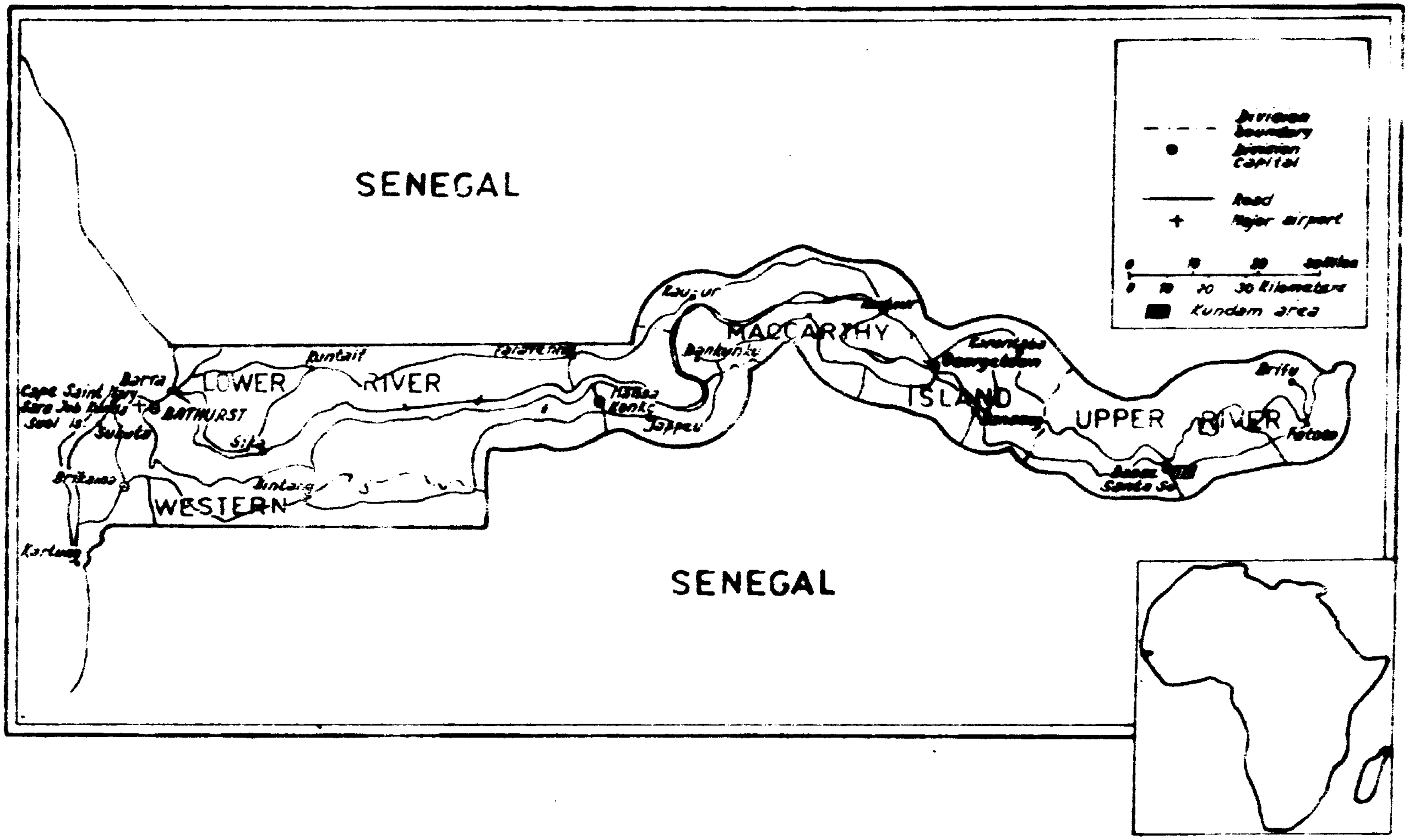

STORE
OF PRODUCTS
KILN
OFFICE
SOCIAL
PEBBLES
STAINS
GLAZE
SEA SHELLS
CLAY FATOTO
CLAYSTONE
PITCHES

TABLE VIII

THE GAMBIA


SENEGAL
SENEGAL
LOWER
RIVER
WESTERN
MACCARTHY
ISLAND
UPPER
RIVER
BATHURST
Barra
Cape Saint Mary
Sukuta
Brikama
Kartung
Sika
Bintang
Kaur
Brifu
Fatoto
Santa Su
Division Boundary
Division Capital
Road
Major airport
10 20 30 Kilometers
Kundam area

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