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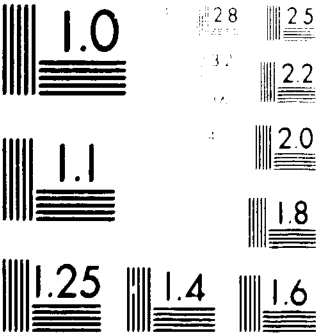
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UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANISATION
VIENNA - AUSTRIA

ASSISTANCE IN THE ESTABLISHMENT OF CLAY PRODUCTS AND NON-METALLIC MATERIALS INDUSTRIES IN BOTSWANA

(SM/BOT/73/001-BOTSWANA)

FINAL REPORT

INSTITUTE FOR CERAMICS
REFRACTORIES AND RAW MATERIALS

HORNÍ BŘÍZA
CZECHOSLOVAKIA

SEPTEMBER 1977

I N T R O D U C T I O N

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION in Vienna (hereinafter referred to as " UNIDO ") concluded the Contract No. [illegible] - Project No.SM/BOT/73/001 with POLYTECHNA, Praha, Czechoslovakia, (hereinafter referred to as " Contractor ") for the provision of services relating to Assistance in the Establishment of Clay Products and Non-Metallic Buildings Materials Industries in Botswana.

The Institute for Ceramics, Refractories and Raw Materials is submitting - as subcontractor to Polytechna - the Final Report giving account of the duties carried out in conformity with Substantive Terms of Reference, page 2, 3, para a) through j) and with Contractor's Proposal of Services, page 12 through 14.

The assignments to be fulfilled were substancially the following ones :

In the first phase deposits of raw materials for clay products and non-metallic materials industries should have been identified, assessed and sampled; taken samples were to be despatched to contractor's laboratories for testing and technological trials. The results should have indicated the suitability of local raw materials to be processed into products.

In the second phase a market survey in Botswana and in the adjacent countries was planned for the products of which the manufacture had been found technically feasible followed by detailed techno-economic feasibility studies for relevant industries.

CONTENTS

II. [illegible]

ANNEXES

MAPS

1. CONCLUSIONS AND RECOMMENDATIONS

The following products and materials are technically feasible from Botswana's raw materials:
brickware facing bricks and facade tiles;
stoneware facade tiles, floor tiles and sewerage pipes;
ceramic wall tiles; glazes; cement-asbestos products;
gypsum /for cement manufacture only/; quick lime.

The following products and materials were recommended by market investigation as saleable in Botswana and adjacent countries or desirable for introduction in Botswana's market:
brickware facing bricks and facade tiles for versification of starting brick manufacture; ceramic wall tiles /2 alternatives/; experimental manufacture of floor tiles; small scale production of quick lime.

The economic examination brought the following results:
Wall tiles: Both the alternatives /Industrial plant 150 000 m^2 and pilot plant 50 000 m^2/ are economically viable. The alternative of pilot plant is recommended to be implemented.
Experimental production of floor tiles: Manufacture is recommended in combination with wall tiles in the pilot plant.
Quick lime: Combined manufacture of 5 000 t quick lime for flushing and painting /replacement of imports/ and 5000 t quick lime for mortars and plasters /newly introduced material/ is economically feasible and recommendable.
Brickware facing bricks and facade tiles for versification of brick ware production are recommended as being profitable.

For implementation of foregoing conclusions the following assignments are recommended:

Pilot Plant or Industrial Plant

Assignments before investment is started:
Systematic drilling tests for determination of the best mi-

ning conditions. Total reserves for 50 years production should be as follows:

Mudstone grey Mr /TS 3/	30 000 t
Mudstone dark Mr /TS 4/	30 000 t
Sandstone background /TS 33/	60 000 t
Clay grey brown Mr /TS 5 + TS 6/	10 000 t
Pegmatite S.P. /TS 18/	20 000 t

Note: The deposits can be indentified by means of the enclosed List of samples and the maps.

Additional investigation of market in SA, Lesotho and Swaziland regarding wall tiles in price categories 10-18 P/m^2 through a wholesale dealer and providing a set of corresponding samples for investor.

Conclusion of an agreement with Zambia on exports of wall tiles /especially in case of industrial plant/.

Assignments during and after investment:

The following UNIDO assistance is recommended:

A short-term mission for drafting orders for machinery and evaluting tenders.

A mission of one year /6 months before and six months after starting production/ for opening mines and introducing the system of mining - profession mining engineer.

A mission of 2 years /starting 6 months before start of production/ for design of patterns and paintings and for training local personnel.

A mission of two technologists for carrying out the following duties: consultancy for investor during guarantee tests carried out by supplier of machinery, training local personnel, supervision of manufacture.

Quick lime plant

Assignments before investment is started:

Verification of limestone deposit LS 23 Tonota, limestone deposit MMadinare or other deposit if need be. Total reserve for 50 years production should be 1 000 000 ton.

Verification of alleged annual imports of 4000 - 5000 t quick lime for painting and flushing.

Campaign explaining advantages of quick lime application in mortars and plasters. This campaign should be sponsered by Chief Architect, carried out by an experienced firm and directed also tu rural areas. Questionnaires and interviews are recommendable.

Assignments during and after investment:

The following UNIDO assistance is recommended:

A short - termed mission for drafting orders and evaluating tenders.

A mission of one year for a technologist to consult the investor during guarantee tests of plant carried out by supplier of machinery, train local personnel and supervise manufacture.

Versification of brickware manufacture

Assignments for implementation:

For the present experimental manufacture of glazed facing bricks in the brick plant in Gaborone production equipment must be completed to a small extent and measures taken for proper firing temperature and against glaze contamination. In the further planned brick plant especially a kiln of a higher standard is recommended.

Future assignments

Pegmatite Selebi Pique /TS 18/ the reserves of which should be verified for application in the body for ceramic wall tiles could be also applied for glaze manufacture. Therefore the samples of pure pegmatite should be also submitted to tests regarding their application in glazes.

As soon as the feasibility study for cement factory in Botswana is finished, regular potential deliveries and price estimates of asbestos fibres from Botswana's mines should be found out and a feasibility study for asbestos-cement manufacture should be prepared.

The reserves of quartz near Halfway Kop should be verified. This quartz is of outstanding quality and could be possibly applied for the manufacture of pure quartz glass. Also quartz from the locality Maapi could be applied for glass manufacture.

2. FIELD ACTIVITY

The following team of experts left Czechoslovakia for Botswana on 12 June 1976 to fulfill the assignments in the field.

Ing Jan Dřevo, team leader (economist)
Ing Josef Franče, geologist and mining engineer
Vratislav Rabštejnek, technologist

The team was joined in Botswana by

Ing Zdeněk Engelthaler, CSc., -special consultant.

Duration of the trip - team of experts : 12.6.1976 - 4.8.1976
- special consultant : 19.6.1976 - 28.6.1976

Official persons contacted during the field trip are listed in the annexe.

The course of the trip

13.6. The team members arrived at the Lusaka Airport on Sunday, June,13,1976 at 12.25 EET.

14-18.6. The days from 14 to 18 June were devoted to establishing a survey of geology and geological research in Southern Africa. To this purpose the Geological Survey was visited and the director Dr. Thieme willingly arranged for the library to be available for the experts. Prior to establishment of the Geological Survey Department in Botswana, the Geological Survey

in Lusaca had covered by their activity Botswana 's territory as well, and consequently the library contains valuable dossiers on Botswana, too.
In this period the experts also visited the UNDP Office where Mr. England willingly provided visa to Botswana.

19-20.6. The team touched down in Gaborone on Saturday June 19, at 12.45 and was met at the airport by Mr. Pintz, Senior Planning Economist of the Ministry of Mineral Resources and Water Affairs and by Mr. de Mul, UNDP Assistant Res.Rep. who was very helpful with the passport and clearing formalities. Mr. Wroblicki, UNIDO Consultant at the Geological Survey was also present. He immediately draw our attention to the fact that geological research in the country, directed exclusively to ceramic raw materials and raw materials for building industry, had been very scarce in Botswana; these raw materials had been reported only sporadically in connection with investigation of other minerals deposits.
To provide the list of potential deposits of raw materials required by the Contract the experts started immediately excerpting the literature submitted by Mr. Wroblicki.

21.6. Arrival of Special Consultant Mr Engelthaler, reception by Mr Svenewik, UNDP Resident Representative, in presence of Mr. Eruwayo, Deputy Res.Rep. and Mr. Wroblicki, UNIDO Consultant. Afterwards financial arrangements for the team were made and in the afternoon the opening meeting of representatives of UNDP, Ministry of Mineral Resources and Water Affairs, Ministry of Commerce and Industry, Botswana Development Corporation and Geological Survey Department Lobatse was convened +/. In this meeting the programme of the team and the cooperation with the present governmental bodies were discussed. Mr. Engelthaler visited also Botswana Enterprises Development Unit.

22.6. Mr. Engelthaler and the team members visited the Geological Survey at Lobatse that was appointed counterpart by the Government and discussed with Mr. Walshaw, Deputy Director, the requirements of traffic, labour, mechanisation, literature, guides, contacts with local authorities and enterprises etc.

23.6. Mr. Engelthaler and the team members visited a pottery workshop with attached kiln for firing limestone of Serowe Brigade Development Trust where they supposed to find traces of local ceramic production and plastic clays. Technological problems were discussed with Mr. Lekoma, Deputy Director of the trust.

24.6. Starting work in the allocated room in the Geological

+/ See the list of official persons contacted

Survey premises. Completion of the list of potentially exploitable deposits and preparation of the working programme in the terrain. Visit of the Thamaga pottery.

25.6. Negotiations with BEDU, Botswana Development Corporation. Building Department and Ministry of Minerals and Water Affairs, and UNDP, before departure of Mr. Engelthaler.

26.6. Final consultations between Mr. Engelthaler and the team, guidelines for further field work. Preparation of samples taken during the week on deposits to be taken to Czechoslovakia for preliminary tests. At 14,00 Mr. Engelthaler left for Lusaka.

27.6. Final preparations for the first expedition

28.6.-2.7. Mr. Franče and Mr. Rabštejnek, accompanied by the geologist Mr. Gold left on a landrover for the area of Mahalapye-Palapye-Selebi Pikwe-Mokame to inspect the preselected deposits :

Mamabula mudstones
Mokame limestone
Makoro mudstone
Molapo River mudstone
Molapo River Quartz
Molapo River marble
Selebi Pikwe tailings
Selebi Pikwe pegmatite

Mr. Dřevo stayed at that time in Gaborone to excerpt five reports of Ministry of Minerals and Water Affairs and of Ministry of Commerce regarding the economy of the country, the development of the building industry, the costs and requirements of building materials. He also collected preliminary data on present imports of building materials at the Statistics Department. On July 2, he moved to Lobatse to discuss further co-operation with Mr. Jones, director of Geological Survey.

3-4.7. On Saturday morning a meeting was held with the representatives of Geological Survey at Lobatse in the presence of Mr. Jones, Mr. Walshaw, Mr. Gold and Mr. Coates. Mr. Franče reported on the experience of the first week spent in the terrain. The most valuable clays seemed to be those of the Makoro deposit. The application of the auger, which was the only available machine for shallow drilling, would hardly be possible because of very hard surface layers. Therefore labourers for digging pits were required. Mr. Jones agreed to send out a truck with 6 diggers and to hire further 5 diggers in the place of investigation. A working programme for the period 5 - 16 July was established. Mr. Dřevo and Mr. Rabštejnek were supposed to inspect the progress of work on the Makoro deposit while Mr. Franče would undertake a further trip to the Francistown area in search for cyanites, feldspars and brick clays. Mr. Coates who was managing a geological camp between Palapye and Makoro was appointed consultant for that period. On Sunday, July 4, reports were written. Mr. Rabštejnek was the both days busy with preliminary tests of samples in the laboratory.

5-16.7. On Monday (July 5) the team arrived on a landrover and the labourers on a truck at Palapye. On the Makoro deposit the pits were marked and dug. On July 7 - 9, Mr. Franče and Mr. Coates undertook a trip to the Francistown area where they took samples from the following occurrences :

Tantebane - Kopjes	pegmatite in adamelite
Halfway Kop	cyanite shale
Matsiloje	syenite
Ramokwe Bana	adamelite
Francistown	brick earth
Foley-Lebung	gypsum

On July 8, Mr. Dřevo and Mr. Rabštejnek went to the Serowe area where they took the following samples :

Motsemaswen River	limestone
Khutswe	sandy clay
Khutswe	residue clay

On July 10 and 11, the team made a trip to the geological area Tuli Block researching for plastic clays. A few samples were taken alongside the river Limpopo.

The stay in the Palapye area was finished by July 16, while the labourers with the foreman were left for another week on the site, as with regard to the thickness of the deposit the underbeds had not been attained by that time and outcrops of finer clays had been found. The team with a considerable quantity of samples moved again to Lobatse.

17-18.7. Saturday and Sunday werespent at Lobatse. A meeting was held at the Geological Survey where team´s programme for the following week was submitted. All requirements for labour and equipment were fulfilled.

19.7. The team removed to Gaborone. Shallow pits were dug and samples of brick earth taken under the dam near Gaborone. Mr. Dřevo reported to Mr. Eruvayo on the progress of the team´s work.

20.7. Mr. Franče and Mr. Rabštejnek accompanied by Mr. Gold went to see the deposit of talc and asbestos investigated and mined by the firm Ceramic Minerals LTD. They were allowed to take samples. At the same time dolomite was sampled which is deposited as waste in mining asbestos. On the back way the quarry and stone dressing plant at Lobatse was visited.

Mr. Dřevo procured visa for the back flight, discussed the transport formalites of the samples with Air Botswana and with Customs. He also ensured the enlargement of the aerial picture of the Makoro deposit.

21.7. Mr. Franče and Mr. Rabštejnek went to see the Quarry L.J.Whyle LTD near Gaborone where they took samples of bolerite (diorite) in the form of fine waste from the dressing plant, and granite. Alongside the airport route they took a sample of laterite.

Mr. Dřevo spent the day at Customs and Excise where he put down yearly exports of some items. He found that these are rather aggregated and that it will be necessary to contact the main importers to specify the items received from the Customs.

22-23.7. Mr. Franče left with Mr. Coates for Palapye for final assessement of pits. Mr. Dřevo and Mr. Rabštejnek had difficulties in providing bags for air transport of samples. At last they got some in a flour mill at Lobatse. They also visited Mr. Davies (Geological Survey) to obtain the required list of prospecting license and mining lease holders for ceramic a building industry raw materials.

24-25.7. Mr. Rabštejnek was sorting and packing samples. Next day Mr. Dřevo and Mr. Rabštejnek were reducing the sorted samples. The total quantity of 1500 kg of taken samples was reduced with regard to preliminary tests to 1208 kg (contracted quantity being 1100 kg). Mr. Franče was compiling documents for the geological part of the Interim Report.

26-30.7. Mr. Dřevo reported to Mr. Eruwayo on the final phase of work. The final session with interested parties was agreed to be convened on July 28. Mr. Dřevo and Mr. Rabštejnek inspected final packing of samples and laboratory equipment and transport from Lobatse to Gaborone. At the airport they were informed that with regard to small aircrafts flying from Caborone the spipment would be delivered in parts to Lusaka. They were recommended to contact Lusaka Airport and arrange for further transport. Mr. Dřevo arranged the final financial affairs and visited also the firm Asbestos Cement LTD, the main importer of asbestos products to get a knowledge of the imported assortment for comparison with the potential production of sewerage pipes. Mr. Franče was drawing maps for the Interim Report. The final meeting at the Ministry of Mineral Resources and Water Affairs :

UNDP :	Mr.C.Eruwayo,Deputy Res.Rep.
Ministry of Min. Resources and Water Affairs	Mr.Pintz,Senior Planning Officer
	Mr.Chanda,Planning Officer
Geological Survey Department:	Mr.Davies,Deputy Director
Ministry of Commerce and Industry :	Mr.Maehler,Senior Planning Officer
	Mr.Cau,Marketing Adviser
Ministry of Commerce Building Department :	Mr. Schutte ,Chief ,Architect

Botswana Development Corp.Ltd Mr.Waller

Polytechna Team : Mr.Dřevo
Mr.Franče
Mr.Rabštejnek

The participants were informed by the team members of the scope of performed work and preliminary results. Mr. Cau was informed that after the technological tests we should be able to say by what products the assortment of the planned brick factory could be enriched. Mr. Dřevo assured Mr.Schutte that the technologist would try to produce severage pipes. Mr. Maehler stressed the necessity of focussing the Market Report on import possibilities of adjacent countries.

He was answered that market investigation of adjacent countries was included in the programme. UNIDO, however, seldom agreed to projects the profilability of which depended predominantly on exports.

Mr. Maehler was promissed that Mr. Dřevo would discuss the matter with UNIDO and was asked to let Mr. Dřevo know in the name of Ministry of Commerce which countries would Botswana promote commercial connections with.

The team of experts left Botswana on July 30, at 16.45 for Lusaka.

31.7.-1.8. In Lusaka the borrowed literature was returned to Geological Survey and the Zambian Airways were contacted. It was agreed that partial deliveries of samples from Gaborone would be assembled and despatched in one shipment to Rome via Luanda. The team left for Rome on August 1st, at 20.00.

2-4.8. Visit of Cargo Department of Alitalia, agreement on immediate further transport of samples to Prague after their arrival, exchange of currencies inconvertible in Czechoslovakia, acquisition of commercial leaffets on technological equipment.

Departure on August 4, at 11.35 EET from Milano, arrival at 12.05 MET in Prague.

3. ASSESSMENT OF AVAILABLE RAW MATERIALS AND SAMPLING IN THE FIELD

In conformity with stipulation of the Contract attention was devoted to the resources of the country, which can enable the development of building materials and ceramics industries. In studying the results of existing geological investigation a comprehensive help was offered to the team of experts by the Geological Survey Department at Lobatse. The experts could study both official and unpublished reports in the Documentation Centre of G.S. inclusive of respective geological maps. Based on this background and consultations with specialists from particular areas the team could carry out a choice of raw materials and localities that were sampled and where incidently further geological investigation was completed. The obtained information was supplemented by information and recommendations of the companies involved in prospection and mining in the country as holders of prospecting licences and mining leases for minerals.

Raw materials for the following products were investigated:
- bricks: brickearth, lateritic soil
- ceramics and refractories: mudstones, feldspar and feldspatic rocks, limestone and dolomite, talc, tailings from the dressing of Cu-Ni ores, quartz, kyanite,
- other raw materials for building industry: limestone, gypsum, asbestos, diatomite

3.1 Outline of geology

Botswana is described as essentially a depression in the ancient Africa shield which was filled in various stages, from the Middle Precambrian upwards, with sedimentary and volcanic deposits culminating in the accumulation of the Calahari Sands. These recent aeolian sands, and the Tertiary-Pleistocene sediments termed the Kalahari Beds mantle some 80% of the surface area. Older rocks outcrop in a broad belt along the eastern border and scattered, relatively wide areas of exposure are also found in the northwest. The basic structural feature is a centrally disposed ancient depositional basin dating back to pre-Karroo times. This basin, elongated along a NE line, is bounded by planed areals of pre-Karroo rocks to the northwest, northeast, southeast and south. Basement Complex in the south-eastern part of Botswana is formed by unmetamorphosed sedimentary and volcanic rocks. Metamorphic complex occurs mainly in eastern part of the country. Granitic gneiss predominates, but ultrabasic rocks, banded ironstones, quartzites, marbles and intrusive granopheres are also known. In the southeast of the country, the Gaborone Granitic Complex, consisting of Rapakivi granite and granitic rocks pass gradually upwards into fine-grained dark-coloured felsites of Kanye Volcanic Group.

The Ventersdorp System comprises a Lower Volcanic Series with rhyolitic tuffs, and quartz-porhyries, the Mogobane Series /shales and siltstones/ and relatively thin andesitic Upper Volcanic Series. Transvaal System overlies the Ventersdorp System with non-angular discordance just across the South African border. The basal Black Reef Series /quartzite/ is succeeded by the Dolomitic Series. At the top there is the Banded Ironstone Formation, which is a quartz-magnetite rock with thin crocidolite bands near the Molopo River. At the contact of dolomite with dolerite dykes and granites, asbestos deposits, resp. talc deposits, are known. The Pretoria Series overlies the Dolomitic Series. There is a horizon of andesitic lavas in this series.

Waterberg System attains a maximum thickness in the southeast of the country, north of Gaborone, where it lies inconformably on the Transvaal System and all earlier rocks. The Waterberg system, formed mainly by sandstones, shales and quartzites, is cut by numerous intrusions, particularly sheets and sills of syenitic to doleritic composition.

Damaran-Katangan Belt: Although this underlies a vast area of northwest Botswana, outcrops are very sparse. The Ghanzi Formation, consisting of sandstones with occasional marly horizons and the Kgwebe Formation, consisting of quartz porphyry, are higher members of the stratigraphical sequence.

Karroo System: Ranging in age from Upper Carboniferous to Jurassic, this includes the sporadically developed Dwyka Series /mainly tillites/, the well-developed Ecca Series /shale, sandstone, mudstone, coal/, possibly the Beaufort Series /shales/ and the Stormberg Series /aeolian sandstone succeeded by basalt lavas/. The maximum recorded thickness of Karroo system in Botswana is 1500 m, of which basalt forms 400 m, and the top of the succession is not seen. The Middle Ecca stage contains several important coal seams, refractory mudstones and in places traces of uranium mineralization. An extensive system of basalt and dolerite dykes cuts the entire Karroo succession and older rocks. Several kimberlite pipes cut the Karroo lavas in the Orapa-Letlhakane area.

Kalahari Beds: These range from Cretaceous to Recents. They consist mainly of poorly sorted aeolian sands, In many places semi-arid weathering processes have produced extensive calcrete and silcrete paths, especially at depth. Contemporaneous with the Kalahari Sands, or at least their upper part, are the deltaic deposits of the Okavango swamps, which are probably much thicker than 200 m. The stratigraphy of Botswana is represented on the enclosed stratigraphic table.

STRATIGRAPHIC TABLE - BOTSWANA

AGE	STRATIGRAPHIC UNIT		LITHOLOGY
Tertiary to Recent		Kalahari Beds	Undifferentiated sands and subordinate gravels, marls, calcretes, silcretes
			Pan and lake sediments and deltaic and swamp sediments
			Dune sands of linear type and of barchan type
Late Carboniferous to Jurassic	Karroo System	Stormberg Series	Basalts with subordinate sandstones and limestones in the Bobonong area
			Sandstones and subordinate shales, mudstones and marlstones
		Dwyka and Ecca Series	Predominantly carbonaceous mudstones and coal seams
			Arkoses and subordinate shales and coal seams
			Mudstones and shales, carbonaceous in the west
			Tillites and varved shales
Late Precambrian	Damara System		Quartz schists, quartzites, dolomitic limestones and marbles
		Ghanzi Formation	Sandstones, subordinate shales and limestones, occasioaal porphyries and diabases
		Kgwebe Formation	Quartz-feldspar porphyries, diabases, sandstones and tuffs
	Waterberg System		Sandstones, grits, conglomerates, shales, subordinate andesites and limestones in the north
		Pretoria and Griquatown Series	Shales, quartzites and subordinate conglomerates, limestones, banded ironstones and andesites

Mid Precambrian	Transvaal System	Dolomite and Black Reef Series	Dolomites and subordinate banded ironstones, cherts, shales and quartzites
		Shoshong "Series"	Quartzites, shales, arkoses, banded ironstones and limestones
	Ventersdorp System		Tuffs, agglomerates, quartz-feldspar porphyry, andesites, silstones, shales and conglomerates
		Kanye Volcanic Formation	Felsite
Early Precambrian	Basement Complex		Undifferentiated acid and intermediate volcanics and subordinate metasediments
			Basic metavolcanics and subordinate metasediments
			Banded ironstones
			Serpentinites and ultramafic schists
			Meta-arkoses and quartzites
			Undifferentiated gneisses

INTRUSIVE IGNEOUS ROCKS

Early Precambrian	Granite (including Gaborone Granite)
	Granodiorite
Early and Mid Precambrian	Diorite, syenite, gabboro, dolerite, anorthosite
Mid Precambrian	Ultrabasic rocks

3.2 Raw materials for brick production

Resources of raw materials for brick production are both the recent sediments, i.e. clayey material from sediments of river plains and weathered rocks of older geological formations, namely mudstones of the Karroo system.

From the viewpoint of quality requirements the raw materials are subdivided into two groups

a/ raw materials for full bricks produced in the centres of local consumption by a simple and unexpensive technological process with application of manual labour and minimum mechanisation, fired in piles or field kilns

b/ raw materials for brick products manufactured on industrial scale:
- light-weight bricks for external walls and partitions
- facing bricks
- façade strips
- pipes, gratings and other decorative building elements

Ad a/
A series of materials suitable to this purpose are described in the Study of the Building Industry VIAK. The results of tested raw materials from the localities Gaborone, Francistown, Lobatse and Palapye were favourable. On these localities samples were taken for laboratory tests. The results from the locality Serowe were not favourable. With regard to a great local interest to promote brick manufacture in this area the team took two samples from accessible sources with the objective to develop a brick body by combination with other potential components. The application of mudstones for this production method is not recommendable because of their hardness and a higher firing temperature.

Ad b/
Based on existing results /VIAK/ and on the teams preliminary

technological tests in the field and with regard to the planned development of the building industry in Botswana it was decided to take samples for further technological trials from these two raw material sources:

1. Clay deposit in the Gaborone Dam Area,
2. Mudstones in the areas Mmamabula and Makoro.

3.2.1 Clay deposit in the Gaborone Dam area

The deposit was investigated in 1963 by Dr. Green who had assessed here 150 000 m^3 of raw material for brick manufacture. In 1976 J. Wroblicki carried out a new investigation of the deposit in 21 boreholes. Based on his research, 3 fundamental technological types of raw materials were distinguished in the deposit and sampled for further technological trials:

G - grey, humic, clayey and plastic silt /+ grey humic clay in the borehole 1/,
R - red-brown, clayey and plastic silt,
Y - brownish-yellow, clayey and plastic silt

Based on documents submitted to the team by Mr. Wroblicki the reserves of the raw materials in the deposit specified in particular types were calculated.

For the calculation the following data were taken:

- minimum thickness of raw material 0,9 m,
- maximum thickness of overburden 0,9 m,
- isolated occurrences of the clay G and beds with interlayers of sandy material were excluded from the calculation.

Taken samples:	Lab. sample	Technol. sample
Gaborone - brown-yellow, clayey and plastic silt /Y/	LS 42, LS 43, LS 44	TS 20, TS 21,
Gaborone - red-brown, clayey and plastic silt /R/	LS 45, LS 46	TS 23, TS 24
Gaborone - grey, humic, clayey and plastic silt /G/	LS 47	TS 25

The calculated reserves amount to:

Clay G	1 201 100	cub. metres
Clay R	672 100	" "
Clay Y	481 300	" "
Total reserves	2 354 500	cub. metres
Overburden	163 900	cub. metres

The situation of the deposit and the calculation of reserves see map No 2.

3.2.2 Mudstones from Mmamabula and Makoro areas

The mudstones from the Karroo system are in general refractory and their processing for brickmanufacture requires fine grinding of raw material and a higher firing temperature. Bricks produced by this method can be applied both as facing and refractory bricks. This manufacture is dealt with in a more detailed way in the part on ceramics and refractory production.

3.2.3 Raw materials for local brick production

Survey of taken samples:

	Lab. sample	Technol. sample
Lobatse - lateritic soil	-	TS 27
Palapye west - brickearth /Losane river/	LS 28	-
Palapye south - brickearth old workshop brick	LS 29	-
Francistown - brickearth bank of Tati river	LS 39	-
Serowe - brickfield brown-red brick clay, humic and plastic	LS 51	TS 30
Serowe - Kutzwe brown silty clay	LS 52	TS 31

3.3 Raw materials for ceramics and refractories

The ceramic manufacture usually combines the ceramic body of more raw materials, each of which adds specific technological properties to the body. As a rule the ceramic body consists of these fundamental components:

- clay component /clays, claystones, kaolin/
- flux /feldspars, feldspar rocks, limestone, dolomite, talc/
- grog quartz raw materials: quartz, quartzite, sandstone
- for refractories special high alumina minerals /kyanite/ are used

In application of multi-component raw materials /e.g. sandy clays or clays with a high flux content/ some of the components may be eliminated or reduced.

The main problem encountered in Botswana is the fact that in the past attention was paid predominately to the clay component /mudstone/ while the other ones were omitted.

3.3.1 Clay components

Mudstones of Karroo system

As it results from the geological survey, the Karroo System is developed on a considerable part of Botswana's territory. Occurrences of claystones, usually named mudstones, are known on a series of localities where they were found mostly in prospecting for coal or in drilling wells. After studying a series of published occurrencies /Massey, VIAK, Green and others/ it was decided with regard to the referred data and preliminary tests to direct the investigation to the localities Mmamabula /130 km north of Gaborone near the main road and railway/ and Makoro /10 km south of Palapye, close to main road and railway/. On Mmamabula deposit the team started from the previous investigations of Mr. Green /The

Mmamabula coal area, 1961/ which was reassessed. On the Makoro deposit a new investigation /pits/ was carried out and the deposit was assessed with regard to bedding condition and the reserves were calculated.

Clay deposit in Mmamabula area

The area around Mmamabula, at the railway siding 130 km north of Gaborone, was thoroughly investigated between 1958 and 1961 in search for coal resources. Boreholes provided detailed information on the lithology and succession, and showed also that the effects of weathering and sub-surface decomposition extended to a depth of approximately 25 m. Consequently, when the argillaceous and carbonaceous beds are traced towards sub-outcrop, they pass into a zone of alteration in which they contain partly plastic, clayey material. Mudstones of this weathered zone are pale grey to yellow, clayey, rather soft. They represent the most common part of mudstones of the locality, which may be compared to the technological type "B" of the locality Makoro. The second technological type of raw material is represented by the light, rather hard, silty mudstone / signed as type "S"/.

Up to Mr. Frančé's assumptions the reserves can be exploited in the quantity of 8 640 thousand cub. metres /of both types together/. The situation of the deposit and the bedding conditions are represented in the map No 3. The samples were taken for laboratory tests and technological trials from the previous pits near the borohole 84 /light silty mudstone/ and between the borohole 84 and 89 /grey to yellow, soft mudstone/.

List of taken samples:	Labor. sample	Technol. sample
Pit near borehole B 84 light mudstone - silty	LS 15	TS 11
Pit between boreholes B 84 and B 89 - dark mudstone	LS 16	TS 12

Clay deposits in Makoro area

Clay deposits in the Makoro area are bound to Ecca series at the margin in the non-carbonaceous mudstones. On the flat margin of the pan the clay beds were dried and chemically changed under the influence of fluctuating water level and weathering conditions. Claystones subjected to those processes are very hard, showing a shell fracture. They are refractory with a high alumina content, in green state they vary from light grey green colour to violet or dark grey in lower positions. Interlayers consist of sandstone, calcrete or grit. Dr. Green describes the occurence of these claystones to be about 1 mile south of the crossing where the Martin's Drift road joins the Palapye-Mahalapye road /about 10 km south of Palapye/. In the publication "The Geology of the Palapye Area", 1963 Dr. Green says: "Sixty five feet of this material, below only a few feet of superficial deposits, were penetrated by a water borehole drilled in the contact zone of the dyke on this northern side". The place of this borehole could not be identified precisely. Mr. Franče gives only its approximate position on the enclosed map.

In searching the terrain two outcrops of the described claystones /usually called mudstones/ were found in pits opened at the margin of the dolerite dyke, where material for road building had been extracted. In the place of these occurrencies and in the neighbourhood of the southern outcrop, pits were dug from which samples were taken for laboratory tests and technological trials. At the southern margin of the pan an outcrop of wheathered mudstone was found. Here a pit was dug in order that the bed of sandstone under the weathered mudstone might be found. The results of these investigations are summarized in the map No 4.

The obtained data show that this research revealed one part of a vast development of noncarbonaceous mudstones in extraordinarly favourable mining conditions. According to the preliminary technological tests the mudstones may be devided into three fundamental types

- F - hard, light, grey-pink to dark-grey mudstone /flintclay on the surface of the basin/
- B - brown /brown-grey, brown-yellow/ soft mudstone /in deeper parts of the basin/
- W - weathered /plastic/ mudstone in the outcrops

In the investigated area these reserves were assessed: /see map No 4./

List of samples taken at the locality Makoro:

		Laboratory sample	Technolog. sample
Pit MR-1	1,1-2,1 m	LS 1	-
"	2,1-2,9 m	LS 2	-
"	2,9-3,9	LS 3	-
"	1,1-2,1	LS 17 /assorted grey mudstone/	TS 10
Pit MR-2	1,1-1,7	LS 4	-
"	1,7-3,1	LS 5	TS 3
"	3,1-4,1	LS 6	TS 4
"	4,1-4,6	LS 60	-
Pit MR-3	1,5-3,0	LS 7	-
Pit MR-4	1,0-2,8	LS 12	TS 7
"	2,8-4,8	LS 13	TS 8
"	4,8-6,2	LS 14	TS 9
Pit MRL-5	0,0-0,5 m	LS 8	TS 5
"	0,5-1,0 m	LS 9	TS 6
"	1,0-2,0 m	LS 56	TS 13
"	2,0-2,4 m	LS 57	-
"	background sandstone	LS 58	TS 33
Pit MRL 6	0,0-0,5	LS 10	-
Pit MRL 7	0,0-0,5	LS 11	-

3.3.2 Fluxes

Feldspars and feldspatic rocks

Research work directed to feldspars has not yeat been carried out in Botswana. The possibility of exploitation of some granitic rocks is mentioned by N.W. Massey in the explanations to geological maps contained in his publication. Pegmatite veins discovered during mapping were mostly of small thickness and irregular position. The above rocks were examined and sampled for chemical analysis.

Characteristics of the sampled rocks:
Granite Mahalapye: finegrained to middlegrained rock, very hard, the outcrop of which can be seen in the dry bed of the river Mahalapye. This type of granite occurs in a great extent in this area.

Tantebane Kopje adamelite: this rock massif with pegmatite veins occurs at the margin of the Granite Timbale. The rock is middle-grained with a thick network of pegmatite veins, of maximum thickness 2 m, very irregularly developed. The mining of pegmatite is possible only in combined mining with adamelite for building stone. The pegmatite content in the rock is about 10%.

Ramokgwebana adamelite: a similar adamelite as that one of Tantebane Kopje.

Matsiloje syenite: north of Matsiloje on the river Ramokgwebana, a big body of syenite, of a high flux content /up to 95%/ is known. Possibility of large scale mining.

Gaborone Rapakivi granite: a big massif between Gaborone and Lobatse. The sample was taken from the overburden in the dolerite quarry near Gaborone.

Apart from a few thick and irregularly positioned pegmatite veins in the deposit Tantebane Kopje, the described rocks contain a certain quantity of minerals containing colouring oxides. Consequently these rocks can be used before all for such ceramic products for which the white firing colour is not required. To this purpose other rocks could be used as well: e.g. powdered waste from the quarries at Gaborone /dolerite, diorite/ and Lobatse /quartz, porphyry/ or waste from the dressing plant at Selebi-Pikwe /very fine slips/ if need be. If the results of some of the above byproducts are favourable, they could be substituted to feldspar in coloured ceramic bodies. The waste is produced in sufficient quantity /in the quarry at Gaborone about 10 tons of powder per day/.

Quite a new raw material occurence was to be found for white ceramic bodies. Based on the study of chemical composition of rocks in Botswana and after consultation with the geologists of the Bamangwato Co Ltd at Selebi Pikwe the attention was focused on some types of lightcoloured rocks /felsites, granites, pegmatite/ from this area. In a 50 m wide strip situated about 2 km from Selebi-Pikwe via airport outcrops of lightcoloured types of anortosite of feldspatic-quartz granite and pegmatite were found, which appeared macroscopically to be applicable for fluxes in ceramic industries.

Characteristic of these rocks:

Anorthosite gneiss, quartzo-feldspathic gneiss and pegmatite in Selebi-Pikwe area

In eastern Botswana, a few sill-like bodies of anorthositic gneiss occur in close association with units of ultramafic rocks. Rocks are isoclinically folded into basin and dome structures with a pronounced orientation towards north-northeast or northeast. The anorthosites occur as large concordant sill-bodies, reaching a maximum thickness of one kilometre in the Selebi-basin and the Pikwe dome. The Pikwe anorthosite body is neighboured by an amphibolite layer and quartzo-feldspathic gneiss. A garnetiferous horizon marks the contact between the arnothosite body and the amphibolite layer while the contact between the quartzo-feldspatic gneiss is often marked by thin bands of plagioclass-quartz granulite. Within the Pikwe anorthosites, layers and lenses of anatectic granite-tonalite gneisses are found. Small bands of amphibolite are also found in the anorthosites. The anorthosite is pale white in colour with greenish patches commonly present. It is predominantly medium to coarse grained. Granitic gneisses are fine to medium coarse grained, pale white or pink in colour. Small pegmatite bodies with brick size feldspars of pink colour occur in granitic gneiss.

Geochemistry of these rocks was studied by A.K. Hor /Department of Earth Sciences, The University of Leeds/ in 1972. Twenty-one specimens taken from a drill core through the anorthosite body, one specimen of granitic gneiss and two specimens of plagioclass-quartz granulite from surface outcrops, were analysed. The analyses of some samples have shown their applicability for ceramics. Interesting results have been obtained with the following samples:

	Anorthosite (borehole Pw 75)		Pink granitic gneiss - Pw 75	Anorthosite (outcrops)
	(535-557) H 10	(733-756) H 16	(387-462) W 2	JI
SiO_2	50,50	57,80	76,20	71,00
TiO_2	0,00	0,00	0,16	0,34
Al_2O_3	29,80	25,80	12,80	16,40
Fe_2O_3	0,00	0,10	1,64 (Fe₂O₃ + FeO)	0,57 (Fe₂O₃ + FeO)
FeO	0,23	0,07		
MnO	0,01	0,00	0,03	0,004
MgO	0,19	0,05	0,20	0,77
CaO	13,00	8,26	1,32	8,82
Na_2O	3,30	6,36	-	-
K_2O	1,02	0,41	4,45	0,09
H_2O^+	0,62	0,09	-	-
H_2O^-	0,09	0,12	-	-
P_2O_5	0,00	0,00	0,00	0,06
Total	98,76	99,06	96,80	98,054

Based on this knowledge two samples of feldspar rock were taken about 2 km south of Pikwe mine beside the road to the airport. One of these samples (LS 26) is a mixture of medium coarse grained anorthosite and anorthosite gneiss, the second one (LS 27) is a coarse grained pegmatite. The investigation of these occurrencies could not be carried out as the field programme did not include the basic geological research and prospecting new as far unknown occurrencies. The existing results of our research indicate some occurrencies of these types of rocks in the Selebi Pikwe area and it can be supposed that further prospecting could discover deposits of valuable raw materials.

Survey of taken samples of feldspar raw materials:

Labor. sample:			Technol.sample:
LS 24	Mahalapye	granite	-
LS 26	Selebi-Pikwe	granitic rock	TS 17
LS 27	Selebi-Pikwe	pegmatite	TS 18
LS 36	Tantebane Kopje	pegmatite	-
LS 37	Tantebane	adamellite	-
LS 38	Ramokgwebana	adamellite	-
LS 40	Gaborone	dolerite /diorite/	TS 19
LS 41	"	granite	-
LS 53	Lobatse	quartz porphyry	-
LS 59	Matsiloje	syenite	-

Dolomite

Dolomite occurs in Botswana as a part of the Transvaal system. It was separated as by-product in mining asbestos in the mine Moshaneng and it is stocked together with the other by-products /minimum 100.000 tons/. Both the assorted lump material and the crushed mixture of accompanying rocks, from which asbestos was obtained, were sampled. Dolomite might be applied as fluxing agent in ceramic bodies for building ceramics. /floor tiles, wall tiles/.

Survey of taken samples:

LS 48	Moshaneng	assorted lump dolomite	TS 28a
LS 49	Moshaneng	crushed dolomite - not assorted	TS 28b

Limestone

There are more occurrencies of limestone in Botswana. They will be dealt with in detail in the chapter on other building materials. Alternatively limestone could be used in ceramics as a component for the manufacture of wall tiles. To this purpose samples of calcrete from the trenches A and C from the locality Mokane were taken. It is supposed that the higher SiO_2 content in calcrete will not hinder the manufacture if a suitable technology is applied. Considerable reserves were calculated in this locality.

Signature of samples:

LS 20 Mokane - trench A - calcrete TS 14
LS 21 Mokane - trench C - calcrete TS 15

Tailings from Selebi-Pikwe

As tailings from the dressing plant at Selebi Pikwe /Bamangwato Consession Ltd - mining and dressing of copper and nickel ores/ would be easily accessible, samples of this material for further trials were taken. The first preliminary tests at Lobatse showed a high content of flux in this material. The practical usage will be limited by the injurant content of sulphur.
Two samples were taken:

LS 18 - clay tailings from the upper part of the sedimentary basin

3.3.3. Talc

Application of talc for ceramic manufacture is taken into account for special ceramics /e.g. steatite/. Prospecting and mining rights have been conferred on the firm Ceramic Minerals /Pty/ Ltd. The technological sample was taken from the stock on the mine Moshaneng. According to the information of Mr. J.C.Davies of Geological Survey the present state of prospecting and mining can be characterised as follows: "Additional trenching adjacent to the Kabelane talc deposit has shown that the best material lies in the vicinity of the large trench from which production occurred in 1965 and from 1967 to 1971. A new mining lease was granted in 1976 to Ceramic Minerals /Pty/Ltd. and hand-cleaned pieces of talc have been stockpiled for export to South Africa".

Signature of the sample taken for laboratory and technological tests:

LS 50 Moshaneng - lump talc + /TS 29/
LS 19 - tailings with high Fe content from the lower part of the sedimentary basin

3.3.4. Kyanite

Kyanite is used as a special refractory raw material with high alumina content. In Botswana, kyanite was mined at Halfway Kop about 14 km southeast of Francistown from 1951 to 1957. The maximum yearly production made 2.000 tons. Four main types of kyanite are described at this locality:

/I/ Massive kyanite rock - consisting of an interlocking aggregate of radiating kyanite crystals up to 75 mm long with minor interstitial pyrophyllite. This forms the central kyanite-rich zone.

/II/ A quartz-kyanite-sericite schist with small kyanite crystals in parallel alignment.

/III/ A compact, brown-coloured, quartz-kyanite schist with irregular plates and bladed crystals of kyanite in a fine grained mosaic of quartz. Minor quantities of sericite, dumortierite and rutile are also found.

/IV/ An asbestiform type of kyanite occurring as veins up tc 40 mm wide, normally concentrated in the zone of massive kyanite rock, but also associated with the compact quartz-kyanite schist.

The deposit was worked initially by opencast and quarrying methods, but once the rich kyanite rock had been extracted the deposit was worked underground by means of two shafts with a number of drives and crosscuts. No attempt was made to beneficiate the ore or to increase the available tonnages by blending low-grade and high-grade ore. Only a limited amount of exploratory drilling was carried out on the deposit and, in the absence of detailed mine records and plans, it is impossible to state whether the deposit still has any economic potential or not.

Two samples of kyanite rock were taken from the waste material in the surroundings of the old mine at Halfway Kop:

LS 34 Halfway Kop - kyanite
LS 35 " - kyanite bearing rock

Also one sample of pure quartz signed LS 33 was taken.

3.3.5 Quartz

Very little work has been carried out to investigate possible sources of high-grade silica materials. As the main type of silica raw material in Botswana is described metaquartzite from the Basement Complex at Maapi, 35 km southeast of Palapye. Reserves are "enormes" and transport along the main Palapye-Martin's Drift road would appear to present no problems. Quartz veins are very common but their small bulk may well rule them out as uneconomic. Quartz reefs are reported to be ubiquitous in the Tati District. They form large rounded hills near Ramokgwebana and also a series of ridges about 13 km north of Francistown near the main road.

In ceramic production, sandstones from Karroo formation can be used as the source of silica in ceramic body.

Three samples of silica raw material were taken for further trials:

LS 25	Maapi - quartzite	TS 16
LS 33	Halfway Kop- quartz of the quartz vein	-
LS 58	Makoro - Moralana - pit No 5, background of mudstone beds - fine grained sandstone	TS 33

3.4. OTHER RAW MATERIALS FOR BUILDING INDUSTRY

3.4.1 Limestone, calcrete, marble

Limestones are fairly widespread within the Basement Complex. Many have suffered metamorphism and serpentinization and have high MgO or SiO_2 content. In general it can be said that all deposits that have been described are very variable in chemical composition

The main limestone deposits are:

- Mokane - calcrete
- Makoro Hills - marble
- Mmadinare - limestone, marble
- Matsiloje - limestone
- Makalaphala - limestone

All these deposits are described in the study of N.W.D. Massey and in the report of VIAK.

Short description of deposits:

Mokane

Mokane is situated about 12 km south of Mmamabula. The raw material is calcrete very variable in chemical composition. The MgO can be expected to increase with increased depth to an unacceptable level /more than 5%/, the silica is also variable and is generally far too high /more than 20%/. The latest investigations have shown that the Mokane calcrete is a very poor source of raw material for the cement industry.

Makoro Hills

This deposit is located 11 km east of Radisele siding, between Mahalapye and Palapye. The deposit is situated in the Basement Complex and consists of hardly metamorphosed limestone. The magnesium content in some parts of the deposit is too high for the stone to be directly useable for cement manufacturing /more than 5%/. It is necessary to make a more detailed investigation /with diamond drilling/ to find out if there are any pure limestone layers of mineable extent.

Mmadinare

This deposit is located about 5 - 10 km north and northwest of the village Mmadinare /near Selebi Pikwe/. The deposit is very big. It is widespread at the area of 6 x 15 km, to the depth up to 50 metres. The total calculated reserves are 70 million tons. After the new investigation it can be said, that the deposit is built up of a stratified series of quartzites, limestones, dolomites, banded ironstones and amfibolites, in the Basement Complex of cataclastic gneisses. Some of these rocks are very pure /dolomitic marble/ and seem to be useable for the production of the lime if special technology is applied. After the recommendation of Dr.R.Key one sample of white dolomitic limestone at Tonota was taken as the type of dolomitic limestone at Mmadinare deposit.

Matsilcje

This deposit is situated south-east of the Tati Concession. The deposit is made up of layers of limestone, dolomite, specular iron ore, jasperoid ironstone, hornblend schist and quartz schist in an older granite. There is only one pure limestone layer in the most southern part of the deposit. The distance of 45 km to the nearest railway means that this deposit could not be a first priority deposit.

Nakalaphala

This deposit is located about 27 km south of Serowe in the Basement Complex. Limestone body is in the area of 24.000 m^2 up to the depth of 50 m. About 3 million tons of limestone are estimated. According to the 12 chemical analyses published in the report of VIAK it can be said that there are some layers of very pure limestone. Some of the samples have a very high content of magnesium, which means that there must be layers or bands of dolomite or scarn in the limestone body.

It is necessary to make a detailed investigation with diamond drillings to find out pure limestone layers and calculate reserves of the suitable raw material.

Survey of taken samples:

LS 20	/ + TS 14/	Mokane - Trench 2 - calcrete
LS 21	/ + TS 15/	Mokane Trench C - calcrete
LS 22		Makoro Hills - marble
LS 23		Tonota - dolomitic marble /type of Mmadinare pure dolomitic limestone/
LS 31		Serowe - calcrete /Motsemasweu river/ /type of Makalaphala limestone/
LS 32		Serowe - lime

3.4.2 Gypsum

Gypsum deposits are known in the area of Foley and Topsi, in the distance of about 15 - 20 km west of the main road Gaborone-Francistown. The gypsum deposits take the form of gypsiferous earth or gypsites, in which selenite crystals are contained in brown sandy soils. The soils also contain calcrete nodules and quartz pebbles. The gypsite is overlain by black cotton soil, barren of gypsum and underlain by Karroo mudstones which also contain large gypsum crystals. The grade of the deposits varies from 0 - 50 percent averaging 25-30%. The gypsite varies in thickness from 0,30 to 2,7 m, averaging 1 m, with an overburden 1,20 - 1,50 m. Total reserves were estimated by Geological Survey over 1 million ton, after special prospecting work by Mineral Research /Pty/ Ltd about another million tons.

Recent development in exploration is characterized by Mr.J.C.Davies /Geological Survey/ as follows:

Since 1971 work has been concentrated in the Bojanamane area where previous exploration had indicated the best potential for exploration. Various tests have been conducted on the raw material to determine the most feasible process. At present it would appear that a wet method is necessary, and that additional sources of water will be requir d before production can be considered. A decision is expected by December, 1976.

Samples were taken from the dressed stockpiled material at the locality Moshaeiwa near Foley.

Samples are signed TS 32a,TS 32b.

3.4.3 Asbestos

Asbestos occurs at several localities throughout Botswana, the most important being in the southeast part of the country, in the region of Moshaneng.

From 1928 until 1948 exploitation was intermittently carried out in the Moshaneng area by prospectors under licence from the Balkis Company, Exploitation continued in the years 1951-1965 by Marble Lime and Associated Industries /Pty/ Ltd. The deposit was worked out in 1965. In 1970 a prospecting lease for asbestos in the Moshaneng area was granted to Asbestos Investments /Pty/ Ltd., who are currently prospecting an associated occurence of iron-free chrysotile asbestos, mainly south of the Lobatse-Ghanzi road.

Chrysotile asbestos has also been found to occur in the south-central Kalahari area in the western part of the Ngwaketse District. The serpentinized body has a strike length of about 50 km.

Recent development in exploration for asbestos is described by Mr. J.C.Davies as follows:

Moshaneng

Drilling in 1971 and 1972 confirmed that asbestos in serpentinised dolomite occurs southwest of the old mine workings. An inclined prospect winze was sunk on the lower of two zones and boxholes were cut to sample the upper zone. Bulk samples taken from these zones were mill tested and it was demonstrated that the mill product could be sold on the European market. The principal problem is that the area defined by the drilling is small, and until additional reserves can be outlined it would be premature to commence mining and milling.

Keng Pan /Keeng Pan/

Drilling in the ultramafic lower portion of an intrusive complex has confirmed that a stockwork of chrysotile is present throughout. Three zones of greater concentration have been defined, which contain marketable-quality fibre, but the amount of fibre is too low to consider development. Additional exploration is planned in the hope that a new zone with a higher asbestos content can be located.

One sample of the asbestos was taken from the new asbestos prospecting mine at Moshaneng.

3.4.4 Diatomite

Several deposits of diatomaceous material have been recorded in Botswana but very little prospecting of these has taken place. Occurrences are described in three main regions:

- Phitshane Molopo /diatomaceous earth/
- Tuli Block - reported as fairly extensive deposits of diatomite developed in shallow drainage depression on Kweneng Ranch near Machaneng Police Camp
- Rakops - diatomaceous limestones and calcareous diatomites along the Boteti River.

One sample of diatomite was taken for laboratory tests from the Tuli Block area, signed LS 55 - Standbeck near Mmasehumana.

3.5 Survey of tested raw materials and their reserves

Raw material	Locality	Samples taken	Available for:	calculated or estimated reserves	Note
1	2	3	4	5	6
Brick-earth	Gaborone dam area	LS 42,43, 44,45,46, 47 TS 20,21, 23,24,25	full bricks, facing bricks (+dolerite) facade strips (+dolerite)	calculated reserves 2 354 500 m^3 overburden 163900 m^3	laboratory and technological trials
Brick earth	Palapye	LS 28,29	not available	-	laboratory testing
Brick earth	Francistown	LS 39	good for full and facing bricks	no geological prospection, possibilities of large reserves	laboratory testing
Brick earth	Serowe, Serowe-Kutzwe	LS 51 LS 52, TS 30 TS 31,	full bricks, ceramics (+mudstone Makoro-type F + B)	no geological prospection	laboratory testing geological prospection necessary
Clay (mudstone)	Mmamabula area	LS 15,16 TS 11,12	facing bricks (+feldspar) well tiles (+calcrete Mokane)	Calculated reserves 8 640.000 m^3 overburden 5.184.000	laboratory tests and technological trials

1	2	3	4	5	6
Clay (mudstone)	Makoro area Makoro I Makoro II Makoro-Moralana	LS 1,2,3, 4,5,6,7, 8,9,10,11, 12,13,14, 17,56,57,58, 60 TS 3,4,5,6, 7,8,9,10,13, 33	wall tiles (type F + sandstone + feldspar) floor tiles (type W + feldspar) facing bricks (assorted type F + feldspar or dolerite, and/or tailings from Selebi-Pikwe refractory (assorted type F + B) stone ware (TS 5,6,13 + fluxes)	Calculated reserves 4.289.200 m^3 overburden 1.002.500 m^3	laboratory and technological trials
Feldspatic rock	Mahalapye granite	LS 24	poor quality	no geological prospection, possibilities of large reserves	laboratory testing
Feldspatic rock	Tantebane Kopje adamelite pegmatite veins	LS 36, 37	pegmatite: good quality for ceramic bodies (flux component) adamelite: poor quality for ceramics, good as a building stone	no geological prospection, possibilities of large reserves. The pegmatite content in the rock about 10%	laboratory testing

1	2	3	4	5	6
Feldspatic rock	Ramokgwebana adamelite	LS 38	poor quality	large reserves	laboratory testing
Feldspatic rock	Syenite-north of Matsiloje	LS 59	poor quality	large reserves	laboratory testing
Feldspatic rock	Gaborone quarry - dolerite	LS 40, TS 19	very good flux component for facing bricks and facing strips	10 tons of very fine powdered waste per day in the quarry	laboratory and technological trials
Feldspatic rock	Gaborone granite	LS 41	poor quality	large reserves	laboratory testing
Feldspatic rock	Lobatse - quartz porphyry	LS 53	poor quality	large reserves	laboratory testing
Feldspar, feldspatic rock	Selebi Pikwe pegmatite, anorthosite quartzo-feldspatic gneiss	LS 26,27 TS 17,18	pegmatite: very good quality for glaz[illegible]es and ceram[illegible] body anorthosit[illegible] quartzo-feldspati[illegible] gneiss: good for ceramic body	no specialy geological prospection	laboratory testing the best feldspar in Botswana, special geological work is necessary
Dolomite (flux mater)	Moshaneng (waste material)	LS 48, 49	poor quality as a component for ceramic bodies	about 100.000 tons	laboratory testing

1	2	3	4	5	6
Calcrete (flux matter) for ceramics	Mokane	LS 20,21 TS 14,15	good for ceramic, as a component in wall tiles	Area about 14 km^2 variable silica content	laboratory and technological trials
Talc	Moshaneng	LS 50 TS 29	good for special ceramics	Prospection work of Ceramic Minerals Ltd	laboratory testing
Tailings (flux material)	Selebi-Pikwe tailings after dressing and processing of Cu-Ni ores	LS 18,19	flux component for facing bricks (+ mudstone Maroko)	waste product	laboratory testing
Kyanite	Halfway Kop Kyanite-bearing rock	LS 34,35	not available due to the low content of kyanite	no reserves calculated	laboratory testing
Quartz	Halfway Kop quartz vein	LS 33	very pute quartz, good for glazures and glass industry	no reserves calculated	laboratory testing special prospection necessary
Quartzite	Maapi	LS 25 TS 16	good for glazures and for glass industry	Reserves allegedly "enormous"	laaboratory testing special prospection necessary

1	2	3	4	5	6
Sandstone	Makoro-Moralana background of mudstone beds	LS 58 TS 33	good for ceramic bodies	estimated reserves minim. 300.000 m	laboratory and technological trials
Limestone	Mokane-calcrete	LS 20,21 TS 14,15	for lime available after special processing (poor source) very pour source for cement production	large reserves (14 km) of very variable quality	laboratory testing
Limestone	Mmadinare (Tonota) (marble)	LS 23	good chemical composition for lime production	total reserves 70 million tons, (all types of limestones)	laboratory testing special geological work and separate calculation for lime production is necessary
Limestone	Makoro Hills (marble)	LS 22	good chemical composition for lime production	no calculation	laboratory testing Basic geological prospection is necessary
Limestone	Serowe (Motsemaswen river)	LS 31, 32	lime	no calculated reserves	laboratory testing special geological prospection necessary
Gypsum	Foley (Moshaeiwa)	TS 32 a, 32 b)	cement production plaster of Paris	estimated reserves several million tons	laboratory testing

1	2	3	4
Asbestos	Moshaveng	LS 54	asbestos cement products
Diatomite	Tuli Block (Standbeck near Mmasehumana)	LS 55	very poor quality

5	6
new prospection work of Asbestos Investments Ltd.	
no calculated reserves	laboratory testing

4. TESTING AND EVALUATION OF SAMPLED RAW MATERIALS

The geological report shows that plastic and non plastic raw materials are available in Botswana.

Plastic raw materials for bricks production are mined mainly in Gaborone, other less important localities are in Francistown and Serowe. Clays for ceramic industry have been found in Mmamabula area near Makoro.

From non-clay mineral samples of feldspars and feldspathic rocks, dolomites, talcum, pegmatite and granitic rocks were taken out.

The last raw materials suitable for building industry are limestone, gypsum, asbestos and diatomite. These raw materials were also sampled.

4.1 Brick clays

16 samples were tested for chemical analysis. The chemical analyses are given in table No 1, technological properties in table No 2. Brick clays No TS 23 and TS 24 were joined together and tested by means of DTA and X-ray analysis. The curves of DTA and X-ray analysis are shown in the diagrams No 1 and 2. Joined were also the samples No TS 20 and TS 21, their curves of DTA and X-ray analysis are shown in the diagrams No 3 and 4. For DTA and X-ray analysis also the sample TS 25 was tested, curves of DTA and X-ray analysis are represented in the diagrams No 5 and 6. The diagrams No 7 for DTA and No 8 for X-ray analysis refer to the sample TS 30.

The samples TS 23 and TS 24 were evaluated as kaolinite with admixture of illite. From non-clay minerals quartz is present in approx. 30 % and feldspars. The colour of samples is red-brown.

The samples TS 20 and TS 21 are of brown colour, they contain kaolinite with admixture of montmorillonite and illite. Non-clay minerals are quartz /25%/, feldspars, Fe-oxides.

Brick clays

Table No 1

Sample No	% L.o.I	% SiO_2	% Al_2O_3	% TiO_2	% Fe_2O_3	% CaO	% MgO	% K_2O	% Na_2O	Total
LS 42 = TS 20	5,39	71,04	13,38	0,68	5,37	0,66	0,67	2,20	0,90	100,19
LS 43 = TS 21	3,38	76,59	10,77	0,60	3,80	0,66	0,63	2,90	0,48	99,71
LS 44	4,20	75,62	11,31	0,62	4,34	0,69	0,73	2,26	0,30	100,07
LS 45 = TS 23	4,77	74,51	11,70	0,60	4,19	0,77	0,75	2,12	0,34	99,75
LS 46 = TS 24	4,59	75,63	11,16	0,65	4,13	0,99	0,75	2,12	0,31	100,33
LS 47 = TS 25	5,01	73,17	11,95	0,75	4,45	0,72	1,00	2,09	0,36	100,50
LS 39	5,02	65,48	15,80	0,66	4,19	2,89	1,40	1,37	2,21	100,90
LS 51 = TS 30	8,69	55,85	12,67	1,66	9,78	6,27	3,67	0,58	1,41	99,98
LS 52 = TS 31	4,01	72,26	11,90	0,69	5,74	1,65	1,67	2,50	0,75	99,77

Table No 2

		Sample No									
		LS 42 =TS 20	LS 43 =TS 21	LS 44	LS 45 =TS 23	LS 46 =TS 24	LS 47 =TS 25	LS [illegible]	LS [illegible] =TS [illegible]	LS [illegible] =TS [illegible]	
Loss on drying %		17,7	17,2	16,7	15,[illegible]	15,[illegible]	14,5	[illegible]	[illegible]	[illegible]	
Water absorption after firing to (%)	1050°C	14,0	14,6	15,2	13,3	13,0	11,2	9,0	16,[illegible]	15,7	
	1100°C	13,0	13,3	13,6	11,2	11,0	14,3	-	14,5	14,7	
	1150°C	11,0	12,2	12,6	10,4	11,0	8,5	5,3	-	-	
Wet-dry shrinkage %		6,2	5,0	5,6	4,0	4,2	3,7	[illegible]	7,9	5,1	
Dry-fired shrinkage after firing to (%)	1050°C	0,9	0,6	0,8	1,0	0,7	1,7	[illegible]	0,2	[illegible]	
	1100°C	1,0	1,3	1,3	1,0	[illegible]	2,0	-	1,[illegible]	[illegible]	
	1150°C	1,9	2,2	2,5	1,5	1,3	2,[illegible]	3,0	-	-	
Rest on the sieve 4900 sp/cm²		29,75	39,[illegible]	41,5[illegible]	33,[illegible]	[illegible],21	32,[illegible]	27,72	[illegible],13	[illegible]	

From DTA and X.ray analysis it results that sample TS 25 is created from kaolinite with montmorillonite, also quartz is present /33%/, feldspars, Fe-oxides and organic matter. Colour is brown-grey.

Clay TS 30 is of brown-red colour, as clay minerals are present mainly montmorillonite with admixture of kaolinite. The content of quartz is about 26%, feldspars 14%, also some Fe-minerals are present.

All these raw materials are suitable for the production of bricks.

4. 2. [illegible] clays

Sample LS 15, TS 11, [illegible] TS 12 [illegible] this area [illegible] No 3.

Sample No	L.o.I. %	SiO_2 %	Al_2O_3 %	TiO_2 %	Fe_2O_3 %	CaO %	[illegible] %	[illegible] %	[illegible] %	Total %
LS 15= TS 11	8,67	62,92	23,36	1,26	1,3[illegible]	[illegible]	0,3[illegible]	0,[illegible]	0,10	99,6
LS 16= TS 12	11,71	52,76	30,60	1,39	1,60	0,66	0,63	0,69	0,13	100,17

Technological properties shown in tables No 4 and 5

Table No 4

	Sample LS 15 + TS 11			
	room	1150°C	1200°C	1250°C
Loss on drying %	16,0	-	-	-
Waterabsorption %	-	16,4	17,[illegible]	15,4
Wet-dry shrinkage %	1,5	-	-	-
Dry-fired shrinkage %	-	2,2	1,2	1,1
Rest on the sieve 4900 op/cm²				

Table No 5

	Sample LS 16 + TS 12			
	room	1150°C	1200°C	1250°C
Loss on drying %	19,4	-	-	-
Waterabsorption %	-	17,3	17,0	15,0
Wet-dry shrinkage %	1,5	-	-	-
Dry-fired shrinkage %	-	5,6	5,7	6,7
Rest on the sieve 4900 op/cm² 35,0				

Refractoriness is 1650°C for the sample LS 15 + TS 11 and 1690°C for the sample LS 16 + TS 12.

X-ray difraction analysis indicates the presence of kaolinite with admixture of montmorillonite in the sample TS 11. Further quartz has been proved approximately 38% and small amount of micaceous minerals. Curves of DTA are shown in the diagram No 9 and X-ray analysis in the diagram No 10. Colour of this sample is light grey.

The sample TS 12 contains mainly kaolinite, the admixture of montmorillonite is low. From non-clay minerals quartz /16%/, further sericite, Fe-oxides and organic matter occur. Colour is light grey. The diagram No 11 shows curves of DTA, X-ray analysis is given in the diagram No 12.

Both samples may be used in ceramic industry, some low standard refractory goods may be produced. It will be a problem with low plasticity of samples especially with the TS 11.

4.3 <u>Makoro clays</u>

From the Makoro and Moralana area a higher number of samples has been taken out and tested. Clay from this area can be divided into three groups. In the first one there are samples for which a rather increased content of CaO is characteristic. Chemical analysis and refractoriness of this group is given in table No 6. To the second group weathered sandstones belong and the third group are raw materials very similar to laterite, non-plastic. Chemical analysis and refractoriness of both groups is given in the table No 7.

Sample TS 10 + LS 17 is assorted grey mudstone. Technological properties of samples from all groups are shown in the table No 8.

Some of the samples were examined by means of DTA and X-ray difraciton. The sample TS 3 was before testing separated in two samples. As it results from curves of DTA, diagram 13 and from X-ray analysis diagram 14, the first one is kaolinite with

Makoro clays

Table No 6

Sample No	Refractoriness	% L.o.I	% SiO_2	% Al_2O_3	% TiO_2	% Fe_2O_3	% CaO	% MgO	% K_2O	% Na_2O	% Total
LS 1	1290°C	10,10	61,54	18,16	0,75	1,96	5,33	0,8[illegible]	1,25	,11	100,19
LS 2	1310°C	11,33	55,51	18,07	0,8[illegible]	1,99	6,49	0,79	0,9[illegible]	,1[illegible]	[illegible]
LS 3	1270°C	14,5[illegible]	55,[illegible]	1[illegible],19	0,83	1,93	[illegible],25	1,26	1,[illegible]	0,27	[illegible]
LS17 + TS 10	1520°C	7,14	67,[illegible]	1[illegible],5[illegible]	0,76	1,56	[illegible]	0,97	1,[illegible]	[illegible],11	[illegible]
LS 4	1400°C	10,56	[illegible],97	1[illegible],27	0,75	1,[illegible]	[illegible],79	1,11	1,[illegible]	[illegible]	[illegible]
LS 5 = TS 3	12[illegible]°C	13,91	56,[illegible]	[illegible]	[illegible]	[illegible]	[illegible],7[illegible]	0, 7	1,15	[illegible]	[illegible]
LS 6 = TS 4	12[illegible]°C	13,19	57,[illegible]	17,21	0,76	[illegible],17	[illegible]	[illegible]	[illegible],7[illegible]	0,18	[illegible]
LS 60	1200°C	9,72	[illegible],53	13,[illegible]	0,[illegible]	1,[illegible]	[illegible],05	1,1[illegible]	0,[illegible]	[illegible]	[illegible]
LS 7	1270°C	12,3[illegible]	5[illegible],72	[illegible],79	0,[illegible]	1,21	[illegible],19	0,85	0,[illegible]7	[illegible]	[illegible],70
LS 12 = TS 7	1[illegible]°C	[illegible]	[illegible],21	[illegible]	1,[illegible]	[illegible],18	[illegible]	1,3[illegible]	0,75	[illegible]	[illegible]
LS 13 = TS 8	14[illegible]°C	[illegible]	5[illegible]	[illegible]	1,[illegible]	[illegible]	[illegible],45	1,[illegible]	0,[illegible]	,1[illegible]	[illegible]
LS 14 = TS 9	155[illegible]°C	[illegible]	57,[illegible]	[illegible],74	1,11	[illegible]	1,79	2,15	1,39	0,[illegible]	[illegible],69

Chemical composition | **Table No 7**

Makoro - Moralana weathered mudstones and laterite											
Sample No	Refractoriness	% L.o.I	% SiO_2	% Al_2O_3	% TiO_2	% Fe_2O_3	% CaO	% MgO	% K_2O	% Na_2O	% Total
TS 5 = LS 8	1530°C	10,26	57,02	22,93	0,98	5,19	0,67	1,32	2,11	0,77	100,55
TS 6 = LS 9	1420°C	12,45	53,76	20,56	0,91	4,80	3,89	1,34	1,98	0,08	99,71
TS 13 = LS 56	1380°C	10,99	54,80	21,74	0,89	4,85	3,66	1,44	1,94	0,09	100,41
LS 57	1200°C	18,31	44,63	15,63	0,72	2,77	12,58	4,19	1,54	0,11	100,48
TS 33 = LS 58	1510°C	10,15	61,20	21,01	1,13	0,83	3,33	1,16	1,03	0,08	99,92
LS 10	1450°C	6,40	76,30	10,08	0,60	2,17	2,55	0,76	0,98	0,07	99,91
LS 11	1490°C	5,27	73,14	9,58	0,55	2,52	0,89	0,80	1,13	0,05	99,93
LS 30	1620°C	10,57	58,42	25,74	1,32	1,12	1,21	0,69	0,72	0,19	99,89

Table No 8

Technological properties of Makoro clays		LS 5 =TS 3	LS 6 =TS 4	LS 12 =TS 7	LS 13 =TS 8	LS 14 =TS 9	TS 5 =LS 8	TS 6 =LS 9	TS 13 =LS 36	LS 57
Loss on drying	%	17,0	20,8	21,9	24,8	29,4	19,9	19,5	20,0	18,4
Waterabsorption after firing to temperature	1150°C	-	17,8	14,6	11,3	6,7	8,2	8,6	8,9	9,2
	1200°C	-	13,3	13,0	10,0	8,5	8,2	8,0	8,1	8,4
	1250°C	-	-	9,0	8,2	12,8	7,2	6,8	6,4	7,1
Wet-dry shrinkage	%	2,3	2,8	-	-	-	6,0	5,0	5,8	4,5
Dry-fired shrinkage after firing to temperature	1150°C	3,9	3,1	4,5	4,6	+0,3	8,2	9,8	9,4	7,6
	1200°C	6,2	4,2	5,3	4,7	+0,8	8,3	9,7	9,8	7,8
	1250°C	-	--	6,2	6,8	+2,1	8,8	9,8	9,2	7,9
Rest on the sieve 4900 cp/cm^2		-	-	-	-	-	14,10	18,37	19,64	32,7

admixture of morillonite and quartz, mica, organic matter, while the second sample contains 89 % of calcite.

The rest are then Fe-oxides /7%/ quartz, kaolinite and mica. Curves of the second part are in the diagrams No 15 /DTA/ and No 16 /X-ray analysis/.

The sample TS 4 is evaluated as montmorillonite with admixture of kaolinite, from non-clay minerals quartz /8%/, mica /4%/, Fe-oxides /3%/ and organic matter /4%/ are present. Corresponding diagrams are No 17 /DTA/ and No 18 /X-ray analysis/.

The diagrams No 19 /DTA/ and No 20 /X-ray analysis/ show that the sample TS 7 contains montmorillonite with ample admixture of kaolinite. Colour is light green. Quartz is present in the quantity of 20 %, Fe-oxides 4%, sericite 3%.

The curves of DTA in the diagram No 21 and X-ray analysis in the diagram No 22 show, that the sample TS 9 is mainly montmorillonite with very low admixture of kaolinite. From non-clay minerals quartz with 8%, Fe-oxides, organic matter and sericite are present.

The sample No TS 6 has its DTA in the diagram No 23 and X-ray analysis in the diagram No 24. It is composed from kaolinite with a very low admixture of montmorillonite. Content of quartz is 8%. Most mentioned raw materials can be used in ceramic industry for wall tiles, floor tiles, stoneware and similar. The details will be given in the following chapter of this report.

The sample No LS 30 can not be recommended, although the chemical analysis is good. The situation on the place, where the sample has been taken from, does not give the slightest guarantee, that the quality will be uniform and technologicaly suitable, because the clay is an outcrop of the mining site and besides, it is mixed with waste material.

4.4 Non-clay raw materials for ceramic industry

Non-clay raw materials were sampled from different places. The quality of these materials is variable, some of them would ask dusting and processing before using in ceramic industry.

4.4.1 Feldspars and feldspathic rocks

In the following table No. 9 the chemical analysis and refractoriness are given for samples No TS 18=LS 27, LS 36, LS 37, LS 38, LS 59 and LS 26=TS 17.

Table No 9

	TS18= LS27	LS36	LS37	LS38	LS59	TS17= LS26
Refractoriness °C	1340	1260	1170	1230	1130	1310
L.Dioi %	0,28	0,35	0,82	0,85	1,41	0,52
SiO_2 %	73,95	72,73	73,11	73,01	62,08	77,46
Al_2O_3 %	14,45	14,98	14,15	15,10	17,56	13,23
TiO_2 %	0,05	0,04	0,20	0,19	0,38	0,11
Fe_2O_3 %	0,12	0,24	1,50	1,26	3,57	0,25
CaO %	0,49	0,88	1,73	1,90	3,52	1,43
MgO %	0,28	0,20	0,67	0,47	1,94	0,71
K_2O %	7,40	7,30	3,40	3,10	2,95	2,71
Na_2O %	2,47	3,40	4,40	4,40	6,45	3,44
Total %	99,49	100,12	99,98	100,36	99,86	99,86

From the chemical analysis given in table No 9 it results that at first the samples TS18=LS27 and LS36 can be evaluated as feldspars suitable for using in ceramic industry and also for glazes. Other samples are not so clean, due to a higher content of Fe_2O_3 adjustment would be needed, however using as a flux material for coloured floortiles is very well possible. In the table No 10 chemical analyses and refractoriness of feldspathic rock samples are given.

Table No 10

		LS24	LS46= TS19	LS41	LS53
Refractoriness	°C	1190	1130	1340	1490
L.o I:	%	0,84	1,73	1,04	2,11
SiO_2	%	73,96	52,30	78,60	78,31
Al_2O_3	%	13,68	14,72	11,78	11,33
TiO_2	%	0,24	1,80	0,19	0,28
Fe_2O_3	%	1,57	12,61	1,65	2,63
CaO	%	1,43	8,80	0,66	0,49
MgO	%	0,63	4,50	0,28	0,55
K_2O	%	4,74	0,94	3,20	4,55
Na_2O	%	2,67	2,90	2,23	0,10
Total	%	99,76	100,31	99,63	100,35

Quality of these samples is variable, LS24 can be used in ceramic bodies for floor tiles, LS40=TS19 as a flux for production of facing bricks and facing strips, other two samples are not good quality raw materials if taken into account as fluxes for ceramic bodies.

4.4.2 Dolomites

The samples of dolomites were taken out and tested. From the following chemical analyses it stands to reason, that sample No LS48=T28a is dolomitic limestone, while sample No LS49=TS28b is dolomite with high content of SiO_2. All samples are due to a higher content of SiO_2, unsuitable for production of refractory goods, but probably can be used in ceramic industry for production of wall tiles.

Chemical analyses:

Sample No LS48=TS28a		Sample No LS49=TS28b
L.OI.	- 39,66	28,52
SiO_2	- 5,59	21,37
Al_2O_3	- 0,20	0,56
TiO_2	- 0,08	0,04
Fe_2O_3	- 0,23	0,70
CaO	- 48,15	24,67
MgO	- 6,47	24,43
K_2O	- 0,01	0,02
Na_2O	- 0,06	0,05
Total	-100,45	100,36

4.4.3 Talcum

The chemical analysis of sample LS50=TS29 shows this material as good quality talcum, usable for different purposes in ceramic and electroindustry. Talcum from the area, where it has been taken, is mined under mining licence in small quantity only.

Chemical analysis of talcum - sample LS50=TS29

	%
L.o.1.	5,10
SiO_2	61,85
Al_2O_3	0,50
TiO_2	0,03
Fe_2O_3	1,60
CaO	0,17
MgO	30,90
K_2O	0,02
Na_2O	0,02
	100,19

4.4.4 Kyanite

The samples of kyanite marked LS34 and LS35 were taken out in the surroundings of the old mining place.

The chemical analysis of kyanite sample:

	Sample No 34	Sample No 35
L.01.	- 0,80 %	1,25 %
SiO_2	- 65,64 %	61,41 %
Al_2O_3	- 32,70 %	33,29 %
TiO_2	- 0,36 %	1,42 %
Fe_2O_3	- 0,19 %	0,01 %
CaO	- 0,22 %	0,44 %
MgO	- 0,32 %	0,36 %
K_2O	- 0,03 %	1,40 %
Na_2O	- 0,04 %	0,47 %
Total	- 100,30 %	100,05 %

Refractoriness: sample No LS34=1 760 °C
" No LS35=1 720 °C

The content of kyanite is low, not suitable for ceramic industry.

4.4.5 Quartz

In the following table No 11 chemical analysis of quartz samples is given.

Table No 11

Sample No	L.oI. %	SiO_2 %	Al_2O_3 %	TiO_2 %	Fe_2O_3 %	CaO %	MgO %	K_2O %	Na_2O %		Total
LS 33	0,10	99,56	0,15	0,04	0,04	0,08	0,04	0,03	0,02		100,06
LS 25= TS 16	0,33	98,10	0,85	0,03	0,07	0,25	0,28	0,20	0,02		100,13

Both samples have refractoriness 1760°C. They may be used in glass industry and for production of porcelain.

Sandstone, sample LS58=TS33, from Makoro-Morolana area, which creates a background of mudstone beds can be used in ceramic bodies as non plastic material. Chemical composition is as follows: Loss on ignition - 10,15%, SiO_2 - 61,2 %, Al_2O_3-21,01%, TiO_2 + Fe_2O_3 - 1,96 %, CaO + MgO -4,49 %, K_2O + Na_2O-1,11 %.

4.4.6 Tailings /flux materials/

Waste products after dressing and processing of Cu - Ni ores were also sampled. From the chemical analysis a high content of Fe_2O_3 is striking. They may probably be used as flux component in the production of facing bricks or facing strips. Samples are marked LS18 a LS19.

4.5. Other raw materials for building industry

From this group of materials samples of marble, limestone (calcrete), diatomite earth, asbestos and gypsum were taken.

4.5.1 Diatomite earth

Under microscopic testing no diatom parts were found out. The sample LS55 will be probably silty clay.

Chemical analysis:

	%
L.OI.	21,16
SiO_2	43,71
Al_2O_3	5,70
Fe_2O_3	1,80
TiO_2	0,81
CaO	17,18
MgO	5,74

No special using is possible

4.5.2 Asbestos

The sample of asbestos LS54 was evaluated as chrysolitic halfsoft asbestos with high effectivity. The using of asbestos for different products is dependent on separating and dressing methods. The production of asbestos goods would be possible.

4.5.3 Gypsum

Two samples of gypsum were sampled and tested. Chemical analysis of samples 32 A and 32 B is given below.

	32 A %	32 B %
L.oI.	20,68	14,94
SiO_2	12,84	31,55
R_2O_3	4,00	3,84
CaO	28,98	21,83
SO_3	33,03	26,76

Both samples were tested by means of DTA, GTA and X-ray analysis. The content of $CuSO_4 \cdot 2H_2O$ is 66,9 % in sample 32 A and 54,5 % in sample 32 B. The content of quartz is high especially in sample No 32 B. For the best kinds of plaster of Paris the required quantity of $CuSO_4 \cdot 2H_2O$ in raw material should be 90 % minimally and for the worse kinds min. 75 %.

DTA curves for sample 32 A are shown in the diagram No 27, X-ray analysis in the diagram No 28. DTA curves of sample 32 B are in the diagram No 29, X-ray analysis in the diagram No 30. GTA curves of both samples shows the diagram No 31.

4.5.4 Limestone

From the Mookane area two samples of limestones were sampled LS20=TS14 and LS21=TS15. Chemical analysis shows the following results.

	LS20=TS14 %	LS21=TS15 %
L.o.I	33,77	36,82
SiO_2	21,95	15,87
R_2O_3	1,99	2,44
CaO	39,86	39,04
MgO	2,20	5,20
unsoluble rest /SiO_2/	9,50	7,70

Samples were tested by means of DTA, GTA and X-ray analysis. They were also fired at 900°C, 1000°C and 1100°C respectively. From all trials it results that tested raw materials are not suitable for the production of lime. It is of course possible to gain a lime, but special conditions are to be observed.

1) Firing temperature must not be higher than 1100°C

2) "Softly" fired lime can be hydrated, the product of hydratation should be valorized. It can be done by separation of calcium hydrate which of course will bring futher production costs. The consumption of energy will be higher and the technological equipment will be complicated.

Further two samples of limestones were taken from Makoro Hills - sample LS 22 and from Tonota - sample LS 23. Chemical analysis given bellow schow that at first sample LS 23 is a very pure limestone and that after firing a good quality lime can be gained.

Chemical analysis:

	LS 22	LS 23
L.o.I	42,70	43,24
SiO_2	1,23	0,43
Al_2O_3	0,31	0,20
TiO_2	0,04	0,04
Fe_2O_3	0,55	0,25
CaO	54,72	56,20
MgO	0,84	0,10
K_2O	0,05	0,03
Na_2O	0,11	0,13
Total	100,53	100,62

5. TECHNOLOGICAL EVALUTION OF BOTSWANAS RAW MATERIALS

Some of the raw materials sampled in Botswana were found usable for manufacture of different ceramic products.

5.1 Brickware

Brickware is noted for a coloured body which is sufficiently firm, porous, mostly non-glazed. These products are resistant against water, different chemical agents and weather and often also froststproof. They are basic and widely spread building materials.

For the production of these materials clays from the Gaborone deposit can be used. A series of laboratory tests has proved suitability of the yellow-brown clay /marked Y/ and the red-brown clay /marked R/ for the manufacture of different brickware.

5.1.1 Full bricks

For the manufacture of full bricks clay Y and R were used. Both clays are very sensitive to drying, a relatively high addition of non-plastic materials is necessary. A series of trials has been made with non-plastic materials found in Gaborone area and in the near vicinity. Following materials were tried:

a) coal ash /TS 26/ - waste product from Gaborone power-plant
b) laterite /TS 27/ - concomitant raw material in the mining place
c) dolerite /TS 19/ - powder waste material from the quarry /L.I.Whyle Gaborone/

From the clays Y and R and the mentioned non-plastic materials three bodies were prepared. Clays Y and R were mixed in the ratio 3:2 /from the laboratory trials this ratio was found as suitable, it corresponds also to the quantitative conditions in the Gaborone deposit/ and different parts of coal ash, laterite and dolerite were added. The weight of each mixture was 50 kg.

Composition and properties of products are given in the table No 12.

Table No 12

		G6-L	G6-CA	G6-CAL
Clay Y	part by weight	3	3	3
Clay R	"	2	2	2
dolerite	"	1	2	1
laterite	"	4	-	2
coal ash 15 mm	"	-	3	1
body moisture	%	16-18	16-18	16-18
dry-fired shrinkage	%	4,2	2,0	3,3
firing temperature	°C	1050 -1080	1050 -1080	1050 -1080
water absorption	%	10,5	17,7	16,0
compression strength	kp/cm^2	288	62	101

Prior to the processing of body, some of the raw materials are to be dressed. The lumps in the clays must be crushed down and coal ash is to be crushed to the grain size not exceeding 5 mm. Laterite and dolerite do not need any dressing.

Bricks are extruded by means of deairing pugmill.

In general it should be said, that Botswana's plastic raw materials and mixtures prepared with them are very sensitive to drying. Addition of non-plastic materials, their right choice and ratio are very important. The drying process must be very carefully controlled, forced wet-drying would be preferable to a natural one. If coal ash as non plastic material is used, compression strength of product decreases, nevertheless, the workability of body is good. In the table No 12 three products G6-L, G6-CA and G6-CAL are given.

The body G6-CAL is most siutable from the production point of view.

Czechoslovak standard CSN 722610 requires for full bricks compression strength min. 75 kp/cm and water absorption min 15 %.

5.1.2 Facing bricks

Facing bricks - brickware used for façades of buildings. The quality and above all appearence of these bricks are rather higher than those of full bricks. For a better effect, the bricks can be partly glazed. For this purpose ordinary earthen glaze is recommendable. Facing bricks and glazed facing strips may be a suitable supplementary product in the manufacture of full bricks. As a basic material the humic clay grey marked G /TS 25/ is considered. For the facing bricks body as a second component dolerite from Gaborone quarry is recommended. For diminishing drying sensitivity the addition of 10% crushed reject from facing bricks production will be suitable.

The technology is the same as in the case of full bricks. The dried products are on the front surface provided with earthen glaze. The glaze is applied by pressed air spraying. The ware is either fired with full bricks on the top layer, where the temperature is rather higher, or in separate chamber by the respective temperature.

In the following table No 13 composition and properties of facing bricks are given. Composition of the glaze A will be given in separate chapter. "Glazes".

Table No 13

		GD-6
clay grey - humic /G/	part by weight	5,5
dolerite	"	3,5
crushed rejects upto 5 mm	"	1
body moisture	%	16-18
wet-fired shrinkage	%	4-6
firing temperature	°C	1080 -1100
glaze	-	A
water absorption	%	6-8
compresion strength	kp/cm^2	400 -700
bulk density	kg/m^3	1900

5.1.3 Façade tiles

It can be a further supplementary product for brickware manufacture. The basic raw materials are clay grey-humic G /TS 25/, dolerite /TS 19/ and laterite /TS 27/ - maximum grain size of laterite should be 3 mm. The mixture was prepared on laboratory scale /20 kg/. Façade tiles were extruded on the laboratory deairing puggmill. Glaze is applied by spraying. Façade tiles were fired in the factory tunnel kiln to temperature 1080-1100°C. After a series of laboratory tests two bodies were finally prepared, the composition and properties of which are shown in the table No 14.

Table No 14

		GD	GD4
clay grey humic G	part by weight	6	6
dolerite	"	4	2
laterite upto 3 mm	"	-	2
body moisture	%	14-16	14-16
wet-fired shrinkage	%	5,8	5,0
firing temperature	°C	1080 -1100	1080 -1100
glaze		A	A
water absorption	%	8,7	11,2
bending strength	kp/cm^2	85	56

For this kind of product no standard is available, however, it may be stated that for the weather conditions of Botswana such type may be useful.

5.1.4 Facing bricks /pressed/ - based on the raw materials from Makoro and Mmamabula areas. In these areas very firm mudstones were found. After a series of 16 laboratory trials two bodies were suggested, the utilization of which may be for building industry or after increasing compression strength as industrial floor tiles non-glazed.

Raw materials were prepared in two fractions

1/ 0-6 mm

2/ 0-2 mm

Bricks were pressed on a friction screw press. Drying was not difficult. Dried pressed pieces were glazed by spraying with glazes 2A and 3A.

Composition and properties are shown in table No 15

Table No 15

		MAKORO FR 10	MWAMABULA FR 7
mudstone-assorted /TS10/ 0-6 mm	part by weight	4	-
" " /TS10/ 0-2 mm	"	1	-
grey-yellow mudstone /TS 9/ 0-2 mm	"	2	-
granitic rock /TS17/ <0,2 mm	"	2	-
dark mudstone /TS12/ 0-6 mm	"	-	5
" " /TS12/ 0-2 mm	"	-	2,5
granitic rock /TS 17/ < 0,2 mm	"	-	2,5
body moisture	%	14-15	14-15
wet-fired shrinkage	%	6,0	7,0
firing temperature	^{o}C	1230	1230
glaze	-	2A,3A	2A,3A
water absorption	%	8,4	10,9
compression strength	kp/cm^2	170	216

5.1.5 Full bricks - Training Centre Serowe

Near Serowe brown-red brick clay /TS 30/ was mined and by very simple technology utilized for manufacture of bricks fired in piles. The quality of bricks was very bad, therefore this production was stopped. We tried to solve this problem with following result:

- brick clay /TS30/ needs a high addition of non-plastic materials
- suitable non-plastic material is laterite
- even if higher addition of non-plastic material is added, certain problems with drying occured, forced drying would be recommendable, which, however, in the given condition is not feasible.

Laboratory tests showed, that only lower quality bricks may be produced, compression strength being 60-75 kp/cm^2, water absorption 15 - 18 %.

5.2 Stoneware products

Stoneware . product with water absorption max. 8 % /stoneware pipes max. 9%/. Stoneware products have a wide range of use in building industry /floor tiles, stoneware pipes/, in chemical industry /acid resistant products/ in agriculture, household and also for art purposes.

On the base of Botswana's raw materials, production of different kinds of stoneware was suggested and tried.

5.2.1 Stoneware façade tiles - glazed by earthen glaze

As basic raw materials weathered mudstones grey-brown /TS5 + TS6/, brown-green /TS13/ from Morolana area were used. Further raw materials are sandstone background /TS33/ and laterite /TS27/. Dolerite /TS19/ was also added for the required water absorption to be reached.

A series of laboratory trials proved that about 30-40% of non-plastic raw materials including fluxes must be added.

From the used raw materials sandstone must be milled to maximum grain size 3 mm and clays must be free from lumps. For clay milling also wheel pugmill can be used. The façade tiles were extruded on the vertical deairing pugmill. Drying brings practically no problems, although wet-dry shrinkage is 4-5 %.

Composition of the body and properties of products are shown in the table No 16

Table No 16

		MRL-SD	MRL-LD
clay grey-brown	%	35	30
clay brown-green	%	35	30
sandstone upto 3 mm	%	10	-
laterite upto 3 mm	%	-	20
dolerite	%	20	20
body moisture	%	14-16	14-16
wet-fired shrinkage	%	9,2	8,6
firing temperature	°C	1230	1230
glaze		2A,3A,4A	2A, 3A, 4A
water absorption	%	9,3	8,2
compressive strength	kp/cm^2	135	110

Glazes are applied by spraying. The suggested composition of glazes is given in chapter "Glazes".

5.2.2 Sewerage pipes

All kinds of these products are glazed, either by earthen glaze applied on dry pressed piece or by salt glaze. Glazing by salt NaCl is done in the firing cycle.

Due to a lack of raw materials only the limited number of trials has been done and the products were prepared in small dimensions only. The lumps in clays were crushed by means of pan mill and the rejects /stoneware grog/ were grained upto maximum grain size 4 mm. Body is prepared in a wheel pugmill. The pipes are extruded on the vertical dearing pugmill. Firing temperature makes 1230 °C. The manufacture of stoneware pipes and agricultural goods is not simple. Sufficient skill and production experience are required to obtain goods of standard quality.

Table No 17 shows compositions and properties of mentioned stoneware products.

Table No 17

		LD - G
clay grey-brown	%	20
clay brown-green	%	20
laterite	%	10
dolerite	%	20
rejects /grog/ upto 4 mm	%	30
body moisture	%	14 - 16
wet-fired shrinkage	%	7,0
firing temperature	°C	1230
glaze		3A
water absorption	%	9,2
bending strength	kp/cm^2	95
acid resistance	%	92,4

According to the Czechoslovak Standard Acid Resistance

The [illegible] should be achieved: AR minimum 90 %, water [illegible] The British Standard requires crushing strength [illegible] lbs per ft, water absorption is not specified.

5.2.3 Floor tiles

Non-glazed floor tiles is a higher standard product. Using of floor tiles in building industry is very wide. Raw materials are located in [illegible]-Morolana area. The basic materials are weathered mudstones, grey-brown /TS5 + TS6/, grey-yellow /TS8 + TS 9/ and sandstone background /TS 33/. Supplementary raw material is pegmatite /TS18/ as flux, for colouring of body laterite /TS27/ is used. If production of different colours of floor tiles is required, certain colouring components are added. Another possible way is based on the fact that if some natural raw materials are added, they give a colour to the product. After many laboratory trials three colour bodies for floor tiles were composed - red, yellow and grey. The colours are not so sharpy distinguished as if colouring admixtures are added, but are prepared exclusively from Botswana's raw materials.

The mentioned three bodies were prepared in 5 kg batches, raw materials were milled in wet ball mill; ratio raw materials: pebbles: water = 1:1, 5:1,2. After milling, rest on the sieve 0,09 mm /4.900 op/cm^2/ showed not to be higher than 2 %. The slurry gained in this way is dewatered and milled to the maximum grain size 2 mm. Floor tiles are pressed on the laboratory hydraulic press and properly dried. Clay grey-yellow /TS8 + TS9/ has high wet-dried shrinkage and requires carefull drying.

In the table No 18 composition and properties of floor tiles are given.

Table No 18

		RED 1/1	YELLOW 5	GREY 10/1
clay grey-brown /TS5+6/	%	70	30	-
" grey-yellow /TS8+9/	%	-	35	40
sandstone /TS33/	%	-	25	55
pegmatite /TS18/	%	10	10	5
laterite /TS27/	%	20	-	-
rest on the sieve 0,09 mm	%	2,1	1,8	1,5
moisture before pressing	%	6-7	6-7	6-7
wet-find shrinkage	%	1,8	2,0	2,2
firing temperature	^{o}C	1230	1230	1230
water absorption	%	4,8	2,1	1,8
bending strength	kp/cm^2	164	170	160
acid resistance	%	98,9	98,4	95,2

Czechoslovak standard CSN 724820 has following requirements:

water absorption - red and grey floor tiles max 4,0 %
yellow floor tiles max 4,5 %

bending strength - min. 120 kp/cm^2
acid resistance - min. 92 %

The British Standard requires water absorption 0,3-5,0 % bending strength 250 kp/cm^2, individual 200 kp/cm^2.

5.3.1 Wall tiles

Wall tiles are porous products, with white or yellowish body, glazed surface, used for wall tiling in households, hospitals and many other buildings. Technology of wall tiles is rather intricate, at first non-glazed product, the so called bis-quit is fired. Then after glazing and second firing final product - glazed wall tiles, is gained.

In the laboratory 12 trials were made with raw materials from Makoro-Morolana area - mudstone grey /TS3 + TS4/, sandstone background /TS33/ and as flux pegmatite /TS18/ from Selebi-Pikwe area was used. Other part of trials was based on Mmamabula raw materials - mudstone light /TS11/, calcrete from deposit near Mokane /LS 20, LS 21/.

Working body was prepared by wet milling in ball mill - ratio raw materials: pebbles: water = 1:1, 5:1,2. Rest on the sieve 0,09 /4.900 op/cm^2/after milling should be very low, max. 0,7 %. The gained slurry is dewatered to the pressing moisture 5,5 - 6,5 %. Wall tiles in dimensions 150x150 mm were pressed on a friction press /60 tons/, dried in laboratory dryer and bisquit fired in industrial kiln to temperature 1060 °C. For glazing, production types of glazes were used. Glost firing was done to temperature 1020-1040 °C. The table No 19 shows composition and properties of wall tiles.

Table No 19

		MAKORO MR2	MMAMABULA MM1/3
mudstone grey MR	%	20	-
" dark MR	%	20	-
mudstone light MM	%	-	70
sandstone background	%	40	-
calcrete	%	-	15
pegmatite	%	10	5
crushed rejects /bisquit/	%	10	10
rest on the sieve 0,09mm	%	0,5	0,3
moisture before pressing	%	6,2	6,0
wet-fired shrinkage	%	1,5	1,0
firing temperature bisquit	^{o}C	1060	1060
" temperature glazed wall tiles	^{o}C	1020 -1040	1020 -1040
water absorption	%	28,5	30,2
bending strength	kp/cm^2	137	82
Harkort test white + coloured	^{o}C	>175	> 200

Chemical composition:

		MR 2	MM1/3
SiO_2	%	66,78	63,80
Al_2O_3	%	19,32	20,63
Fe_2O_3	%	1,50	1,20
TiO_2	%	0,95	1,06
MgO	%	1,03	1,65
CaO	%	5,04	10,15
Na_2O	%	0,35	0,23
K_2O	%	4,85	1,23
Total	%	99,82	99,95

To the reached quality of wall tiles it should be said that in the laboratory kiln biscuit was fired to the temperature 1080-1100°C and water absorption was 20-22 %. Unfortunately in the industrial kiln the firing was done to lower temperature, thus getting higher water absorption.

Used glazes were of Czechoslovak production made in "Glazura" Roudnice. Production of fritted glasses and glazes is not easy, in any case it is better to start with glazes from known producers such as:

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., Pitsburg, USA.

5.4.1 Refractory products

Refractory products must withstand the temperature of minimum 26 SK and are used for building of different furnaces and kilns in the metallurgical industry as well as in cement, glass and ceramic industry. Many different qualities are known and used in the world.

In the following table No 20 some standards are given.

Table No 20

	GREAT BRITAIN	Czechoslovakia CSN 72 61 06		
	BS1758:61 Grade 3	SI	SII	SIII
P.C.E SK	33	33/34	32/33	31/32
Al_2O_3 content %	-	min.40	min.37	min.35
Fe_2O_3 " %	-	< 2,4	<2,8	<3,5
waterabsorption %	-	< 10	<13	<16
Refractoriness under load °C	1520 /5%/	1410 /0,3%/	1370	1330
compression strength	105	min. 100 kp/cm²	min. 100 kp/cm²	
spec. gravity g/cm³	-	min.2,00	min1,9	1,8

From the characteristics of raw materials available in Botswana it is difficult to prepere refractory products of average quality. From mudstone dark /TS12/ a grog was prepared by firing to 1350 °C. Water absorption reached is 12,5 %. As a binding material mudstone dark and mudstone yellow were used.

Table No 21 brings composition and properties of tried firebricks.

Table No 21

		MM1	MM2
mudstone dark-grog 0-3 mm	%	40	50
mudstone dark 0-2 mm	%	40	30
mudstone grey-yellow 0-2 mm	%	20	20
body moisture	%	15,0	14,3
wet-fired shrinkage	°C	3,8	3,2
Al_2O_3 content	%	33,2	33,5
Fe_2O_3 content	%	1,65	1,59
refractoriness	°C	1630	1640
compression strength	kp/cm^2	120	75
refractoriness under load	°C	1350	1310
water absorption	%	15,3	18,7

The main problem is in the fact that no good quality binding clay with sufficient refractoriness is available.

5.5.1 Glazes

The glaze is a thin, hard and usually glossy layer of specific kind of glass, melted on the ceramic body surface, which becomes intransparent , mechanically more firm, more resistant against abrasion and against chemical substances. Each glaze also enhences aesthetic appearence of product. Glaze must correspond to the physical and chemical properties of the body, to the different firing temperatures and firing conditions. There is an enormous number of different glazes compositions, which are a result of combinations of different basic raw materials. If the glaze is prepared from the materials soluble in water, it is necessary to change them in insoluble glass through melting with other components. Such glazes are known as fritted glaze or fritted glass.

For glazing some products mentioned in preceding chapters several kinds of glazes have been developed and tried, substantially the earthen ones. The Botswana's raw materials were used. These glazes are not usable for wall tiles.

Glaze for firing temperature 1080-1100 °C

Using: 1/ Facing strips /chapter 5.1.3/
2/ Facing bricks

Colour of glaze is brown, glossy. The glaze is marked "A". In the glaze "A" composition, a transparent fritted glass 205 from Czechoslovakia has been used.

Composition of glaze "A"

transparent fritted glass 250	50 %
dolerite /TS 19/	40 %
mudstone grey-yellow MR /TS 9/	10 %

Fritted glass 250 is produced in CSSR by the firma Glazura.

Glazes for firing temperature 1230°C /1250°C/

Use: 1/ Facing bricks - with basic raw material mudstone /TS10 and TS12/
2/ Stoneware facade tiles
3/ Severage pipes and agricultural stoneware

Glaze "2A" is black, semidull
Glaze "3A" is grey-brown, semidull
Glaze "4A" is red-brown, semidull

Preparation of glazes is not so difficult. All components are milled in wet ball mill till the rest on the sieve 0,06 mm e. g. 10.000 op/cm^2 is less than 3 %.

Composition of glazes 2A, 3A, 4A

	2A	3A	4A
transparent fritted glass 205	20 %	-	-
dolerite /TS19/	40 %	-	45%
pegmatite /LS36/	30 %	45 %	45%
mudstone grey-yellow ME /TS9/	10 %	10 %	10%
syenite /LS59/	-	45 %	-

All glazes were applied by spraying with pressed air.

5.6 Limestone based products

The most important product prepared from limestone is lime. The lime is gained from limestone through firing by temperatures 1000 - 1200 °C. Limestones from Mookane area / LS 20 = TS 14 and LS 21 = TS 15/ were in the laboratory fired by different temperatures /900 °C, 1000 °C and 1100 °C respectively /. The results of testing were not satisfactory; in both cases lime was gained, but with technological difficulties and with high production costs. More detailed information are available in "Report of physical and chemical tests of Botswana's limestones" included in Annexes page 1 - 18.

Limestones marked LS 22 and LS 23 were fired at temperature 1000 °C and by the way gained limes were hydrated.

Lime from sample LS 22 had after firing brown colour, what was not expected. Brown colour did not change even after hydratation. Due to a brown colour and SiO_2 content which is higher than 2 % can be evaluated as average product only.

On the other side, limestone marked LS 23 gives after firing lime of white colour, with low content of SiO_2, and its hydratation is very good. This lime can be evaluated as a first quality lime.

5.7 Gypsum-made products

The semiproduct plaster of Paris is used for plastering, casting moulds and cases in different industries and for partitions in building industry. Gypsum itself can be applied in cement production as one component in quantity of about 5 %. The perforemed tests have indicated that the found gypsum of the Mashaeiwa deposit can be used for cement industry only.

5.8 Cement-asbestos products

These products could be technically manufactured in Botswana with regard to the good quality of tested asbestos. However, the prospection carried out by the lease holders, Asbestos investments Ltd., in the Moshaneng area has not yet discovered sufficient reserves worth mining and milling. A similar situation is on the Keng Pan deposit.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 The manufacture of brickware from the raw materials deposited near the Gaborone Dam is technically feasible. The erection of a brick plant, which is supposed to satisfy present needs of industrially made bricks in the country, is already under preparation in Gaborone. Consequently the assignment of the team of the Institute for Ceramics, Refractories and Raw Materials consist in this case in submitting results on brickware supplements - partly glazed facing bricks, facade tiles and pressed facing bricks if need be - for potential extention of production programme proposed in the layout plan of the brick plant.

6.2 The manufacture of stoneware - façade tiles, severage pipes and floor tiles - of a satisfactory quality is technically feasible. Most raw materials are available in the Moralana deposit. Waste dolerite from Gaborone could be used as a flux.

6.3 The manufacture of wall tiles of satisfactory quality is technically feasible. Suitable mudstones and sandstone for the production are available in the Makoro-Moralana deposit. The body composition contains also pegmatite from Selebi Pikwe, the reserves of which should have to be verified. Glazes are supposed to be imported in the first years of production. Wall tiles can be also successfully produced with light silty mudstone of Mmamabula and calcrete Mokane.

6.4 Refractory products based on raw materials found till now in Botswana are of insufficient quality.

6.5 Glazes on facing bricks and façade tiles as well as on stoneware façade tiles were made from dolerite, syenite and pegmatite available in the country. For wall tiles Czechoslovak glazes were used.

6.6 Cement-asbestos products could be technically manufactured in Botswana with regard to the good quality of tested asbestos. However, the prospection carried out by the lease holders, Asbestos Investments Ltd., in the Moshaneng area has not yet discovered sufficient reserves worth mining and milling. A similar situation is on the Keng Pan deposit.

6.7 Gypsum-based products

The semiproduct plaster of Paris is used for plastering, casting moulds and cases in different industries and for partitions in building industry. Gypsum itself can be applied in cement production as one component in quantity of about 5%. The performed tests have indicated that the found gypsum of the Mashaeiwa deposit can be used for cement manufacture only.

6.8 Limestone-based products

Large deposits of Mookane calcrete appeared to be unsuitable for the manufacture of quick lime in consequence of their high silica content /see Annexe - Report on physical and chemical tests of Botswana's limestones/. On the other hand, this material was successfully applied in wall tiles /see preceding para 1.3/.

Marbles of Makoro Hills and Tonota could give qick lime of good quality, but these deposits have not yet been prospected. The investigation of demands for quick lime will be carried out in the Market Study, which should indicate whether industrial production of quick lime would be recommendable.

As far as marble tiles and marble plates are concerned, none of the found raw materials was suitable.

The team did not look for limestones for cement production as a feasibility study for establishment of cement industry in Botswana is being prepared by die Deutsche Gesellschaft für technische Zusammenarbeit, GMBH. The marble deposit Mmadinare 25 km northwest of Selebi Pikwe contains allegedly up to 50 % CaO, under 3 % MgO and is suitable for cement production. Also the reserves estimated on special prospection are sufficient.

6.9 Scope of Market Study

With regard to preceding results the Market Study should comprise the following products:

- stoneware façade tiles
- sewerage pipes
- floor tiles
- wall tiles
- cement- asbestos products
- quick lime

7. FIELD ACTIVITY

The experts

Ing. Jan Dřevo, team leader (economist)
Ing. Miroslav Stockert, technologist and market specialist

left Czechoslovakia for Botswana on 21 May to fulfill the assignments in the field.

Duration of the trip: 21. 5. 1977 - 25. 6. 1977

Public institutions, commercial firms and persons contacted are listed in the Annexe.

The course of the trip

22. 5. The experts arrived at the Lusaka Airport on Sunday, 22 May, at 11.55 EET.

23.-27. 5. On the first working day the experts called on the Regional UNDP Office where they were provided by a covering letter for contact with local authorities and commercial firms. At the same time UNDP Office requested UNDP Resident Representative in Gaborone to arrange for visas for the experts on their arrival at Gaborone.
During the week persons listed in the annexe were interviewed about local production in Zambia of clay-based and ceramic products as well as building materials; their opinions on potential future imports of those products from Botswana were examined.

28. 5. The experts left Lusaka for Botswana at 13.45. With regard to the hot frontier between Zambia and Rhodesia the route of the flight was diverted and the arrival to Gaborone took place at 18.30.

29. 5. Free day

30. 5.-11. 6. At the opening of the field work in Botswana the experts were received by Mr. O. Swenevik, UNDP Resident Representaive. Mr.Eruwayo, Deputy Resident Representative was arranging during the experts' stay in Botswana their contact with the Ministry of Commerce and Industry and contacts with UNDP offices in further countries.

After the reception at the UNDP Office a meeting at the Ministry of Commerce attended by Mr. Bareki, Mr. Esche, Mr. Setswayelo, Mr. Mogopodi, Mr. Cau, Mr. Eruwayo and both experts was held. Mr. Setswayelo was appointed guide of the experts and was arranging during their stay contacts with governmental authorities, public institutions and private firms (see the Annexe).

At this occasion Mr. Stockert submitted samples of products manufactured in Czechoslovakia from Botswana's raw materials:

- brickware - partly glazed facing bricks
- glazed façade tiles
- stoneware - façade tiles and floor tiles
- wall tiles,
- refractory products.

The samples were deposited in custody of Mr. Cau.

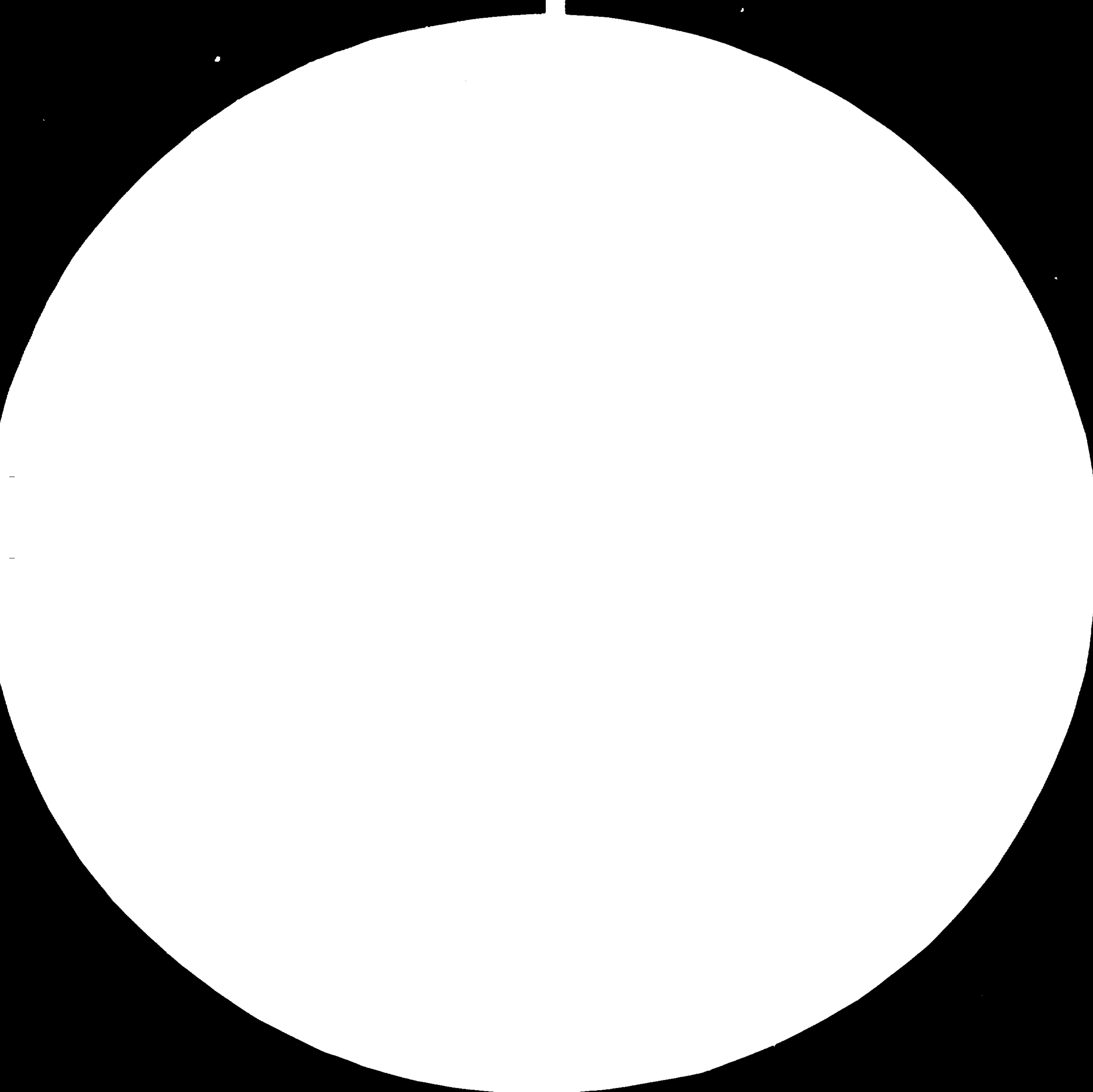
12. - 15. 6. The experts left on 12 June for Johannesburg where they spent night in the transit hotel being not provided with visas for South Africa, and left in the morning for Lesotho. In the capital Maseru they were received by Mr. F. W. von Mallincrodt, UNDP Resident Representative. The working programme was prepared by Mr. Yücer, Programme Officer. Mr. Wm. Buchanan, UNIDO Consultant for development of brick industry agreed to be guide of the experts for the three days and was very helpful in getting informations about the local market.

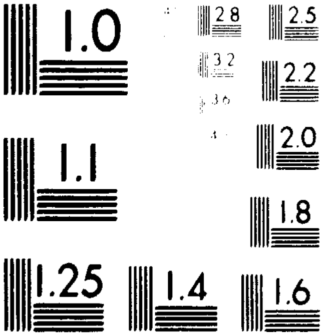
16. - 17. 6. On 16 May in the morning the experts undertook a flight by a charter from Maseru to the Matsapa Airport in Swaziland and went on by car to the capital Mbabane. They were received by Mr. S. S. Hussein, UNDP Resident Representative. The working programme was prepared by Mr. T. Van Gaallen, Programme Officer. The visited institutions and firms are listed in the Annexe.
On 17 June in the evening the experts went by air to Johannesburg and returned to Botswana (Gaborone) next day in the morning.

16. 6. Free day

20. - 22. 6. The experts were collecting further information promissed to them before departure to Southern Africa. Next day they visited the Geological Survey at Lobatse, where the proposal of recommendations concerning this Institute was discussed.
On 22 June the final meeting in the Ministry of Commerce and Industry was convened. The session was presided by Mr. Barcki and attended by Mr. Esche, Mr. Mogopodi, Mr. Cau, Mr. Gregor, Mr. Setswayelo, Mr. Dřevo and Mr. Stockert. The experts informed the participants about preliminary results of the mission and answered questions.

23. - 25. 6 On 23 June the experts boarded for return flight. At 9.45 they left Gaborone and arrived at Lusaka at 16.00 from where they left at 21.30 for Frankfurt where they landed at 7.30 on 24 June. They reached Prague next day in the morning.





MICROCOPY RESOLUTION TEST CHART

8. MARKET STUDY

8.1 Introduction

The market study should submit the results of market investigation related to the products and materials recommended in the conclusions of Phase A of this report (page 88,para 7.9), namely

- stoneware façade tiles
- sewerage pipes
- floor tiles
- wall tiles
- cement - asbestos products
- quick lime

The conclusions of the market study should indicate products and materials that can be produced and sold in Botswana; besides,this ware should be also marketable in adjacent countries if local market is not large enough to secure economic production. The market of the above products and materials is closely connected with building and construction industry and is an integrated part of the national economy characterized by the following indications.

Note: Costs and prices are based on rate of exchange valid in June 1977 in Gaborone

1 Pula = 1.0434 Rand (SA, Lesotho, Swaziland)
1 Pula = 0.9530 Kwacha
1 Pula = 1.2000 US Dollars
1 Pula = 2.8230 German Marks
1 Pula = 0.6986 Lstg
Imports before 1977 are priced 1 Pula = 1 Rand

Table 22:

Gross Domestic Product and Population

	1976/1977	Estimate 1980/1981
Gross Domestic Prod.	299 m Pula	431 m Pula
GDP per head	400 Pula	500 Pula
Population	748 000 inh.	863 000 inh.
Total labour force	373 000 inh.	434 000 inh.
Not in formal employment	261 000 inh.	307 000 inh.
In formal employment	66 000 inh.	81 000 inh.
Working abroad	46 000 inh.	46 000 inh.

The table shows a relatively high anticipated growth of Gross Domestic Product, which, however, is not sufficcient to diminish high unemployment.

Table 23:

Projected Growth of Gross Domestic Product in Sectors

P million

Sector	1976/77	1980/81
Agriculture	75,8	89,3
Mining	36,7	93,3
Manufacturing	16,2	27,0
Water and electricity	7,7	9,6
Construction	18,1	23,8
Trade, hotels	64,2	79,0
Transport and communications services	9,1	13,-
Finance, Insurance Bussiness Real Estate	24,3	33,-
Community and Personal Services	15,1	20,2
General Government	31,5	43,2
Total	298,7	431,4

Mining, manufacturing, water and electricity and construction sectors are of interest in connection with Market Study. The mining sector comprises diamonds (73 %), nickel-copper (14 %), prospecting, quarrying, coal, etc. (13 %). Manufacturing includes food industry (72 %) and other manufacturing industries (28 %). Water (29 %) and electricity (71 %) is represented predominantly by public utilities. The Construction sector consists of building and civil engineering by companies and Ministry of Works. The absolute value of the GDP of this sector should rise from 21 million Pula in 1973/74 to 24 million Pula in 1980/81.

Table 24:

Imports of Goods by End Use
(P million)

	1976/77	1980/81
Intermediate	83.5	100.0
Capital formation	20.0	4.9
Consumption	82.2	109.7
Total	185.7	214.6

The low value of capital formation in 1980/81 means that investement in mineral industry in planned period will be finished prior to this year.

Table 25:

Exports of Goods by Broad Groups
(P million)

	1976/77	1980/81
Meat and meat products	37.4	52.1
Nickel-copper	44.0	66.6
Diamonds	31.5	73.2
Other (incl. re-exports)	17.0	24.9
	12[illegible].9	216.8

In the year 1976/1977 imports substancially exceed imports. However, in 1980/1981 imports and exports will nearly balance. It implies extraordinary export achievement especially in the nickel-copper and diamond industry.

8.2 Development programmes

The National Development Programme includes projects concerning all spheres of economy. As far as minerals are concerned large projects for diamonds, and copper-nickel have been prepared and implemented. In the last planning period (1971-1976) studies on development of building industry were prepared and investigation of possibilites to exploit local materials were recommended. In this connection a preliminary study of potential establishment of cement industry and a feasibility study of clay bricks were elaborated. In the present planning period (1976/77-1980/81) the project of a brickfactory was prepared and the plant has been erected in Gaborone. A project for a cement plant is under preparation. A further item in the development programme is clay products. With this theme the presented study is mainly concerned.

8.3 Method of assessing market requirements and trends of production

Raw materials and ceramic products are widely spread in most countries and the first criterion for establishing these industries is as a rule expressed by the requirement to satisfy the needs of local market and to reduce imports. If local market is not large enough for a certain production to be run economically, markets of adjacent countries are taken into account where either raw materials for a certain product do not yet occur, or the relevant industry has not yet been developed, or cannot be run economically. Therefore the statistics of imports are one of the important sources of information. Unfortunately their reliability varies in different countries. Besides, the statistical items cannot be specified deep enough e. g. under the item bricks there are normal bricks, facing bricks and other brick products in total quantity and total value. Besides, in some statistics quantities are lacking or are allegedly unreliable. The evaluation of statistical data for derivation of future trends is in these years of economic depression also very problematic.

For these reason the following procedure was adopted:

- Accept as basis of investigation products and materials recommended in technical conclusions (page 89, para 7.9)
- Submit and comment import statistics where available
- Exclude products and materials the consumption of which is insignificant in Botswana
- Contact main importers as the most reliable source of information on imported specific products and prices
- Assess cautiously future consumption in the year 1981 after consultation with planning authorities, architects and contractors
- Extend the recommendations of production programmes by proposing versification of existing production, experimental production or small scale production of products, where the introduction on Botswana's market would be desirable and profitable.

8.4 Botswana's market

8.4.1 Existing production, imports, assessment of future market requirements

None of the investigated products is produced in Botswana. Statistical data on import are indicated in the following table.

Table 26

Imports c.i.f. Botswana's border

Commodity Code number Unit		Year	Quantity	Value Pula
Unglazed ceramic setts flags and tiles 69.07	m^2	1974 1975 1976	NA 17 116 NA	85 226 34 251 49 832
Glazed ceramic setts flags and tiles 69.08	m^2	1974 1975 1976	NA 17 321 NA	23 552 75 824 68 320
Piping, conduits and guttering 69.06	kg	1974 1975 1976	NA 40 891 NA	22 852 18 188 26 584
Articles of asbestos, cement of cellulose fibre-cement and the like 68.12	kg	1974 1975 1976	NA 1 345 [illegible] NA	212 171 466 799 NA
Quick lime, slaked lime and hydraulic lime, other than calcium oxide and hydroxide 25.22	kg	1974 1975 1976	NA NA NA	155 430 219 142 NA

The investigated products are included under the above code numbers:

Stoneware facade tiles are supposed to be included under the code number [illegible] if unglazed and under the code number 69.08 if glazed.
Severage pipes are included under the code number 69.06.
Floor tiles are included under the code number 69.07 as only unglazed floor tiles are imported.
Wall tiles are under the number 69.08.
Cement asbestos products are under the code number 68.12.

The values for the years 1974 and 1975 in the table were taken from External Trade Statistics 1975, the values for 1976 from the not yet published statistics. Quantities in this publication are not indicated.
Mr. Stockert tried to complete quantities from the tabulations of Customs and Excise which, however, appeared to be unreliable for code numbers 69.07 and 69.08. Besides, the quantities and values of aggregated items do not give any picture on imports of particular products.

Estimates of imports (1976) by local importers

Stoneware façade tiles

Stoneware façade tiles and mozaics are materials suitable for Botswana's conditions. Because of their high price they are imported only exceptionally for outer walling of public buildings. Regular imports do not exist.
Manufacturing stoneware facade tiles for non-existing market cannot be recommended. They could be produced only in combination with other saleable products.

Severage pipes (ceramic)

Only 20 - 30 ton are imported for year especially for aggressive sewage. Otherwise asbestos - cement pipes prevail and vinyl type pipes for conduits inside houses are applied. The consumption of ceramic sewer pipes is not supposed to rise in future. The proportion of ceramic severage pipes compared to asbestos-cement a vinyl type sewer pipes is not supposed to increase and local manufacture is not recommended.

Wall tiles

Average present imports of glazed ceramic wall tiles are estimated as 17 000 m^2 per year. Imported wall tiles are mainly

of commercial quality. Only smaller quantities are sold in high grade quality.
In 1981 the consumption is supposed to rise to 20 000 m^2. This quantity is insufficient for an industrial plant. Industrial production can be recommended if exports are sufficient.

Cement-asbestos products

About 500 t of water piping, 400 t of sewer piping and 500 t of roof sheets, slabs and other building parts are yearly imported. These quantities may increase by 15 % by the year 1981.

Quick lime

4 000 t of powdered quick lime are estimated to be imported per year. Quick lime is used for painting and flushing. In the country limestone is burnt in some places in small kilns and quick lime used for mortars.
The abstention from use of lime mortars in commercial construction is explained by easier handling with cement. Architects and some contractors, however, object that walls built with cement mortars are cracking in the dry and warm climate and are of the opinion that home-burnt quick lime at acceptable price would sell.
Small scale production is recommendable.

Brickware facing tiles and facing bricks

The investigation of brickware products was not carried out in the market study as a brickware project for the brick plant producing 4,500,000 bricks per year was prepared by Ingenjörsfirma L. Svärd AB.
Neverthless, samples of clays for bricks were verified in phase A, in agreement with Geological Survey and samples of facing bricks and facing tiles were produced which could contribute to versification of the planned production. The extent of this additional manufacture will depend on technical conditions of the brick plant and on absorption capacity of the market.

8.4.2 Prices of ceramic products and building materials

Nearly all investigated ceramic products and building materials are supplied from the Republic of South Africa (RSA). Botswana, RSA, Lesotho and Swaziland are associated in the Customs Union. Consequently Botswana does not impose duty on goods produced in RSA or any other member of Customs Union. Exceptionally the member states can apply duties on imports from the Customs Union to protect infant industries up to 8 years. The goods imported from countries outside the Common Customs Area is of course subjected to duty.

Building and ceramic materials are purchased either directly from factories in RSA or from wholesale merchants. For quantities currently sold to Botswana there are not great price differences between these two sellers, as factories are not anxious to compete with wholesale merchants who are their clients.

Average landed cost of products and materials based on average prices in RSA + transport + insurance (for fragile products only) is listed in the table 27.

It should be said that landed cost is the base on which the wholesale price is calculated. The wholesale margin includes transport cost from railway station, handling, stocking and sales expenses and profit. The margin fluctuates between 12 - 18 % for different products.
The landed cost, however, is an important characteristic which must be taken into accout in setting out price limits for products of industries to be established.

Table 27

Item	Unit	Price RSA	Transport cost	Insurance	Landed cost Botswana	
		Rand	Rand	Rand	Rand	Pula
Stoneware façade tiles	m^2					
Stoneware sewer pipes (200 mm)	r.m.	3.00	0.70	-	3.70	3.50
Ceramic floor tiles	m^2	20.40	0.60	-	21.00	19.87
Quarry tiles (flooring)	m^2	4.88	0.90	-	5.78	5.47
White wall tiles	m^2	4.29	0.32	0.11	4.72	4.47
Coloured wall tiles (uni colours)	m^2	7.88	0.32	0.20	8.40	7.95
Cement asbestos products:						
sewer pipes (200 mm)	r.m.	4.00	0.50	-	4.50	4.26
water pressure pipes (200 mm)	r.m.	7.50	0.50	-	8.00	7.57
sheets	m^2	1.65	0.35	-	2.00	1.89
Quick lime	t	55.50	4.50	-	60.00	56.76
Cement	t	30.20	3.80	-	34.00	32.18
Facing bricks	1000pcs	40.00-100.00	20.00	-	60.00-120.00	57.00-114.00
Stock bricks	1000pcs	34.00-47.00	20.00	-	54.00-67.00	51.00-63.00

8.5 Markets in countries of Common Customs Area and Zambia

The following review of Trade 1973 - 1975 shows, that import from C.C.A. countries has grown from 69,3 % in 1973 upto 79,8 % in 1975. The main part of imported goods is of SouthAfrican origin.

Botswana's export to the C.C.A. countries is substantially lower than corresponding import. The main customer for Botswana's goods is United Kingdom which participates by more than 40 % in Botswana's export.

The Direction of Botswana's trade 1973 - 1975 is shown in the following table.

Table 28

(all values in 000's Rand)

Area	1973		1974		1975	
	Imports	Exports	Imports	Exports	Imports	Exports
C.C.A.	79 530	11 071	94 393	30 771	27 109	24 772
Other Africa	12 438	4 338	17 265	3 436	20 310	4 704
U. K.	6 358	40 154	4 324	35 450	3 875	49 727
Other Europe	2 214	3 013	2 498	3 200	3 404	2 816
U. S. A.	12 564	33	5 064	8 617	3 831	22 644
Rest of World	1 860	591	1 874	516	759	1 007
Total	114 964	59 200	125 418	81 990	159 288	105 040

From the adjacent countries except C.C.A. Zambia is the most potential customer for Botswana's goods. The mutual trade is still insufficiently developed.

In the part 8.4.1 manufacture of wall tiles and quick lime was recommended. In the first case, however, local consumption is insufficient to start industrial production, therefore potential imports to adjacent countries must be examined. As far as the other products and materials are concerned, general situation in imports and local production in respective countries should be caracterized.

..5.1 Republic of South Africa

Industry of building and ceramic materials is very well developed in the Republic of South Africa, nevertheless, data from External Trade Statistics show, that certain quantity of ceramic materials, namely wall tiles and mosaics (of exceptional quality and décors) are imported.

Data regarding wall tiles and mosaics import are shown in the following table:

Table 29

Commodity code number unit	Year	Quantity	FOB price Rand	Rand per m^2
wall tiles 69.08.40 m^2	1974	1,596.343	3,678.248	2,30
	1975	712.150	2,502.617	3,51
	Jan-May 1976+	291.861	902.345	3,08
Mosaics glazed 69.08.10 m^2	1974	161.049	334.684	2,08
	1975	39.571	151.519	3,83

+For the year 1976 the statistical data were available until May only.

In imports of wall tiles to the Republic of South Africa many countries participate. All prices are quoted FOB country of origin. Differences are due different qualities and designs.

Table 30

All values in Rand per m^2

Exporting country		UNITED KINGDOM	WEST GERMANY	SPAIN	ITALY	BRASIL	JAPAN
FOB	1974	2,30	4,41	2,82	4,66	2,97	2,64
prices	1975	2,38	5,44	1,17	3,37	1,82	2,91

The indications in these tables refer to FOB prices to which freight and insurance must be added to receive CIF price and port dues + duty to obtain landed cost. Then further costs and wholesale margin are added and the wholesale price is calculated:

Average price FOB ports of exporting countries (1975)	3.51
freight	0.93
insurance	0.145
CIF price SA ports	4.59
duty 20 %	0.92
warfage and handling 3 %	0.14
landed cost RSA ports	5.65
average railway transport and handling in RSA	0.47

landed Cost Johannesburg	6.12
15 % wholesale margin	0.92
Wholesale price Johannesburg	7.04

The price calculation is demonstrated on the average price of imported wall tiles the year 1975.

Ceramic factories in the Republic of South Africa (Johnson Tiles, Pilkington's Tiles, Cerama, National Ceramic Industries) manufacture very wide assortment of wall tiles, mosaics, floor tiles and other products. Import is mainly concerned with exclusive wall tiles, mosaics etc., according to the requirements of customers. From 1975 import dropped to the half quantity compared with 1974. The level of 1976 will be approximately the same (extrapolated from import values for January - May). The decrease of import is caused partly by the fact that a new factory started production partly owing to recess in building industry.

South African producers are able to safisfy local demands as well as requirements of Lesotho, Swaziland, Botswana and other countries in standard wall tiles. The 700 000 m^2 of yearly imported wall tiles from U. K., West Germany, Spain, Italy, Brasil und Japan are, as said before, special déoors and designs. On interviewing South African contractors in Lesotho and Swaziland the experts came to the conclusion that 10 % of these imports i. e. 70 000 m^2 could be replaced by imports from Botswana under the condition that

a) deliveries of wall tiles would be in coloured décors, with application of local and rural motives, partly manually applied,
b) prices of deliveries would be competitive with prices of imported products,
c) deliveries in minimum quantities of 2000 m^2 on special demand would be possible (at higher prices).

The other ceramic industries as that of facade tiles and severage pipes are sufficiently developed to cover the demands of local market. The manufacture of floor tiles and mozaics is being developed and is therefore protected by a high duty (25 % + 290 c/m^2). In 1975 still 40 000 m^2 of glazed mozaics were imported.

The building materials such as cement-asbestos products, cement and lime are produced in sufficient quantities and also exported. This applies to brickware products as well. Average prices of most of these products were indicated in part 8.4.2.

8.5.2 Lesotho

Lesotho with its population of about 1,000.000 inhabitans has a low consumption of building and ceramic materials. Nevertheless from "Data on building materials (selected) imports 1972 - 1975" the increasing trend is visible.

Following table shows the consumption of building materials:

Table 31

All values in Rand

Item	1972	1973	1974	1975
Quick lime cement	} 338 000	40 000 428 000	32 000 609 000	63 000 942 000
asbestos-cement products	N.A.	N.A.	203 000	373 000
bricks	180 000	125 000	199 000	242 000

All this above mentioned products are supplied from the Republic of South Africa. The data on imported wall tiles were not available and had to be assessed by local contractors. The demand for wall tiles is about 8 000 - 10 000 m^2 per year. They are both of South African and Europ(e)an origin. For Lesotho it is characteristical that demand for wall tiles varies from the cheapiest ones in white colour upto the most expensive coloured and highly decorated tiles imported from Europ(e)an countries

(Italy, German Federal Republic). In Lesotho wholesale does not exist, wall tiles are imported directly by contractors from RSA. Prices are very different, depending on colour, décor and quality. They range between 5 and 60 Rand per m^2.

What was said about conditions for import of wall tiles to South Africa it applies to Lesotho as well or even more as tourist industry is being quickly developed in the country and architects are anxious to apply original decorations in hotels and catering industry. Potential imports from Botswana in 1981 can be estimated at 5 000 m^2 per year.

Ceramic floor tiles are practicaly not used, only terazzo type, thickness 12 mm, prices vary from 3 - 16 Rand depending on quality. Situation with the quick lime is the same as in Zambia and Botswana. People are not accustomed to work with quick lime and cement is highly preferred.

Other building materials - facade tiles, facing bricks, are supplied to Lesotho from the nearest South African factories and brick plants. Products from Botswana most probably could not compete.

8.5.3 Swaziland

A similar situation as in Lesotho exists also in Swaziland. This country with half a million inhabitants has not its own ceramic industry. All building and ceramic materials are imported. The Republic of South Africa is practically the only supplier of these materials.

From the statistical dates a certain recess in consumption is remarkable.

Table 32

All values in Rands

Item	1972	1973	1974	1975
bricks and other +	81.000	76.000	214.000	53.000
quick lime	102.000	103.000	48.000	87.000
cement	555.000	842.000	1023.000	787.000

+Wall tiles are not listed separately.

The housing programme enables a market for approximately 10 000 m^2 of wall tiles. From this quantity Botswana's products could replace 5 000 m^2 in the year 1981. The quality requirments are commercial grade, landed cost of imported wall tiles ranges from 5.0 - 8.0 Rand per m^2. Wall tiles are supplied in the size 150 x 150 x 6 mm from the Republic of South Africa and a small quantity also from Europe at considerably higher prices.

8.5.4 Zambia

Zambia, the northern neighbour of Botswana with 7 million inhabitants is a more developed country than Botswana. Both the countries are interested in promoting mutual business. The trade between Botswana and Zambia is not much expanded till now. The construction of Botswana - Zambia road will undoubtedly help to promote deeper economic relations between both countries. Zambia's economy depends on mining industry, especially on copper. World copper market influences the whole economy of Zambia; lower export of copper has its consequencies on imports.

Zambia's imports of ceramic products 1971 - 1976 are shown in the table 33.

Wall tiles on Zambia's market are of commercial quality, dimensions 150 x 150 x 6 mm. More than 90 % of white wall tiles are required. Wall tiles are not yet manufactured in Zambia. They are imported from different countries via Dar es Salaam. The cost of transport makes a substantial part of price. Yearly imports a bit waver, however, 70 000 m^2 per year is a fair number. Due to a complicated transport, the price of wall tiles is unusually high. Landed cost in Lusaka is in average 9,50 Kwacha/m^2. On account of breakage which makes sometimes 20 - 25 %, the in stock price amounts to 11,0 - 12,0 Kwacha per m^2. Wall tiles are subjected to 25 % duty. Zambia can be considered a good market for wall tiles, it is estimated, that yearly import of 50 000 m^2 of white wall tiles from Botswana

Table 33

Imports of ceramic products and building materials 1971 - 1976
(Values FOB exporting countries)

Commodity Code number Unit	Year	Quantity	Value Kwacha	Kwacha per unit	Remarks
Ceramic unglazed setts, tiles, paving, etc.	1971	17 725	23 712	1,337	
	1972	12 274	19 924	1,623	
	1973	92 097	24 340	0,264	duty=20%
	1974	14 613	11 017	0,754	
66 244 m^2	1975	3 972	9 108	0,293	
	1976	53 849	34 496	0,640	
Ceramic glazed setts, tiles, paving, etc.	1971	129 349	115 671	0,894	
	1972	162 279	157 731	0,792	
	1973	24 697	32 035	1,297	duty=25%
	1974	120 668	148 812	1,233	
66 245 m^2	1975	74 142	125 051	1,686	
	1976	80 767	166 950	2,067	
Ceramic piping, coduits and fittings	1971	2 483	716	0,288	
	1972	1 517	813	0,536	
	1973	1 882	1 705	0,906	duty free
	1974	98	247	2,520	
66 243 kg	1975	3 824	2 141	0,559	
	1976	1 053	758	0,719	
Asbestos-cement products	1971	4,577 721	531 610	0,116	
	1972	74 529	30 829	0,413	
	1973	2 050	3 031	0,478	duty free
66 188 kg	1974	3 000	800	0,266	
	1975	2 050	3 050	1,487	
	1976	1 681	1 784	1,060	

are edequate. At present, however, Zambia is resolutely cutting down import licences. If the erection of a ceramic plant in Botswana is agreed with a production programme involving also exports to Zambia, a bilateral agreement should be concluded on this subject between Botswana and Zambia in advance.

Floor tiles as flooring material have no chance in Zambia, their use is very rare. For flooring in houses and offices mainly vinyl type of flooring material is used. Sometimes also quarry tiles and terrazzo are used. Terrazzo is also imported, landed cost in Lusaka being 18.50 Kwacha per m^2. The price of quarry tiles is 0,2 Kwacha per piece.

The production of cement in Zambia is sufficient, no import is necessary. Quick lime is used in a limited quantity only, the use of cement is highly preferred.

Also in the production of asbestos-cement products Zambia is independent, import is of no importance. Asbestos for manufacture of asbesto-cement products is imported from Swaziland. Brick industry is fully developed as well to cover local demand.

8.8 Conclusions and recommendations

The results of investigation of market requirements for products and materials recommended in technical conclusions (page 88, para 7.9) can be summarized as follows:

Stoneware facade tiles

These products are imported to Botswana occasionally in small quantities for representative buildings. Market in the Customs Union countries is abundantly suplied by RSA. Zembian importers are not interested in importing these products. Industrial production of stoneware facade tiles in Botswana is not recommended.

Severage pipes

Imports of ceramic severage pipes make only a few tenths of tons per year. Ceramic pipes could partly replace asbestos-cement pipes imported from RSA. However, building contractors prefer asbestos cement - pipes because of easier handling and assembling. Small consumption of ceramic severage pipes in Customs Union countries is fully covered by deliveries from RSA. Zambia uses exclusively asbestos-cement pipes produced by local industry. Industrial production of ceramic severage pipes in Botswana is not recommended.

Floor tiles

Floor tiles are imported in small quantities because vinyl type is preferred. Ceramic wall tiles are applied in class rooms because of their resistance to abrasion. Architects are of the opinion the consumption of ceramic floor tiles of good quality would increase if they were available locally. In Lesotho and Swaziland the consumption is low, in RSA the manufacture of floor tiles and mosaics is being developed and is protected by high import duties. Imports of floor tiles in Zambia are negligible. Terrazzo tiles are prefered. Industrial production of floor tiles in Botswana is not recommended. In case of a pilot plant manufacture, experimental production for market acquisition could be recommended.

Wall tiles

With regard to existing imports to Botswana and the other countries of Customs Union and to Zambia as well two alternative production programmes are recommended to be subjected to economic examination:

Table 34

Maximum production programme of wall tiles (m^2)

Country of destination	White wall tiles	Coloured wall tiles	Totals
Botswana	15 000	5 000	20 000
R.S.A.	-	70 000	70 000
Lesotho	-	5 000	5 000
Swaziland	-	5 000	5 000
Zambia	45 000	5 000	50 000
Totals	60 000	90 000	150 000

Table 35

Minimum production programme of wall tiles (m^2)

Country of destination	White wall tiles	Coloured wall tiles	Totals
Botswana	15 000	5 000	20 000
R.S.A.	-	15 000	15 000
Lesotho	-	5 000	5 000
Swaziland	-	5 000	5 000
Zambia	-	5 000	5 000
Totals	15 000	35 000	50 000

+Experimental production 5 000 m^2 of floor tiles and mozaics per year

The maximum production programme involves local production and all potential exports. Should this manufacture not meet economic criteria, then the minimum production programme should be examined which comprises also local production, exports are cut down and should be concentrated predominantly on special décors saleable at higher prices.

In case of adoptation of the maximum programme an agreement should be signed with Zambia including imports of wall tiles to this country.

Cement-asbestos products

Yearly imports of these products fluctuate between 1500 and 2 000 ton. The Customs Union countries are supplied by sufficient production in R.S.A. Also Zambia erected an industrial plant in recent years covering nearly the whole consumption of the country. For the time being industrial production of cement-asbestos products is not recommended in the country. However, if the project for a cement plant is implemented and if the development of mining asbestos comes so far as to guarantee regular deliveries, then the manufacture of asbestos-cement products should be taken into account.

Quick-lime

Quicklime in all countries of Southern Africa is used only for flushing and painting and produced on an industrial scale only in RSA. With regard to technical and possibly economical advantages of quick lime mentioned in part 8.4.1 it is recommended to subject a small scale production of lime to economical examination.

Brickware facing bricks and facade tiles

Brickware was not included in the investigation for the market as brickware project was being prepared by ING.FA.L.SVÅRDAB, Engineers and Consultants, and the new brick plant is expected to start production just now. Nevertheless the team of Czech experts took samples of brick clays from the Gaborone Dam area in the year 1976. The clays are evaluated in the technical part of this report. Samples of products manufactured from these materials were submitted to the Ministry of Commerce and Industry and production of some of them will be tried in the new brick plant for versification of assortment. Preliminary assessment of profitability is recommendable.

During the field work in Phase A brick clay samples were taken in Serowe where local brick production had to be stopped because bricks were cracking. During the second field mission in Phase B a recipe for brick manufacture from the Serowe clay with admixture of a clay from Makoro was handed over to the Geological Survey for the Serowe Brigade to enable them to start again brick production.

Review of scope of production and prices of products recommended in the foregoing conclusions

Table 36

Product	Proposed max. quantity per year	Proposed min. quantity per year	Country of destination	Present imports in country of destination
Wall tiles white	15 000 m^2	15 000 m^2	Botswana	14 000 m^2
"	-	-	R. S. A.	-
"	-	-	Lesotho	3 000 m^2
"	-	-	Swaziland	3 000 m^2
"	45 000 m^2	-	Zambia	60 000 m^2
Wall tiles white total	60 000 m^2	15 000 m^2		80 000 m^2
Wall tiles coloured and decorated	5 000 m^2	5 000 m^2	Botswana	3 000 m^2
"	70 000 m^2	15 000 m^2	R. S. A.	700 000 m^2
"	5 000 m^2	5 000 m^2	Lesotho	7 000 m^2
"	5 000 m^2	5 000 m^2	Swaziland	7 000 m^2
"	5 000 m^2	5 000 m^2	Zambia	10 000 m^2
	90 000 m^2	35 000 m^2		727 000 m^2
Quick lime	4000-5000 t	4000-5000 t	Botswana	5000 t

Prices	Pula
Wall tiles white	4.90/m^2
Wall tiles plain colour	7.60/m^2
Wall tiles decorated with local motives (smallorders)	12.00/m^2
Wall tiles manually decorated with local motives (small orders)	16.00/m^2

Experimental production of floor tiles and mozaics:

average price 10P/m^2

Quick lime: Present price of imported lime for painting and flushing 60P/t

On pages 99 and 112 small scale production of lime is recommended by which the lime for mortars and plasters is meant of which the price is unknown. It should be calculated in adequate relation to cement. Also the combined production of both grades of quick lime incl. replacement of import could be taken into account.

9. E C O N O M I C   S T U D Y

9.1 Introduction

This techno-economic study is based on the conclusions of Phase A of the feasibility study on the market study and the economic investigation carried out in the field in the Phase B. The manufactures of the following products were recommended to be examined economically:

- 150 000 m^2 of wall tiles
- 50 000 m^2 of wall tiles (alternative)
- 5 000 m^2 of floor tiles and mozaics(as experimental production for market acquisition
- 5 000 t of quick lime for mortars and plasters

Besides a preliminary assessment of profitability of some brick products developed within this feasibility study for versification of starting brick industry was recommended.

Note: Cost and prices are based on rate of exchange valid in June 1977 in Gaborone

1 Pula = 1.0434 Rand (SA, Lesotho, Swaziland)
1 Pula = 0.9530 Kwacha
1 Pula = 1.2[illegible] US Dollars
1 Pula = 2.[illegible]30 German Marks
1 Pula = 0.6986 Lstg
Imports before 1977 are priced 1 Pula = 1 Rand

9.2 Industrial plant 150 000 m^2 of wall tiles

It is well known that yearly production of 150 000 m^2 is not sufficient to be manufactured economically in standard wall tiles. Cheaper labour and raw materials in Botswana cannot compensate for more expensive machinery imported from overseas and low economic efficiency of small scale manufacture.

To paralyse these disadvantages it is necessary to concentrate on a promotional assortment of special products with original designs, partly hand decorated and produced in small quantities at considerably higher prices. Standard products should be produced only for home consumption and for promoting some favoured market.

3.4.? <u>[illegible]</u> [illegible]

[illegible]	
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Working capital	
Inventories	137 000
Accounts receivable	77 000
	214 000
[illegible]	
Fixed assets	2 084 000
Other investment	335 000
Working capital	214 000
Total investments	2 633 000

9.2.2 Table 37 **Industrial plant 150 000 m^2 wall tiles - cash flow (Pula)**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Production m^2			75 000	120 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 [illegible]
A. Source of cash:															
1. Equity (800 000)	210000	590 000													
2. Loan (1 726 000)		1726 000													
3. Sales revenue			704 000	1126 000	1408000	1408000	1408000	1408000	1408000	1408000	1408000	1408000	1408 000	1408000	1408 000
Source of cash-total	210000	2316000	704 000	1126 000	1408000	1408000	1408000	1408000	1408000	1408000	1408000	1408000	1408 000	1408000	1408 000
B. Uses of cash:															
1. Fixed capital expenditure															
1.1 Buildings	150000	40000													
1.2 Machinery and equipment		1873000													
1.3 Transportation		21000													
1.4 Replacement								21000					21 000		
Fixed capital expenditure	150000	1934000						21000					21 000		
2. Net working capital															
2.1 Investories		68500	41 100	27 400											
2.2 Accounts receivable		38500	23 100	15 400											
Net working capital-total		107000	64 200	42 800											
3. Other costs:															
3.1 Pre-investment cost	60000	213000													
3.2 Start-up expenses		62000													
Pre-investment and start up exp.-total	60000	275000													
4. Production expediture															
4.1 Raw materials			9 000	13 000	16028	16028	16028	16028	16028	16028	16028	16028	16 028	16028	16 028
4.2 Glazes and stains			60 000	90 000	112065	112065	112065	112065	112065	112065	112065	112065	112 065	112065	112 065
4.3 Energy			87 000	130 000	145299	145299	145299	145299	145299	145299	145299	145299	145 299	145299	145 299
4.4 Operating supplies			33 000	53 000	66012	66012	66012	66012	66012	66012	66012	66012	66 012	66012	66 012
4.5 Personal costs			157 496	157 496	157496	157496	157496	157496	157496	157496	157496	157496	157496	157496	157496
4.6 Administrative costs			11 000	13 000	14475	14475	14475	14475	14475	14475	144,5	14475	14475	14475	14 475
4.7 Sales costs			25 000	34 000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45 000
Production expenditure - total			382 496	490 496	556375	556375	556375	556375	556375	556375	556375	556375	556375	556375	556 375
5. Debt service															
5.1 Interest on loan			189 860	189 860	189860	165000	132000	99000	66000	33000	-	-	-	-	-
5.2 Repayment of loan					226000	300000	300000	300000	300000	300000	-	-	-	-	-
Debt service - total	-	-	189 860	189 860	415860	465000	432000	399000	366000	333000	-	-	-	-	-
6. Profit tax paid-total	-	-	-	-	-	-	54006	256768	268319	279869	291418	291418	298069	298069	298 [illegible]
Uses of cash-total	210000	2316000	636556	732156	972235	1021375	1042381	1233143	1190694	1169244	847793	847793	875444	854444	854 [illegible]
C. Surplus/Deficit (A-B)			67444	402844	435765	386625	365619	174857	217306	238756	560207	560207	532555	533556	533 556
D. Depreciation reserve			67444	202844	235765	186625	165619	25143	17306	38756	280207	280207	252556	273556	273556
E. Suplus for dividend			-	200000	200000	200000	200000	200000	200000	200000	280000	280000	280000	280000	280000
Percentage of equity				25 %	25 %	25 %	25 %	25 %	25 %	25 %	35 %	35 %	35 %	35 %	35 %

9.2.3 Evaluation of industrial plant

Sensitivity analysis

The foregoing Cash Flow gives a complex picture of funding, capital expenditure and development of sales, costs, loan repayments and resulting surplus values during the years of investment and life time of production equipment.
The presented Cash Flow is based on presumptions refered to in the analytical part (9-8-1) which of course may be changed. The following relations represented graphically in the enclosed Break-even point chart show to which extent particular changes in input data change the resulting surplus.

The surplus is given by the equation:

$$Spl = Pr \times Q - FC - VC - I - LP$$

where Spl = Surplus before tax
Q = Quantity of production in m^2
Pr = Average price per m^2 of produced quantity
FC = Fixed costs
VC = Variable costs
VC_s = specific variable costs per unit of production
I = Interest
LR = Loan repayment
d = Change of any value

Application:

Price changes

If prices are lowered or innoreased the resulting diference is sales revenue brings the same difference to suplus.

Example:

If the price of coloured [illegible] wall tiles (see part 9.8.1.3) is decreased from [illegible]/m² to [illegible]/m², the total difference will be

$$2500[illegible]\ (m^2) \times [illegible]$$

By the same sum would be reduced the surplus.

<u>Changes in scope of production</u>

Changes in produced quantity influence sales revenue and bring forth changes in variable costs and surplus as well. These relations can be expressed by the following equation.

$$dSpl = Pr \times dQ - VCs \times dQ$$
$$dSpl = dQ\ (Pr - VCs)$$

Example:

The current production of 150 000 m² per year should be increased by 10 % according to market demand in all grades.

$Pr = 9.387\ P$ (average price 1 408 000 : 150 000)
$dQ = 15\ 000\ m^2$
$VC = 384\ 404\ P$ (Raw materials + glazes and stains + energy operating supplies + sales costs)
$VCs = 2.56\ P$ (384 404 : 150 000 = 2,56 P)
$dSpl = 15\ 000\ (9.387 - 2.560)$
$dSpl = 102\ 405\ P$

The increase of surplus would be 102 405 P.

<u>Changes in production costs</u>

These changes due mostly to changed prices of supplies have direct impact on the surplus

$$dSpl = \pm dPr \times Q$$

Example:

The projected yearly consumption of fuel oil is 603 t at 183 P/t = 110 349 P

In case of increase of prices by 1 % the price difference would be 1.83 P/t

$$dSpl = -dPr \times Q$$
$$dSpl = -1.83 \times 603$$
$$dSpl = -1103,45\ P$$

The surplus would be reduced by 1103,45 P

Changes in capital expenditure

If some component of capital expenditure or all components (fixed capital expenditure, net working capital, pre-investment and start-up expenses) are changed, then surplus is changed in case that the investor decides to change the loan. In this case the change of loan brings about change of repaymant, change of interest and consequently change of surplus.

$$dSpl = dLM + dLM \times 0.11$$

Example:

The plant cost would be decreased by 100 000 P and by this amount would be reduced the loan.

The surplus will be affected as follows:

3rd - 5th year	$dSpl = + 100\ 000 \times 0.11$	
	$dSpl = +\ 11\ 000$ P yearly	
6th year	$dSpl = + 100\ 000$	if the repayment programme is not redistributed

Total surplus elevation of surplus is 133 000 P in the 3rd - 6th year.

Table 38

Internal rate of return

Year	Equity P	Surplus P	Factor at 34 %	Equity discounted P	Net inflow discounted P
1	210 000		1.000 000	210 000	
2	590 000		0.746 268	440 298	
3		67 444	0.556 915		37 561
4		402 844	0.415 607		167 425
5		435 765	0.310 154		135 154
6		386 625	0.231 458		89 487
7		365 619	0.172 729		63 153
8		174 857	0.128 902		22 539
9		217 306	0.096 195		20 904
10		238 756	0.071 787		17 140
11		560 207	0.053 572		30 011
12		560 207	0.039 979		22 397
13		532 556	0.029 835		15 889
14		553 556	0.022 264		12 324
15		553 556	0.016 614		9 197
15	Res.value of assets	139 600	0.016 614		2 319
15	Working capital	214 000	0.016 614		3 555
				650 298 ≙	649 055

Table 39

Net present value

Year	Equity	Surplus	Factor at 11%	Equity present value	Cash inflow present value
	P	P		P	P
1	210 000		1.000 000	210 000	
2	590 000		0.900 900	531 531	
3		67 444	0.811 620		54 739
4		402 844	0.731 188		294 555
5		435 765	0.658 727		287 050
6		386 625	0.593 447		229 441
7		365 619	0.534 636		195 473
8		174 857	0.481 653		84 220
9		217 306	0.433 921		94 294
10		238 756	0.390 919		93 334
11		560 207	0.352 178		197 292
12		560 207	0.317 277		177 740
13		532 556	0.285 834		152 223
14		553 556	0.257 507		142 544
15		553 556	0.231 988		128 418
15	Res. value of assets	139 600	0.231 988		32 385
15	Working capital	214 000	0.231 988		49 645
				741 531	2213 353

Present value of return	2 213 353
Present value of equity	741 531
Net present value	1 471 822

Direct value added and employment effects

	P
Average annual profit before tax	560 657
Wages and salaries	157 496
Average interest	81 890
Direct value added per year	800 040

The plant would give employment for 11 members of technical and administrative staff and for 57 workers.

Social marginal productivity of capital

Each 100 Pula of capital investment will bring out 31.60 Pula of direct value added per year on an average.

Balance of payment effect

	P/year	
Revenue in foreign currencies	1 296 500	
Savings for imports	111 000	
	1 407 500	
Less:		
Glazes and stains	112 065	
Fuel oil	110 349	
Electricity (70 % of total cost)	19 740	
Spare parts	29 780	
Depreciation of technological equipment	141 000	-412 934
Annual savings in foreign exchange		994 566

Risks of the enterprise

The above results give a picture of very efficient economy of the proposed plant. The proposed price for special products produced for small orders are attainable as the experts verified during field work.

The main risk is a great dependence on foreign markets.

	%	m^2	%	P
Sales in Botswana	13.33	20000	7.92	111 500
Exports to Customs Union	53.34	80000	73.72	1038 000
Exports to Zambia	33.33	50000	18.36	258 500
	100.00	150000	100.0	1408 000

The local production for home consumption lies low under the break-even point. There is a great dependence on Customs Union countries, especially on R.S.A (63.78 % of total sales). This phonomenon is characteristic for most developing countries that try therefore to build up braader economic systems.

Note: Break-even point diagram is enclosed.

9.3 Pilot plant

The presented alternative is based on the following principles:

- Introduce ceramic small scale manufacture in Botswana
- Provide training of technicians and workers in ceramic manufacture for present needs as well as for future extention
- Cover local consumption of wall tiles and floor tiles or mozaics
- Reduce dependence on exports (compared to the industrial plant)

The production programme is based on the minimum production programme referred to in the Market study (p. 111)

- 50000 m^2 of wall tiles and 5000 m^2 of floor tiles and mozaics (specification see part 9.8.2.3)

9.3.1 Investment

Fixed assets	P
Buildings and other civil engineering works	117 000
Technological equipment	882 000
Transportation	21 000
Fixed assets - total	1 020 000

Other investment	P
Preinvestment costs	134 000
Start-up expenses	30 000
Other investment - total	164 000

Working capital	
Investories	69 000
Accounts receivable	35 000
Working capital - total	104 000

Summary

Fixed assets	1 020 000
Other investment	164 000
Working capital	104 000
Total investment	1 288 000

9.3.2 Table 40 **Pilot plant - 50 000 m² wall tiles, 5 000 m² floor tiles and mozaics - cash flow (Pula)**

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	[illegible]
Wall tiles	Production m²	-	-	33000	44000	55000	55000	55000	55000	55000	55000	55000	55000	[illegible]	55000	[illegible]
A.	Source of cash:															
1.	Equity (400 000 P)	60000	340000													
2.	Loan (846 000)		846000													
3.	Sales revenue			373000	497000	621000	621000	621000	621000	621000	621000	621000	621000	621000	621000	621000
	Source of cash - total	60000	1186000	373000	497000	621000	621000	621000	621000	621000	621000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B.	Uses of cash:															
1.	Fixed capital expenditure															
1.1	Buildings (117 000)	30000	87000													
1.2	New machinery and equipment		882000													
1.3	Transportation		21000						21000					21000		
1.4	Replacement		-													
	Fixed capital expenditure-total	30000	990000						21000					21000		
2.	Net working capital															
2.1	Inventories		41000	14000	14000											
2.2	Accounts receivable		21000	7000	7000											
	net working capital -total		62000	21000	21000											
3.	Pre-investment and start-up expenses															
3.1	Pre-investment costs	30000	104000													
3.2	Start-up expenses		30000													
	Pre-investment and start-up expenses-total	30000	134000													
4.	Production expenditure															
4.1	Raw materials			3845	5126	6408	6408	6408	6408	6408	6408	6408	6408	6408	6408	6408
4.2	Glazes and stains			26220	34960	43700	43700	43700	43700	43700	43700	43700	43700	43700	43700	43700
4.3	Energy			40000	51000	59997	59997	59997	59997	59997	59997	59997	59997	59997	59997	59997
4.4	Operating supplies			20474	27300	34124	31124	34124	34124	34124	34124	34124	34124	34124	34124	[illegible]
4.5	Personal costs			107897	107897	107897	107897	107897	107897	107897	107897	107897	107897	107897	107897	107897
4.6	Administrative costs			7196	8096	8995	8995	8995	8995	8995	8995	8995	8995	8995	8995	8995
4.7	Sales costs			10800	14400	18000	12000	18000	18000	18000	18000	18000	18000	18000	18000	18000
	production expenditure-total	-	-	218432	248779	279121	279121	279121	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.	Debt service															
5.1	Interest on loan			93060	93060	93060	88550	75900	63250	50600	37950	25300	12650			
5.2	Repayment of loan					41000	115000	115000	115000	115000	115000	115000	115000			
	Debt service-total			93060	93060	134060	203550	190900	178250	165600	[illegible]	140300	127650			
6	Profit tax paid-total	-	-						35611	88041	[illegible]	106708	111135	118658	118658	118658
	Uses of cash-total	60000	1186000	332492	362839	413181	482671	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	Surplus/Deficit (A-B)	-	-	40508	134161	207819	138329	150979	117018	78264	86649	94871	103094	201221	222221	222221
D	Depreciation reserve			40508	76161	149819	80329	92979	59018	20264	28649	36871	45094	143221	164221	164221
E	Surplus for dividend (C-D)			-	58000	58000	58000	58000	58000	58000	58000	58000	58000	58000	58000	58000
	Percentage of equity				14,5	14,5	14,5	14,5	14,5	14,5	14,5	14,5	14,5	14,5	14,5	14,5

9.3.3 Evaluation of pilot plant

Sensitivity analysis

The presented Cash Flow shows a complex picture of funding, capital expenditure and development of sales, costs, loan repayments and resulting surplus values during the years of investment and life time of production equipment. Specifications are included in the analytical part (9.8.2)

The following calculations show the impact of potential changes in input data on resulting surplus.

The surplus is given by the equation:

$$Spl = Pr \times Q - FC - VC - I - LR$$

where Spl = Surplus before tax
Q = Quantity of production in m^2
Pr = Average price per m^2 of produced quantity
FC = Fixed costs
VC = Variable costs
VCs = Variable costs per production unit
I = Interest
LR = Loan repayment
d = Change of any value

Price changes

If prices are reduced or increased the resulting difference in sales revenue brings the same difference to surplus.

Example:
If the price of coloured hand painted wall tiles (see part 9.8.2.3) is reduced from 16P/m^2 to 14P/m^2, the total difference will make

$$25000\ (m^2) \times 2P = 50\ 000\ P$$

By the same price would be reduced the surplus.

Changes in scope of production

Changes in produced quantity influence sales revenue and bring forth changes in variable costs and surplus as well. These relations can be expressed by the equation:

$$dSpl = Pr \times dQ - dVCs \times dQ$$
$$dSpl = dQ\ (Pr - dVCs)$$

Example:

The current production of 50 000 m^2 wall tiles and 5000 m^2 of floor tiles and mozaics should be increased by 5 % in all grades.

Pr = 11.29 P (average price 621 000 : 55000)
dQ = 2750 m^2
VC = 162229 P (Raw materials + glazes and stains + energy + operating supplies + sales costs
VCs = 2.95 P (162229 : 55000 = 2.95 P)

$$dSpl = 2750\ m^2\ (11.29 - 2.95)$$
$$dSpl = 22935\ P$$

The surplus increased by 22935 P.

Changes in production costs

These changes are mostly preceded by price changes of supplies and they influence directly the surplus

$$dSpl = \pm dPr \times Q$$

Example:

The projected annual consumption of fuel oil is 253 t fuel oil at 183 P/t = 46229 P. Should the price be increased by 1.5 % the price difference would make 2.745 P/t.

$$dSpl = -dPr \times Q$$
$$dSpl = -2.745 \times 253$$
$$dSpl = -894\ .\ 48\ P$$

The surplus would be reduced by 894.48 P.

Changes in capital expenditure

If some component of capital expenditure or all components are changed then surplus is changed in case that investor decides to change the loan too. In this case the change of loan brings about change of repayment and consequently change of surplus in general

$$dSpl = dLR + dL \times 0.11$$

$$dSpl = dLR \times 1.11$$

Table 41

Internal rate of return (1)

Year	Equity P	Surplus P	Factor at 25 %	Equity discounted	Net inflow discounted
1	60 000		1.000 000	60 000	
2	340 000		0.800 000	272 000	
3		40 508	0.640 000		25 925
4		134 161	0.512 000		68 690
5		207 819	0.409 600		85 123
6		138 329	0.327 680		45 328
7		150 979	0.262 144		39 578
8		117 018	0.209 715		24 477
9		78 264	0.167 772		13 131
10		86 694	0.134 218		11 636
11		94 871	0.107 374		10 187
12		134 094	0.085 899		8 856
13		201 221	0.068 719		13 828
14		222 221	0.054 976		12 217
15		222 221	0.043 980		9 773
15 Residnal value of assets		76 630	0.043 980		3 370
15 Working capital		104 000	0.043 980		4 574
				332 000	376 693
					332 000
					+ 44 693

Table 42

Internal rate of return (2)

Year	Equity P	Surplus P	Factor at 27 %	Equity discounted P	Net inflow discounted P
1	60 000		1.000 000	60 000	
2	340 000		0.787 401	267 716	
3		40 508	0.620 001		25 115
4		134 161	0.488 189		65 496
5		207 819	0.384 401		79 886
6		138 329	0.302 678		41 689
7		150 979	0.338 329		35 983
8		117 018	0.187 660		21 956
9		78 264	0.147 764		11 565
10		86 649	0.116 349		10 082
11		94 871	0.091 613		8 691
12		103 094	0.072 136		7 437
13		201·221	0.056 800		11 429
14		222 221	0.044 724		9 939
15		222 221	0.035 215		7 825
15	Residual value of assets	79 630	0.035 215		2 804
15	Working capital	104 000	0.035 215		3 662
				337 716	343 739
					337 716
					+ 06 023

Internal rate of return $= p_1 + \left[\frac{\alpha}{\alpha - \beta} \cdot (p_2 - p_1)\right]$

$= 25 + \left[\frac{44\,693}{44693 - 6023} \quad 2\right]$

$= 25 + \frac{38\,386}{38\,670}$

$= 27.31\ \%$

Table 43

Net present value

Year	Equity	Surplus	Factor at 11 %	Equity present value	Cash inflow present value
	P	P		P	P
1	60 000		1.000 000	60 000	
2	340 000		0.900 900	306 406	
3		40 508	0.811 620		32 877
4		134 161	0.731 188		98 097
5		207 819	0.658 727		136 896
6		138 329	0.593 447		82 091
7		150 979	0.534 636		80 719
8		117 018	0.481 658		56 362
9		78 264	0.433 926		33 960
10		86 649	0.390 919		33 873
11		94 871	0.352 178		33 411
12		103 094	0.317 287		57 516
14		222 221	0.257 507		57 223
15		222 221	0.231 988		51 553
15	Residual value of assets	76 630	0.231 988		17 777
15	Working capital	104 800	0.231 988		24 127
				366 306	829 191

Present value of return	829 191
Present value of equity	366 306
Net present value	462 885

Direct value added and employment effects

	Pula
Average annual profit before tax	199 060
Wages and salaries	107 897
Average interest	48 680
Direct value added per year	355 637

The plant would provide employment for 6 members of technical and administrative staff and for 43 workers.

Social marginal productivity of capital

Each 100 Pula of capital investment will bring out 28.54 Pula of direct value added per year on an average.

Balance of payment effect

		P/year
Revenue in foreign currencies		490 000
Savings for imports		111 000
		601 000
Less:		
Glazes and stains	43 700	
Fuel oil	46 299	
Electricitity (70 % of total cost)	7 000	
Spare parts	13 000	
Depreciation of technological equipment	66 150	- 176 149
Annual savings in foreign exchange		424 851

Risks of the enterprise

The economy of the proposed pilot plant is not so efficient as that of the industrial plant which is quite characteristic for decreasing production volume. On the other hand the risks of dependence on foreign markets are partly reduced. It should be also taken into account that the objective of the pilot plant is to train workers and technicians for later extension of ceramic industry and that similar enterprises (brigades) are run in Botswana without profits while here the net surplus is 14.5 % of equity per year and the internal rate of return 27 %.

Dependence on foreign markets

	%	m^2	%	P
Sales in Botswana	40	22 000	21.1	131 000
Exports to Customs Union	49	27 000	64.4	400 000
Exports to Zambia	11	6 000	14.5	90 000
	100	55 000	100.0	621 000

Local production lies again under the break-even point. The situation is favourable if the production for the Customs Union is looked upon as for one economic system. The break - even point diagram is enclosed.

[illegible] 4000–5000 t of [illegible] The price of this [illegible] as that of cement. [illegible] for this manufacture based [illegible] oil fired shaft kiln is not economically viable. [illegible] alternative with coal fired kiln for 5000 t of [illegible] failed. The only feasible solution seems to be [illegible] production by another 5000 t [illegible] estimate of present annual import [illegible] product used [illegible] flushing and painting. The whole quantity of 10 000 t [illegible] in a coal-fired sh_aft kiln.

9.[illegible].1 Investment

	[illegible]
Fixed assets:	
Buildings	[illegible] 000
Technological equipment	[illegible] 000
Transportation	[illegible] 000
Fixed assets – total	[illegible]
Other investment:	
Pre-investment costs	[illegible] 000
Trial run costs	[illegible]
Other investment – total	[illegible]
Working capital:	
Inventories	[illegible]
Accounts receivable	[illegible]
Working capital – total	[illegible]
Summary:	
Fixed assets	[illegible]
Other investment	[illegible]
Working capital	[illegible]
Total investment	[illegible]

Table 44 Quick lime plant - 10 000 t - cash flow (Pula)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Production (t)	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	[illegible]	[illegible]
A. Source of cash:														
1. Equity (240 000)	240000													
2. Loan (537 000)	537000													
3. Sales revenue		390000	390000	390000	390000	390000	390000	390000	390000	390000	390000	390000	390000	390 [illegible]
Source of cash-total	777000	390000	390000	390000	390000	390000	390000	390000	390000	390000	390000	390000	390000	[illegible]
B. Uses of cash:														
1. Fixed capital expenditure:														
1.1 Buildings	9000													
1.2 New machinery and equipment	585000													
1.3 Transportation	22000													
1.4 Replacement	-						22000					22000		
Fixed capital exp.-total	616000													
2. Net working capital														
2.1 Inventories	44000													
2.2 Accounts receivable	21000													
Net working capital-total	65000													
3. Other investment:														
3.1 Pre-investment costs	84000													
3.2 Trial run costs	12000													
Other investment-total	96000													
4. Production expenditure														
4.1 Raw materials		60000	60000	60000	60000	60000	60000	60000	[illegible]	[illegible]	[illegible]	60000	[illegible]	[illegible]
4.2 Energy		39008	39008	39008	39008	39008	39008	39008	[illegible]	[illegible]	39008	39008	[illegible]	[illegible]
4.3 Operating supplies		11700	11700	11700	11700	11700	11700	11700	[illegible]	[illegible]	11700	11700	11700	11 [illegible]
4.4 Personnel costs		55905	55905	55905	55905	55905	55905	55905	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4.5 Administrative costs		1677	1677	1677	1677	1677	1677	1677	[illegible]	[illegible]	1677	[illegible]	[illegible]	[illegible]
4.6 Sales costs		20000	20000	20000	20000	20000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Production exp. - total		188290	188290	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5. Debt service														
5.1 Interest on loan		59070	47190	35310	23430	11550								
5.2 Repayment of loan		108000	108000	108000	108000	1[illegible]5000								
Debt service - total		167070	155190	143310	131430	116500								
6. Profit tax paid - total		-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Uses of cash - total	777000	355360	343480	331600	319720	338055	280573	258573	258573	258573	258573	[illegible]	258888	258 888
C. Surplus/Deficit (A-B)	-	34640	46520	58400	70280	51945	109427	131427	131427	131427	131427	109112	131112	131 112
D. Depreciation reserve		34640	- 1480	10400	22290	3945	61427	83427	83427	83427	83427	61112	83112	83 112
E. Surplus for dividend			48000	48000	48000	48000	48000	48000	48000	48000	48000	48000	48000	48 000
Percentage of equity			20 %	20 %	20 %	20 %	20 %	20 %	20 %	20 %	20 %	20 %	20 %	20 %

[illegible] Evaluation of quick - lime plant

Sensitivity analysis

Specifications regarding the input data of each [illegible] are included in the analytical part [illegible]

The following calculations show the impact of potential changes in input data on results [illegible] surplus.

The surplus is expressed [illegible] the equation:

Spl = [illegible]

where Spl = Surplus before tax

Q = Production quantity [illegible]

P = Average price per ton of produced quantity

FC = Fixed costs

VC = Variable costs

[illegible] = [illegible] cost [illegible]

Cs = Specific cost per production unit in general

I = Interest

LR = Loan repayment

d = Change of any value

Price changes

dSpl = dP x Q

Example:

In case of price [illegible] for [illegible] quick lime [illegible] and painting by 2 [illegible],

dSpl = [illegible]

dSpl = 10 [illegible]

Changes in amount of production

Changes in production quantity influences sales revenue, variable costs and surplus

[illegible]

[illegible]

Example:

The production of the higher priced lime will be reduced by 1000 t

$dQ = 1000$ t, ir = 60%, $dUCs = \frac{84\,700}{5000} = 16.94$ P/t

$dSpl = 1000$ ([illegible] - 16.94)

$dSpl = 1000 \times 48.06$

$dSpl = 43060$ P

Surplus will be reduced by 43 060 P.

Changes in production costs

In part 9.3.3 an example was demonstrated on price change of fuel oil. Next example shows the effect of fuel substitution: In preliminary calculation fuel oil was calculated; in the presented cash flow coal is taken into account.

Specific cost of fuel oil FCs = 19.03 P per ton of quick lime

$$dSpl = Q\ (FCs - Coal\ Cs)$$

$$dSpl = 10\ 000\ (19.02 - 3.60)$$

$$dSpl = 10\ 000 \times 15.42$$

$$dSpl = 154200\ P$$

Surplus increased by 154 200 P.

Changes in capital expenditure

$$dSpl = dLR + dLR \times 0.11$$

This equation again has only general application. There will be years before repayments when only unpaid difference in interest will affect surplus and years of planned repayment when lower repayment will be applied, too.

Table #5

Internal rate of return (1)

Year		Equity P	Surplus P	Factor at 25 %	Equity discounted P	Net inflow discounted P
1		240 000		1.000 000	240 000	
2			34 640	0.800 000		27 712
3			46 520	0.640 000		29 773
4			58 400	0.512 000		29 901
5			70 280	0.409 600		28 786
6			51 945	0.327 680		17 021
7			109 427	0.262 144		28 686
8			131 427	0.209 715		27 562
9			131 427	0.167 772		22 050
10			131 427	0.134 218		17 640
11			131 427	0.107 374		14 112
12			109 112	0.085 899		9 372
13			131 112	0.068 719		11 262
14			131 112	0.054 976		7 208
14	Residual value of assets		27 745	0.054 976		1 525
14	Working capital		65 000	0.054 976		3 573
						276 183
						240 000
						+36 183

Table [illegible]

Internal rate of return (2)

Year	Equity P	Surplus P	Factor at 30 %	Equity discounted P	Net inflow discounted P
1	240 000		1.000 000	240 000	
2		34 640	0.[illegible] 231		26 646
3		46 520	0.591 716		27 526
4		58 400	0.[illegible] 166		26 582
5		70 280	0.350 128		24 607
6		51 945	0.269 329		13 990
7		109 427	0.207 176		22 670
8		131 427	0.159 366		20 945
9		131 427	0.122 589		16 111
10		131 427	0.094 300		12 393
11		131 427	0.072 538		9 533
12		109 112	0.055 799		6 088
13		131 112	0.042 799		5 627
14		131 112	0.033 017		4 329
14	Residual value of assets	27 745	0.033 017		916
14	Working capital	65 000	0.033 017		2 146
				240 000	220 109
				220 109	
				- 19 891	

Internal rate of return $= p_1 + \left[\frac{r}{r - s} \cdot (p_2 - p_1) \right]$

$= 25 + \left[\frac{36\ 183}{36\ 183 + 19\ 981} (30 - 25) \right]$

$= 25 + 3.22$

$= 28.22\ \%$

Table 47

Net present value

Year	Equity P	Surplus P	Factor at 11 %	Equity present value P	Cash inflow present value P
1	240 000		1.000 000	240 000	
2		34 640	0.900 900		31 207
3		46 520	0.811 620		37 756
4		58 400	0.731 188		42 701
5		70 280	0.658 727		46 295
6		51 945	0.593 447		30 827
7		109 427	0.534 636		58 503
8		131 427	0.481 653		63 302
9		131 427	0.433 921		57 029
10		131 427	0.390 919		51 377
11		131 427	0.352 178		46 285
12		109 112	0.317 277		34 619
13		131 112	0.258 834		37 476
14		131 112	0.257 507		33 762
14	Residual values of assets	27 745	0.257 507		7 144
14	Working capital	65 000	0.257 507		16 738
				240 000	595 021

Present value of return	595 021
Present value of equity	- 240 000
Net present value	355 021

Direct value added and employment effects

	P
Average annual profit before tax	132 110
Wages and salaries	55 905
Average interest	13 580
Direct value added per year	201 595

The plant would provide employment for 32 workers and 2 persons for management and administrative.

Social marginal productivity of capital

Each 100 Pula of capital investment brings out 25.94 P of Direct value added per year.

Balance of payment effect

		P/year
Savings for import		60 000
Less:		
Electricity (70 %)	2 000	
Spare parts	11 000	
Depr of t. equipment	44 000	57 000
Annual savings in foreign exchange		3 000

Risks of the enterprise

The project proposes production of 5000 t quick lime as bond for mortars and plasters and 5000 t of first class quality quick lime for painting and flushing.

In the first case a new product will be introduced in the market. Preliminary acquisition campaign and training in application should eliminate any failure. In the second case the imported quantity of 5000 t quick lime for flushing and painting is an assessment of contractors and architects; the statistics are not so deeply specified as to confirm this sum. It should be verified before any investment e. g. by checking all invoices on imported lime during last 3 years with the Customs.

9.5 Versification of brickware production

Contribution of the technical part of this study to the presently starting brickware industry in Botswana consists in verification of raw materials and development of additional brick products the samples of which were handed over to representatives of the Ministry of Commerce and Industry. From these products especially glazed facing bricks (p.69) and facade tiles (p. 70) seem to be suitable for extension of the existing assortment.

Glazed facing bricks

Glazed facing bricks should be made in the same dimensions as bricks of current production. The recipe of body composition is indicated on page 70, glaze composition on page 83 (glazes for temperature 1080 - 1100 °C).

Glazed facing bricks would be produced by the same technology as common and face bricks manufactured in the brick plant in Gaborone. The body however consists of three components that must be mixed on feeding the mixer before the extruder. The grains should not exceed 3 mm in grain size.
Dried bricks are glazed on one lateral longitudinal side by a spray gun. The glaze prepared by half from local materials is prepared by grinding in a small ball mill (drum mill).

Required additional investment:
1 spray gun
1 small drum mill (can be made in a local mechanical shop)
Total investment, which can be second hand is estimated at 700 P
In case of increasing demand an aditional mixer, a crusher for crushing fired breakage and a pan mill with sieves would be recommended.

Calculation of costs and profit is based on Revenue costs and results analysis regarding production of 2 592 000 common and face bricks in Gaborone (L. SVÄRDAB: Study on claybricks 3) to which additional costs are added relating to glazed facing bricks

Production costs depreciation and interest	Pula per 1000 glazed facing bricks	
1. Salaries and wages		
Salaries	1.870	-
Wages	7.284	0.540
Total No. 1	9.154	0.540
2. General expenses - total	0.201	-
3. Material costs		
Clay	-	-
Laterite	-	3.430
Material for glaze	-	1.012
Coal 280 kg/1000 bricks at 10.60 R/t	3.272	-
Ash transport at 1R/t	0.308	-
Total No. 3	3.580	4.442
4. Electricity at 0.07R/kWh-total	.377	0.086
5. Repair and maintenance		
Spare parts	0.031	0.015
kiln	0.046	-
Maintenance of roads etc.	0.062	-
Sundry hand tools	0.031	0.031
Contingencies	0.092	-
Total No. 5	0.262	0.046
6. Total 1 + 2 + 3 + 4 + 5	15.574	5.114

7. Depreciation - total	1.[illegible]28	0.432
8. Interest - total	0.[illegible]24	0.302
9. Total 6 + 7 + 8	17.536	5.848
Extra costs	5.848	
Total costs per 1000 glazed facing bricks	23.384	

Face bricks produced in brick plant - unglazed and made from brick clays only are priced 35P/1000 bricks. Prices of glazed facing bricks range from 45 to 114 P/1000 bricks with regard to quality. The submitted glazed brick with well sintered body due to laterite addition could sell at 50 P/1000 bricks which is a very careful estimate.
The increase of profit before tax depends then on to which of the current products and in which quantity the new product is substituted.

	Common brick	Face brick	Glazed facing brick
Price P / 1000 pcs	25.00	35.00	50.00
Costs	17.54	17.54	23.38
Profit before tax	7.46	17.46	26.62

Glazed facade tiles

These products are supposed to be manufactured in dimensions 250 x 65 x 13 mm. Other sizes can be applied as well. The body composition is referred to on page 71, the glaze composition on page 83 (glazes for temperature 1080 - 1100 ^{o}C).
Again machinery and kiln of the existing brick plant would be used for manufacture of new products and the same additional equipment proposed for manufacture of glazed facing bricks.
The mixed body, however, is not extruded in shape of a quadrangular band to be cut in bricks, but in a hollow sexagonal band cut then to pieces 25 cm long. To this purpose an extruder core and a hexagonal liner must be attached to the press (extruder).

In further process (drying, glazing, firing) the semiproducts travel in this form of hexagonal tube [illegible] cm long. After firing these tubes are easily broken into particular tiles by a slihgt hammer stroke as the joints between strips are very thin. This technology has the advantage of firing without any kiln furniture.

Required additional investment is the same as in the case of glazed facing bricks.

Calculation of costs and profit is based again on Claybrick Study 3, Appendix No. 1.4.

Production costs, depreciation and interest	Rnds per 100 m² glazed facade tiles
1. Salaries and wages	
Salaries	6.73
Wages	34.00
Total No. 1	40.73
2. General expenses - total	0.72
3. Material costs	
Clay grey humic G	-
Dolerite 1.8 t x 2.5 R	4.50
Materials for glaze (100 kg/100 m²)	10.20
Coal ([illegible] kg/100 m²) 0.33t x 10.60 R	3.50
Ash transport 0.33 t x 1 R	0.33
Total No 3	18.53
4. Electricity - total	9.32
5. Repair and maintenance	
Spare parts	0.33
Kiln	0.17
Maintenance of roads etc	0.22
Sundry hand tools	0.22
Contingencies	0.33
Total No 5	1.27

6. Total 1 + 2 + 3 + 4 + 5	70.58
7. Depreciation - total	5.25
8. Interest - total	4.45
9. Total 6 + 7 + 8	80.28

The prices of glazed facade tiles are the only item the experts could not manage to receive from contractors although this information was promissed to be delivered by Berger and Gibbons Ltd. For this purpose consequently a careful price estimate of $5P/m^2$ is set out and it is hoped that the invetor will be able to substitute a corresponding price.

Between the calculation unitsof 100 m^2 of glazed façade tiles a 1000 bricks there is the equation 100 m^2 = 3600 pcs regarding the output given by kiln capacity while the weights 100 m^2 of wall tiles and 1000 bricks are almost identical.

	Common brick	Face brick	Glazed façade tile
Price per calculation unit	25.00	35.00	500.00
Costs per calculation unit	17.54	17.54	80.28
Profit before tax per c.u.	7.46	17.46	419.72

Substitution of glazed facade tiles to common bricks:

If 100 m^2 are substituted the output of common briks must be reduced by 3600 pieces and consequently the above profit on facade tiles will be reduced by 3.6 x 7.46 = 26.86 P

Substitution of glazed facade tiles to face bricks (unglazed):
If 100 m^2 are substituted the output of face bricks will be reduced by 3600 pieces and consequently the above profit on facade tiles will be reduced by 3.6 x 17.46 = 62.86 P

Risks of the substitutions:

The risks are only of technical nature. Both the new products can be successfully fired if firing temperature of 1080 - 1100°C is attained and glazed surface must be protected against contamination during firing.

9.6 <u>Assistance to rural manufacture of building materials</u>

In some places bricks are still fired in [illegible] and limestone is fired in small shaft kilns, as fuel [illegible] is applied. Bricks are of very low quality [illegible] Serowe brick manufacture had to be stopped [illegible]. Samples of brick clay were therefore taken in Serowe last year, tested and a recipe for brick body was handed over to the Geological Survey in Lobatse this year which should enable to start the brick production again.

The burnt lime produced locally is also of low quality. To this purpose a general solution was proposed in part 9.4 by small scale industrial production of quick lime.

9.7 Conclusions

Alternative - Industrial plant /150 000 m^2 wall tiles/ or Pilot plant /55 000 m^2 wall tiles, floor tiles, mozaics/: As said before only manufacture with prevailing proportion of special products produced in small series or even "tailored to measure" has a chance in Botswana. Sale of such products requires not only an experieneed sales organisation, but also a good climate in the market i. e. readiness of entrepreneurs to investment especially in catering and tourist industry and willingness of citizens to buy houses and improve flats.
From this viewpoint the pilot plant would be less risky. It should be said that this production unit, although performing some function of a pilot plant has infact industrial equipment and could expand in future.

Quick lime plant is feasible only with combined production of 5000 t grade for painting and flushing and 5000 t for mortars and plasters as a bond and coal fired. This combination was not discussed in Botswana and existing imports 4000-5000 ton should be verified before starting investment.

Enrichment of existing brickware manufacture seems to be very profitable.
If the required technical conditions are not attained in the first brick factory in Gaborone, they should be taken into account in the planned factory at Francistown.

A feasibility study for a cement factory has not yet been prepared and the development of asbestos mines has not yet been finished. Consequently the data are not yet available on which an asbestos - cement plant based on local materials could be run in Botswana.

9.8 Analytical part (A. P.)

9.8.1 Industrial plant 150 000 m^2 of wall tiles

9.8.1.1 Technology and technological equipment

The plant should be located on the Makoro-Moralana deposit next to the railway. Raw materials except for pegmatite will be mined within short distance from the factory. Bush, surface layer and overburden will be removed once a year or in a longer period by bulldozer and excavator. Where overburden or raw material should surpass the hardness acceptable for earthmoving machinery, blasting will be applied for disintegration.

The mined raw materials are transported onto piles from which they will be successively delivered to the plant by a team of 4 workers and 1 driver. This team will be equipped with a tractor and trailer, a transportable conveyor driven by petrol engine and with hand tools.

Pegmatite will be transported from a distance of about 70 km in the same way. It will be mined once in two years or in a longer period in a similar way as the other raw materials. Glazes and stains if need be, will be transported by railway. The reserve of raw materials stored in the plant will be for one month only as their maturing will take place on the dumping grounds on the deposit. This reserve will be increased up to triple quantity before the rainy season.

Raw materials delivered in lumps are passed through the jaw crusher and the disintegrated material is passed by conveyors into boxes protected by a light roof. Here they are loaded on a travelling balance and transported after being weighed onto a platform over the ball mills and are charged manually. A metered quantity of water is added as well. The mixture is finely ground to sieve residue 2-3 % relating to sieve openings 0.063 mm. After milling the slurry is discharged, passed through a vibrating screen into a cistern where it is blunged with a propeller mixer. From the cistern the slurry is pumped through a vibrating screen and over a magnetic separator into further two storage cisterns one of which is filled while the slurry from the other one is pumped into filter pressess by diaphragm pumps. Dewatered cakes are dried in a tunnel drier. The dried body is passed into a pan mill with perforated path (openings 2 and 3 mm) where it is ground to the pressing powder of humidy 5-7 %.

Wall tiles are pressed on a hydraulical press in dimensions 150 x 150 x 6 mm. Pressed wall tiles are stacked, stacks loaded on kiln cars and dried in the channel drier by lost heat from biscuitfiring. Dried tiles are fired in the tunnel kiln to the temperature of 1100 °C. After firing damaged biscuits are rejected and sorted biscuits are transported to the glazing machine. In this phase manual underglaze decorations can be applied before glazing as well as overglaze decorations can be made after glost firing.

The glazed wall tiles are inserted into saggars on kiln cars and fired to temperature of 1030 °C. The fired ware is sorted, packed into crates or cartons and transported to the store.

Industrial plant - technological equipment

The following technological equipment is proposed for the described process:

Pos.	Pcs.	
1		Mining clays and pegmatite
2	2	Transportable petrol-driven conveyor 10 m/400 mm
3	1	Tractor with trailer
4	10	Roofed boxes for raw materials attached to the production premises
5	1	Belt conveyor 6 m /400 mm
6	1	Belt conveyor 15 m / 400 mm
7	1	Clay crusher 6 t/h
8	1	Belt conveyor 15 m/600 mm
9	1	Belt conveyor 15 m/600 mm provided with discharge tippler
10	10	Boxes for crushed raw materials in the production hall
11	1	Travelling balance 1000 kp
12	1	Skip elevator 0.5 m^3, 8 m
13	1	Charging platform over the ball mills
14	2	Flow meters 100 l / min.
15	2	Ball mills for wet grinding of capacity 4400 l
16	1	Vibrating screen 236 meshes/cm^2
17	1	Vibrating screen 2500 meshes / cm^2
18	1	Propeller mixer 3,5 m^3
19	1	Diaphragm pump 100 l / min
20	1	Electromagnetic separator 8 m^3/h
21	2	Propeller mixer 1.7 m^3
22	2	Pressure pump for transport of slurry to filter-presses
23	4	Filter-press 2000 l
24	1	Collecting belt conveyor, 800 mm
25	1	Cutting and tearing equipment for cakes
26	1	Belt conveyor 600 mm
27	60	Drier car of cage type

Pos.	Pcs.	
28	1	Channel drier 11x5x1.65 m with 4 channels, incl. 2 oil heaters
29	1	Box feeder 6 m^3/h
30	1	Clay crusher 6 t/h
31	1	Bucket elevator 10 t/h
32	1	Belt conveyor 600 mm provided with side rake
33	2	Pan grinder 3 t/h
34	2	Vibrating screen 800 x 2000 mm
35	1	Belt conveyor 600 mm
36	3	Concrete box for working body
37	3	Turnstile feeder Ø 500 mm, 6 m^3/h
38	1	Belt conveyor 600 mm
39	1	Vibrating screen 800 x 200 mm
40		Transport routes towards presses (covered belt conveyors)
41	1	Hydraulic press with 2 cavities and pressure 125 - 250 t
42	210	140 kiln cars for drier of pressed tiles and for biscuit firing kiln
43	1	Channel drier heated with waste heat from biscuit firing
44	2	Circulation fan
45	1	Fan for air exhausting
46		Circulation air distributing piping
47	2	Insulated door of drier
48	2	Thermometer for inlet and outlet temperature
49		Insulated air distribution piping between kiln and drier
50	2	Hydraulic pusher and driving unit
51a	1	Tunnel kiln 44x3.2x2.25 m for biscuit firing incl. steel accessories, air conditioned, oil heating system, control system, electric insultation.
51b	1	Tunnel kiln for glost firing of dimmensions and accessories as 51 a
52	4	Hand operated crossing tranfer table

53	4	Hydraulic jacks
54	2	Feeder of biscuits incl. disintegrating equipment
55	2	Glazing line
56	2	Travelling container for pitches, o.5 m^3
57	2	Sorting belt conveyor
58	6	Table for packing
59	4	Travelling container for breakage o.25 m^3
60	2	Platform truck for transport to store
61	1	Travelling pulley block
62	1	Charging platform over ball mill
63	1	Ball mill for wet grinding, capacity 800 l
64	1	Double vibrating screen 800 x 2000 cap.
65	1	Electromagnetic separator
66	2	Diaphragm pump capacity 50 l/min.
67	1	Propeller mixer, capacity 1.7 m^3
68	1	Propeller mixer, capacity 1 m^3
69		Tubing for glaze distribution
70		Rail transport system
71		Air compressor for discharging ball mills

9.8.1.2 Industrial plant - investment

Fixed assets

Site development, buildings and civil engineering work (1)

	Kula
Site development incl. price of land	[illegible] 000
Production hall 2 000 m^2 incl. [illegible] boxes for raw materials at [illegible]	130 000
Office premises and laboratory [illegible] m at 50 P/m^2	6 000
3 septic tenks incl. piping	1 [illegible]
Fencing 280 r. m. a. 4.20 P/r.m.	1 1[illegible]
Water supply connection	1 2[illegible]
Transformer and ower line connection	11 000
Factory rail connection siding	20 000
Total	1[illegible] 576
Unforseen	17 4[illegible]
Site development and buildings - total	1[illegible]0 000

Machinery and equipment (2)

(as per specification) - FOB price		935 000
Sea transport cost and insurance	[illegible]	117 [illegible]
Terrestre transport in Africa	1[illegible]	[illegible] 000
		1151 [illegible]
Erection costs	25 [illegible]	2[illegible] [illegible]
Subtotal		1439 000
Locally delivered seel accessories and bricks for driers and Kilns		140 000
Unforseen		1[illegible] 000
Machinery and technological equipment total		1[illegible] 000
Fixtures, laboratory and workshop equipment		150 000
Transportation:		
1 tractor		7 500
1 trailer		2 500

1 truck	11 000
Transportation total	21 [illegible]
Machinery equipment and transportation total	1 8[illegible]4 000
Fixed assets - total	2 084 000

<u>Pre-investment and start-up expenses</u>

<u>Pre-investment costs</u>	Kula
Preliminary expenditure and lay-out plans	52 000
Interest during construction (11% of 1 726 000)	190 000
Engineering during construction	31 000
Total	273 000
<u>Start up expenses</u>	
Trial run costs	62 000
Other investment - total	335 000

<u>Working capital - inventories</u>	
Raw materials (6 months)	8 000
Glazes and stains (3 months)	28 000
Fuel oil (1 month)	9 000
Auxiliary materials and spareparts (3 months)	8 000
Work-in-process	16 000
Finished products (1 month)	62 000
Packing material (2 months)	6 000
Total	137 000
<u>Accounts receivable</u>	
Customers 20 days	77 000
Working capital - total	214 000

<u>Summary:</u>

Fixed assets	2 084 000
Pre-investment a start up expenses	335 000
Working capital	214 000
Total investment	2 633 000

9.8.1.3 Industrial plant - production and prices

Table 48

Commodity	m^2	Pula/m^2	Total value Pula
White wall tiles 150 x 150 mm	60 000	4.90	294 000
Coloured wall tiles 150 x 150 mm (plain colours)	15 000	7.60	114 000
Coloured wall tiles 150 x 150 mm (rural décors applied by silk screen small scale orders)	50 000	12.00	600 000
Coloured wall tiles 150 x 150 mm (manually applied rural décors small scale orders)	25 000	16.00	400 000
	150 000		1 408 000

The table is based on the maximum production programme of wall tiles proposed in the Market Study (p. 111)
The price are based on the present level. Also operating cost and investment costs will be calculated at present prices.

White wall tiles would be sold in Botswana and exported to Zambia only (see Market Study p. 111). As a protective duty (of 25 %) is proposed on imported white wall tiles in conformity with Customs Union regulations (infant industry) the price 490 P/m^2 will be under the sum of the present landed cost+future 25 % protective duty value (4.47 + 1.12 = 5.59 P, f.page 101). As far as Zambia's market is concerned the difference between the price 1.[illegible] P/m^2 in Botswana and landed cost 9.50 K/m^2 of white wall tiles imported at present to Zambia is sufficient to cover transport cost and import duty in Zambia and to leave still a sufficient margin in favour of Botswana's products.

Coloured wall tiles had to be subdivided into three groups with regard to quality and different prices. Plain colours are priced (7.60 P/m^2) lower than present landed cost (7.95P/m^2). Prices of silk screen décors and manually applied décors are substancially lower than those of comparable products.

9.8.1.4 Operating costs

Raw materials

Raw materials	Quantity ton	Price P/t	Cost Pula
Mudstone grey MR /TS 3/	450	6.99	3 146
Mudstone dark MR /TS 4/	447	6.99	3 125
Sandstone background /TS 33/	848	7.69	6 521
Pegmatite SP /TS 18/	192	16.00	3 072
Crushed biscuits	192/100/	1.64	164
Total	2 129		16 038

The costs of raw materials include only mining and stock piling in the deposit provided by a contractor and contingencies connected with opening and running the mine. The cost of crushed biscuits includes only direct costs for 100 t biscuits per year. The other 92 t will be returned from kilns as pitches /rejects/.

Glazes and stains	Quantity ton	Price P/t	Cost Pula
Glazes	150	665	99 750
Stains	2.7	4 560	12 315
Total			112 065

Energy	Pula per year
Consumption of electricity is based on calculated specific consumption of 400 kWh per ton of wet products:	
1 500 x 400 KWH = 600 000 KWH	
600 000 x 0.047 P =	28 200

Consumption of fuel oil:

2 heaters for drying of [illegible]

evaporated water: [illegible]

specific consumption [illegible]

450 000 x 1600 Kcal = 720 [illegible] = 72[illegible] 000 Mcal

1 tunnel kiln for [illegible] firing

1450 Mcal/t of net products

1 tunnel kiln for glost firing

1780 Mcal/t of net products

Consumption of both kilns:

1500 x 3230 Mcal = 4 8[illegible]5 000 Mcal

Summary:

2 heaters for drying cakes	72[illegible] 000 Mcal
2 tunnel kilns	4 845 000 Mcal
	5 565 000

5 565 000 Mcal:9231 Mcal = 603 t of fuel oil

603 x 183 P =	110 349 P

Water consumption:

1500 x 1,5 m^3 = 2250 m^3

2 250 x 3 P =	6 750 P
Cost [illegible] - total	145 299 P

Operating supplies /Materials, spare parts and repairs provided externally/	Cost Pula
Buildings and civil engineering works	
2 % of 172 575 P	3 452
Production equipment	
4 % of 1 43[illegible] 000 P	57 560
Maintenance of transportation	2 000
Consumption of fuel for transport	3 000
Total	66 012

Wages

Workers -manning table	1st shift	2nd shift	3rd shift	4th shift	Total
Transport of raw materials	5				5
Crushing raw materials	1				1
Charging and discharging ball mills	1	1	1		3
Filterpressing and drying cakes	1	1	1		3
Attendance of press for wall tiles	1	1			2
Loading on kiln cars	1	1			2
Handling kiln cars and kiln furniture	1	1	1	1	4
Attendance of kilns	1	1	1	1	4
Sorting fired biscuits	1				1
Glazing and painting	5				5
Inserting glazed ware into saggars	5				5
Sorting glazed wall tiles	2				2
Packing	1				1
Transport to store	1				1
Store of products	2				2
Kiln car repair shop	1				1
Machine work shop and maintainance	6				6
Off site transport	3				3
Guards, cleanrs, etc.	3	1	1	1	6
Total	42	7	5	3	57

Profession	Number	Wages (Pula)		
		per hour	per year	total cost
Foreman	4	1.40	2 800	11 200
Fitter	4	1.20	2 400	9 600
Electrician	2	1.20	2 400	4 800
Skilled worker	33	0.90	1 800	59 400
Unskilled worker	8	0.30	600	4 800
Driver	2	3.40p.day	850	1 700
Security guard	4	2.50p.day	625	2 500
	57			94 000

Wages are calculated on 250 working days and 2000 working hours per year.

Other expenses connected with wages	Cost Pula
6 paid holidays	2 256
15 days paid leave	5 640
paid sickness, medical care	10 000
Total	17 896

Salaries (local personnel)	Cost Pula
1 Manager	7 200
3 Technicians	14 400
1 Bookkeeper	4 800
2 Assistant and typist	4 800
4 Purchase and sales staff	14 400
11 Total	45 600

Besides 1 miningengineer, 1 technologist and 1 designer will be requested by the Government for the start-up period in the framework of United Nations Development Programme.

Personnel cost - summary:	Pula
Wages	94 000
Other personal expenses	17 896
Salaries	45 600
Total	157 496

Administrative costs	Cost Pula
Administrative costs	
5 % of personal costs	7 875
Housing allowances	6 600
Total	14 475

Sales costs	Cost Pula
Packing, travel expenses and publicity (excl. personal costs)	45 000

Table 49

Summary of production expenditure:	Pula
Raw materials	16 028
Glazes and stains	112 065
Energy	145 299
Operating supplies	66 012
Personal costs	157 496
Administrative costs	14 475
Sales costs	45 000
Total	556 375

Depreciation

1. Physical depreciation (Pula)

Assets and pre-investment	Original value	%	Production 1-5 yearly	years 6-13 yearly	Res. value
Machinery equipment	1873000	7.5	141 000	141 000	40000
Transportation	21000	20.0	4 200	4 200+	8400
Buildings	190000	4.0	7 600	7 600	91200
Pre-investment	335000	20.0	67 000	-	-
	2 419 000		219 800	152 800	139600

+replacement

2. Depreciation rezerve

After 13.3 years machinery will be worn out and the following minimum reserve should be available for financing new equipment and a partial reserve for buildings to be further increased till the 25th year of production:

	Pula
Machinery, equipment	1 873 000
Transportation	12 000
Buildings	99 000
Pre-investment	200 000
Total minimum reserve	2 184 000

3. Depreciation allowances for tax computation

According to the Income Tax Act allowances in respect of various types of expenditure are granted as follows:
New industrial buildings - total equals 115 %, 15 % being an annual allowance granted at rate of 10 % per year for ten years.
New plant and machinery - total equals 125 %, 25 % being an investment allowance granted in the year of first use and 100 % being an annual allowance granted at whatever rate investor chooses provided that the total allowed shall be not more than the total relevant expenditure.

Table 50 Calculation of income tax - Industrial plant

Year	1	2	3	4	5	6	7	8
	Investment		Production					
Sales			704000	1126000	1408000	1408000	1408 000	1 408 000
Loss brought forward				2283356	1856712	1213947	546322	-
Production expenditure			382496	490496	556375	556375	556375	556 375
Depreciation on buildings			47500	19000	19000	19000	19000	19 000
Depreciation on machinery			2367500	-	-	-	-	-
Interest			189860	189860	189860	165000	132000	99 000
Total			2987356	2982712	2621947	1954322	1253697	674 375
Taxable profit/loss			-2283356	-1856712	-1213947	- 546322	+ 154303	+ 733 625
Tax 35 % on profit			-	-	-	-	54006	256768

Year	9	10	11	12	13	14	15
Sales	1 408 000	1408 000	1408000	1408000	1 408 000	1 408 000	1 408 000
Loss brought forward	-	-	-	-	-	-	-
Production expenditure	556 375	556 375	556 375	556 375	556 375	556 375	556 375
Depreciation on buildings	19 000	19 000	19 000	19 000	-	-	-
Depreciation on machinery	-	-	-	-	-	-	-
Interest	66 000	33 000	-	-	-	-	-
Total	641 375	608 375	575 375	575 375	556 375	556 375	556 375
Taxable profit/loss	766 625	799 625	832 625	832 625	851 625	851 625	851 625
Tax 35 % on profit	268 319	279 869	291 418	291 418	298 069	298 069	298 069

9.8.1.5 Financing

Total investment comprises the following figures:

	Pula
Fixed assets	2 084 000
Pre-investment and start up expenses	335 000
Working capital	214 000
Total investment	2 633 000

Funding:

As only half of the working capital is needed before starting production the required sum of funds will be lower:

2 633 000 - 107 000 = 2 526 000 P

The increase of working capital in the first and second year of production will be covered from sales revenue.

The funds will consist of

Equity (31.7)	800 000 P
Loan (68.3)	1 726 000 P
Total 100.0 %	2 526 000 P

Repayment of loan and interest:

Year	Outstanding loan	Repayment	Interest 11 %
1 investment			
2 investment	1 726 000	-	included in pre-inv. cost
3 production	1 726 000		189 860
4 "	1 726 000		189 860
5 "	1 726 000	226 000	189 860
6 "	1 500 000	300 000	165 000
7 "	1 200 000	300 000	132 000
8 "	900 000	300 000	99 000
9 "	600 000	300 000	66 000
10 "	300 000	300 000	33 000
		1 726 000	

9.8.2 Pilot plant - 50 000 m^2 of wall tiles, 5 000 m^2 floor tiles and mozaics

9.8.2.1 Pilot plant - technology and technological equipment

The plant would be located on the Makoro-Moralana Deposit next to the reilway. Raw material except for pegmatite will be mined in occurrences near the plant. Bush, surface layer and over burden will be removed once a year by bulldozer and excavator. Where the hardness of overburden or raw material should exceed capacity of earthmoving machinery, blasting will be applied for disintegration.
The mined raw materials are transported on to piles from where they will be successively delivered to the plant by a team of workers and 1 driver. This team will be equipped with a tractor and trailer, a transportable conveyor provided by a petrol driven engine and with hand tools. Pegmatite will be transported from a distance of about 70 km in the same way. It will be mined once in a longer period depending on availability of earthmoving machinery. Glazes and stains will be delivered by railway. Raw materials will be stored in roofed boxes attached to the production premises.

Finegrained raw materials are delivered directly into boxes, materials in lumps are manually fed to the jaw crusher and transported into boxes after crushing. Raw materials are loaded according to the recipe into the hopper of a travelling balance. The hopper is transported by a travelling pulley block onto theplatform over the ball mill where raw materials and water are charged. After milling slurry is discharged and passed through vibrating screens into a cistern where it is mixed by a propeller mixer and pumped into filterpresses. Dewatered cakes from filter presses are dried in a channel drier to a humidity of 6 %, then they are ground,granulated and moistened if need be in a pan grinder with perforated path provivided with openings 2-3 mm up to a humidity 5-7 %. Pressing body is fed into hoppers from where it is transported over a checking vibrating screen into the hopper of the press. Wall tiles are pressed on a mechanical press provided with two cavities. Press tiles are dried in the shuttle drier and fired in the oil fired shuttle kiln to 1100 °C. Glazes are delivered to the plant ready made and packed in bags. Glaze is delivered by a travelling block on a platform over a ball mill into which it is charged with water. The ground glaze is discharged from the ball mill over vibrating sereens and electromagnetic separator into a cistern provided by a propeller mixer. Products are glazed on a glazing machine or are decorated by hand as underglaze or overglaze.

In case of experimental manufacture of floor tiles or mozaics the same equipment for body preparation can be used. For pressing, however, other pressing dies and stamps are required. Therefore one additional second hand press is recommended for experimental production of floor tiles and mozaics. Floor tiles are fired in stacks interlaid by chamotte slabs. Insofar as they are not glazed they are fired only once to 1200 °C. After firing the stacks are unloaded, disintegrated, classified with regard to quality, shade and dimensions if need be.

Mozaics requires also different pressing dies and stamps. In experimental manufacture mozaics taken from the press can be immedietly iserted into saggars in vertical direction. Insofar as mozaics is not glazed it is only once fired to the temperature of 1200 °C. After firing mozaics pieces are glued on paper in squares 30 x 30 cm or 40 x 40 cm.

Pilot plant - technological equipment

The following technological equipment is proposed for the discribed process:

Pos.	Pcs.	
1		Mining clays and pegmatite
2	1	Transportable motorized, petrol-driven conveyor 10 m/400 mm
3	1	Tractor with trailer
4	4	Roofed boxes for raw materials attached to the production hall
5	1	Belt conveyor 6 m/ 400 mm
6	1	Belt conveyor 10 m/400 mm
7	1	Clay crusher 6 t/h
8	1	Belt conveyor 10 m/600 mm
9	1	Belt conveyor 10 m/600 mm provided with discharge tippler
10	4	Boxes for crushed raw materials in the production hall
11	1	Travelling balance 1000 kp
12	1	Travelling pulley block 1000 kp
13	1	Charging platform over the ball mill
14	1	Flow meter 100 l/min
15	1	Ball mill for wet grinding capacity 3200 l
16	1	Vibrating screen 236 meshes/cm^2
17	1	Vibrating screen 2500 meshes/cm^2
18	1	Propeller mixer 3,5 m^3
19	1	Diaphragm pump 50 l/min
20	1	Electromagnetic separator 8 m^3/h
21	2	Propeller mixer 1 m^3
22	1	pressure Pump for transport of slurry to filter presses
23	2	filter-press 1000, 2000 l
24	1	Collecting belt conveyor, 800 mm
25	1	Cutting and tearing of cakes

Pos.	Pcs.	
26	1	Belt conveyor 600 mm
27	30	Drier car of cage type
28	1	Channel drier 11x2.5x1,65,2 channels, incl. 1 oil heater
29	1	Box feeder 6 m^3/h
30	1	Clay crusher 6 t/h
31	1	Bucket elevator 10 t/h
32	1	Belt conveyor provided with side rake
33	1	Pan grinder 3 t/h
34	1	Vibrating screen 800 x 2000
35	1	Belt conveyor 600 mm
36	2	Concrete box for working body
37	2	Turnstile feeder Ø 500 mm, 6m^3/h
38	1	Belt conveyor 600 mm
39	1	Vibrating screen 800 x 2000
40		Transport routes towards presses (covered belt conveyors)
41	2	Mechanical presses with two cavities and pressure 125-250 t each. One of the pressess with additional dies and stamps for floor tiles and mozaics (second hand)
42	12	Kiln car
43	1	Shuttle drier 14,5 m^3 incl. oil heater
44	1	Circulation fan
45	1	Fan for air exhausting
46		Circulation fan distributing piping
47	2	Insulated door of drier
48	2	Thermometer 0-200 °C for inlet and outlet temperature
49		
50		
51a	1	Shuttle kiln, oil heated, 14.5 m incl. accessories, air conditioning, control system, electric instalation
51b	1	Shuttle kiln, oil heated, 28 m^3 with the same equipment

Pos.	Pcs.	
52	2	Hand operated crossing transfer table
53	3	Hydraulic jacks
54	1	Feeder of biscuits incl. disintegrating equipment
55	1	Glazing line
56	1	Travelling container for pitches 0,5 m^3
57	1	Sorting belt conveyor
58		
59	2	Travelling container for breakage 0,5 m^3
60	1	Platform truck for transport to store
61	1	Travelling pulley block
62	1	Charging platform over ball mill
63	1	Ball mill for wet grinding, capacity 400 l
64	1	Double vibrating screen 800 x 2000 cap.
65	1	Electromagnetic separator 8 m^3/h
66	2	Diaphragm pump 50 l /min.
67	1	Propeller mixer 1 m^3
68	1	Propeller mixer 0,7 m^3
69		Tubing for glaze distribution
70	1	Sorting belt conveyor incl. disintegrating equipment
71	2	Table for packing
72	1	Travelling container for pitches
73	6	Table for glueing mozaics
74	2	Table for packing mozaics
75		Rail transportation system
76	1	Air compressor

9.8.2.2 Pilot plant - investment

Fixed assets

Site development, buildings and civil enginnering work /1/

	Pula
Site development incl. price of land	2 000
Production hall 1400 m^2 incl. attached boxes for raw materials at 65 P/m^2	91 000
Office fremises and laboratory 100 m^2 at 50P/m^2	5 000
2 septic tanks incl. piping	800
Fencing 280 r. m. at 4.20 P/r.m	1 176
Water supply connection	1 200
Power line connection	5 000
Subtotal	106 176
Unforeseen	10 824
Site development and buildings total	117 000

Machinery and equipment /2/

/as per specification/- FOB price	400 000
Sea transport cost and insurance 20 %	80 000
Terrestre transport 10 %	40 000
	520 000
Erection costs 25 %	130 000
	650 000
Locally delivered steel accessories and bricks for driers and kilns	50 000
Unforeseen	52 000
	752 000
Fixtures, laboraty and workshop equipment	130 000
Transportation	
1 tractor	7 500
1 trailer	2 500
1 truck	11 000
Transportation total	21 000
Machinery, equipment and transportation - total	903 000
Fixed assets - total	1 020 000

Pre-investment and start-up expenses

Pre-investment costs	Pula
Preliminary expenditure and lay-out plans	25 700
Interest during costruction 846x0.11	93 000
Engineering during construction	15 300
Total	134 000
Start-up expenses	
Trial runcosts	30 000
	164 000

Working capital - inventories	
Raw materials /6 months/	3 204
Glazes and stains /3 months/	10 925
Fuel oil /1 month/	3 858
Auxiliary materials and spare parts /3 months/	4 265
Work-in-process	9 177
Finished products /1 month/	35 738
Packing material /2 months/	1 833
Total	69 000
Accounts receivable	
Customers 20 days	35 000
Working capital - total	104 000

Summary:

Fixed assets	1 020 000
Pre-investment and start-up expenses	164 000
Working capital	104 000
Total investment	1 288 000

Note: 104 000 P of working capital refer to full capacity operation. For starting production only 62 000 P will be required. Consequently the inital funding will be only 1 246 000 P.

9.8.2.3 Table 51 Pilot plant - production and prices

Commodity	m^2	Pula/m^2	Total value Pula
White wall tiles 150 x 150 mm	15 000	4.90	73.500
Coloured wall tiles 150 x 150 mm /plain colours/	5 000	7.50	37 500
Coloured wall tiles 150 x 150 mm /décors applied by silk screen, small orders/	5 000	12.00	60 000
Coloured wall tiles 150 x 150 mm /manually applied rurul décors, small orders/	25 000	16.00	400 000
	50 000		571 000

Experimental production:			
Floor tiles 100 x 100 mm	3 000	10.00 /average/	50 000
Mozaics 20x20, 20x40	2 000		
	5 000		50 000

The indications are based on the minumum production programme of wall tiles proposed in the Market Study /p. 111/. Coloured wall tiles are specified with regard to quality and prices. Applied prices for Industrial plant a Pilot plant are indentical.

9.8.2.4 Operating costs /1st year of full production/

Raw materials

Raw materials for wall tiles:

Raw materials	Quantity ton	Price P/t	Cost Pula
Mudstone grey MR /TS3/	150	6.99	1049
Mudstone dark MR /TS4/	149	6.99	1042
Sandstone-background /TS 33/	283	7.69	2176
Pegmatite SP /TS18/	64	16.00	1024
Crushed biscuits	64/33/	1.64	54
Total	710		5345

The cost of crushed biscuits includes only direct costs for 33 t biscuits per year. The other 31 t will be returned from kilns as pitches /rejects/.

Raw material for floor tiles and mozaics:

Raw materials	Quantity ton	Price P/t	Cost Pula
Clay green-brown MRL /TS 5/6/	109	7.10	774
Pegmatite /TS 18/	13	16.00	208
Laterite /TS 27/	27	3.00	81
Total	149		1063

Glazes and stains	Quantity ton	Price P/t	Cost Pula
Glazes	52	665	34 580
Stains	2	4 560	9120
Total			43700

Energy

	Pula per year
Consumption of electricity:	
specific value 390 KWH per ton of net products	
600 x 390 KWH = 234 000 KWH	10 998
234 000 x 0.047 P =	

Consumption of fuel oil:

1 heater for drier of dewatered body /cakes/

ewaporated water : 600 x 0.3 t = 180 t

specific consumption: 1600 kcal/kg of evap. water

180 000 x 1600 kcal = 288 000 000 kcal = 288 000 Mcal

1 heater for shuttle drier /pressed products/

evaporated water: 600 x 0.07 t = 42 t

specific consumption 1600 kcal/kg of evap. water

42000 x 1600 kcal = 67 200 000 kcal = 67 200 Mcal

2 shuttle kilns

3500 Mcal/t of net products /wall tiles/

2300 Mcal/t of net products /floor tiles and mozaics/

500 x 3500 Mcal = 1 750 000 Mcal

100 x 2300 Mcal = 230 000 Mcal

1 980 000 Mcal

Summary:

1 heater for drying cakes	288 000 Mcal
1 heater for shuttle drier	67 200 Mcal
2 shuttle kilns	1 980 000 Mcal
	2 335 200 Mcal

2 335 200 Mcal : 9 231 Mcal = 253 t of fuel oil

	Pula/continued/
253 x 183 P	46 299
Water consumption	
600 x 1.5 m^3 = 900 m^3	
900 x 3P	2 700
Cost of energy - total	59 997

Operating supplies /materials, spare partsand repairs provided externally	Cost Pula
Buildings and civil engineering works	
2 % of 106 176	2 124
Production equipment	
4 % of 650 000	26 000
Maintenace of transportation	2 000
Consumption of fuel for transport	4 000
Total	34 124

Wages

Workers - manning table	1st shift	2nd shift	3rd shift	4th shift	Total
Transport of raw materials	4				4
Crushing raw materials	1				1
Charging and discharging ball mills	1				1
Filter pressing and drying cakes	1	1	1		3
Attendance of press	1				1
Loading on kiln cars	1				1
Handling kiln cars and furniture	1	1	1		3
Attendance of kilns	1	1	1		3
Sorting fired biscuits	1				1
Glazing and painting	3				3
Inserting glazed ware in saggars	2				2
Sorting glazed wall tiles	1				1
Packing	1				1
Store of products	2				2
Kiln car repair shop	1				1
Machine workshop and maint.	6				6
Off site transport	3				3
Guards, cleaners etc.	3	1	1	1	6
Total	34	4	4	1	43

Profession	Number	Wages /Pula/ per hour	per year	total cost
Foreman	3	1.40	2 800	8 400
Fitter	4	1.20	2 400	9 600
Electrician	2	1.20	2 400	4 800
Skilled worker	22	0.90	1 800	39 600
Unskilled worker	6	0.30	600	3 600
Driver	2	3.40p.day	850	1 700
Security guard	4	2.50p.day	625	2 500
Total	43			70 200

Wages are calculated on 250 working days and 2000 working hours per year.

Other expenses connected with wages	Cost Pula
6 paid holidays	1 685
15 days paid leave	4 212
paid sickness, medical care	4 000
Total	9 897

Salaries of local personnel:	Cost Pula
1 Manager	6 200
1 Technician	4 800
1 Bookkeeper	4 800
1 Typist	2 400
2 Purchase and sale staff	9 600
Total	27 800

Summary of personal costs:	Pula
Wages	70 200
Other personal expenses	9 897
Salaries	27 800
	107 897

Administrative cost	Cost Pula
5% of personal costs	5 395
Housing allowances	3 600
Total	8 995

Sales costs	Cost Pula
Packing travel expenses and publicity (excl. personal costs)	18 000

Table 52

Summary of production expenditure:	Pula
Raw materials	6 408
Glazes and stains	43 700
Energy	59 997
Operating supplies	34 124
Personal costs	107 897
Administrative costs	8 995
Sales costs	18 000
Total	279 121

Depreciation

1. Physical depreciation (Pula)

Assets	Original value	%	Production years 1-5 yearly	Production years 6-13 yearly	Residual value at the end of 13th production year
Machinery equipment	882 000	7.5	66150	66150	22 050
Transportation	21 000	20.0	4200+	4200+	1 680
Buildings	117 000	4.0	4700	4700	55900
Pre-investment	1[illegible] 000	20.0	22800	-	-
	11[illegible]4 000		107850	75050	79630

+Replacement

2. Depreciation reserve

After 13.3 years machinery will be worn out and the following minimum depreciation reserve should be available for financing new equipment and a partial reserve for buildings to be further increased till the 25th year of production:

	Pula
Machinery equipment	882 000
Transportation	21 000
Buildings	117 000
Pre-investment	71 000
Total	1091 000

3. Depreciation allowances for tax computation Rates of allowances are indicated in part 9.8.1.4.

4. Computation of income tax
   See following table No. 53

Table 53 **Calculation of income tax - Pilot plant**

Year	1	2	3	4	5	6	7	8
	Investment		Production					
Sales			373 000	497000	621000	621000	621000	621000
Loss brought forward			-	1070242	926781	689662	448033	193754
Production expenditure			218 432	248779	279121	279121	279121	279121
Depreciation on buildings			29 250	11700	11700	11700	11700	11700
Depreciation on machinery			1102500	-	-	-	-	-
Interest			93 060	93060	93060	88550	75900	63250
Total			1443 242	1423781	1310662	1069033	814754	547825
Taxable profit/loss			-1070 242	-926781	-689622	-448033	-193754	+73175
Tax 35 % on profit			-	-	-	-	-	25611

Year	9	10	11	12	13	14	15
	Production						
Sales	621 000	621 000	621 000	621 000	621 000	621 000	621 000
Loss brought forward	-	-	-	-	-	-	-
Production expenditure	279 121	279 121	279 121	279 121	279 121	279 121	279 121
Depreciation on buildings	11 700	11 700	11 700	11 700	-	-	-
Depreciation on machinery	-	-	-	-	-	-	-
Interest	50 060	37 950	25 300	12 650	-	-	-
Total	340 881	328 771	316 121	303 471	279 121	279 121	279 121
Taxable profit/loss	280 119	292 229	304 879	317 529	341 879	341 879	341 879
Tax 35 % on profit	98 042	102 280	106 703	111 135	119 658	119 658	119 658

9.8.2.5 Financing

Total investment consists of the following items:

	Pula
Fixed assets	1 020 000
Pre-investment and start-up expenses	164 000
Working capital	104 000
Total investment	1 288 000

Funding:

Half of the working capital being only needed before starting production, the required sum of funds will be lower:

1.288 000 - 42 000 = 1 246 000 P

Further increase of 42 000 P in the first years of production will be covered from sales revenue.

The funds will consist of

Equity	(32.1 %)	400 000 P
Loan	(67.9%)	846 000 P
Total	/100.0%/	1 246 000 P

Repayment of loan and interest:

Year		Outstanding loan	Repayment (At the end of each year)	Interest 11 %
1	investment			
2	investment	846 000	Interest included in start-up expenses	
3	production	846 000		93 060
4	"	846 000		93 060
5	"	846 000	41 000	93 060
6	"	805 000	115 000	88 550
7	"	690 000	115 000	75 900
8	"	575 000	115 000	63 250
9	"	460 000	115 000	50 600
10	"	345 000	115 000	37 950
11	"	230 000	115 000	25 300
12	"	115 000	115 000	12 650
			846 000	633 380

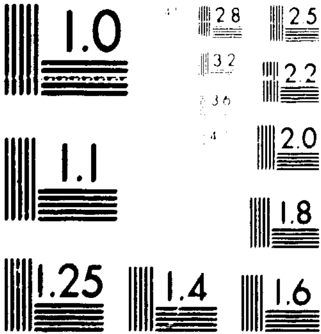
9.8.3 Quick lime plant

9.8.3.1 Quick lime plant - technology and technological equipment

The location of the plant being not yet decided it is supposed to be next to a deposit /Mmadinare or other deposits/ for these considerations.
The technology is very simple. Limestone is blasted by explosives, bigger pieces of disintegrated rock are broken down by heavy hammers. Limestone for quick lime applied for painting and flushing must be very pure without any contaminations. Therefore it should be stored separately in the quarry. Sorted limestone is loaded on cars or narrow gauge railway tip trucks and transported to a jaw crusher where it is crushed to sizes 80 - 120 mm.
Crushed limestone and coal are delivered by means of a skip equipment into the dome of the kiln and charged according to a programme. The kiln is fired by local coal. Burnt lime is transported by a roofed belt conveyor onto a roofed ramp where it is stored, lime for painting and flushing is filled in bags, binding lime for mortars and plasters is stored and despatched in bulk.

Technological equipment

Pos.	Pcs.	
1		Mining limestone
2	4	Cart/Tip Truck
3	1	Jaw crusher 600 x 180 mm, 4 m^3/h
4	1	Box feeder 6 m^3/h
5	1	Belt conveyor 10 m/600 mm
6	1	Skip elevator 0.5 m^3
7	1	Shaft kiln, coal fired, with accessories
8	-	
9	-	
10	1	Fan
11	1	Roofed conveyor belt 12 m/600 mm
12	1	Storage of burnt lime in roofed



MICROCOPY RESOLUTION TEST CHART

Pos.	Pcs.	
13	1	Transportable belt conveyor 6m/400 mm
14	1	Filling and weighing equipment
15	1	Belt conveyor of bags onto lorries
16	1	Belt conveyor of bulk limestone

9.8.3.2 Investment

Fixed assets

Site development and buildings

	Pula
Site development	1 000
Office premises 50 m^2 at 50 P/m^2	2 500
Porer line connection	2 000
Roofed storing and loading ramp	3 000
	8 500
Unforseen	500
	9 000
Machinery and equipment - FOB price	360 000
Sea transport cost and insurance - 20 %	72 000
Terrestre transport in Africa - 10 %	36 000
	468 000
Erection costs - 25 %	117 000
	585 000
Transportation: 2 trucks	22 000
Technological equipment and transportation - total	607 000
Fixed asets - total	616 000

Other investment

Pre-investment costs:	
Lay-out plans	15 000
Interest during construction	59 000
Preliminary expenditures	10 000
Total	84 000

Start up expenses:	
Trial run costs	12 000
Other investment - total	96 000

Working capital

Inventories:	
Raw materials (1 month)	10 000
Coal (1.5 month)	4 500
Spare parts (3 months)	12 000
Finished products (1 month)	13 500
Packing material (2 months)	4 000
Total	44 000
Accounts receivable	21 000
Working capital - total	65 000

Summary:	
Fixed assets	616 000
Other investment	96 000
Working capital	65 000
Total investment	777 000

9.8.3.3 Production and prices

Annual production

	Quantity t	Price F/t	Total value F
Quick lime for flushing and painting	5 000	60.00	300 000
Binding quick lime for mortars and plasters	5 000	18.00	90 000
	10 000		390 000

9.8.3.4 <u>Operating costs</u>

<u>Raw materials</u>

The only raw material is limestone which must be blasted. About the double quantity by weight is required compared to tonnage of fired product.

The cost per ton of limestone exclusive of wages is lower than costs of ceramic materials indicated in preceding parts where application of heavy earth moving machinery was calculated. The cost of limestone includes only cost of quarry development, explosives, drilling tools, 10 % contingencies and estimated at 3P/t exclusive of wages.

	Quantity t	Price P/t	Cost P
Limestone	20 000	3.00	60.00

<u>Energy</u> — Pula

Electricity:
64000 KWH x 0.047 P — 3 008

<u>Coal</u>

Applied coal - local coal of calorific value 5660 Kcal/t

Calorific consumption for 10 000 t burnt lime: 1150 Kcal x 10 000 = 11 500 000 Kcal

Consumption of coal:
11 500 000 Kcal : 5660 Kcal = 2032 t

The specific consumption 5660 Kcal/t applies to fuel oil. With regard to lower efficiency of coal firing double quantity of coal is applied for cost calculation:

4000 t x 9P = 36 000 +

Total cost of energy 39 008

+Cost for fuel would be 190 18[illegible] P if heavy oil is applied

Operating supplies (spare parts and repairs provided externally)	Cost Pula
2 % of 585 000 P	11 700

Wages and salaries

Workers - manning table	1st shift	2nd shift	3rd shift	4th shift	Total
Blasting and supervision of quarry	1				1
Drilling holes for explosives	1				1
Manual crushing, sorting, transport	6	6			12
Charging lime and coal into skip	2	2	2	2	8
Operation of kiln and accessories	1	1	1	1	4
Filling bags and loading	2				2
Maintenance	1	1			2
Driver	2				2
Total	16	10	3	3	32

	Number	Wages (Pula) per hour	per year	total cost
Foreman	1	1,40	2 800	2 800
Fitter/electrician	2	1,20	2 400	4 800
Skilled workers	11	0,90	1 800	19 800
Unskilled workers	16	0,30	600	9 600
Driver	2	3,40p.day	850	1 700
	32			38 700

Wages are calculated on 250 working days and 2000 working hours per week.

Other expenses connected with wages	P
Leave pay, sick pay, paid holidays, medical treatment	
15 % of 38 700 P	5 805

Salaries	Cost Pula
1 Manager	5 000
1 Accountant	4 000
1 Typist	2 400
Total	11 400

Personnel costs - summary	38 700
Wages	5 805
Other expenses	11 400
Salaries	
Total	55 905

Administrative costs	Cost Pula
3 % of personnel costs	1 677

Sales costs	Cost Pula
Packing and other excl. wages	20 000

Table 54

Summary of production expenditure :	Pula
Raw material (excl. wages)	60 000
Energy	39 008
Operating supplies	11 700
Personnel costs	55 905
Administrative costs	1 677
Sales costs	20 000
Total	188 290

Depreciation

1. Physical depreciation (Pula)

Assets and pre-investment exp.	Original value	%	Production years 1 - 5 yearly	6 - 13 yearly	Residual value
Machinery equipment	585 000	7.5	43 875	43 875	14 625
Transportation	22 000	20.0	4 400	4 400*	8 800
Buildings	9 000	4.0	360	360	4 320
Other investment	96 000	20.0	19 200	-	-
	712 000		67 835	48 635	27 745

*Replacement

2. Depreciation rezerve

After 13 years machinery will be wornout and a minimum reserve should be available for financing new technological equipment and adequate reserves for machinery and buildings to be further increased during remaining yars of their life times:

Machinery	585 000
Transportation	13 200
Buildings	4 680
Other investment	89 220
	692 000

3. Depreciation allowances for tax computation

Rates of allowances one indicated in part 9.8.1.4

4. Computation of income tax

See following table

Table 55

Calculation of income tax

Year	1	2	3	4	5	6	7
	Investment		Production				
Sales		390000	390 000	390 000	390 000	390 000	390 000
Loss brought forward		-	590 860	437 240	271 740	94 360	-
Production expenditure		188290	188 290	188 290	188 290	188 290	188 290
Depreciation on buildings		2250	900	900	900	900	900
Depreciation on machinery		731250	-	-	-	-	-
Interest		59070	47 190	35 310	23 430	11 550	-
Total		980860	827 240	661 360	484 360	295 100	189 190
Taxable profit/loss		-590860	-437 240	-271 740	- 94 360	+94 900	+200810
Tax 35 % on profit			-	-	-	33 215	70 293

Year	8	9	10	11	12	13	14
	Production						
Sales	390 000	390 000	390 000	390 000	390 000	390 000	390 000
Loss brought forward	-	-	-	-	-	-	-
Production expenditure	188 290	188 290	188 290	188 290	188 290	188 290	188 290
Depreciation on buildings	900	900	900	900	-	-	-
Depreciation on machinery	-	-	-	-	-	-	-
Interest	-	-	-	-	-	-	-
Total	189 190	189 190	189 190	189 190	188 290	188 290	188 290
Taxable profit/loss	+200810	+200810	+200 810	+200 810	+201 710	+201 710	+201 710
Tax 35 % on profit	70 283	70 283	70 283	70 283	70 598	70 598	70 598

9.8.3.5 Financing

Total investment of the following items

	Pula
Fixed assets	616 000
Other investment	96 000
Working capital	65 000
Total investment	777 000

Funding

The funds will consist of

Equity	30.89	240 000
Loan	69.11	537 000
Total	100.00%	777 000

Repyment of loan and interest:

Year	Outstanding loan	Repayment	Interest 11 %
1	537 000		-+
2	537 000	108 000	59 070
3	429 000	108 000	47 190
4	321 000	108 000	35 310
5	213 000	108 000	23 430
6	105 000	105 000	11 550

+Note: Interest is paid at the end of each year. Interest before start of production is included in pre-investment costs.

ANNEXE I,II,III

List of authorities, institutions and persons contacted during the first field trip (12. 6. - 4. 8. 1976)

Zambia

Geological Survey, Zambia :
Dr. Thieme, Director
Mr. Franke, geologist

Pragobuilders Ltd. Lusaka :
Ing. Čestmír Hemral, Contract Manager

Botswana

UNDP Gaborone:
Mr. Olav Svenevik, Resident Representative
Mr. C. Eruwayo, Deputy Resident Representative
Mr. Erick de Mul, Assistant Res. Rep.

Ministry of Mineral Resources and Water Affairs Gaborone :
Mr. Mustheng, Undersecretary
Mr. Pinta, Senior Planning Economist
Mr. Chanda, Planning Officer

Ministry of Commerce and Industry Gaborone :
Mr. Maehler, Planning Officer
Mr. J. Ter Haar, Director of Industrial Estate
Mr. Cau, Marketing Adviser
Mr. Schotte, Chief Architect

Botswana Development Corporation Ltd. Gaborone :
Mr. Paul Waller, Investment Officer

Geological Survey Department, Lobatse :
Mr. C. Jones, Director
Mr. K. O. Walshaw, Deputy Director
Mr. J. Davies, Assistant Director
Mr. Wroblicki, UNIDO Colsuntant
Mr. Gold, Geologist
Mr. Ermanovics, Geologist
Mr. Coates, Geologist
Mr. Key, Geologist
Mr. Spinner, Geologist

Serowe Brigade Development Trust, Serowe :
Mr. M. O. Brien, Director
Mr. Kopano Lekoma, Deputy Director

Statistics Department, Gaborone :
Mr. T. Bessel, Statistician

Customs and Excise, Gaborone :
Mr. Stone, Statistician
Mr. Tabor, Statistician

De Beers Botswana Mining Company, Gaborone :
Mr. Rose, Director General

Bamangwato Consession Ltd. Selebi Pikwe
Mr. Gordon, Chief Geologist

Coal Mines, Moropule
Mr. Thomas, Director

List of authorities, insitutions and persons contacted during the second field trip (21. 5. - 25. 6. 1977)

Zambia

UNDP Regional Office for Southeast Africa :

Mr. J. England, Senior Field Advisor
Mr. J. E. Kitzenberger, Administrative Assistant

Central Statistical Office, External Trade Section :
Mr. Snell, UNDP Expert
Mr. R. J. Mwena

Department of Customs and Excise :
officers in attendance

Zambian Industrial and Commercial Association, Chamber of Commerce :
Mr. L. P. Edwards - Chief Executive

Zambia National Import and Export Co.Ltd :
Mr. Maudu, General Manager
Mr. Tembo, Deputy General Manager

Zambia Clay Industries, Ltd. :
Mr. A. S. Mwemba, Sales Manager

William Jaks & Co (Zambia) Ltd. :
Mr. G. A. P. Cochram - General Manager

E. W. Tarry Zambia Ltd. :
Mr. J. B. Gomm, Manager

Pragobuilders Ltd. :
Mr. V. Štěpán, Contract manager

Botswana

UNDP Office Gaborone:
Mr. O. Svenevik, UNDP Resident Representative
Mr. C. Eruwayo, UNDP Deputy Resident Representative
Mr. P. Coinidis, Administrative Officer
Mr. G. P. Nyirenda, Senior Administrative Assistant

Ministry of Commerce and Industry :
Mr. K. G. [illegible], Chief Industrial Officer
Mr. H. [illegible], Senior Industrial Officer
Mr. H. [illegible]elo Industrial Officer
Mr. [illegible], Director of Botswana Enterprises Development Unit (BEDU)
Mr. Mogopodi, Marketing Officer
Mr. Cou, Marketing Advisor
Mr. Mechler, Planning Officer

Ministry of Finance and Development Planning
Mr. Isackson, Planning Officer
Mr. C. Kamp, Tax Advisor

Ministry of Local Government and Lands :
Mr. Watson, Planning Officer

Ministry of Works and Communications :
Mr. Schutte, Chief Architect
Mr. Collin Campbell, Building Coordinator
Mr. Swanson, Architect

Department of Taxes

Department of Customs and Excise:
Mr. D. [illegible]. Sandall
Mr. J. Stoneham

Department of Labour :
Mr. B. Magwabi, Commisioner of Labour
Mr. P. Olsen, Acting Chief, Industrial Relations Officer

National Statistics Office:
Mr. Cris Alison
Miss M. Nolefi

Geological Survey Lobatse :
Mr. Walsham, Deputy Director
Mr. B. Merengwa, Mr. Lüdtke

Botswana Housing Corporation :
Mr. Richardson, Managing Director

The Botswana Development Corporation, Ltd. :
Mr. Johnson, Deputy Managing Director
Mr. Waller, Investment Officer

Botswana Power Corporation :
Mr. Jackson, Mr. H. Baury

Botswana Water Utilities Corporation :
Mr. Skans, Direcotr
Mr. Ashford, Deputy Director

Building Contractors and Commercial firms in Botswana

Minestone Botswana Ltd. :
Mr. Adams, Manager General
Mr. Fraser, Contracts Manager

Botoka Construction Ltd. :
Mr. A. Woolls, Director

Costain Construction Ltd. :
Mr. A. Me Derment, Manager

Berger & Gibbon Ltd. :
Mr. W. Gibbon, Manager General
Mr. Hughes

Builders Merchants Botswana Ltd. :
Mr. C. R. Page, General Manager

Haskins & Sons Ltd. :
Mr. R. P. Coulter, General Manager

Powerglo Botswana Ltd. :
Mr. F. Holden, Manager

S. & B. Construction Ltd.; Barthmoving Contractors
Mr. D. J. Swart, Managing Director

British Petroleum Co. Ltd.
Mr. P. J. April, Manager

Earthmoving machinery Co. Ltd:
Sales Officer

Toyotha Co. Ltd.: Sales Manager

Layland Co. Ltd.: Sales Manager

International Trade and Transport Ltd.:
Service Gaborone: Contract Manager

Lesotho

UNDP Office:
Mr. Mumm von Mallincrodt, Deputy Resident Representative
Mr. Ö. Yücer, Programme Officer
Mr. William Buchanan, UNIDO Consultant

Ministry of Finance:
Mr. S. Brushett, Planning Officer

Ministry of Works:
Mr. Dahlerup, Senior Architect

Lesotho National Development Corporation:
Mr. B. Moshloli, Deputy Manager

BEDCO (Building Enterpreneur Development Corporation):
Mr. N. Fagan, Managing Director
Mr. B. Sebatene, Deputy Managing Director
Mr. B. Gunn, Project Officer

Forrest Construction Ltd.:
Mr. Forrest, Manager

Building Design Group of Architects - Inland Construction
Natal Ltd.:
Mr. Leaderack, Manager

Peter Hancock, Dipl. Arch., Chartered Architect

Steinbridge Housham and Mc Pharson-Architects:
Mr. Housham, Director

Thaba Bosin Ceramics Ltd.:
Manager

Swaziland

Mr. S. S. Hussein, UNDP Resident Representative
Mr. T. Van Gaallen, Programme Officer

Ministry of Industry, Mines and Tourism:
Mr. Hans Peter Hansen, Planning Officer

Ministry of POwer, Works and Communication:
Mr. H. Laroya, Senior Architect

Ministry of Finance and Economics:
Mr. J. R. Pater, Senior Statistician

Factory Distributors Ltd.:
Mr. J. Camp, Manager

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List of samples sent to the Institute for ceramics at Horni Briza

Czechoslovakia

(UNIDO Contract 76/1 - Botswana)

Signs: PRAGUE
EUROPE
VUK No. 1.....33

CONTENT

BAG No.	Sample No.	Area-Pit	Thickness	Species
	LS 1	MR-1	1,1 - 2,1	grey mudstone (flintclay)
	LS 2	MR-1	2,1 - 2,9	grey mudstone
	LS 3	MR-1	2,9 - 3,9	dark mudstone
	LS 4	MR-2	1,1 - 1,7	grey mudstone (flintclay)
	LS 5	MR-2	1,7 - 3,1	grey mudstone(calcrete and sandstone)
	LS 6	MR-2	3,1 - 4,1	dark mudstone
	LS 7	MR-3	1,5 - 3,0	grey mudstone,quartzite,sand-stone
1	LS 8	MRI-5	0,0 - 0,5	grey, humic and sandy clay
	LS 9	MRI-5	0,5 -1,0	brown-green clay
	LS 10	MRL-6	0,0 - 0,5	grey,humic and sandy clay
	LS 11	MRL-7	0,0 - 0,5	grey,humic and sandy clay
	LS 12	MR-4	1,0 - 2,8	light-grey mudstone (flintclay)
	LS 13	MR-4	2,8 - 4,8	grey-yellow mudstone
	LS 14	MR-4	4,8 - 6,2	grey-yellow mudstone
	LS 15	MI-B 84	-	light mudstone (silty)
	LS 16	HM-B 84/89	-	dark mudstone
	LS 17	MR-1	1,1 - 2,1	assorted grey mudstone(flintclay)
	LS 18	SP-1	-	clay tailings
	LS 19	SP-2	-	tailings (Fe)
	LS 20	MO-A	-	calcrete
	LS 21	MO-C	-	calcrete
	LS 22	Makoro Hills	-	marble (east on the road)
2	LS 23	Tonota	-	dolomitic marble(type Mladinare)
	LS 24	Mahalapye	-	granit (east Mahalapye river)
	LS 25	Maapi	-	quartzite biasement(Molapo river)
	LS 26	SP	boulders	granitic rock(from road to the airport)

cont.

CONTENT

Bag No.	Sample No.	Area-Pit	Thickness	Species
2	LS 27	SP	boulders	pegmatite(from road to the airport)
2	LS 28	Palapye	west	brick earth(Lotsane river)
2	LS 29	Palapye	south	old work shop brick
2	LS 30	Morupule	-	mudstone outcrop
3	LS 31	SW	river	calcrete(Motsemaswen river)
3	LS 32	SW	-	lime(pottery-training centre)
3	LS 33	Halfway kop	-	quartz
3	LS 34	Halfway kop	-	kyanite
3	LS 35	Halfway kop	-	kyanite bearing rock
3	LS 36	Tantebane kopje		pegmatite (one rock)
3	LS 37	Tantebane kopje		adamellite (one rock)
3	LS 38	Ramokgwebana		adamellite
3	LS 39	Ftown-brickearth		bricklay (bank Tati river)
3	LS 40	Gab. area quarry		dolerite (diorite) - L. J. Whyle Gaborone
3	LS 41	Gab. area quarry		granite-L.J.Whyle Gaborone
4	LS 42	Gab. deposit	-	brown-yellow,clayey and plastic silt
4	LS 43	Gab.deposit	-	brown-yellow,clayey and plastic silt
4	LS 44	Gab.deposit	-	brown-yellow,clayey and plastic silt (Fe scrumbles)
4	LS 45	Gab. deposit	-	red-brown,clayey and plastic silt
4	LS 46	Gab.deposit	-	red-brown,clayey and platic silt
4	LS 47	Gab.deposit	-	grey,humic,clayey and plastic silt
4	LS 48	Moshaneng	-	assorted lump-dolomite
4	LS 49	Moshaneng	-	crushed dolomite-not assorted
4	LS 50	Moshaneng	-	lump-talc
4	LS 51	SW-brickfield		brown-red brick clay,humic and plastic
4	LS 52	SW-Khutzwe		brown, silty clay
4	LS 53	Lobatse area quarry		stone crushes Lobatse
4	LS 54	Moshaneng new prosp.		asbestos
4	LS 55	Tuli Block	-	standbeck (near Mmasehumana)
4	LS 56	MRL-5	1,0 - 2,0	brown-green clay

CONTENT

Bag No.	Sample No.	Area-Pit	Thickness	Species
4	LS 57	MRL-5	2,0 - 2,4	brown-green clay and sandstone
4	LS 58	MRL-5	background	sandstone (fine grained)
4	LS 59	Matsilojе	-	syenite (north of Matsiloje)
4	LS 60	MR-2	4,1 - 4,6	grey mudstone and sandstone
-	TS 1	This sample was eliminated because of excess weight		
-	TS 2	This sample was eliminated because of excess weight		
5	TS 3	MR-2	1,7 - 3,1	grey mudstone(calcrete and sandstone)
6	TS 4	MR-2	3,1 - 4,1	dark mudstone
7	TS 5	MRL-5	0,0 - 0,5	grey,humic and sandy clay
8	TS 6	MRL-5	0,5 - 1,0	brown-green clay
9	TS 7	MR-4	1,0 - 2,8	light-grey mudstone(flintclay)
10	TS 8	MR-4	2,8 - 4,8	grey-yellow mudstone
11	TS 9	MR-4	4,8 - 6,2	grey-yellow mudstone
12	TS 10	MR-1	1,1 - 2,1	assorted light mudstone (flintclay)
13	TS 11	MM-B 84	-	light mudstone (silty)
14	TS 12	MM-B 84/89	-	dark mudstone
15	TS 13	MRL-5	1,0 - 2,0	brown-green clay
16	TS 14	MO-A	-	calcrete
17	TS 15	MO-C	-	calcrete
18	TS 16	Mappi	-	quartzite basement(Molapo river)
19	TS 17	SP	boulders	granitic rock (from road to airport)
19	TS 18	SP	boulders	pegmatite (from road to airport)
20	TS 19	Gab. area	quarry	dolerite (diorite)- L.J.Whyle Gaborone
21	TS 20	Gab. deposit	-	brown-yellow,clayey and plastic silt
22	TS 21	Gab. deposit	-	brown-yellow,clayey and plastic silt
-	TS 22	This sample was eliminated because of excess weight		
23	TS 23	Gab. deposit	-	red-brown,clayey and plastic silt
24	TS 24	Gab. deposit	-	red-brown,clayey and plastic silt
25	TS 25	Gab. deposit	-	grey,humic,clayey and plastic silt

BAG No.	CONTENT			
	Sample No.	Area-Pit	Thickness	Species
26	TS 26	Gab. power plant		coal ashes
27	TS 27	Lobatse area		laterite
28	TS 28a	Moshaneng	-	assorted lump - dolomite
	TS 28b	Moshaneng	-	crushet-dolomite not assorted
29	TS 29	Moshaneng	-	lump-talc
30	TS 30	SW-brickfield		brown-red clay, humic and plastic
-	TS 31	SW-Khutzwe		brown, silty clay
31	TS 32a	Moshaciva-8	-	coarse-gypsum, foley
	TS 32b	Moshaciva-8	-	fine-gypsum, foley
32	TS 33	MRL-5	background	sandstone (fine grained)
33	Petrographic samples			

Legend

MR = Makoro

MRL = Makoro-Moralana

MM = Mamabula

SP = Selebi-Pikwe

MO = Mookane

Gab. = Gaborone

Sw = Serowe

LS = Labora tory sample

TS = Technological sample

Lobatse, 27 July 1976

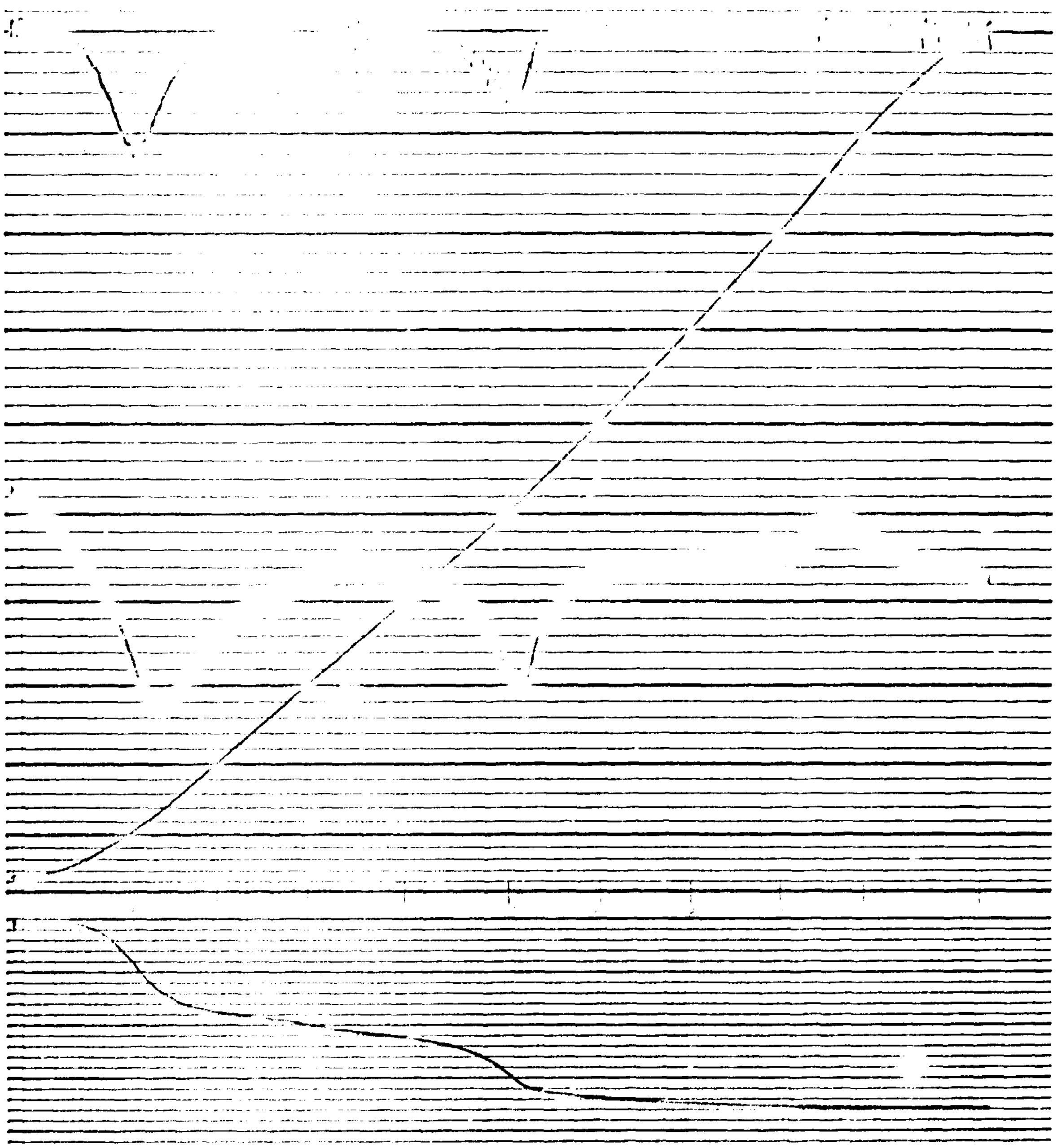
J. Drevo

Team Leader

UNIDO Contract Botswana 76/1

ANNEXE IV

TS 23 + TS 24 Diagram No. 1



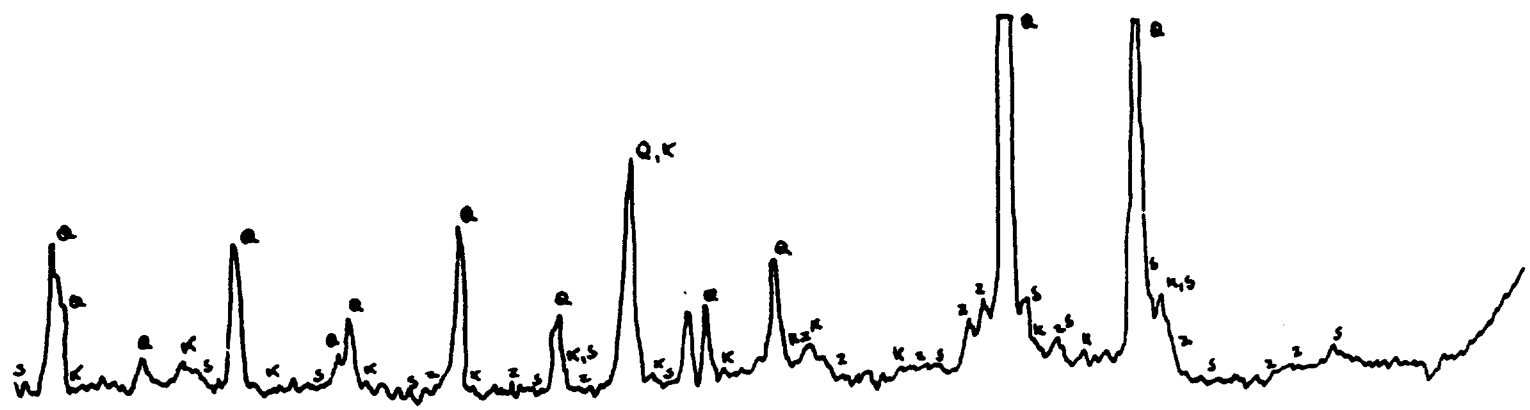
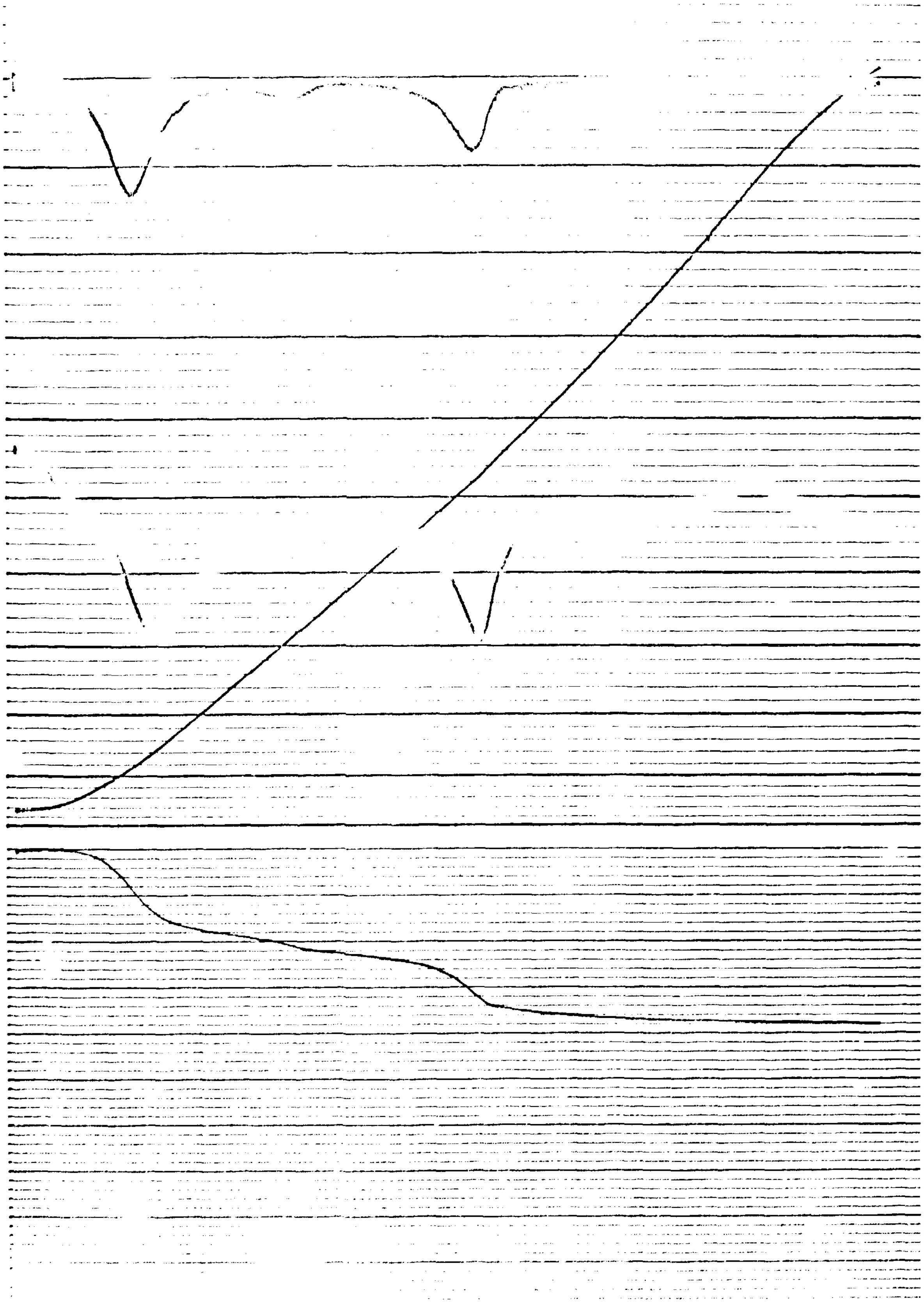


Diagram No. 2.

TS 20 + TS 21

Diagram No. 3



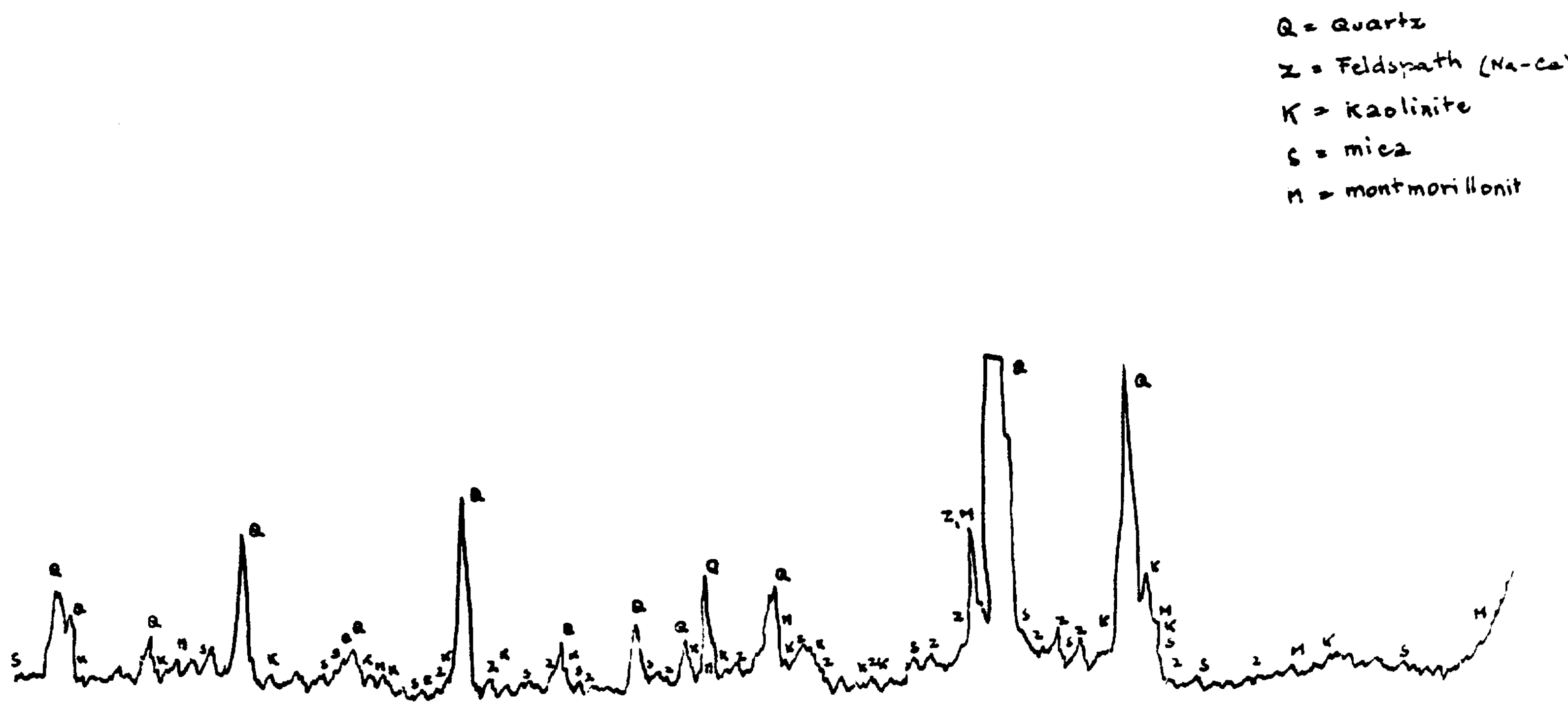

Q = Quartz
Z = Feldspath (Na-Ca)
K = Kaolinite
S = mica
M = montmorillonit

Diagram No. 4.

TS 25 Diagram No. 5

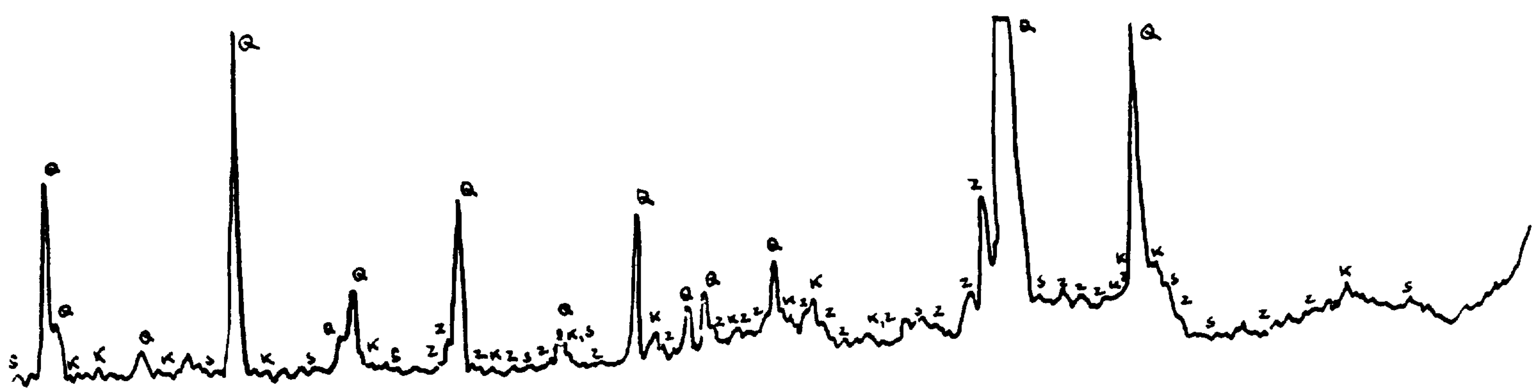
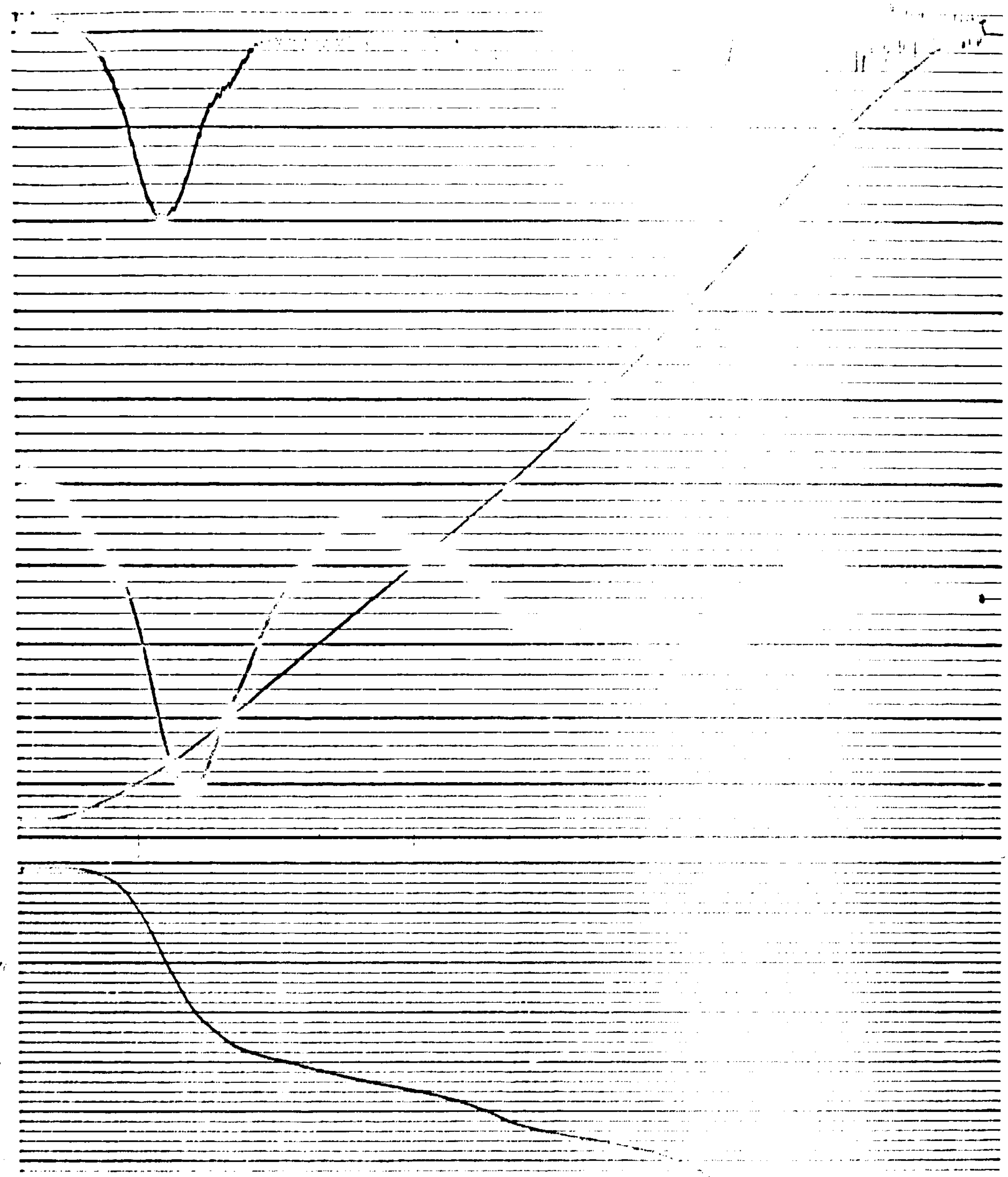


Diagram No. 6.

TS 30 Diagram No 7



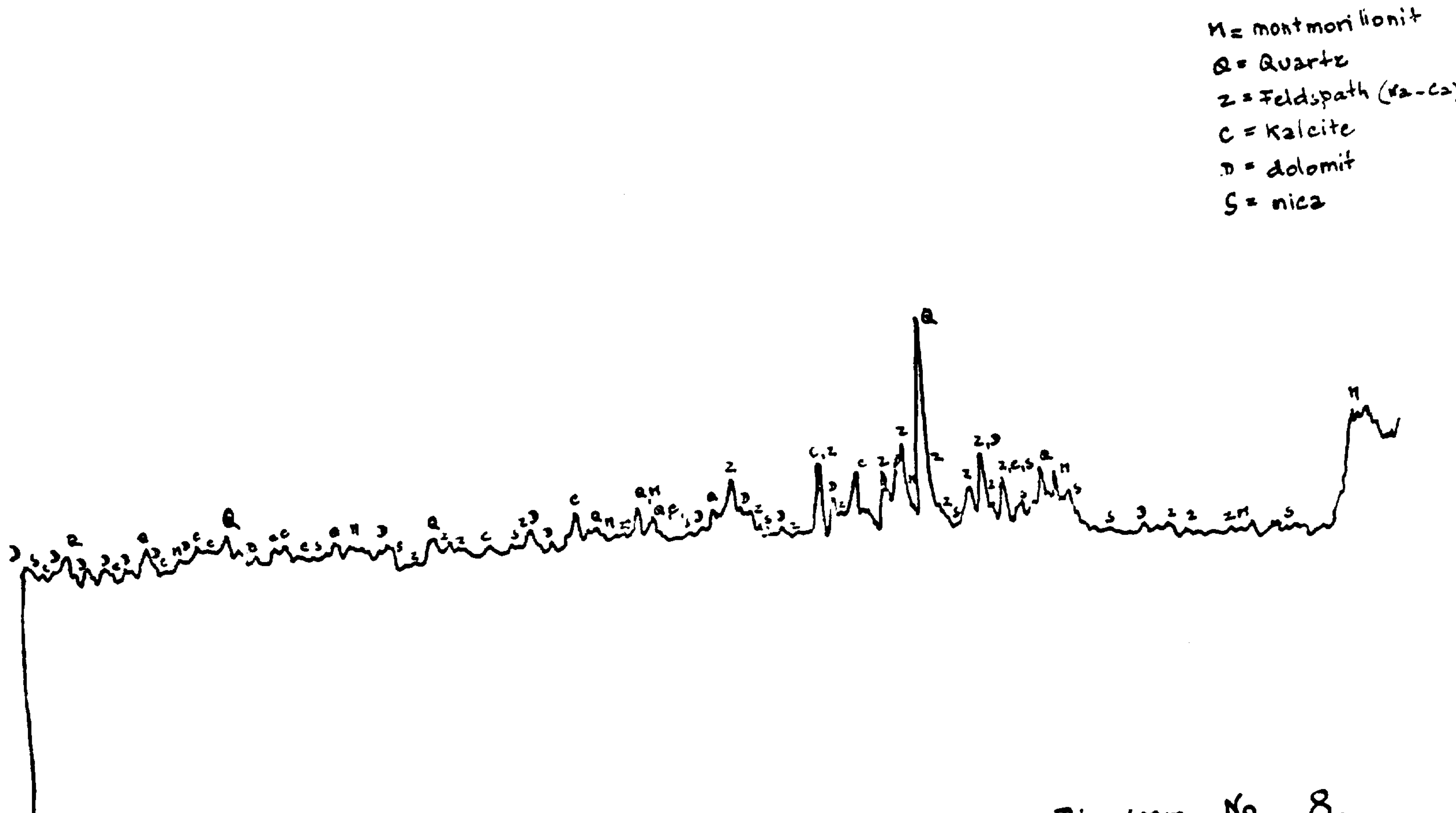
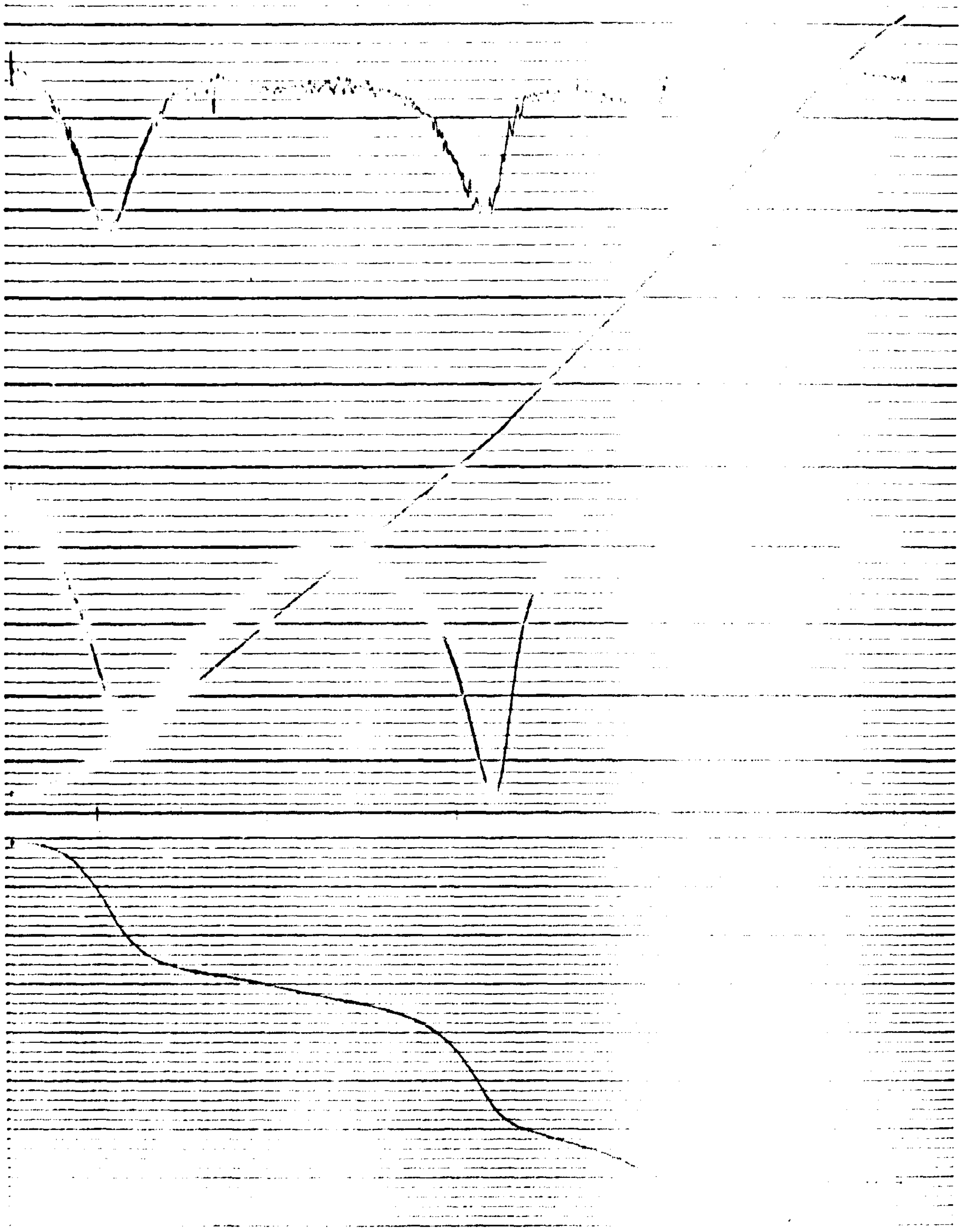

M = montmorillonit
Q = Quartz
Z = Feldspath (Na-Ca)
C = Kalcite
D = dolomit
S = mica

Diagram No. 8.

TS 11



Q = Quartz

K = Kaolinite

S = mica

M = montmorillonit

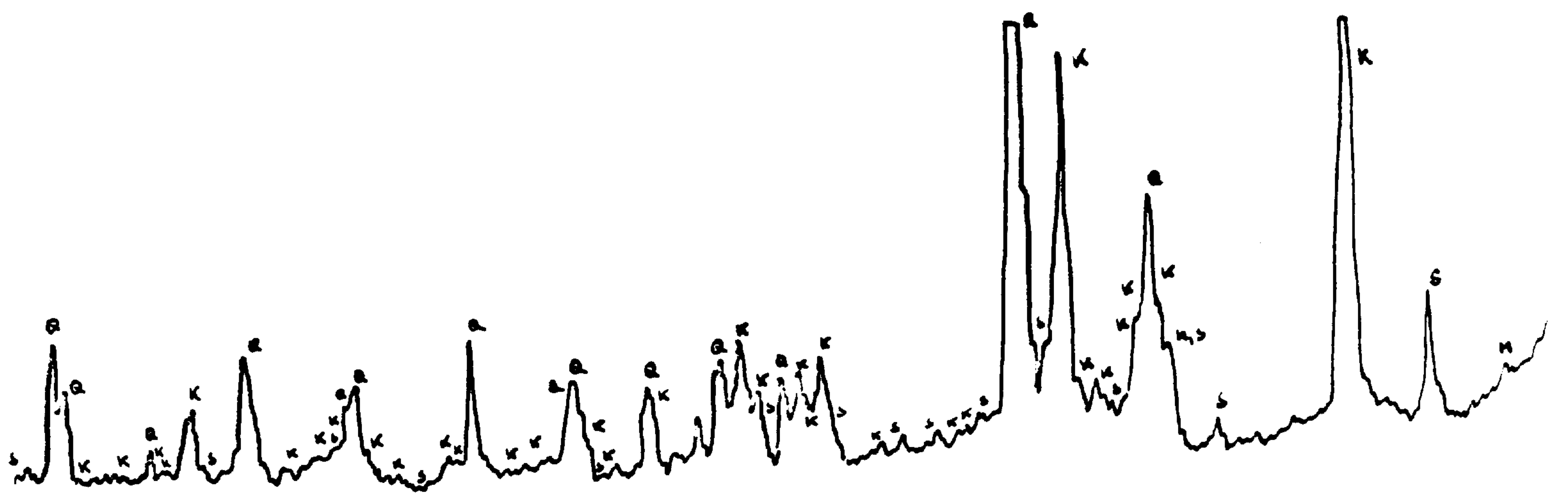
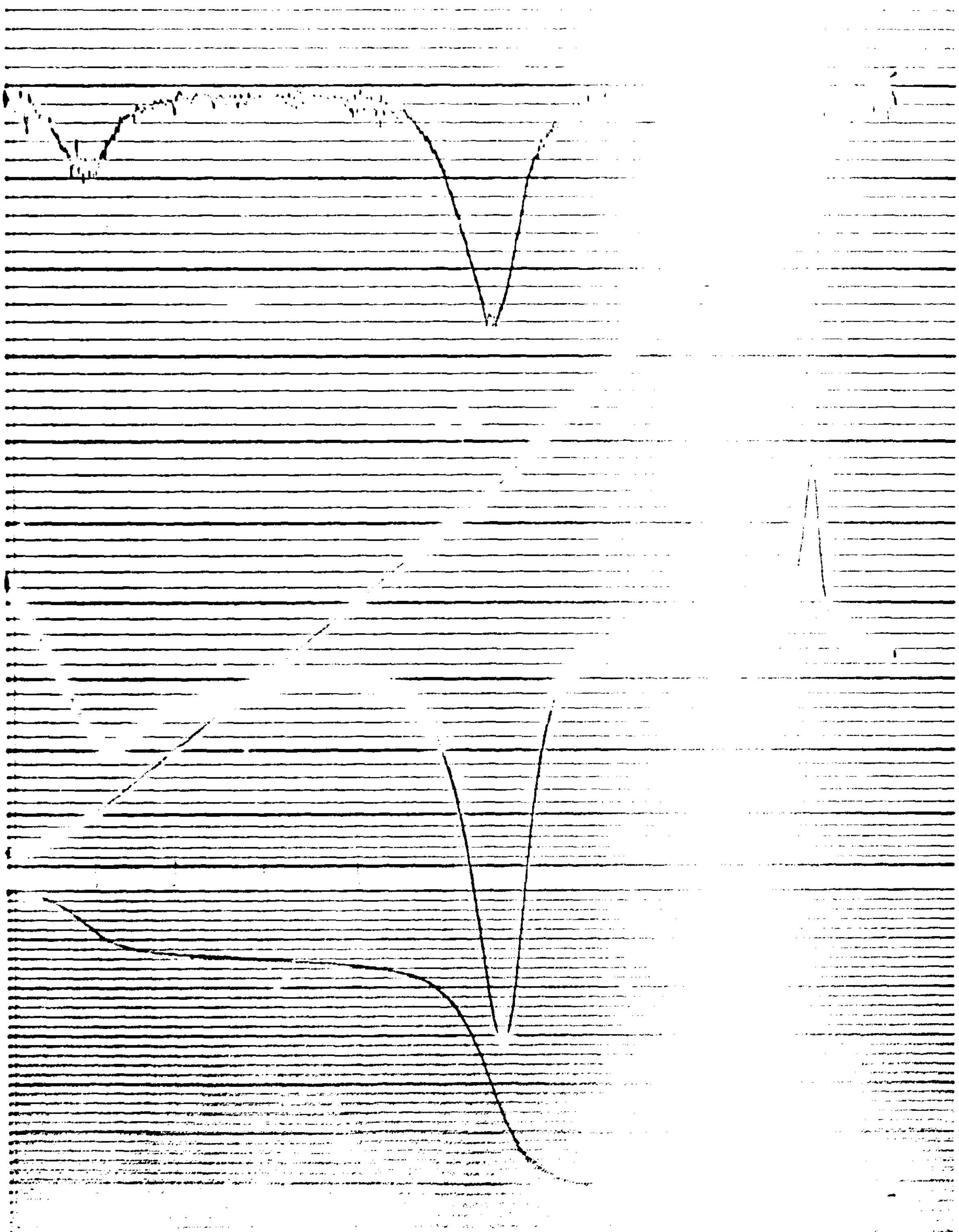


Diagram No. 10.

TS 12

Diagram … 11



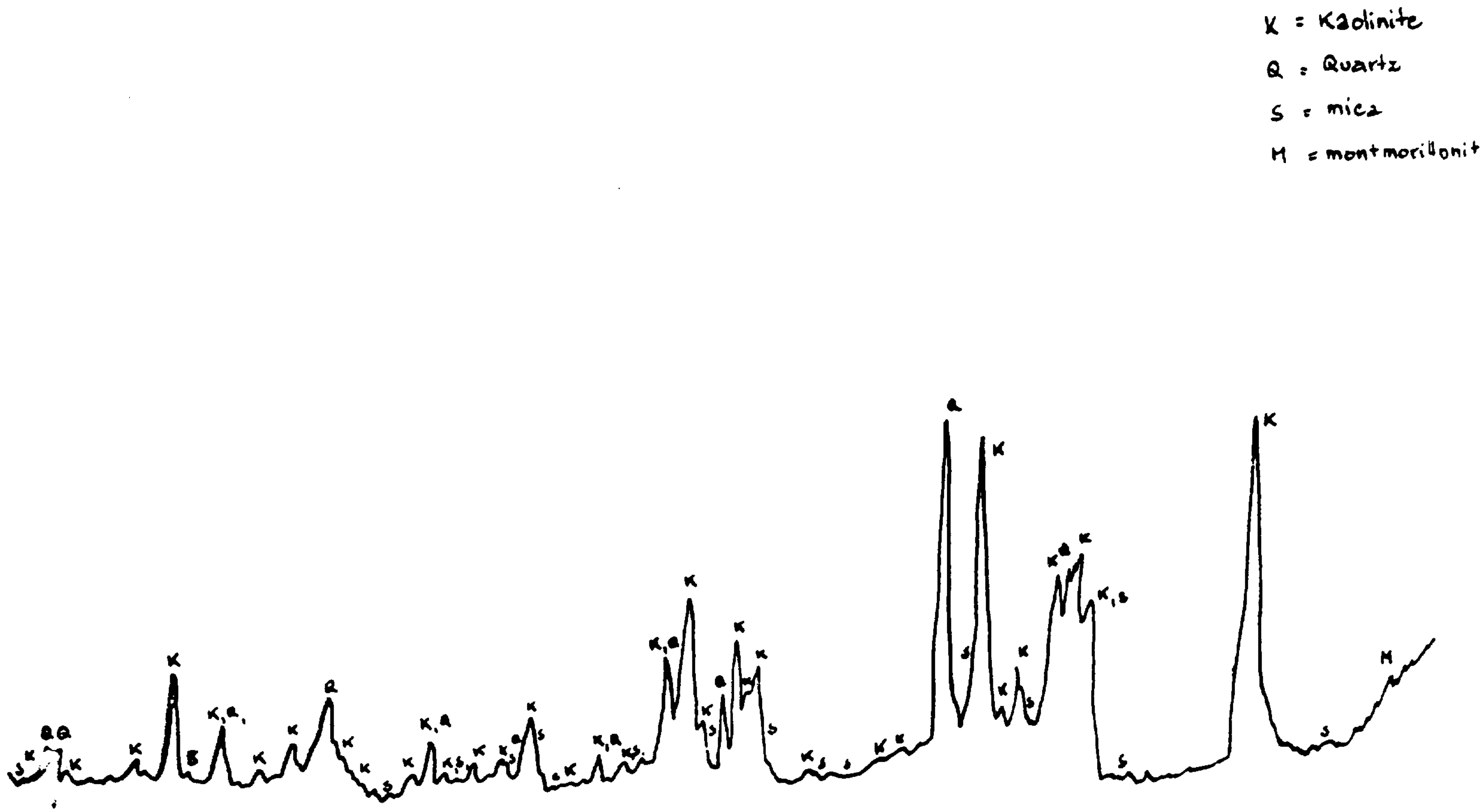
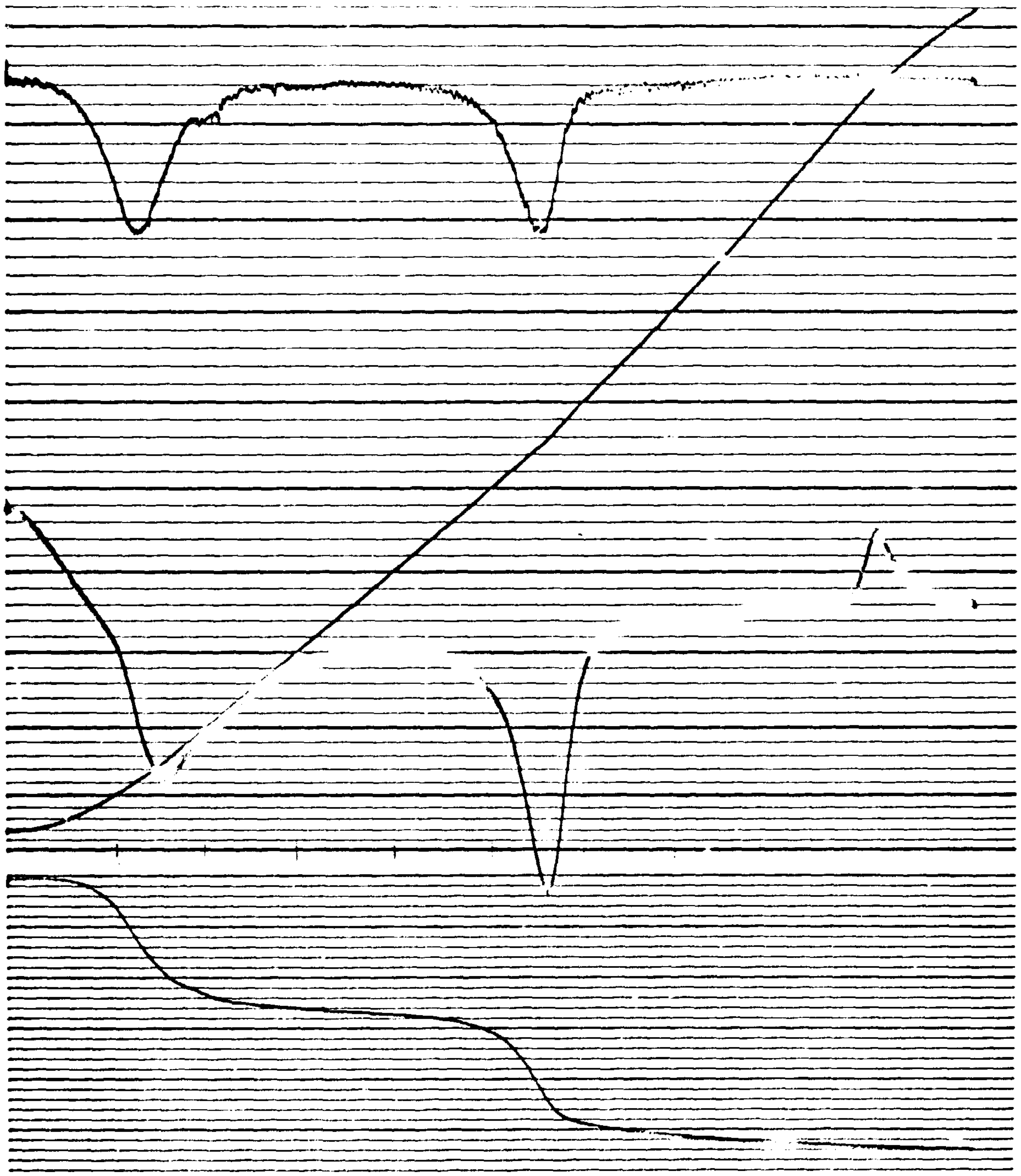


Diagram No. 12.

TS 3 Diagram No. 13



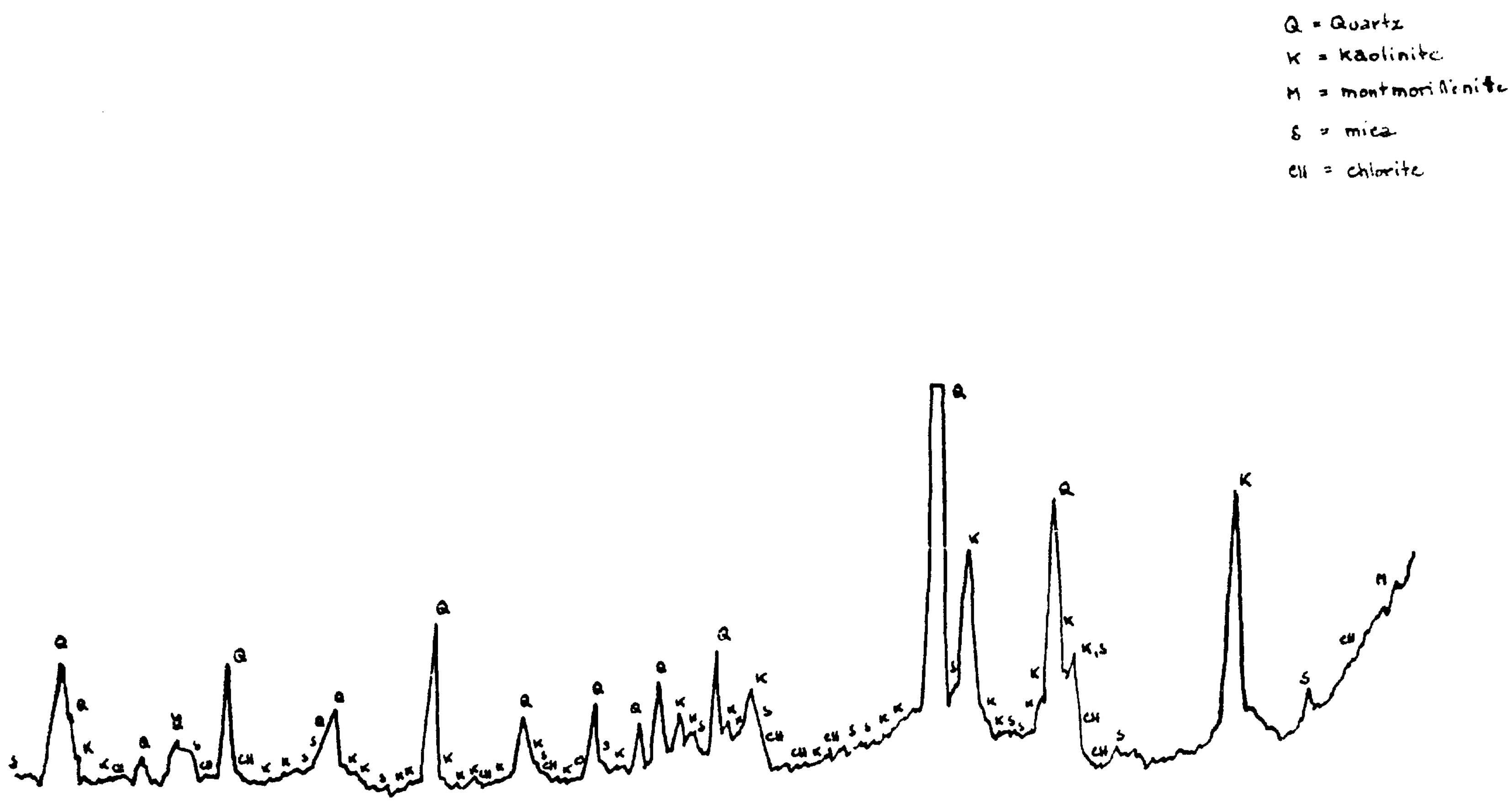
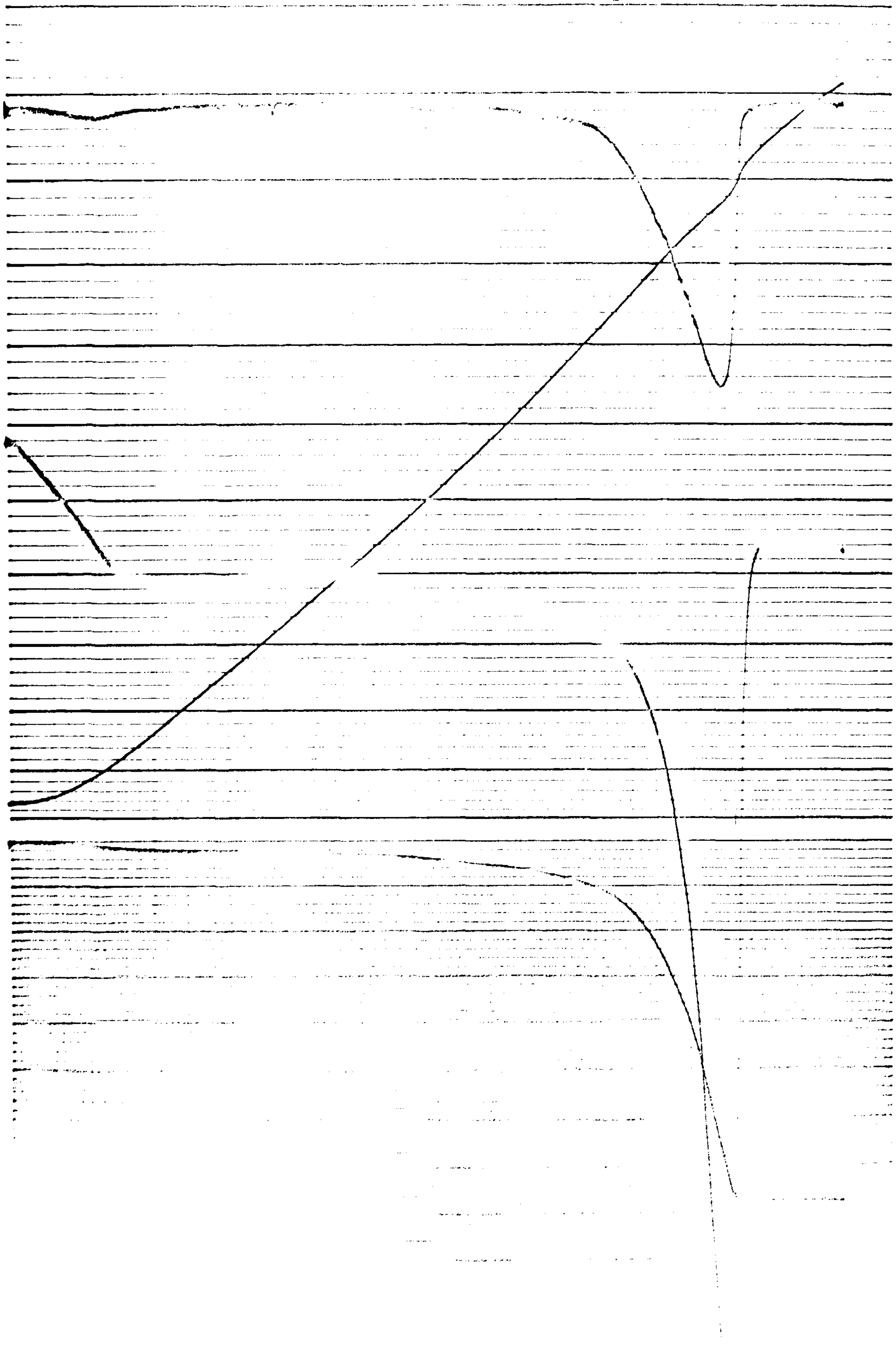


Diagram No. 14.

TS 3 calcite

Diagram No. 15



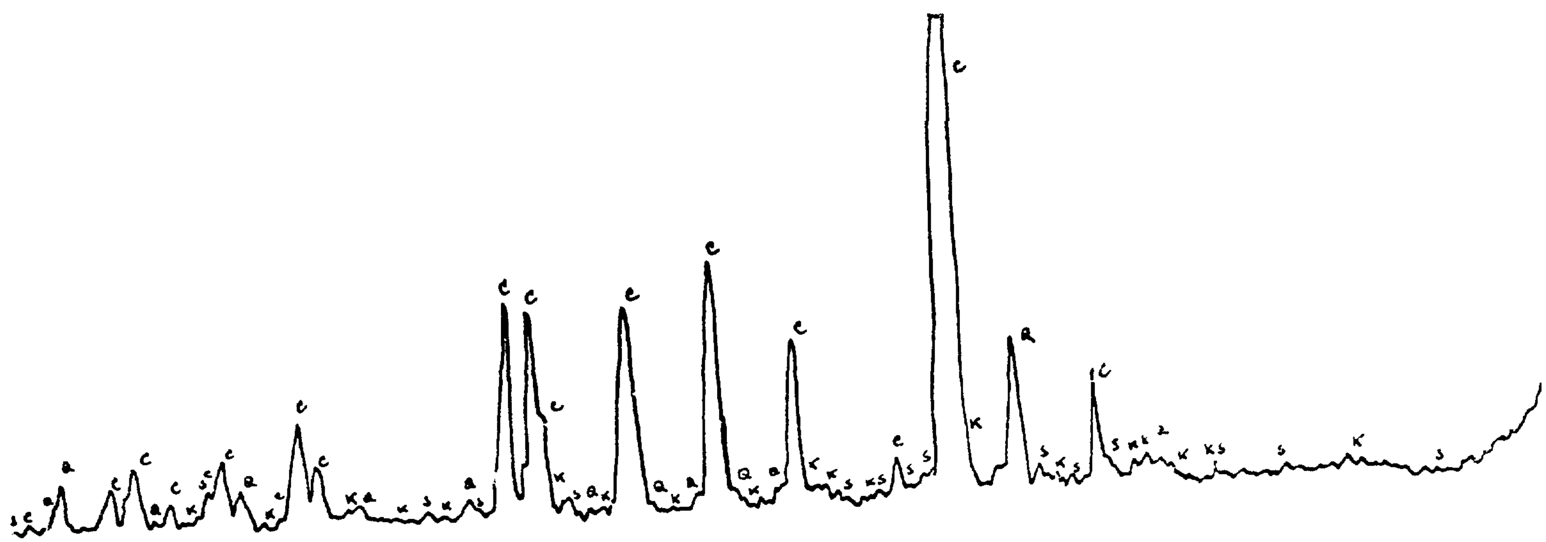
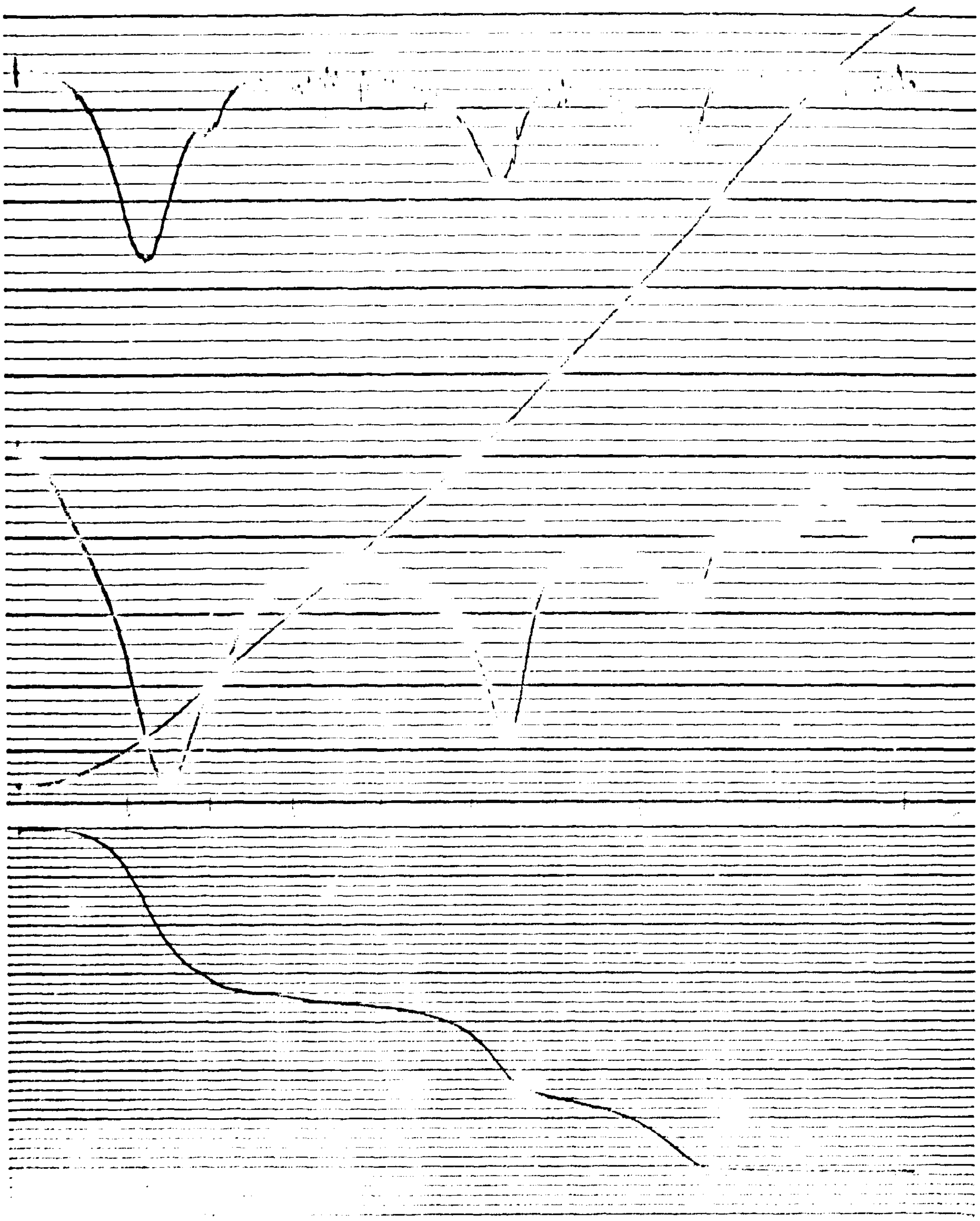


Diagram No. 16.

TS 4 Diagram No. 17



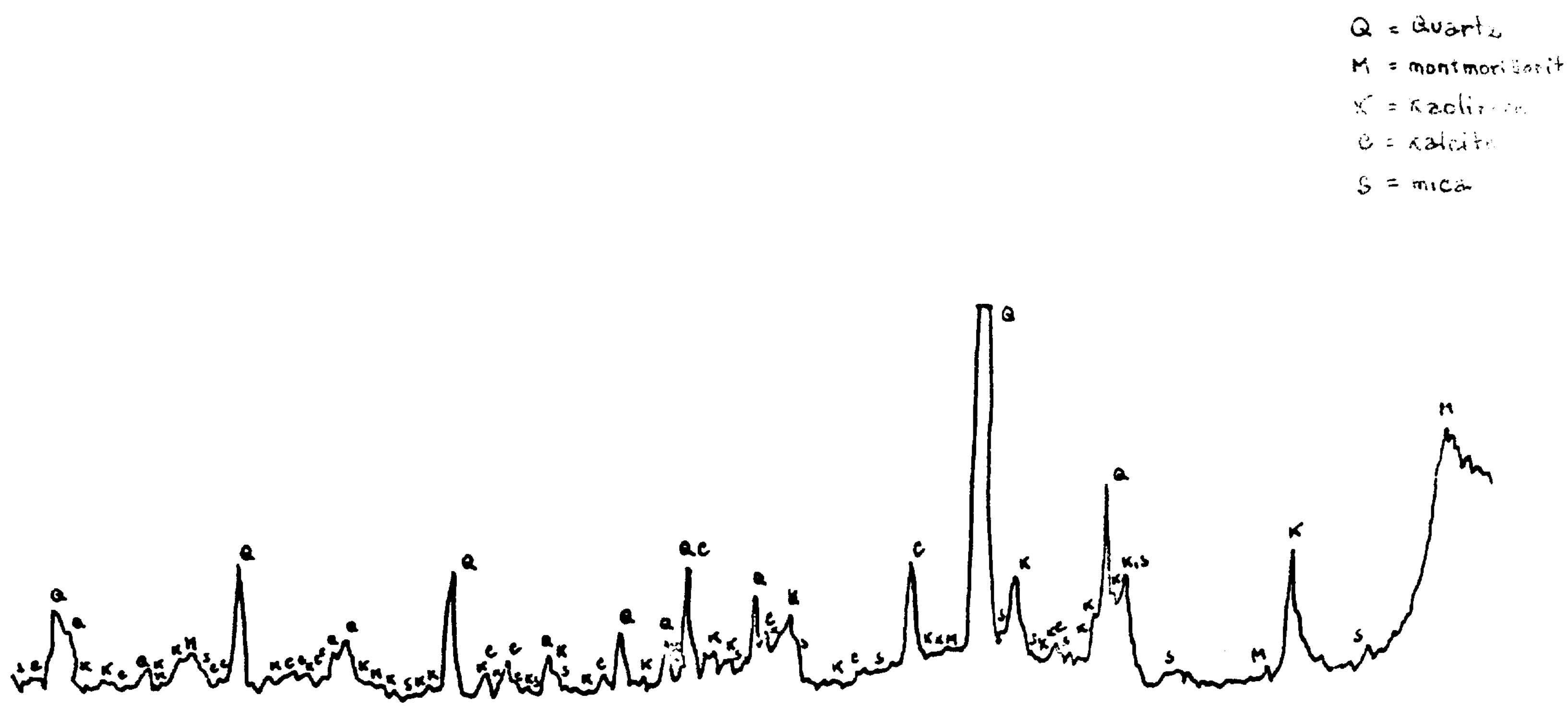
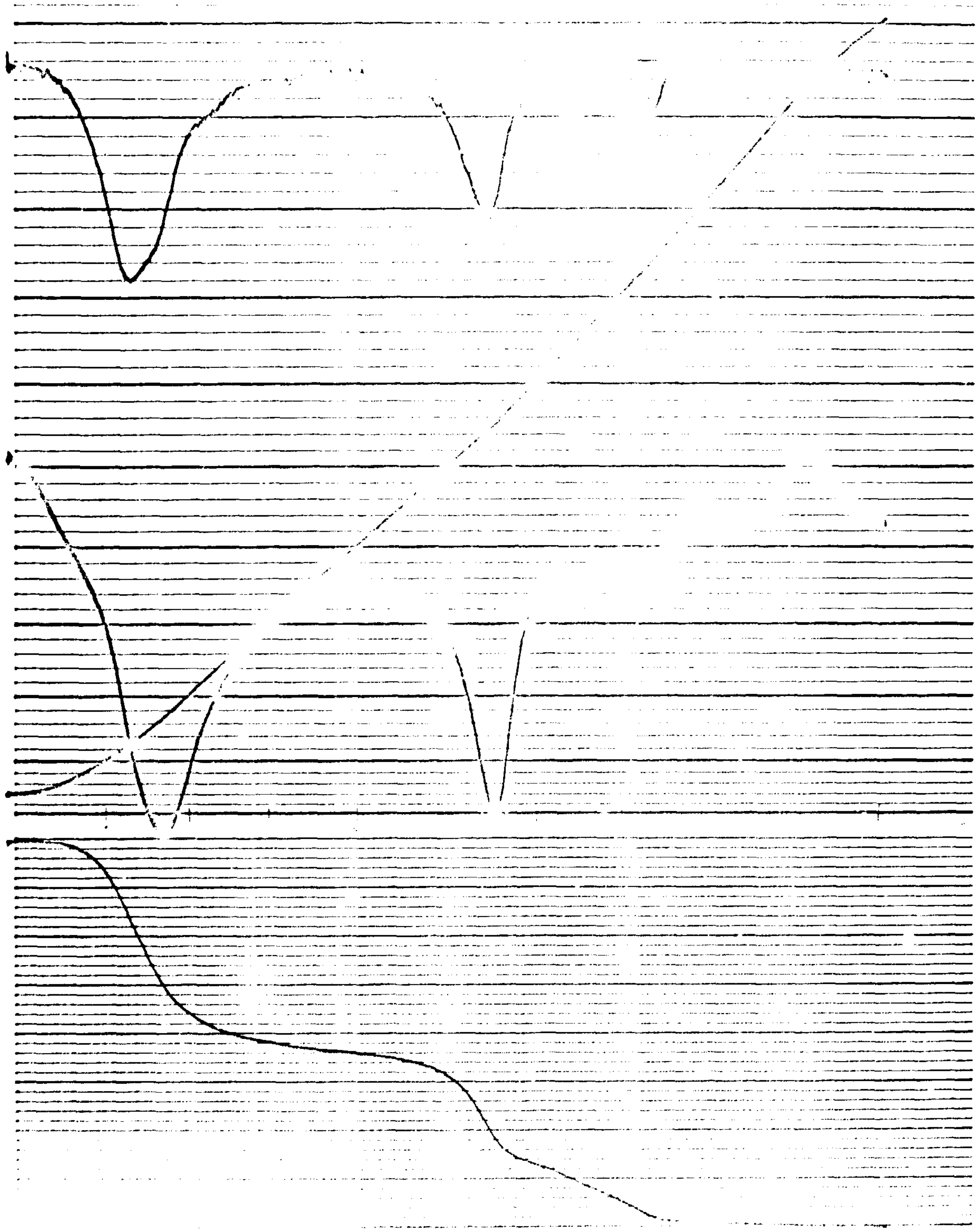


Diagram No. 18.

TS 7

Diagram No. 19



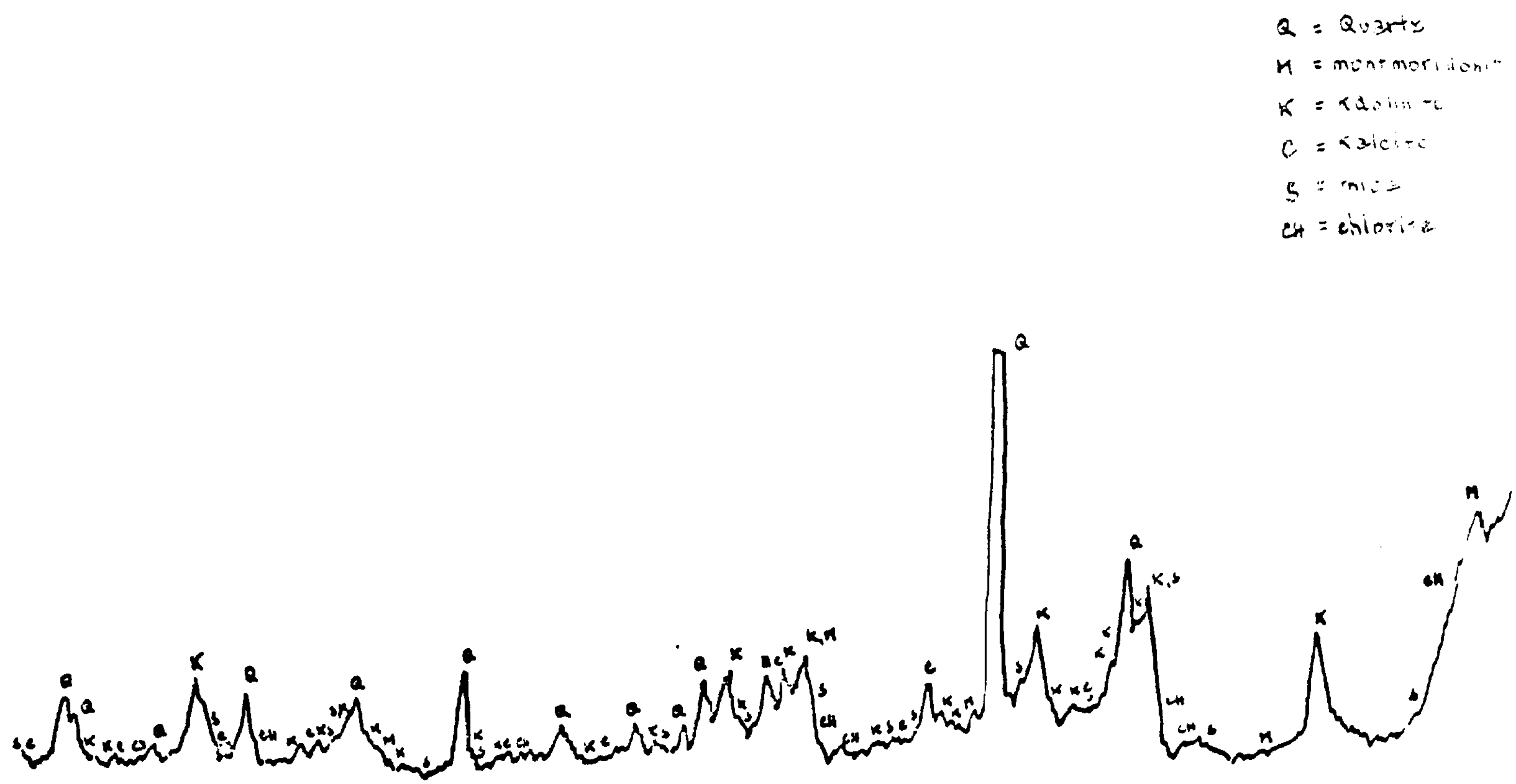
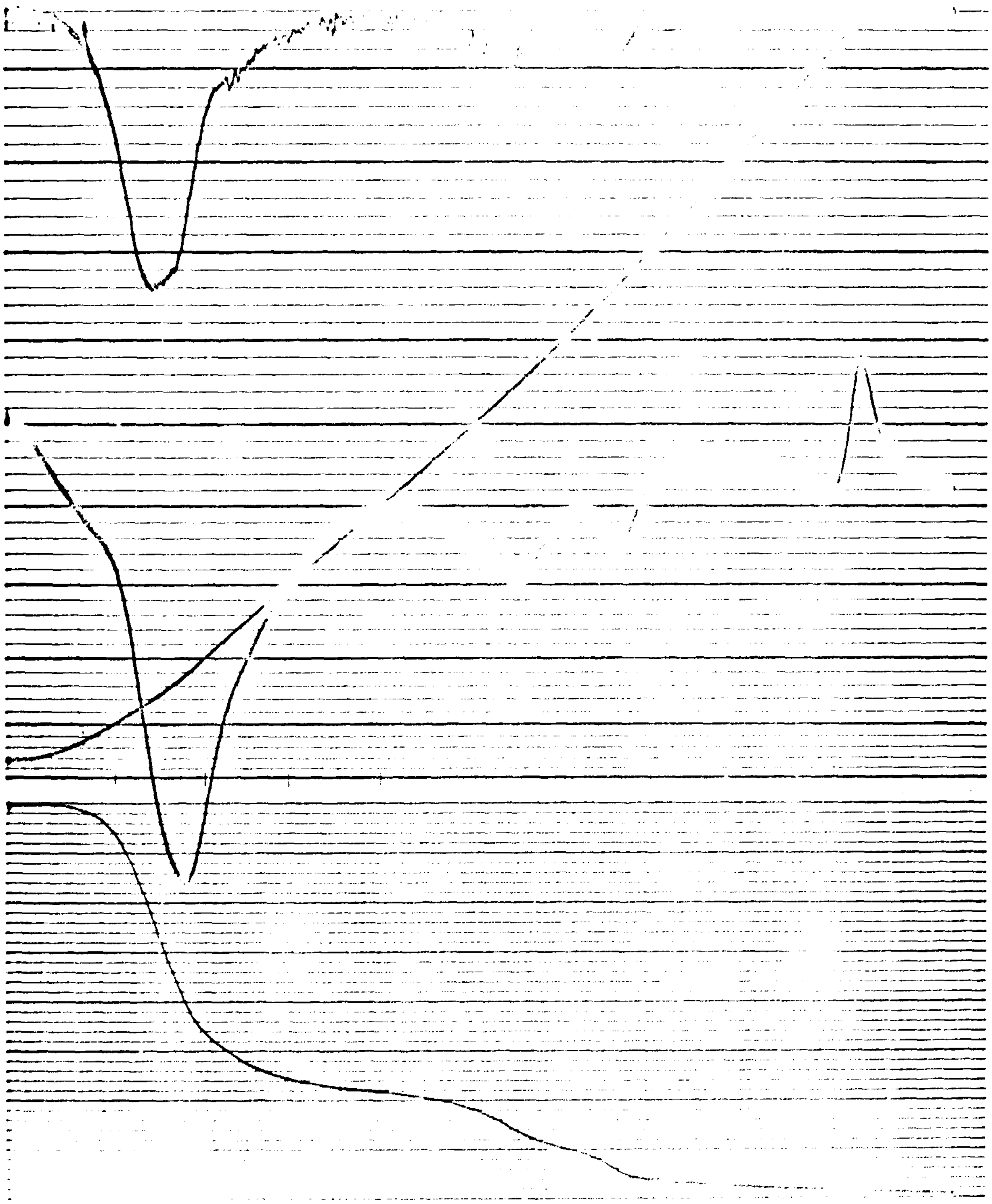


Diagram No. 20.

TS 9 Diagram No. 21.



M = montmorillonit
Q = Quartz
S = mice
K = Kaolinite

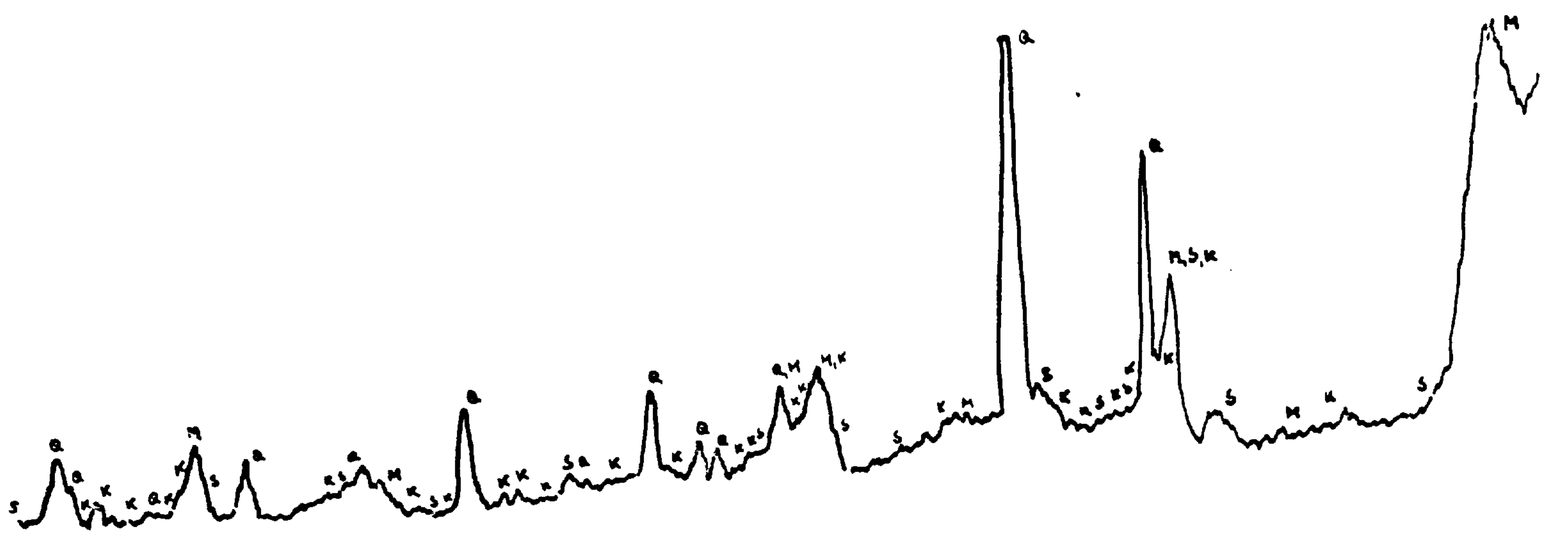
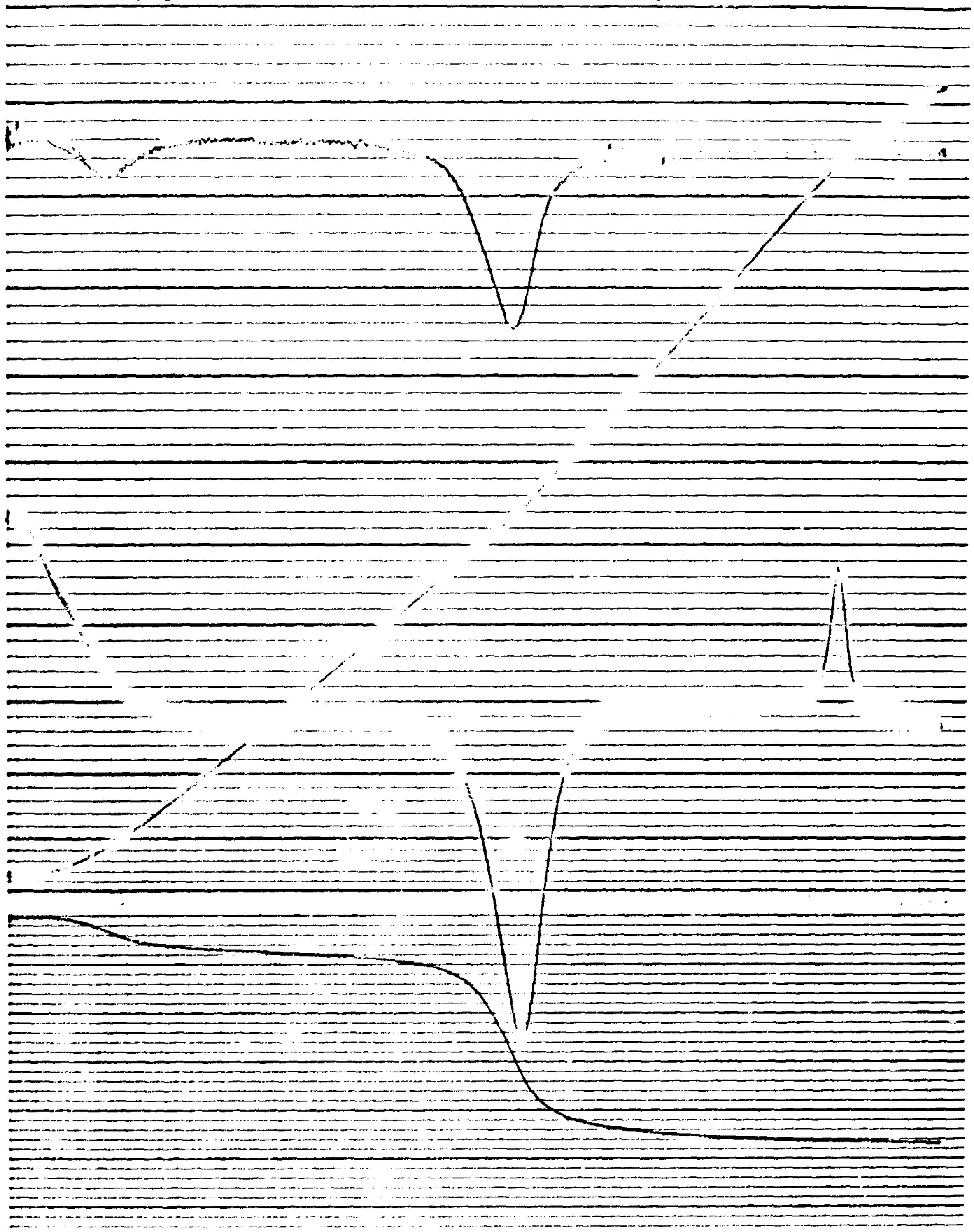


Diagram No. 22.

IS 6 Diagram No. 23.



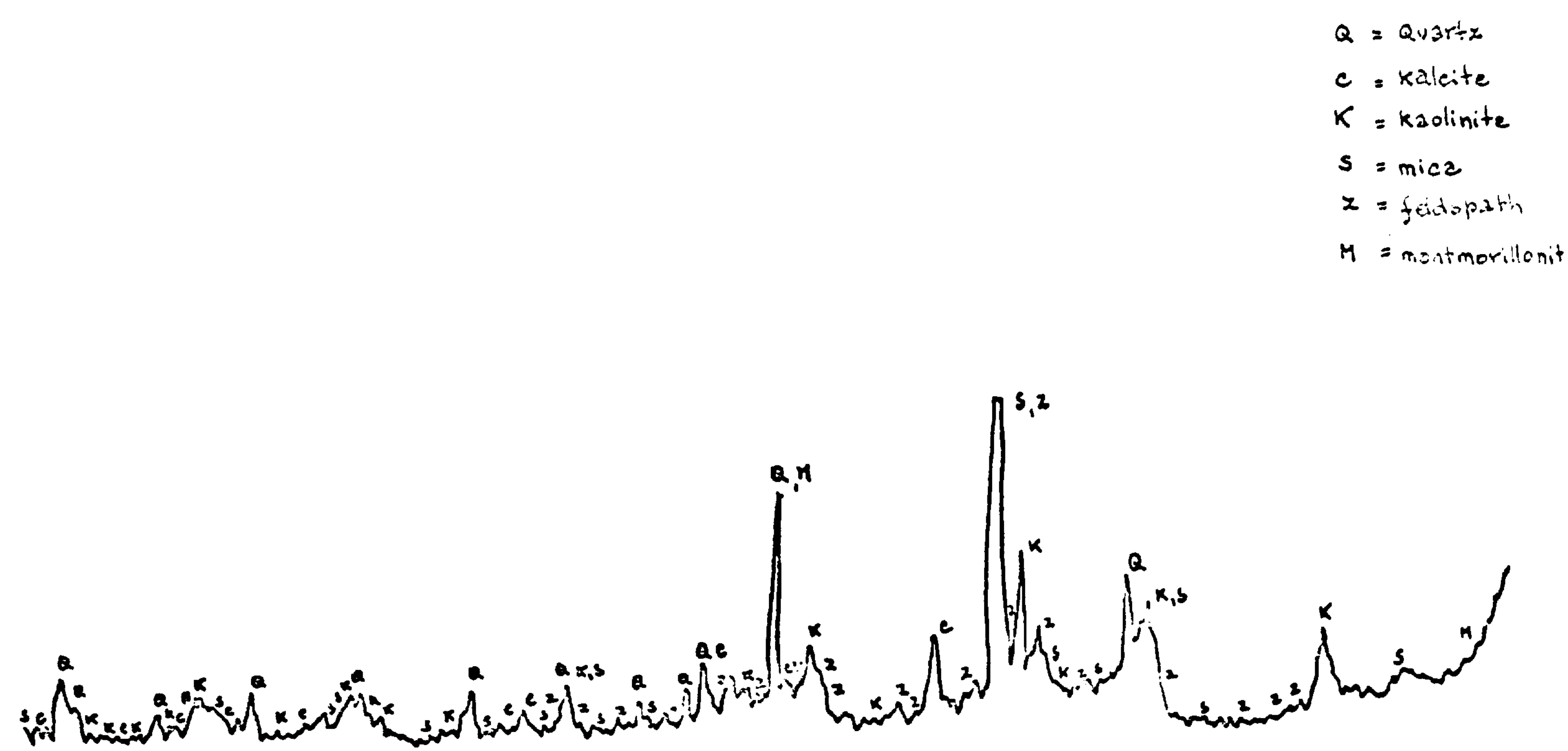
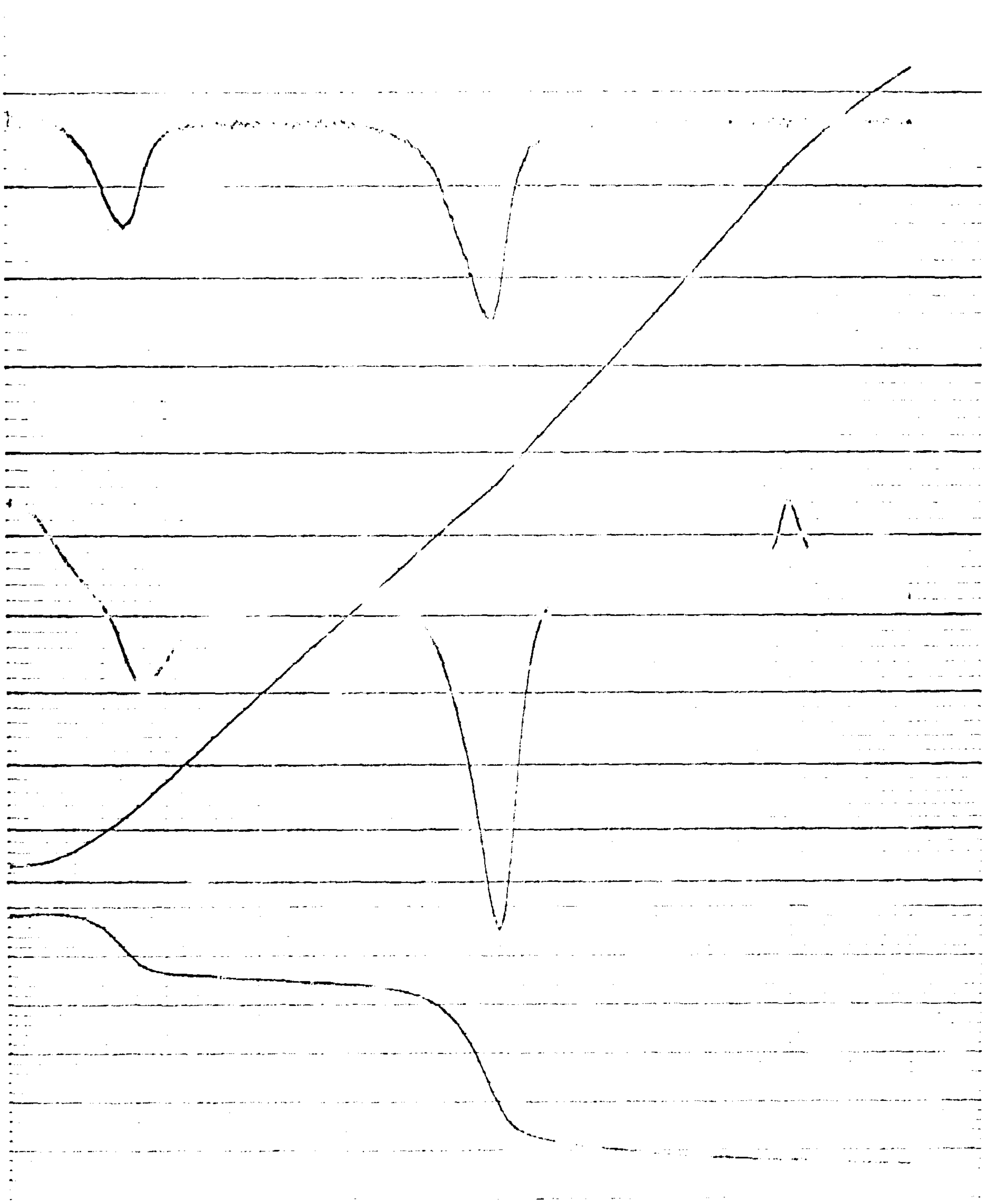


Diagram No. 24.

S 3 Diagram № 25



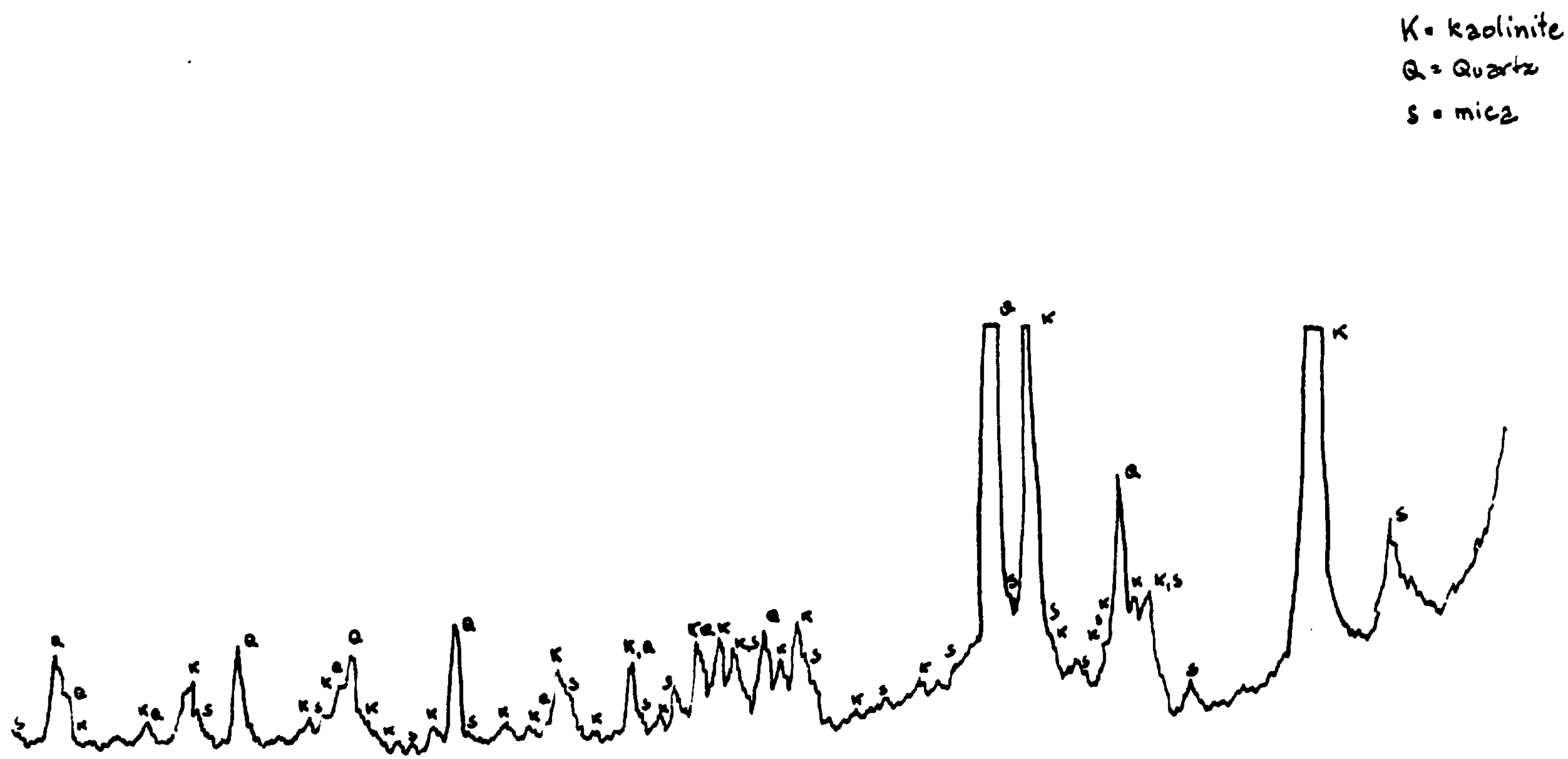
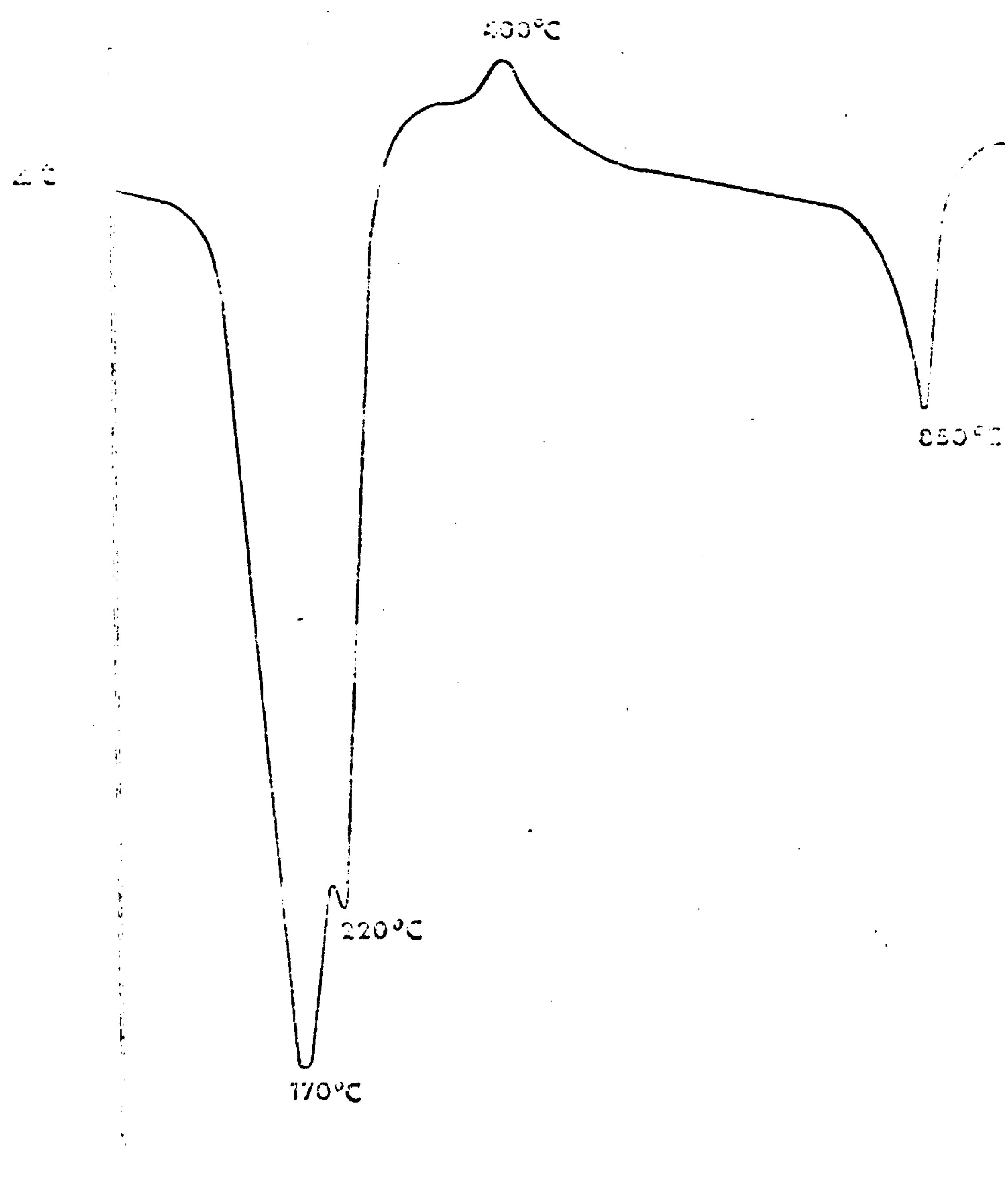


Diagram No. 26.

Diagram No. 27



DTA curve - gypsum sample A

Křivka DTA vzorku sádrovce A

X - ray pattern - gypsum sample A

Rentgenogram vzorku sádrovce A

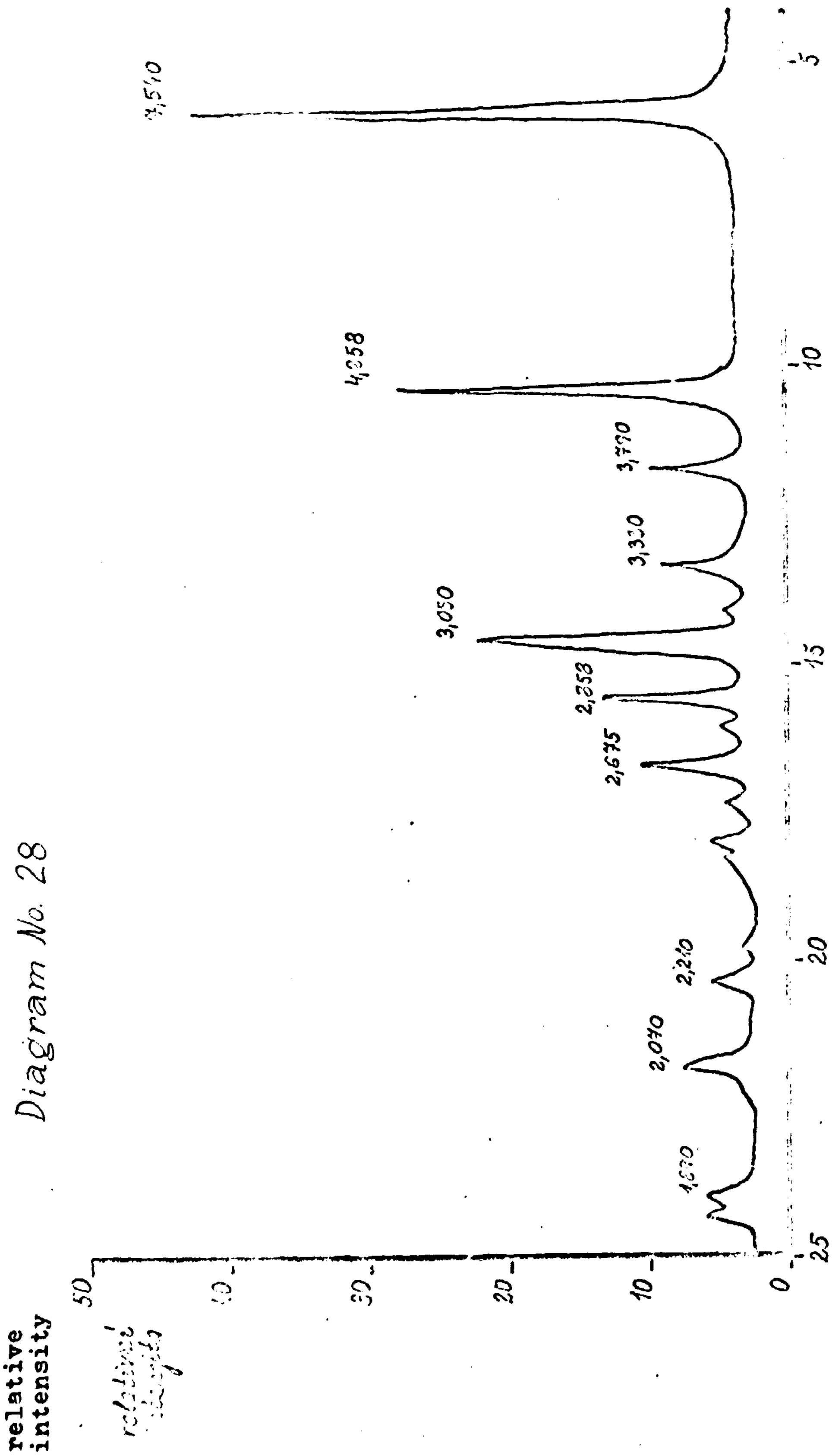
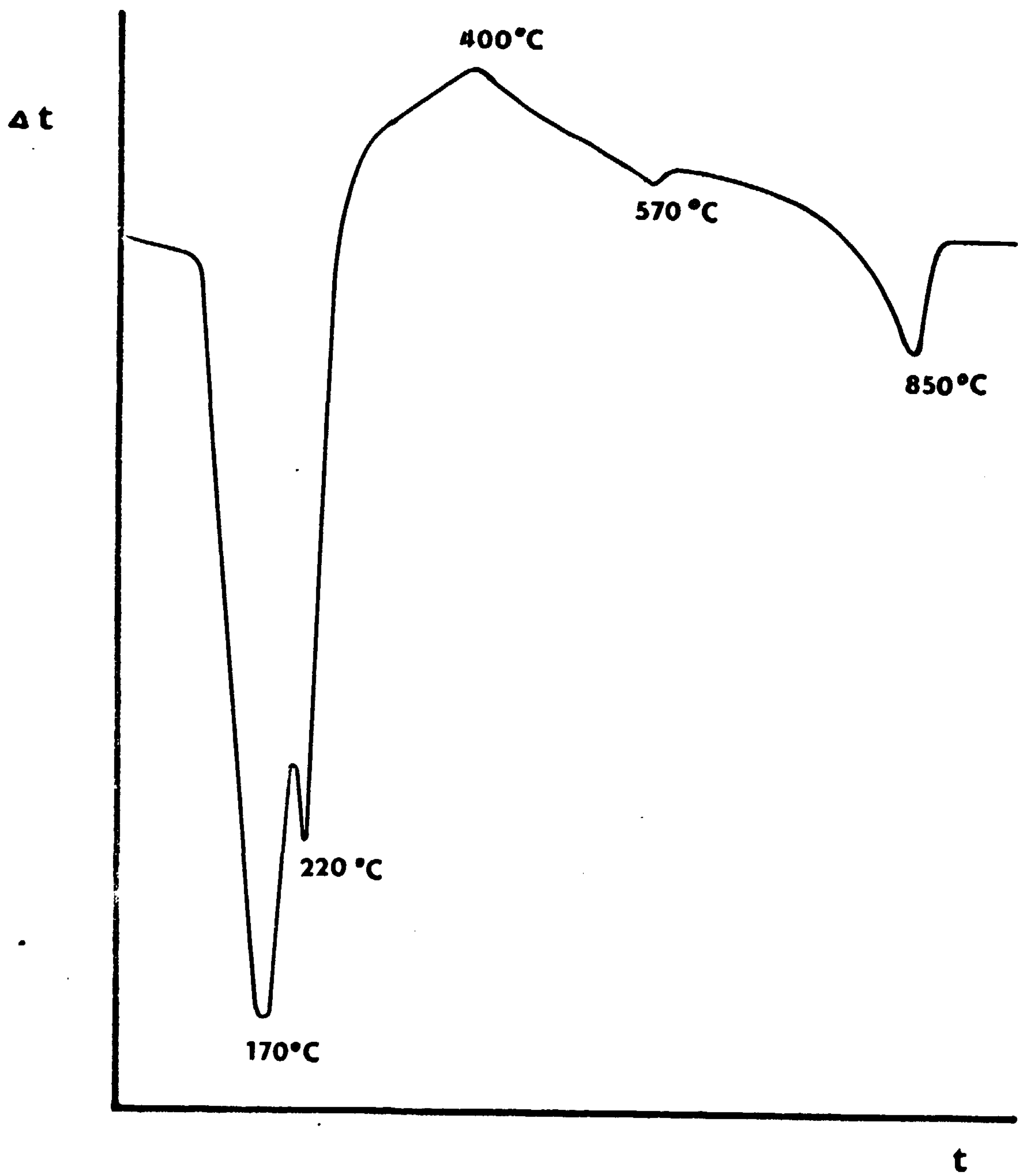


Diagram No. 28

Diagram No. 29



DTA curve - gypsum sample C

X-ray pettern - gypsum sample C

Rentgenogram vzorku sádrovce C

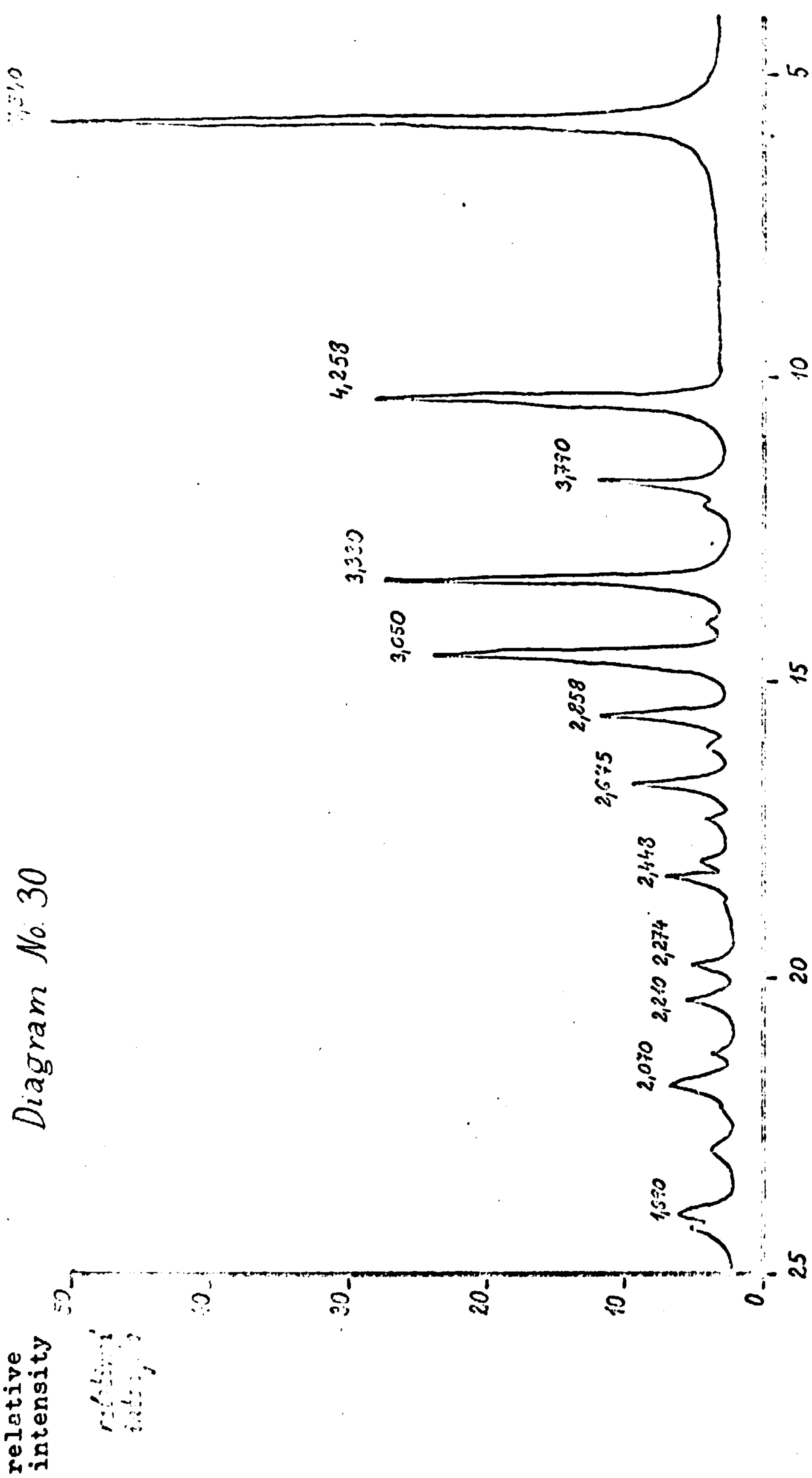
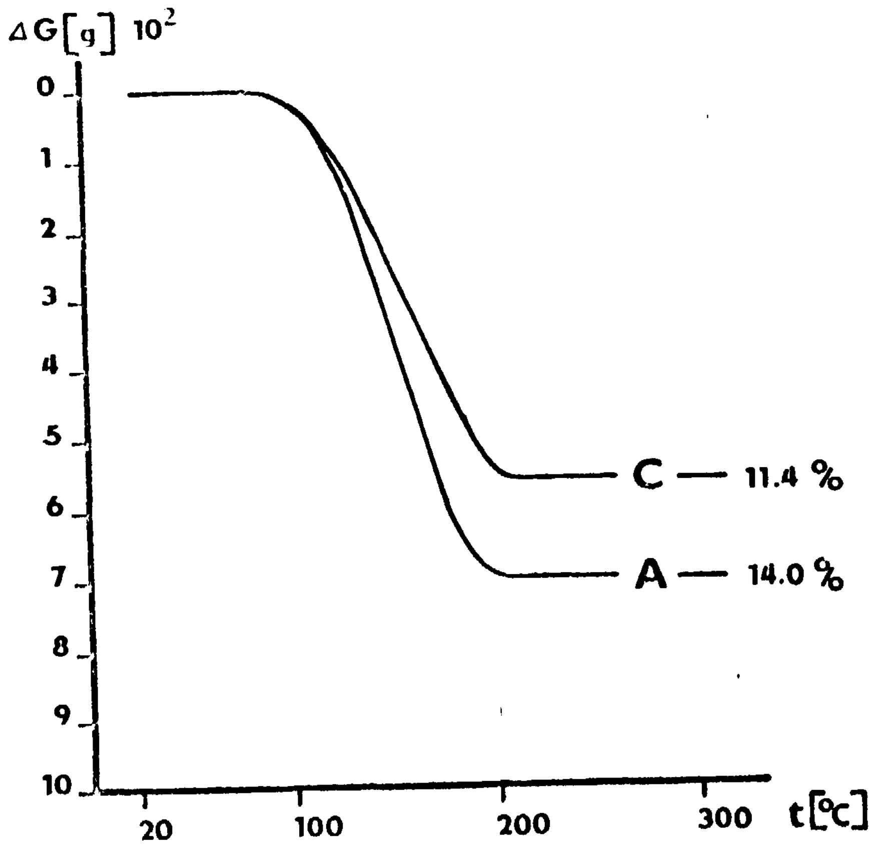


Diagram No. 31



GTA curves - gypsum samples A and C

ANNEXE V

R E P O R T

ON PHYSICAL AND CHEMICAL TESTS OF [illegible]

Prague, 15 December 1976

Elaborated by:

Ing. Josef Jedlička, CSc.

Ing. Jindřich Bláha, CSc.

Ludvík Šanda

Introduction

In the preword of the Report on Physical and Chemical Tests of Botswana's Limestones we would like to remark that we formerly proposed and elaborated a number of laboratory physical and chemical tests, based on which we can determine both the behaviour of limestone during firing and the quality of lime with regard to firing conditions of limestone. From these tests we can indirectly deduce the application of a suitable technological firing equipment for the tested sample.

The first part of this series of tests consists of chemical, microscopical and thermal analyses. The results of these tests indicate the content of carbonates, further quantity, species and a kind of distribution of non-carbonaceous admixtures and finally the behaviour of sample during the thermal processing.

The second part of tests consists of firing a sample at defined conditions and of determination of lime quality on basis of carbon dioxide content, bulk density, specific surface and activity.

The quality of hydrate prepared by the defined method of slaking fired limes on laboratory scale is evaluated on basis of specific surface and percentage of combined water. The measuring is completed by rheologic measurement of lime pastes.

Finally firing tests of limestone cubes complete the preceding tests with regard to break down of limestone and to determination of volume and strength changes during firing.

The results of measurements provide a sufficient information on the tested raw material if the whole series of tests is performed.

Having taken into account the low percentage of calcium oxides and a very high content of silicium oxide in the both delivered samples and consequently unsuitability of these limestones according to Czechoslovak standards and further standards for lime production for building purposes, we did not carry out the whole series of tests. Nevertheless, we tried to find the way how to valorize the limestones and limes prepared from them for a product to be used for building works at least. Such a way is viable in firing limestone in such conditions as to avoid chemical bond between calcium oxide and silicium oxide, followed by slaking the free calcium oxide and mechanical separating the turned out hydrate.

In applying this method of exploitation of limestones of lower value, it is supposed of course that no deposits of first quality limestones are available; the production costs per unit of hydrate will be higher than those for the production of pure limestones.

Experimental part

We received the samples of limestones in a quantity of about 10 kg marked Calcrete Mookane A and Calcrete Mookane C.

About one half of the sample grained under 100 mm was crushed in a laboratory jaw crusher to pieces under 15 mm. By quartation a sample in quantity of about 200 g was selected, which after further crushing was ground for chemical, thermical and X-ray analysis. The left part of the primarily crushed limestone was recrushed and separated into grains 5 - 7 for firing.

Chemical analysis

Based on our experience with limestones from Africa we know that they contain a part from main components /CaO,MgO,SiO_2 and R_2O_3/ often further oxides, which occur scarcely in our limestones. As these can influence the process of chemical analysis, first of all the composition of the delivered samples was determined by semi-quantitative spectral emmission analysis. The result of the spectral analysis is given in table No.1.

Table 1: Results of spectral analysis of limestones Mookane A,C

	sample			sample	
	A	C		A	C
Si	1	1	Mn	-2	-1
Al	-2	-1	Pb	-2	-2
Fe	-1	-1	Cu	-4	-4
Ti	-3	-3	Ba	-2	-1
Ca	1	1	K	-2	-1

The numbers given in the table are orders of concentration of relative elements in percentages.

The sample was liquefied by melting with soda with regard to a high SiO_2 content. Further process followed in conformity with the ČSN 720 105 /ČS Standard/, silicic acid was determined by double evaporization with HCl to the dry state, heated SiO_2 was evaporated with HF + H_2SO_4 and the residue was added after melting with $H_2S_2O_7$ to the filtrate for estimation of R_2O_3 and CaO + MgO.

R_2O_3 were determined by repeated precipitation with ammonia and separated hydroxides were decomposed by heating to oxides. CaO and MgO were determined by the complex measurement on murexid or eriochrome black.

With regard to indication of quartz by X-ray analysis in both samples /confirmed also by microscopical and thermic analysis/ the determination of the decomposable part by acid according to ČSN 720 107 /Cs.Standard/ was carried out. The principle of determination consists in dissolving silicic acid, separated during dissolution of the sample in HCl, in 5% Na_2CO_3 solution.

This method appeared to be unsuitable for the delivered samples. Already in dissolving in HCl, the separation of silicic acid takes place in such a quantity that evidently cannot be dissolved by a short boiling with soda. The results of this determination /19,2% for A and 13,00% for C/ indicate that 87% or 82% SiO_2 are present in the form of quartz. Therefore the insoluble residue was determined by a modified method where the soluble silicic acid was removed by decanting the sample with a hot 5% Na_2CO_3 solution. The obtained results 9,5% or 7,7% for the sample C seem to be more reliable. The results of chemical analyses are given in table 2.

Tab. 2: Chemical analyses of samples A and C

Component	Mookane A	Mookane C
firing loss	33,77	36,82
SiO_2	21,95	15,87
R_2O_3	1,99	2,44
CaO	39,86	39,04
MgO	2,20	5,20
insoluble SiO_2	9,50	7,70

Mineralogical analysis

For the mineralogical analysis thin sections of limestone samples were prepared, which were investigated under microscope.

Mookane A:

Sample A is a homogenous limestone consisting of tiny crystals of calcite in sizes 0 - 15 μm. In the sample sporadic stringers occur and irregularly isolated places filled with larger crystals of calcite in sizes under 160 μm. Their distribution is mostly regular and they may represent less than 10% of limestone volume. The volume of quartz in the sample is estimated at 10%. The grains of quartz are isometric, rounded, without cracks as a rule. In the quartz cavities occur sporadically in the form of schliers and veinlets in diameters under 20 μm, predominantly filled with gas.

No mutual reaction took place between quartz and calcite, because there are calcite crystals on the contacts of quartz. However, a different granularity of these crystals can be observed on the contact where tiny crystals prevail as a rule, forming around the quartz worse transparent fringes under 20 µm thick. Sporadically locally concentrated hydroxides and iron oxides occur in the limestone forming not transparent to rusty brown schliers and irregular configurations.

Mookane C:

The sample C is less homogenous than the sample A from the point of structure and texture. In the limestone irregularly limited areas occur with distinctly different structure in comparison with the predominant mass. These fragments attain the size under 5 mm, they are badly transparent to translucent in the thin section and a very fine-grained calcite with crystals 1 - 5 µm predominates in them. Quartz is associated in considerable quantity in the fragments with expressively rounded grains in consequence of the preceding transport process. The proportion of quartz in opaque fragments of limestone is estimated 5 - 10%, with grains 15 - 150 um. On the contact of quartz there are only calcite crystals, rather coarser than in the other part of the fragment.

The areas of local concentration of iron are in the fragments quite isolated. The basic phase prevails, it is more coarsely crystalline than the badly transparent fragments and is expressively polydispersive and perfectly transparent. Calcite crystals in the basic phase attain 2 - 50 µm. This phase is also relatively rich in quartz. It is irregularly limited, rounded and attains the size from 30 to 600 µm, predominantly, however, up to 150 µm. There are also calcite crystals on the contact, calcite has protruded cross-sections so that it forms fringes around the quartz with radial structure.

The pictures of thin sections enlarged 35 times are in the pictures 1 and 2.

Thermal analysis

For preliminary determination of the phase composition of delivered samples the differential thermal analysis was carried out. In measuring, the linear temperature rise was 10°C/min, the sample and the standard /Al_2O_3/ were placed in a corundum block. Temperature and temperature differencies were taken down by Pt - Pt/Rh thermocouple. Temperature was read off on a milivoltmeter and temperature difference after being amplified was registered on a line recorder. Thermograms of the both samples are in the pictures 3 and 4.

Firings and properties of limes

The sample of limestone grained 5 - 7 mm placed in a Pt crucible was fired in electric resistance kiln to preselected temperatures maintained at constant value by compensation temperature controller for the carbonates to be fully broken down. Before firing the sample was being preheated for 5 minutes within the temperature range up to 300°C. After firing the sample was immediately freely cooled in the air and kept in a closed vessel for further treatment. Based on former experience firing temperatures 900, 1000 and 1100°C were used for firing these samples of limestones. For assessment of fired samples, their bulk density and calcium carbonate were determined. Results of measurements are given in table 3.

Table 3: Properties of limes fired from the samples A and C

sample	firing		bulk density	% $CaCO_3$
	temperature in °C	time in min.	g/cm^3	
A	900	150	1,69	3,2
	1000	40	1,81	1,1
	1100	25	1,87	1,5
C	900	150	1,58	0,7
	1000	40	1,66	1,4
	1100	25	1,76	0,9

Hydration of limes and assessment of hydrates

The sample of lime in quantity of 10 g was sprinkled by water 20°C warm according to the rate of hydration. The total added water made 7 ml. By this method of slaking in substance the dry hydrate was produced, which was dried in a drier at 105°C after 30 minutes of maturing. The dried hydrates were subjected to gravimetric thermal analysis in order that the adsorbed water, the quantity of hydration water in calcium hydroxide or magnesium hydroxide and the quantity of the secondary produced calcium carbonate might be determined. The method of gravimetric thermal analysis was applied in order that particular proportions of firing loss might be distinguished, which the analytic determination of firing loss does not enable.

In measuring, the linear temperature rise was 5°C/min., temperature of the sample was measured in the bottom of the Pt crucible and the reduction of mass was registered by a mass recorder by means of an inductance sensor, recording the deflection of analytic balance arm caused by the change of the weight in heating.

From the measured values of mass reduction the following indications were calculated: the quantity of calcium oxides or magnesium oxide bonded with hydroxides, total quantity of calcium oxide bonded immediately after hydration with hydroxide /CaO from hydroxide + CaO from the secondary carbonate/ and degree of hydration as the ration of the actually hydrated CaO content to the CaO content capable of hydration with regard to the chemical composition of the sample.

In the pictures 5 and 6 are represented only the curves GTA of lime hydrates of the sample C fired to 900 and 1100°C /HC 900 and HC 1100/. A similar course have also the curves of the other hydrates. The calculated results for all hydrates are given in the table 4.

Table 4: Properties of prepared hydrates

sample	CaO bonded with $Ca/OH/_2$	MgO bonded with $Mg/OH/_2$	Total bonded CaO	Degree of hydration
900	40,16	-	41,34	0,83
Ha 1000	40,44	-	42,92	0,86
1100	36,71	-	38,51	0,75
900	35,47	3,87	39,15	0,78
Hc 1000	38,20	2,80	41,02	0,81
1100	37,99	2,91	41,23	0,82

X ray analysis

X ray diagrams were taken on the X ray-diffraction-meter with Cu anode, Ni filter at anodal voltage 24 kW and anodal current 20 mA for wave lengths corresponding to diffraction angles of relevant minerals.

Data published by Kitajgorodski, Taylor and Bogue were applied for assessment of diagrams.

Discussion of results

If we are to assess the samples of limestones, then already the chemical analysis shows they are unacceptable with regard to the high silica content, which makes after recalculation on fired state 25,12% with the sample C and even 33,14% with the sample A. The produced limes will have in the best case, if mutual reaction between CaO and SiO_2 does not take place during firing, only 60,12% or 61,79% calcium oxide capable of reacting with water to produce hydrate. Such limes do not comply even with the class V of the ČSN stipulating the minimum CaO + MgO content equalling 65% and being acceptable only as fertilizers.

High silica content in both the samples of limestones is sure to support the possibility of mutual reaction of the both oxides - calcium oxide with silicium oxide in calcinating limestones. The degree of bond will depend besides firing temperature mainly on the character of the present silica and on grain sizes. If SiO_2 is present in the form of quartz and the particles are large enough, then the degree of change will be low. On the contrary, if all the SiO_2 is present in the form of amorphous SiO_2, then the mutual reaction will take place at the lowest firing temperature and the degree of bond will be only the function of homogenity and firing time.

Based on this analysis we decided to find out in what form silica is present in limestones. After first experiments with hydrating fired limes we came to the conclusion after subjective assessment of sieve residues /sieve openings 0,2 mm/ that quartz is contained in limestones. After these experiments the performed thermal analysis with the maximum adjustable precision /see picture 7/ as well as the X-ray analysis /see pictures 9 and 10/ and at last the former microscopical analysis confirmed our assumptions from the qualitative point of view. The quantitative analysis was made by analytic method;

the quartz content is 9,5% in the sample A and 7,7 in the sample C. This result is in conformity with the semiquantitative determination of quartz by DTA /picture 7 and 8/. The sample applied for calibrating DTA was prepared by adding finely ground quartz to the sample A in quantity of 10%. The surfaces of the both endothermic minima were compared. Hence it appears that only a smaller part of SiO_2 is in limestones in the form of quartz, which is difficult to react with CaO at given firing temperatures. Consequently it may be assumed that the remaining part of SiO_2 is in amorphous form and will react easily with CaO while forming dicalcium silicate and binding calcium oxide the content of which is even so very low from the viewpoint of production of good limes.

In selecting temperatures for firing limestones we were based on the above facts and as the most convenient temperature eliminating the bonds of CaO with Si_2O would be the temperature just over the break down point. Such a temperature is, however, very low and the firing would be very long and economically unbearable.

In rising firing temperature both rising the degree of bond between CaO and SiO_2 and sintering could take place. We tried to find a limit in laboratory experiments for a still acceptable firing temperature. This limit makes 1100°C. At the temperature of 1200°C and to a full extent at 1300°C both sintering of particular lumps of fired lime and forming dicalcium silicate /C_2S/ takes place. The rise of C_2S is demonstrated by the phenomenon that after emptying the lime from the furnace its breakdown takes place during cooling, which is caused by modification change of C_2S - β form changes to γ. This phenomenon is well known from cement manufacture and it takes place in an inconvenient cooling of fired clinker, when in slow cooling especially within the phase 700-800°C a modification change of the unstable β C_2S to the stable γ C_2S. This process is accompanied by expansion of volume of the original C_2S, which is demonstrated by total breakdown called also "dusting of clinker". This process was confirmed by X-ray measuring the broken fired sample separated from left fragments of lime. At 1200°C the binding of CaO with SiO_2 does not take place to such a great extent as X-ray measuring the lime sample fired to 1200°C showed in the end. The results of X-ray analysis are given in pictures 11 and 12.

Besides, it is necessary to draw attention to breakdown inclination of limestones in the preheating zone. This from the technological viewpoint unpleasant factor is induced by considerable inhomogenity of the both limestone samples with regard to SiO_2. The nonhomogenity is accompanied with different dilatation of particular phases at increased temperature gradient in the preheated stone and consequently with great inclination to cracking. This fact would bring about considerable operation troubles in firing in shaft furnaces of all types connected with drop of quaranteed output and lower quality of final product.

By hydration of limes of the both samples fired to temperatures 900-1100°C hydrates are produced, the quality of which does not comply with the respective ČSN. However, the hydration proceeds willingly, only the limes must not be "drowned". Because of the unsatisfactory quality of the limes with regard to ČSN further tests for their complete assessment were not carried out, namely the determination of specific surface and rise of temperature in dependence of time of hydration. On the other hand, measurements were completed with GTA, as it was especially the assessment of GTA curves which enabled to calculate the hydration degree of particular limes fired to different temperatures.

It can be said in general that even at these low firing temperatures a partial bond between CaO and SiO_2 arises as it results from the degree of concentration and from the total CaO capable of hydration /see table 4/. The limes of the sample A show the decrease of hydration with increasing firing temperature because of the high SiO_2 content. Hence it may be concluded that quantity of CaO bonded with SiO_2 increases with rising temperature. The limes of the samples C give the degree of hydration of about 0,8. In this connection it should be said that in the sample C magnesium oxide is partly hydrated /at lower firing temperatures a higher quantity of MgO is hydrated/ in consequence of which the degree of hydration is influenced as it is calculated on CaO capable of hydration only.

To enable the utilization of fired lime as well as of hydrate prepared from limes in building industry we proposed a method of its valorization. After slaking softly fired lime to dry hydrate, the fine hydrate could be separated from larger grains, especially from those of quartz, in an air-separator and in this way a product of a better quality would be achieved. On laboratory scale we replaced this process by separating coarse grains after slaking a greater quantity of lime sample A 1100 on the sieve with openings 0,09 mm. The sieve residue makes 42% and the CaO content of screened lime capable of hydration, calculated from GTA, makes 51,42%. In this way the lime content in the hydrate increases from 38,51% to 51,42% - determined by means of GTA and the total CaO content, determined in hydrate analytically, rises from 50,43% to 64,31%. The degree of hydration of this product, where analytically 64,31% CaO were determined, is 0,80. Although the degree of hydration is in principle the same as in the original hydrates, which shows that undersize contains also CaO bonded with SiO_2 in the same ratio as in the original hydrate, the original hydrate is valorized 1,3 times by separation. On the contrary, the coarse sieve residue /0,09 mm op./ has only 23,88% CaO capable of hydration /determined by GTA/ as against 38,51% in the original hydrate.

It should be said, however, that this method was subjected to laboratory tests only, the conclusions give an information to be verified, which would require a series of measurements for the above results to be definitely proved.

Conclusion

In assessing possibilities of utilizing samples A and C for the production of lime with regard to their chemical composition and requirements stipulated by our and some other standards we have come, based on all the tests, to the conclusion that these raw materials are not suitable for lime production. However, if there are no limestones of better quality in the given area, nor in its surroundings, and these raw materials would have to be applied for lime production, we must draw attention to some facts resulting from our measurements.

1/ In firing limestones Mookane A and C it is unconditionally necessary for the firing temperature not to exceed 1100°C and therefore to choose such a technological equipment which would guarantee this condition.

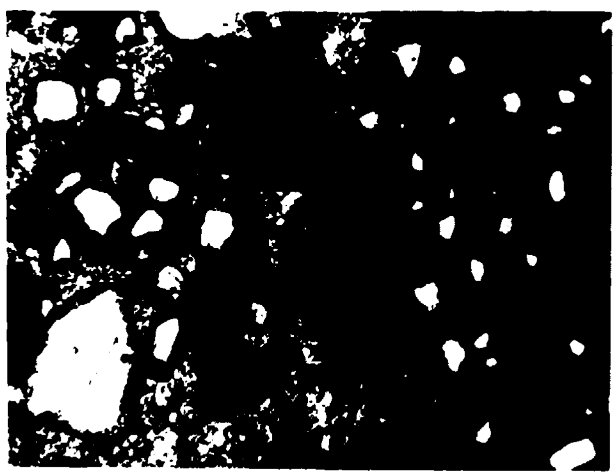
2/ The production costs, mainly those on energy, will be higher because there are 25 or 33% SiO_2 in the raw material recalculated on fired state. Silicium oxide, in the lime is an inactive component and it is not desirable with regard to lime.

3/ Softly fired lime can be hydrated and hydration product can be valorized by separating calcium hydrate.

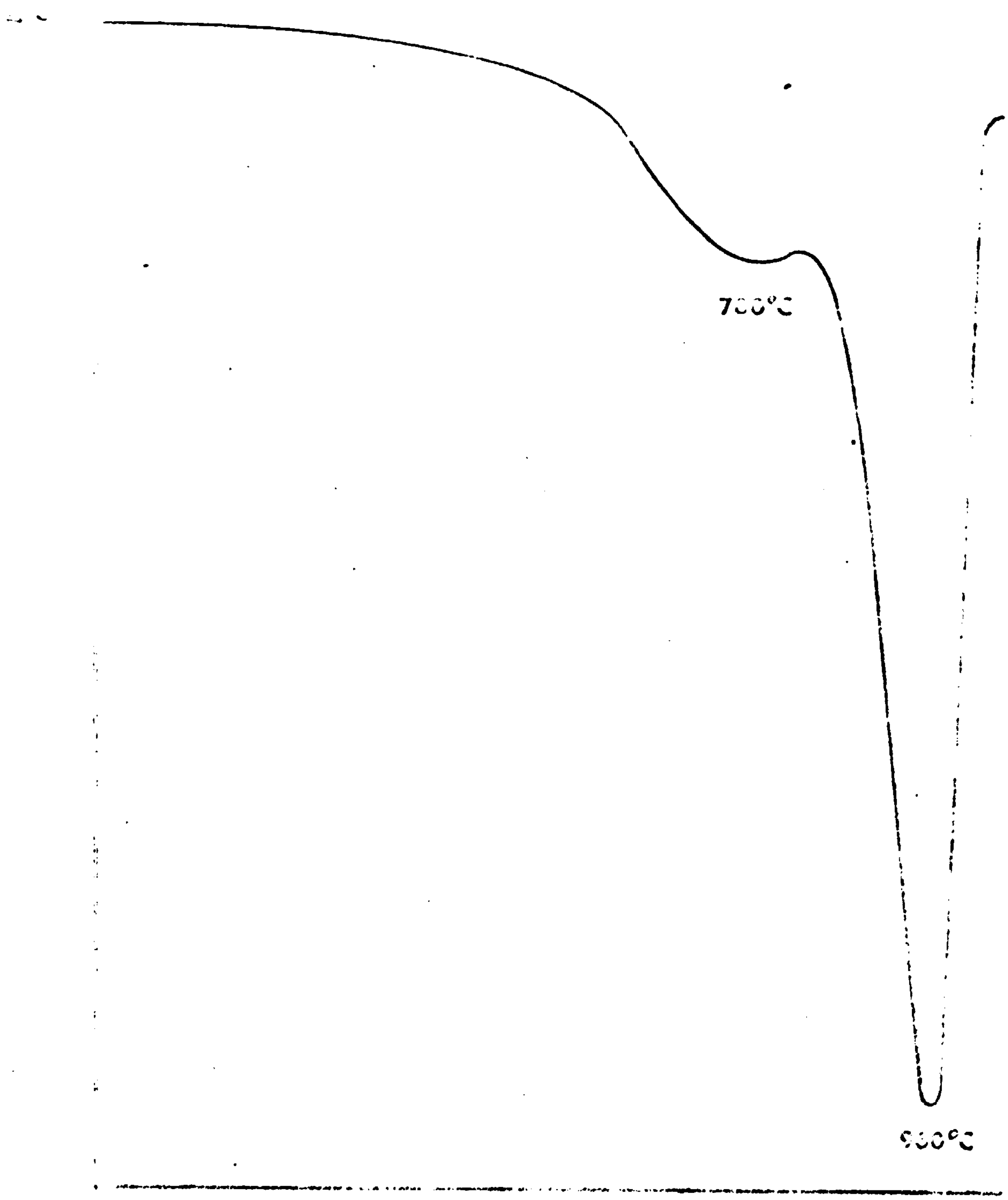
4/ With regard to a high SiO_2 proportion in the fired product it could be advantageously applied for the production of lime sand autoclaved products, suppose that MgO hydration coincides with CaO hydration and that MgO does not disturb by its later hydration the volume stability of products.

Although the last two possibilities take into account the utilization of the given samples of limestones for lime production, we recommend to look for limestones of better quality which would quarantee the production of good lime in a simple process and with wider application.

Picture 1: Sample Mookane A - microscopic picture-enlarged 35x

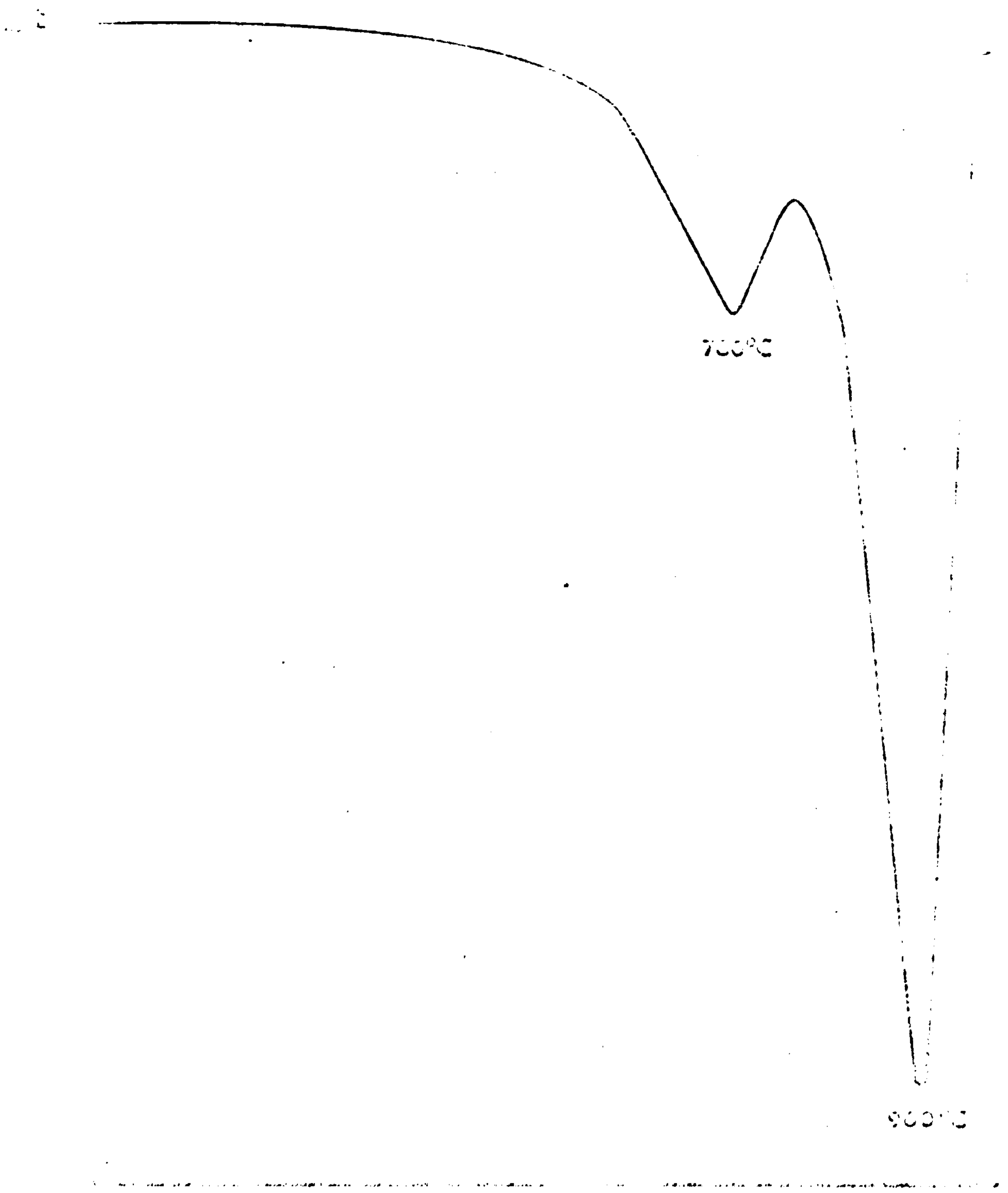


Picture 2: Sample Mookane C - microscopic picture-enlarged 35x



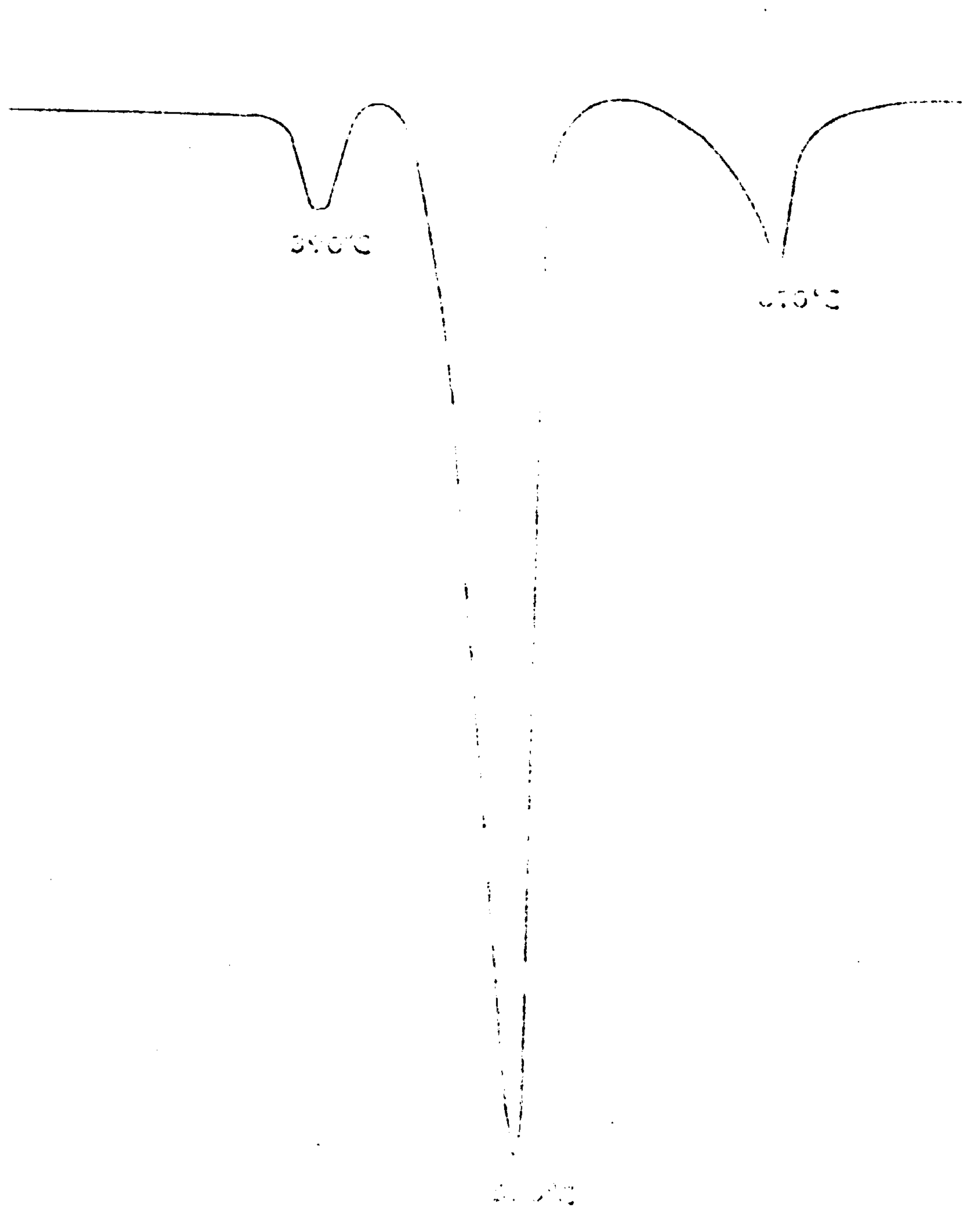
Picture 3: DTA curve - sample A

Obr.3. Křivka DTA vzorku A



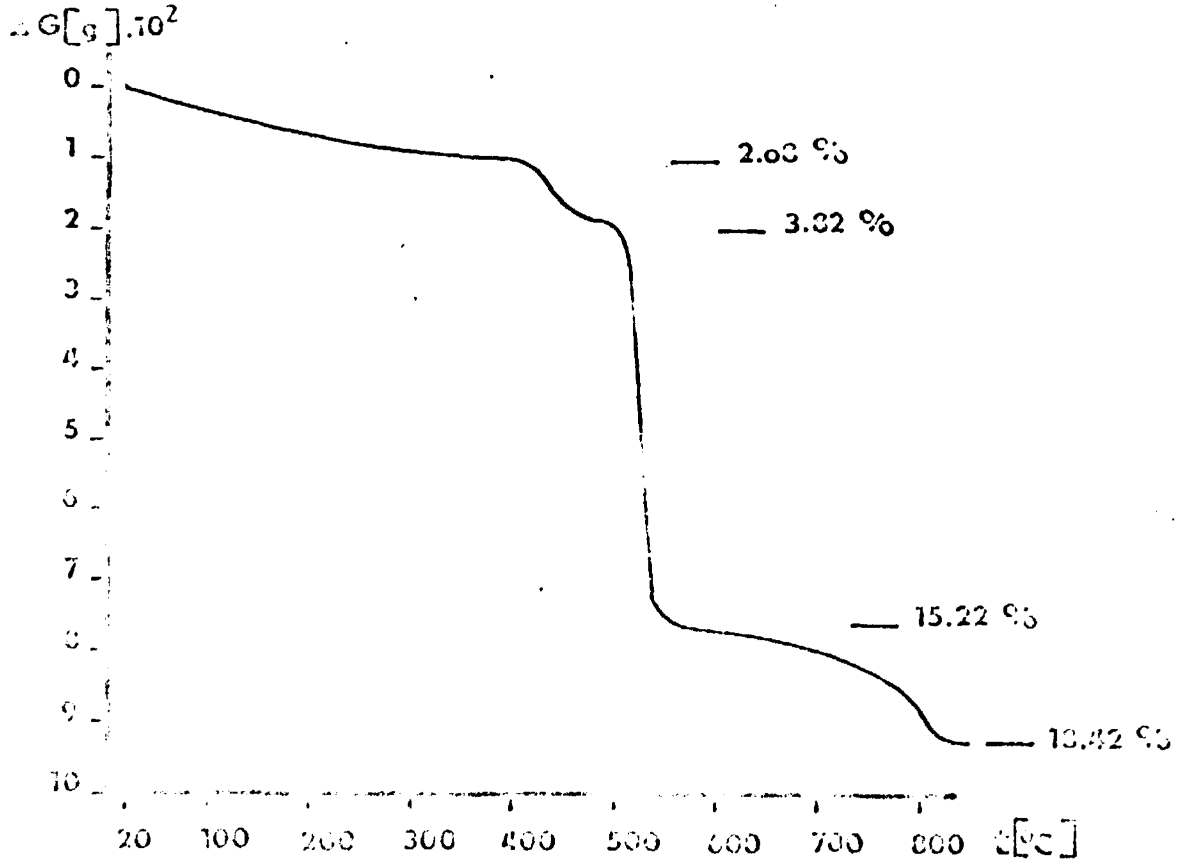
Picture 4 : DTA curve - sample C

Obr.4. Křivka DTA vzorku C



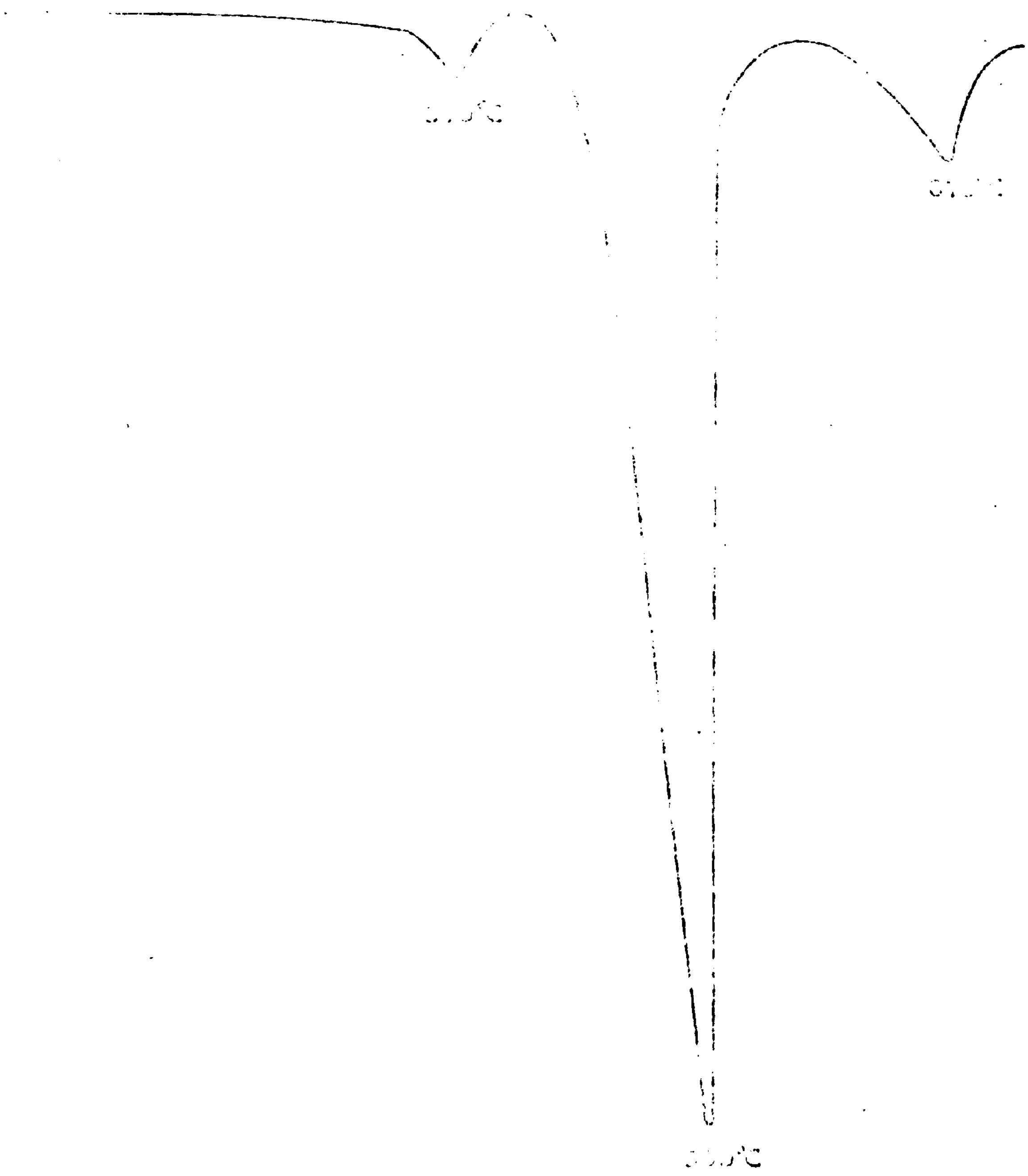
Picture 5 : DTA curve - sample HC 900

Obr.5. Křivka DTA vzorku HC 900



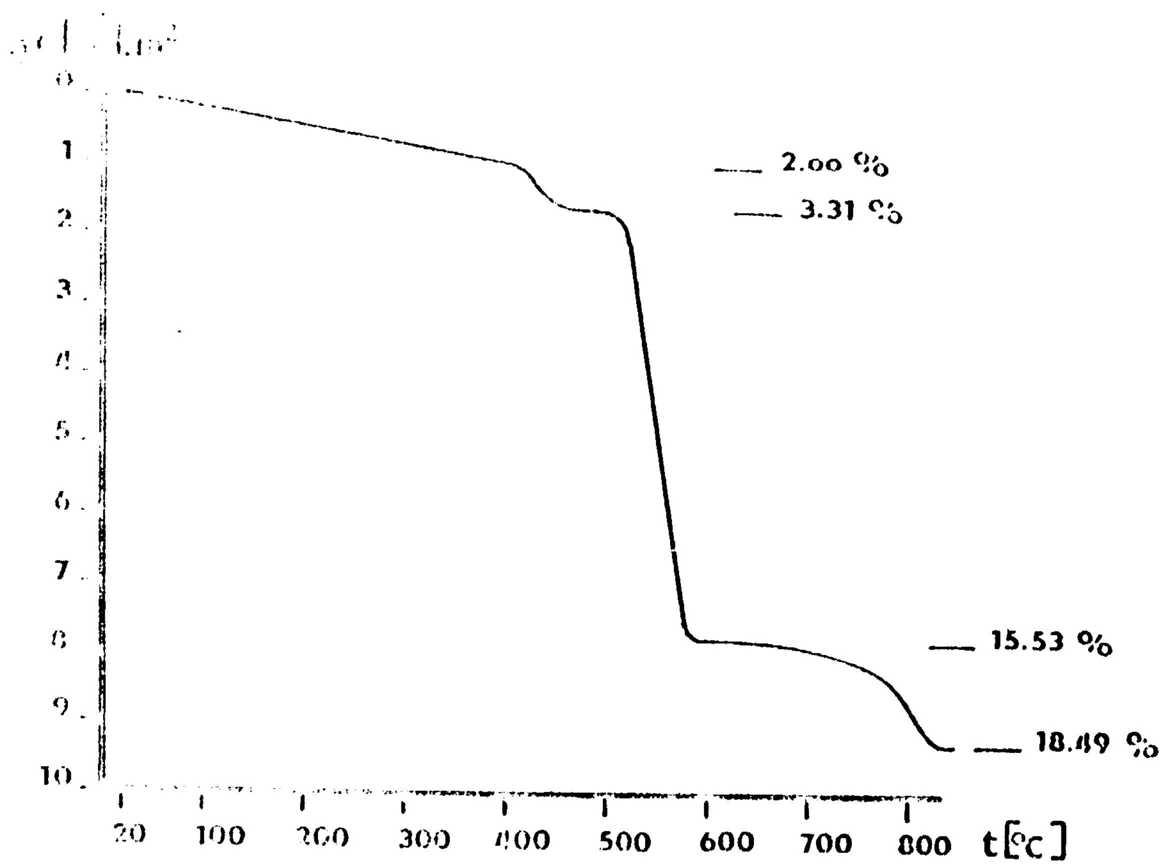
Picture 5a : GTA - sample HC 900

Obr.5a. Křivka VTA vzorku HC 900

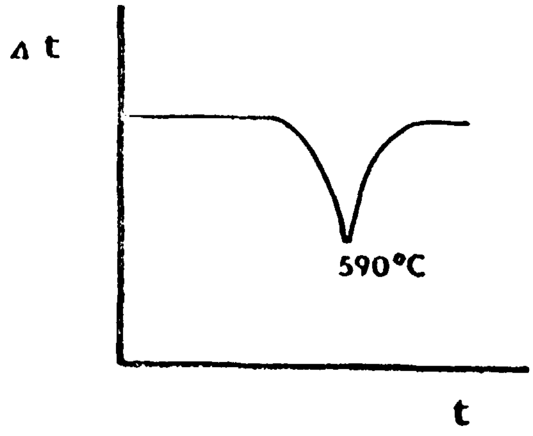


Picture 6 : DTA curve - sample HC 1100

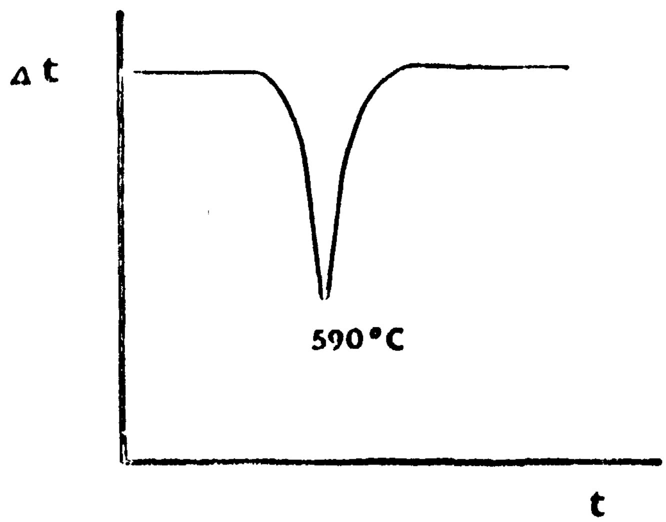
Obr.6. Křivka DTA vzorku HC 1100



Picture 6a : GTA curve - sample HC 1100



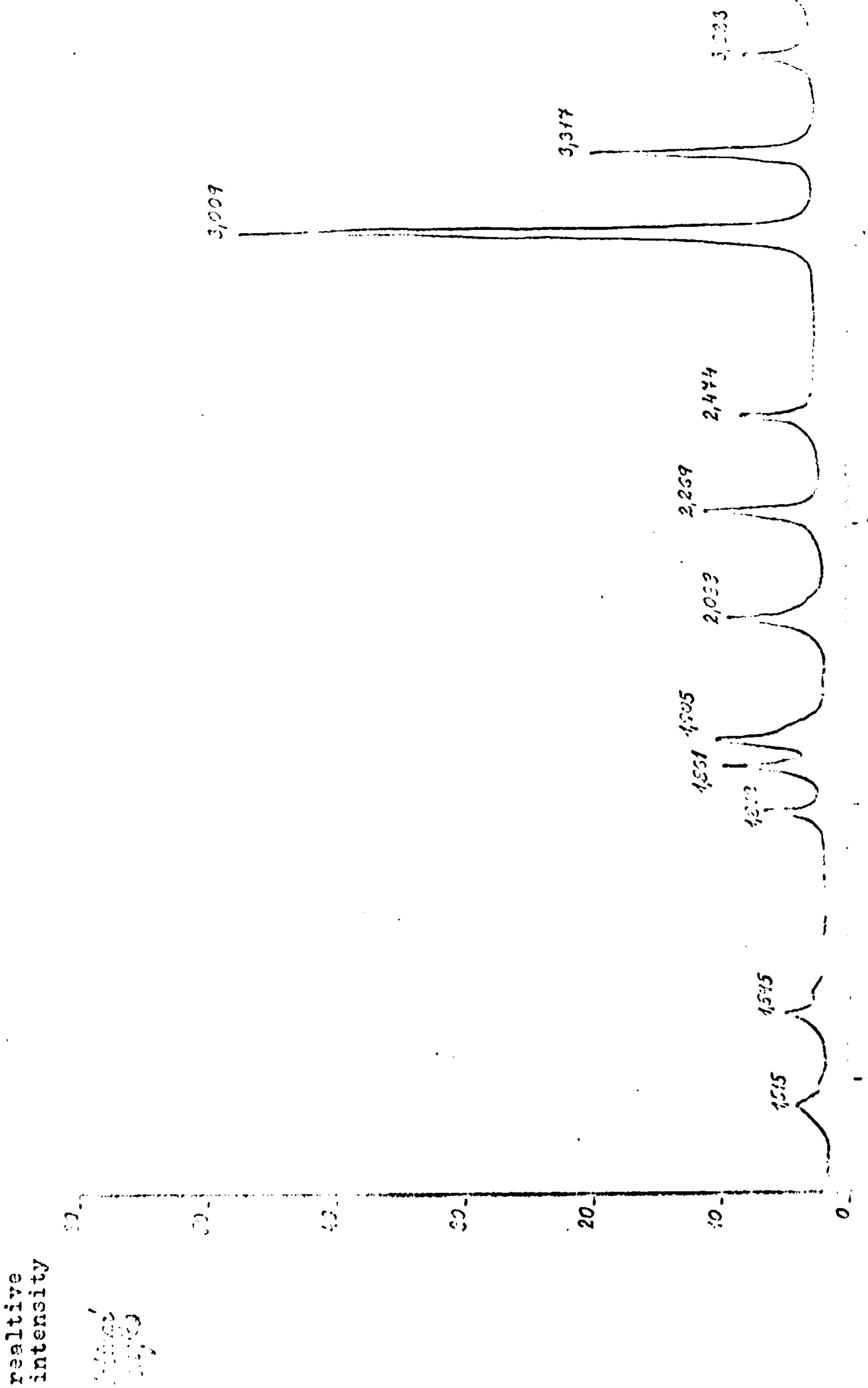
Picture 7 : DTA curve - sample A



Picture 8: DTA curve - sample A with 10 % quartz

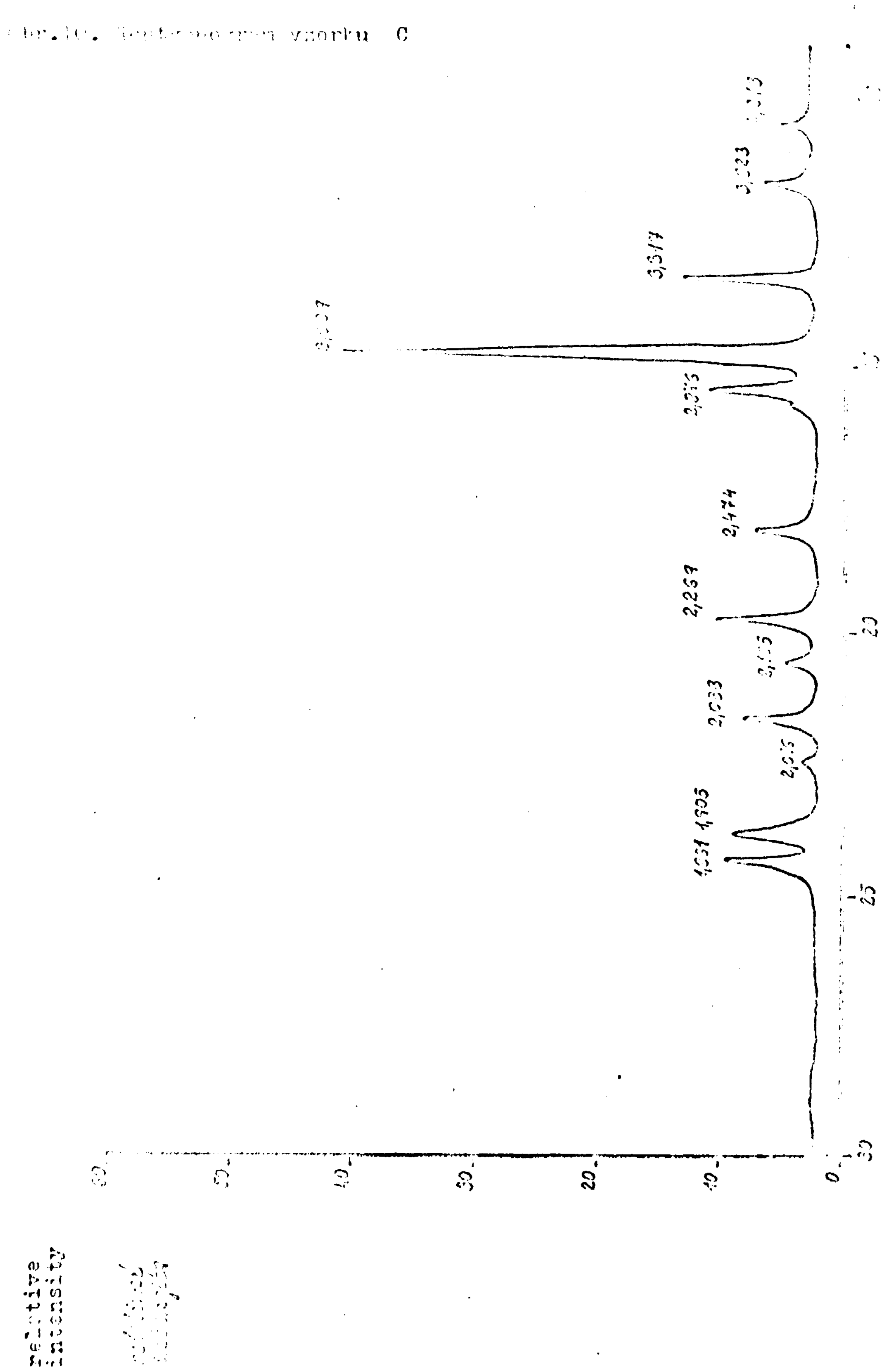
Picture 9 : X-ray pattern - sample A

Obr.9. Rentgenogram vzorku A



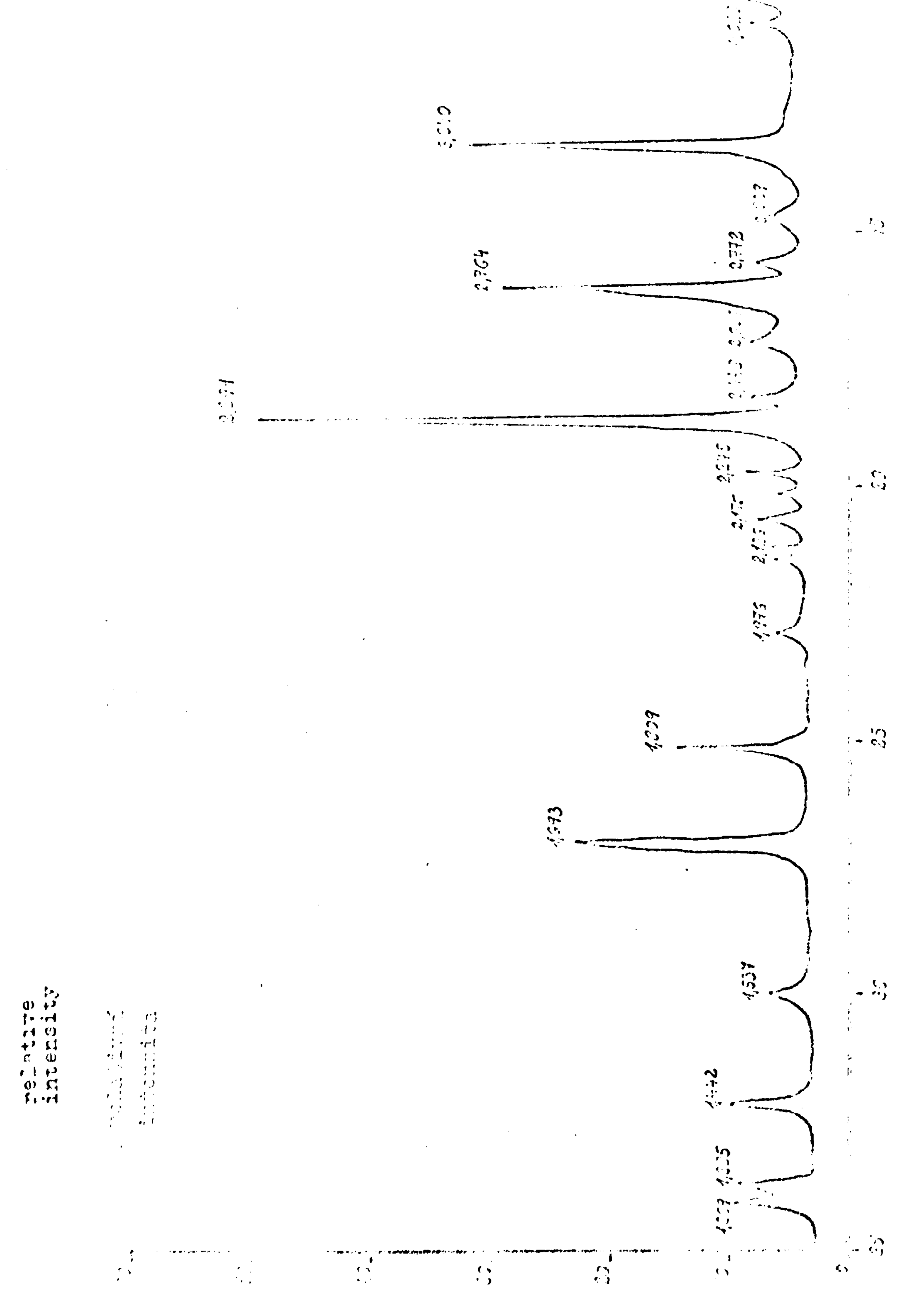
Picture 10 : X-ray pattern - sample C

Obr.10. Rentgenogram vzorku C



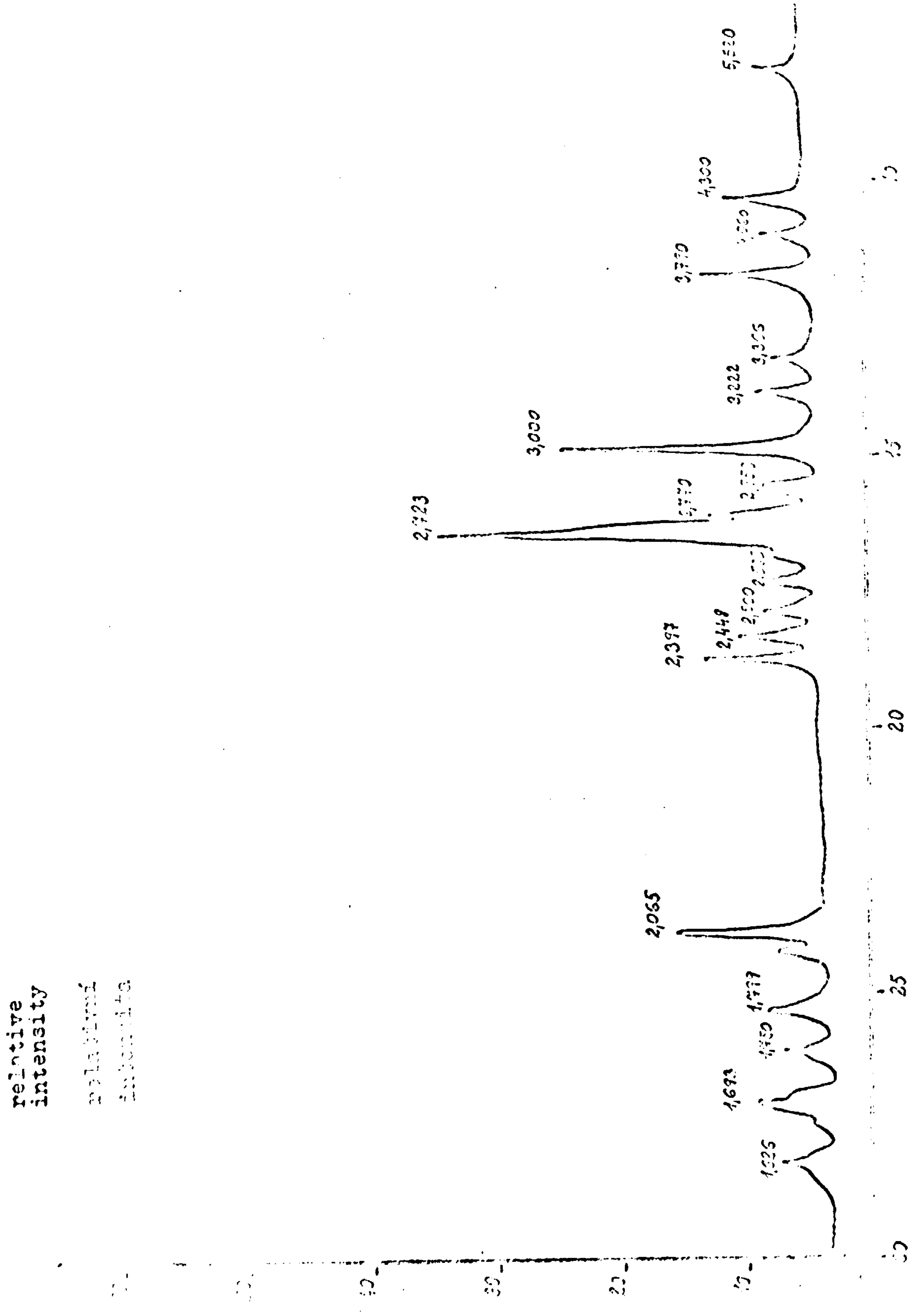
Picture 11: X-ray pattern - sample A 1200

Obr. 11. Rentgenogram vzorku A 1200



Picture 12 : X-ray pattern - sample A 1300

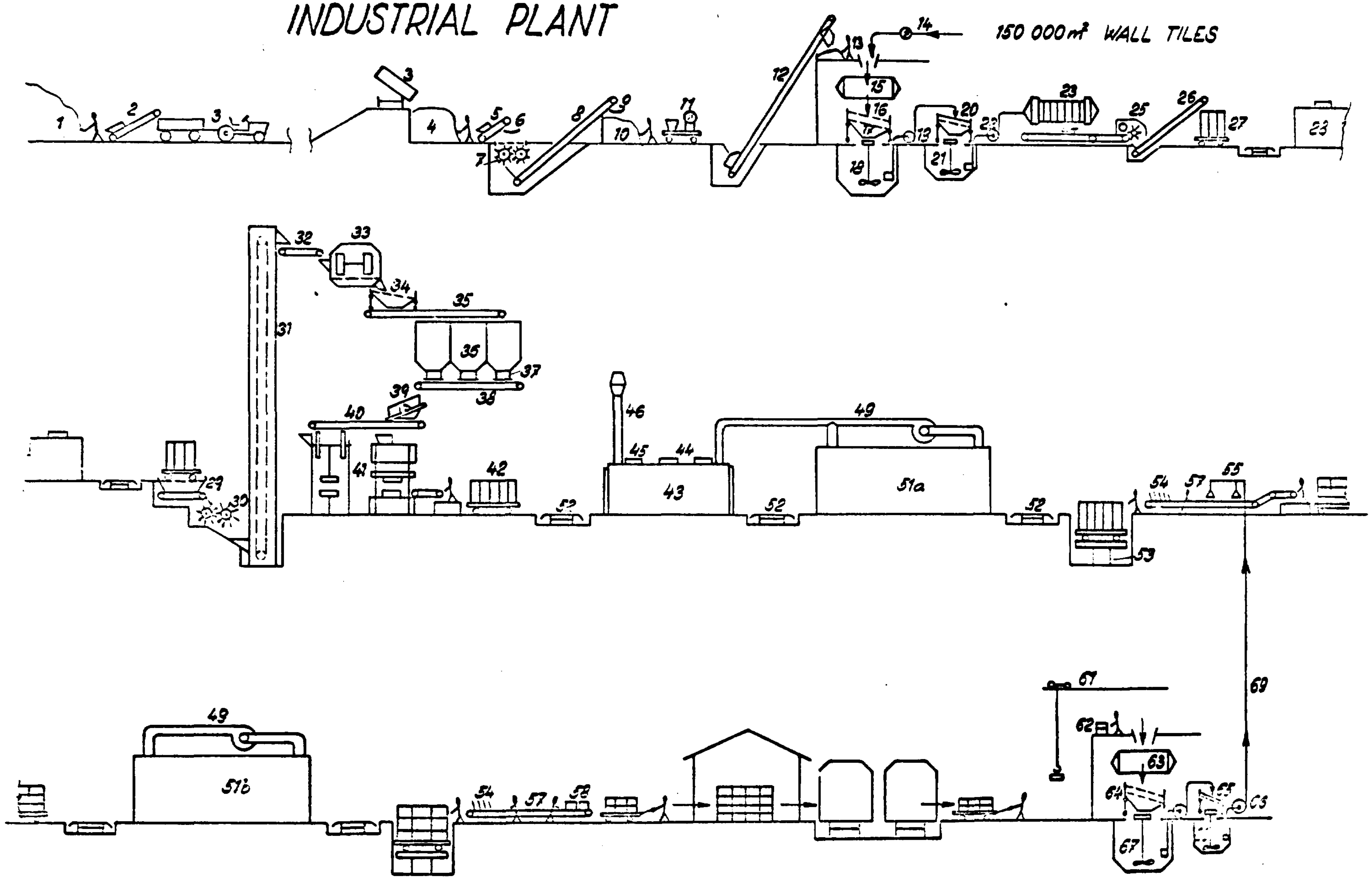
Obr.12. Rentgenogram vzorku A 1300



ANNEXE .VI,V

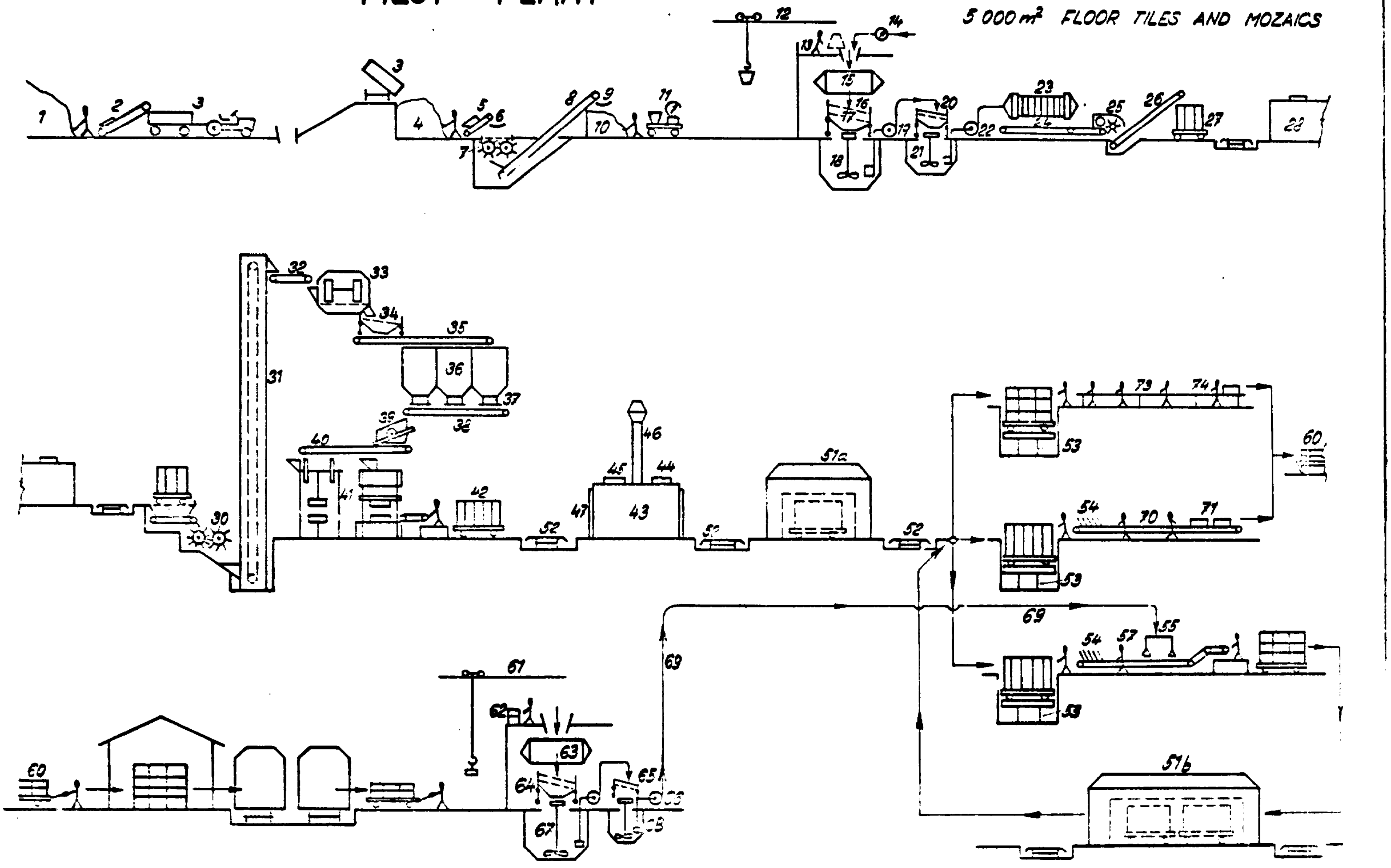
INDUSTRIAL PLANT

150 000 m² WALL TILES



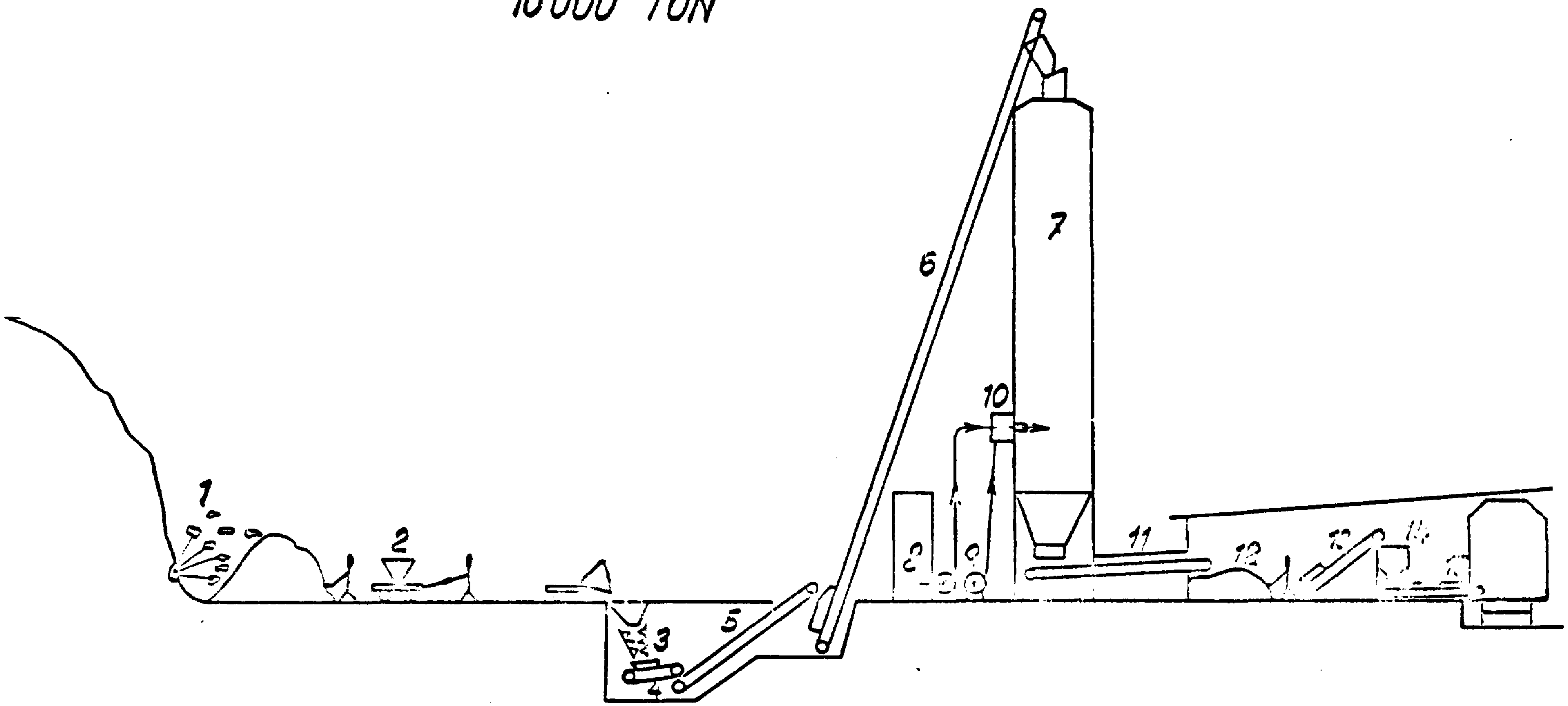
PILOT PLANT

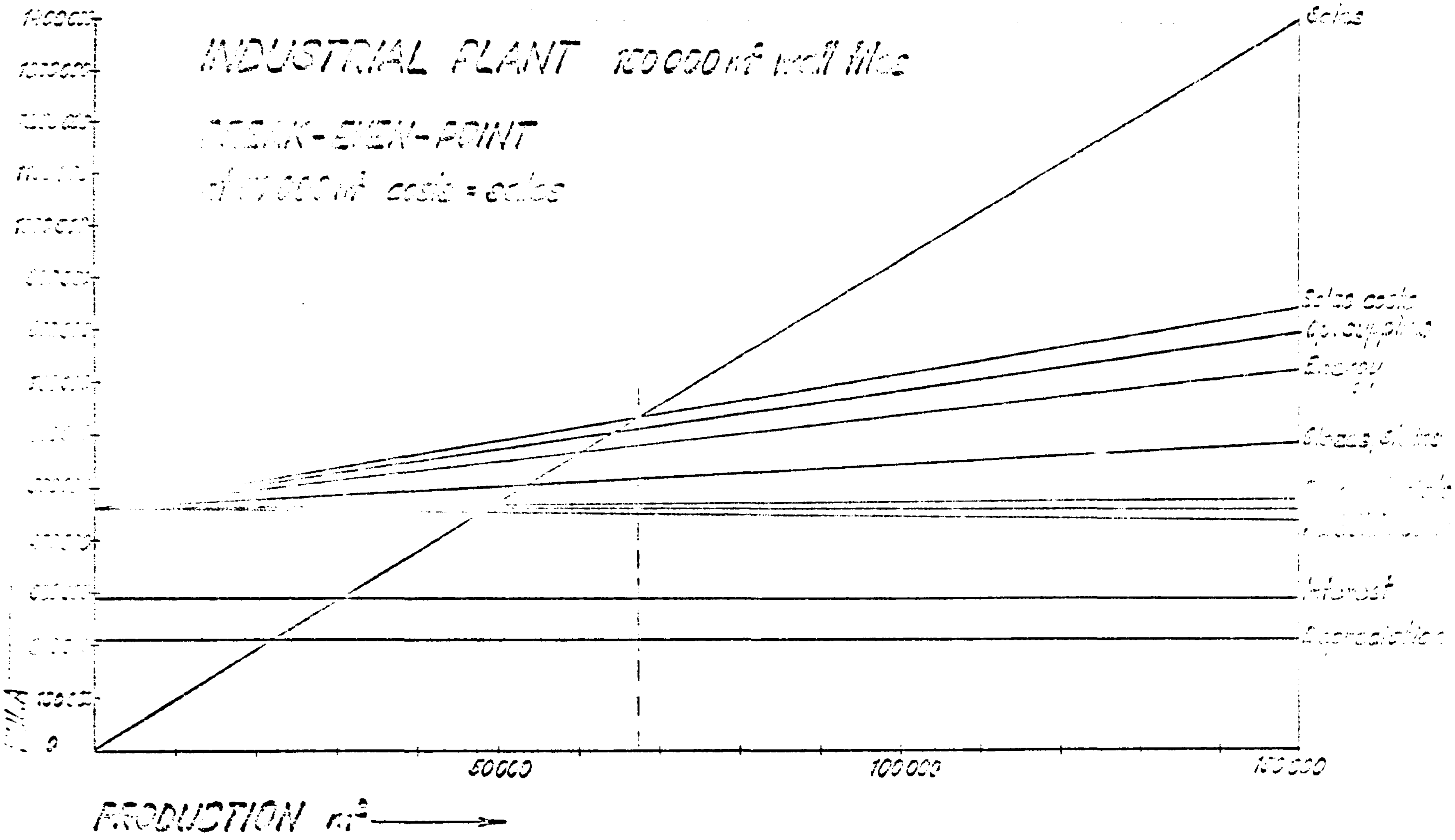
50 000 m² WALL TILES
5 000 m² FLOOR TILES AND MOZAICS



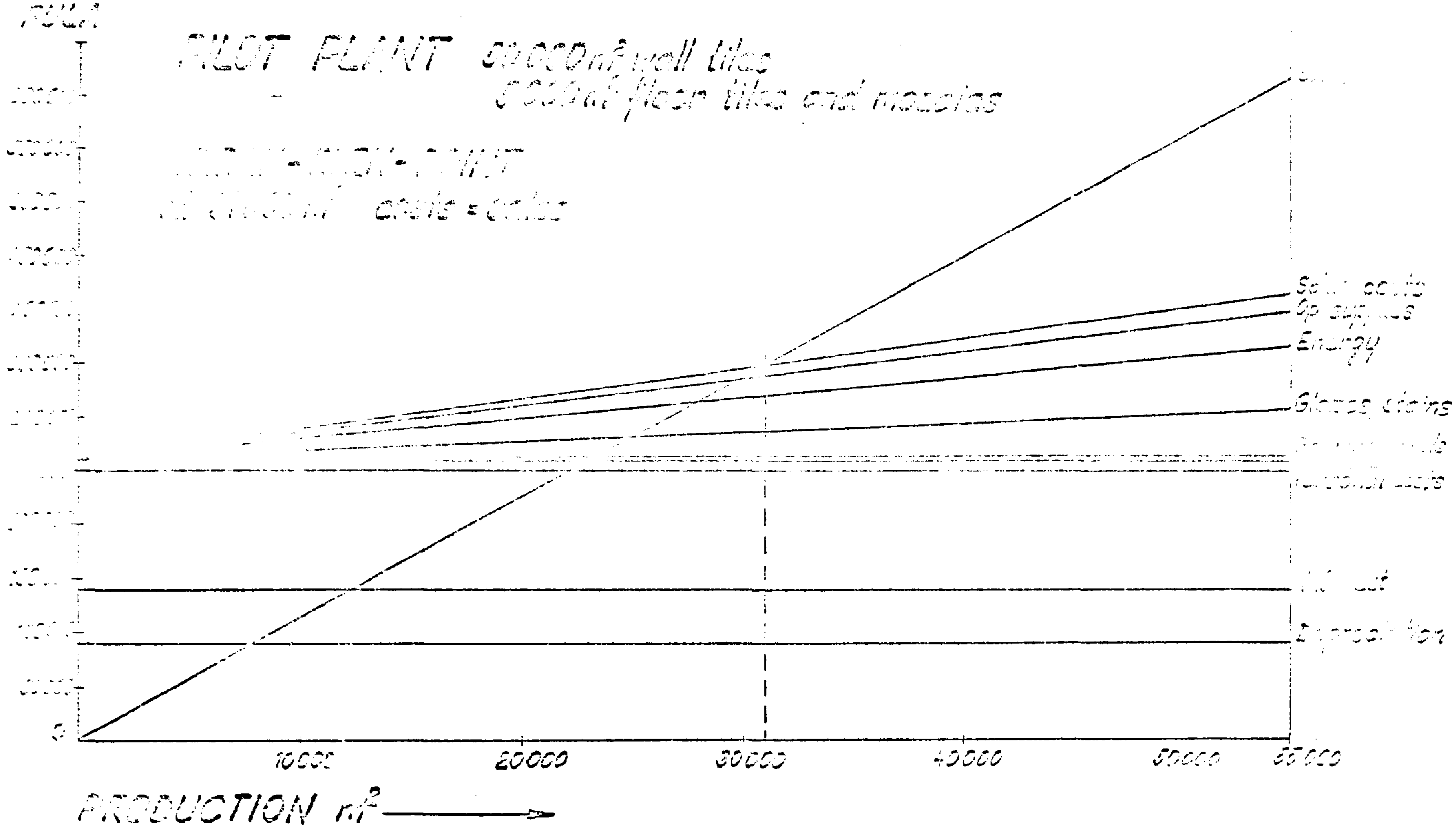
BURNT LIME PLANT

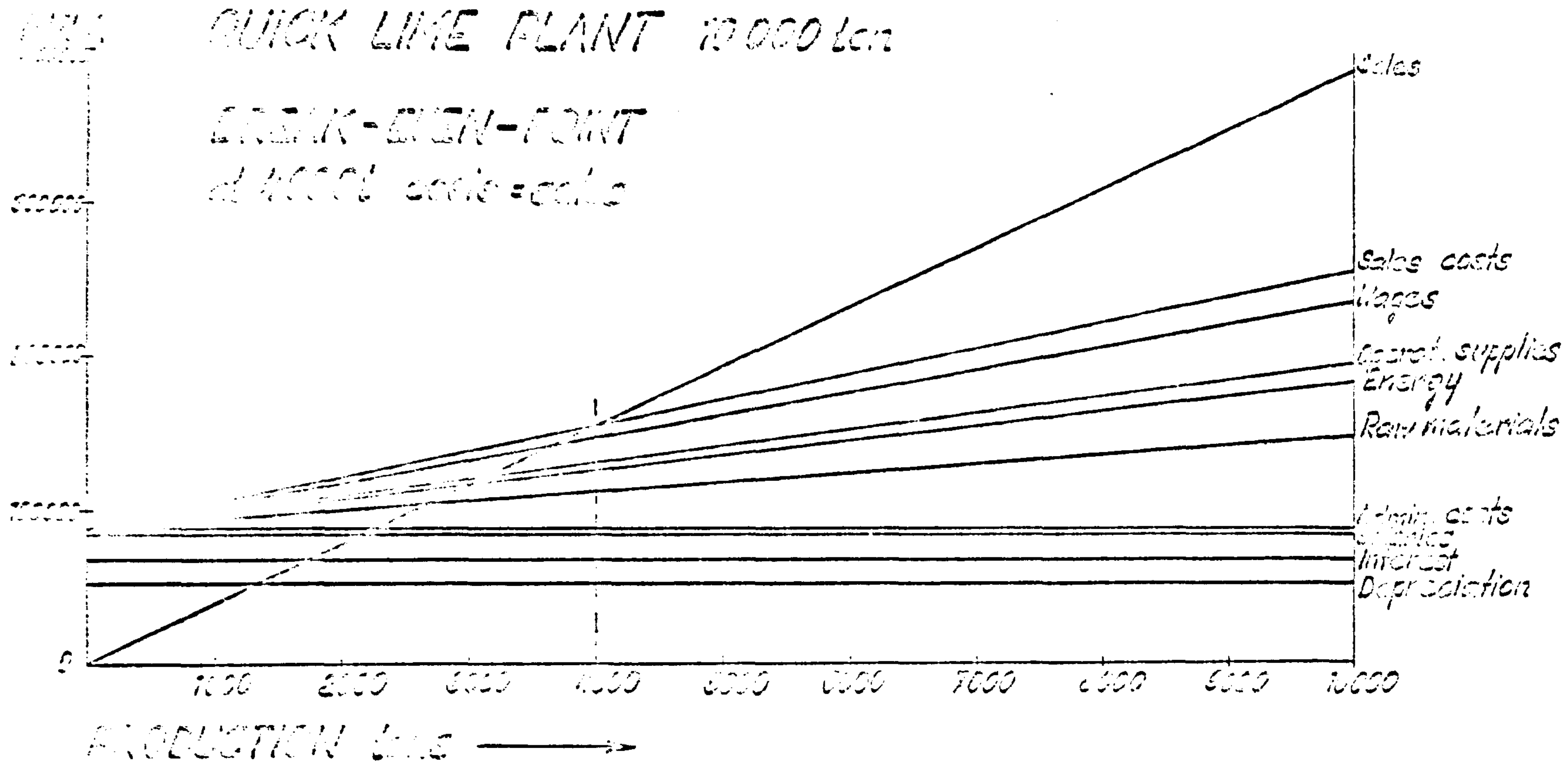
10 000 TON





INDUSTRIAL PLANT 100 000 m² wall tiles
Sales
Energy
50000
100000
PRODUCTION m²


PILOT PLANT
wall tiles
floor tiles and mosaics
Energy
Glazes stains
10000
20000
30000
40000
PRODUCTION m²


QUICK LIME PLANT 10 000 ton
Sales
Sales costs
Wages
Interest
Depreciation
0
7000
10000

SOME FIGURES
OF THIS DOCUMENT
ARE TOO LARGE
FOR MICROFICHING
AND WILL NOT
BE PHOTOGRAPHED.