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Industrial minerals of Uganda – An interim report

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INDUSTRIAL MINERALS OF UGANDA - AN INTERIM REPORT

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Cover Illustration
The cover depicts the
artesanial brickworks at
Seta near Kampala

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INTRODUCTION

This report contains scientific data gathered by S.J. Mathers during a visit to the Uganda Geological Survey and Mines Department (GSMD) from 28 July - 16 August 1992, together with the results of the laboratory evaluation of some of the samples collected, undertaken at BGS Keyworth by C.J. Mitchell.

The study builds on the data already gathered by Morgan (1991) and Mitchell (1992) as part of the ODA/BGS Minerals for Development R & D project initiative in Uganda. The data will be incorporated in an industrial minerals inventory of Uganda which will be prepared in collaboration with the GSMD and the United Nations Development Programme (UNDP). The main aim is to publicize the potential of Uganda's industrial minerals, both for domestic consumption and export, in the hope of attracting the much needed investment for the mining sector.

A further visit to Uganda is scheduled for January 1993; this will continue the study by gathering outstanding data required for the preparation of the inventory.

SUMMARY OF WORK UNDERTAKEN

The most recent systematic description of the mineral potential of Uganda (Barnes, 1961) was published over 30 years ago! Despite a troubled recent history, many subsequent studies of industrial mineral deposits in Uganda have been conducted, principally by staff of the GSMD. The unpublished reports of these studies (about 80 in all) were examined at GSMD and the principal observations noted.

In addition to this literature review, some 14 key companies were visited to establish the present requirements for industrial minerals in Uganda. These enterprises represent the core of Uganda's industry and include brickworks, cement factories, breweries, paper, paint and ceramic manufacturers. Many companies were found to be operating well below their production capacity; some factories are on a care and maintenance basis. Data were obtained on their current production, capacity, industrial mineral requirements and sources of supply. From these discussions an accurate picture of the industrial mineral needs and degree of dependence on imports is being established.

A dozen geological sections and quarries were also examined in order to assess the quality and quantity of many of the key industrial mineral deposits and to obtain samples for their characterization. The studies included a four-day excursion to the Western Rift around Kasese and Fort Portal and day trips to Tororo near the Kenyan border and to sites around Kampala. Plans to visit a diatomite deposit near Packwach in West Nile were abandoned on advice from the British High Commission regarding the security situation in northern Uganda. Deposits studied included limestones, brickclays, gypsum, potential bentonitic clays and kaolins.

The samples returned to the UK for further study included clays, limestones, silica sand and diatomite. These were investigated using a blend of appropriate techniques to determine the physico-chemical properties of the samples. The results are described below in an integrated account of the field and laboratory studies; also included are notes on the literature review and the consultations with industry.

DETAILS OF FIELD AND LABORATORY STUDIES

Notes on data gathered during visits to individual companies and geological localities are presented below together with results of laboratory tests conducted on the samples recovered.

Uganda Clays Ltd. Kajansi.

Uganda Clays Ltd are located at Kajansi (Kajjansi), about 12km south of Kampala on the road to Entebbe and operate the only mechanized brick and tile factory near the capital. The site has produced bricks at least since the 1940s; Pallister (1959) records the presence of variable raw materials including some highly plastic clays (ballclays) together with "ideal" brickclays. Today the brickclay is dug from an opencast pit 1km west of the factory located in the shallow valley of the River Kajansi which runs southeastwards down to Lake Victoria.

Sections in the working face show up to 2.5m of sandy clay, pale grey at depth but leached to pale brown in the upper metre. Within the clay are patches of medium grained sand occurring as thin beds and perhaps also as channel infills. These are unsuitable for brickmaking and are thus left unworked as waste "islands" up to 20m by 15m within the pit. Working northwestwards upstream means that the height of the working face gradually diminishes since a slope is required on the quarry floor for drainage. Ample reserves exist adjacent to the pit and the installation of a drainage channel would enable the depth of extraction to be increased by a further 1 - 2m. A systematic survey using an EM 31 portable Ground Conductivity Meter coupled with the use of extendable augers of trial pits would probably delineate the waste sand bodies in the areas still to be worked. For further details of this approach see Mathers & Zalasiewicz (1985). If successful the survey would enable the company to plan its future extraction more efficiently.

The factory produces bricks and rooftiles of several sizes together with short drainage pipes. Floortiles are also manufactured on-site by a sister company - Gobbot Ltd. The raw material is regarded as adequate for the bricks and rooftiles, but some difficulty is experienced with the floortiles due to the variable nature of the raw feedstock. Bending of 1m long extruded drainage pipes during drying has led to just a short 30cm version being manufactured. I recommended that the raw feedstock should be stockpiled to weather for 1 - 2 weeks in order to try and overcome the difficulty of bending in the long drainage pipes. Clay extracted straight from the pit tends to contain residual stresses which can manifest themselves by distorting extruded pieces, alternatively the clay may simply be too plastic and require the addition of non-plastic material to give it strength.

Production follows the standard procedure of crushing the raw material to remove lumps, adding water and pressing through screens prior to the extrusion of the pieces. The machinery in use is from the Italian Bongiammi company, and because of its considerable age spare parts have to be specially manufactured sometimes resulting in protracted down times. Drying takes place above and adjacent to the kiln where the heat can be readily directed, in the dry season outdoor shaded racks are also utilized. The kiln is a Hoffmann continuous firing type which burns horizontally with the control of valves and fans, some 24 chambers are used as the fire progresses through the rectangular kiln. Firing is of about 8 hours duration so that the fire reaches the same chamber every eight days. The fuel is provided by discarded coffee husks which supply sufficient energy through their carefully regulated addition to attain optimum firing temperatures of around 1000°C.

A sample of the raw feedstock for the factory was obtained for characterization. It contains mainly feldspar and quartz with a small amount of kaolinite and smectite (Ca-)(Figure 1, Table 1). The clay fraction (<2μm) comprises 65.4% of the sample (Table 2) and is chiefly composed of kaolinite and smectite. The Liquid Limit is 38, the Plastic Limit 20 and the Plasticity Index 18. The Kajansi brickclay has optimum moulding properties for brickmaking as can be seen from the plot of Plastic Limit against Plasticity Index shown in Figure 2. Figure 3 presents a plot of porosity and shrinkage against temperature (vitrification curve). The porosity falls sharply with increasing temperature whereas shrinkage increases, this indicating a rapid vitrification of the clay. There is no evidence of bloating below 1200°C. (Figure 4), in contrast for example with the Kibuku clay sample. The Kajansi clay fires to a brick red colour (Figure 4). The sharp reduction in porosity between 1000°C and 1100°C (from 22% to 0.1%)

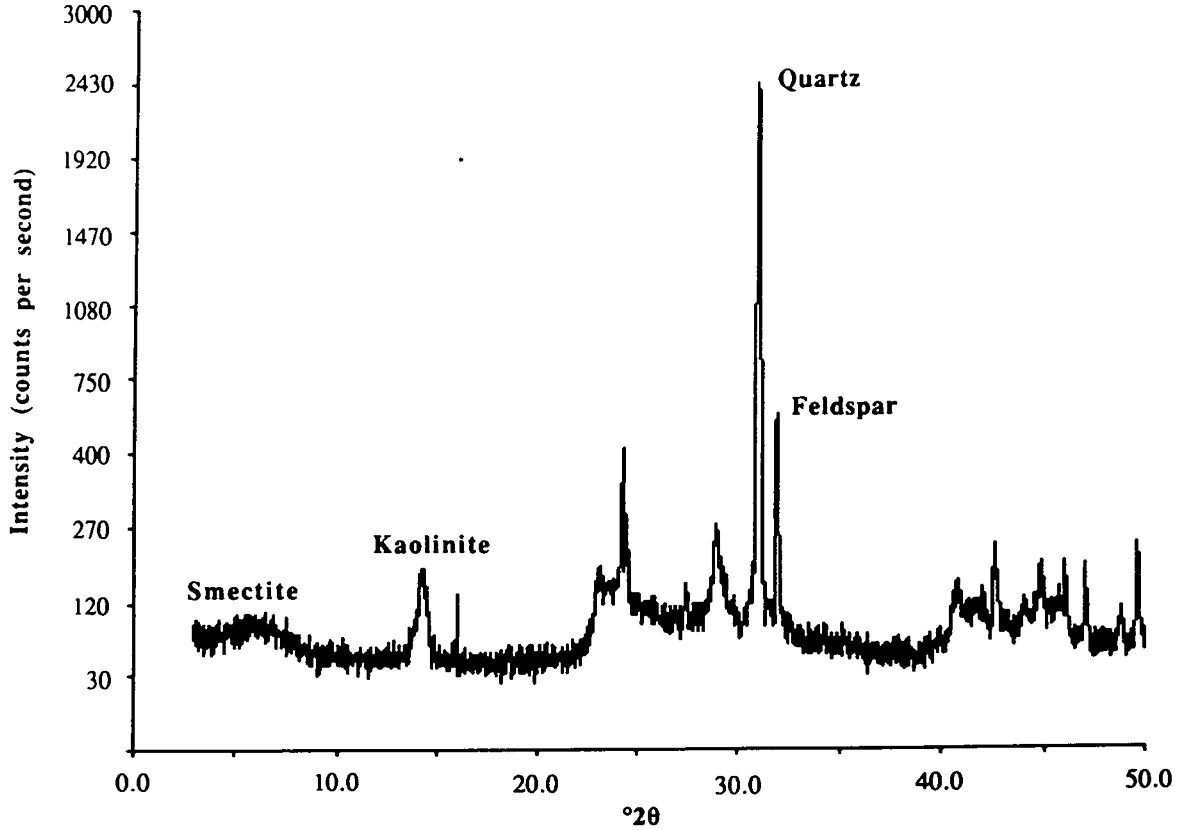

Figure 1 X-ray diffraction trace of brick clay, Kajansi, Uganda

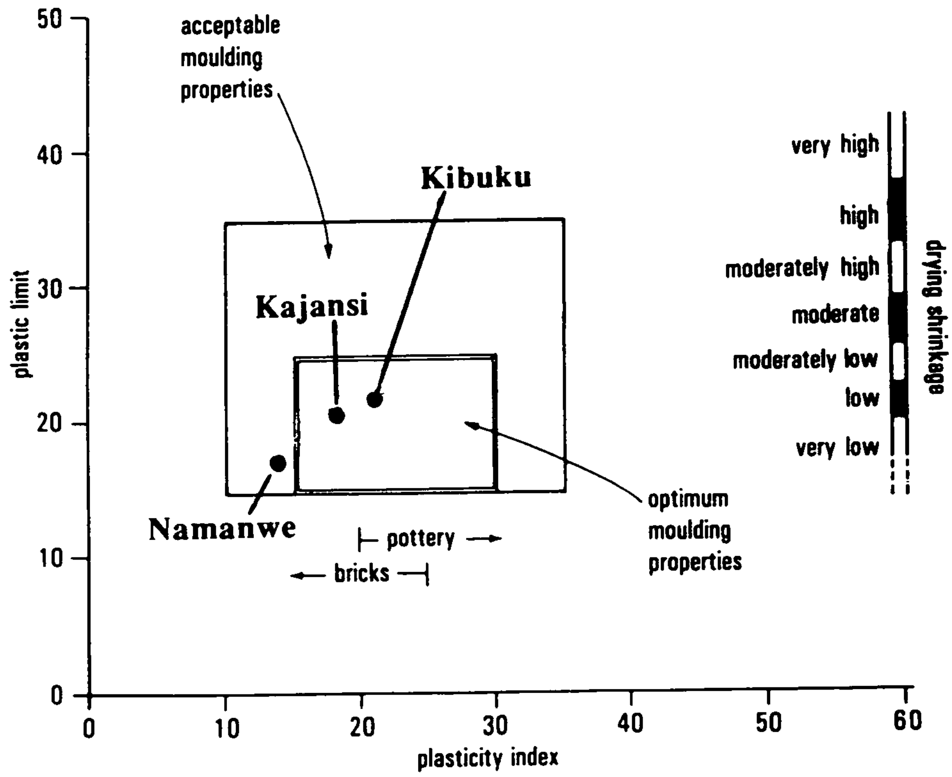

Figure 2 Plasticity of selected Ugandan clays.

Table 1. Mineralogy of industrial minerals examined from Uganda determined by XRD.

Sample	Mineralogy
Brick clay, Kajansi	Feldspar ****, quartz ***, kaolinite **, smectite *
Potential brick clay, Namanve	Quartz ***, kaolinite **, feldspar **, smectite *
Clay, Kibuku	Smectite (34%), quartz ***, feldspar **, gypsum **
Silica sand, Dima	Quartz (99%), iron oxides
Diatomite, Pakwach	Diatomite ****, kaolinite (39%)
Tuff, Rubirizi	Feldspar ***, quartz **, mica **, amphibole (hornblende?) *, smectite *, zeolite *.
Limestone, Hima	Calcite, quartz
Limestone (dark type), Muhokya	Calcite, quartz
Limestone (whitewash type), Muhokya	Calcite, quartz

NOTE

A Phillips PW 1700 X-ray diffractometer was used. The bulk mineralogy was determined by scanning randomly oriented mounts over 3-50°2θ and clay mineralogy was determined by scanning oriented mounts over 1.5-30°2θ (<2 μm samples only).

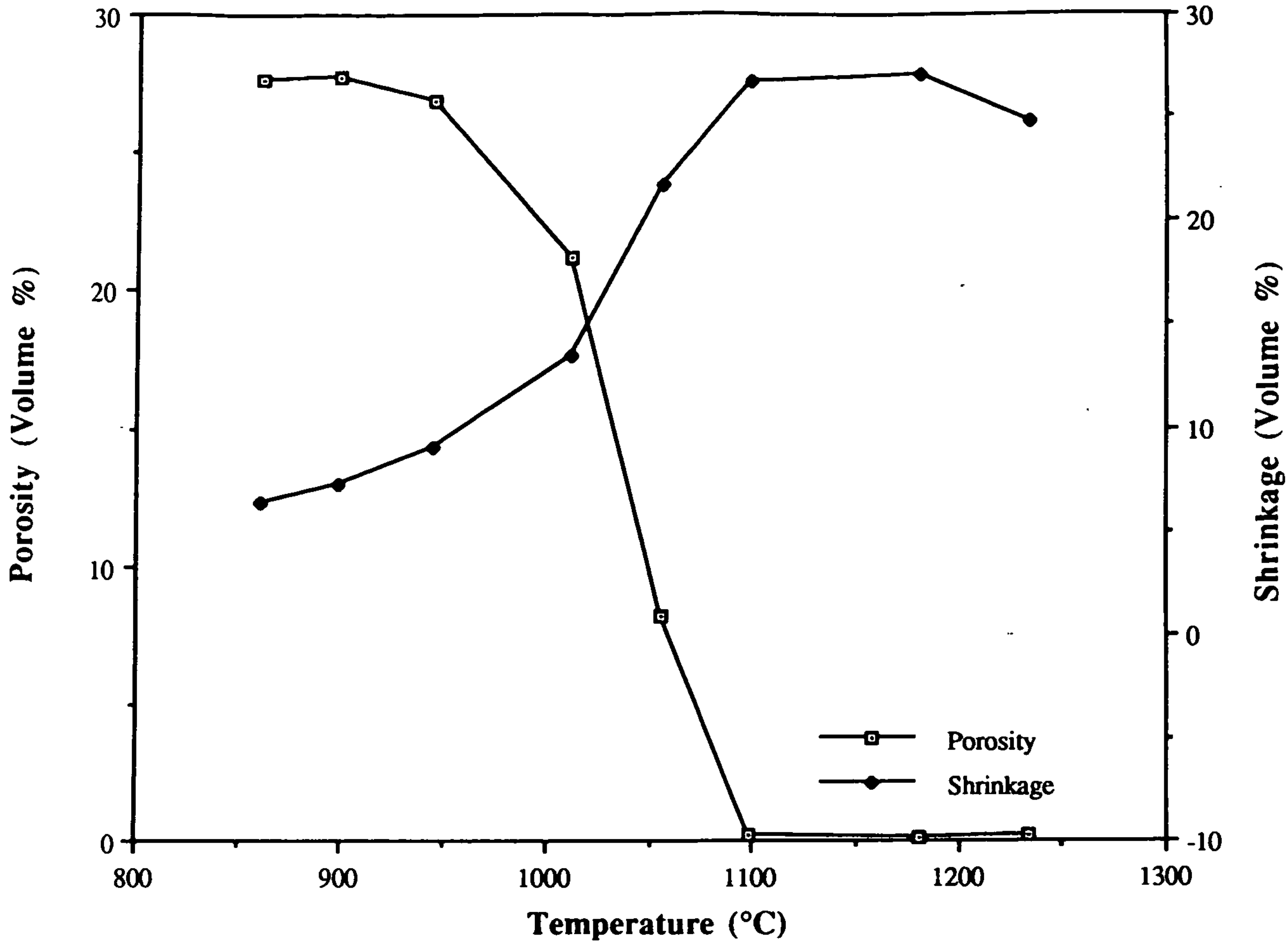

Figure 3 Vitrification curve for brick clay, Kajansi, Uganda

Table 2. Particle-size distribution of clay, Kajansi and Namanve, Uganda

Particle-size range	Kajansi (Wt %)	Namanve (Wt %)
>63 μm (sand)	3.1	24.2
2 - 63 μm (silt)	31.5	30.3
<2 μm (clay)	65.4	45.5
Total	100.0	100.0

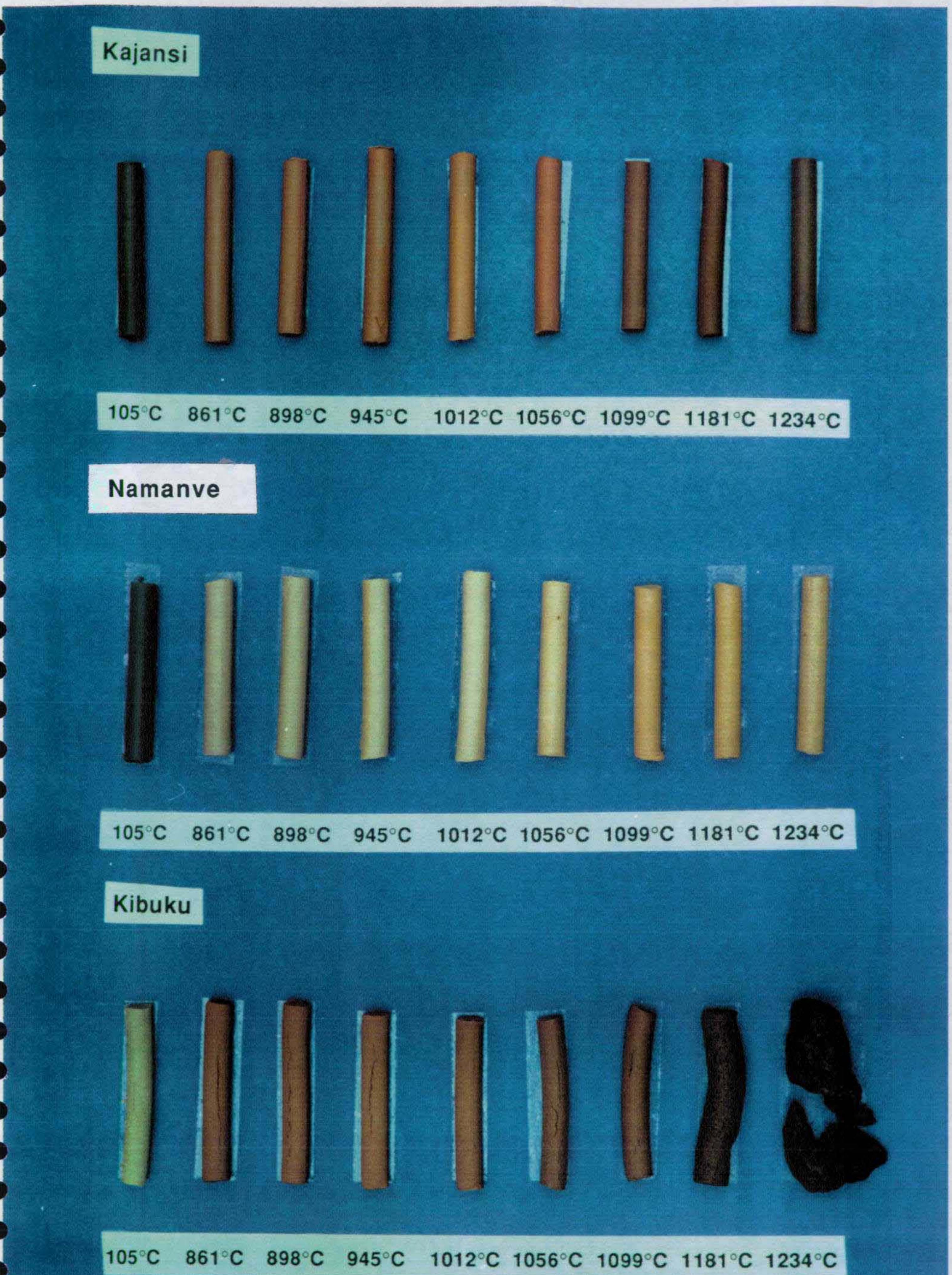

Figure 4 Ceramic test pieces (before and after temperature gradient firing)

indicates that any variation in kiln temperature will be reflected by differing brick properties.

The company has a production of 65-70 tonnes of products per day and employs about 350 people. Plans to expand production to levels around 100 tonnes per day are in hand involving in particular more efficient utilization of the kiln waste gases for drying. Reserves of raw material are sufficient for 100 years at present production levels. Contacts are Mr Magambo - Operations Manager and Mr Cosmos Orwoch, Ceramist. Address: Uganda Clays Ltd., PO Box 3188 Kampala.

BK Industries Kampala.

A brief visit was made to BK Industries who manufacture polyester resin based sanitaryware. They utilize small quantities of quartz sand from the beaches near Entebbe which they grind and sieve to less than 0.1mm together with finely ground calcium carbonate, which they import from Kenya; both act as fillers in their products.

African Ceramics Ltd.

African Ceramics Ltd are located north of Mukono and make ceramic tableware for the domestic market using national materials. Since its establishment in 1985 the company has been dogged by problems, the most serious being a lack of working capital, unreliable power supply (no stand-by generator) and uncertainty over the future public or private ownership of the company have also hampered progress. The factory is presently on a care and maintenance basis awaiting resolution of these issues.

Production utilizes several raw materials; white silica sand from the shores of Lake Victoria at Dima (see below), kaolin and K-feldspar from Mutaka mine in southwest Uganda (also see below) and grey plastic ballclay from near Mukono. Kaolin from Namasera Hill, north of Kasanje was tried several years ago as an alternative to the Mutaka kaolin but its low whiteness, high iron content and gritty texture (see also Mitchell, 1992) made it completely unsuitable for use. Pallister (1959, pgs 94-95) provides some basic data particle size and chemical data for the Mukono ballclay; Gill (1965) classes it as a sedentary (residual) clay which is developed on granite-gneiss basement. The residual washed surficial layer is worked comprising blue-grey sandy clay of high plasticity, despite a substantial quartz content; it is white-firing.

Gypsum for moulds and preparatory glazes are imported from the UK. The silica sand and feldspar are ground so that at least 33% is finer than 10μm, it is then blended with the kaolin and ball clay to make the slip which is passed through a pugging mill to remove the air, prior to extrusion as sticks of clay for placing in the gypsum moulds. The formed ceramic ware undergoes two stages of firing, first in raw form and second with the glaze applied. The kilns in use are from Kilns and Furnaces Ltd. of Stoke-on-Trent. Finished products are sold via the company's shop in Kampala.

Silica sand, Dima

A sample of unprocessed silica-rich beach sand from Dima (Dumu, Dimu, Diimu) on the western shore of Lake Victoria was collected at African Ceramics Ltd for examination. This deposit has reportedly been assessed recently by a Dutch company as a potential glass sand. Parts of the deposit have also been investigated by Mukinda (1973) who concluded that the deposit is generally too coarse for use in the glass industry.

The sample is mainly quartz and chemical analysis shows that it contains 99.7% SiO_2 and has low TiO_2 (0.11%), Fe_2O_3 (0.14%) and Cr_2O_3 (12ppm) contents (Table 3). The sand grains are virtually all (99.2%) between 125μm and 500μm in diameter (Figure 5) and are sub-rounded to sub-angular in shape. Unprocessed, this sand is possibly suitable for a variety of industrial applications,

Table 3. Chemistry of silica sand and diatomite from Uganda

Major element oxides (Wt %)	Silica sand, Dima	Glass sand	Diatomite, Pakwach	Celite (commercial filter aid)
SiO_2	99.65	99.7	63.33	86.9
TiO_2	0.11	0.02	0.87	0.18
Al_2O_3	0.29	0.08	21.86	3.1
Fe_2O_3t	0.14	0.025	2.75	1.1
MnO	0.000	-	0.007	NA
MgO	0.00	0.01	0.63	0.65
CaO	0.04	0.01	0.28	0.41
Na_2O	0.00	0.004	0.12	} 0.88
K_2O	0.03	0.005	0.48	
P_2O_5	0.01	-	0.04	0.15
LOI	0.16	-	9.29	3.8
Total	100.43	-	99.66	
Trace element chemistry (ppm)				
Mn	-	-	80	60
V	-	-	63	200
Cr	12	2	108	100
Co	-	-	10	120
Ni	-	-	22	120
Cu	-	-	20	40
Zn	-	-	47	<10
Rb	-	-	19	10
Sr	-	-	49	20
Y	-	-	12	100
Zr	-	-	154	20
Nb	-	-	31	5
Mo	-	-	2	5
Ag	-	-	2	<0.5
Sn	-	-	1	<1
Sb	-	-	3	2
Ba	-	-	37	30
La	-	-	52	10
Ce	-	-	15	2
Pb	-	-	15	2
Th	-	-	10	5
U	-	-	1	5
As	-	-	5	5
Bi	-	-	<1	<0.5
W	-	-	8	<0.5

N.B. Chemistry of glass sand and Celite from SJ Lefond (Ed.) "Industrial Minerals and Rocks" 3rd Ed. 1983.

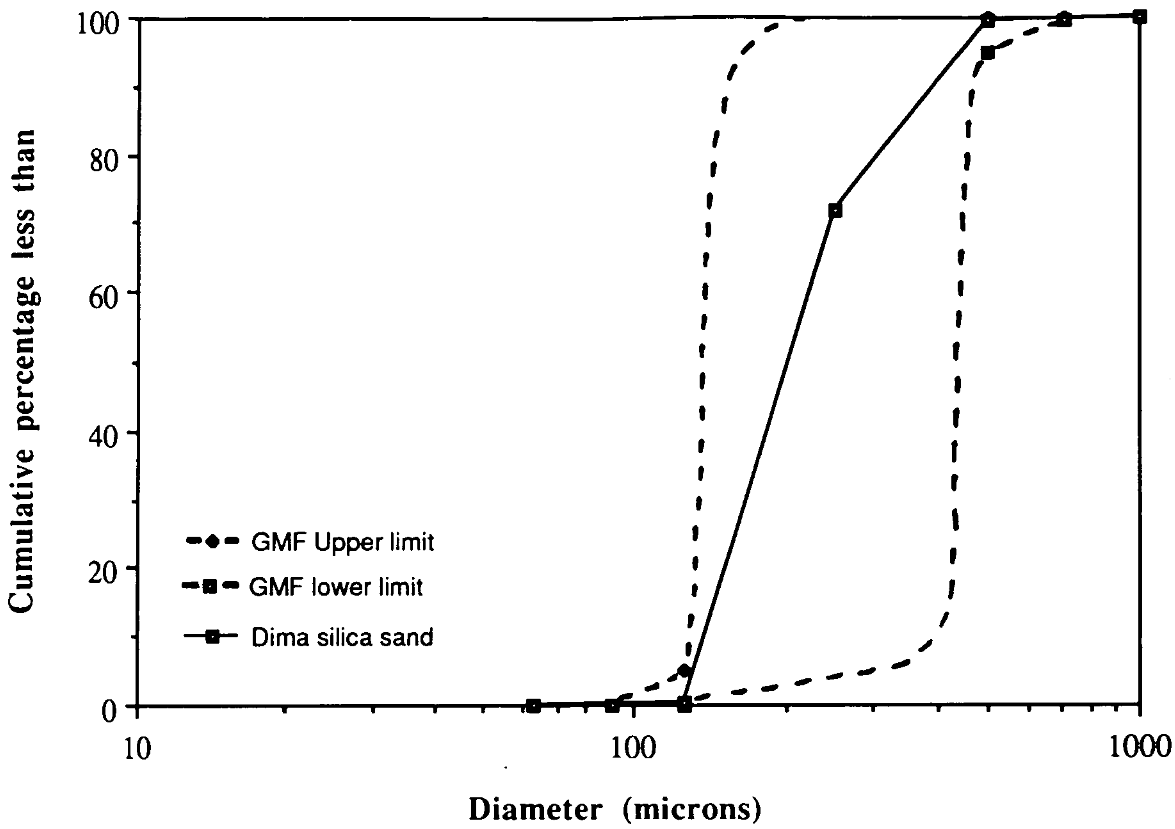

Figure 5. Particle-size distribution of glass sand

N.B. GMF sand refers to the upper particle size recommended by the Glass Manufacturers Federation for container and flat glass manufacture (Highley, 1977)

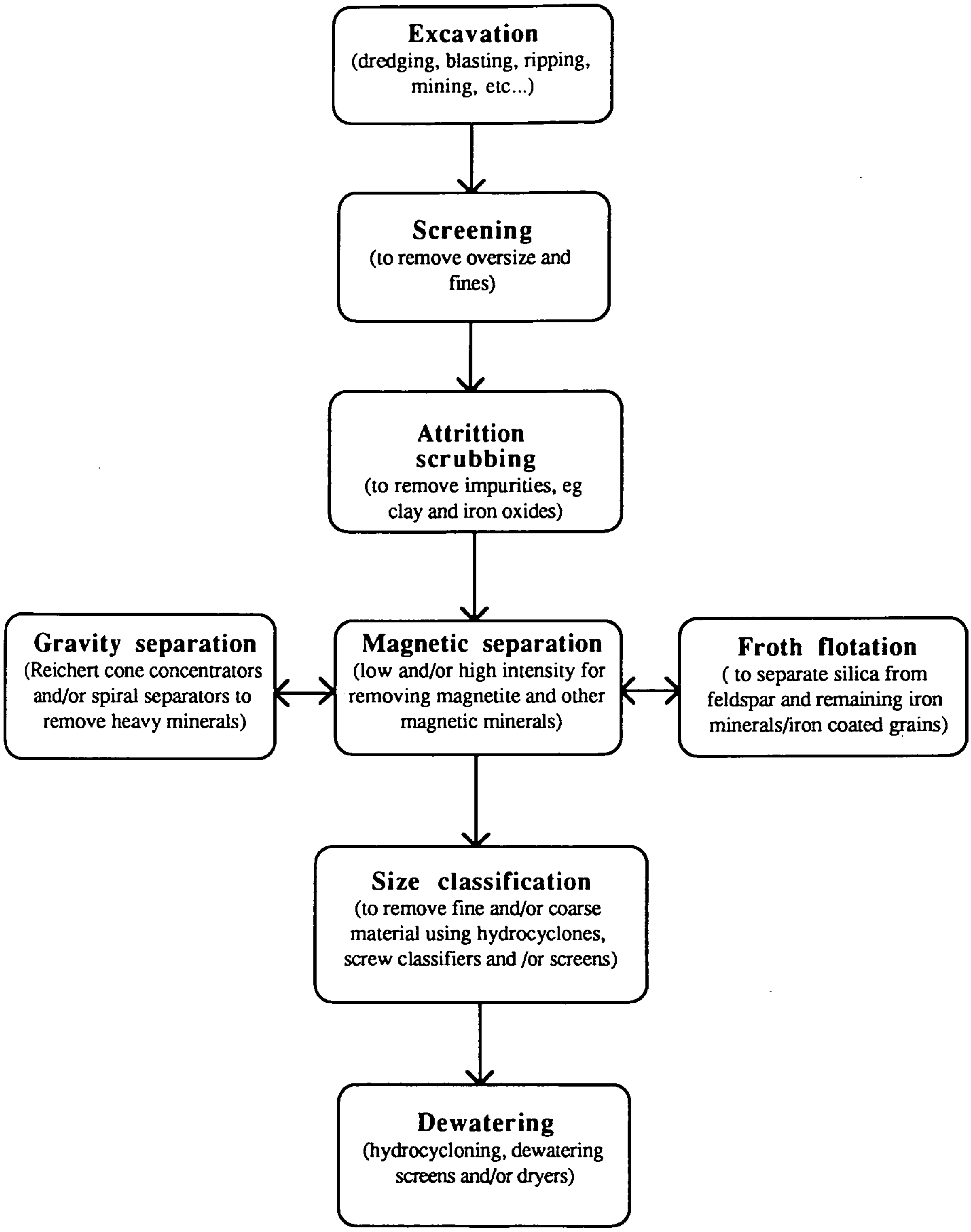

Figure 6 Flowsheet for the processing of glass grade silica sand

including the manufacture of coloured glass and use as a filler in ceramics. A minimal amount of processing to reduce the Fe_2O_3 and Cr_2O_3 content would be required to upgrade the sand; figure 6 shows a typical processing scheme that could be applied. The sand finer than 125μm contains a relatively high proportion of dark coloured minerals and simple screening may be enough to remove these impurities and also reduce the Fe_2O_3 and Cr_2O_3 contents. Published specifications for glass sand suggest that for flat glass production the sand should contain <0.1% Fe_2O_3, and for colourless glass it should contain <0.03% Fe_2O_3 and <5ppm Cr_2O_3. The sand should also have a maximum of 1% of grains >600μm in diameter and a maximum of 15% <150μm.

Diatomite, Packwach

A detailed chemical analysis of the diatomite from Packwach has been obtained following earlier studies of the material by Mitchell (1992) which showed the diatomite to be very white but impure, containing 39% kaolinite. The analysis is presented in Table 3. Without processing the deposit does not meet the specifications for filter-aids or fillers which generally require SiO_2 >85%, CaO <1% and Fe_2O_3 <1.5%. The trace element chemistry is similar to that published for commercial filter-aids (see Table 3). Processing trials are recommended to try and upgrade the diatomite through hydrocycloning or air classification.

Seta Artesanial Brickworks

Traditional methods of brickmaking were examined at Seta where a grey-brown mottled bauxitic laterite is being exploited. The deposit has developed by in situ weathering of the underlying granite-gneiss basement. Solid "Kifufu" bricks approximately 30 x 20 x 15 cm are hand-cut from the clay face, stacked in mounds up to 3m high (see cover photo), then covered with straw and fired. The result is a variable, relatively underfired, but useable, brick. This particular clay deposit around Seta has been the subject of interest from the Kenyan glass industry due to its high alumina content; however, the Ugandan Government decided that it should be expoited for national benefit.

Namanve Valley

The site of a recent GSMD geological evaluation (Musisi, 1986; Tuhumwire, 1988; Tuhumwire & Katto 1990) of a clay deposit in the Namanve Valley was also visited. This deposit is a close analogue of the deposits at Kajansi, comprising up to 2.5m of grey plastic clay suitable for brickmaking. The deposit was evaluated at the request of the Ministry of Defence with a view to providing materials for the construction of a nearby barracks. An opposing environmental group wanted to see the area re-afforested. The decision in favour of tree planting was finally made by government so the deposit is presently sterilized but could be worked in the (long term) future. Since no mineralogical or compositional data were reported during the evaluation a representative sample (GSMD Ref. No. NV/XL 7/P3) was taken for characterization.

The sample contains mainly quartz, with a small amount of kaolinite, feldspar and smectite (Figure 7; Table 1). The clay fraction, some 45.5% of the sample (Table 2), is mainly kaolinite and smectite. The Liquid Limit is 31, the Plastic Limit 17 and the Plasticity Index 14 (Figure 3). The Namanve clay has acceptable moulding properties for brickmaking. The vitrification curve (Figure 8) indicates gradual vitrification with no evidence of bloating; the moderate porosity reduction indicates that the bricks should be more uniform than those made from the Kajansi clay given an equal variation of kiln temperature. The clay fires to an attractive cream-buff colour (Figure 4).

Muhindo Enterprises

Mr Muhindo is a businessman and entrepreneur with interests in mining in Uganda. He has for many years been attempting to get financial backing for a scheme to develop the Mutaka pegmatite

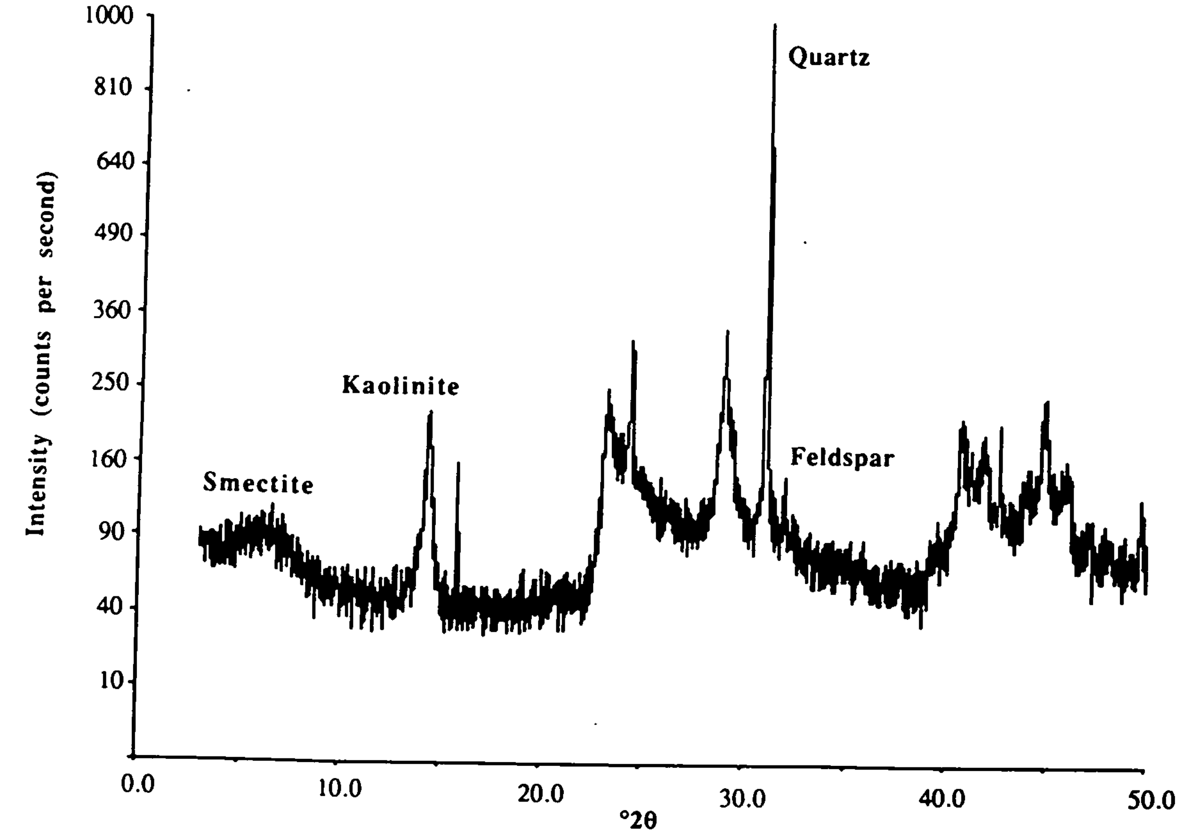

Figure 7 X-ray diffraction trace of potential brick clay, Namanve, Uganda

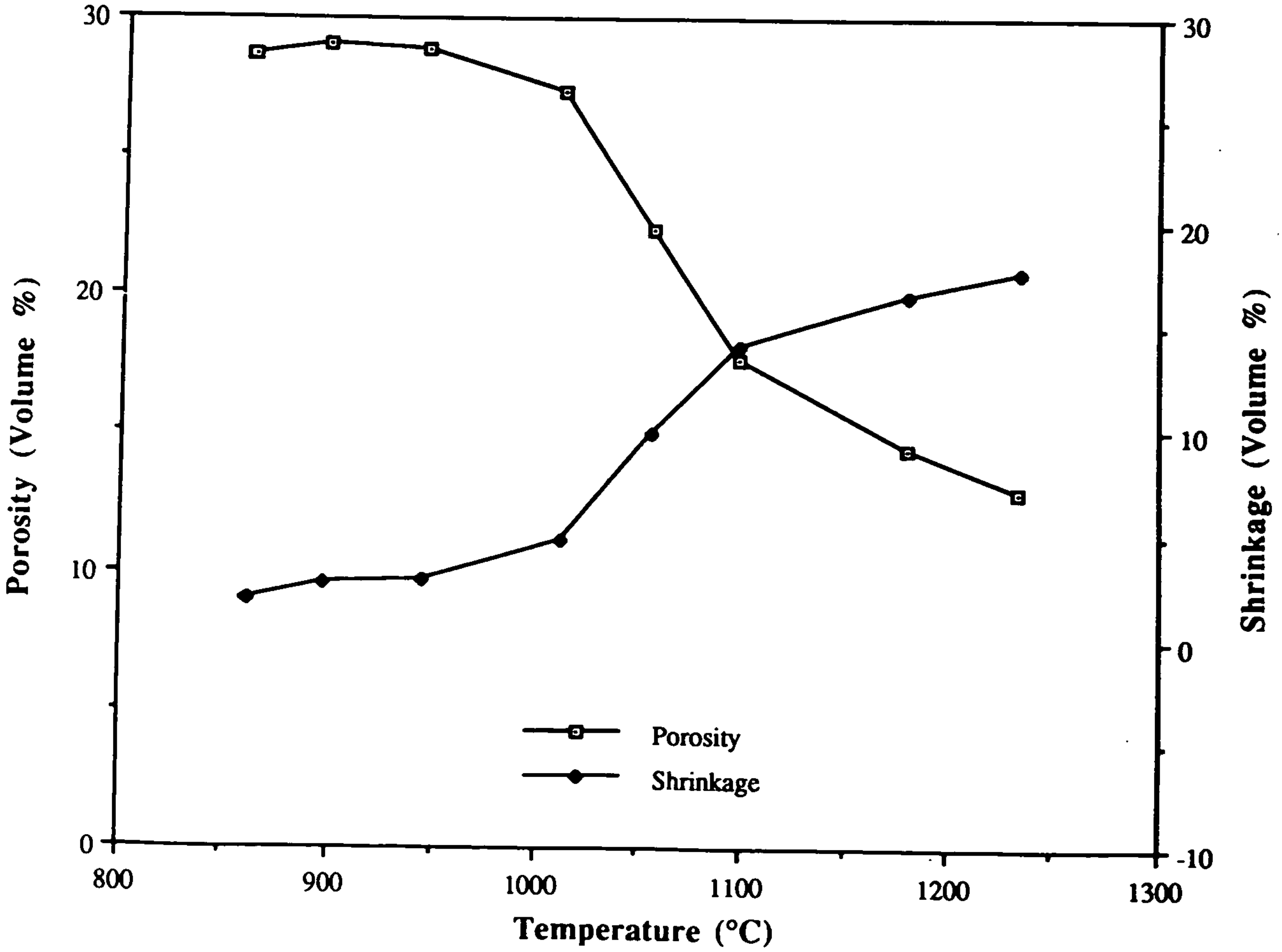

Figure 8 Vitrification curve for potential brick clay, Namanve, Uganda

to produce kaolin for the paper and ceramics industries. He supplied a copy of a technical report on the Mutaka kaolin done by the German company AKWU. This report contains very similar conclusions to the BGS study of the material (Mitchell, 1992, see below) in stating that the kaolin is of good quality and can be beneficiated through wet processing to a product likely to be acceptable for paper and ceramic manufacture. It is already being used for the latter application by African Ceramics Ltd.

Mr Muhindo explained that on the basis of the German report he had obtained backing from the Uganda Development Bank for a feasibility study of the kaolin reserves at Mutaka. After tender the Tanzanian Industrial Studies Company (TISCO) had been appointed and were expected to carry out the evaluation over the next two months before the deadline for utilizing the grant expires. Mr Muhindo said he would send the terms of reference for the study; he also referred to a Commonwealth Development Corporation (CDC) report on Mutaka. Mr Muhindo requires advice on the availability of small pilot plants to attempt on-site processing of the kaolin.

Robbialac Paints

Robbialac Paints supplied the following information: they use about 5 tonnes per annum (tpa) of TiO_2 pigment, 15 tpa of calcium carbonate (whiting), 3 tpa of dolomite together with small amounts of talc, kaolin and coloured pigments. Almost all these materials are imported. The TiO_2 pigment costs about US$80 per kilo whilst the carbonate fillers cost about US$2 per kilo.

National Enterprise Corporation (NEC)

Capt. Sikidde of the NEC is concerned with the production of lime in western Uganda, principally for use in road construction but also its potential use in agriculture. He would like the limestone occurrence at Dura east of Lake George investigated; he stated that three types of limestone occur here: spar (presumably crystalline calcite), travertine and iron-stained limestone. The deposit is inaccessible except by rail. Capt. Sikidde is obtaining representative samples for examination. He also mentioned that much of the lime he receives from the two companies at Muhokya is underburnt and problems result in using it. He therefore wondered whether some advice could be offered to the producers on kiln design (but see below). He also specified a need for bentonite for use as a binder in foundry mouldings. In the east Uganda has very favourable terrain for bentonite and exploration might well detect economic deposits.

Uganda Associated Industries (UAI).

UAI are part of the Unilever group and manufacture washing powder, soaps, soft drinks and other household products. Most of the products are currently made in Kenya and some are then shipped to Uganda for finishing, packaging and selling in the national market. UAI in Nairobi and Kampala would be a potential customer for Ugandan feldspar and calcium carbonate, which are currently imported. Mr Odwori-Mboke, Sales Manager, promised to supply more details of the Kenyan operations and demand for raw materials.

Kampala Chalk Factory

Mr H. Rugasira, the company president, explained that he imports calcined gypsum to make chalk from Germany. He was very unsure of the quantity but expressed his desire to continue using this imported material since his source Hans Guschner Ltd. of Dusseldorf also supplied his machinery.

Uganda Breweries

Uganda Breweries import about 36 tpa of processed diatomite filter aids for the production of beer. The brands they normally utilize are Standard Supercel (for beer), Superfine (for soft drinks) and Kensil 90. Mr Katorobo Of Uganda Breweries expressed considerable interest in the prospect of national diatomite production mentioning that such products could easily be exported to Rwanda, Burundi, Zaire and Congo.

Lunya Pegmatite

The site of former workings in a small pegmatite at Lunya, about 8km NNE of Lugazi, were visited. Spoil heaps of coarse crystalline quartz, muscovite, pale green microcline (var. amazonite) and white rotted orthoclase feldspar were apparent. The deposit was worked during the 1940's for mica and beryl; Roe (1944) provides detailed plans of the surface and underground workings. Pollock (1964) visited the site in order to assess the suitability of feldspar for the Kenyan glass industry, and reported the following analyses.

Table 4. Analyses of feldspars from the Lunya pegmatite, taken from Pollock (1964).

Type	Green microcline	White orthoclase
SiO_2	63.71	63.73
CaO	0.32	0.22
MgO	0.08	0.13
K_2O	15.00	15.00
Na_2O	1.75	1.75
Fe_2O_3	0.14	0.48
Al_2O_3	19.51	19.37

The site has difficult access; the former underground workings are flooded and further evaluation is not recommended.

Papco Industries Ltd.

Based at Jinja, Papco Industries manufacture packaging and writing paper by recycling waste paper. They do not utilize raw pulp and therefore have a minimal present requirement for kaolin since the waste paper already contains a moderate amount. Present consumption of kaolin therefore is only 12.5 tpa although the potential level, should production from wood pulp recommence, is at least ten times this figure. The kaolin in use is imported from F. Hanson of the UK and costs US$620 per ton on delivery. Papco report that they have tried using an indigenous kaolin supplied by African Ceramics Ltd. (?Namasera) but found it unsuitable (cf. Mitchell, 1992). Rehabilitation of the plant is planned to expand production from the present 400-500 tonnes per annum (tpa) to around 3,600 tpa.

The paper production line was examined to see the methods used; old Swedish machinery is in use. The waste paper is mixed with water and pulped, kaolin and chemical additives are then introduced and the slurry is passed through a defibrator to produce the refined pulp stock. Aluminium sulphate is then added to produce a frothy pulp (pH 4.5) which passes through a Headbox which spreads it evenly onto a conveyor. The sheet is then passed over suction dryers and rollers to remove much of its water content before moving onto steam rollers to finally dry the paper. Calendering - a process akin to ironing - then completes the process and the continuous sheet of paper produced is wound onto a drum. From the drum the paper can then be cut to size and packaged. Contacts: Mr Milton Ebong, Production Superintendent; Mr Joshua Kwebiiha, Production Manager.

Nile Breweries

Nile Breweries at Jinja utilize about 12 tpa of diatomite for beer filtration. Their supplier is Hamburg, Main, Nebelung and Laensee K.G. The brands used are equivalent to Hyflo Supercel (8.4 tpa) and Filter Cel (3.6 tpa). Present production, about 50,000 crates/month, is 40% of the full installed capacity. The company also used about 1.5 tpa of gypsum for treating their water supply. Contact: Sam. K. Ndaula, Production Manager.

Mutaka Mine

Mutaka Mine is reached by the following route: turn south off the

Mbarara - Fort Portal road at Ishaka (MBR 59.5) and proceed 6km to Ruhindu, fork left, after another 11km arrive at Kitagata and turn right past the Travellers Hotel, after 8km reach a village with a teaching college, continue a further 7km to a turn off left (3km after bridge in steep valley and 2km before Kabira). From here proceed 1km to a right fork, go through a village (?Buharambo) and straight on for 6km until, on entering a trading centre, take an overgrown track northwards for 2km to the river, cross on foot to the quarries.

Mutaka is the largest of a suite of pegmatites associated with the post-tectonic granites of the Kibaran Orogenic Belt in southwest Uganda with dimensions of at least 800m long and locally over 100m wide. It cuts mica schists of the Karagwe-Ankolean System which occur as synformal wedges between domes of basement granite-gneiss. The primary pegmatites of this suite are of microcline-muscovite type, although Mutaka is one of two examples which have been classified as a Li-muscovite - albite replaced pegmatite (Reedman & Lowenstein, 1971).

During the 1960's kaolin, feldspar (microcline perthite) and quartz were produced for the ceramic industry from Mutaka, and by 1971 it was estimated that 400 tons of beryl had also been produced (Reedman & Lowenstein, 1971). Today the workings are abandoned, although in recent years small amounts of kaolin and feldspar have been dug sporadically from shafts and adits for use in ceramics. Although a broad zonal structure has been defined comprising a quartz core flanked by wide zones of kaolinised feldspars, the variable extent of kaolinization makes it very difficult to delineate reserves of kaolin or feldspar. Whilst this simple picture holds true at the western end, at the eastern end of the pegmatite an ordered zonal arrangement is absent, with several 1-2m wide quartz stringers present rather than a distinct well-defined quartz core.

Any future mining at Mutaka is likely to be artesanial and on a small-scale and it would have to rely heavily on the experience

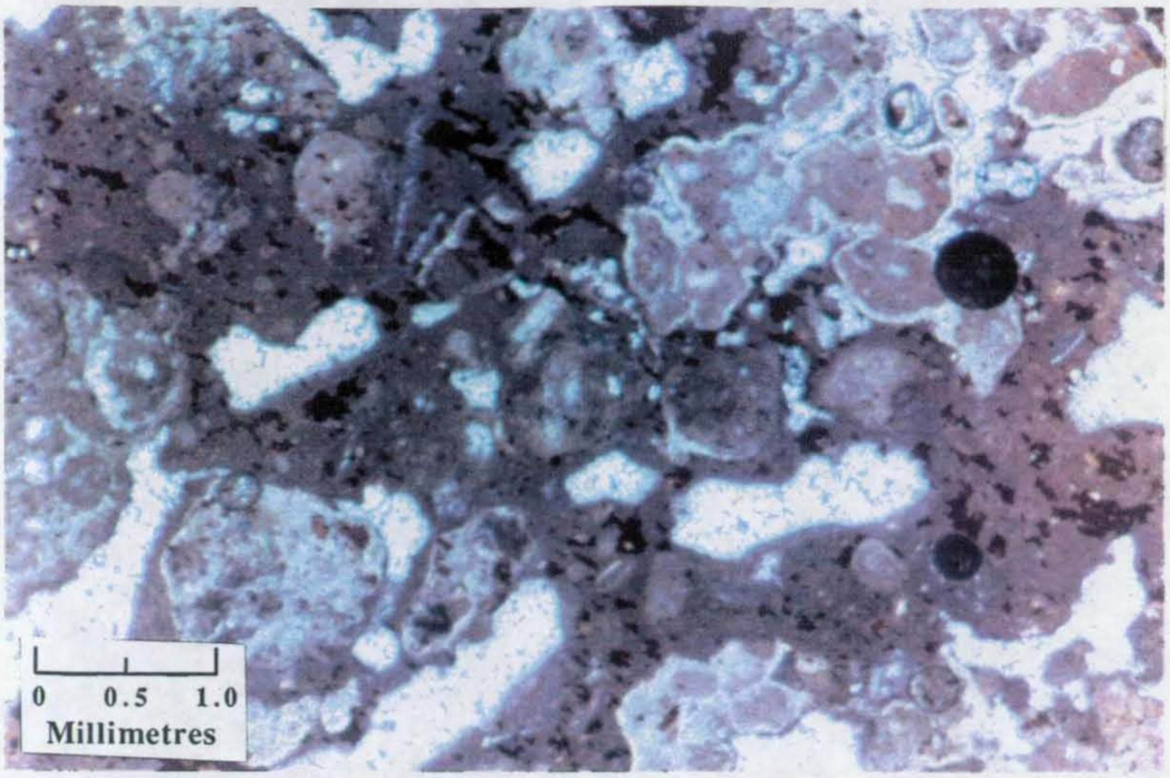

Figure 12 Photomicrograph of limestone, Hima, Uganda. A micritic limestone with a cluttered texture, biogenic fragments and pores infilled with sparry calcite. Transmitted light (PPL).

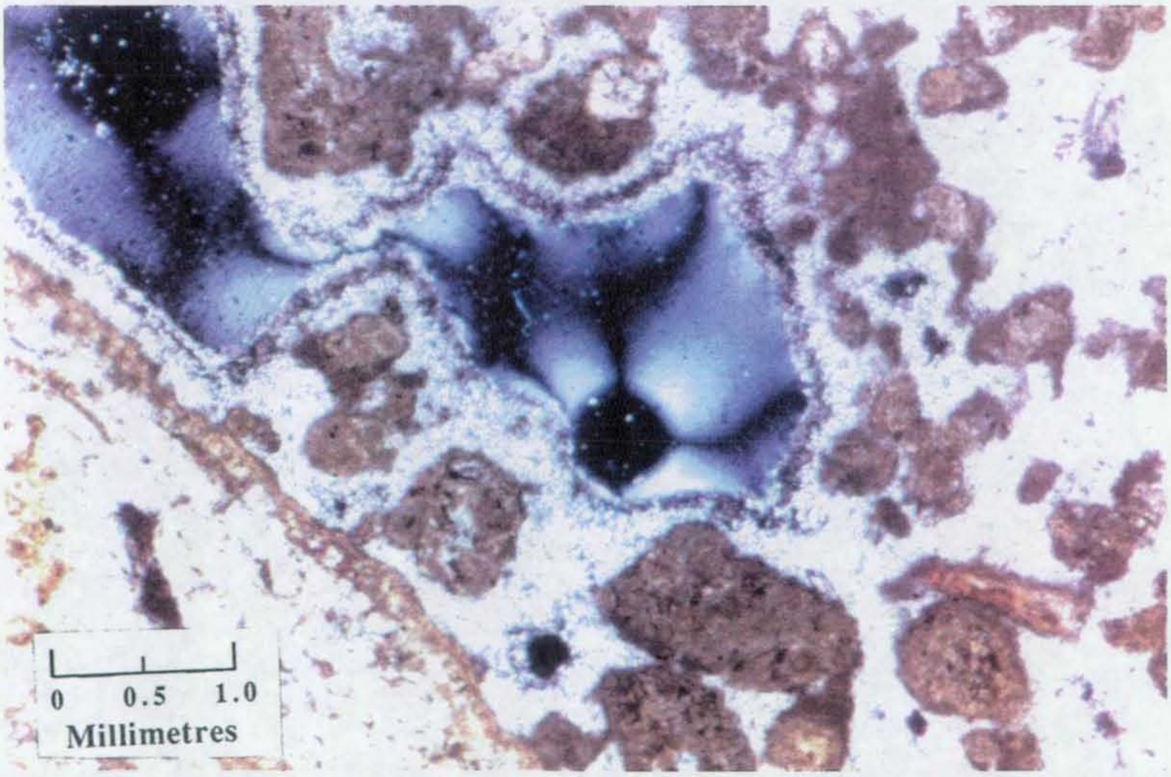

Figure 13 Photomicrograph of calcrete, Muhokya, Uganda. A biomicrite sparite with a wackestone texture, calcite banding around cavities, fossil fragments and limestone intraclasts and chalcedonic silica growth within some cavities (as in this figure). Transmitted light (PPL).

of former workers some of whom still live in the vicinity of the mine. Despite such experience it appears that in many cases mining for specific minerals has proceeded simply on a trial and error basis.

Mineralogical and beneficiation studies of the Mutaka kaolin have recently been reported by Mitchell (1992). He concluded that the material contains 65% kaolinite with small amounts of (unaltered) K-feldspar, quartz and mica. Sieving and hydrocyclone separation yielded a product containing 87% kaolinite with 54% of the particles being <2μm in size. This material had a brightness of 80% (unfired) and 87% (fired). These results agree well with a study undertaken on similar material by AKW Apparate + Verfahren GmbH of Hirschau, West Germany, who concluded that the kaolin could be processed into a product suitable for use as a paper filler. Its use in ceramics is already established.

The feldspar from Mutaka, which is being utilized by African Ceramics Ltd, was examined by Mitchell (1992) and the following analysis was reported for the ground +1mm sample;

Table 5. Analysis of feldspar from Mutaka, from Mitchell (1992).

SiO_2	64.82%
Al_2O_3	19.41%
Fe_2O_3	0.53%
Na_2O	2.04%
K_2O	13.23%

There seems little doubt of the acceptable quality of the kaolin and feldspar from Mutaka for ceramics and the kaolin as a paper filler, However the unpredictable and variable extent of kaolinization in the Mutaka pegmatite make quantification of reserves and extraction impractical. It is worth recalling that in their study of the pegmatites of southwest Uganda, Reedman & Lowenstein (1971) mention some 42 occurrences where kaolinization is almost complete. The larger of these other pegmatites may well provide more readily quantifiable reserves of good-quality kaolin which could probably be mined by mechanical means.

Kyamahunga "talc"

A small roadside exposure opposite the Itega Manengo church was examined. The outcrop is some 2m wide and 1.5 m high, it comprises foliated, steeply dipping chlorite-talc schist (trend 124-304) with pods of asbestiform fibres which pass laterally into weathered granite-gneiss. The surrounding area is also supposedly granite-gneiss, so the schist mass is probably small and may represent an altered basic-ultrabasic dyke. It is not thought to have any economic importance. Mineralogical examination of samples of "talc schist" from this locality have shown them to be composed dominantly of chlorite (Mitchell, 1992).

Tuff near Rubirizi

A sample of volcanic tuff from a roadside exposure near Rubirizi was collected to see whether it contained any zeolites due to diagenesis. These deposits form part of a block of Quaternary volcanics located on the eastern rim of the Western Rift between Mbarara and Kasese.

X-ray diffraction shows that the tuff is predominantly feldspar with a small amount of quartz, mica and amphibole and traces of smectite (Ca-) and zeolite (?analcime) (Figure 9, Table 1). A thin section revealed abundant rounded glass fragments, partly devitrified to feldspar with occasional phenocrysts of quartz, mica and amphibole (?hornblende). These glass fragments are cemented by a microcrystalline overgrowth.

Lake Katwe

A brief visit was made to see Lake Katwe - a saline crater lake - which lies on the northeastern shore of Lake Edward in the Western Rift. The brines in the lake, together with the underlying evaporites, constitute a total resource estimated at 22 million tons of various salts, of which about 10% is NaCl

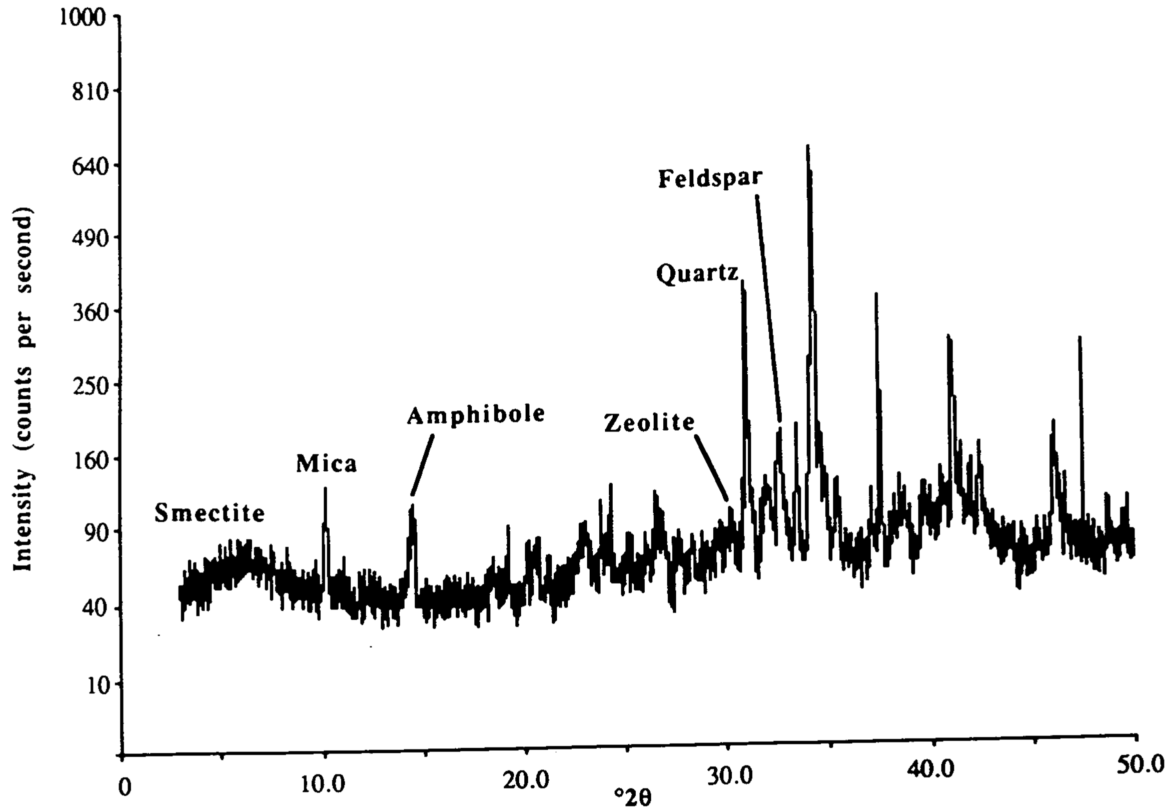

Figure 9 X-ray diffraction trace of tuff from near Rubirizi, Uganda

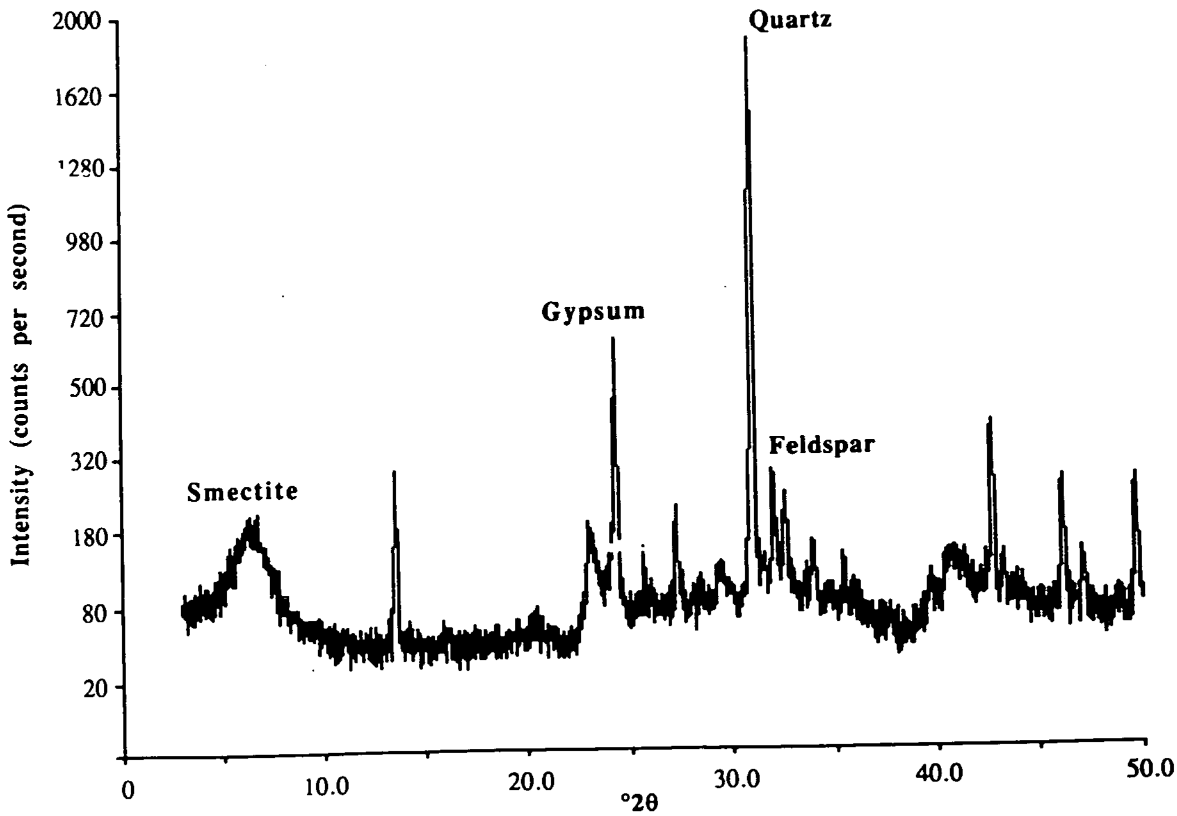

Figure 10 X-ray diffraction trace of clay, Kibuku, Uganda

(Morton, 1973). Salt has been extracted from the lake for centuries; Barnes (1961) describes artesanial production of salt by the Katwe Salt Trust. In more recent times the ?German-owned Lake Katwe Salt Company has extracted sodium salts from the lake brines. Production ceased when the pipeline to the nearby processing plant became badly corroded, having been constructed of unsuitable material. Replacement of the pipeline and refurbishment are needed to renew production.

Kibuku gypsum

Kibuku lies at the northern tip of an uplifted horst block that juts into the Western Rift as a northward continuation of the Ruwenzori Mountains. At the edge of the rift gently uplifted and tilted Quaternary sediments are exposed around the area where the Kisege River flows northwards out of the mountains onto the rift floor. The presence of gypsum was recorded as "float" within the clay strata of the Kaiso-Kisege Beds by Johnson (1950) although at the time the deposit was not thought to be economic. However detailed investigations in more recent years (Kagambe-Kaliisa, 1977) involving detailed geological mapping and pitting has enabled the delineation of some 12 million tonnes of gypsum-bearing clay. The deposit is 1 - 6 m thick with minimal overburden.

In the shallow artesanial diggings around Maweno camp, near Kibuku, the gypsum mainly occurs as large transparent selenite crystals up to 20cm long within a horizontally-stratified host green soapy clay. According to previous work the selenite is preferentially concentrated near the surface. It is thought to originate diagentically from the interaction of the calcareous clays with sulphate, derived from the dissolution of volcanigenic sulphur from intercalated sandstone layers. Rapid weathering enables selenite crystals to be hand-picked from the "float" in the dry season, as well as to be dug out of the clay with hand tools. The material is then hand washed and sorted to produce a pure product acceptable to the Hima Cement Factory. About 50

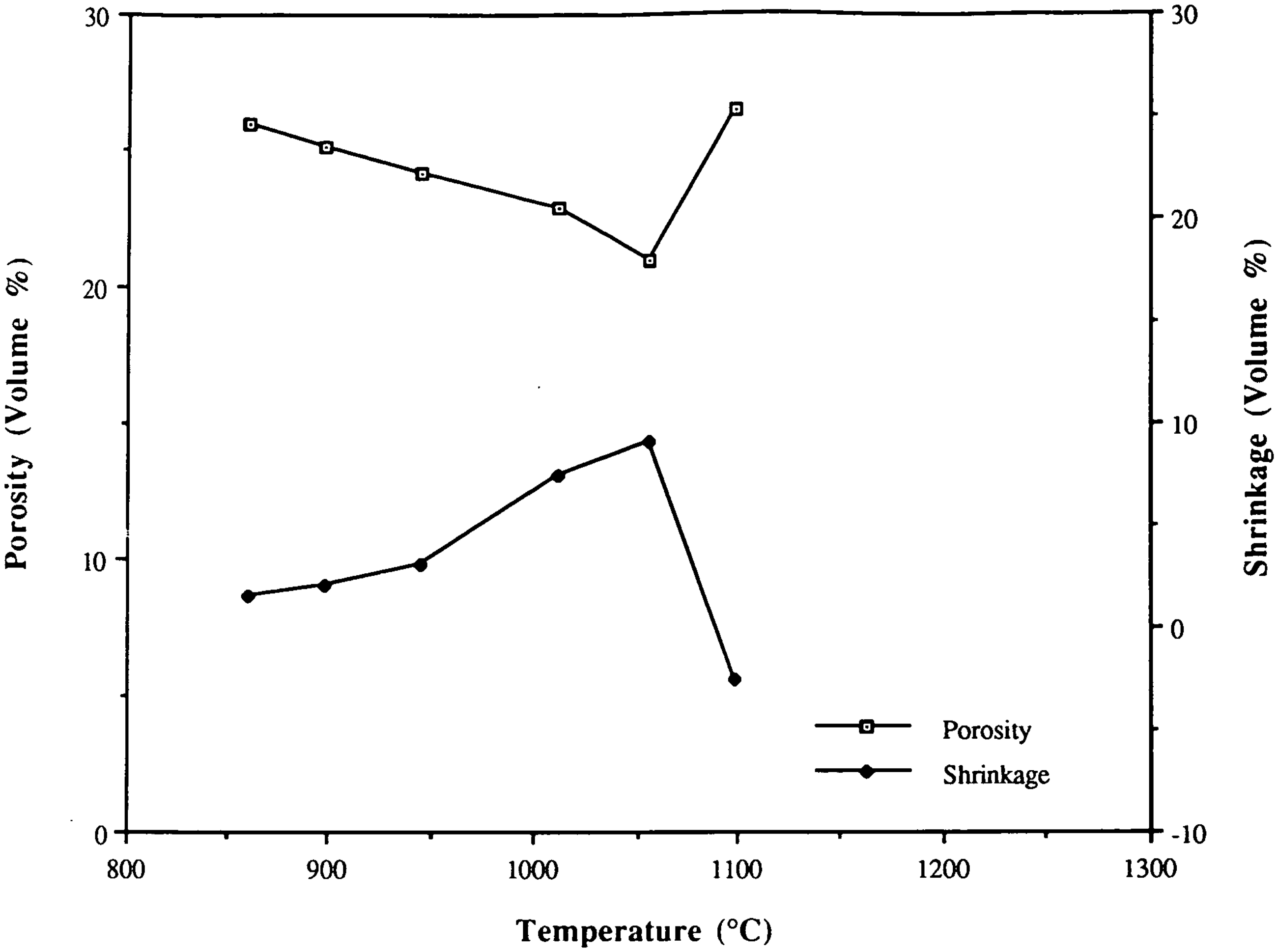

Figure 11 Vitrification curve for clay, Kibuku, Uganda

people are involved in the artesanial recovery of the gypsum, which is transported by wagon 128km to the factory. This source is currently supplying all Hima's needs for gypsum although present cement production is at a very reduced level (see below). Because of its pale green colour and soapy texture, the host clay was sampled to determine whether it contains bentonite.

X-ray diffraction and surface area measurements indicate a smectite content of 34% - too low for a commercial bentonite - other constituents include quartz and a small amount of feldspar and gypsum (Figure 10, Table 1). The clay fraction is predominantly smectite with some kaolinite. The Liquid Limit is 43, the Plastic Limit 22 and the Plasticity Index 21. The Plasticity Index is well below that of a commercial bentonite (60-600).

Although the Kibuku clay has never been used for structural ceramics, comparative data have been obtained to illustrate the likely effects of a moderate-high smectite content on fired products and thereby the importance of selecting appropriate raw materials for the manufacture of bricks, tiles, pottery etc. The vitrification curve of the Kibuku clay shows only a small amount of fusion at temperatures up to 1050°C yielding products with insufficient strength for structural use. Above 1050°C, the clay bloats dramatically (Figure 4) probably due to the decomposition of the sulphate component.

Hima Cementworks

Hima Cementworks is one of Uganda's two cement manufacturing facilities and is located on the flank of a segment of the Western Rift to the north of Lake George, near Kasese. Despite some rehabilitation of the plant in 1990 it is still operating at 10 - 20% of its production capacity. Reasons include unreliable power supplies (remote from generating facilities) and a lack of working capital, which means cement batches have to be sold to raise money to buy the furnace oil to manufacture the next cement batch. Demand far outstrips production, with Uganda currently producing only 25% of its cement needs. The shortfall is being met by imports from Kenya and Tanzania. Present production at Hima averages about 3 - 4,000 tonnes a month when operational.

Currently the cementworks uses national raw materials. The plant is sited on the Lake George Flats adjacent to an outcrop of the Hima Limestone, covering about 2.5km^2. The deposit comprises fossiliferous lacustrine limestone precipitated around springs whilst the lake stood at a higher level; similar deposits occur elsewhere within the Western Rift.

The principal pit is located about 1km southeast of the plant and extends 400 x 50m. The working face is 2 - 3 m high and extraction extends down to the water table, although at least another 2m of useable limestone is proven below the pit floor and could be worked by pumping to lower the watertable.. The limestone is fairly massive, tough and compact, with numerous freshwater gastropod shells (many still have their ornamentation) and extensive burrows. Subordinate clay seams pick out the essentially horizontal stratification. A second adjacent pit is also used to supply limestone but its higher MgO content, about 6% as opposed to 1% in the main pit, leads to the need to blend together material from the two pits.

Published chemical analyses of the limestone are reported by McConnell, (1953) and Barnes, (1956). Most are relatively impure containing 40 - 50 % CaO, MgO is generally less than 3% but increases markedly southeastwards within the deposit. Locally Fe_2O_3 contents exceed 10% but generally they are below 2% and commonly less than 1%.

A representative sample (SM 13) of material from the pit was thin sectioned and examined. The limestone is a micrite containing ferroan calcite with a clotted (nodular) texture and widely scattered biogenic shell fragments (?gastropods or bivalves). It has a well-developed vughy porosity with pores of variable size and elongate, ovoid or irregular in section. Some of the pores probably result from the dissolution of fossil debris; some have the appearance of algal colonies although no filaments could be discerned. There is calcite and chalcedonic silica growth in some cavities and some secondary calcite cement in vughs.

To date about 1 million long tons of limestone have been extracted. A further 17 million long tons are proven by drilling and pitting (McConnell, 1953; Barnes, 1956) providing reserves for many decades, even if plant production were to return to full capacity.

Original plans had included using the 1m soil overburden developed on the Hima Limestone as a source of Al, Fe and Si for the cement. However, the presence of unmanageable amounts of limestone pebbles and boulders within it resulted in clay being brought some 3km from an adjacent deposit.

Gypsum had traditionally been imported from either Tanzania or Kenya until recently when, following investigations by the Department of Geological Survey and Mines (e.g. Kagambe-Kaliisa, 1977), adequate reserves were established at Kibuku (see above). Misunderstandings have arisen between the artesanial suppliers and the factory over exactly what is acceptable in terms of quality although this has now been resolved through consultation.

Equatorial Lime Co. Muhokya

Another outcrop of limestone occurs in the Rift west of Lake George around Muhokya, south of Kasese. Here the Equatorial Lime Co. and one other concern manufacture lime. This deposit was provisionally evaluated by McConnell (1953) who estimated at least 250,000 tons of recoverable limestone. He reported that the limestones were dominantly calcretes showing some solution and redeposition of tufa. The limestones rest on a distinct geomorphic bench but are irregularly overlain and channelled into by recent alluvial sands and gravels.

At the Equatorial Lime Co. shallow 2m deep scrapes in the limestone show it dips towards the lake at about 3 degrees; this is conformable with the general slope of the ground. The company have a concession area of about 1 km^2 and investigations show the limestone outcrop is unpredictable with channels of sand, gravel and boulders cutting across the limestone. The limestone is generally overlain by about 1m of black sandy soil with limestone pebbles. Locally faulting may have affected the limestones since McConnell recorded a locality near Muhokya where the beds dipped at 15 degrees.

Petrographic examination of a dark and light variant of the limestone was carried out. The "dark" limestone (sample SM 15) is a micrite with a vughy/porous texture showing tufa growth; chalcedonic silica infills some cavities. The "light" type (sample SM 16) is a microsparite with minor zones of dolomite. Numerous cavities are present and relate to the precipitation of tufa outward from centres. Vughs contain secondary calcite cement and in some cases are infilled with chalcedonic silica. Rare shell fragments (? thin walled bivalves) are present. Some patches of micrite with a clotted texture occur between zones of tufa microspar.

The company use a shaft kiln fired by dry grass and charcoal to burn the limestone. The lime produced is then slaked and sieved and material passing a 0.8mm screen is retained. Despite the problems with the lime reported by the NEC (see above) the owner is satisfied that his product is almost completely burnt and represents the best possible product that can be obtained. Equatorial Lime Co. have contracts with the Ugandan Government to supply material for road construction, other outlets include sugar refining (at Kakira), tanning and lime for mortars. A special type of lime is also made for use as whitewash, this is produced from the whitest variants of the limestone. The company are trying to expand and plan the construction of a new gas-fired 20m high shaft kiln which if built will be the largest in East Africa. Current production is about 2.5 - 3 tonnes of lime per working day.

The UNDP - DGSM Minerals Promotion Project plans to investigate the limestone deposit around Muhokya in detail in late 1992-93.

Tororo Cementworks

The cementworks at Tororo in eastern Uganda is currently operating at 10% of its installed capacity, due to a lack of working capital and a warped horizontal rotary kiln. The company have received various estimates for the repair or replacement of the damaged plant varying from a few million US$ to patch it up in order to restore modest production (about 60,000 tpa), to a quote of over US$150 million to build a completely new plant with a rated capacity of 300,000 tpa.

Raw materials include carbonatite from the adjacent Tororo complex, kaolin from near Mbale and imported gypsum and fluorspar (flux, and helps to counteract P_2O_5) from Kenya. In 1988 SCANCEM undertook an evaluation for the African Development Bank (ADB) of the Tororo and Sukulu Carbonatites. At Tororo they identified 7 million tonnes of high-grade carbonatite in Lime Kiln Hill, together with a further 75 million tonnes of medium-grade material in the Reservoir and Cave hills; a variable P_2O_5 content means that the medium-grade material would have to be mined selectively. The carbonatite of the Tororo Rock and the Sukulu Complex has P_2O_5 values up to 6% which are undesirable for cement manufacture. Mafic dykes up to 3m wide cut the carbonatite of the Lime Kiln Hill create difficulties for extraction.

Uganda currently produces about 25,000 tpa of cement, only 25% of its needs, the balance being met by imports from Kenya and Tanzania who are currently overproducing to satisfy demand.

The cement company at Tororo formerly used to manufacture asbestos fibre sheets and pipes; full production was about 17,000 tons of pipes and 25,000 m^2 of sheets. Asbestos was imported from Swaziland, Zimbabwe, Canada and Australia. PVC pipes and transparent sheets were also made on-site but are now imported.

A lime plant utilized the Sukulu carbonatite to make "aglime" and lime for the chemical industry. The adjacent Tororo Industrial Chemicals and Fertilizers Ltd (TICAF) plant was liquidated several years ago and now lies moribund. In the past TICAF extracted phosphate for fertilizers together with by-product iron (magnetite), rare earth elements (pyrochlore) and ?vermiculite from the residual soils of the Sukulu carbonatite complex.

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