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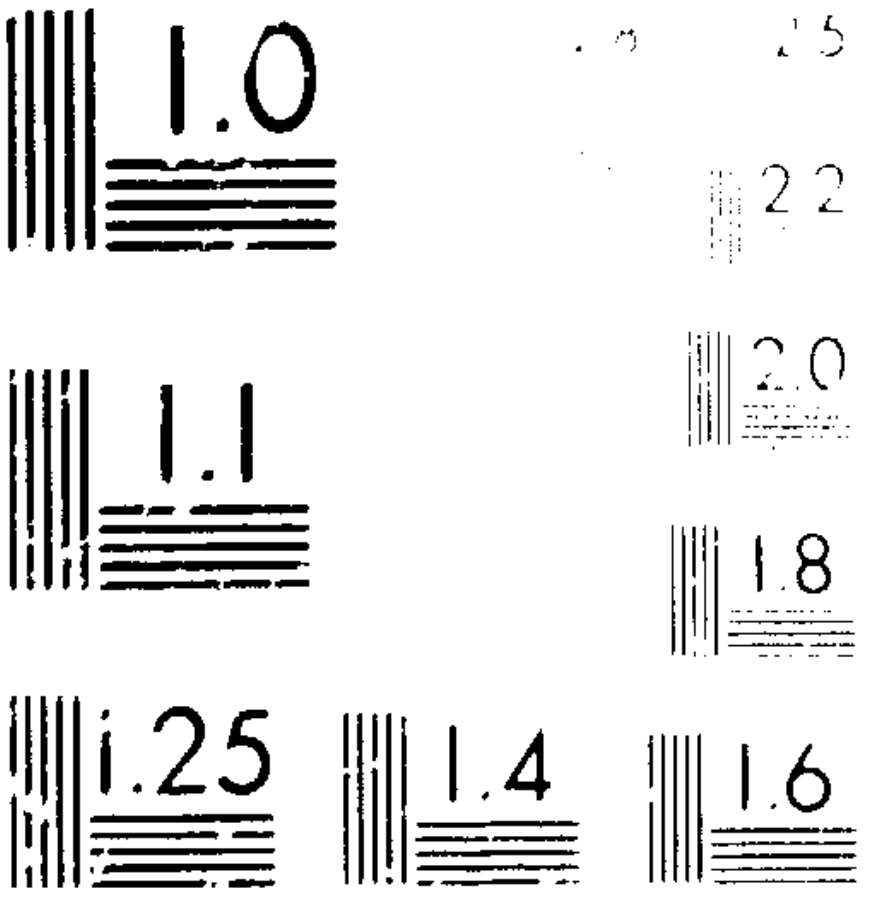
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PROJECT TITLE

Malawi.

DEVELOPMENT OF BRICKMAKING IN [illegible] AND INVENTORY OF INDUSTRIAL CERAMIC RAW MATERIALS

DP/MLW/78/003

DRAFT TERMINAL REPORT [1]

Prepared for the Government of the Republic of Malawi, the United Nations Development Programme, and the United Nations Industrial Development Organisation.

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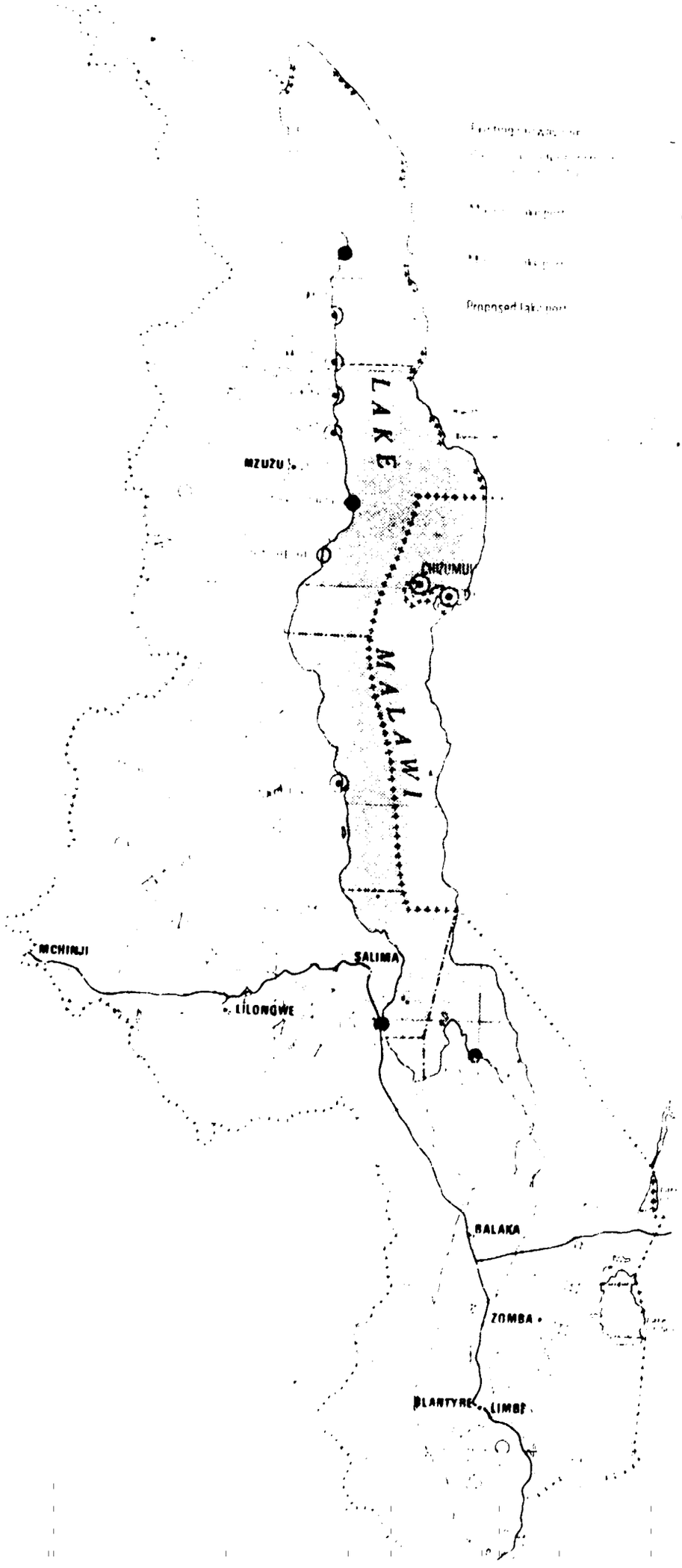
1. The views and opinions expressed in this DRAFT report are those of the author and do not necessarily reflect the views of the UNIDO. The document is presented without formal editing.

1982

# REPUBLIC OF MALAWI



## Contents

## 1. INTRODUCTION

1.1 A UNIDO Special Industrial Services project (SI/MLW/77/002), implemented to give assistance to the small scale brickmaking industry showed that the industry was a major employer throughout the country. The SIS project defined problems facing the industry, indicated how these problems might be solved, and initiated assistance to these brickmakers, both directly and through the Geological Survey Department of the (then) Ministry of Agriculture and Natural Resources.

1.2 It was obvious that within the limitations of time, personnel and finance, the SIS project could not give adequate support to development of the brickmaking industry. It was also obvious that training in improved manufacturing techniques, locating suitable clay deposits, testing the clays and evaluating their quality, called for major UNDP financing.

1.3 The Geological Survey Department (GSD) foresaw that there was a need to institute a programme of investigation into the occurances and potential uses of industrial minerals in Malawi. The GSD put considerable emphasis on the importance of such a programme, recognising that it would be long term but essential to the industrial development of the country. Concurrent with this, were seen the needs to train Malawian professional and technical staff to the point where they could independantly carry out work initiated with UNDP - UNIDO assistance. In this way, the project was developed as one in which :

a) an inventory of industrial minerals and materials would be

started, being implemented mainly by the GSD but assisted financially and with technical expertise through UNIDO where necessary;

b) [redacted] with a view to developing their potential for brickmaking, ceramic and glass industries, but also for industries where the proving of suitable deposits could [redacted]; and

c) an [redacted] would be developed [redacted] to give direct technical assistance to brickmakers throughout the country. It was envisaged that one trained extension officer would be based in each of the three regions of the country. Control of the extension service would be through a technically qualified professional officer based in the MTI Headquarters in Lilongwe.

1.4 It was acknowledged that in a project which involved a considerable amount of mineral exploration across a broad sector of industrial minerals, considerable versatility would be required, as well as, possibly, additional inputs to UNDP/UNIDO aid and expertise. This would be particularly important where such exploration indicated the potential for rapid development of mining or mineral based industries.

## 2. SUMMARY

2.1 The project has achieved its objectives with two exceptions :

a) the lack of counterpart staff has prevented the formation of a viable extension service which would initially have served the brickmaking, and then diversified to serve the pottery and lime industries. Due to the lack of counterparts it was not possible to utilise funds provided for their Fellowship training;

b) one of the immediate objectives, ie. testing of other ceramic raw materials to assess their potential, could not be completed due to a major, negative project revision which took place with effect from January 1982.

2.2 Recommendations have been made which include, inter alia :

a) a second phase of the project should be implemented such that a variety of potential mineral based industrial activities can be developed;

b) a viable extension service should be established for brick and lime producers, possibly under the auspices of the Small Enterprise Development Organisation of Malawi (SEDOM);

c) there should be development of fuelwood plantations for industrial use.

d) provision of an expert in small scale lime production with the objective of developing the industry on a countrywide basis at cottage industry to medium scale level;

e) a consultant should be engaged to assist with the evaluation of the extensive deposits of nepheline syenite. It should be

determined if the deposits are commercially viable, and if so, a feasibility study should be carried out to evaluate the viability of supplying both local and international markets;

f. a centre should be established to carry out development and design work related to using local raw materials for construction and building. Such a centre should develop methods of raw material supply, manufacture, and use. Full utilisation of local expertise should be considered, possibly as consultants to the centre, with permanent staff being kept to a minimum.

g. Major brick clay deposits have been defined near Lilongwe and Blantyre. An evaluation should be made of the social, ecological, and other implications related to establishing these areas as exclusive brickmaking areas for the two cities.

OBJECTIVES AND LOGIC

1.1 The Government Statement of Development Policy, covering the period 1971 - 1980, states inter alia :

"The establishment of capital intensive industries [illegible] capital would make little direct contribution to the elimination of poverty or even to aggregate domestic income if they involved an increase in domestic prices as a result of over protection or the closing down of existing labour intensive Malawian enterprises (eg. brickmakers, carpenters, and grain millers), their effect could only be to depress the standard of living of the people.

... general rule therefore, Malawi's development strategy rules out the promotion of highly capital intensive undertakings, unless their function is clearly essential and there is no choice of technology.

The basic objectives of the Malawi Government's industrial development policy are to complement its programme in the natural resources sector by expanding the range of economic activities, providing additional income and employment opportunities and reducing pressure on the balance of payments caused by the need to import imports of capital goods as the rate of development ...

... ing foresee an urban growth rate ... of ... ... will continue; the total urban population ... considerably ... over its 1970 size ... ... persons per household, the increase in the number of ... units will be roughly ... or more ... per year."

... objectives :

... improved manufacturing techniques ... country.

... Training of extension, technical and professional personnel ... provide technical services to the heavy clay industry.

... exploration for reserves of good quality ceramic raw material ... industries using such materials. The primary aim is to ... reserves of heavy clay and pottery clays, ... which being prospected for ...

of the evaluation.

4.3.4 Basic testing of raw materials such that heavy clays are evaluated to determine their suitability for brick and tile making, and other ceramic raw materials are assessed at least sufficiently well enough to indicate their potential.

4.3.5 The making of a training film on brick making which will be shown in conjunction with practical demonstrations throughout the country.

4.3.6 The setting of standard specifications for [illegible] tiles.

4.3.7 The operation and evaluation of a simple downdraft [illegible].

4.4 Industrial ceramic materials are part of the [illegible] industrial minerals. With particular reference to [illegible] wall and roofing products the value per [illegible], locally, transporting of the raw material and [illegible] finished product is often [illegible] very high. [illegible] small scale producers cannot afford to transport [illegible] the supply of adequate building materials [illegible] primary is essential to support development. It is therefore necessary to define suitable raw materials from which such building materials can be produced.

4.4.1 There are some industries, such as glass making, [illegible] whose production could be maintained from imported raw materials. However, in a landlocked country with [illegible] fuel supply routes, there are both [illegible]

and economic benefits from using local raw materials. Qualitative knowledge of the existence of suitable raw materials must be transformed into quantitative knowledge of deposit sizes and quality.

3.3.3 In a production environment which favours small scale, labour intensive industry, the producers lack the funds and technical expertise to find and evaluate suitable raw materials. Even where more capital intensive industry can be developed, the humble nature of most ceramic materials does not attract the attention or investment of outside investors. It is left to Government to promote industrial development based on industrial minerals, particularly when such minerals have a strategic development value which far outstrips their dollar value per tonne. Where the Government cannot carry out evaluations from its own resources, international aid is logically requested.

3.3.4 When substantial deposits of unusual raw materials are found, the small local market may be secondary to the larger potential international market. In fact, processing of such materials to supply a local market may only be economical if a wider market can be developed. Such development has the effect of reducing the net capital outflow by reducing imports and foreign exchange generated helps to stimulate development in other spheres.

3.3.5 With respect to brick making, the traditional industry is usually characterised by low quality of product in terms of strength, shape and aesthetic appeal. This precludes the

industry from reaching its full potential (see also Appendix I). At the same time, urban development is slowly but surely encroaching on land traditionally used by brick makers. Fuelwood supplies are receding and diminishing at a time when transport costs are rapidly increasing. Defining deposits of clay suited to the technological status of the small scale brick makers is necessary for both short term and longer term planning and development.

3.3.4 Upgrading the existing quality of bricks and diversifying into floor and roof tiles will lead to strengthening and expansion of the industry. Introducing a standard specification for bricks and training producers how to meet the specification will develop more confidence in the brick as a building unit, reduce building costs, and further strengthen the industry.

3.3.5 The Government has a well developed and professionally staffed Geological Survey Department within the Ministry of Forestry and Natural Resources. The GSD has the capacity to carry out field work and laboratory testing. The constraints are that operating funds were inadequate for an intensive field programme, there was a shortage of suitable equipment, and expertise was need in some areas of raw materials evaluation. By meeting these deficiencies with the aid of UNDP - UNIDO, it was planned that, within a few years, the GSD would develop its own resources of staff and equipment to make independant evaluations of ceramic raw materials. Only in special cases would outside expertise be called for in the form of consultants.

3.4 Special Considerations :

3.4.1 Defining suitable deposits of ceramic raw materials permits more effective town planning, and zoning of industrial areas. This, in turn, encourages environmental control which limits degradation of agricultural land, and makes it more feasible to develop planned fuelwood reserves where necessary. Better control can be effected of the random tree cutting which leads to deforestation.

## 4. ACTIVITIES CARRIED OUT AND OUTPUTS PRODUCED

4.1 Evaluation of heavy clay deposits :

4.1.1 Lilongwe : Two main areas have been examined, these being the north Lilongwe and Chadza areas.

4.1.1.1 North Lilongwe : Report no. ERP/4(T738) Geological Survey reference. Reconnaisance Exploration of Brickclays of the North Lilongwe Area. Abstract : "A reconnaisance (Phase I) exploration, pitting and quality appraisal of laboratory test results of brick clays in the north Lilongwe area show that over most of the area the residual clays are shallow and of poor quality for brickmaking except in limited areas. Detailed auger drilling over Chakhala Ridge indicate reserves of 10,695,700 $m^3$ (equivalent to 6 900 million bricks) of suitable quality heavy clay. The clays would have to be selectively won since laboratory test results show that the ceramic characteristics of the clays vary over the ridge."

4.1.1.2 Chadza : (This area was later subdivided into Chadza I and Chadza II). Report no. FRP/6 (T754) Geological Survey reference. Abstract : "A Reconnaisance exploration of brick clays, by auger drilling and pitting was cond ed over an area of about 140 $km^2$ in the Chadza area. Evaluation of field and laboratory test results shows that, over a considerable portion of the area, the residual clays are shallow but of good quality for the manufacture of bricks by traditional methods. Qualitative estimates indicate that there are more than sufficient heavy clay reserves that would support a number of traditional brick makers for a long time. The area is therefore recommended for further detailed surveys and evaluation on selected areas to prove adequate reserves."

4.1.1.3 Chadza Area I : Report no. FRP/8(T765) Geological Survey reference. A Detailed Investigation and Evaluation of the Brickclay Resources of Chadza Area I (Kilombe). Abstract : "A detailed exploration for residual brickclays, by auger drilling and pitting was carried out over an area (Chadza Area I) of about 4 $km^2$ about ½ km north of Chadza Court. An assessment of the field results shows that the clays are of shallow thickness (average about 2 m). An evaluation of the laboratory test results show that four areas underlain by consistently good quality clay can be delineated. The ceramic characteristics indicate that the clays are suitable for the manufacture of good quality brick by

both traditional and mechanised brick makers. Subject to certain assumptions the indicated brickclay reserves are placed at an equivalent 900 million bricks."

It has been recommended to Government that the area be considered as the future brickmaking area for Lilongwe traditional brick makers. Further laboratory evaluation is in hand to confirm that the clays have a reasonable vitrification range, and that they are suitable for kiln firing.

4.1.1.4 **Chadza Area II:** Report FRP9(T775) Goelogicial Survey reference. Exploration and Evaluation of the Brickclay Resources of Chadza Area II, Lilongwe. Abstract : "Detailed exploration was conducted in the residual clays over Chadza Area II by auger drilling and pitting. The area investigated covers about 5.5 $km^2$ and lies about ½ km to the south of Chadza Court. An evaluation of the field results show that the development of the clays by weathering of the perthite augen gneiss is shallow and the thicknesses of clay averages 1.88 m. An evaluation of the laboratory test results shows that three areas underlain by consistently good quality heavy clay can be delineated. The ceramic properties indicate that the clays are suitable for the manufacture of good quality bricks by both traditional and mechanised brickmaking.

Taking into account certain assumptions the heavy clay raw material reserves are estimated to 950 million bricks

4.1.1.5 The Geological Survey has proved the existence of large clay reserves to the north and south of Lilongwe. In making the inventory, the Survey has tried to avoid areas within the boundary of the Capital City, and the Lilongwe Agricultural Development Division. However the Chadza deposit lies partly within the LADD area. Late in 1980 the Office of the President and Cabinet asked the Ministry of Trade & Industry to make a prefeasibility study based upon developing Chadza as a major brick making area for Lilongwe. Meetings were held between Trade and Industry and other Goverment ministries who might be involved in the development of Chadza. The essential issues were :

a) confirmation of laboratory results that bricks could be made profitably and to a satisfactory standard;

b) social effects of designating the area as one which would be reserved for brick making, considering that it is currently developed by small scale farmers;

c) proving of suitable and adequate supplies of water, probably from boreholes;

d) social effects related to an influx of brick makers and their employees, possibly numbering several thousand over a period of time;

e) development of fuelwood plantations to serve the brickmakers and for domestic use;

f) evaluation of cost of developing access roads to all weather standards.

Since Chadza is some 30 km from the city centre, the first brick makers to set up production there would be at a disadvantage to other brick makers still producing within the city boundaries. Discussions with the Ministry of Works and the Management of a CIDA (Canada) funded project for construction of a Natural Resources College, indicated that if bricks could be available in the 1981 brick making season (May - November) they would be purchased for the College and the initial problem of a market would be solved. At the same time it was probable that the CIDA project would fund the construction of a small kiln for production of higher quality bricks, paving bricks and floor tiles. The final outcome was that, although the Ministry of Trade and Industry pur[illegible]bout 6 acres of land at Chadza, final clearance [illegible]ead was not received before the onset of the wet season and production could not start in 1981. The Natural Resources College project had no option but to find supplies of bricks elsewhere. The situation at present is that the prefeasibility study has not been prepared and most of the issues above (a) to (f) have yet to be resolved.

4.1.2 **Chintheche** : Report no. FRP/7(T75[illegible]) Geological Survey reference. A phase I Exploration and Assessment of the Brickclays Potential of Chintheche Area (Nkhata Bay). Abstract : "A Phase I

(reconnaisance) exploration and assessment of brickclays in the Chintheche area was carried out over an area of about 15 $km^2$. The geology of the area and laboratory testing show that, except in three limited blocks, the area is underlain by very unsuitable material for making good quality bricks because of its sandy nature and poor ceramic characteristics, especially fired strength. The results also indicate that reliance may still have to be placed on anthills (ie. termite mounds) as a source of suitable brick clays. Two belts in which anthills would be a source of suitable brick clays have been outlined. The area as a whole is recommended for a very limited follow up investigation."

4.1.2.1 Chintheche is a small village located some 30 km south west of Nkhata Bay, the district Headquarters. Rapid development of the area was anticipated if a proposed paper pulp mill project had gone ahead.

4.1.3 **Mzuzu** : A preliminary investigation has been carried out at Mzuzu. The samples are still awaiting laboratory evaluation and a report is expected by mid 1983. The town of Mzuzu is the major centre of the Northern Region. This region is one of the most scenic in the country, and with development of bitumen roads has considerable tourist potential. A new hotel is due to be opened in 1982 with 30 double rooms, and provision made to add another 30 rooms. A small Government brickworks exists. virtually in the centre of the town, where hand made bricks and a type of roof tile are made and fired in small downdraft kilns. This facility has had severe problems in the past in obtaining suitable clay. Production is intermittent and geared mainly to

Government requirements.

4.1.4 **Zomba** : Limited work has been done, with about 20 auger holes and pits sunk. Testing and reporting as well as further field work are scheduled to be completed in 1982 - 1983.

4.1.4.1 Zomba was the Capital City before Lilongwe, but is now mainly a university town. The Geological Survey, Parliament, Government Printer and the National Statistical Office are still based there.

4.1.5 **Linthipe** : The existence of ceramic clays in the Linthipe area (about 55 km south of Lilongwe) has been known for many years. More intensive and wide ranging work has been carried out within the past four years by the Geological Survey assisted by UNDP - UNIDO and by consultants provided through German aid. The first stage of testing should be complete in May 1982. Useful advice on field and laboratory testing has been provided by a UNIDO consultant to the project, Mr. G.A. Bertoldi. Based on this a series of mixtures of clay, bedrock and chamotte are being tested.

The clays in Linthipe are potentially useful not only for production of general ceramics, but also for production of a range of bricks and tiles which could not be produced from the red burning clays of Chadza.

4.1.6 **Blantyre** : Deposits of apparently good brick clays have been defined at Bangwe, which straddles the eastern border of the city. A report of these deposits is due to be finalised in May 1982.

4.1.6.1 By virtue of its size, being the largest city in the country, Blantyre is a major consumer of bricks. The main brick making area lying to the north of Blantyre on the Chileka road and stretching for several miles, is slowly being taken over by the expanding city. Both town planners and brick makers are anxious to see alternate clay reserves proved. At the same time, as with Lilongwe, supplies of fuelwood are becoming more expensive as the available sources recede further and further from the city. Although there are planned reserves of fuelwood adjacent to the city, they will be for general use and no special allowance has been made for the brick making industry.

4.1.7 Numerous ad hoc requests have been made to the Geological Survey for assistance in defining clay deposits in many parts of the country. These requests have been met, where and as possible taking into account a very substantial workload related to clays and other non metallic minerals. Two of the main areas which have been examined are Liwonde and Ncheu. Suitable clay deposits have not yet been confirmed in Liwonde where many of the samples examined to date are contaminated with calcareous material. Ncheu samples show mixed results, but those are expectations of defining suitable reserves and a report will be presented later in 1982.

4.2 Training of Extension Officers :

4.2.1 The extension service was to have comprised one professional officer (PO) based in the Ministry of Trade and Industry in

Lilongwe, and three Senior Technical Officers. The PO would have been responsible for the technical operation of th service, and it was anticipated he would have been a useful addition to the Ministry staff by strengthening their technical capacity to deal with industries other than brickmaking.

4.2.2 Only one Senior Technical Officer has been made available to the project (since 1979) and it is now unlikely that other officer will be made available within the life of the project. This STO has had on-the-job training as well as six months Fellowship training attached to Ibstock Building Products Limited in UK. His training concentrated on manual moulding of bricks and tiles, but also included training as a trainer, mould making, supervision technical drawing, kiln firing, industrial safety, and production efficiency. The STO is competent to carry out field work, but requires intermittent supervision.

4.2.3 A number of steel brickmoulds have been supplied through the project, and given to brick makers. Only limited training could be given in the use of these moulds and effective follow up is being hampered by the lack of staff.

4.3 Training Laboratory Staff of the Geological Survey in Clay Testing - Evaluation :

4.3.1 This work started in 1978 and has been followed up throughout the project. The range of tests now being done include moisture determination; loss on ignition; linear change from wet to dry, and at various temperatures; water absorbtion; and sieve analysis. Based on these tests and backed up by chemical analysis and mineralogical examinations, a reasonable assessment can be made

as to the potential of clays for brick and tile making. Intermittent assistance will still be useful to help with evaluation in certain cases.

4.3.2 A paper entitled "Methods of Test and Basic Evaluation of Materials for Use in the Making of Burnt Clay Bricks" was produced in 1979 for use by the Geological Survey. This was enhanced by assistance from a UNIDO consultant (post MLW/78/003/11-04) who being (also) a mineralogist provided useful guidance to field tests which may be done to reduce the number of samples going for full laboratory testing.

4.3.3 The Geological Survey has opened an Industrial Minerals Laboratory with a considerable amount of the equipment being supplied through UNDP - UNIDO. A thermal gradient/furnace which was received damaged (in transit) in 1981 has still to be repaired. When suitable repairs are effected, the scope and processing of samples should be considerably enhanced. Although in the initial stages of the project, laboratory testing was a considerable bottleneck, the new Industrial Minerals Laboratory and additional equipment have largely eliminated this problem.

4.4 Construction - Evaluation of Simple Wood Fueled Downdraft Kiln :

4.4.1 A kiln with a capacity of 20 000 standard bricks was constructed late in 1979. It is located in the Chirimba brick fields within the City of Blantyre. The objectives in building the kiln were :

a) introduction of a firing method suited to production of higher quality hand made bricks and tiles ;

b) provision of opportunities for small scale brick makers to broaden the scope of their operations into higher quality bricks, and diversify into roof and paving tiles;

c) construction of a kiln of simple design which could be operated effectively with limited prior training being provided;

d) operation of the kiln to be developed using a simple series of fairly standard actions;

e) design of the kiln to be such that capital costs are minimal, but consistent with a structural life lasting for a reasonable amortization period. The design was also to be suited to low cost building methods.

4.4.2 Following eight firings of the kiln, a summary of the findings is :

a) the kiln is suitable for firing bricks and tiles provided that clay with a fairly long vitrification range is used in their manufacture;

b) improvements are required to the grate, and the chimneys shoul be fitted with dampers;

c) fuel consumption (wood) might be of the order of 2 stacked cubic yards of hardwood per 1 000 bricks, but will vary according to the type of wood and load in the kiln;

d) possible by-products are charcoal and soap from the wood ash.

4.5 A training film entitled "Brickmaking in Malawi" was completed in 1980, and showing to selected audiences commenced in 1981. The film which has been well received by brick makers, includes brief sections on historical sites where bricks have been used, modern brick

buildings in the country, fuelwood planting, with the bulk of the film dealing with brick making throughout the country.

4.6 Those activities which relate specifically to the industrial minerals geologist will be the subject of a final report prepared by him and presented as a supplement to this report. The reason for this is that the Chief Technical Advisor (CTA) will be leaving the country prior to the end of his contract on 21st July, 1982. It is anticipated that the industrial minerals geologist will continue until September 1982, by which time he will have completed 15 months of the 24 months originally scheduled.

4.7 A consultant analytical chemist was attached to the project for two months in July - August 1981 (Mrs. A. Marabini, post MLW/78/003/11-03). The consultant was based in the chemical laboratory of the Geological Survey in Zomba. Originally the consultancy was scheduled to comprise four visits of two months each. A shortage of funds leading to a negative project revision limited the consultancy to the two months in 1981. The consultant was expected to do :

- examine the range of present and future analysis requirements;
- check on working methods, laboratory apparatus and equipment;
- assess the skills of the technical personnel;
- set our recommendations for improving or reviewing existing analytical methods.

4.7.2 A report was prepared on 13th October 1981, reference DP/ID/SER.A/320. The main findings are summarised later under the section in this report dealing with findings and recommendations.

4.8 Although one of the original activities was to promote the establishment of Brickmakers Associations at district level, this was later discontinued as a direct project responsibility. However it is felt that largely through activities of the project in stimulating more interest in brick making, the Blantyre Brickmakers Association has been re-activiated and there are possibilities of groups being formed in Mzuzu and Chitipa.

4.9 It was decided that formal seminars would not be held but small groups of brickmakers and their employees would be visited by the extension service. The main benefit of this system is that even though the same type of information is passed on, it reaches the employees who cannot usually attend regional seminars.

4.10 It had been allowed that Fellowship training would be provided for the four officers of the extension service, a trainee manager from the Brick and Tile Company and (later) a geologist from the Geological Survey.

4.10.1 The sole extension officer, and the trainee manager started Fellowship training at Ibstock Building Products Limited in UK in October 1980, returning to Malawi on completion of their training in April 1981. During this period, the Brick and Tile Company ceased production and the trainee manager has not, to date, been re-employed in the brickmaking industry.

4.10.2 A geologist from the Geological Survey went to Hull University in UK for a post graduate course in Industrial Minerals leading to a Masters degree. The course, with a duration of

one year, started in October 1981 and is due to be completed by September 1982. Additional funding has been made available such that the Fellow can attend the Industrial Minerals International Congress in Madrid, Spain in April 1982.

4.11 As part of a Technical Committee, convened by the Malawi Bureau of Standards, the CTA drafted a specification for burnt clay bricks (metric units). Following the due process of discussion and amendment, a specification for burnt clay bricks was adopted: MBS 006-1979. With effect from 1982, the Ministry of Works and Supplies is advising that all bricks used in Government contracts should comply with the metric specifications.

5. ACHIEVEMENT OF IMMEDIATE OBJECTIVES

The immediate objectives are listed below, taken from the Project Document. The first paragraph in each case gives the objective, and the subsequent sub-paragraphs summarise the results.

5.1 Provision of improved manufacturing techniques to the heavy clay industry.

5.1.1 This has been accomplished in two ways, but due to shortages of national staff the number of brickmakers contacted is less than was desired.

a) introduction of improved moulds at reasonable cost, coupled with practical demonstrations of moulding method has raised the quality of product of a number of brick makers.

b) The brick making extension officer working closely with the CTA has concentrated on contacting as many brick makers as possible. Aided by a booklet and film on brick making, provided through UNDP - UNIDO funding, the brick makers have been shown the faults which often exist in their existing method and encouraged to correct them by simple methods under their own control.

5.1.2 A type of roof tile, called a "cooler tile" is used in Malawi on top of IBR roof sheets, and was previously made only by extrusion machines. Handmaking of these tiles has now been introduced in Blantyre and Lilongwe.

5.1.3 Some old, hand operated, brick and tile machines were purchased in February 1982. Work is in hand to renovate the machines with a view to introducing them to selected brick makers to make Marseilles and Ridge tiles. The possibility of having similiar machines manufactured locally could be investigated. However, since the machines were only discovered towards the en of the project when funds for their repair are limited, it is not certain if such repairs can be effected in time.

5.2 Training of extension, technical and professional personnel to provi technical services to the heavy clay industry.

5.2.1 The CTA and a consultant in clay testing have given training t professional and technical staff of the Geological Survey. Th training has been well received, and with increasing experienc the Survey is becoming increasingly effective in supplying technical advice on raw materials to the clay based industries

The future need for intermittent specialist advice should not be ruled out.

5.3 Exploration for reserves of good quality ceramic raw materials for industries using such materials. The primary aim is to define reserves of heavy clay and pottery clays, but with related materials being prospected for during the course of the examinations.

5.3.1 Major deposits of heavy clay have been defined at Lilongwe and Blantyre, with lesser deposits being investigated at Chintheche, Mzuzu, Ncheu, Kasungu, Liwonde, Zomba and Balaka. Investigations are continuing into the ceramic clay deposits at Linthipe and the Mchinji glass sands deposits appear to be associated with a ceramic grade clay which will be separated from the sands during beneficiation.

5.3.3 Extensive deposits of nepheline syenite exist in Malawi. Limited drilling, analysis and evaluation of nepheline syenite as a component of a glass making mixture have been carried out. Limitations in finance and expertise have precluded further work being detailed at this time (see Appendix II).

5.3.4 A consultant to the project indicated that a variety of small industries could be based upon minerals existing in the country but further technical assistance would be required to make a fuller evaluation of their potential. Such minerals included nepheline syenite, phosphate rich carbonatites, limestone, garnets and bentonitic clay. The industrial minerals geologist has indicated a number of uses for quartz sand (other than glassmaking) for lime as a stabilising material; and lime and

pozzolana as cementiceous materials.

5.4 Basic testing of raw materials such that heavy clays are evaluated to determine their suitability for brick and tile making and other ceramic raw materials are assessed at least sufficiently well enough to indicate their potential.

5.4.1 This objective has been achieved with respect to heavy clays, glass sand, and to a lesser extent with ceramic clays. There are indications that nepheline syenite will be a suitable ceramic material, but further specialist advice is required (see Appendix II).

5.5 The making of a training film on brick making which will be shown in conjunction with practical demonstrations throughout the country.

5.5.1 This has been done and will be a continuous process in terms of showing the film. See also the section under Activities, paragraph 7.5.

5.6 The setting of standard specifications for bricks and tiles.

5.6.1 The specification on bricks has been issued by the Malawi Bureau of Standards. The Technical Committee decided that a specification on tiles was not required at this time. See also the section under Activities, paragraph 7.12.

5.7 The operation and evaluation of a simple downdraft kiln.

5.7.1 The kiln has been constructed and evaluated favourably in that it is suitable for firing heavy clay products after

minor modifications have been carried out. The wider objective of introducing the kiln to brick and tile makers may have to be delayed until facilities are available to train brick setters and kiln firemen. Fuel consumption was of the order of 2 cubic yards of hardwood for 1 000 bricks, but this will vary according to the type of wood, loading, etc.

## 6. UTILISATION OF PROJECT RESULTS

6.1 As indicated in section 5.1, improved methods of brick making are being introduced to brick makers. The rate at which improvements take place will be related to the ability of the extension service to cope with requests for assistance. At present, a single extension officer to cover the whole country is inadequate.

6.2 Other than the extension service, trained staff are now able to provide limited technical services to the heavy clay industry by way of raw material evaluation. In the GSD Industrial Minerals laboratory, evaluations of heavy clays for hand made bricks are being done almost completely independent of outside help.

6.3 Following the report by the consultant analytical chemist, further training of the senior technical officer has taken place, new fume cupboards are on order, and some equipment items have been ordered. However, the major equipment items recommended are beyond the financial resources of the Government at this time.

6.4 Work is in hand through UNDP - UNIDO project MLW/80/004 to encourage formation of a company to produce a range of glass wares based upon the

glass sand deposits at Mchinji.

6.6 The training film "Brick making in Malawi" is being shown fairly regularly by the extension officer, and is proving most useful in encouraging brick makers to make better bricks.

6.7 The standard specification for bricks is being implemented, more so with effect from 1982.

6.8 Although a small kiln has been evaluated, there are no plans for its use by brick makers. A definite need is foreseen by 1982/1983 when better quality bricks (in terms of shape and size) will benefit from kiln firing. There will then be a need for further training in the use of the kiln.

6.9 The full potential of Malawi to supply all requirements for lime, eg. as chemical grade lime for the sugar industry and lime for the construction industry, has still to be realised. A specialist in small scale lime production is needed.

6.10 Considerable information has been received from UNIDO on the wide use of nepheline syenite and passed on to the GSD. Some work has been done but further work and specialist advice is required.

6.11 The potential for a variety of small industries, based upon minerals existing within the country, needs to be followed up by the Ministry of Trade and Industry, assisted by the GSD.

## 7. FINDINGS

### 7.1 Brickmaking.

7.1.1 The small scale sector of the industry is established throughout the country, applying a labour intensive technology which is well suited to generating employment and supplying low cost bricks especially in rural areas (see also Appendix I).

7.1.2 The shape, size, strength and durability of hand made bricks vary considerably. In general, overall quality is lower than that desired by the construction industry, but not altogether inconsistent with the prices being charges, ie. about K10.00 to K25.00 per 1 000 (equivalent to US$11.11 to US$27.78 per 1 000).

7.1.3 Building design, more particularly that employed for domestic use in rural areas, is well suited to the use of bricks, which might otherwise be susceptible to depreciation through, for example, rain. The wide verandas on such houses not only provide shade, but also protect the wall material whether it be formed of earth or burnt bricks.

7.1.4 The physical strength of bricks as reported in the past must be viewed with caution since the samples were seldom representative and the method of test has room for much improvement. This situation will change with implementation of improved sampling and test method incorporated in the new (and first) Malawi Standard on burnt clay bricks - MBS 006-1979.

7.1.5 The quality of bricks as made in Malawi can be improved without any substantial cost to the brickmaker by :

a) supply of raw material which is more suited to the technology being employed;

b) making the brick makers aware of the benefits of implementing better production control to achieve bricks of better shape;

c) disseminating information on the preferred standard size for bricks and showing brick makers how this size can be achieved in practice.

7.1.6 Sand faced bricks can be made which would be acceptable as facing bricks in most low rise domestic and commercial buildings. A range of colour effects can be achieved by using different coloured sands, or by adding suitable minerals to the sand, eg. manganese dioxide.

7.1.7 Roof tiles can be made by hand moulding, the Malawi "cooler tile" type being simplest to make. Other tiles such as Roman tiles, Spanish tiles and plain nibbed tiles find less acceptance due to increased roof-timber costs. A Marseilles tile would be acceptable, at the right price, since it gives an efficient cover (being interlocking as opposed to overlapping). However, well seasoned timber must be used under such tiles since distortion of the timber can break the interlocking effect.

7.1.8 Paving bricks and paving tiles could be made by hand given that suitable clays were used that that kiln firing is employed.

7.1.9 The country's major textile manufacturer, David Whitehead and Sons (Malawi) Limited, has as a by-product some five tons of coal ash and clinker per day. Some of this may be suitable as a supplementary fuel for firing bricks in Blantyre. Tests are

being carried out to ascertain the residual calorific value of this potential fuel.

7.1.10 The introduction of hand made bricks suitable for use as facing bricks is progressing as fast as possible with one extension officer who is concentrating on a few selected brick makers in Lilongwe, but also has obligations in Blantyre and other parts of the country. The current downturn in economic activities has reduced the market for bricks. When this situation is reversed, there will be (as before) a heavy demand for higher quality bricks. Unless this demand can be met, there is every likelihood that mechanised brick making may develop. This form of brick making is not essential in the medium future, ie. 5 - 10 years.

7.1.11 Major clay deposits have been defined close to the main urban areas of Lilongwe and Blantyre. Work is in hand on other deposits in other parts of the country. This work will continue for many years to come, and the results will increasingly become more useful to brickmakers and planners.

7.1.12 Kiln firing of special bricks and tiles would expand the market available to small scale brick makers. The raw materials used must be suitable for kiln firing, ie. they must have a vitrification range of 100 - 150$^{o}$C.

7.2 Extension Services.

7.2.1 The planned extension service comprisng three senior technical officers headed by a professional officer, has not been formed. Only one extension officer has been made available at Senior

Technical Officer level. This leaves three main weaknesses in the extension service :

a) without a professional officer, control and future development of extension work may be inhibited;

b) a single officer cannot easily cover the whole country and there is a danger that by trying to help too many people, his services in training brick and tile makers may become ineffectual;

c) with only a single trained man, the whole future of the extension service relies upon his remaining in his post.

7.2.2 The potential has always existed for the extension service, under the guidance of the professional officer, to diversify into promoting and demonstrating the production of other building materials such as lime.

7.3 Quartz Sands.

7.3.1 In May 1979, Dr. S.M. Cox, a UNIDO glass technology consultant to the (then) Ministry of Trade, Industry and Tourism, was shown potential glass sand deposits by the Geological Survey Department. The extensive deposits at Lake Chilwa were considered to be unsuitable due to iron staining on the quartz grains. An examination of several dambo sands near Mchinji selected by the Geological Survey in 1978 as having potential for glass making, indicated that an acceptable white glass could be made. This was later borne out by melting tests of grain samples which gave encouraging results.

7.3.2 The Geological Survey aided by two UNIDO projects (MLW/

80/004) has proven the existence of deposits of quartz sand adequate in quality and quantity, for glass making in the Mchinji district. Chemical analysis and melting tests have indicated that acceptable glass can be made although the behaviour of the glass in production and the characteristics of the product cannot be determined yet.

7.3.3 Mining trials planned by the GSD supervised by a senior geologist from the Survey and the UNIDO Industrial Minerals Geologist have shown that labour intensive mining is feasible. Reports on the various deposits and the mining trial are available from the Geological Survey in Zomba.

7.3.4 The UNIDO Industrial Minerals Geologist has indicated a number of alternate uses for the sands, these being :

- foundry sand;
- water filtration;
- mortar for building use;
- standard sand for Portland Cement testing;
- other uses such as in soapmaking, match production (after fine grinding), etc.

The by-products from benefitating the sands for glassmaking may be of use in some of the above applications.

7.3.5 As a by-product from washing the sands, eg. for glassmaking, a plastic clay will become available which may have some applications in a future ceramic industry.

7.3.6 Using the white quartz sand and white portland cement there is potential to make white cement bonded bricks. Although the cost would likely be higher than for burnt clay bricks, they may well

find a market in some high cost or prestige buildings, and as feature walls in those and other buildings.

7.4 Nepheline Syenite.

7.4.1 Nepheline syenite is an igneous rock with a granite like texture consisting essentially of a mixture of nepheline with varying proportions of alkali feldspars and dark minerals. Its industrial application is generally limited to deposits in which iron-bearing accessory minerals can readily be removed. Major users are the glass and ceramics industries, but it also finds application in the construction industry. The main producers for the western world are Canada, from the Blue Mountains deposit, and Norway from the Star Island deposit. This rock, though generally uncommon, exists in large quantities in several parts of Malawi.

7.4.2. Insufficient data is available on the Malawi deposits of nepheline syenite to say what the potential is for exploitation. Expert advice is required to assist the Geological Survey on further evaluation, and to advise the Ministry of Trade and Industry on the potential export market.

7.4.3 It is probable that the potentially small market in Malawi (less than 2 000 tons per year) would not justify the mining and beneficiation requirements to supply a useable product. However there could well be reasonable markets in the adjacent countries of Zambia, Mocambique and Tanzania, whilst Zimbabwe is also a potential market. There is some potential to reduce the future imports of soda ash for glass making if the nepheline syenite is of suitable composition. Expert advice is needed

to confirm this.

7.5 Limestone and Lime.

7.5.1 Malawi is fairly well endowed with deposits of limestone which vary from high calcium stone to dolomite.

7.5.2 Lime is currently produced at small scale level in the central to southern part of the country. The quality is variable, and total production is not known.

7.5.3 Air classified lime hydrate is imported for use in the sugar industry, with 1981 imports from Zambia being put at 2 500 tons costing about K600 000. Although this is not a large tonnage there is an opportunity for the existing industry to expand and, provided suitable quality lime can be produced, to supply the sugar industry from local resources. Due to uncertainty of supply, the sugar industry may have to obtain some supplies from Kenya in 1982. There is also a market for chemical grade lime in Zimbabwe.

7.5.4 Work is in progress to assist the small scale lime producers in recognising high calcium limestone, and to upgrade the efficiency of production.

7.5.5 Laboratory level trials have indicated that these limestones, though coarse grained, might be suitable for calcining in a shaft kiln as opposed to the less effecient trench kilns which are currently used. Both continuous and batch type shaft kilns could be introduced, with the latter being more suited to true small scale production. The batch type kiln requires a lower level of capital, and is more flexible in meeting fluctuating

demand, although fuel consumption might be higher per ton of product then for a continuous kiln. It is, however unfair to make a straight comparison based only on fuel consumption.

7.5.6 Hydraulic lime is not made in Malawi. The proving of suitable deposits of impure stone, from which hydraulic lime could be made, still has to be done. If hydraulic lime were available at reasonable cost, it could be a useful source of cementiceous material for low cost housing, and could replace portland cement in most low rise buildings. It would not be a substitute for structural concrete.

7.5.7 A considerable amount of work has to be done to evaluate the potential of both hydrated lime and hydraulic lime in road stabilisation and for other construction uses.

7.5.8 Lime - pozzolana. Volcanic ashes exist in the Karonga District which may also provide a means of making an alternate cementiceous material for building purposes.

7.6 Clays.

7.6.1 Brickclay deposits have been defined in various parts of the country, with major deposits proved near Lilongwe and Blantyre. This will enable planners to designate such areas as industrial land for brick making. At the same time, opportunities now exist for Government to assist the industry concentrated on such deposits, by developing supplies of fuelwood and water. Technical assistance will be more efficiently given where there are concentrations of brick makers.

7.6.2 Ceramic grade clays in large quantities have been defined at

Linthipe, and also associated with the glass sands at Nchinji. Final assessment of quality, the size and nature of the market, and optimum production methods still have to be made.

7.6.3 With the development of tile making, either by hand forming or moulded in simple machines, there is a need to define sources of suitable clay, although Linthipe clay is one possible source.

7.7 Analytical Chemist - Summary of Findings with respect to Geological Survey Analytical Laboratory. (For fuller details, the report must be consulted).

7.7.1 Sample size is not properly related to grain size, whilst manual crushing and grinding operations are not effective in terms of quality and quantity of output.

7.7.2 The laboratory ovens are sufficient for laboratory needs, but the single pan analytical balance, purchased in 1969, is of a type that does not guarantee fast and reliable results.

7.7.3 Equipment available for use in sample decomposition is satisfactory with the following exceptions :

a) the fume cupboard and extraction system should be overhauled or, preferably, replaced;

b) an additional 13 platinium dishes are required.

7.7.4 The portable deionizer and distillation unit to produce distilled water work satisfactorily but a second, improved type of deionizer is required.

7.7.5 There is an adequate supply of general glassware, but a need for bulk pipettes, automatic pipettes, rapid filtration funnels and Buchners, and a new vacuum pump for vacuum filtration.

7.7.6 The main instruments used in the laboratory, eg. Colourimeter, Atomic Absorbtion Spectrophotometer, Flame Photometer, Ph meter and conductivity bridge, are considered to be inefficient and/or obsolete. More modern equipment, and training of staff in its maintenance and use, are required. Fume extraction is essential in the Atomic Absorbtion Spectrophotometer room.

7.7.7 A range of analyses were carried out to check analytical methods for commonly analysed constituents. Some of the improvements recommended require replacement of the obsolete equipment referred to in the above paragraph 7.7.6. Tables 1 to 13 of the consultant's report show analytical results for standard samples analysed for CaO, MgO, $Fe_2O_3$, $Na_2O$, $K_2O$, $Al_2O_3$ and $SiO_2$, giving certificate values, amount found, absolute error and percentage error.

8.7 Clay Testing Consultant - Summary of Findings (for fuller details the report must be consulted).

7.8.1 No changes had to be made to the present methods of test detailed by Buchanan (CTA) and Knoblick (KfW consultant) but additional tests are necessary to complete the range of tests. Special attention should be paid to field testing where, if there are no significant differences between samples, one sample would be sufficient for full laboratory testing. This would drastically reduce the number of samples submitted to the laboratory and red overloading of its facilities.

7.8.2 A range of equipment is required for the Industrial Minerals laboratory of the Geological Survey. This includes 25 litre ba mill, 5 litre flotation cell, colour charts, sedimentation

cones, millivolt meters, platinum and platinum 10% Rhodium thermocouple wire, pycnometer flasks, mixing and kneading machine, platinum crucibles, laboratory crusher, laboratory mill, filter press, and autoclave. A range of chemicals is also required for testing ceramics, glass and glazes.

7.8.3 Some remarks are made about bricks in Zomba and Blantyre, noting that it is hardly possible to make hard fired bricks since the clays being used have a short vitrification range. Other remarks in the report indicate : the potential of looking for Stavrolite (a mineral used in sandblasting for which there is a shortage on the world market) hydraulic lime production from siliceous limestone which can develop up to 60% of the comprehensive strength of normal (portland) cement; possibility of recycling the lime used in the sugar industry; the possibility of a small scale sandpaper industry based upon garnets found in Malawi; the potential to examine a multi-product quarry for the northern coalfields with the products being a) coal, b) clay, and c) limestone made into hydraulic lime; calcium and dolomite limestone milled to produce a filler for white paint and light coloured small particled mica, chlorite talc, milled down 100, 50, 10, 2 microns for filler in paints. nepheline syenite should have the same priority as quartz sands, noting that in the USSR 70% of glass raw material is nepheline syenite; the potential exists to develop a small glass industry (free blowing in steel moulds) in parallel with the main proposed glass factory; that sawdust be considered as a source of feed to make methane gas for driving stationary engines, eg. for driving sawmill machinery.

7.9 **Building or Construction Development Centre.**

7.9.1 One of the problems facing the ministries of Trade and Industry, Forestry and Natural Resources, and Works and Supplies, is the lack of knowledge pertaining to application of known technoligy in localised situations. Often such applications can have industrial potential. Some examples are :

a) use of lime as a mortar, or as a stabilising agent in soils for roads, or for wall material;

b) use of pozzolana material;

c) use of different limestones in small kilns for local rural use, eg. at village level;

d) wider application of local material, through correct material selection, and applying optimum design and production criteria to make durable building and construction material.

7.9.2 A development centre is required which, whilst having a cadre of permanent staff, could draw upon the expertise of Government and the private sector, and would aim at developing better production methods or materials based on local conditions.

7.10 Constraints to Implementation.

7.10.1 The inability of Government to provide counterpart staff for the extension service has had a serious negative effect which reaches far beyond the extension service itself.

7.10.2 When, in March 1981, the Ministry of Trade and Industry advised that it could not operate a technical extension service on a long term basis, a suitable host for the extension service was sought. The Ministry of Works and Supplies was willing to take over the extension service if Treasury made provision for the posts

and operations. This has not yet been resolved.

7.10.3 If the extension service were to be moved out from Trade and Industry into another ministry, it appeared to be a logical step to make the Ministry of Forestry and Natural Resources the Government Implementing Agency. On the other hand, the eventual outcome of work done in the natural resources sphere is the potential for industrial development, ostensibly within the field of competence of the Ministry of Trade and Industry. This question has also not been resolved.

7.10.4 Late in 1981, the effective budget scheduled for the 1982 - 1984 Country Programme was reduced by over 20%. The fact that the future of the extension service was uncertain and that there were queries as to which ministry would or should become the implementing agency left the Ministry of Trade and Industry in a weak position to defend the maintenance of the project budget and to follow through with a proposal for a major expansion of the project which had been put forward in 1981.

NOTE : It may appear somewhat contradictory to the foregoing paragraphs that an effective and virtually problem free relationship has been maintained between the Ministry of Trade and the Geological Survey Department in implementing the project.

7.10.5 In January 1982, Trade and Industry proposed a second phase of the project to start in October 1982 and concluded that the extension service could operate from a new parastatal body - the Small Enterprise Development Organisation of Malawi (SEDOM). Since SEDOM comes under the aegis of Trade and Industry, it would effectively retain the extension service. At the same

time, it was proposed that the Ministry of Forestry and Natural Resources become Implementing Agency through its Geological Department. The Treasury, through which application for aid funds must be made, postponed any decision until the institutional arrangements, within Government, were settled.

## 8. RECOMMENDATIONS

8.1 In view of the opportunities for industrial development based upon Malawi's own resources of industrial minerals, the External Aid Section of the Treasury should co-ordinate activities to achieve a decision on the best form of Government institutional arrangements which would lead to a second phase of the project. The second phase would concentrate on industrial minerals from the proving stage through to promotion of industrial activities being set up. The brick making extension service should be brought up to full strength within SEDOM, and allowance made for training in both brick and lime making, but it would be separate from the second stage of the project.

8.2 The small scale sector of the brick making industry should be given continued encouragement to diversify and expand. A small demonstration kiln should be built at Chadza and training given in kiln operation to fire higher quality bricks and tiles.

t.a. required for two brickmaking seasons

yes. re social and ecological studies.

8.3 The Ministry of Works and Supplies should upgrade its brick testing facilities at the Regional test laboratories.

agreed.

8.4 A study should be made on the major brick clay deposits of Chadza and Bangwe to determine the social, ecological affects and logistical

requirements in designating these areas as brick making areas for Lilongwe and Blantyre respectively. Brick makers should be encouraged to buy or lease larger areas of land such that they can consider year round production, and such that they can work around occurences of unsuitable raw material. Areas of from 1 - 4 hectares each would be appropriate.

8.5 The Ministry of Forestry and Natural Resources should develop fuelwood plantations for industrial use, including brick makers, since wood for domestic consumption is not necessarily suitable for brick making.

8.6 The work started in refurbishing simple machines to make Marseilles interlocking tiles and ridge tiles, should be completed and brick makers should be encouraged to diversify into tile making. The prerequisite is that suitable clay must be available. Local manufacture of the machines should be investigated.

8.7 An expert in small scale lime production should be engaged for a period of not less than two years to develop more efficient production of lime, and to encourage production in selected centres throughout the country. It should be noted that lime, especially hydraulic lime, has the greatest potential to upgrade the living standards of rural poor since it can be produced at almost any level from a fraction of a tonne per day to many tonnes per day, according to the demand. The production facility can vary from a very small kiln at cottage industry level up to capital intensive operations for more widespread use of the lime.

8.8 Continued encouragement should be given to development of a glass making industry based upon quartz sands, nepheline syenite, and limestone

deposits which exist in the country. Consideration should also be given to setting up a small facility, eg. employing free blowing in steel moulds, in parallel with the larger factory which would produce general glass ware and bottles. The smaller facility could be a separate company from the larger one, but may buy molten glass from the larger company.

8.9 The production of "special" cement bonded bricks using white sand and cement and possibly a range of colours, should be investigated, since it may have potential in both Blantyre and Lilongwe.

8.10 A consultant should be engaged to assist the Geological Survey evaluate in more detail, the deposits of nepheline syenite which exist in various parts of the country. The consultant would assist in determining which deposit(s) should be given priority for evaluation. He would also give preliminary guidance on the economics of supplying a) the market adjacent and close to Malawi and b) the world market. Provision should be made for a further consultancy to conduct a feasibility study on exploiting the nepheline syenite deposits should laboratory evaluations prove positive.

8.11 Deposits of calcareous material, suitable for making hydraulic lime should be prospected for and evaluated. The production of hydraulic lime should then be encouraged.

8.12 Provision should be made to upgrade and supplement the equipment status of the Geological Survey's chemical laboratory in line with the recommendations of the consultant analytical chemist. Suitable training should be provided for laboratory staff in operating and

maintaining new equipment.

8.13 Consideration should be given to supplying additional equipment to the Industrial Mineral laboratory, as recommended by the consultant in clay testing. Consideration should also be given to providing short Fellowships for the senior staff in the Industrial Minerals laboratory. The Fellowships should be of a practical nature related to the use of ceramic materials.

8.14 Government should investigate the possibility of having a centre at which development work would concentrate on the supply, treatment or manufacture, and application of local raw materials for the civil engineering and building industries. The work would also concentrate on developing optimum design features to accept locally produced construction materials. Such a centre might come under the Ministry of Works and Supplies.

8.15 The Ministry of Trade and Industry should establish at least one post for a professional officer with a broad technical background, eg. in industrial engineering. In the interim period, whilst a suitable candidate is being trained (5 - 7 years) consideration should be given to engaging an advisor through bilateral or multinational aid sources.

## *APPENDIX I*

*The Small Scale Brick Making Industry in Malawi*

1. *A survey carried out during the UNIDO SIS project MLW/77/802, led to useful information being compiled on the small scale sector of the industry. Results (repeated below) were passed on to all District Commissioners, who are responsible for registering brick makers, to the Office of the President and Cabinet, the ministries of Agriculture, Works and Supplies, Trade and Industry and to the Malawi Housing Corporation.*

| | | |
|---|---|---|
| 1. | *Estimated number of brick makers* | *400* |
| 2. | *Total number of employees* | *15 240* |
| | *comprising - men* | *5 840* |
| | *- women* | *4 000* |
| | *- young people* | *5 400* |
| 3. | *Total number of bricks made* | *53.68 million* |
| 4. | *Total amount of firewood used in stacked cubic yards* | *56 600* |
| 5. | *Average duration of brick making season* | *4.36 months* |
| 6. | *Average distance from which firewood is transported* | *11.73 miles* |
| 7. | *Method of transporting firewood* | |
| | *- lorry* | *66.5%* |
| | *- ox cart* | *22.0%* |
| | *- manually* | *11.5%* |
| 8. | *Average distance from which water is carried* | *0.39 miles* |
| | *- method of carrying water - buckets* | |
| 9. | *Source of water supply* | |
| | *- river* | *58.0%* |

| | |
|---|---|
| - well | 36.0% |
| - lake | 4.0% |
| - pipe | 0.6% |
| - dam | 1.9% |

10. Time for which bricks lie before sale

| | |
|---|---|
| - less than one month | 39.0% |
| - more than one month, less than six months | 56.0% |
| - more than six months | 5.0% |

11. Problems which the brick makers think would hold them back from increasing production

| | |
|---|---|
| - operating funds | 43.0% |
| - labour | 11.0% |
| - clay | 6.0% |
| - water | 5.0% |
| - wood | 19.0% |
| - transport | 12.0% |
| - lack of market | 5.0% |

12. Problems given by the brick makers as existing at present

| | |
|---|---|
| - operating funds | 26.0% |
| - wood and transport | 33.0% |
| - labour | 12.0% |
| - market | 12.0% |
| - clay | 7.0% |
| - water | 6.0% |
| - no problems | 4.0% |

2. The foregoing information relates mainly to 1978, and was compiled from nearly 200 completed questionnaires. It is though that, additional to the above, are bricks made by individuals for personal use and for self help schemes.

3. In order to appreciate some of the work being done through the project, it is necessary to have some understanding of the brick making industry and the market for bricks. The manufacturing sector (for bricks) can be divided quite clearly into :

   a) machine made bricks, totalling less than 1 million bricks per year in 1981 and selling at relatively high prices of from K50.00 to about K250.00 per thousand (US$55.56 to US$277.78); and

   b) hand made bricks which could be as many as 70 million bricks per year.

   Apart from the fact that exact production figures are difficult to determine, it seems certain that the industry is a major employer and production will fluctuate according to demand.

4. Bricks made in the rural areas are very cheap due to lower labour costs and easier - cheaper availability of fuel. This contrasts with bricks made in the main urban areas, especially Blantyre and Lilongwe, where labour costs are higher, fuel has to be transported long distance, eg. up to 80km, and the quality is more often subject to testing.

5. All hand made bricks are fired in wood fueled "clamps" or field kilns. Clamps, in this case, are simply stacks of bricks, usually 20 000 to 120 000 (in extreme cases 5 000 to 500 000 have been seen), with open channels running through at ground level in which the fuelwood is burned. The important features of such clamps are that they can be built to almost any size simply by extending the length; they can be built at the site of the brick making; there is no fixed capital tied up such as in a kiln; and they seldom reach a high enough temperature to overfire the bricks. This latter feature is important for two reasons :

   a) the bricks, being underfired, do not develop their full potential strength. In many cases they are not durable in exposed situations.

   b) Clays which have a short vitrification range, (ie. the temperature range across which the brick develop a strong ceramic bond but below that at which they 'melt' and distort) can be safely used in clamp firing. Such clays could not easily be used in kiln firing where higher temperatures are expected. This means that a wide range of clays can be used, without prior testing, provided that a low quality product is acceptable.

6. It will be apparent that although the present system is versatile enough and fulfills a definite need for low cost bricks, it is nevertheless limited. Higher quality bricks are always in demand and much of the work assisted by the project is to define suitable clay deposits and introduce improve methods of production which will enable traditional brick makers to expand and to diversify into higher quality bricks. The alternative is to introduce more mechanised brick making which will substantially raise the cost of bricks, involve importation of expensive machines and spare parts, and reduce

employment opportunities. Even so, there is a use for limited mechanisation where the hand made product cannot meet the demand for high strength bricks.

## *APPENDIX II*

### *Nepheline Syenite*

*There are extensive deposits of nepheline syenite in several parts of Malawi. The material, though generally uncommon, has a wide range of industrial application which depend upon or are limited by the chemical composition and nature of the minerals present. At this point in time it is not possible to say if any of the Malawi deposits are suitable for beneficiation to make a marketable product. However, if subsequent investigations show that one or more Malawi deposits can produce nepheline syenite which is competitive on the world market, a major mining based industry could evolve. It is therefore considered that such investigations should be given high priority.*

*UNIDO was contacted on 21st January 1981 with a request to provide information on nepheline syenite. A considerable quantity of data was received in March 1981 and selected extracts follow. It will be seen that whilst, apart from the Soviet Union, the main uses are in glass and ceramics manufacture epheline syenite is also used, or has potential uses in the following :*

- *filler for plastics, rubbers and paints;*
- *source of sodium carbonate;*
- *aluminium production;*
- *fertiliser;*
- *in vitreous enamels;*
- *in electrical porcelain;*
- *co-filler in paints, vinyl furniture unholstery, foam rubber cushions, foam rubber carpet backings, and floor and wall tiles;*
- *in the manufacture of fibre glass;*
- *in the manufacture of mineral wool;*
- *as an aggregate.*

*Canadian mine production of nepheline syenite in recent years is :*

| *Year* | *Metric Tons* | *% Increase Over Previous Year* |
|---|---|---|
| *1975* | *468 000* | - |
| *1976* | *541 000* | *15.6%* |
| *1977* | *574 000* | *6.1%* |
| *1978* | *579 000* | *0.87%* |

1. *The following extracts are from the magazine "World Mining" (August 1973, p.39).*

   1.1 *"What is nepheline syenite used for? The four main fields of application are glassmaking, ceramics, enamel, and as a filler for plastics, rubbers, and paints. The greatest quantities are used in the glass and ceramics industries.*

   *Ordinary soda-lime glass contains, amongst other things, $Al_2O_3$, $Na_2O$, and normally also $K_2O$. Nepheline syenite gives the glass the desired content of $Al_2O_3$. At the same time the glass is supplied with alkalis; thus the consumption of other and more expensive sources of alkalis such as soda and potash is reduced."*

   1.2 *Referring to the Norwegian mining operation on Stjernoy (Star Island).*

   *"Total investment in the mine and related facilities since start-up amounts to around 70,000,000 Norwegian Crowns (about US$11,000,000) and current improvements and modernisation steps being undertaken or planned include the new compressor station underground and the new primary crusher station.*

   *The glass grade product is shipped in bulk in vessels with capacities of about 5 000 tons. The bagged ceramic grade is shipped out in lots*

*of about 850 tons per time.*

*The growth of Norwegian (Norsk Nefelin) production of nepheline syenite in recent years is shown in the table along with that of the leading producer, Canada, where two mines are in operation. Shipments are made either direct to consumers, or to several large stockpiles which the company maintains in Western Europe from which final deliveries to customers are made."*

*Norwegian and Canadian Production of Nepheline Syenite from 1965 through 1972 in Metric Tons*

| Year | Norway | Canada |
|---|---|---|
| 1965 | 41 000 | 308 000 |
| 1966 | 57 000 | 333 000 |
| 1967 | 67 000 | 363 000 |
| 1968 | 83 000 | 387 000 |
| 1969 | 129 000 | 454 000 |
| 1970 | 147 000 | 440 000 |
| 1971 | 160 000 | 470 000 |
| 1972 | 165 000 | 508 000 |

2. Source : Chemical Economics Handbook, November 1980.

2.1 *"There is an additional natural source of sodium carbonate (as a by-product). Nepheline syenite (a sodium, potassium aluminosilicate), with additional raw materials, can be processed to alumina, cement, and potassium and sodium alkalis. This process was development by the Soviets in order to be self sufficient in aluminium and is not currently practised elsewhere. The final form of the alkali material is not know, but is probably either a mixture of sodium carbonate*

and potassium carbonate or one contaminated with small amounts of the other. The Soviet Union is believed to process over a million metric tons of nepheline syenite into these products annually and may be planning to more than double that throughput.

3. The possibility of agricultural utilisation of the nepheline syenite of Pocos de Caldas, State of Minas Gerais, V. Ilchenko and Djalma Guimaraes (Inst. technol, ind., Belo Horizonte, Brazil). Estado Minas Gerais, Inst. technol, ind., Avulso no. 15, 1 - 15 (1953) - determination of $K_2O$ and $Na_2O$ are given for 20 samples. The high $K_2O$ content (up to 12.77%) and the easy decomposition of nepheline syenite suggest that these rocks could be applied directly as fertilisers.

4. Source : Canadian Minerals Yearbook 1974. Preprint no. 31, Pearse, G.H.K., Nepheline Syenite and Feldspar.

4.1 "Although nepheline syenite is a rock type known to occur in many parts of Canada, its industrial application is limited to those deposits in which iron-bearing accessory minerals can readily be removed; its major uses are in the glass and ceramics industries."

4.2 "In the glass industry, 15 - 20 per cent by weight of the glass batch is nepheline syenite. Material with a size range of minus 30 mesh to plus 200 mesh and with an iron content of less than 0.1 per cent is required in the production of flint glass. An iron content as high as 0.6 per cent, expressed as $Fe_2O_3$, is allowable for the manufacture of coloured glass. A typical chemical analysis for high quality nepheline syenite produced in Canada for glass manufacture

is :

| | |
|---|---|
| Silica $SiO_2$ | 60.00 |
| Alumina $Al_2O_3$ | 23.60 |
| Iron $Fe_2O_3$ | 0.07 |
| Lime CaO | 0.30 |
| Magensia MgO | 0.10 |
| Potash $K_2O$ | 5.30 |
| Soda $Na_2O$ | 10.20 |
| Loss on ignition | 0.50 |

A growing market is developing for finely ground material in the whiteware industry. The finer grades used for ceramic applications are produced by reducing the basic minus 30 mesh material in pebble mills. In ceramics, nepheline syenite is used as both a body and glaze indegredient. High purity material in the minus 200 - plus 375 mesh size and with an iron content of 0.07 per cent $Fe_2O_3$ or less is most frequently used. Products utilising this material include bathroom fixtures, vitreous enamels for appliances, china, ovenware, electrical porcelain and ceramic art wares.

Very finely ground material is being increasingly used as a filler in plastics, foam rubber and paints. Fine grinding down to 10 microns is accomplished in pebble and fluid-energy mills. The very fine grain size, high reflectance and low oil absorbtion are important physical characteristics which make nepheline syenite an excellent filler co-material in such finished products as paints, vinyl furniture, upholstery, foam rubber cushions, foam rubber carpet backings and floor and wall tiles.

A low grade nepheline syenite is sold in bulk for use in the manufacture

*of fibre glass and for glazing on brick and tile. Some material with iron content is used in the manufacture of mineral wool and as an aggregate."*