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CERAMIC RESEARCH LABORATORY

DP/SRL/86/005

SRI LANKA

Terminal Report*

Prepared for the Government of the
Democratic Socialist Republic of Sri Lanka
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

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United Nations Industrial Development Organization
Vienna

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- Dr.C.T.S.B.Perera , General Manager , Ceylon Ceramics Corporation.
- Dr. M.M.J.W.Herath and his staff - Head, Ceramic Research and Development Centre.
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- Mr.F.L.Nihal Dissanayake and his staff , - Factory Manager , Piliyandala Factory and all other Colleagues from Ceylon Ceramics Corporation and its factories who participated actively in obtaining the results and achievments mentioned in this report.

INTRODUCTION

The UNIDO Project DP/SRL/86/005 has been designed as a bridging project between the two phases of project US/SRL/76/207 following to the recommendation of the evaluation team on December 1985 to extend the running project under the Federal Republic of Germany fund for other two years.

The expert started his mission in Vienna on 23.11.1986 and in the duty station on 28.11.1986. The mission expired on 22.3.1987.

During this mission two consultants have been assigned by UNIDO for one month each namely Dr.F.A. von Metzsch and Dr.Z.A.Engelthaler with whome the expert cooperated to the interest of the project, the Ceramic industry in country and the other allied industries in general. The two consultants have produced final reports setting out their findings , activities and recommendations.

The expert has been briefed at UNIDO Headquarter on the back ground of this assignment with specific duties as:

- Assesment of the status of the project.
- Designing the project document for the second phase of the project to reflect the actual need of the Ceramic Research and Development Centre and the Ceramic industry in general.
- Planning , with his local senior counterpart, the work plan for the group of experts to be assigned to the second phase of the project.
- Planning , with his local senior counterpart , the fellowship programme.
- Identification of the new equipment and spare parts to be purchased by UNIDO for the second phase of the project.
- Advise on the day to day work of the laboratory.

SUMMARY & RECOMMENDATIONS

The activities of the project DP/SRL/86/005 Ceramic Research Laboratory started on 27.11.86 by the arrival of the first consultant Dr.F.A.von Metzsch and expired on 22.3.1987.

During this period the experts:

M.M.Morsi Tantawy : CTA , Expert in Ceramic Technology

Dr.F.A.von Metzsch : Consultant in Use and Maintenance of Ceramic Loboratory Equipment.

Dr.Z.A.Engelthaler : Consultant in Ceramic Research Management.

have visited different factories beloning to C C C and other companies related to this field activities and negotiated the current technical and management problems and advised as for as concerned.

Concerning the CRDC the experts shared in the technical management of tests and research work conducted by the research officers and sugessted new field of interest in research work.

At the end of their mission Dr.von Metzsch and Dr.Z.A.Engelthaler produced terminal reports setting out their findings , activities and recommendations.

Following are the recommendations strongly suggested to the different parties associated with this project.

A - Recommendations to UNIDO /UNDP

- Continue the support to this project through the second phase of the project US/SRL/78/207 which is a very promising project build to increase the infrastructure of the country.
- Help in strengthening the contact between this project and other international research centres of the same field of activity.
- Introduce this research centres to other interested research professors as a possible centre for implementing their research programmes. Exchange of research officers can help in widening the scope of vision of both parties to a new horizon of activities.
- New fields of activities have been proposed for further assistance.

- Presence of only one vehicle for CTA and National Consultant is hampering the activities of the consultants - Especially in presence of the short term consultant this leads to tieing them together. The need of another car is unavoidable.

B - Recommendations to Ceylon Ceramics Corporation.
(CCC)

- The assignment of the head of laboratory should be extended as long as needed for a new generation to be qualified to carry on the activities and responsibilities of the Centre.
- The recruitment of a second generation of research officers as planned. A start with a probation period of at least six months before granting a long term appointment is advisable
- Strong backing of the Centre till the time comes , very soon , for the Centre to be self dependant financiallly.
- Expand the premises as agreed upon for the new equipment and also for designing and glaze sections.
- The reports prepared by the planning section at CCC should be passed periodically to the Centre to be used as a guide for control and research work.
- Implementation of the recommendations mentioned the report of December 1986 about Piliyandala Factory. The same can be applied , to some extend, to Negombo factory.
- Building of a clay drier at Meetiyagoda refinery as that one in Boralesgamuwa.
- Make use of the waste material from Boralesgamuwa refinery in place of Nattandiya sands in crockery and sanitary ware factories 'Piliyandala and Negombo'
- Use of exhaust gases from the rotary kiln in Hungama lime factory to dry the sea shells before firing to decrease the fuel consumption.
- Change and diversify the designs of the ornamentals factory in Haloya to reflect the Heritage and traditions of the country. This will improve the marketing through export as well as Tourisam Industry.
- Improve the quality control system on refractories at Meepe factory using the European or the custemers standard to increase the reliability of the product.

- Production of Zircon mullite Blocks for the melting tanks of the glass industry using the locally available Zircon.
- Production of graphite Crucibles using the high quality graphite available in the country.
- The field work done by the research officers whatever it is should be covered by laboratory internal orders and charged to the substantive factory, even in book-keeping only. This will help in monitoring the activities of the research centre.

C - Recommendations to Ceramic Research and Devellopment Centre (CRDC)

- Extend the relation to the customers and potential customers through personal visits and advertizement.
- Continue the work on the squatting par body and glaze using local raw materials without using glass cullet.
- Exploration of new quarries for Ball caly and China Clays. It is well known that the higher the number of different raw material in the body, or glaze , the better the result and the lower the risk in case of one shipment is out of standards.
- Improving strict Quality Control system on China clay refineries especially those clays for lanka Porcelain. A brightness tester should be supplied to the refinery in addition to the hydrometer present already for measuring the particle size ditribution.
- Continue the research work on wall tile body for lanka wall tiles to replace the imported pyrophyllite and reduce the water absorption.
- It is advisable to check the accuracy of the equipment and procedure from time to time using standard sample or even a previously tested samples to see the reproducability of the results.
- It is recommended to test the imported ceramic materials espcially refractories to be the starting point for improving the quality of the Domestic products.
- The work on laboratory porcelain should be continued using the facilities of pilot plant for preparation of the body and Pilliyandala factory for the production. Those items are usually imported at high price.
- The equipment available now and those ordered for the second phase are all of high value and it should be handled with care and serviced promptly to keep it in tact. These equipment should last for life time and is difficult to replace.

LIST OF VISITS

1. Ceylon Ceramics Corporation
2. Piliyandala Factory
3. Dediyawela Clay refinery
4. Lanka Wall Tiles Limited
5. Lanka Tiles Ltd.
6. Meepe Refractories Factory
7. Lanka Porcelain Company
8. Gampola Ornamental Factory
9. Negombo factory
10. Dankotuwa Porcelain Company
11. Meetiyagoda China Clay Refinery
12. Boralesgamuwa China Clay Refinery
13. Hungama Lime Plant
14. Raw Material Mines (Feldspar, Ballcaly , Calcite & Dolomite)
15. Sithara Ltd.
16. National Aquatic Resources Agency
17. State Mining and Mineral Development Corporation
18. Graphite Mines at Kahatagaha
19. Ceylon Glass Company Ltd.
20. Faculty of Science - University of Ruhuna - Matara
21. faculty of Science - University of Peradeniya

LIST OF REPORTS PRODUCED

1. Therminal Report	Dr.F.A.von Metzsch
2. Terminal Report	Dr.Z.A.Englethaler
3. Quality Improvement in Piliyandala Factory	M.M.Morsi Tantawy
4. Crystallization in Glazes : Cause & Cure	M.M.Morsi Tantawy (attached)

I - FINDINGS

A - Ceramic Research and Development Centre

1 - Management

The CRDC is headed since January 1986 by Dr.M.M.J.W.Herath who gave the CRDC a great push and encourage the research officers to create new research programmes as well as to present papers and register for post graduate degrees at Sri Lanka Universities. The fields of these thesis are choosen carefully in the same direction of the research activities of CRDC.

The research officer are assigned to the different laboraotries of the Centre, usually two officers for each laboratory, as follows:

- X-ray & Thermal Analysis Lab:
  Mr.Siritunge & Mr.Ranatunge
- Mineralogical Lab :Mr.Karunasinghe & Mrs.Rajapakse.
- Pilot Plant : Mr.Gaspe & Mr.Alles
- Kiln Section: Mr.Mithraratne & Mr.Soysa
- Physical Lab.:Mr.Pannila
- Chemical Lab.:Mr.Dharmasiri & Miss.Pigera.
- Designing Section: Mrs.Hemalatha
- Glaze Section: Mr.Sarath Silva Senior Research Officer
- Library & Secretored Assistance:
  Mrs.Perera & Mrs.Talwatte

Aware of the fact that a new generation of research officer has to be build up CCC is going to recruit additional research officers as well as research assistants to help in the running of routine tests and save the time of the research officers for the higher research programs and sophisticated analysis.

2 - Equipment

The CRDC is equiped with a good number of Scientific equipment most of it is running well enabling CRDC to test and analyse all the needs of CCC factories in addition to other end users like Glass factories , Cement factories, Steel factories and some Universities. The charges of these tests help the CRDC to be

not much depenant on the finance from CCC and in the near future it is envisaged that the CRDC can be self dependant and need no subsistance from CCC.

A list of equipment at present is given in Annex I

Due to the fact that there are still some bottle neck for the research programs and towiden the scope of tests and analysis additional equipment have been ordered for the second phase of the project as shown in annex II. In the meantime several spare parts have been ordered to gurantee the smooth running of the equipment without troubles during the life span of the second phase.

Despite the fact that most of the equipment is running in good condition. The most important and may be the most expensive ones namely XRD, XRF and Bickley PCE kiln was out of order. Several measures have been taken to repair it.At the moment the XRD has been repaired and functioning well. The Bickley PCE kiln has been examined by Bickley Technician and the parts needed will be delivered and assembled after one month. The XRF is still out of order waiting for the arrival of Philips engineer who is expected to come and repair it within 2 - 3 months. A survey of the faults and malfunction noticed has been send along with some spare parts needed to start testing of the equipment.

3 - Premises

The premises , for the time being , is farely sufficient for the equipment and research programs. On the arrival of the newly ordered equipment it is of need to increase the area of the Centre. It is already agreed upon with the General Manager, CCC to expand the site of the Centre by evaccuating the rooms on the upper floor occupied now by some administration officers of CCC. An air - conditioned room is needed for the atomic absorption and spectrophotometer apparatus. Another room for designing section with the potters wheel, moulds and raw materials for designing. A third room is needed for glazing section to install the spraying booth, frits , glazes, colours and samples. A separate room for the library, which is occuping now part of the office of the head of laboratory, furnished with appropriate shelfs and reading table will be advantageous.

4 - Market

For this types of tests and analyses done by the centre there is a good market both inside CCC and outside of it. It is not only the ceramics industry which need these analyses but others like glass industry, cement industry, steel industries , mining industries in addition to other research centres like universities and stanardization organizations. Even the Archeological Project run by UNESCO show interest in some tests. However due to the newly establishment of this centre it is not easy to invade this field of business. It need time, advertisment relaibility and fast service. The change of the official name of the laboratory, following the recommendation of the evaluation team , is one of the steps to reflect the activities of the Centre to the end user as a research and development centre rather than the old name usually misunderstand as concerned only with academic research . In the same direction the production and distribution of a brochure showing the facilities and activities of the Centre has helped in widening the range of end users. The strong connections of the head of CRDC to several organization is helping also in luring some customers to the centre.

For future these connections should be strengthened more and more till the time comes, very soon, for the centre to be accepted as a certified laboratory in the quality control network. This will not be achieved only through advertisment but through hardwork , reliability assesment of the results, participation in national and international seminars & conferences and assimilation of experiences gained by all these contacts.

As far as the last 3 months the market evaluated as income of CRDC is going upwards. The value of orders done are as follows:

January 1987	Rs.11,224
February 1987	Rs.26,645
March 1987	Rs.36,000

For the month of April it is expected to be still higher as only one order for testing 14 samples of Plaster of Paris amounting to Rs.20,000.00.

B - Piliyandala Factory

As CRDC located within the premises of this factory it is quite understood that it take more time and activities of the expert more than other factories. The factpry produces crockery , sanitary ware and the frit for crockery glaze in Piliyandala and Negombo factories. Body glaze and frit compositions are shown in Annex III . The expert has monitored the production cycle of this factory and advised on the necessary measures to improve the quality. This recommendations have been produced in a separate report in December 1986. Several glaze compositions have been recommended and tested during this mission which are shown in Annex iv. Ohter recommendations for the scnedule of quality control in addition to some modifications of the standard methods of testing have been released.

During this mission this factory has got an order for the production of a hanging commode for Oberoi hotel. This model is too complicated in production but highly priced. There are two different moulds for this model one designed by a previous UNIDO consultant Mr.Fawzi El-sobky and the other designed by the moulding section. The expert has shared actively in the implementaion of this new type of production and advised on the way to cast, dry, and fire it successfully.

There is a project under consideration to expand the sanitary ware production with the technical and financial assistance of AGROB or NETZSCH F.R.G. which will enable the factory to cover the local market especially in squatting pans , and also to export to the neighbouring countries. Strict quality control measures should be watched to gurantee the export possibilities.

With the present quality of crockery production it is not possible to explore the foreign market except as discussed with the Marketing Manager, of art ware decorated in exotic motives of the country style.

C - Negombo factory

This factory is about 35 km North of Colombo and it produces the same type of production like Piliyandala factory i.e. Crockery and sanitary ware in addition to electric insulators. The production of this factory is a little better concerning crockery and of the same quality of sanitary ware. This factory roughly uses the same body composition and glaze composition of Piliyandala factory. This factory has also Transfer paper Production Unit to serve their own production in addition to Piliyandala factory. This factory produces also Ball mill liniing of good quality and porcelain balls but only manually which lowers its quality.

It is possible to use the available Zircon in the country to produce high density balls using a jiggering machine. The drying and firing of the jiggered balls should be sm ooth to avoid cracking. This type of Zircon Mullite balls have higher grinding efficiency due to its higher density.

Due to the market need of squatting pan and not availability of firing possibility in the sanitary kiln, trials was made to use glass cullets as a fluxe to lower the maturing temperature to match the firing temperature of crockery glost kiln where there is a possibility of firing. This trend has led to serious production problems due to the bad and diverse quality of glass cullet used and the possibility of hydrolysis of this glass during aging of the slurry leading to difficulties in defflocculation of the slurry and thixtrophy problem. Several pieces of advice have been made to overcome this problem.

Several tests has been made to introduce local ballclay in the body composition, after testing its reheological properties and in the same time blending of glaze compositions to suit this type of product which should be of low cost. Glaze compositions are shown in annex V and body compositions in Annex VI.

D - Ball Clay Refinery plant

Ball clay is mined from an open cast quaries with an overburden of about 50 cm. There are 3 distinct - coloured layers : Yellow blue and black. The black layer is the lower most layer and it is not much excavated yet while the blue and yellow layers are not preciously defined and therefore is used mixed and supplied together as one clay. There is not much analytical difference between the 2 Ball clays which shows that this colourization is due to the type of organic material contaminated with the ball clay rather than the amount of this contamination. In the meantime the black ball clay shows higher L O I which means it has higher content of organic material which improves its plasticity as well as the rheological behaviour and lowers the diffluculant demand for casting slip. The Ball clays (mix of blue and yellow) is used mainly for the production of crockery and not yet used in sanitary ware. An extensive study of the reheological properties of these clays separately shows not much difference in diffloculant demand and therefore the mix of the 2 types blue and yellow has been worked togeter. Annex VII shows the chemical and minerological characteristics of these clays while annex VIII shows the diffloculation curves of the mixture of the blue and Yellow clay. According to these curves it is noticed that addition of 0.05% soda ash and 0.2% Barium Carbonate improves the casting behaviour and lowers the diffloculant demand. These results was the basis for one research project to introduce the local clay in the sanitary ware production, this project is still going on .

As this Ballclay is used without refining it would be advisable to study the possibility of refining each clay separately and also the possibility of blending these different types of refined clay to get more than one clay each with specific characteristic and for specific use.

E - China Clay Refineries (Boralesgamuwa & Meetiyagoda)

The local china clay is excavated from two open cast areas in Boralesgamuwa and Meetiyagoda. The raw clay contains about 50% of Kaolinite practically free from iron or titanium contaminations, Although Boralesgamuwa deposit has a little higher content of iron oxide. The study of these two clays shows that the iron oxide concentrates in the coarser fraction of the clays , therefore and also according to the needs of the customers (porcelain paper and tyres industries , the raw clay is refined using a series of hydrocyclones to extract the finer partcles (most pure ores) from the ore and through sedimentation filter pressing and drying. The refined kaolin is produced at different grades to suit the different industries. Annex IX shows the characteristics of Boralesgamuwa clays and annex X the Meetiyagoda clays.

Due to the fact that Lanka porcelain company (one of the limited liability companies under CCC) is the main consumer of Meetiyagoda china clay and its quality demand is high concerning the particle size distribution and brightness a great deal of the work of CRDC is assigned to monitoring and quality controlling of the china clays produced. The hydrocyclone efficiency and parameters are under strict control and the technological problems are immediately overcome by the assistance of the research officers.

Paper industry consumes a great amount of china clay of about 1500 t/y and the main complaint is the presence of high moisture content in the china clay delivered by Meetiyagoda factory which necessitates the presence of a clay drier like that one in Boralesgamuwa to overcome this problem.

A study has been done on the waste material from the Boralesgamuwa refinery indicated that the waste consists of sand a little coarser than the sand used in crockery and sanitary ware production but with less iron content (0.05% instead of 0.2% of the sand used) This study has put to test on industrial scale and the result was satisfactory. However no practicle use of this study till now. In the meantime new locations for china clay are looked for and new quarry for china clay near Boralesgamuwa is surveyed now under the supervision of CRDC research officers. the primary evidence showed now the presence of Ball clays and china clays in the new site at different levels. The extension and feasibility of these clays are still under study.

F - Lime Factory (Hungama)

In addition to the presence of calcite mineral of high quality the CCC has a lime factory for the production of Calcium hydroxide from sea shells. This factory supplies its lime production for building contractors in addition to small quantity used for the production of frits and glazes in ceramic industry. The quality of lime produced isnot high and therefore most of the consumption in the ceramic industryis shifting now to raw calcite.

The production cycles starts by washing sea shells and then firing it in a rotary kiln. The lack of a drier to dry the sea shells before entering the kiln especially during the rainy season reduces the quality of lime produced and increases the fuel consumption for firing the sea shells. Recommendation has been given to use the effluent hot gases from the kiln to dry the shells before firing.

G - Ornamental Factory (Haloya - Gampola)

This factory was originally producing graphite crucibles but it has been shifted to produce status and ornamental ware. It has one ball mill for the body properties , a spacious casting and glazing area and one shuttle kiln with 2 cars. At the begining earthen ware body was used then porcelain body is used now.Coloured glazes , matt and brilliant , is used as well as over glaze and under glaze colours. These articles has not yet marketed and it is doutful to find good market for it. The designes used are an immitation of European style which could suit the local market but the price is relatively highe . For tourists and export market this primitive im itation is not attractive. It was recommended to lay out a specific strategy for this factory either to produce relatively cheap articles for the local market or to choose the exotic designes which reflects the heritage and tradition of the country to suit the tourisam and export market. The work done and the high quality of the production should be ucilized in a better way.

H - Meepe refractories (Meepe - Hanwella)

Other than the refractory section at Lanka Porcelain for its own consumption this is the only refractory factory in Sri Lanka which produces refractories for ceramic industry as well as other industries like cement and steel industries. The production is mainly low and medium alumina refractories. Some trials are going on for the production of carborundum plates as well as cordierite refractories.

Some complaints have been received about the quality of refractories for cement and steel industries claiming the quality is much less than theimported ones. The laboratory and quality control in the factory is not well equipped which should not be . A good quality control system has to be build to compare the quality of the imported with the local one. As a beginner a slight deviation from the quality of the imported refractories can be tolerated as long as in the long run the quality is to be improved gradually. the relation between CRDC and this factory should be increased to test the production samples and the new achievment till a reasonable quality control section is established.

A refractory material consultant is recommended in the project document The consultant should have extensive experience in the new trends of refractory production especially what is urgently needed by meepe factory Viz carborundum , graphite and cordienite refractories . For the future production Mullite refractories , Zircon refractories and Oxide refractories should be also in mind as time will soon come , with the vast industrialization of the country , these type of Ceramic products will be needed.

With the high quality graphite production in the country graphite crucibles should also be tried.

Also the presence of local zircon can be used for the production of fused corrundum - Mullite Block with the addition of 30% ZrO_2 which is needed for glass tanks as it is resistant to the attack of slag and molten glass. Also glass melting crucibles should be tried.

I - Lanka Tile Ltd. (Jaltara)

This is a limited liability company under CCC which produces 200 x 200mm tiles of about 22,000 tile / day . They use a spray dried powder and the fast firing technique in a roller heart furnace. 80% of the production is exported. They seem to have good control of the quality of the product without any technical problems. The relation to CRDC is very low mainly for chemical analysis of raw material.

J - Lanka Wall Tiles Ltd. (Balangoda)

As Lanka Tiles , Lanka Wall Tiles is a limited liability company which produces about 5000 m^2/day wall tiles of different size and colours. 80% of production is exported to the surrounding countries as well as to USA . In USA they could not reach the standard specification due to the higher water absorption. The other problem they face is the high raw material cost due to the use of about 24% of the mineral pyrophyllite imported from Korea.

A research project is running now in CRDC to replace the imported pyrophyllite by using talc , although to be imported also but cheaper and not more than 7%. In the same project it is envisaged also to decrease the water absorption to suit the USA standards. The preliminery results of this project is very good.

K - Lanka Porcelain Ltd. (Matale)

This company (limited liability) is built using Japanese technical Assistance from Noritake. They produce 3500 set / month in addition to their own consumption of refractory , transfer paper and packing materials. The production is under strict control of the Japanese mother company under lisence with which they export most of the production. The biggest contact with CCC is through the use of Meetiyagoda china clay for which they have strict control concerning the particle size distribution and the brightness. As they are the best customers for this china clay great effect is done to gurantee the quality of china clay for their consumption. Every shipment of china clay tested at CRDC before shipping in addition to the routine test for particle size in the clay refinery.

In addition to the local china clay they import a super white china clay from NewZeland at a price more than double that of the local one. Much attension to the quality of the local china clay , through increase of brightness and assurance of the steady supply of the high quality china clay help the company to replace the imported china clay with the local one.

L - Dankotuwa Porcelain Factory

This factory producing table ware porcealin and using the same body and glaze composition of Lanka Porcelain , is facing troubles in the marketing of its products. There have been also some management problems but it is nearly solved and the over estimated number of workers been reduced.

Despite the problem of marketing seems to be managment problem the production faces an acute problem of wapage which can be traced to the green state while transfering the production from the first drier to the second one. This problem can be solved by increasing the temperature of the first drier to ensure solid product not destorted by handling .This increase should not be higher than $60^{o}C$, Otherwise the gypsum mould be damaged. Other alternative is to slow down the speed of the first drier to give time for drying of the articles.

M - Raw Material Mining

The Feldspar , Quartz , Calcite and Dolomite are mined from several mines mainly in the hilly areas around Kandy. The materials are sorted in the mine by hand picking without any mechanisation or refining. The quality of all these materials are reasonably high. The CCC is working now to licence a new field for Feldspar near Matale area where the Feldspar is found in an extended bed with more or less the same quality.

The mining of these material from different sites in the country gives rise to different qualities and chemical analyses. However , the CRDC is aware of this fact and the different materials are periodically tested and analysed. In the meantime the quality control sections in the different factories are testing every shipment of these materials before running into the production line.

Zircon is extracted from black sands and it is micronised and used as opacifier forglazes. There is possibility of using it for the production of Zircon - mullite blocks for glass industry.

Other ceramic raw materials like gypsum talc , wollastouite pyophyllite or nephyline syenite are not found yet on commercial scale in the country. However further survey may lead to the nepheline syenite in the igneous rack adjacent the kaolin deposits which is widely used in Europe and other countries for production of porcelain.

II ACTIVITIES

Most of the activities have been mentioned among the findings in the previous chapter , however it is summerised here as follows:

A - Design of the Project Document

As this bridging project is designed mainly to draft the project document of the second phase of the original project it took most of the time of the expert to asses the actual situation of CRDC in particular and the ceramic companies rellated to CCC in general. According to the findings and the spesific needs of the project the project doccument has been designed to reflect the status of the project and the needs oftechnical assistance to run the project during the life span of the second phase and ensure that after the expiry of the project the centre, with its highly qualified personnel and the sphosticated equipment they have, can continue its role in strengthening and improving the ceramic industry in the country and adds to the infrastructure of the country by developing this specialised centre. The planning for the team of consultants and the schedule for the study tours and fellowships has been ATTACHED TO THE PROJECT DOCCUMENT AS WELL AS THE NEEDS FOR EQUIPMENT AND SPARE PARTS.

B - Assesment of the Ceramic Industry

Through several visits to the ceramic enterprises the experts could monitor the main problems hampering the improvement of the quality of the ceramic products. On the spot advise have been given in addition to indepth study of Piliyandala factory for which a separate report has been produced stating the draw backs in the production cycle and suggesting several measures to be taken to improve the quality of the products. This report can be used as a quide to understand and modifies the system in other factories. Several glaze compositions have been modified and tried some of it proves its value and have been put to semi - industrial scale for final evaluation. Study of the rheological properties of local ball clays and subsequent trial to introduce this clay in the sanitary production to substitute the imported ball clays.
A schedule for the routine tests for quality control of both crockery and sanitary ware has been proposed to ensure complete control of the production cycle with strong emphesis on the feed back of these results to the production management.

A report has been prepared about the cure of crystallisation noticed in the crockery glaze in Piliyandala Factory.

C - Work Plan for the research in CRDC 1987.

After assessment of the ceramic industry in the country and pointing the needs of the ceramic factories a series of research projects has been assigned to the research officers (list in annex XI). These research projects has been assigned to the research officers according to the laboratory they run and the equipment they have.

The most essential research programme is the identification of the properties of the local raw materials which should be the corner stone for futher research programs. Despite the big amount of tests and analyses run on the local raw materials, the complete picture of these materials and its potentials in the ceramic industry is not yet crystallised.

Other fields of interest can be seen also in the list of research program among which the further utilization and industrial trials on the 2 patented research which should be complated.

Without under estimating the value of the basic research the trend of the program designed has been oriented more towards the technological and industrial research like the rhological properties of local ball clays, introduction of local ball clays in sanitary ware, using red orchre in the tile production and introduction of tale in place of pyrophyllite in wall tiles production of which the preliminary results are very promising.

D - Advice on the day-to-day work

Theteam of experts had shared, with the senior counterpart , in the technical management of CRDC, advise on the day to day work, improve the efficiency and introduce new tests to be done as well as new standards for testing. The experts advised on the ways to study the production problems in a practical way on Piliyandala factory production such as:

- examination of 'Body holes' in the crockery production which shows under the microscope the presence of molten coarse feldspar granules.
- The problem of glaze crowling which was due to thick glaze on these parts double that on other parts.
- The cure of piholes by lowering the viscosity (at high temperature) pf the glaze which was one of the reasons to prepare the glaze trials for crockery and sanitary ware.
- Production of porcelain hydrocyclone which was imported at exorbtic price.

The experts have been taken several steps to repair the idle laying equipment and the XRD is already repaired and working , the Bickley PCE kiln is examined by Bickley technician and the malfunctioning parts will be replaced in one month while the XRF will be repared soon after the arrival of the technician from Philips after 2 -3 months.

For art ware the expert has prepared a series of crystal glazes which gave , good results and it is listed in Annex XII and advised on the implementing and the firing cycle of it.

Different glazes for crockery, sanitaryware , porcelain in addition to art glazes with different artistic effects have been calculated but unfortunately the time was short to test it. However a list of these trials are in annex XIII for further implementation.

The expert has requested the purchase and though field purchase orders most of the spare parts needed have been ordered. In the mean time requisition have been issued for the sale of surplus equipment to the government authorities interested in it.

E - Relation to Companies outside CCC

A series of visits have been undertaken to other companies to strengthen the relation between CRDC and customers and potential customers and to introduce the service facilities of CRDC and ensure the fast and reliable results.

- Sithara limited (Manufacturers of printing inks) who ordered a Porcelain ball mill and the prototype delivered was not up to the mark. The mould of the mill should be revised by the mould making consultant already into consideration in the second phase.

- Ceylon Glass Company : Studing the production cycle , raw materials and the production problems mainly the greenish tint in the product due to iron contamination from sand. An agreement could be reached to send the glass raw materials periodically for different tests and analyses in CRDC. Also advised on the possible diversification of production, especially in the presence of over capacity of the machinery, by producing tumblers and ash trays. This factory could be a goodsite of UNIDO assistance as they have all infra structure and personnel needed.

- The Paper Corporation: As one of the best customers of China clay the paper Corporation, consuming 1500 tons/year , is complaining from the humidity and the particle size distribution. An agreement could

be reached to lower the humidity to the standard level of 10% and to prepare two clay samples (15 tons each) of different particle size distribution to be tested on an industrial scale which if successful could increase the demand on china clay to 2500 tons/year. The production cycle of Meetiyagoda refinery has been revised to suit this demand and the samples should be ready for delivery by Mid April 1987.

It should be mentioned here again the necessity of establishment of a clay drier at Meetiyagoda to dry the clay to the agreed upon value of 10% humidity.

III NFW FIELDS FOR UNIDO ACTIVITIES

The success of this UNIDO project and the achievements reached show that the country is willing to accept new technologies and favours the design of new project in several fields of industrys. The following project is recommended according to the findings and assesment of the industry in the country.

1 - Introduction of Modern Industrial Effluent Treatment Technology in Asian Countries

This project has been ad opted by UNIDO in January 1987 to serve Asian Countries. Unfortunately, possibly by mistake, Sri Lanka was not mentioned among the participants of this project. However a draft of this project has been offered to the National Aquatic Resources Agency 'NARA' and found great interest in it. As NARA has already some activities in this field and already monitoring the effluents of the Industrial free zone factories it could be an ideal site for this regional project. All the infrastructure needed for this project, site, laboratories , personnel and some equipment are already available.
In addition to NARA , The Central Environment Authority can be another possible participant in this program although NARA has more facilities.

2 - Development of Glass Industry:

Despite the availaboity of most of the glass raw materials in the country namely Quartz,Felspar,Calcite and Dolomite in high quality the glass industry is not developing as expected. The two glass factories are concentr ting thier production on bottle production and according to the machinery available they have over production and have to stop production about 3 months/year.There is a possibility of production of tableware and even lead crystal glass if the right assistance and advice is offered.A project for glass development can overcome the need for assistance and it can be sited either in CRDC as a by - project of the original one using the equipment available or at the Ceylon Glass Company, Colobo, which has a small quality control laboratory and the staff of personnel with sufficient experiance.

3 - Upgrading of Graphite Production

The graphite ore is available in the country at high quality with carbon content of 90 - 97%. The ore is contaminated with pyrite and chalcolyrite which increases the sulphur content to 1 - 2 % while the maximum should be 0.02%. There is a possibility of a small project to upgrade the production and introduction of new techniques for the production of graphite for lubricant, varnish and graphite refractories.

4 - Pilot Plant for China Clay Refineries

Despite the fact that china clay refinery is one of the activities of CRDC it is worthwhile to design a small project for pilot plant refinery of china clay. As the china clay refinery is one of the biggest activities of CCC and it contribute a lot to the earnings of the corporation. It is of importance to upgrade the refinery process and to introduce modern technology of clay refinery to open the market for export of china clay. The available china clay reservoir is sufficient for the local industry for decades and still there is a possibility of new deposits which are surveyed in the time being.

ANNEX I

Equipment Available

Chemical Laboratory

Analytical Balance 2024 MP6
12000g Sartorius platform balance
11000g Sartorius balance 1501 BMP8 - 1
Centrifuge Rotanta HETTICH
6 Platinum Crucibles (48, 99g)
3Pt - dishes (66,25g)
6Ni-Crucible
02 Crucibles Pt/Au belongs to X-ray room
pH - meter TPS
S7 I R quick dryer
S7a Balance
Ion Sensitive Electrodes for Pb, Ag/AgCl Reference electrode for F
Magnetic Stirrer
Commodore Computer
Flame Photometer corning with Na+ K Filters
Li Filters -----CCC
Ca Filters
Colorimeter corning for Fe
for Phospherus ------ CCC
for Mn
Crucible Furnace - simon muller - 02Nos.
Electric drying Oven OSK
Stirrer Handilab Minor with 3 rotors
Water distillation plant
Multitest tube dryer
Timer
Glass micro Kjeldhal apparatus
Soxhlet apparatus
Sand bath
Heating plate
Meker burners 04 Nos.
Water jet pump.
Glassware
Chemicals.

X - ray and thermal analysis Laboratory

Zephir cooler
X-ray Diffractometer
X-ray Spectometer
HEWLETT PACKARD Computer 85.
One line recorder PM 8203 A
Argon Methane Cylinders 02Nos.
Helium Gas Cylinder
Printer KSR 43
STA - unit
STA Measuring Unit
Differential Dilatometer

X-ray Laboratory (contd..)

Thermostat for STA
Thermostat for Dilatometer
Test piece extruder
Drying Oven OSK
Air conditioner
Vibratom mill
Boron Carbide Mortor
Dilatometer BAHR
Dilatometer ISEKYU
RETCH agate mortor
Metler Balance ---CCC
Achate Mortor
Dehumidifier
Humidity Control (British)
Humidity Control (Japanese)
Small agate mortor
Desiccators.

Electron Microscopic Laboratory

Joel electron Microscope
Photo Equipment
Stereo microscope
Refractive Index Liquid set
Micrometer Dispensing device
Mohs hardness set (incomplete)
Air Conditioner
Fibre Glass lamp
Dehumidifier

Dark Room - Belongs to Microscopic Laboratory

Dark room Bulbs.

Split Model Air conditioner
Developing tanks
Developing trays
Bobins 02 Nos.

Physical Laboratory

Electric drying oven
Humidity Chamber (Material Test cabinet)
Multi Test Tube dryer
Stirrer Handilab
Laboratory Sieveing Machine RETCH Vibro with sieves
Hydrometer (0 - 60g/ltr.) 02Nos
Andreason Sendimentation Apparatus 02Nos.
Sedimentograph (Centrifugal particle size analyser) 02Nos
Permeability meter
Glaze thickness tester

.....contd

Physical Laboraotry (..contd.)

Bend and tensil strength tester TONI 6300
NETSCH Bending strength tester 401
Sample splitter
Thermostat (8 ltr./min.)
Digital vacuum meter
Colorimeter LF 90 lange with measuring unit
S6 I R Quick dryer
S6a Balance
Needle Penetrometer for testing non plastic surface
Thickness Tester
Moisture expansion apparatus
Cannon statistic Calculator
Vernior calipers
Micrometer Screws 02Nos.
HEYDOLPH Stirrer
Ultrsonic Bath
Test Sieves.

Pilot Plant

150kg sliding platform balance
Stirrer 0.12kW
Glaze pump with motor 0.54kW (with two nozzels)
Mixer with tub and agitator
7 plastic vessels
Jaw crusher
Ball Mill (NETZSCH)
Ball Mill (From Negombo Factory - CCC)
Muller mixer
Jar Mill with 6 jars 9" (5 ltr.)
Jar Mill with 6 jars 11" (10 ltr.)
OSK pot mill with 15cm jar (1½)ltr.
Small Norton jar (left) 400cc
Small norton jar mill (right)
High speed stirrer NETZSCH
Filter press with 16 filter plates & cloths
Hydrometer (0 - 60g/ltr.)
3 Aluminium Tubs
plastic tubs
2kg Spring balance
Test sieves
Potters wheel withstand
Potters wheel tub model
Rock used for shaking ---- CCC
Rock used for pot milling ---- CCC

....contd.

Annex I/3

Pilot Plant (...contd.)

De-airing extrusion machine
Hand throwing machine
Hand operated Hydraulic press (20 tons)
Jigger Machine 02Nos.
Plateform Balance 12000g
Needle Penetrometer
Clay hardness tester 'SE' for Pugmill testing
Test piece extruder BRCA
Green strength tester
Gallenkamp Viscometer
Large dryer with fan
Small dryer
Pfeffercone Apparatus
Vernior Caliper
Cannon Calculator

Kiln Room

Gradient Kiln
Small Naber Kiln
Large Naber Kiln
Gas kiln
Bickley PCE Kiln 1200°c without control board
Seger cones
Thermocrome - crayons
Bullers ring gauge
Filament Pyrometer upto 1450°C
6 channel Printing recorder
Calibrator for thermocouple
Potentiometer 02 Nos.
DC Microvoltmeter
High Voltage tester UHP
Orsat Apparatus
Adiabatic Calorimeter with Beckmann thermometer
Redwood viscometer 02 nos.
Thermoshock (dry) equipment
Autoclave (Used for the work done by the Physical Lab.)
Chain Block (Part of Autoclave0

Glaze - Station (belongs to kiln section)

Spraying box (Glaze booth)
Compressor + Spraying gun with 6 nozzels
OSK Drying Oven

Hereaus Kiln (to be used by the X-ray Lab.)

contd.....

Work Shop (Sample preparation room)

Microtome
Grinding and polishing Machine
Hand throwing machine
Stone sawing machine
Vibratom mill (belongs to x-ray lab)
Boley lathe
Hanning Grinder
Hot Plcte

Store room

Muller Mixer
Stains
Glazes
Raw materials

Secretariat -(Office Room + conference room)

Olympia Electronic Type Writer
U-Bix Copier
Manual Type writer
Over head projector
Magi Board
Split Model Air conditioner
Library
Vacuum cleaner

List of Equipment Needed

		US $
1.	Spectrophotometer Lange "CADAS"	8500
2.	Sedigraph 2000 "Hawlet & Packard" for measuring particle size 60-0.2 um	20000
3.	Voltage Stabilizer 15 - 20 Amp. output	2000
4.	Electric Stirrer with stepless speed adjustment 200-2000 r.p.m., with revolution counter, stainless steel stirrer and stainless steel container, capacity 5 litres	1500
5.	Hammer Mill 'Retsch Rotor Beater Mill type SR 2'	8500
6.	Rotary or Tilting Kiln for frit production, capacity 5-10 kg	7000
7.	Sartorius Platform Balance, capacity 10 kg sensitivity 0.01 g	1300
8.	Sartorius Balance, capacity 200 gm sensitivity 0.1 mg	1800
9.	Polarizing Microscope with hot stage attachment & photographic attachment	20000
10.	Enlarger for photographing and processing "Focomat v35" Leitz	1000
11.	Monochromator and vacuum conditions for XRD 'Philips'	8000
12.	Portable Battery Operated Optical Pyrometer up to 2000°C	4400
13.	Digital Temperature Indicator for Pt/Pt 13%/Rh thermocouple	300
14.	20 m compensation cable for Pt/Pt 13%/Rh thermocouple	100
15.	RVF Synchrolectric Viscometer with 7 spindle and stand	1200
16.	Double Deck Vibrating Screen dia 50 cm with permanent magnet	2900
17.	Universal Testing m/c for testing compressive strength at high temperature up to 1700°C and MOR of fired bodies	10000
18.	Slide Projector Type 'PRADOVIT' with sound attachment "Leitz"	400
19.	Atomic Absorption Apparatus "Double Beam Variant" Basic Model	10000
20.	Hezog Vibrator Mill Model HSM 100 including Tungsten Carbide Motor	8000
21.	Additional equipment for Energy Auditing Kit Divers Note: All offers should include spare parts for 2 years	10000
22.	Various technical books	2000

Annex III/1

Composition of sanitaryware Piliyandala Factory

	Body	Glaze
Feldspar	36	40
Sand	22	Quartz 15
Local china clay	21	05
BWS Ball clay	14	-
EWVA Ball Clay	7	-
Dolomite	-	2
Calcite	-	13
ZnO	-	8
Zircon	-	17

Annex IV
Crockery Test Glazes

Frit	Pc/0	Pc/1	Pc/2	Pc/3
China clay	96	94	90	92
ZnO	1	1	1	1
Quartz	3	5	5	3
Quartz	-	-	2	2
Dolomite	-	-	2	2

Crockery test Frit

Based on glaze Pc/1 which proved to be the best one in the above trials.

	CF/1
ZnO	4.6
Zircon	16.2
Borax	13.6
Boric acid	5.5
Dolomite	2.9
Calcite	7.6
Feldspar	24.7
China clay	6.7
Quartz	18.6

Annex V

Squatting Pan test Glazes

	SP/1	SP/2	SP/3	SP/4
Feldspar	35	35	35	35
Quartz	30	30	28	30
Dolomite	2	7	2	12
China Clay	3	3	3	3
Calcite	12	7	12	2
ZnO	8	8	10	8
Zircon	10	10	10	10

Annex VI

Squatting Pan / Bodies

	SPB/1	SPB/2	SPB/3	SPB/4
Sand	24	24	20	18
Feldspar	28	28	26	28
China clay	20	20	20	20
BWS Ball clay	14	14	14	14
Dediyawela Ball clay	10	10	10	10
Dolomite	4	-	-	-
Pitches	-	4	10	10

Annex VII

Dediyawela Ball clay

1 - Chemical Analysis

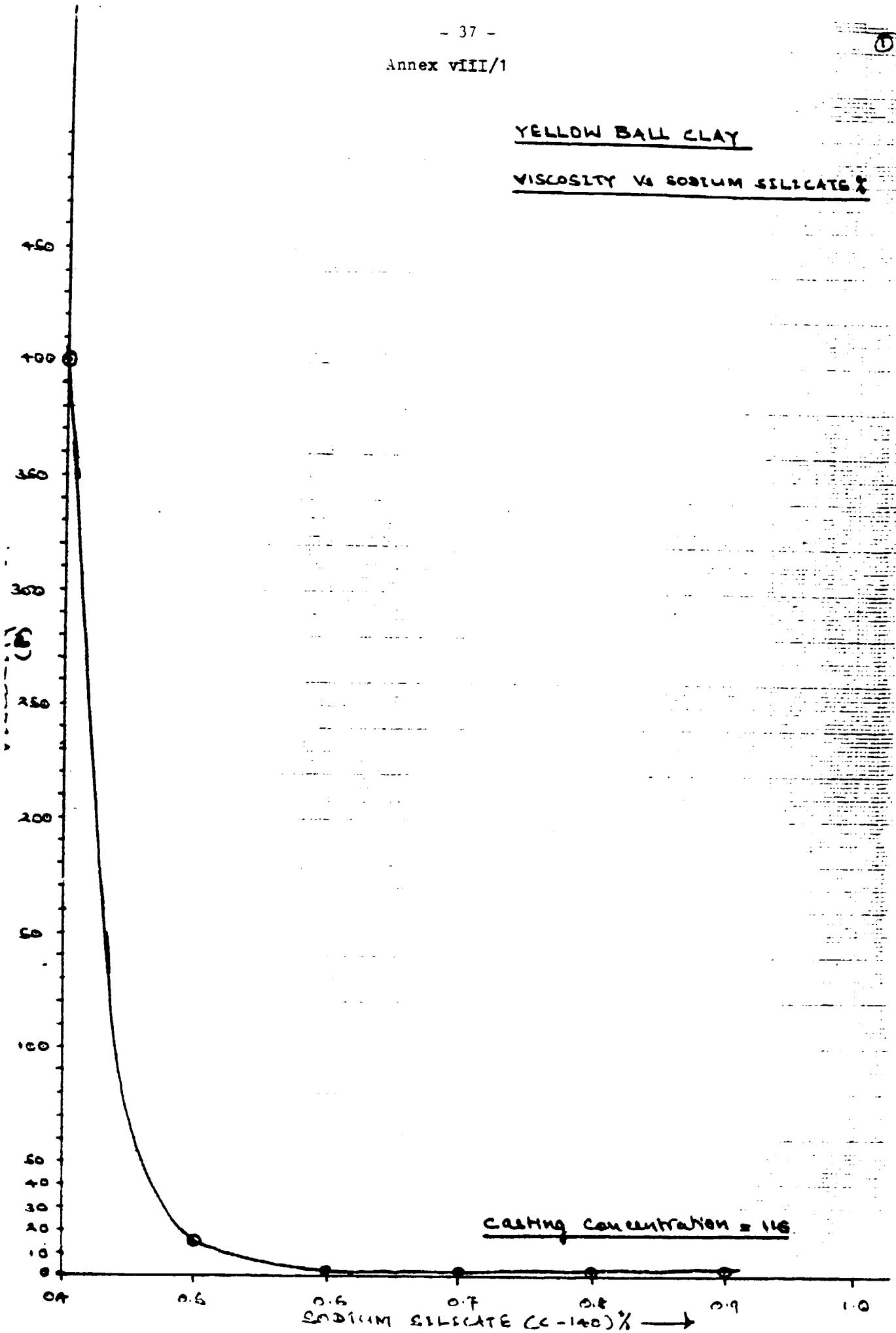
	Yellow	Blue	Black
SiO_2	44.38	44.45	42.10
$Al_2O_3 + TiO_2$	38.09	38.50	33.46
Fe_2O_3	2.16	1.97	2.14
CaO	0.22	0.24	0.25
MgO	0.52	0.52	0.67
Na_2O	0.12	0.12	0.21
K_2O	0.77	0.74	0.72
L O I	13.74	13.46	18.97

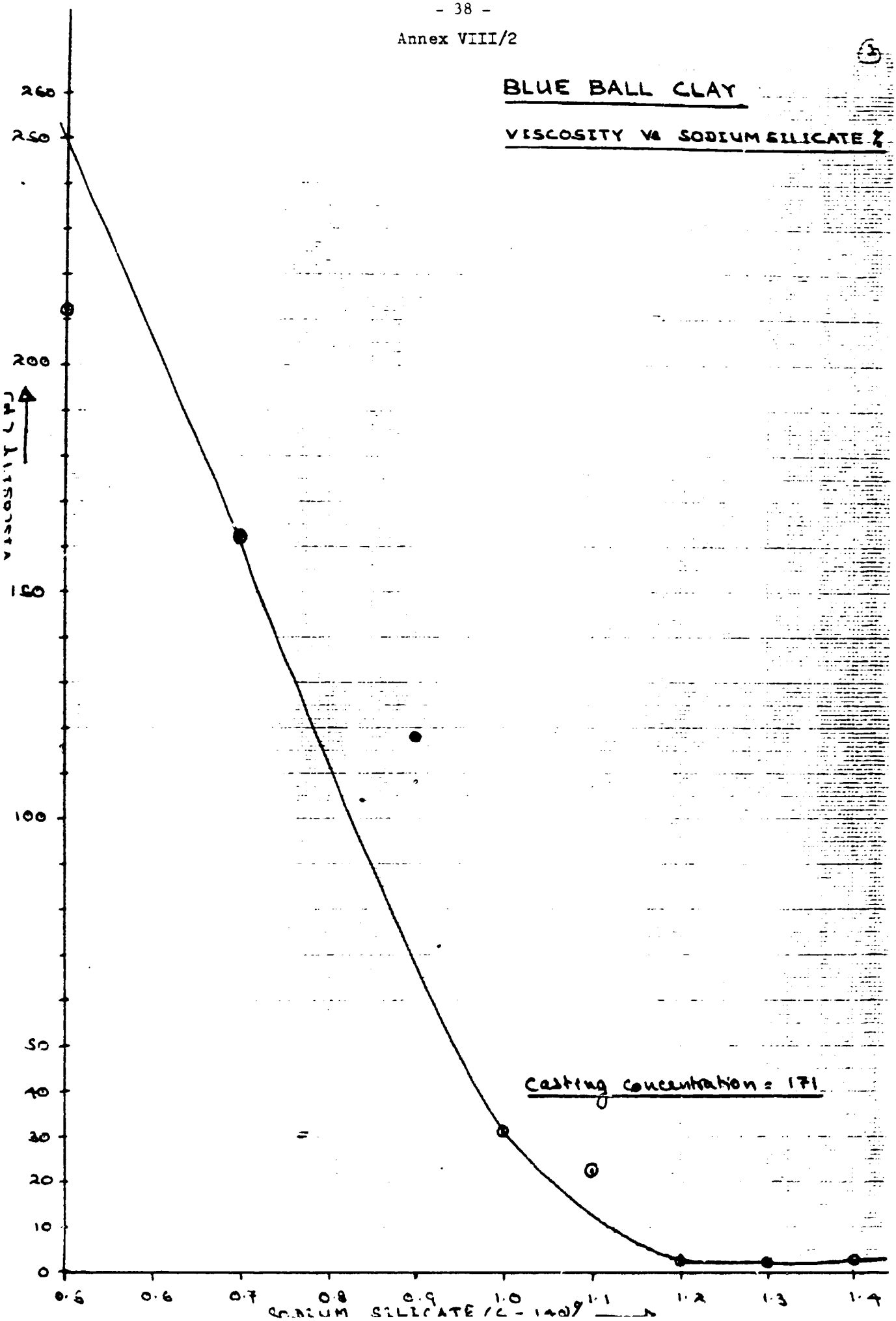
2 - Particle size distribution

< 40 um	98.79	98.8	98.80
20	98.03	98.15	98.25
15	97.52	97.60	97.62
10	97.07	97.00	97.25
5	95.78	96.00	95.80
3	91.20	92.50	92.00
2	87.00	89.15	88.50
1	70.15	79.00	77.50

3 - Mineralogical Composition XRD

Kaolinite %	53.0(tricilinic)	52.0 (triclinic)	52 (Triclinic)
Gibbsite	Traces	Traces	Traces
Quatrz	present	present	present
Bending strength kg/cm^2	21.2	23	25
Dry/Firing shrinkage 1230°C	16.7 %	19 %	18.7%
Water absorption at 1230°C	1.2%	0.6%	1 %

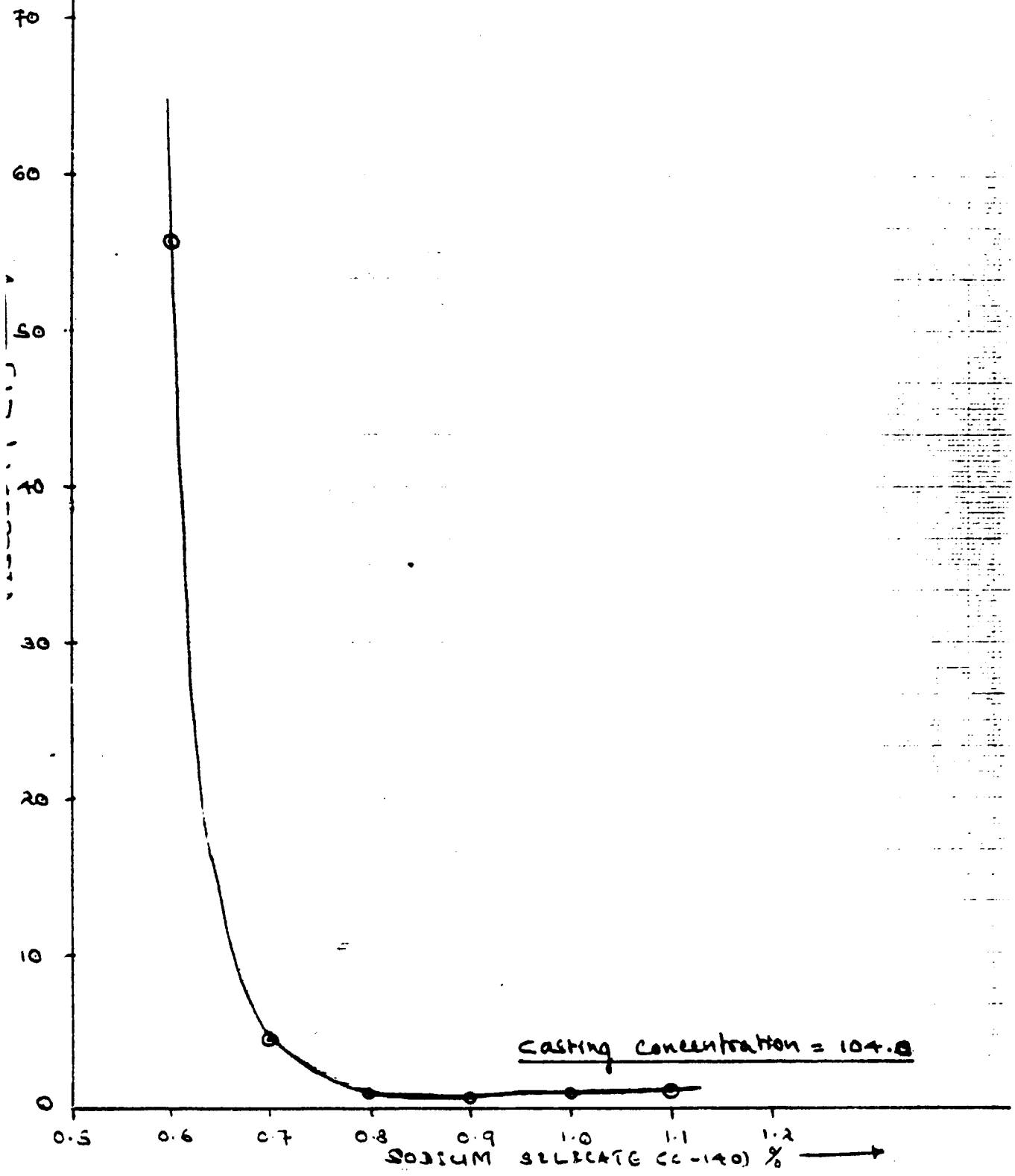

YELLOW BALL CLAY
VISCOSITY Vs SODIUM SILICATE %
450
400
350
300
250
200
50
100
50
40
30
20
10
0
0·4
0·6
0·6
0·7
0·8
0·9
1·0
SODIUM SILICATE (c-140) % →
Casting Concentration = 116

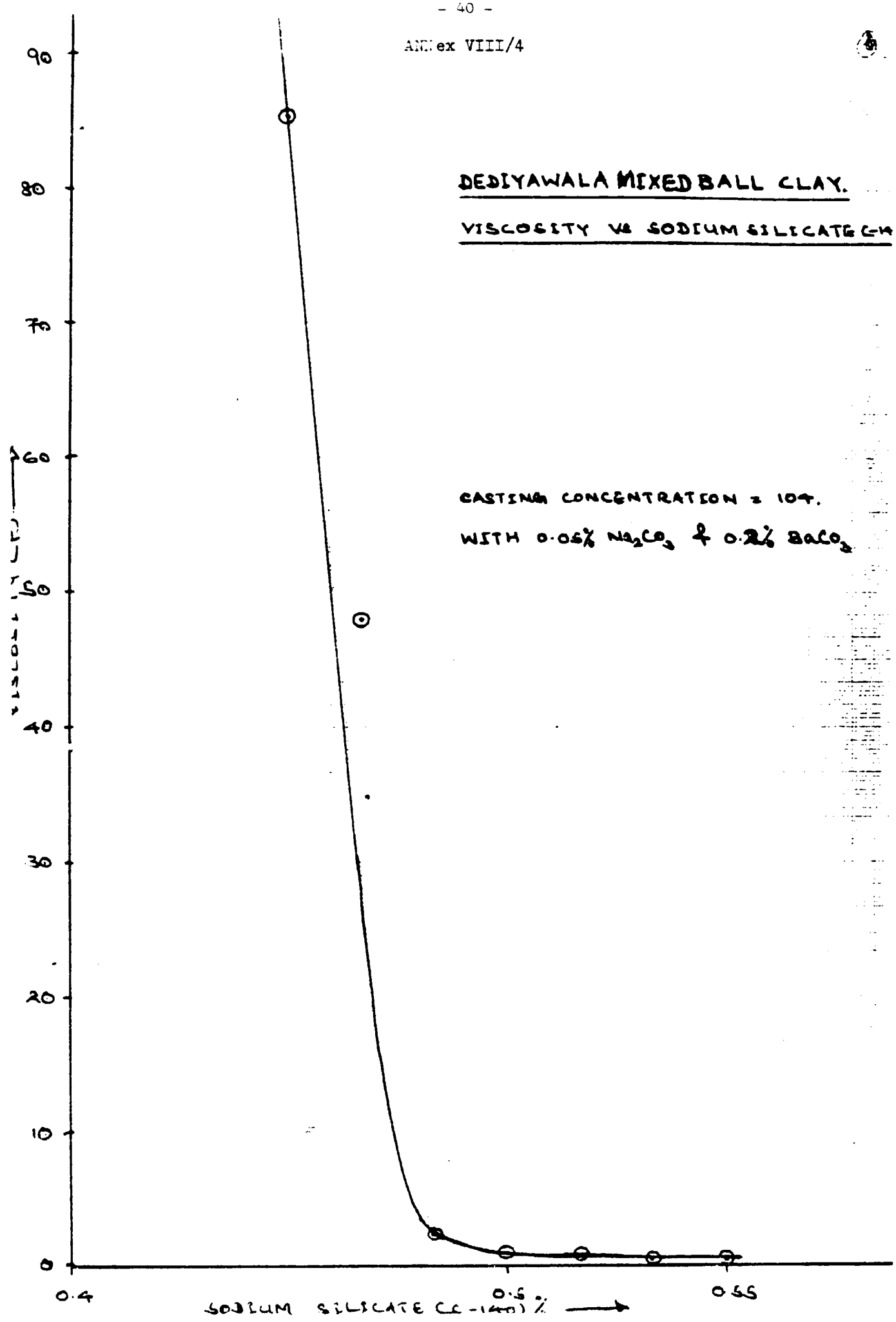

BLUE BALL CLAY
VISCOSITY Vs SODIUM SILICATE %
260
250
200
150
100
50
40
30
20
10
0
VISCOSITY (cP)
0·6
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
SODIUM SILICATE (S.G. - 1·40)
Casting concentration = 171

(2)

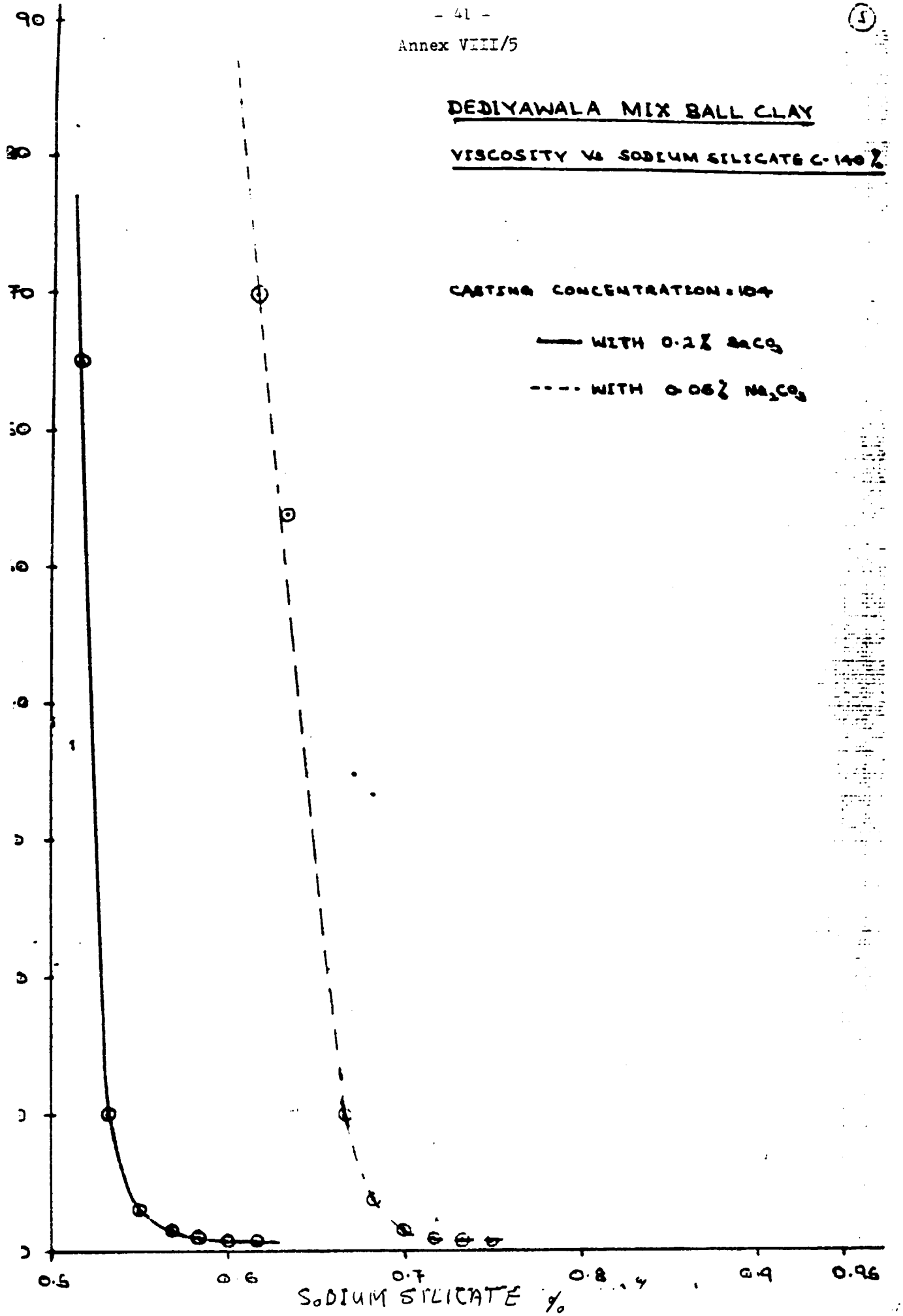
MIXED BALL CLAY

VISCOSITY Vs SODIUM SILICATE %




DEDIYAWALA MIXED BALL CLAY.
VISCOSITY VS SODIUM SILICATE C-N
CASTING CONCENTRATION = 104.
WITH 0.05% Na2CO3 & 0.2% BaCO3
VISCOSITY (CP)
90
80
70
60
50
40
30
20
10
0
0.4
0.5
0.55
SODIUM SILICATE CC-(40) % →

(5)


DEDIYAWALA MIX BALL CLAY
VISCOSITY Vs SODIUM SILICATE C-140 %
CASTING CONCENTRATION : 104
WITH 0.2 % Na2CO3
WITH 0.06 % Na2CO3
90
70
0.5
0.6
0.7
0.8
0.9
0.96
SODIUM SILICATE %

Annex IX

Properties of Refined China clay 'Boralesgamuwa'

1 - Chemical Analysis

	grade H	Pressed cakes
SiO_2	47.36	46.5
Al_2O_3	36.25	37.5
Fe_2O_3	0.80	1.1
TiO_2	0.54	0.31
CaO	0.12	traces
MgO	0.16	0.25
K_2O	0.76	0.27
Na_2O	0.14	0.14
L O I	13.36	14.4

2 Physical tests

% Particle size > 63 um	98.5	99.4
2 um	58.5	57.8
M O R dry kg/cm^2	26	25
Fired strength 1100^oC kg/cm^2	235	200
Wet - Dry shrinkage %	7.9	8.0
Fired - Dry %	11.1	11.6
Brightness %	70	67

Annex X

Properties of Refined China Clay ' Meetiyagoda'

1 - Chemical Analysis

	Grade 'H'	Super Grade
SiO_2	45.7	45.58
TiO_2	0.147	0.141
Al_2O_3	37.30	38.29
Fe_2O_3	0.57	0.231
CaO	traces	0.135
MgO	0.20	0.149
K_2O	0.18	0.08
Na_2O	0.43	0.272
L O I	14.7	14.7

2 - Physical Tests

		Grade 'H'	Super grade
% Particle size distribution	63 um	99.45	99.8
	2 um	56.0	56.0
M O R Dry kg /cm^2		26	28
Fired strength at 1100^{o}C kg /cm^2		210	240
Wet - Dry Shrinkage		6.9%	6.5%
Fired - dry shrinkage		11.7%	11.7%
Brightness		86%	80%

Annex XI

Research Projects for 1987

1 - Sri Lanka Ceramic raw material resources, reserves, production export and consumption.

2 - Process Technology of the efficient refinery of China Clay

3 - Constitution and properties of local raw materials

4 - Chemical characteristics of Sri Lankan ceramic raw materials.

5 - Thermal Analysis of Sri Lankan ceramic raw materials

6 - Regeneration of Plaster of Paris from used moulds

7 - Mathematical analysis and experimental confirmation of temperature distribution within ceramicware during heating

8 - Historical development of the pottery industry in Sri Lanka and current market Trends, Introduction of new designs

9 - Paddy Husk and its industrial importance.

10 - Efficient Quality Control procedure as a means to achieve increased production and higher Quality in an perating plant.

11 - Particle size analysis of red-ochre

12 - Particle size analysis of local china clays

13 - Comparison of CaO and L.O.I. of dried and wet sea shells.

14 - Comparison of standard solutions by Flame photometer (Ca & K)

15 - Fluoride content of ceramic raw materials

16 - Cross section of pinholes , warts and cracks in crockery & Porcelain (photographed by SEM)

17 - Establishment of computer typed list for each of the ball mills at Piliyandala factory.

18 - Establishment of computer typed list for the maximum rpm allowed for the operation of a ball mill

19 - Establishment of a well demonstration of all faults in crockery for quality control purposes.

20 - Establishment of flow sheets for all kilns in Piliyandala & Negombo.

contd.....<

contd.....>

21 - Test damaged ball mill jar for defects and production of new one.

22 - Determination of Feldspar content required with red orchre to obtain a product with water absorption less than 10%.

23 - Plasticity of Sri Lanka clays used in the manufacture of Bricks & tiles.

24 - Cpmparison of the 3 types of Dediyawela Ball clays

25 - Rheological properties of Dediyawela Ball clays.

26 - Introduction of Dediyawela ball clay in sanitaryware production

27 - The use of red orchre (without grinding) as a colourant (spotted) in crockery transparent glaze and tiles production

28 - Introduction of talc in wall tiles to replace pyrophyllite and decrease the water absorption bellow 18%.

29 - Comparison of the mineral phase in wall tile production using pyrophyllite and talc in the body (using SEM)

30 - Production of yellow-orange - red colours using Cal-Sc.

Annex XII

Crystalline Glaze

	Xl/1	Xl/2	Xl/3	Xl/4
Feldspar	45.50	45.60	12.71	27.10
Zinc Oxide	23.00	12.30	24.97	3.60
Calcite	15.90	-	-	9.10
Dolomite	-	-	-	16.30
Quartz	7.00	6.30	36.17	27.90
Titanium Oxide	7.00	-	-	10.70
China Clay	1.60	5.00	-	10.30
Barium Carbonate	-	30.80	-	-
Borax	-	-	17.77	-
Sodium Carbonate	-	-	7.88	-
Cobolt Oxide	-	-	0.50	-
Firing temp. ^{o}C	1200 - 1250	1200 - 1280	1200 - 1230	1200 - 1230

	Xl/5	Xl/6	Xl/7	Xl/8
Glaze Xl/4	100	100	100	100
Cr_2O_3	4	-	-	-
Fe_2O_3	-	10	-	-
CaO	-	-	0.2	-
V_2O_5	-	-	-	01

Annex XIII/1

Crockery Glazes with different Opacifier

	Zircon opacifier	Zn Opacifier	Ti Opacifier
Borax	21.17	23.40	14.60
Boric acid	6.82	9.77	-
Feldspar	-	-	5.56
Dolomite	9.54	11.42	5.04
Calcite	2.84	1.39	18.87
China Clay	26.33	21.51	14.87
Quartz	16.30	17.85	35.40
Zircon	17.00	-	-
Zinc Oxide	-	14.66	-
Titanium Oxide	-	-	5.66
Firing temp. ^{o}C	1060 - 1080	1000 - 1040	1000 - 1040

Sanitary Ware Glazes

Sc 7 - 8

Feldspar	20.30	26.80	25.53	19.15
Quartz	34.44	26.77	27.30	32.66
Calcite	9.33	9.42	14.15	11.18
Dolomite	6.99	7.59	-	3.42
Barium Carbonate	3.69	6.04	-	-
Zinc Oxide	1.31	3.25	7.72	-
China Clay	4.62	68.13	5.42	5.48
Cac. China Clay	6.07	-	7.88	11.81
Zircon	13.52	12.00	12.00	12.00
Boric acid	-	-	-	4.30

Annex XIII/2

Cadmium - Selenium Colours

Quartz	55	55	55	55
Potasium Carbonate	30.3	30.3	30.3	30.3
Zinc Oxide	10.6	10.6	10.6	10.6
Borax	4.1	4.1	4.1	4.1
Selenium	30	20	15	10
Cadmium Sulphade	-	10	15	20

Melt at 1300°C and quenche in water. Fine grinding

Fluxe for Cd - Se Colours

Colour	14.3
Feldspar	23.5
Sand	18.4
Borax	35.6
Boric acid	5.7
Zinc Oxide	2.5

Annex XIII/3

Coloured Glazes

Intensive Red Glaze : Firing temperature 960 - 1040°C (Reduction)

Lead oxide	15.33
Tin Oxide	1.42
Borax	26.15
Feldspar	18.46
Sodium carbonate	5.21
Calcite	4.80
Quartz	28.63

Egyptian tarquise Glaze

Feldspar	34.17	67.72
Sodium Carbonate	19.37	-
Borax	-	18.25
Calcite	9.75	-
Quartz	33.71	2.07
Copperoxide	3.00	3.00
China Clay	-	8.96
Firing Temp. °C	1020 - 1040	1100 - 1120

Annex XIII/4

Some Selected Glaze Stains

	Brown Colour	Yellow Brown	Pink colour
Ferric Oxide	9.7 %	Ferric oxide 13. 7 %	Ferric oxide 13.1%
Chromium Oxide	9.7%	Chromium oxide 13.1%	Chromium oxide 13.2%
Zinc Oxide	6.46%	Zinc oxide 55.6%	Zinc Oxide 56.1%
Quartz	16.0%	Aluminium oxide 17.6%	Aluminium oxide 17.6%
Firing temperature	1300°C	1400°C	1250°C

	Black Colour	Blue Colour	Turquise Colour
Ferric oxide	43%	Cobolt Oxide 11%	Cobolt Chromate 61%
Chromium oxide	43%	Aluminium Oxide 89%	Aluminium oxide 39%
Cobolt oxide	4%		
Manganese dioxide	10%		
Firing temperature °C	1400	1410	1410
Atmosphere	Reduction	Reduction	reduction

	Green Colour	Violet Colour	Orange Colour
Chromium Oxide	25%	Cobolt oxide 15%	Tin oxide 12.8
Feldspar	50%	magnesium Carbonate 28%	Ferric oxide 14.9%
Quartz	25%	Atomic oxide 57%	Red lead 42.8%
			Antinony oxide 29.5%
Firing temperature °C	1410	1410	1410

Annex XIII/5

Porcelain Glazes

1320 - 1360°C

Feldspar	43.73	41.33	31.77	58.77	42.45
Dolomite	1.52	20.84	-	-	-
Calcite	1.00	5.83	14.73	15.37	34.73
Calc.china clay	7.53	22.29	12.42	-	15.45
China clay	4.50	4.28	5.43	3.70	4.99
Quartz	41.72	5.16	35.65	22.16	2.38
Tin Oxide	-	0.27	-	-	-

CERAMIC RESEARCH AND DEVELOPMENT CENTRE

established by
United Nations Industrial Development Organization (UNIDO)
and Ceylon Ceramics Corporation

Piliyandala
6th March, 1987.

CRYSTALLIZATION IN GLAZES
CAUSE AND CURE

Introduction

It is noticed, in the green colour produced now in the Piliyandala Crockery Factory, a tendency to crystallization. This appears on the surface of the plates, especially in the flat horizontal parts, as spots of different colours, with a little matt appearance.

The composition of the glaze is:

Transparent Frit	79 %
Green Stain	12 %
Zircon	8 %
Kaolin	1 %

Frit Composition:

Feldspar	10.92 %
Kaolin	24.32 %
Sand	24.98 %
Sea Shells	15.36 %
Borax	24.42 %

Stain Composition

Cr_2O_3	7.5 %
$Co\ SO_4$	2.5 %
Feldspar	52.0 %
Quartz	23.0 %
Zircon	10.0 %
China Clay	5.0 %

A - Theory of Crystallization

The glaze, as a special type of glass, is a network of vitreous material distributed at random. It can be considered as a super cooled liquid. The molten liquid is cooled without crystallization to form a rigid

body at room temperature. As a super cooled liquid, glazes can be devitrified (crystallize), if they have the optimum condition for it. These conditions act mainly to lower the viscosity of the melt, to allow for the re-arrangement of molecules in crystal pattern and to prepare some elements as nuclei for the start of this devitrification. Therefore, one can divide the factors affecting devitrification into 2 factors.

1. Cooling Rate: The slower the cooling rate the longer the glaze will have a viscosity low enough to help in bringing the molecules together. The ideal cooling for crystallization is to keep the glaze as long as possible (2-3 hours), at a temperature 20°C lower than the maturing temperature.

2. Chemical Composition:

The chemical composition can favour the process of crystallization in 2 ways:

2-1 - lowering the viscosity of the glaze. The lower the viscosity of the glaze, the higher the possibility for molecules to gather together in a crystal form, in addition to keeping the glaze for a longer time near the melting temperature, some elements decrease the viscosity of the glaze. These elements are in increasing the effect order-
ZnO-SnO-BaO-CaO-MnO-PbO-K_2O- Na_2O-B_2O_3-LiO_2
Other elements which increase the viscosity of the glaze are:
Fe O - NiO - SnO_2 - Cr_2O_3 -SiO_2 -ZrO_2 -Al_2O_3

It must noted here that although B_2O_3 lowers the viscosity but as a glass former, it prevents the formation of crystals.

2-2 - Creation of Nuclei for Crystallization

The presence of some nuclei of easily crystallising elements can favour the formation of crystals. Those oxide forming nudei are - TiO_2 - ZnO - BaO - LiO_2 - CaO - MgO.

B - Cure for Crystallization

Despite the fact that, for some art ware, crystallization is desired and hardly reached, however, for normal ceramic production, it is a defect and should be remedied. The remedy for it is just opposite to the factors mentioned above:

1- Fast Cooling: especially after reaching the maturing temperature, without forming a soaking period.

2- Change of Glaze Composition: by eliminating or decreasing as much as possible, the elements favouring the formation of crystals or increasing the element that prevents this formation.

C - Conclusion

For the Filiyandala Factory, as it is not feasible to change the firing curve, as the other products in the kiln could be affected. For the same reason, it is not wise to change either of the stain composition or the frit composition. Therefore, the only possibility is to change the mill addition for the glaze preparation. One or both of the 2 alternatives can be used.

1 - Increase the China clay addition from 1-2%. This may affect slightly the glass of the glaze.

2 - Addition of 1% Boric Acis to the glaze. Although Boric Acid is water soluble but the addition of small amount of it is widely used in the raw state, as it improves the rheological properties of the glaze slurry on one hand and on drying it forms a solid layer on the surface of the glaze, which increases its mechanical properties in the dry state. It also will increase the gloss of the galze.

The addition of both Boric Acis and kaolin could be the best solution, as the Boron Oxide will counteract the undesirable effect of China clay on the gloss.

As a conclusion the following glaze composition is recommended:

Transparent frit	77 %
Green Stain	12 %
Zircon	8 %
Kaolin	2 %
Boric Acid	1 %

Ceramic Research and Development Centre,
Piliyandala.
2nd March, 1987.

Chairperson/General Manager
(For the information of the Board)

PROGRESS REPORT FOR FEBRUARY 1987

Meetiyagoda and Boralesgamuwa Kaolin Refineries

During the period under review, the CRDC had to concentrate once again on problems encountered at the Meetiyagoda and Boralesgamuwa Refineries. The main problem at the Meetiyagoda Factory was a drop in the particle size distribution of clays supplied to Lanka Porcelain Limited. The particle size requirement of over 86% less than 8 microns had dropped to nearly 69%. The iron content Fe_2O_3 had also increased to 0.40%. The Boralesgamuwa kaolin also revealed variations in the particle size and grit content.

The CRDC immediately took action and increased the particle size of kaolin, at the Meetiyagoda Factory to over 85% less than 8 microns. The CRDC has repeatedly mentioned and instructions were given for remedial measures to be undertaken, when the particle size of the kaolin drops below the required levels. It is a simple procedure and if properly followed, the particle size of the kaolin could be maintained with ease. Procedures to be adopted at the Boralesgamuwa Factory have also been discussed.

I have, on more than one occasion stressed the need to reorganize the Raw Materials Division. This division should monitor every aspect of production at the various factories. The quality, quantities produced, whether the quality meets the requirement of end-users and future production aspects, including unforeseen problems due to drought or unusual rains, should all be seriously studied by the Raw Materials Division. If this is not considered seriously, we are bound to [illegible] problems, at both factories.

Writing letters is not going to solve a problem. The problem should be solved at the site. I thought of mentioning these facts, as this area of activity is not the function of the CRDC. The CRDC has been lately blamed for actions, where the CRDC has not been involved. The name of the Head of the CRDC has also been mentioned, as responsible for certain actions, when in fact, the Head was in the employment of another organization.

In order to further help the Raw Materials Division to arrive at an appreciation of kaolin reserves, both at Meetiyagoda and Boralesgamuwa and to calculate accurately the kaolin supplies available (the marketable output) detailed surveys were undertaken in both areas, on a 100 foot grid system. This was also a condition laid down by Lanka Porcelain Limited, as they were interested in reserves available at Meetiyagoda. The Meetiyagoda survey is in progress, and the Boralesgamuwa survey has been completed.

National Paper Corporation

Discussions were also held with the National Paper Corporation. The NPC requires kaolin of coarser particle size than what is delivered to them at present. If this requirement could be fulfilled by the Ceylon Ceramics Corporation, they are in a position to double their supplies of kaolin from the CCC. The CRDC is now taking action to re-design the production process, in order to meet this demand by the National Paper Corporation. This procedure would also help to obtain an efficient supply of kaolin for the Lanka Porcelain Factory at Matale.

Production of Porcelain Dolls

The CRDC was also involved in the production of large porcelain dolls, for a private concern, for export purposes. A 6 cm porcelain doll, sells in the foreign market at around US $ 43 a piece. The making of these dolls, proved to be an extremely difficult task to achieve, as the local agent required the dolls by the end of March 1987. The proposal now, is to transfer the making of these dolls to the

Haloya Factory, to be undertaken on a large scale. Careful consideration should be given to the costing of each piece delivered.

Two vacancies occur in the CRDC for research officers. One created, due to the death of Mr. K.P.A. Jayakody and the other as Mr. P. Mithraratne is to leave the CRDC to join the C.I.S.I.R. The Centre should also recruit 4 Laboratory Assistants, at the earliest.

Research topics assigned to the various research officers as listed in the Programme of Work for 1987, are been undertaken and satisfactory progress has been made. We have had discussions with the Ceylon Glass Factory for testing of their raw materials on a continuous basis.

External and Internal Orders have been serviced to the value of Rs.26,645/-. The survey undertaken at Meetiyagoda and Boralesgamuwa have not been taken into consideration. A break-down of services rendered is attached, for information.

Dr. M.M.J.W. Herath
HEAD/CRDC

Ceramic Research and Development Centre,

Piliyandala.

3/2/87.

Chairperson/General Manager
(For the information of the Board)

PROGRESS REPORT FOR JANUARY 1987

The annual report of the Ceramic Research and Development Centre (1986) was prepared and submitted to the Ceylon Ceramics Corporation and UNIDO. Together with this report, the CRDC programme of work for 1987 was also forwarded.

In January 1987, we have had 2 consultants attached to the CRDC. The Chief Technical Advisor, Mr. Morsi Tantawy continues as Chief Technical Advisor (CTA),for the bridging period, up to the 15 March,1987, with possible extension for another 2 years. Dr. Z.A. Engelthaler joined the CRDC on a short term contract as Consultant and will be leaving on the 15th February, 1987. Mr. Tantawy is at present preparing the final document (project report) for the entire duration of UNIDO financial support.

The CRDC has taken steps to assist the Raw Material Division in whichever way it is possible. The Meetiyagoda Kaolin Refinery has been studied and attempts are made to up-grade the quality of kaolin produced at the plant. The Quality Control Laboratory has been asked to determine the particle size analysis of kaolin, using the Hydrometer. The test method was explained to them and a hydrometer was provided.

The Designs Section of the CCC has been requested to model hydrocyclones for production and use by the refineries. Mr. Ratnayake, the Designs Manager, has kindly agreed to undertake this work. Arrangements have been made to carry out a detailed survey of the Meetiyagoda kaolin field. The Director of the Geological Survey Department, has kindly agreed to release a surveyor to lay out a grid system. The drilling investigations would be done by the CRDC.

A similar survey to cover the Beralesgamuwa field woul also be undertaken, after the completion of the Meetiyagoda work.

Problems at the Beralesgamuwa Refinery concerning particle size and the grit content, have been studied.

The blue glaze crawling problem was solved at the Piliyandala Factory. A detailed report on the Piliyandala Factory was submitted to all Board Members. A new fritt, with calcite instead of sea-shells has been produced and the fritt is far superior, to the material using sea-shells, as the calcareous material.

A report on the monitoring of the Negombo Factory is in the process of being prepared. The problem with the sanitaryware body using glass has been studied. The proper selection of glass is important to overcome this problem, as indicated by the General Manager, Ceylon Ceramics Corporation.

Raw Material Standards have been discussed and it is the intention of the CRDC to gradually introduce a system for the efficient supply of raw materials, keeping to factory standards.

Servicing of both internal and external orders was also undertaken in January, 1987. The following is a list of orders serviced.

1.	Orders from U.N. Experts, Head and Officers of the CRDC	- 09
2.	Orders from factories of the CCC	- 17
3.	External orders from customers	- 05
	Total	31

Dr. J.V. Herath
HEAD/CRDC