OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

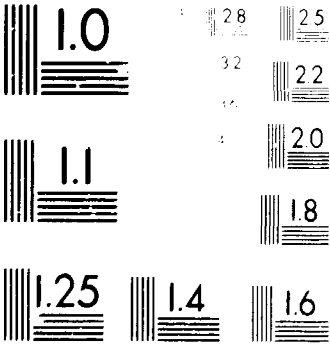
FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



MICROCOPY RESOLUTION TEST CHART

Establishment of Heavy Clay and Ceramic Industries

SI/SEY/82/801

13781

FINAL REPORT

Seychelles.

TECHNOLOGICAL TESTS OF CERAMIC RAW MATERIALS

Prepared for the Government of Seychelles by the United Nations Industrial Development Organization, the executing Agency of the United Nations Development Programme

Performed by: Research Institute for Ceramics, Refractories and Raw Materials, Pilsen, Czechoslovakia

In co-operation with: UNIDO-Czechoslovakia Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries, Pilsen, Czechoslovakia

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

VIENNA

ABSTRACT

To assist Seychelles in the establishment of ceramic industries, the technological evaluation of local ceramic raw materials was carried out by the Research Institute for Ceramics, Refractories and Raw Materials in Pilsen in the co-operation with the UNIDO-Czechoslovakia Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries in Pilsen under UNIDO project SI/SEY/82/801.

Selected samples from four local deposits were analysed and put into semi-industrial tests to verify casting technology of earthenware production. A set of products demonstrates convincingly that the local raw materials can be a basis on which a small-scale production of earthenware can be established.

TABLE OF CONTENTS

I. INTRODUCTION

Early 1983, four samples of clays coming from two deposits on Seychelles (Montagne Posée and La Gogue) were evaluated by the UNIDO-Czechoslovakia Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries in Pilsen. Clays from Montagne Posée deposit were found suitable for structural ceramics and it was recommended to follow the research of the deposit from the point of view of its industrial exploitation.

UNIDO Headquarters mission "Establishment of Heavy Clay and Ceramic Industries", SI/SEY/82/801 was organized in 1983 which reviewed the situation on the spot and recommended further steps. It also selected samples of clays to be tested abroad with special attention paid to the production of earthenware.

There was established a ceramic workshop on Seychelles which produced gift ceramics and souvenirs by jiggering. The production was mastered sufficiently and despite the simple installed equipments and the fact that workers were ceramic apprentices or students the outputs were very good.

Having collected information from basic geological survey of Seychelles (B. H. Baker and W. E. Stephens) and managers of the ceramic workshop, the UNIDO mission investigated four deposits of clays on Mahé Island and collected 14 samples of different grades of ceramic raw materials. According to the objectives of the UNIDO project SI/SEY/82/801 clays appropriate to the manufacture of red bricks, roofing tiles and fence bricks were sought for mainly. Because there were found deposits of good ceramic clays (Anse Soleil Road and Val d`Endor Estate) with properties required for dinnerware, the mission initiated recommendations to utilize these clays in the production of artistic and gift ceramics. Due to the existing ceramic production on Seychelles based on jiggering process, the efforts were put into verification of casting technology based on the selected clays that would considerably widen and diversify the assortment of ceramic products manufactured on Seychelles.

The technological tests of the collected ceramic raw materials were carried out by the Research Institute for Ceramics, Refractories and Raw Materials in Pilsen and have proved that ceramic clays from Seychelles are appropriate to the production of earthenware, especially if they are mixed so that required properties **may** be reached by combination of components.

During the semi-industrial verifications, products were manufactured by casting into plaster moulds which were of good quality. In comparison with the jiggering which the existing ceramic production on Seychelles is confined to the casting technologies enable comprehensive diversification of assortment by non-rotary shapes. In addition to it, the casting is not demanding for skillness.

On basis of the semi-industrial tests technology of upgrading and casting has been designed with a view to meeting constraints by which a small-scale ceramic production is characterized, i.e. simple machines and equipment, simple processes not demanding for high skilled technicians, based on semi-skilled or unskilled labour.

Despite the simplicity of the technological line, a further technical assistance from abroad will be necessary, especially in preparation for casting slips and plaster moulds until local experts have been trained sufficiently, inter alia.

II. CONCLUSIONS AND RECOMMENDATIONS

A Chemical and Mineralogical Compositions, Physical Properties

1. Montagne Posée Road deposit

   a) The clays consist of kaolinite, quartz, aluminium and iron oxides and hydroxides. Iron minerals share significantly.

   b) The clays are of low mechanical strength, low plasticity and high vitrifying temperature which limits their applicability in the ceramic production.

   c) The clays are suitable for the production of structural ceramics, namely red bricks and roofing tiles on condition they are corrected by components of higher plasticity and lower vitrifying temperatures.

2. Val D'Endor Estate deposit

   a) The clays are of low ferric oxide contents and of high contents of aluminium oxides and hydroxides which brings about high loss on ignition.

   b) The clays represented by Sample 5 W have good physical properties, especially sufficient bending strength which is comparable with washed kaolins.

   c) The clays contain high share of sandy particles, they must be upgraded by simple washing technologies.

   d) The clay represented by Sample 5 W shows high share of particles under 1 μm which is most likely to cause cracking and fissuring during firing from which necessitates that firing process should be carefully controlled.

   e) The white and grey clays of the deposit, which are of white colour after firing, are suitable for the production of ceramics. They comply well with requirements for proper ceramic bodies made by casting.

3. La Gogue deposit

   The clays were found to have inferior physical properties and to be unsuitable for the ceramic productions of any provenance.

4. Anse Soleil Road deposit

a) The yellow clays represented by Samples 4 and 13 contain higher portions of alkalis and iron trioxide. They are of good physical properties, namely mechanical strength.

b) The yellow clays are suitable for the ceramic production in raw state without any upgrading process.

c) The yellow clays can be applied as a sole component or in admixtures to preparing proper casting bodies.

B Suitable Glazes

a) The properties of the cast and fired bisque require glost-firing temperatures about 1000°C. Higher temperatures 1200 - 1400°C except for increased energy consumption will cause deformations of fired bodies and, consequently, high percentage of rejects.

b) The most suitable glazes were found which contained lead. The lead glazes fire at temperatures 960 - 1000°C, however, their applicability is confined to artistic and gift ceramics only excluding application to food and beverage containers.

c) It is recommended to produce gift ceramics and artistic souvenirs in initial phases of industrial production in Seychelles.

C Technological Verification of Casting Process

a) The manufacture of artistic and gift ceramics has been mastered by jiggering in Seychelles. Casting technology will enable to widen the assortment by new non-rotary shapes.

b) Combinations of clays from Val D`Endor Estate and Anse Soleil Road deposits were verified suitable for casting ceramic products. The clays were washed-out to be deprived of fractions above 0.06 mm. The casting slip containing 50% of dry matter was adjusted by dispersion agents. The casting into plaster moulds was perfect then.

c) The clays have high contents of free hydroxides and oxides of aluminium and iron and therefore the firing temperature in the interval of their dehydroxylation (250 - 500°C) must grow slowly in order to prevent crushing the products. The bisque firing ran up to 1050°C with 30-minute prolongation.

d) Casting products is not demanding for skilled labour, however, expert in preparation of moulds will be necessary.

e) Simple technology line was designed. The production will be based on local clays and imported dispersion agents and plaster.

f) To settle raw material basis of the earthenware production, detailed mapping of both the deposits (Anse Soleil Road, Val D`Endor Estate) in order to determine extraction ways i recommended.

g) To have the feasibility study on the production of earthenware elaborated before taking any industrial venture.

h) To train local technicians in the production of earthenware.

i) To apply to UNIDO through the relevant UNDP office for technical assistance during pre-investment and start-up phases, e.g. geological research, conducting feasibility study, training technicians and assignment of international experts.

D Red-Brick Production

a) Red clays from Montagne Posée Road deposit are suitable for the production of red bricks on condition that they are fired at temperatures above 1200°C.

b) In order to lower firing temperatures and, consequently, conserve energy, the clays are to be corrected by clays of higher plasticity and lower vitrifying temperature.

c) The clays from Montagne Posée Road can be considered as red-brick manufacture input only in case of manual manufacture since their low binding capacity in green state will cause high share of rejects during handling the moulded products.

d) It is recommended to look for other clay deposits suitable as correcting part of Montagne Posée clays.

e) To carry out semi-industrial tests in order to verify technology of structural ceramics production based on new found clays.

III. TECHNOLOGICAL EVALUATION OF CERAMIC RAW MATERIALS

1. Sample Decleration

The technological tests of delivered raw materials aimed at finding optimal ceramic bodies and glazes based on local available raw materials for the small-scale manufacture of earthenware.

In order to widen assortment of produced souvenirs in the ceramic workshop which is operated on Seychelles, the tests aimed at elaborating technology of casting which is expected to bring about new non-rotary shapes and satisfy new demands.

The samples of clays delivered to Czechoslovakia for technological evaluation were selected by the UNIDO mission SI/SEY/82/801 in May - June 1983. Based on the preliminary tests of physical properties carried out by the above mission on the spot, promising clays, from the point of view of the production of earthenware and red bricks, were selected and appropriate quantity of them was taken to be tested in Czechoslovakia.

The samples were taken from four known ceramic clay deposits on Seychelles:

Locality Montagne Posée Road
(Mahé Island, cadastre 3473)

Sample 1 declared as red clay
Sample 2 declared as yellow clay
Sample 3 declared as lateritic soil
(Situation chart of takings demonstrated in picture 1)

Locality Val d'Endor Estate
(Mahé Island, cadastres 3273, 3473)

Sample 5 declared as white clay
Sample 6 declared as yellow clay
Sample 7 declared as grey clay
Sample 8 was grey clay from other drill

For information in greater detail, the terminal report on the mission SI/SEY/82/801 is quoted here (page 13):

Depositing of samples

Depth of drill (cm)	Drill 1	Drill 2	Drill 3
0 10 20		arenaceous soil	arenaceous soil
30			
40 50			
60 70 80 90 100 110	white clay sample 5	grey clay sample 7	grey clay sample 8
120	yellow clay sample 6		
130 140		white cley	

(Situation chart of takings demonstrated in Picture 2)

Locality La Gogue
(Mahé Island, cadastre 2692)
Sample 9 declared as brown clay
Sample 10 declared as yellow clay
Sample 11 declared as red clay
Sample 12 declared as lateritic soil
(Situation chart of takings demonstrated in Picture 3)

Locality Anse Soleil Road

(Mahé Island, cadastre 2875)
Sample 4 declared as yellow clay
Sample 13 declared as yellow clay
Sample 14 declared as brown clay
(Situation chart of takings demonstrated in Picture 4)

All the above samples were delivered for chemical and mineralogical analyses (except for Sample 12 which was not ceramic raw material), each weighing about 100 g.Samples 13 and 14 respectively were sent to be put into technological evaluation (á 5 kgs). Samples 1, 2, 3 and 5 respectively weighed 20 kgs each.

The samples determined for technological tests were upgraded in two phases, first for the physical tests and then for the technological evaluation.

Note : The samples were labelled according to the two phases of treatment. Those added by index W were samples upgraded to have maximum grain size 0.15 mm. Samples without any index were those that were taken from the deposits.Samples labelled by index U were upgraded under 0.06 mm.The system of labelling is presented in Table 15.

2. Testing Methods Applied

The samples delivered were evaluated macroscopically, then prepared for X-raying, differential, gravimetry and chemical analyses.

a) X-ray photography was made under conditions: radiation CuK-α, filter Ni, arm traverse 1^o, input slot $10'$,output slot $10'$, paper motion 600 mm.hour^{-1}. All the angle values of diffractions were read on the X-ray photograph and their relative intensities were determined and interpreted according to the index ASTM.

b) Differential and gravimetry thermal analyses (D.T.A. and G.T.A. respectively) were made under conditions: sample charge 500 mg, balance sensitivity 100 mg, D.T.A. sensitivity 500 mA, G.T.A. sensitivity 250 mA, temperature gradient $10^{o}.min^{-1}$, inert kaolin $1250^{o}C$, oxidizing atmosphere, paper motion 300 $mm.hour^{-1}$.

By means of D.T.A. curves the top temperatures of endothermic and exothermic reactions were read, measured values were compared with laboratory standard curves (Standards of the Research Institute for Ceramics, Refractories and Raw Materials, Pilsen).

c) Chemical analyses were a combination of gravimetry, titrimetry and absorption photometry.

d) Contraction - dilatation thermal analyses (C.D.T.A)

Testing briquettes were fired under controlled conditions up to temperatures of degradation and length changes were measured and set out in graphs according to the rate between changed length and original length $\Delta l : l_o$.

e) Granularity analyses were carried out under conditions: sedimentation of materials, recorded intensity of X-rays which pass through the measuring cell filled with the thickened sample.

3. Compositions and Properties of Particular Samples

A Locality Montagne Posée Road

a) Physical properties

The results are demonstrated in Table 1. The clay has low mechanical strength, the testing briquettes were turned into debris.

b) Chemical compositions

All the samples tested consist of large portion of iron oxides, in case of Sample 3 W the content of aluminium hydroxides is conspicuously high of which the high loss on ignition is testimony. The results are demonstrated in Table 2.

c) Differential thermal analyses

The D.T.A.'s of Samples 1 W and 2 W are characteristic for the mineral kaolinite of derranged structure which has the endothermic deviation at about 570°C and the exothermic deviation at 940 - 950°C. The conspicuous deviation at 340°C in case of Sample 3 W corresponds to the dehydroxylation of gibbsite $Al(OH)_3$. Other endothermic deviation at 525°C was caused by the coincidence of the deviations of hydrated ferric oxide and kaolinite. The D.T.A. curves of Samples 1 W, 2 W and 3 W are demonstrated in Graph 1.

d) Gravimetry thermal analyses

Mass reductions of particular samples during heating according to different temperature intervals are shown in Table 3. It is worth noting that the mass reduction is higher than the loss on ignition as the sample heating starts at the ambient temperature, the mass reduction comprises also dried-up moisture.

e) Contraction - dilatation thermal analyses

The curves of contraction - dilatation thermal analyses are recorded on graphs 2 and 3 in case of Samples 1 U and 2 U respectively. Sample 3 U deteriorated during the test. The curve of both the samples is typical for kaolinite. (Note: Clay upgraded to have the upper granularity limit 0.06 mm was subject to the test).

f) Grain distribution

The Graphs 4, 5 and 6 show the grain distribution of Samples 1 U, 2 U and 3 U. The upper granularity limit was adjusted to be 0.06 mm.

g) X-ray diffraction analyses

The X-ray photographs of Samples 1 W, 2 W, 3 W are annexed to as Graph 18. They show diffractions of laminated silicates, oxides and hydroxides of aluminium and iron and non-clayey components.
They are distinct:
- kaolinite having diffraction d = 0.718 nm, d = 0.448 nm, d = 0.358 nm
- iron oxides and hydroxides predominantly bound in the amorphous form $Fe_2O_3.n\ H_2O$ are witnessed by the enhanced diffuse background
- gibbsite $Al(OH)_3$ is contained in Sample 3 W. Diffractions d = 0.485 nm, d = 0.437 nm and d = 0.331 nm
- quartz is significantly contained in Samples 1 W and 3 W, diffractions d = 0.426 nm and d = 0.334 nm

Table 12 shows the above diffractions.

h) Conclusions

The clays of the deposit Montagne Posée Road consist of kaolinite, quartz and oxides and hydroxides of aluminium and iron. The principal clay mineral is the kaolinite of low crystallinity. Quartz is dominating as far as non-clayey mineral representation is concerned. Sample 3 consists of significant share of gibbsite. Comparatively high share of iron minerals is conspicious.

The clays of the deposit are of low mechanical strength and consequently not suitable to the ceramic production. They can be added as components of clay blends and as a correction component of ceramic bodies.

B Locality Val d`Endor Estate

a) Physical properties

Only Sample 5 was put into these tests which showed the sufficient mechanical strength in green state. The results are demonstrated in Table 4.

b) Chemical composition

The Samples 5 W, 7 W and 8 W are distinct for very low ferric oxide contents so that they were white after firing. Aluminium oxide content is high brought about by contents of free hydroxides or oxides of aluminium. The high loss on ignition makes it obvious that hydroxides are present prevailingly. The results are shown in Table 5.

c) Differential thermal analyses

The record of D.T.A. curves (graph 7) demonstrates the presence of gibbsite (endothermic deviation at 300 - 310°C) in all the samples. Kaolinite of low grade of arrangement is comprised in the samples, too. The asymmetrically arranged endothermic deviation at 545 - 550°C stands for it.

d) Gravimetry thermal analyses

Mass reduction of particular samples in different temperature intervals are shown in Table 6.

e) Contraction - dilatation thermal analyses

Sample 5U was analysed with results exhibited in Graph 8 (fraction under 0.06 mm). The C.D.T.A. curve is characteristic for kaolinite.

f) Grain distribution

The course of the granularity curve shown in Graph 9 is not typical in case of kaolinite clays having considerable portion of partbles below 1 µm.

g) X-ray diffraction analyses

The dominating clay mineral is derranged kaolinite, in case of non-clayey minerals quartz and gibbsite are prevailing. In Sample 8 W, small quantity of feldspar, dolomite and illite - montmorillonite interstratification is contained. Table 12 shows particular diffractions of Samples 5 W, 6 W, 7 W and 8 W. Graph 19 shows dffractions of Samples 5W and 5 W while Graph 20 those of Samples 7 W and 8 W.

h) Conclusions

The Sample 5 W was analysed to find mechanical properties (other samples had unsufficient mechanical strength). The bending strength was found sufficient which is comparable to that of washed kaolins. Because the clays are arenaceous to a high extent, their upgrading by washing is regarded as necessary and choosing only grey and white clays of this deposit is recommended which are of white colour after firing.

The clays contain derranged kaolinite and gibbsite and quartz to mention only important minerals.

The clay represented by Sample 5 W shows high content of fine particles under 1 µm which is most likely to cause the cracks and fissures occurring during firing. This effect is described in greater detail in paragraphs 4 and 5 which deal with the technology of casting earthenware.

C Locality La Gogue

a) Physical properties

The clays coming from this locality were not subject to the tests as their mechanical strength was so low that they did not stand drying and testing briquettes deteriorated.

b) Chemical analyses

All the tested samples contain large quantity of iron trioxide, especially the Sample 11 W which also contains gibbsite and its loss on ignition is therefore high. The results are exhibited in Table 7.

c) Differential thermal analyses

The endothermic deviation corresponding to the dehydroxylation of gibbsite occurs in case of Sample 11 W. Asymetrically arranged endothermic deviation of kaolinite at temperatures 530 - 555°C is apparent in case of all the samples tested. The exothermic deviation (at 475°C) of Sample 9 W is brought about by transition of hydroxide form of iron into the oxide one. The D.T.A. curves are recorded in Graph 10.

d) Gravimetry thermal analyses

The results are shown in Table 8.

e) Contraction - dilatation thermal analyses

The samples were not subject to the above analyses because of their low mechanical strength.

f) Grain distribution

The samples were not tested.

g) X-ray diffraction analyses

The X-ray photographs of Samples 9 W and 10 W show dominating diffractions of kaolinite, quartz and micaceous mineral of illite type. In case of Sample 10 W diffractions of feldspar and illite-montmorillonite interstratification are distinct, too. In case of Sample 11 W only diffuse lines of kaolinite, gibbsite, quartz and feldspar are apparent. Graph 21 shows X-ray photographs of Samples 9 W, 10 W and 11 W.

h) Conclusions

All the tested clays are of inferior physical properties so that forming briquettes was impossible. They consist of high portion of aluminium and iron hydroxides, especially Sample 11 W. As far as mineralogy is concerned, their principal component is kaolinite of low extent of arrangement, further micaceous mineral of illite type is apparent. The clays occuring in La Gogue deposit are not applicable as a sole component to the ceramic production. They can be added as components of clay blends.

D Locality Anse Soleil Road

a) Physical properties

The physical properties of these clays are presented in Table 9. From the point of view of mechanical strength Sample 13 W shows the best results. Sample 14 W has the mechanical strength rather inferior.

b) Chemical analyses

The results are presented in Table 10. The iron trioxide content of all the samples is high, Sample 14 W has also high content of Al_2O_3 and high loss on ignition which is to be ascribed to the gibbsite presence. Samples 4 W and 13 W (yellow clay) consist of comparatively large quantities of alkali brought about by feldspar and magnesium and calcium carbonates.

c) Differential thermal analyses

As the D.T.A. curves recorded in Graph 11 show only lesser deviations at temperatures 525 - 530°C and 900 - 930°C, kaolinite of lower arrangement is present. Sample 14 W shows a distinct deviation corresponding to the gibbsite dehydroxylation.

d) Gravimetry thermal analyses

The results are presented in Table 11.

e) Contraction - dilatation thermal analyses

The course of C.D.T.A. curve which is recorded in Graph 12 is typical for kaolinite. The effect of high alkali content is performed by the sharp shrinkage between 1000 and 1100°C. The fractions under 0.06 mm were put into C.D.T.A.

f) Grain distribution

The distribution curve of Samples 13 U and 14 U were found for fractions under 0.06 mm. Sample 14 U contains considerable portion of fine particles under 2 µm. The grain distributions of Samples 13 U and 14 U are shown in Graphs 13 and 14 respectively.

g) X-ray diffraction analyses

The analyses proved that all the samples contain feldspar in addition to kaolinite and quartz. Samples 4 W and 13 W contain also dolomite and Sample 14 W gibbsite. The review of minerals present is exhibited in Table 12, X-ray photographs of Samples 4 W, 13 W and 14 W in Graph 22.

h) Conclusions

Clays occuring in locality Anse Soleil Road, especially those presented by Samples 4 W and 13 W are superior to other tested clays as for their physical properties, namely, mechanical strength. Consequently, they are applicable to the ceramic production either as a sole component or in admixtures. That clay labelled as Sample 14 W has low mechanical strength and it is not appropriate to the ceramic production. The Anse Soleil Road clays were subject to our concern to prepare the optimal casting slips.

4. Technological Evaluation of Clays for Casting

As the production of artistic and gift ceramics by jiggering has already been mastered on Seychelles which has been based on local raw materials, one of the principle objectives was to investigate other processings which would make possible to diversify the assortment and serve wider demands. The casting into plaster or other porous moulds would enable to produce more sophisticated shapes and patterns so that casting slips and technologies based on local raw materials were the subject of technological tests conducted in the Research Institute for Ceramics, Refractories and Raw Materials, Pilsen.

Preparation for dispersed clay slip

Wherever the casting technology is applied to produce ceramic products of sophisticated shapes (sanitary ceramics, porcelain), the decisive factor is the slip. The prerequisite is high portion of dry matters contained in the casting slip lest the porous mould should drain large quantities of water to create body of sufficient thickness. Further requirement is for the casting slip not to settle quickly, otherwise the coarser particles get separated in the mould or settle in storage tanks and transport pipelines. The casting slip must be liquid regardless the content of dry matters to fill in whole the mould, even the most intricate reliefs. The creation of body must be finished as soon as possible that the product could be separated from the mould without its deterioration.

After stirring the water and clay a suspension comes into being the solid particles of which settle rapidly on the bottom. Consequently, to prevent the rapid sedimentation, dispersion agents so called dispergators are added which are chemical compounds either of industrial products or natural raw materials or their mixtures, if need be. The dispergators affect the surface charge of solid particles to the effect that they, having the same charge, are mutually repelled and their sedimentation is decelerated.

Because the clays tested contain large quantities of aluminium and iron hydroxides which accelerate flocculation (i.e. coagulation and following sedimentation), the optimal dispergator finding was difficult. Dispex N 40, a manufacture of Messrs. Allied Colloids of G.B. acted best. The optimal addition of the above dispergator was experienced by means of a viscosimeter for the suspensions containing 50% of dry matters and 50% of distilled water. The optimum quantities are presented in Table 13. The admixture of dispergator to clays enabled to mould testing specimens by means of the casting into plaster moulds to determine the bending strength in green state. Applying this technique the particles of clays cling together more closely than particles of clays moulded manually from plastic body. The cast specimens showed high strength, especially that of specimen cast from mixture C (Table 13) can be regarded as extremely high.

Bending strength of selected samples

Sample	Bending strength (MPa)
5	4.6
13	8.3
mixture C	12.9

The used dispergator, especially Dispex N 40 which is a polyacryl, is likely to contribute to increasing the strength of specimens. Consequently, dispergators will enhance low mechanical strength of used clays in casting slips.

All the dispersion tests were carried out with clays the upper grain limit of which was adjusted to be 0.06 mm. It resulted into substantially reduced sedimentation of coarser fractions recorded in case of fraction under 0.15 mm.

The C.D.T.A. curves of all the mixtures are recorded in Graphs 15, 16 and 17.

5. Semi-industrial Casting of Artistic Ceramics

In order to experiment as many as possible factors influencing casting, bisque firing, drying, glazing, glost firing and decorating, a special sophisticated testing mould was used. (Photographs 1 - 8). It was a vase 65 mm high and of diameter 40 mm decorated with a relief. The used plaster moulds consisted of four parts.

a) Moulding vases by casting

Based on test results of applications of different dispergators, the Samples 1 U, 2 U, 3 U and 14 U were left aside. Also Sample 13 U itself was not tested as its dispersion capacity was low. After removing the plaster mould, 38 % of products from Sample 5 U and 75 % of products from mixture A were deteriorated. Mixtures B and C showed the best results since no product was damaged.

b) Used glazes

16 different glazes were applied in the production of vases which were of different colours and tints. The glazes were applied both to the green body and the fired bisque. Principally lead glazes were applied to fired bisque,

the glost firing temperature being between 960 - 1000°C. The glazes applied to the green body were glost-fired at temperatures 1160 - 1180°C.

The best results were attained with glazes applied to fired bisque, green, brown, black and white cover glazes and translucent glaze. The results of glaze optimization tests are demonstrated in Table 14.

c) Bisque firing

According to the directions of use for the applied glazes, the temperature of bisque firing was higher about 50°C than that of glost firing, i.e. max. 1050°C. Rounded plates were made from respective testing casting slips of diameter 40 mm to experiment the appropriate glazes by means of which the run of firing was observed. If the speed of firing was high, the plates cracked at the temperatures of clay dehydroxylation (250 - 500°C). It was necessary that the increase of temperature in the interval of dehydroxylation should have been as slow as possible. Despite small cracks occurred, especially in case of products made from Sample 5 U.

d) Glazing the fired bisque

The powdered glaze was mixed with water to get suspension containing 50% /wt/ of dry matter. Application of glaze by a fine brush was not successful, especially in case of cover glazes, since the painted layer was irregular as far as the thickness was concerned so that the coloured body shone through the fired glaze. Good results were achieved once the products had been dipped into glaze. The absorptivity of the bodies caused that the product get covered with regular and sufficiently thick glaze film after some seconds when it had been dipped. The inside of

products was filled with glaze which was again dipped.
The application of two different glazes to outside and inside of products is easy and results into interesting colour combinations. The combinations are demonstrated in attached Photographs 1 - 8.

c) Application of glaze to green body

This way of glazing is accompanied by many problems which are not easy to be settled. The green products cannot be glazed by dipping in or pouring glazes since they are of low mechanical strength which is further reduced by soaking water from glazing suspension which makes the product walls soften and a deformation or cracking of products set in. Painting or spraying glazes are ways which have to be applied. In case of cover glazes which require to be applied in thick film, the procedure must be reiterated with alternating drying. Consequently, the number of operations goes up and the possiblity of damaging products increases, too. If glazes are sprayed only small portion of glaze is utilized which can cause considerable losses taking into consideration high price of glaze. The glazes that were applied to the green body during above tests are ready-made for floor tiles. The results achieved were not good and corrections of thermal expansion coefficient of glazes based on wider research should have to be done.

6. Upgrading and Casting Methods

Bearing in mind that small-scale production of cast ceramic products on Seychelles is in question as a first step of development, upgrading and casting technology was designed based on all the analyses and semi-industrial tests. Mixtures of clays from localities Anse Soleil Road and Val d`Endor Estate (mixture B and C described in Table 13) are recommended to be input of casting slips. These clays contain coarse admixtures and, therefore, their simple upgrading is necessary.

Whole the process is broken down in some technological phases which are schematically plotted in Picture 5.

a) Raw material homogenization

The gradual lamination of a pile of delivered clays will be sufficient accompanied by reiterated manual overturning of materials. Larger pieces or blocks are to be crushed. These larger pieces get collected, as a rule, at the pile footing and worsen the homogenity. Homogenization of larger quantity of clays is recommended that a sufficient operation stock should be ready, however, large storage tanks and area are needed.

b) Blunging

Sea water is not applicable. In case of small-scale production a concrete mixer suffices to prepare for inputs or a basin provided with a stirrer. The following technology requires for raw material suspension to contain dry matters in ratio 150 g/ litre as a maximum.

c) Sand separating

Simple equipment such as vibrating sieves or bucket or worm elevators will do to remove washed-out sand.

d) Grading suspension

The most reliable means of fine fraction preparation is the hydrocyclone. Due to small quantity of material, a hydrocyclone with inside diameter 50 - 150 mm is recommended. A pump, storage tank, connecting pipelines and air chamber with pressure gauge are components of a hydrocyclone plant.

e) Sedimentation and dewatering

C[illegible] sedimentation basin or a rounded tank provided with conical bottom are recommended equipments. Dewatering could be done by the filterpress or de-airing press (pressure or vacuum filtration). Only a part of [illegible] input is to be dewatered as the settled slurry will be mixed with dry clays gathered from the dewatered suspension and dried in the open air, if need be. The dewatered material (filterpress output) will be utilized for jiggering.

f) Preparation for casting slip

The tank provided with stirrer is fed by settled clay which is added by the dispergator. The slip is constantly mixed and added crushed filterpress cakes. Dried-up cakes blunge better than humid ones. The slip is corrected by further charge of dispergator or water or dry material according to the properties.

The casting slip is then pumped and stored in a tank provided with stirrer which will also be fed by returned casting slip rejected during moulding.

g) Preparation for plaster moulds

Casting into plaster moulds is regarded as the most simple way even though other porous materials are used, e.g. different plastic materials.

The production of moulds is conceived to be manual one based on designs corresponding to the local custom and culture. Gypsum is to be imported since there are no appropriate local sources.

h) [illegible] and cleaning [illegible]

The [illegible] is not demanding qualifications, [illegible] [illegible] are [illegible] to master it after training. After removing products from moulds they will be stored [illegible] for drying by the ambient air. [illegible] products will be then subject to brushing joints which occur on products since the moulds are joined by some parts to be dismantled and the product separated easily. The plaster moulds will be then dried at room temperature.

i) Bisque firing

Two prerequisites must be kept up. Slow temperature gradient in interval of dehydroxylation of aluminium and iron hydroxides, i.e. between 250 - 500 °C. Second, the bisque must be fired at higher temperature than glaze.

j) Glazing

The glazing may be done by dipping, painting or spraying. The best way was proved to be dipping products into glaze bath. Improvement can be done by brush. The glazed products must be perfectly dried-up before they are put into glost firing.

k) Glost firing

The process will run according to the glaze producer`s instructions since it is assumed they will be purchased ready - made. It is important to [illegible] coefficient of thermal expansion of both glaze and ceramic body for cracks not to occur. Owing to the properties of tested clays, it will have to be taken care of.

7. Decoration Techniques

There are many techniques to decorate ceramic products which distinguish according to the materials applied. Ceramic stains, compounds of different metals, precious metals and also glazes proper are utilized to decorate ceramic products. Decorations are applied to the fired glazed product or to fired bisque (under glaze). The choice of decoration depends on firing temperature and colour and character of ceramic body.

a) Decorations by glazes

Trickling

Run-off glazes are very impressive decorations of artistic ceramics. Low-melting glazes are used which have some tens of centigrades lower firing temperature than the bisque. They are applied in thick films and they run off down the walls of products during firing. The application is usually a combination of versatile ways - in stripes or one over the other by brush, spraying or dipping. The series of colours and tints and compositions is almost infinite and they can be applied to either fired bisque or to other already applied harder glaze.

Crazing glazes (crackle)

These glazes are those of dense screen of tiny, irregularly situated cracks which are usually underlined by rubbing colouring matters. These cracks originate as a consequence of firing glazes with higher thermal expansion coefficient than that of the body to which they are applied. To underline the effect, different colouring matters are rubbed in. In China and Japan, they were painted with drawing ink. Frequently, ceramic stains are applied which are then fired again at lower temperatures.

Crystalline glazes

The glaze charge is oversaturated by matters which solve in melted glaze. After annealing they precipitate either together with other glaze components or alone creating crystals with interesting effects, such as blooms. The crystalline glazes are recommended to be applied to vitrified bodies so that they can be applied to other fired glazes.

b) Decoration by stains

Ceramic stains are substantially coloured metal compounds (silicates, aluminosilicates) or suspensions of precious metals with ceramic materials or glazes.

Under-glaze stains

These stains are applied to green body or fired bisque. The firing temperatures vary 800 - 1410°C. The colour set gets narrower with growing firing temperature. The most frequent way of application is hand-painting, however, screen-print is applied, too.

Metal compounds - salts

Water solution of chemical compounds of metals are applied under glazes. These decorations distinguish themselves by appropriate temperature stability and excellent colour effects. The usual inputs are nitrates or chlorines of colouring matals which are applied to the fired bisque (spraying, dipping, hand-painting). These soluble compounds can be turned into in-soluble state before glazing by either firing at 900 - 950°C or by ammonia vapour affect.

Over-glaze stains

These stains are applied, by hand-painting or by decalcomania, to the fired product in thin films. The firing temperature varies 700 - 850°C. The set of these stains is as wide as application techniques; hand-painting, decalconainia, spraying, screen-print.

The hand-painting is the most usual technique to decorate the artistic or gift ceramics. However, decalcomania can be successfully applied, too, since it is not demanding for qualifications and brings about good results even though small-scale production is established. Screenprint is usually applied in the large-scale productions.

Lustres

Lustres are thin metal or oxide films on glazes of fired products. They are characterized by high gloss and pearl-like appearance of various colours. Chemically, they are resin soaps of metals. They are applied by brush or spraying and fired in muffle kilns at 650 - 750°C.

c) <u>Precious metals</u>

The most used material is gold, also platinum and rarely silver. For ceramic decoration resin soap of gold is frequent which is solved in turpentine and other oils. The tint depends on gold concentration and other-metal admixtures. The firing temperature is 750 - 810°C. After firing, the organic compounds are burnt-up and only very thin golden film remains.

8. Utilization of Clays for Red-brick Manufacture

Ceramic clays taken from the four deposits on Seychelles are characterized by so called lateritic weathering by which clays deposited in tropics are characterized. Higher temperature and abundant rains bring about leaching out alkalis (Na_2O, K_2O) and silicon dioxide (SiO_2). The share of Al_2O_3 and Fe_2O_3 in hydrated form /$Al(OH)_3$, $Fe(OH)_3$/ is then enhanced proportionally and the clays correspond rather to bauxite or iron ore.

The principal effect on properties of ceramic clays (namely on plasticity and compression strength of dried-up material) clay minerals wield, mainly kaolinite, montmorillonite and illite. However, these minerals share unsufficiently which brings about low quality of bricks and troubleshootings during the manufacture of bricks from the tested clays.

To avoid the occurrence of cracks or complete deterioration of products during drying and firing, the homogenization and handling of the clays must be paid attention to for the quality and humidity of moulded products to be uniform. The kneading and moulding is recommended to be done by machines (edge mill and brick moulding press). If products were moulded manually the products would not be compressed uniformly into the moulds with consequences for final product quality. On the contrary, manual handling during the following phases is recommended with regard to the low mechanical strength of products. To fire ca 2 million bricks annually, intermittent kilns will do well which can be fired by wood (the approximate wood consumption to fire one brick 290 x 140 x 65 mm is 1 kg). In case of other fuels consumed the average consumption 14.5 GJ per 1000 bricks is counted. The firing temperature must be 1000 - 1100°C when vitrifying sets in resulting into strengthening the ceramic body. The vitrification is shown in Pictures 9- 12 for 3 clays from Montagne Posée Road and one clay from La Gogue. The tests showed that bricks made from the tested clays are of low mechanical strength and they are applicable only to the one-storey buildings.

[illegible], clays from [illegible] Rosée [illegible] [illegible] with other clays of [illegible]:

[illegible] 50 – [illegible]% red clay from [illegible] Rosée [illegible]
50 – [illegible]% yellow clay from [illegible] Soleil [illegible]

The clays from [illegible] Rosée Road and/or La [illegible] [illegible] be [illegible] without adding other clays. The clays from Val [illegible] are [illegible] and will have to be [illegible]. It is worth noting that deposits from Soleil Road and Val d'[illegible] [illegible] consist of clays of good quality applicable to the production of both structural ceramics and artistic [illegible]. That similar clays will be found in other locations on [illegible] can be expected and, therefore, the [illegible] of [illegible] and looking for new deposits is the [illegible] of [illegible] stipulating further development of [illegible].

IV. FINAL NOTE

The ceramic clays from Seychelles which were collected by the UNIDO Headquarters mission SI/SEY/82/801 were studied technologically from the point of view of their applicability to the intended diversification and expansion of [illegible] manufacture on Seychelles, namely, to the production of earthenware by casting and to the production of pots and brick products, if possible.

All these analyses had to be carried out by the [illegible] Institute for Ceramics, Refractories and Raw Materials in Pilsen [illegible] aimed at selecting raw materials suitable to preparation the casting slips and production of [illegible] on semi-industrial scale. The semi-industrial tests [illegible] verified the casting technology and were a basis of recommendations to go on developing ceramics by casting from local Seychelles clays.

[illegible] results of tests, the [illegible] raw materials and casting was [illegible] to comply with conditions of small-scale production, i.e. as simple as possible equipment, reduced energy consumption and lowest possible demand for skill. Bearing in mind the intention to market the production as gift and artistic ceramics, mainly, decoration techniques was paid special attention to which would enable to decorate the products according to the local culture patterns.

[illegible]

1. [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

2. [illegible]

[illegible]

[illegible]

[illegible] ...hellen, [illegible] C-Czech[illegible] ... [illegible]
[illegible], [illegible] 3, [illegible]/15[illegible]/43

9. [illegible] Standards, Research Institute for C[illegible],
[illegible] and Raw Materials, [illegible], Czech[illegible]

VI. APPENDIX

1. List of Tables

2. List of Graphs

Graph 17 - Contraction-Dilatation Thermal Analysis
Blend C

18 - X-ray Photographs
Samples 1 W, 2 W, 3 W

19 - X-ray Photographs
Samples 5 W, 6 W

20 - X-ray Photographs
Samples 7 W, 8 W

21 - X-ray Photographs
Samples 9 W, 10 W, 11 W

22 - X-ray Photographs
Samples 4 W, 13 W, 14 W

3. Pictures

4. Photographs

Photograph 1 - Products with translucent glaze

2 - Product with translucent glaze

3 - Products with efflorescence Celadon glaze

4 - Product with efflorescence Celadon glaze

5 - Products with brown cover glaze

6 - Product with brown cover glaze

7 - Products with black mat glaze

8 - Product with black mat glaze

9 - La Gogue - yellow clay
Fired at 1000, 1250 and 1400 °C

10 - Montagne Posée Road - yellow clay
Fired at 1000, 1250 and 1400 °C

11 - Montagne Posée Road - red clay
Fired at 1000, 1250 and 1400 °C

12 - Montagne Posée Road - lateritic soil
Fired at 1000, 1250 and 1400 °C

Table 1 Physical properties of Montagne Posée Road clays

	Sample		
	1 W	2 W	3 W
Bending strength after drying /MPa/	Testing briquette cracked		
Formationwater WR / % wt./	64.0	60.0	43.5
Plasticity number by Pfefferkorn method PL_p	39.5	39.8	30.7

Table 2 Chemical composition of Montagne Posée Road clays

/ % wt. /

	Sample		
	1 W	2 W	3 W
Loss on ignition	12.36	14.47	23.10
SiO_2	43.40	34.72	21.22
TiO_2	1.53	2.30	1.05
Al_2O_3	28.99	27.54	45.25
Fe_2O_3	13.12	20.64	9.17
MgO	0.13	0.14	0.03
CaO	0.04	0.02	0.10
Na_2O	0.04	0.03	0.04
K_2O	0.39	0.14	0.04

Table 3 Thermogravimetric analyses of Montagne Posée Road clays

Sample 1 W							
temperature range (^{o}C)	18-215	215-275	275-370	370-420	420-660	660-1000	18-1000
mass reduction (%)	3.56	0.80	1.68	0.70	7.62	0.90	15.26
Sample 2 W							
temperature range (^{o}C)	23-210	210-245	245-375	375-430	430-690	690-1000	23-1000
mass reduction (%)	3.16	0.40	2.87	0.70	7.91	0.79	15.83
Sample 3 W							
temperature range (^{o}C)	20-145	145-220	220-400	400-465	465-605	605-1000	20-1000
mass reduction (%)	1.80	1.64	15.90	1.48	3.44	1.48	25.74

Table 4 Physical properties of Val d´Endor Estate clays

	Sample			
	5 W	6 W	7 W	8 W
Bending strength after drying /MPa/	1.62	-	-	-
Formation water WR / % wt. /	51.5	-	-	-
Plasticity number by Pfefferkorn method PL_p	35.0	-	-	-

Table 5 Chemical composition of Val d´Endor Estate clays

/ % wt. /

	Sample			
	5 W	6 W	7 W	8 W
Loss on ignition	16.37	15.79	17.00	15.89
SiO_2	43.66	34.75	42.05	44.86
TiO_2	1.17	1.64	0.96	0.97
Al_2O_3	36.75	34.33	38.51	36.60
Fe_2O_3	1.33	13.10	0.98	1.20
MgO	0.15	0.10	0.13	0.17
CaO	0.04	0.04	0.02	0.04
Na_2O	0.14	0.03	0.08	0.08
K_2O	0.39	0.22	0.27	0.19

Table 6 Thermogravimetric analyses of Val d'Endor Estate clays

Sample 5 W							
temperature range (^{o}C)	20-180	180-240	240-350	350-410	410-620	620-1000	20-1000
mass reduction (%)	2.12	0.49	4.90	0.98	8.50	0.98	17.97
Sample 6 W							
temperature range (^{o}C)	20-160	160-240	240-370	370-430	430-665	665-1000	20-1000
mass reduction (%)	2.12	0.98	6.51	0.81	7.65	0.98	19.05
Sample 7 W							
temperature range (^{o}C)	20-160	160-250	250-340	340-415	415-665	665-1000	20-1000
mass reduction (%)	1.80	0.49	4.74	0.82	9.64	0.65	18.14
Sample 8 W							
temperature range (^{o}C)	20-190	190-240	240-325	325-410	410-630	630-1000	20-1000
mass reduction (%)	2.80	0.49	3.29	1.15	9.38	0.82	17.93

Table 7 Chemical composition of La Gogue clays

/ % wt./

	Sample		
	9 W	10 W	11 W
Loss on ignition	13.70	13.08	14.65
SiO_2	35.73	37.44	29.52
TiO_2	2.38	2.08	3.09
Al_2O_3	28.35	29.82	28.48
Fe_2O_3	18.68	16.49	23.36
MgO	0.90	0.90	0.33
CaO	0.12	0.02	0.11
Na_2O	0.05	0.05	0.04
K_2O	0.09	0.12	0.42

Table 8 Thermogravimetric analyses of La Gogue clays

Sample 9 W							
temperature range (°C)	22-225	225-420	420-590	590-735	735-840	840-1000	22-1000
mass reduction (%)	6.25	1.15	4.44	1.81	1.97	0.16	15.78
Sample 10 W							
temperature range (°C)	21-200	200-255	255-345	345-410	410-660	660-1000	21-1000
mass reduction (%)	2.63	0.66	1.15	0.66	9.05	0.82	14.97
Sample 11 W							
temperature range (°C)	24-190	190-250	250-370	370-410	410-615	615-1000	24-1000
mass reduction (%)	3.47	0.83	4.46	0.50	6.27	1.32	16.85

Table 9 Physical properties of Anse Soleil Road clays

	Sample		
	4 W	13 W	14 W
Bending strength after drying /MPa/	-	2.37	0.93
Formation water WR / % wt. /	-	43.50	30.50
Plasticity number by Pfefferkorn method PL_p	-	31.3	23.0

Table 10 Chemical composition of Anse Soleil Road clays

/ % wt. /

	Sample		
	4 W	13 W	14 W
Loss on ignition	9.25	7.51	18.82
SiO_2	51.33	53.92	33.62
TiO_2	1.48	1.09	1.23
Al_2O_3	22.85	21.09	34.06
Fe_2O_3	9.98	9.26	11.73
MgO	0.87	0.78	0.13
CaO	1.14	2.50	0.12
Na_2O	0.40	1.25	0.05
K_2O	2.70	2.60	0.24

Table 11 Thermogravimetric analyses of Anse Soleil Road clays

Sample 4 W							
temperature range (°C)	24-205	205-255	255-345	345-410	410-605	605-1000	24-1000
mass reduction (%)	3.29	0.49	1.32	0.66	4.77	0.99	11.52
Sample 13 W							
temperature range (°C)	18-185	185-260	260-345	345-425	425-610	610-1000	18-1000
mass reduction (%)	2.63	0.66	1.32	0.66	3.78	1.15	10.20
Sample 14 W							
temperature range (°C)	22-195	195-325	325-380	380-435	435-590	590-1000	22-1000
mass reduction (%)	4.79	7.10	2.31	1.16	5.28	1.49	22.13

Table 12 <u>X-ray diffractions of particular minerals of samples</u>

Deposit	Sample	IM	S	K	G	Q	F	D	B
Montagne	1 W	5	-	20	-	55	-	-	10
Posée	2 W	-	5	30	-	5	5	d	14
Road	3 W	-	-	5	90	20	5	-	6
Val	5 W	-	5	30	65	50	d	-	4
d'Endor	6 W	-	-	25	50	20	-	-	10
Estate	7 W	-	-	50	95	25	d	-	3
	8 W	5	d	40	30	45	5	3	4
La Gogue	9 W	d	5	25	d	10	d	-	11
	10 W	5	5	10	-	10	10	-	9
	11 W	-	-	d	d	d	d	-	13
Anse	4 W	d	10	10	d	50	20	10	9
Soleil	13 W	-	-	10	5	50	25	15	7
Road	14 W	5	-	15	30	55	10	d	8

Legend: IM - illite-montmorillonite; S - micaceous mineral of illite type; K - kaolinite; G - gibbsite; Q - quartz; F - feldspar; D - dolomite; B - diffuse background; d - diffusion diffraction; - - diffraction absence

Note: In attached X-ray photographs (Graphs 18 - 22), the diffraction of hematite is labelled H, that of calcite C and that of montmorillonite M.

Table 13 Dispersion Agent Additives

Sample	Dispersion agent	%	per cent of
1 U	Dispex N 40	0.3	dry matter
2 U	Dispex N 40	0.7	dry matter
3 U	Dispex N 40	0.2	dry matter
5 U	Dispex N 40	0.1	dry matter
13 U	Dispex N 40	2.0	dry matter
	natrium huminate	0.5	dry matter
	HMP +	0.5	dry matter
14 U	Dispex N 40	0.35	dry matter
Mixture A			
50 % sample 1 U	Dispex N 40	2.0	sample 13U share
50 % sample 13 U	natrium huminate	0.5	sample 1 U share
	HMP +	0.5	sample 1 U share
Mixture B			
75 % sample 5 U	Dispex N 40	0.5	sample 13U share
25 % sample 13 U	natrium huminate	0.5	sample 13U share
	HMP +	0.5	sample 13U share
Mixture C			
50 % sample 5 U	Dispex N 40	0.1	sample 5 U share
50 % sample 13 U	Dispex N 40	0.5	sample 13U share
	natrium huminate	0.5	sample 13U share
	HMP +	0.5	sample 13U share

+ HMP = hexametaphosphate

	[illegible]	[illegible] temperature (°C)	[illegible]	Application [illegible]	bisque	[illegible] result
[illegible]	[illegible]lucent [illegible]	[illegible]-1000	[illegible]	-	yes	[illegible] additive
[illegible]	[illegible] yellow cover [illegible] G 959	960-1000	44.9	-	yes	glaze [illegible]ooth wit[illegible] cra[illegible]
[illegible]	[illegible] Celadon [illegible] blooms	880-1000	62.0	-	yes	glaze smooth without cracks
[illegible]	[illegible] black mat [illegible]	940-1000	46.0	-	yes	glaze smooth, gloss without cracks
5	[illegible] dark brown cover glaze Md 530	960-1000	31.3	-	yes	glaze smooth, gloss without cra[illegible]
6	Lead white cover glaze Lw 153	940-1000	29.0	-	yes	glaze smooth, gloss without cracks
7	Leadless trans-lucent glaze P 16	1040-1160	0	-	yes	great difference between thermal expansion of bisque and that of glaze - crackling and pelletizing
8	Brown cover glaze	1160-1180	unknown	yes	-	great difference between thermal expansion of bisque and that of glaze - crackling
9	Brown cover glaze	1160-1180	unknown	yes	-	great difference between thermal expansion of bisque and that of glaze - crackling
10	Grey cover glaze	1160-1180	unknown	yes	-	great difference between thermal expansion of bisque and that of glaze - crackling
11	Lead translucent blue glaze G 201	960-1000	48.7	-	yes	inelegant colour combination with brick-red bisque
12	Leadless white cover glaze CPw 6451	960-1000	0	-	yes	great difference between thermal expansion of bisque and that of glaze - crackling
13	Lead yellow cover glaze G 910	880-920	62.6	yes	-	low glost firing temperature for the bisque to have appropriate mechanical strength - unsuitable
14	Zircon white [illegible]	960-1160	0		yes	great difference between thermal expansion of bisque and that of glaze - crackling
15	Zircon white cover glaze Pw 141	960-1160	0	-	yes	great difference between thermal expansion of bisque and that of glaze - crackling
16	Brown cover [illegible] 11	1160-1180	unknown	-	yes	inexpressive colour tint

[illegible]: Glazes tested manufactured by Messrs. Spolek pro chemickou a hutní výrobu, Ústí nad Labem. Other deliverers of glazes and stains can be listed: Bayer AG, 5090 Leverkusen, F.R.G., Reimbold and Strick, 5000 Köln, F.R.G., FERRO Holland.

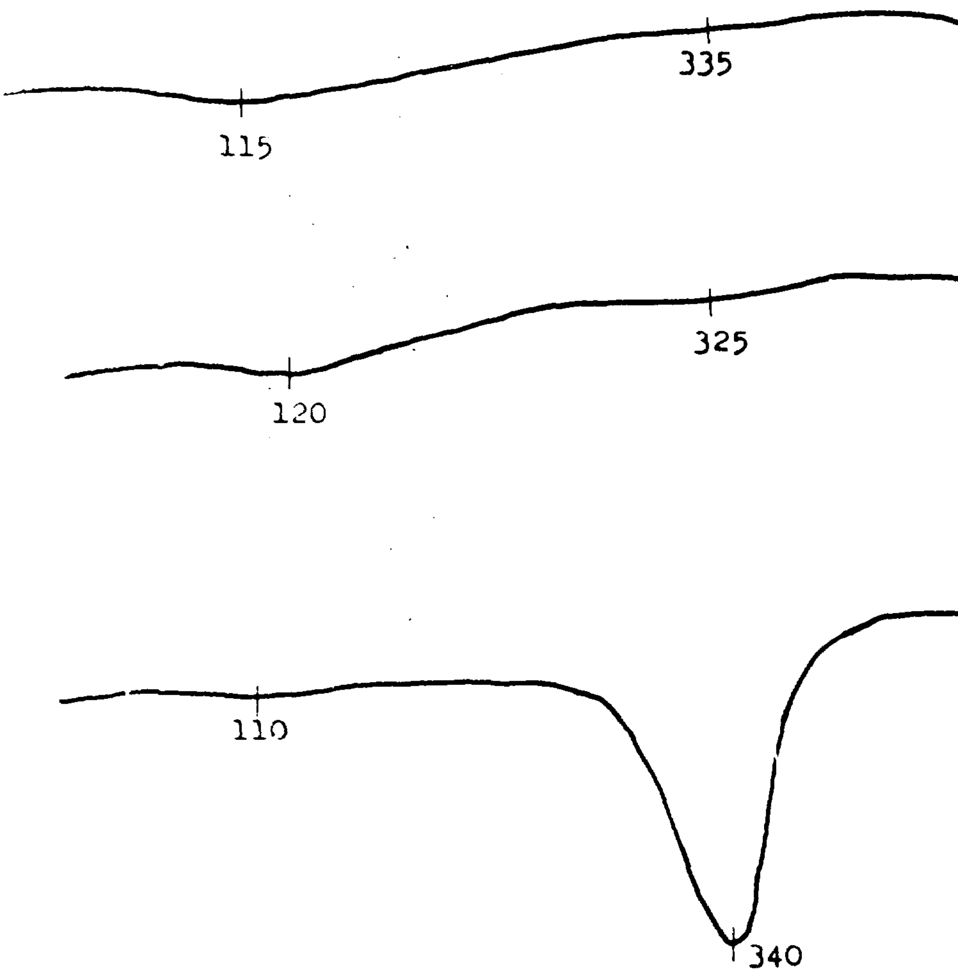
Table 15 Sample Declaration

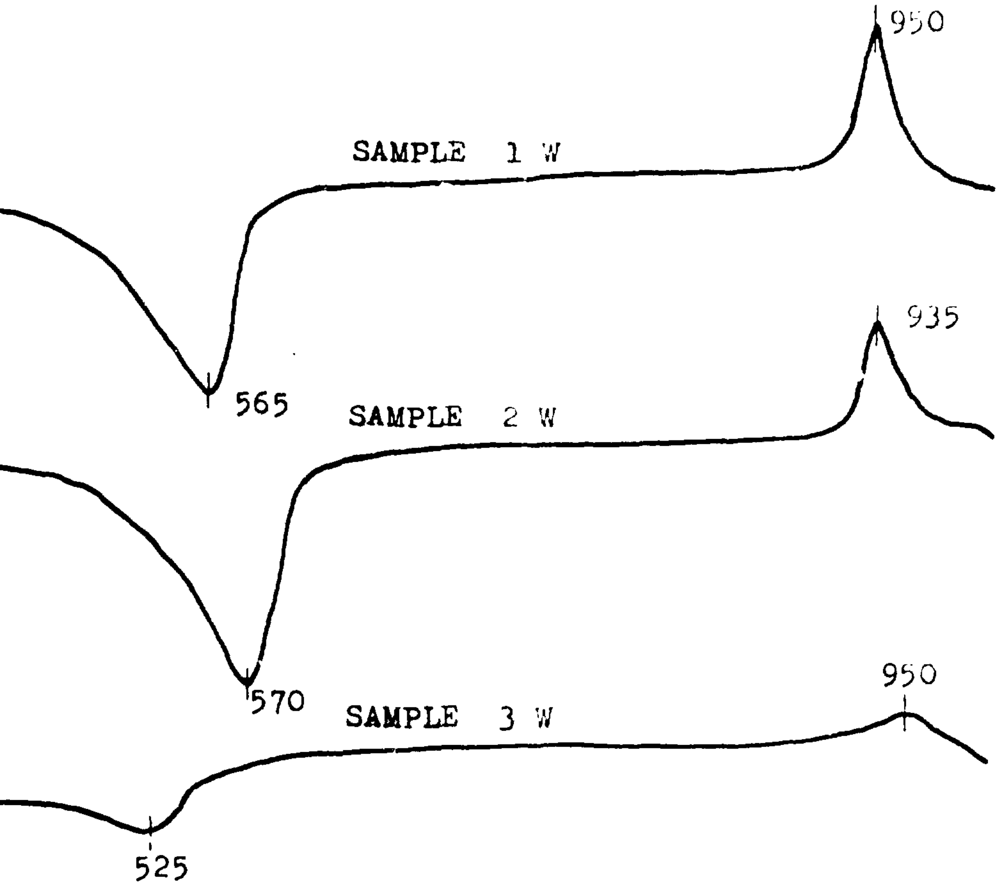
Deposit	Sample	Description	Labelling of upgraded samples	
			grain fraction under 0.06 mm	grain fraction under 0.15 mm
Montagne Posée Road	1	red clay	1 U	1 W
	2	yellow clay	2 U	2 W
	3	lateritic soil	3 U	3 W
Val d'Endor Estate	5	white clay	5 U	5 W
	6	yellow clay	-	6 W
	7	grey clay	-	7 W
	8	grey clay	-	8 W
La Gogue	9	brown clay	-	9 W
	10	yellow clay	-	10 W
	11	red clay	-	11 W
Anse Soleil Road	4	yellow clay	4 U	4 W
	13	yellow clay	13 U	13 W
	14	brown clay	14 U	14 W

GRAPH 1

DIFFERENTIAL THERMAL ANALYSIS

MONTAGNE POSÉE ROAD

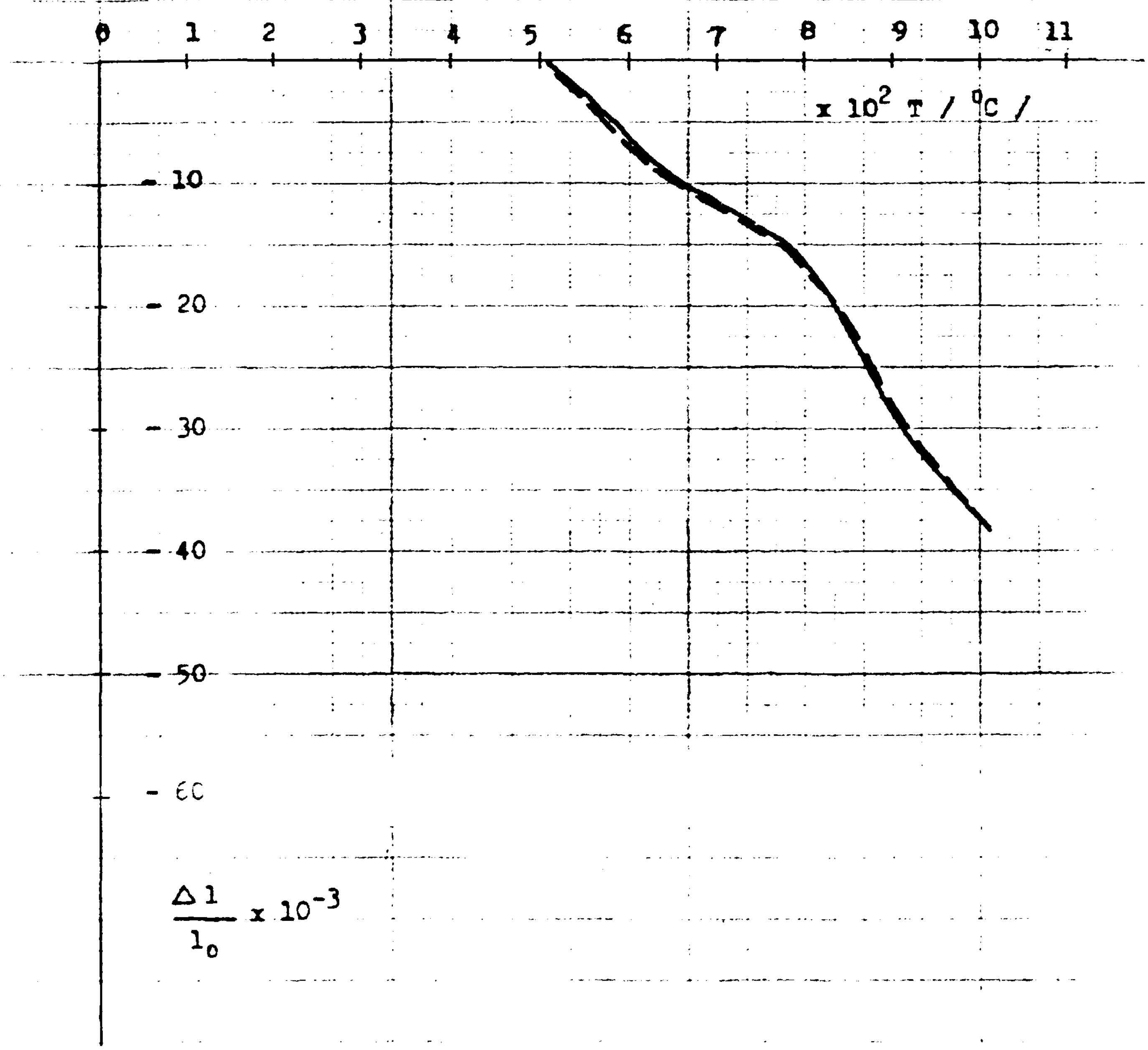



950
SAMPLE 1 W
565
935
SAMPLE 2 W
570
950
SAMPLE 3 W
525

GRAPH 2

CONTRACTION - DILATATION THERMAL ANALYSIS

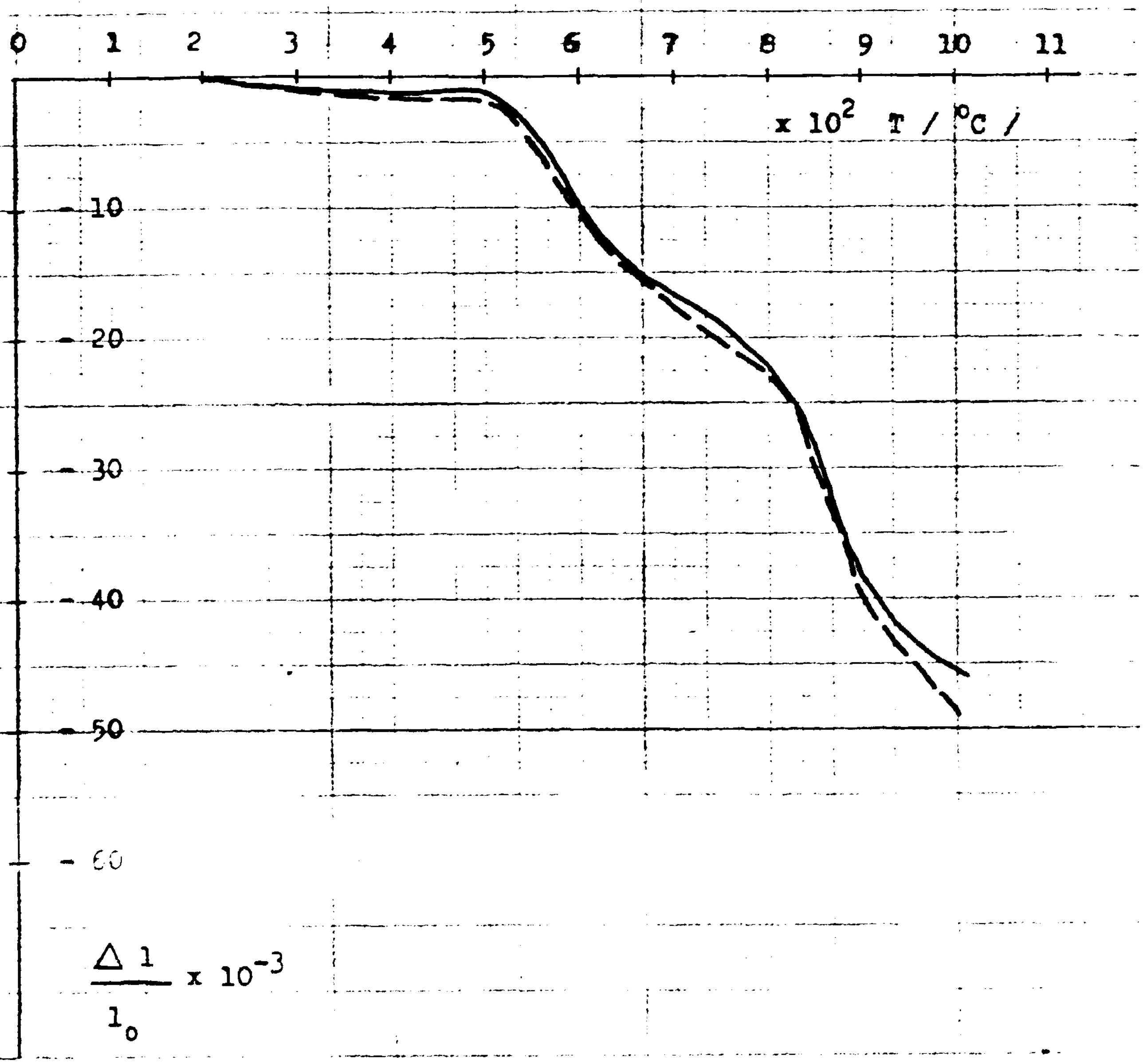
SAMPLE 1 U

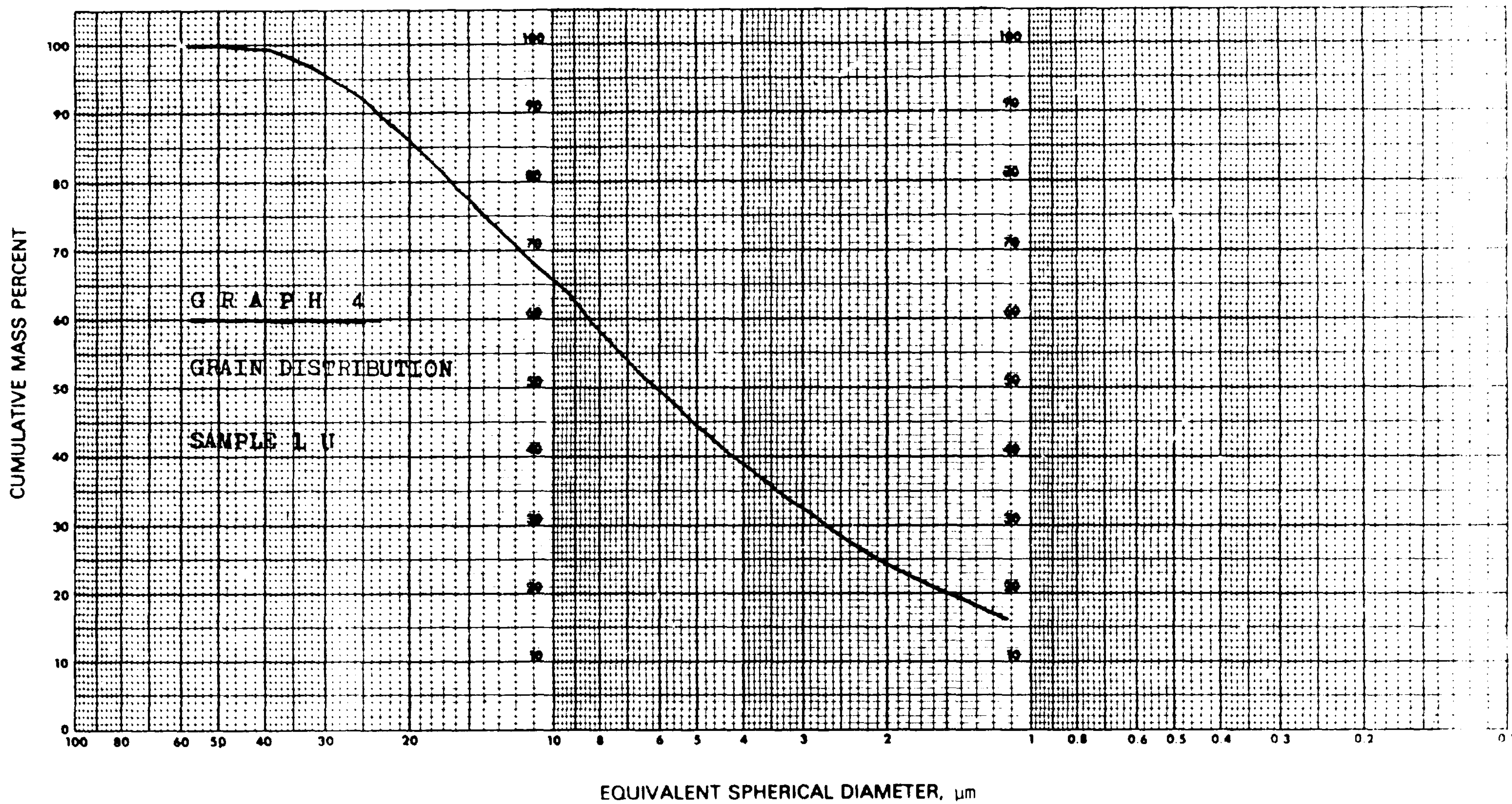


G R A P H 3

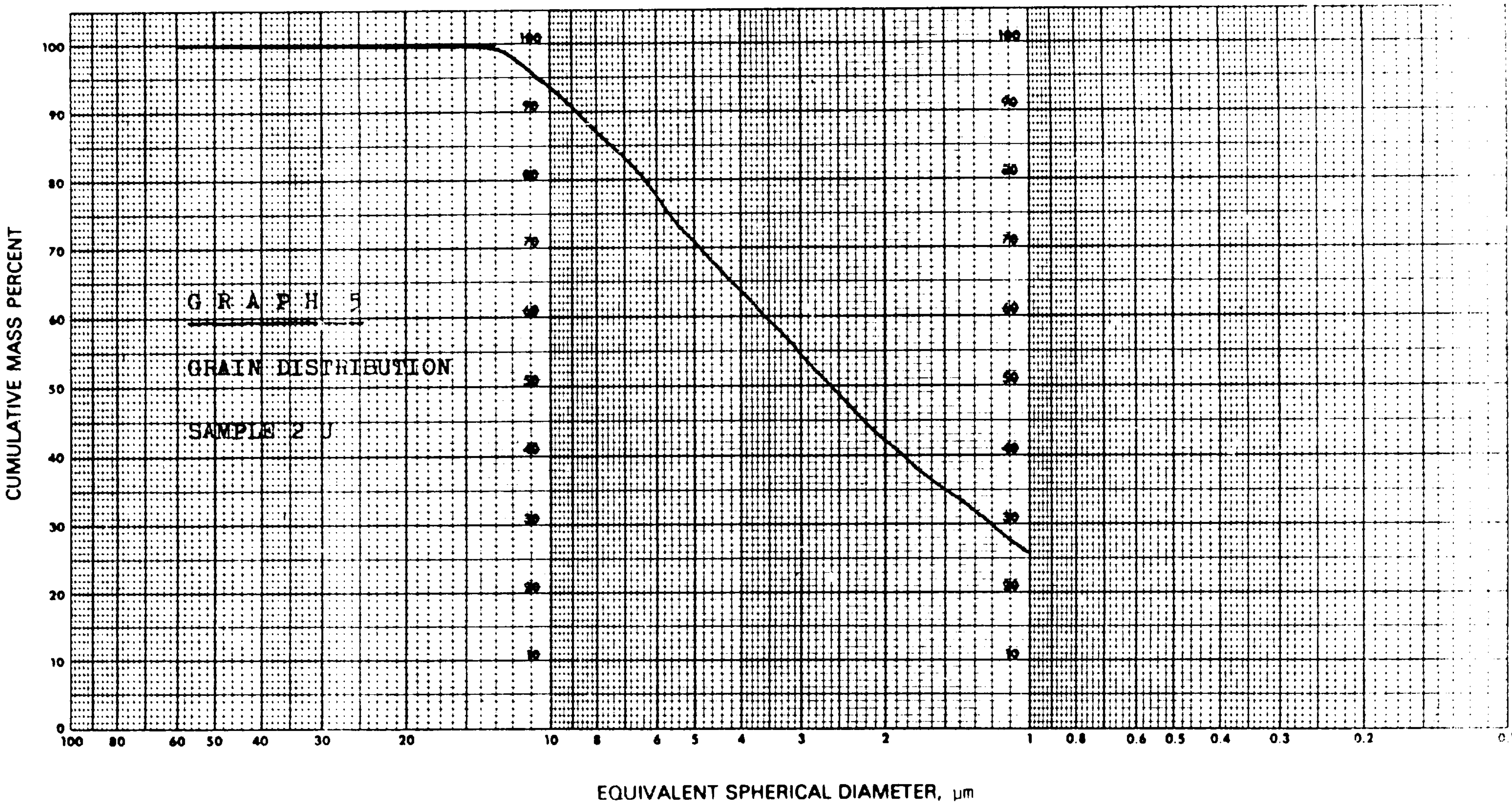
CONTRACTION - DILATATION THERMAL ANALYSIS

SAMPLE 2 U

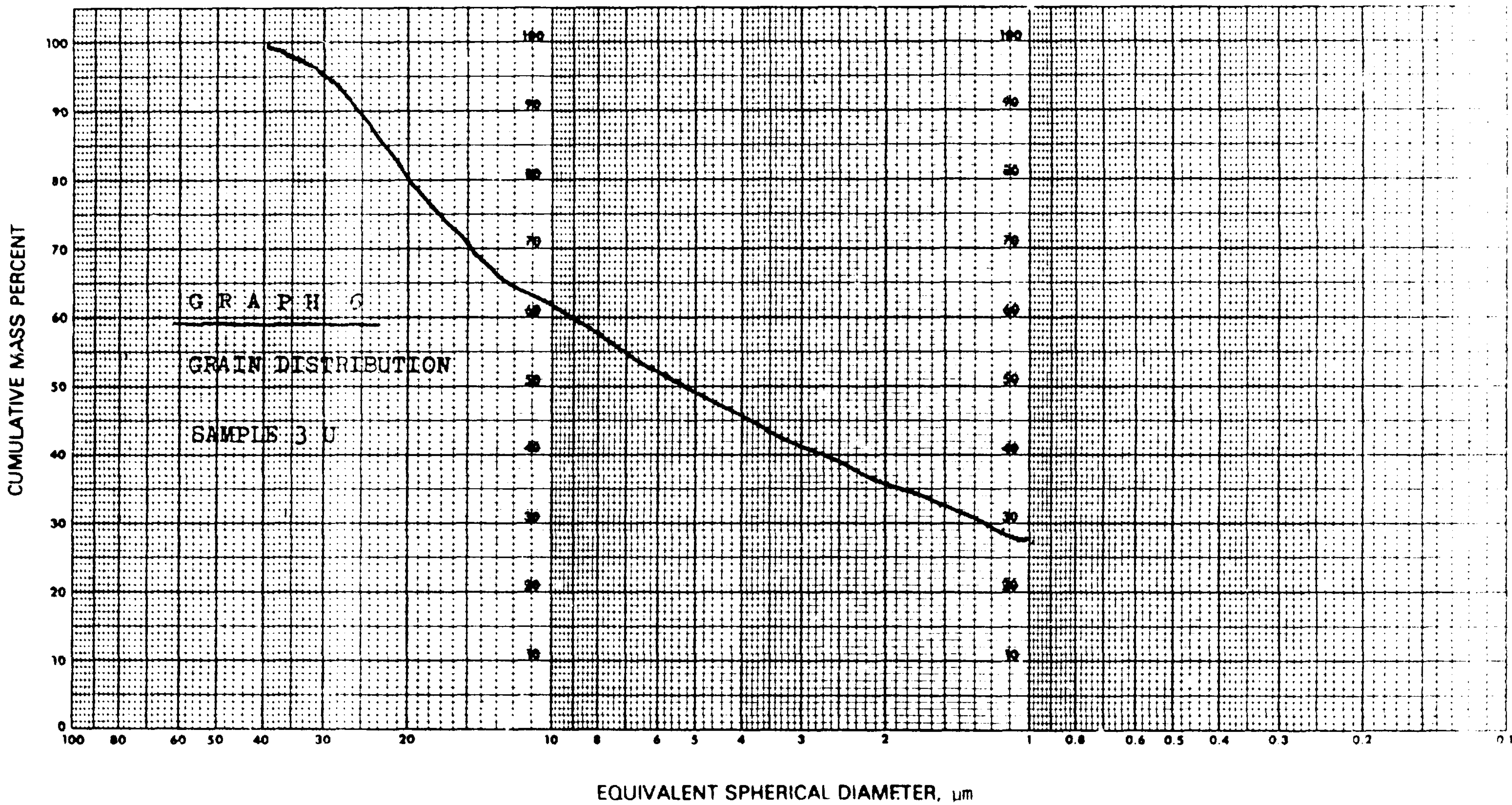




micromeritics
instrument corporation



micromeritics
instrument corporation

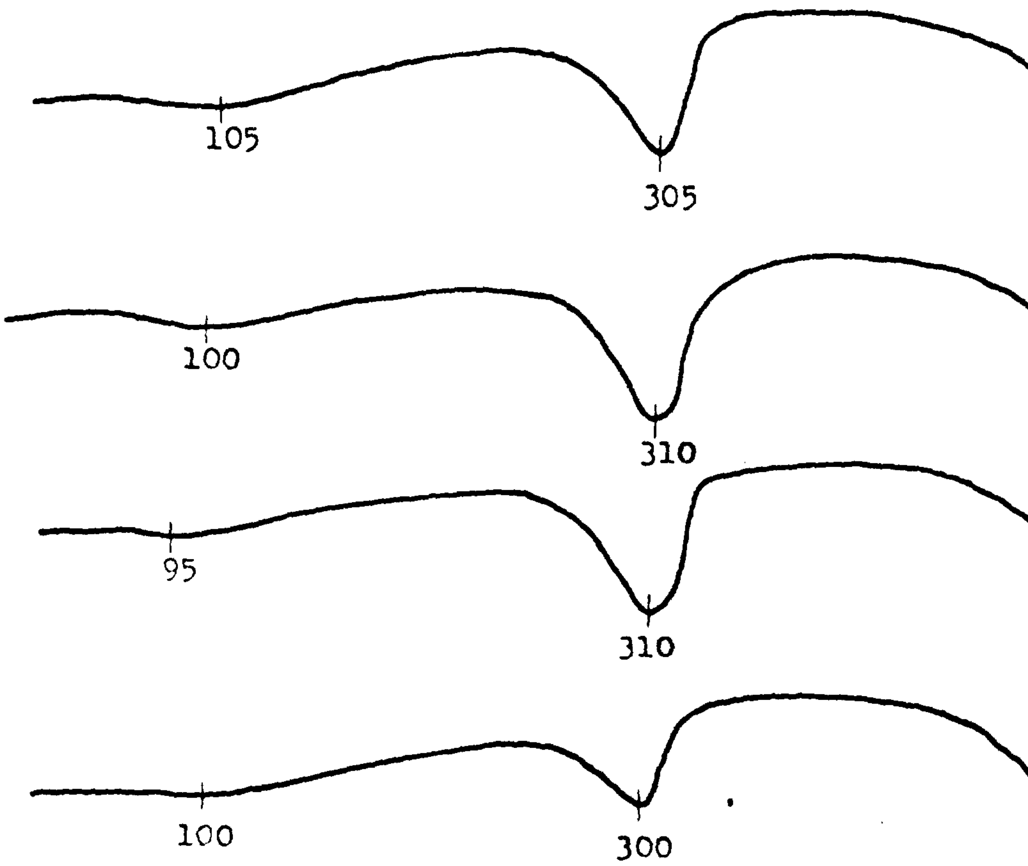


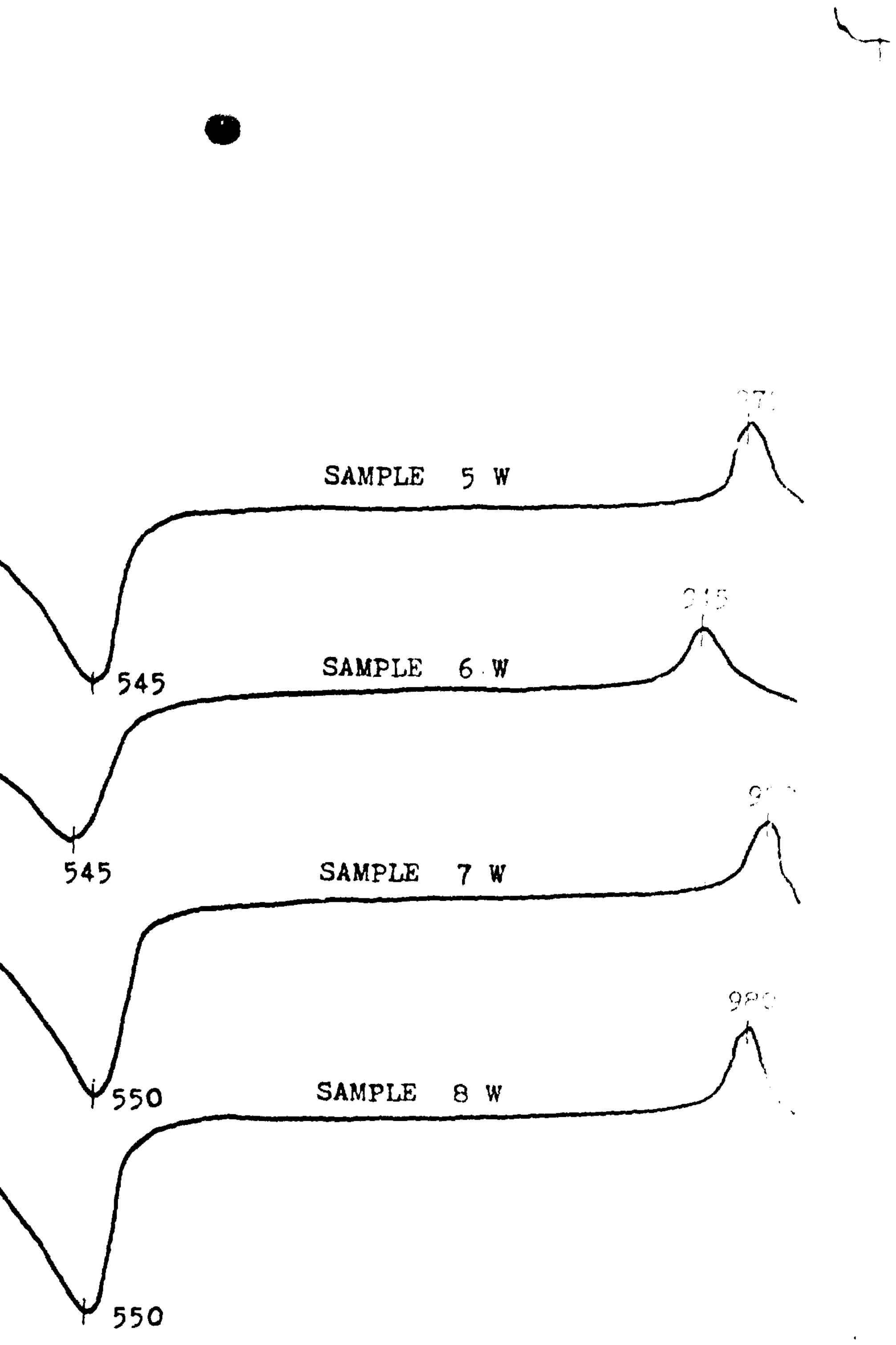
micromeritics instrument corporation

G R A P H 7

DIFFERENTIAL THERMAL ANALYSIS

VAL D'ENDOR ESTATE

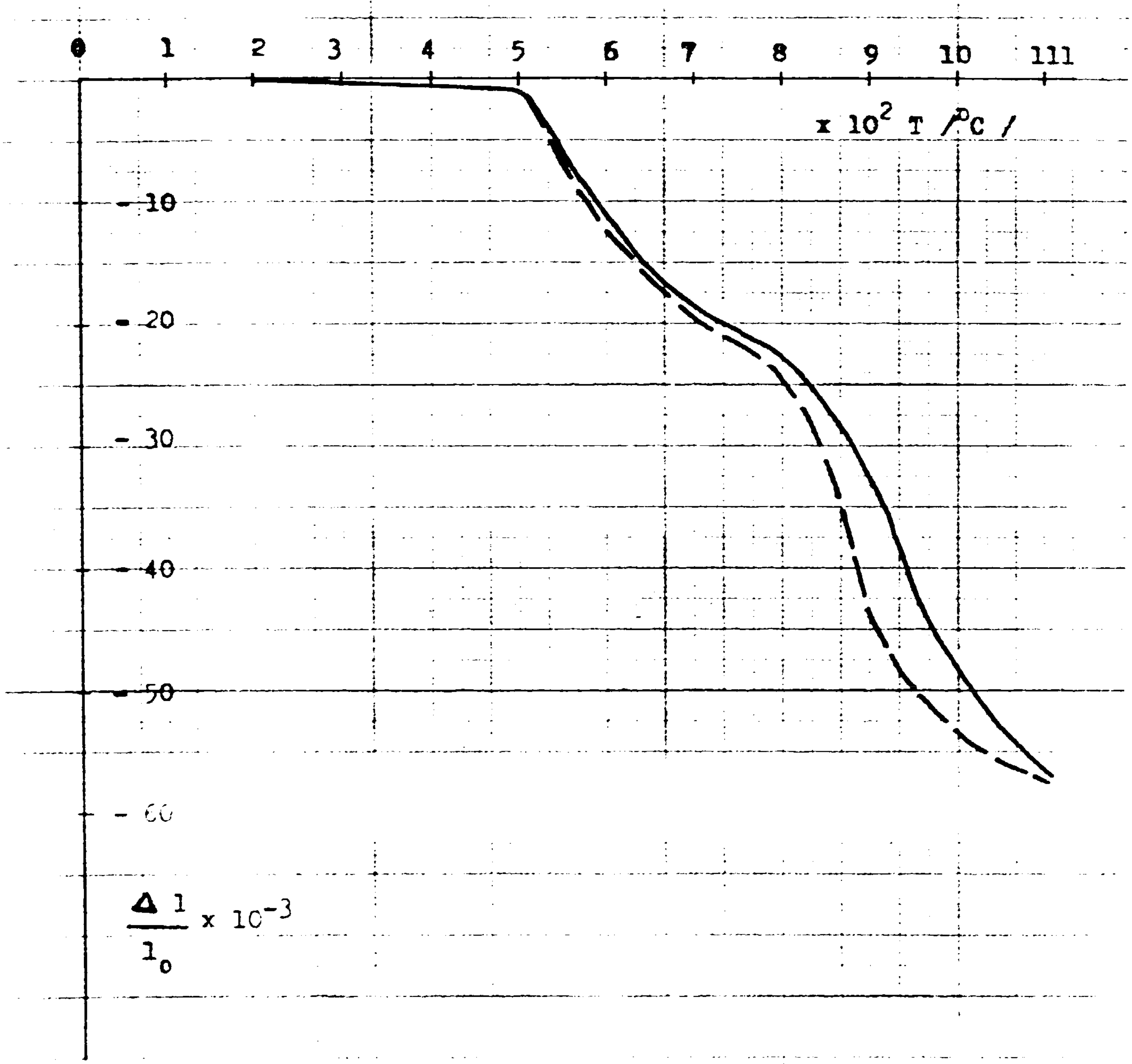



SAMPLE 5 W
545
SAMPLE 6 W
545
SAMPLE 7 W
550
SAMPLE 8 W
550

GRAPH 8

CONTRACTION - DILATATION THERMAL ANALYSIS

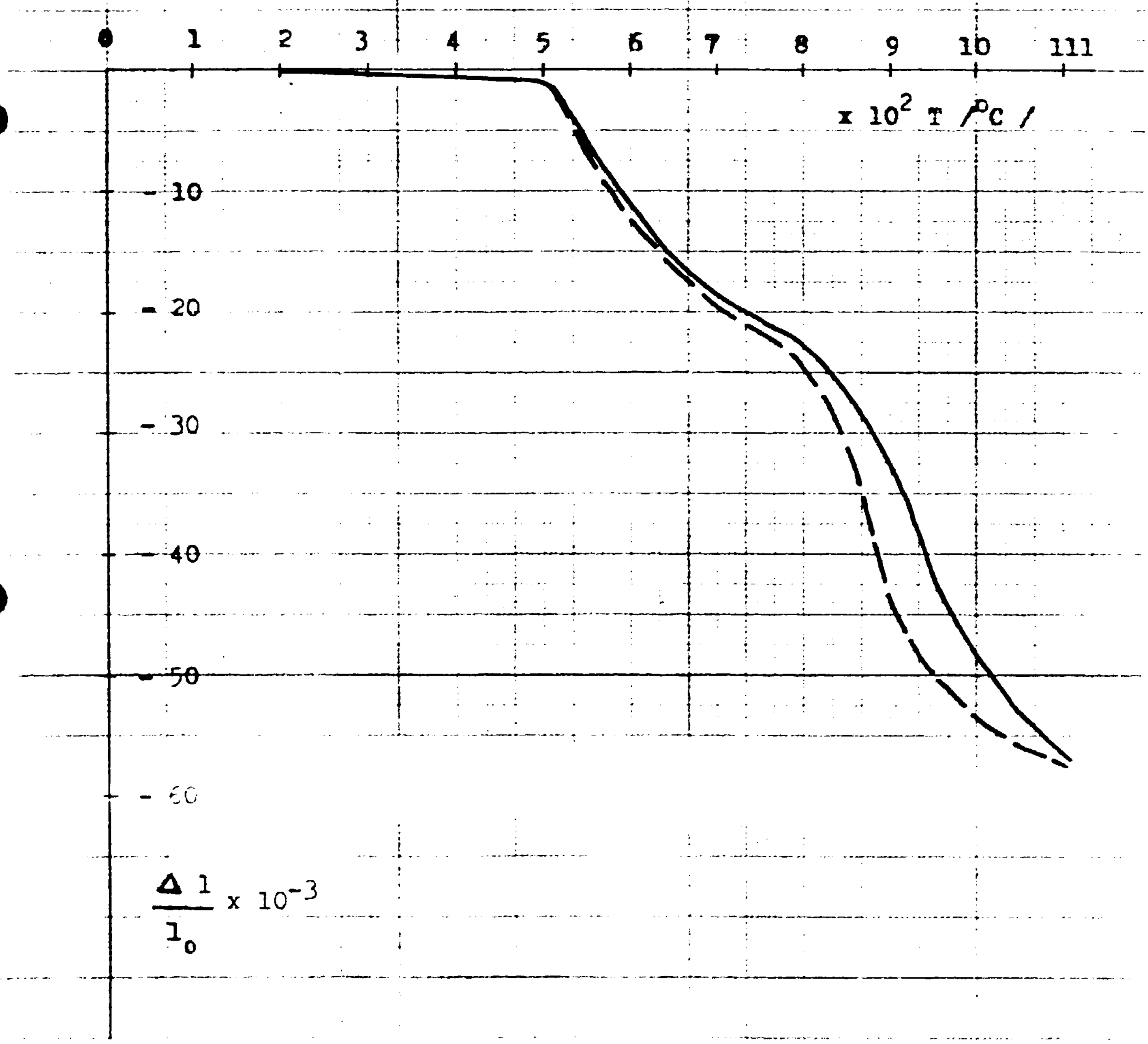
SAMPLE 5 U

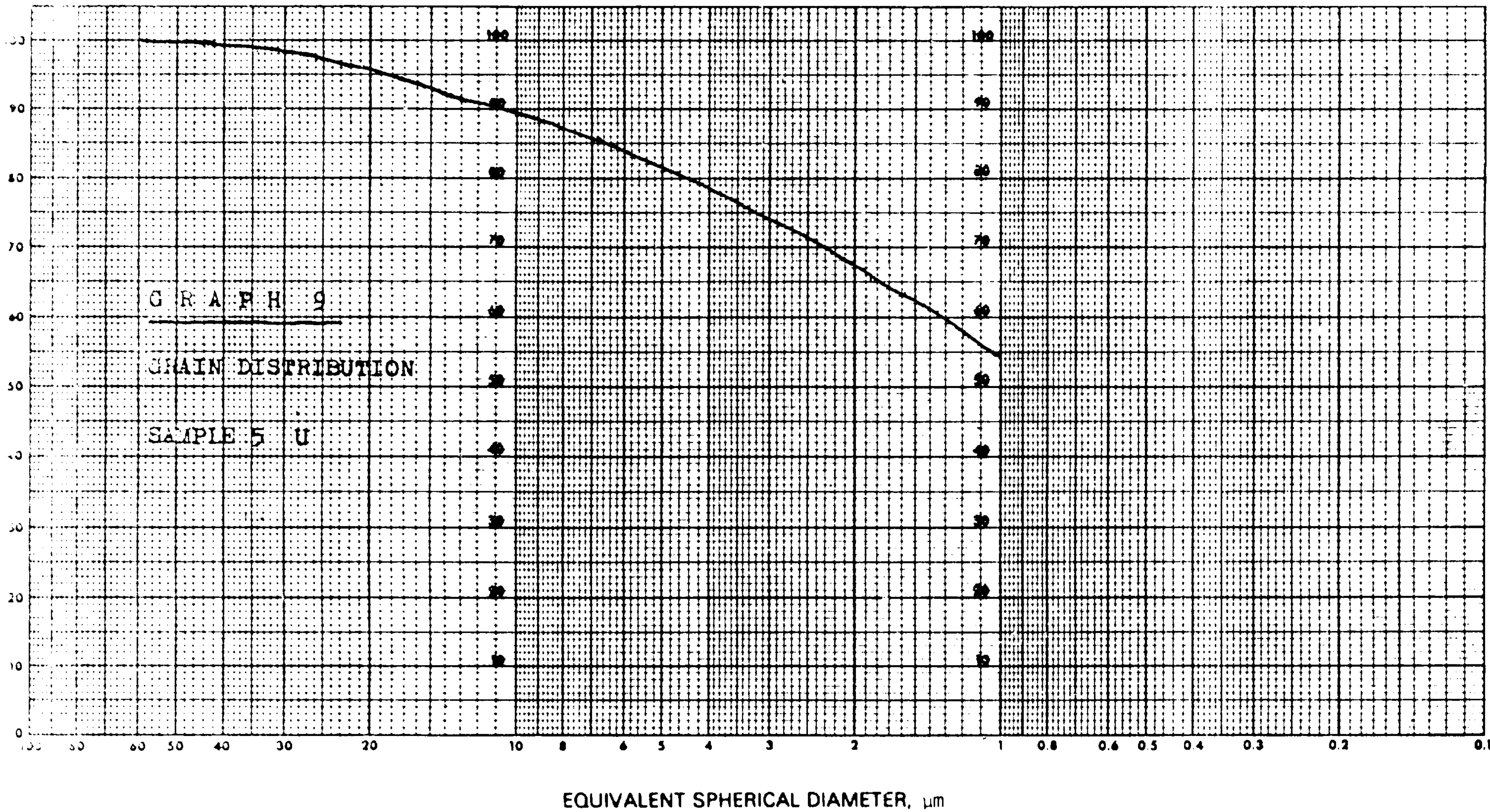


GRAPH 8

CONTRACTION - DILATATION THERMAL ANALYSIS

SAMPLE 5 U



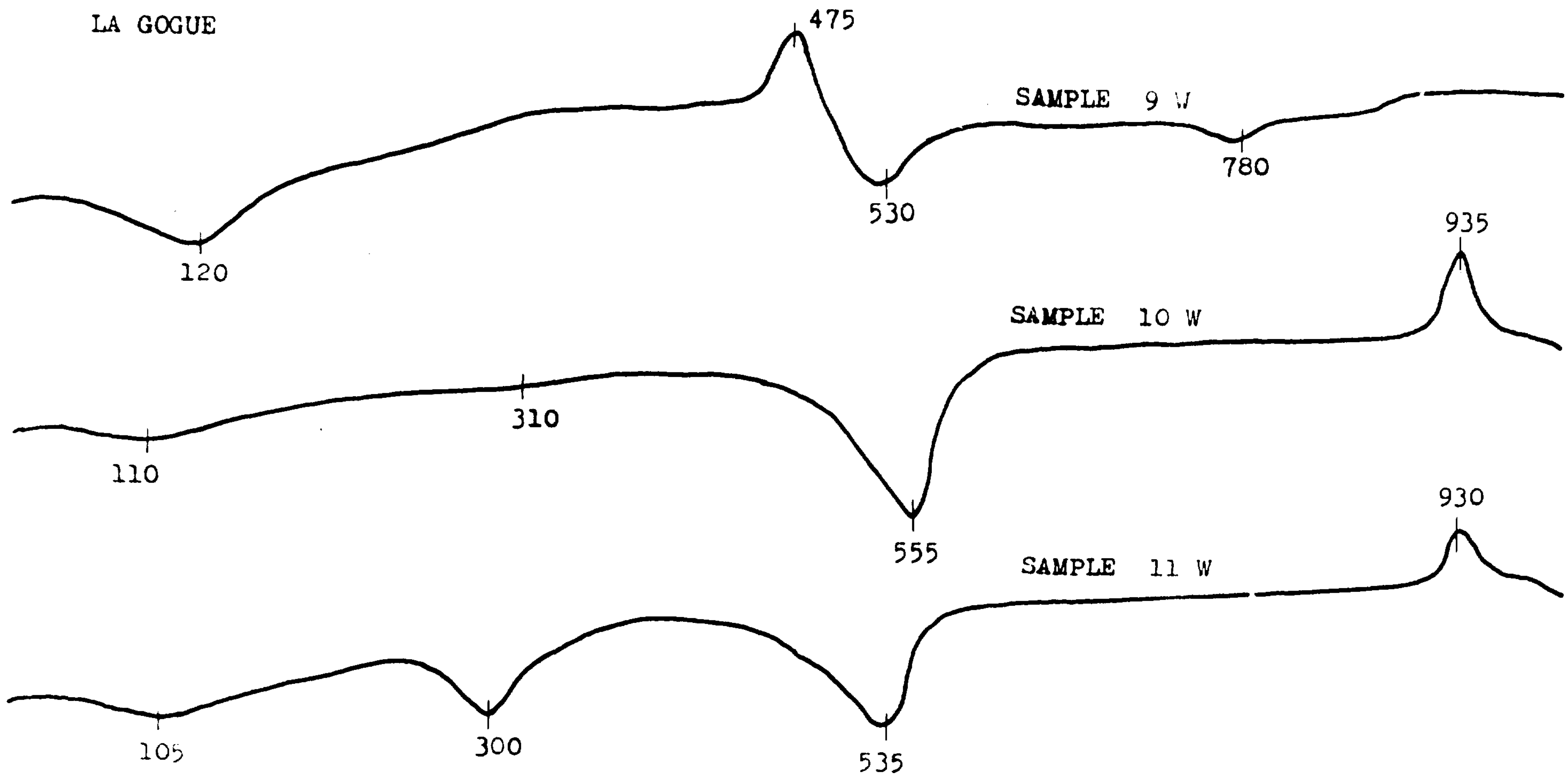


micromeritics
instrument corporation

G R A P H 10

DIFFERENTIAL THERMAL ANALYSIS

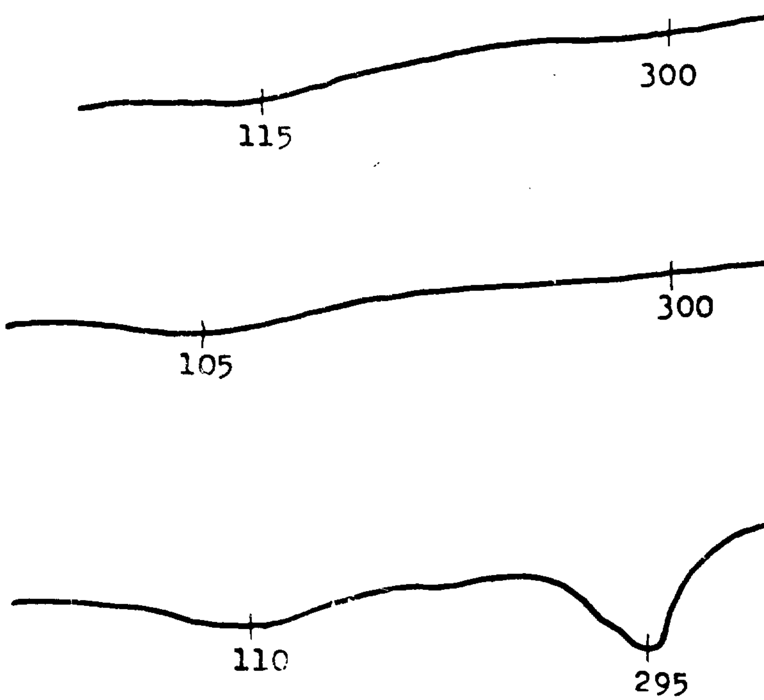
LA GOGUE

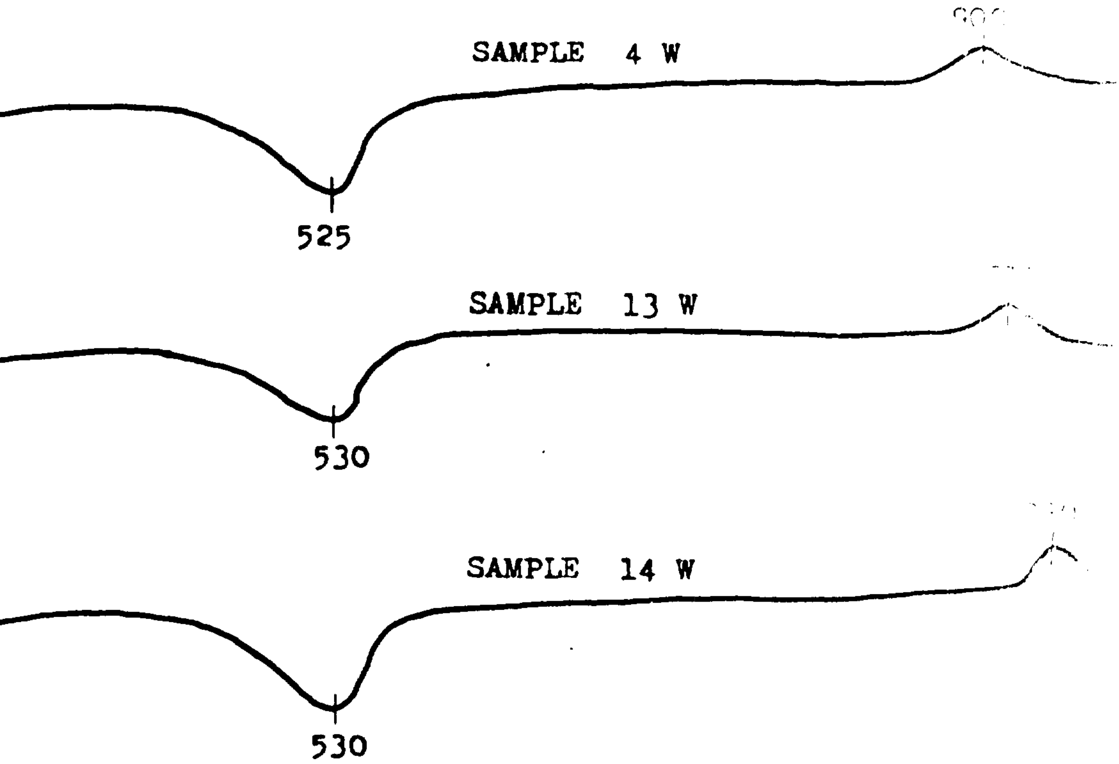


GRAPH 11

DIFFERENTIAL THERMAL ANALYSIS

ANSE SOLEIL ROAD

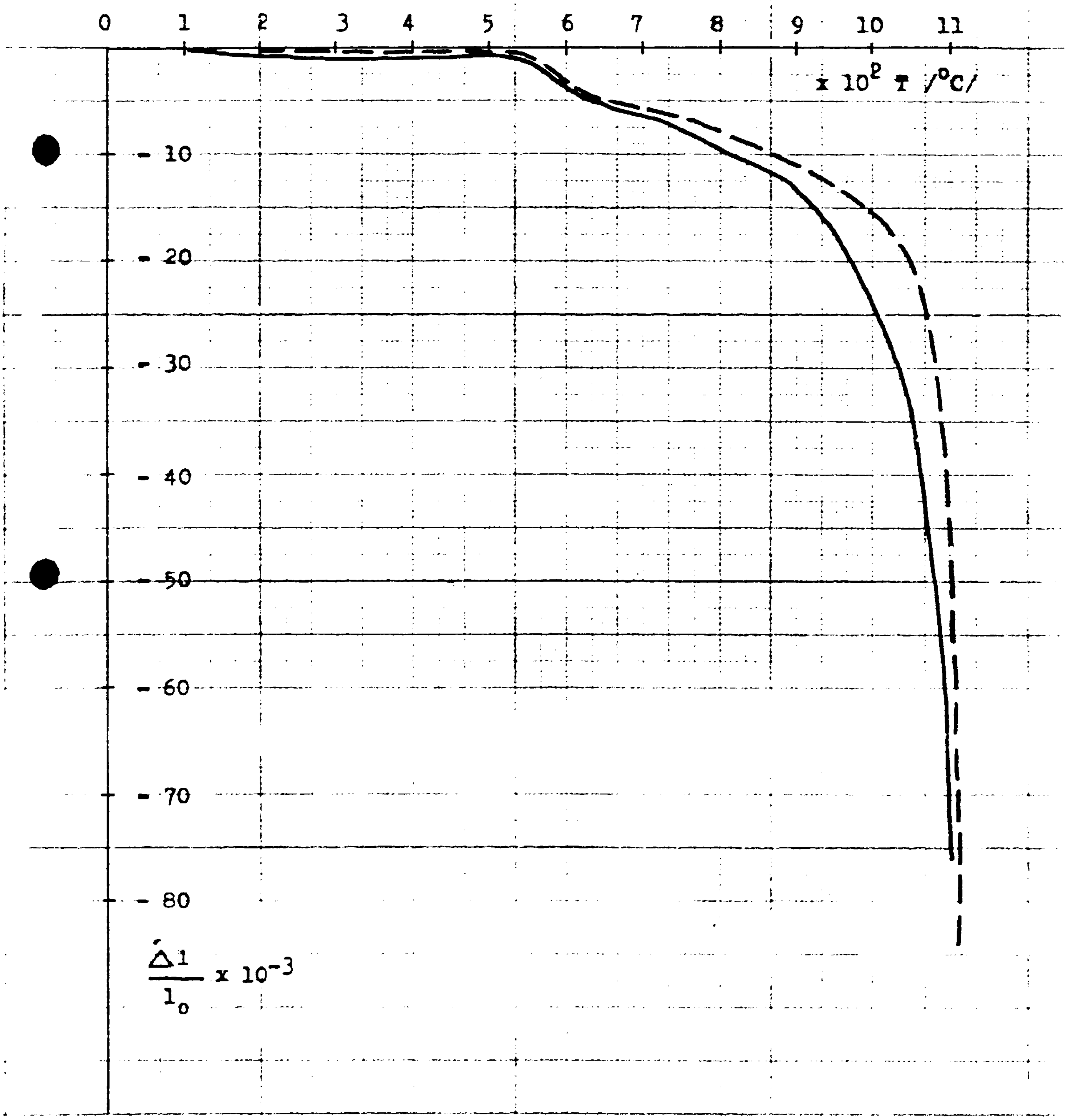


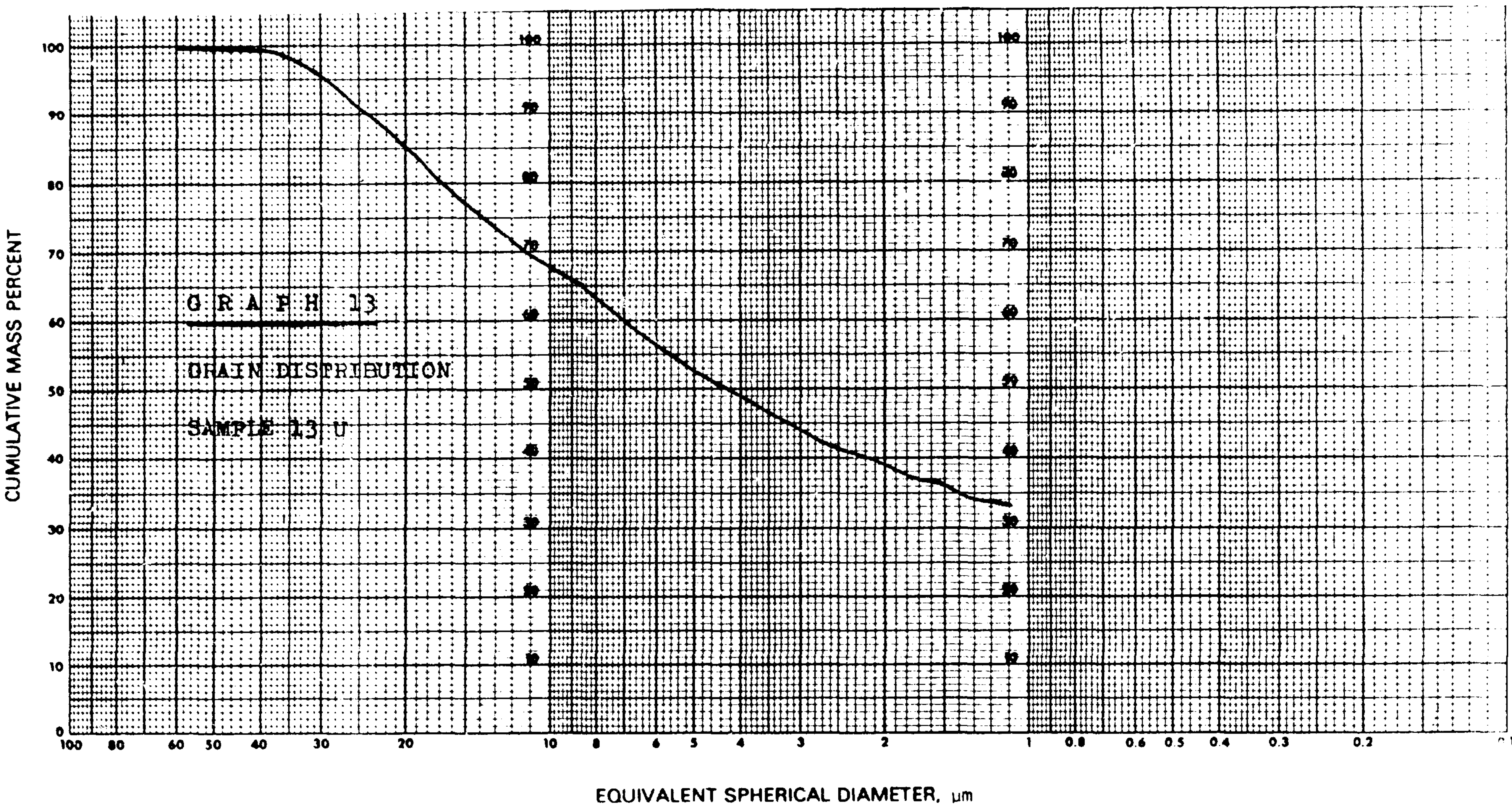

SAMPLE 4 W
525
SAMPLE 13 W
530
SAMPLE 14 W
530

GRAPH 12

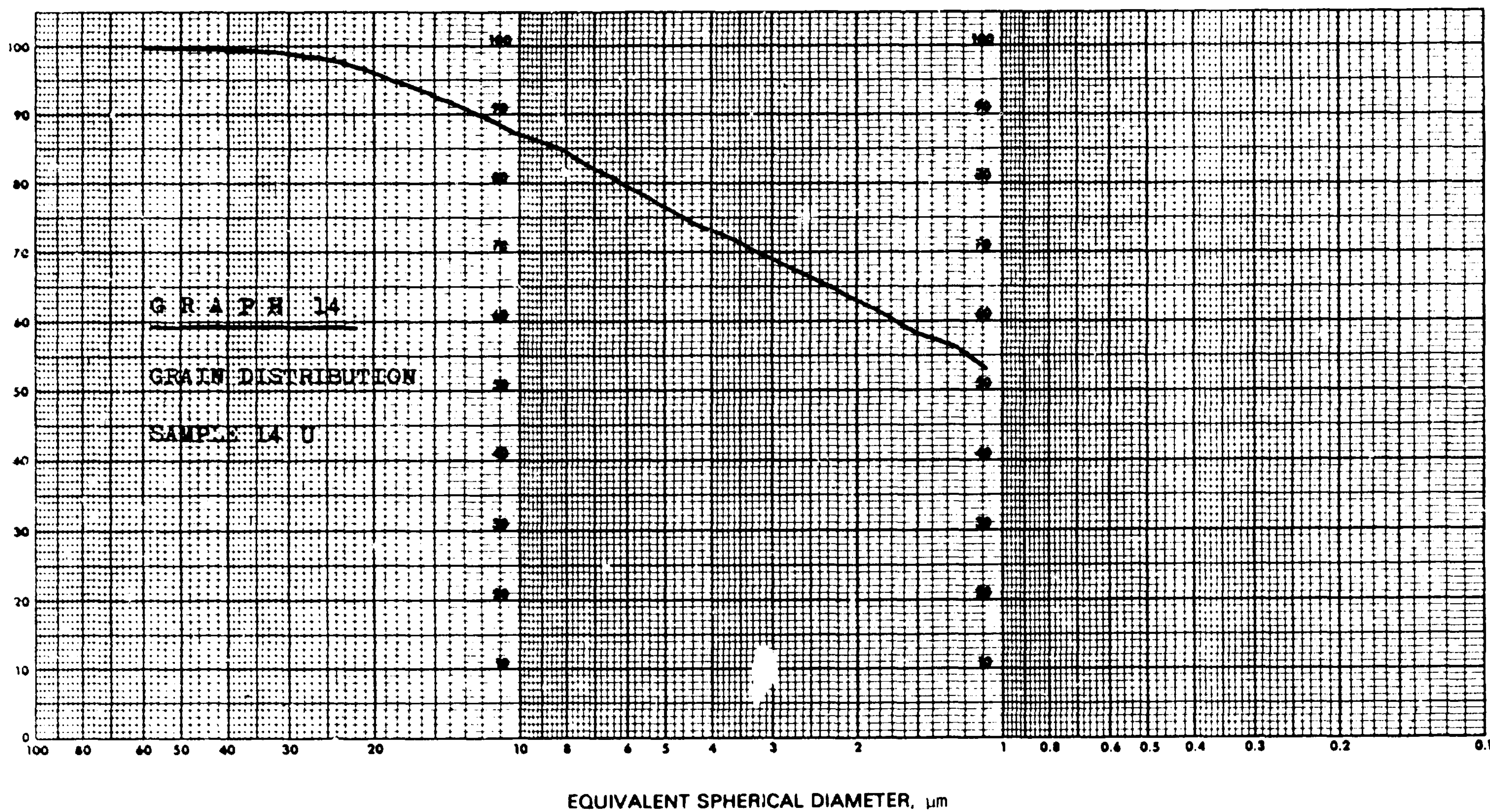
CONTRACTION - DILATATION THERMAL ANALYSIS

SAMPLE 13 U





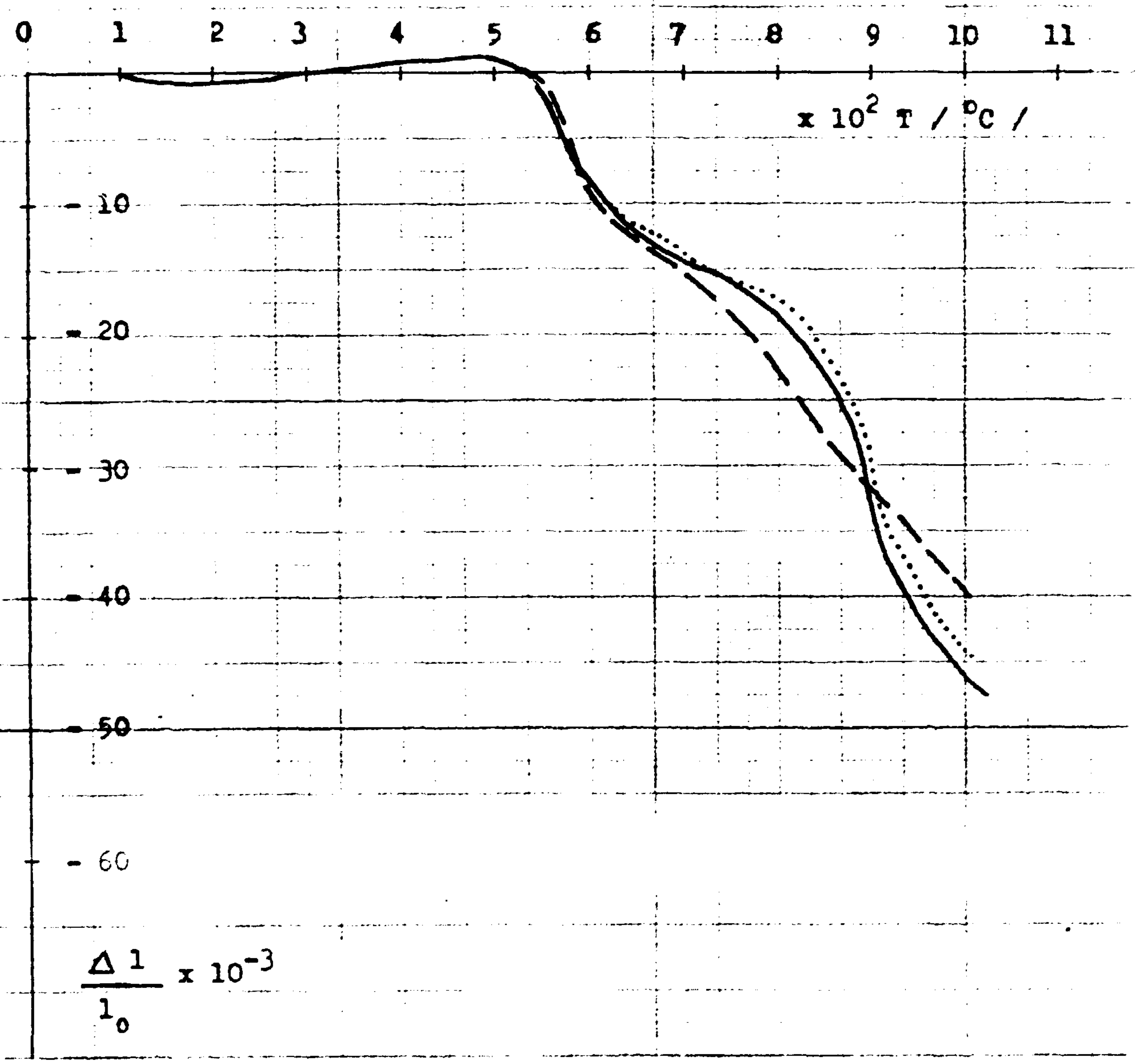
micromeritics
instrument corporation


GRAPH 14
GRAIN DISTRIBUTION
SAMPLE 14 U
100
90
80
70
60
50
40
30
20
10
0
100 80 60 50 40 30 20 10 8 6 5 4 3 2 1 0.8 0.6 0.5 0.4 0.3 0.2 0.1
EQUIVALENT SPHERICAL DIAMETER, μm
micromeritics instrument corporation

GRAPH 15

CONTRACTION - DILATATION THERMAL ANALYSIS

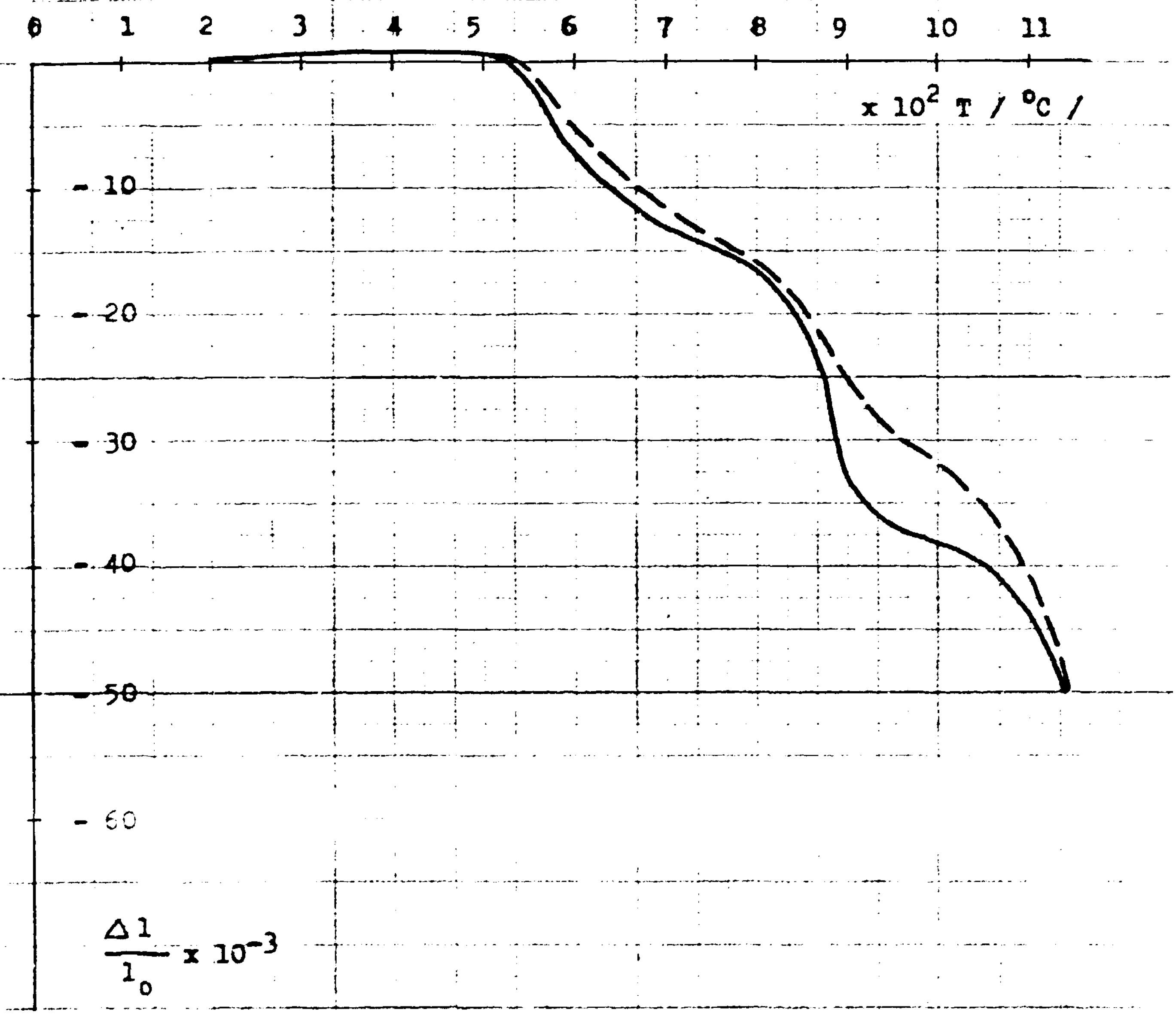
BLEND A



GRAPH 16

CONTRACTION - DILATATION THERMAL ANALYSIS

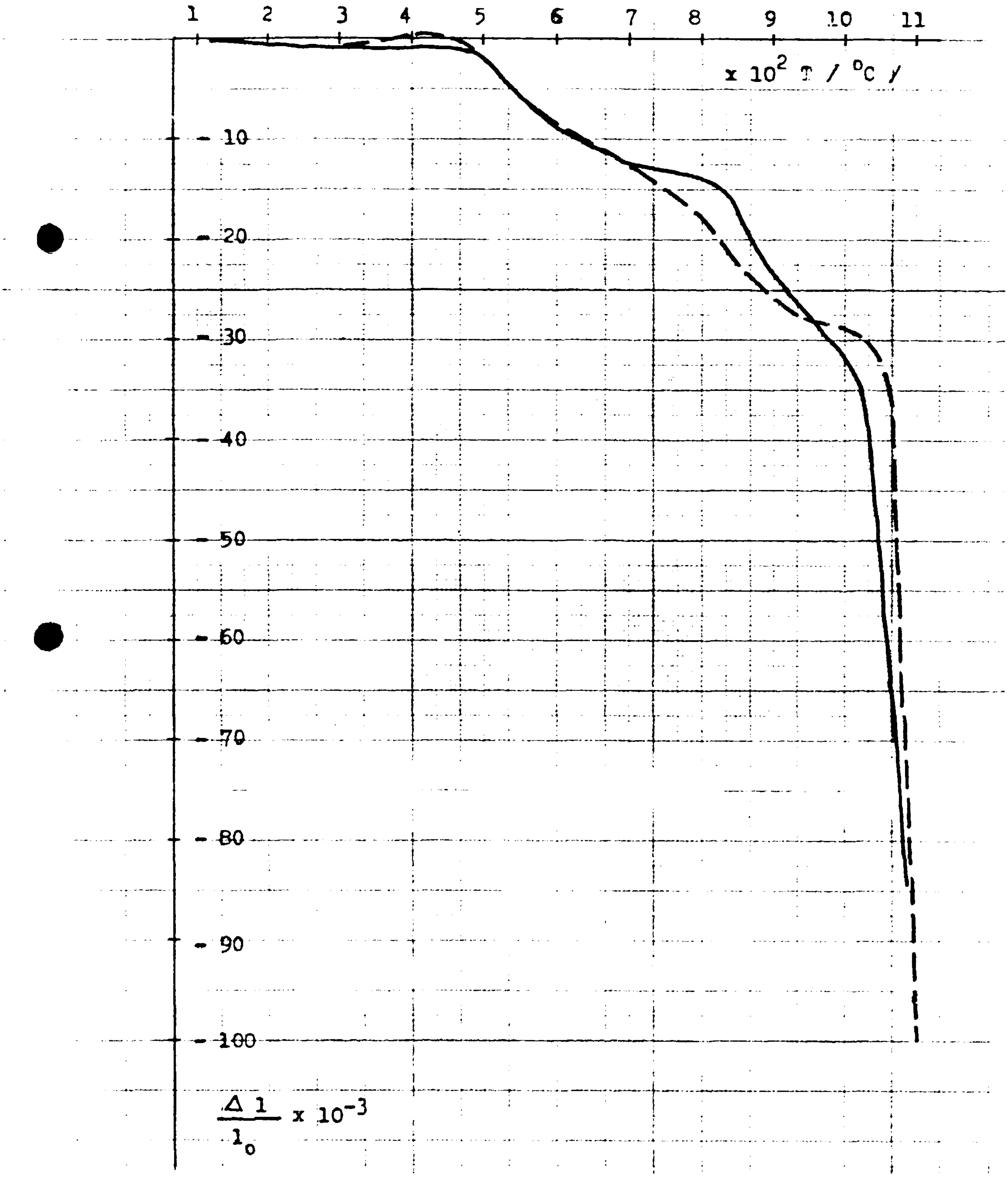
BLEND B



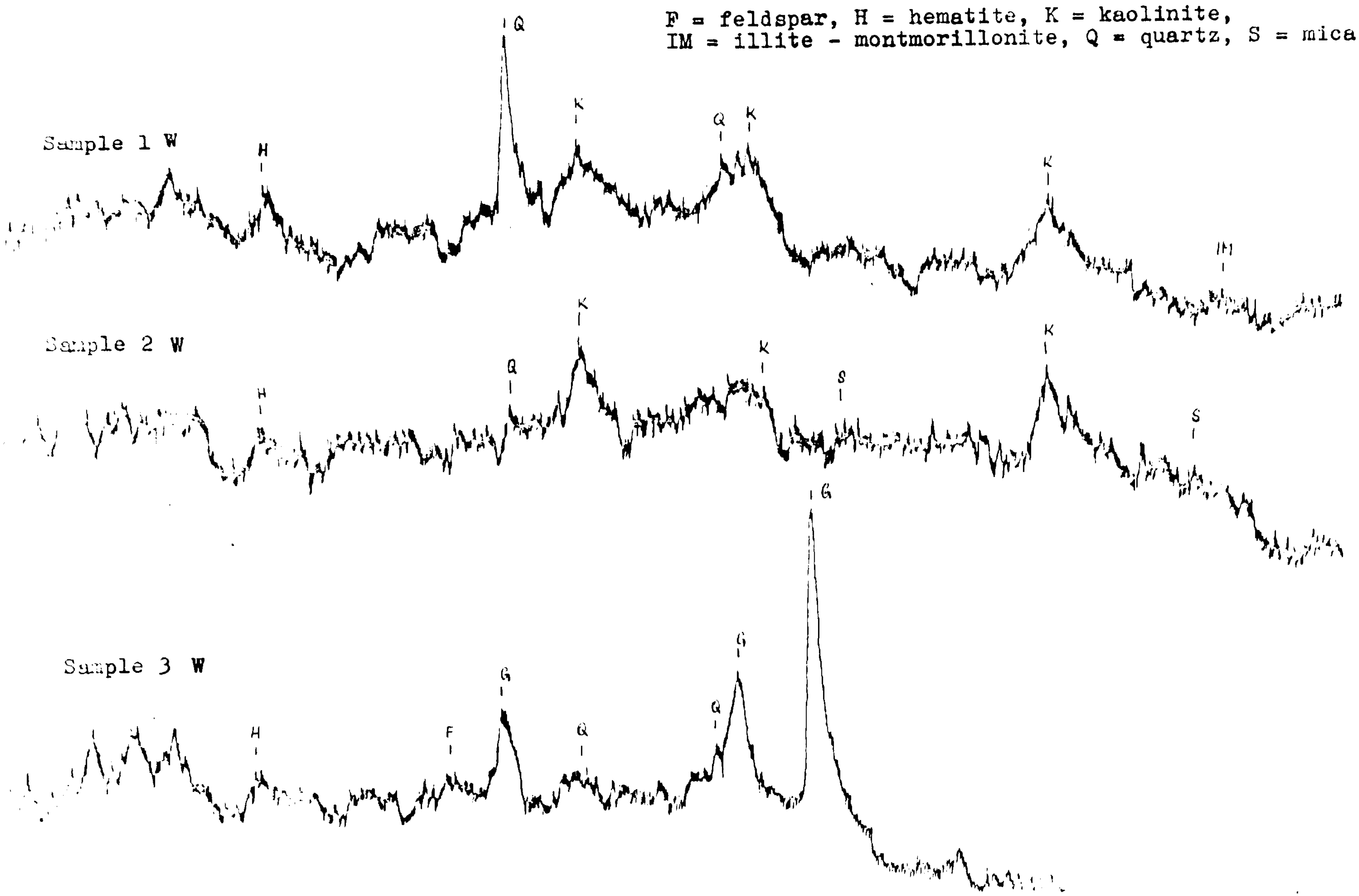
GRAPH 17

CONTRACTION - DILATATION THERMAL ANALYSIS

BLEND C

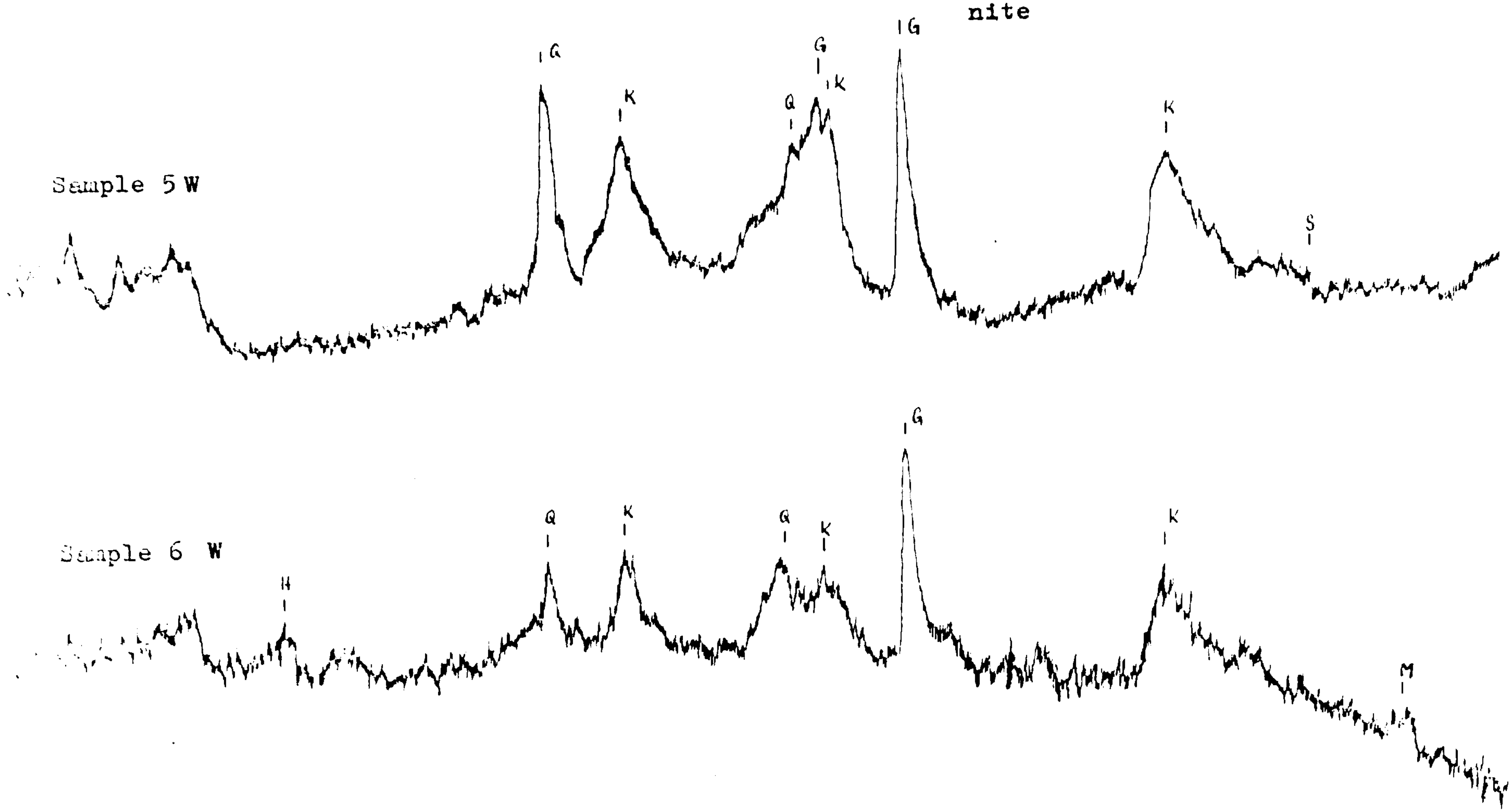


Graph 18 <u>X-ray photographs of Samples 1W,2W,3W</u>



Graph 19 X-ray photographs of Samples 5W, 6W

Q = quartz, K = kaolinite, G = gibbsite, S = mica, H = hematite, M = montmorillonite

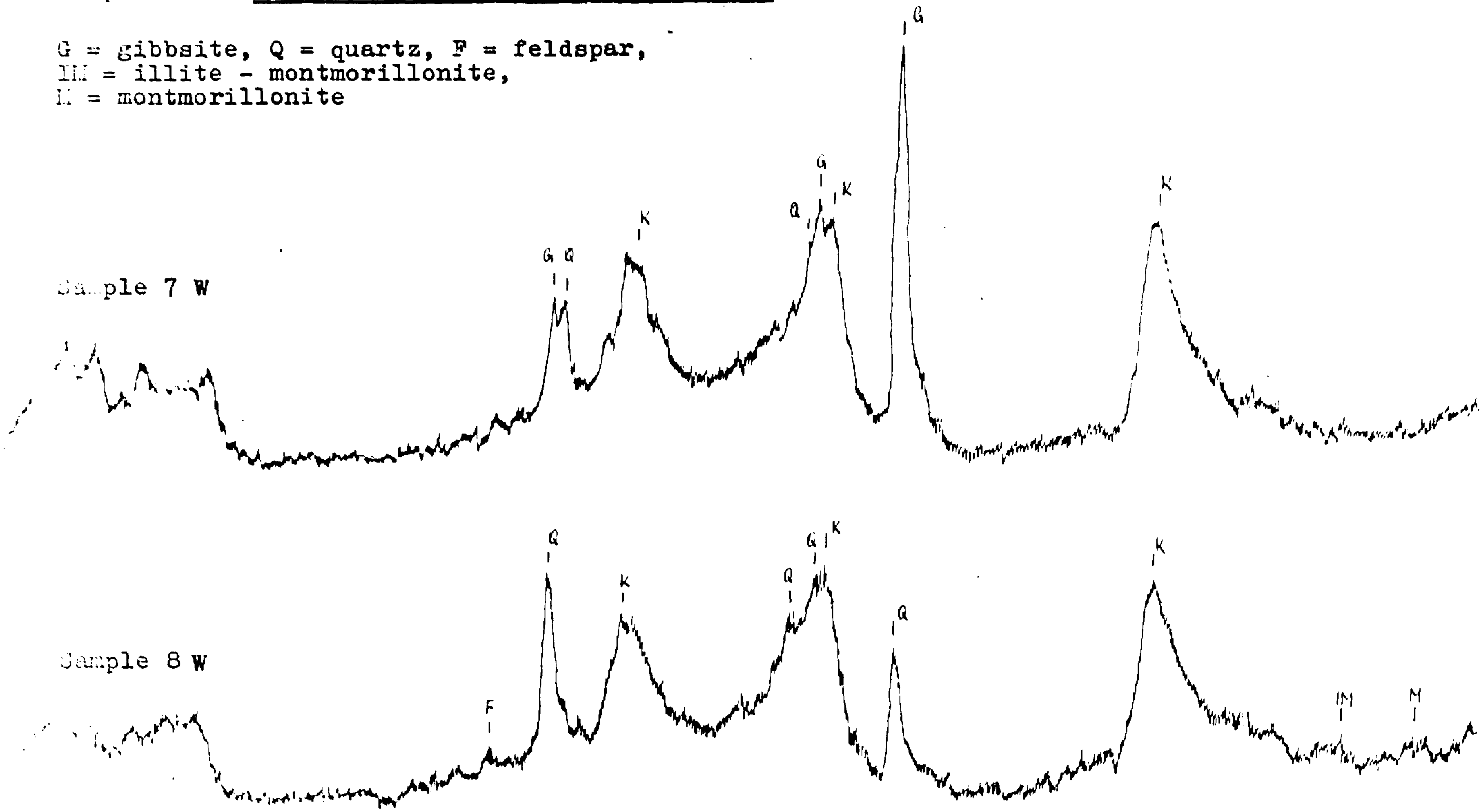


Graph 20 <u>X-ray photographs of Samples 7W,8W</u>

G = gibbsite, Q = quartz, F = feldspar,
IM = illite - montmorillonite,
M = montmorillonite

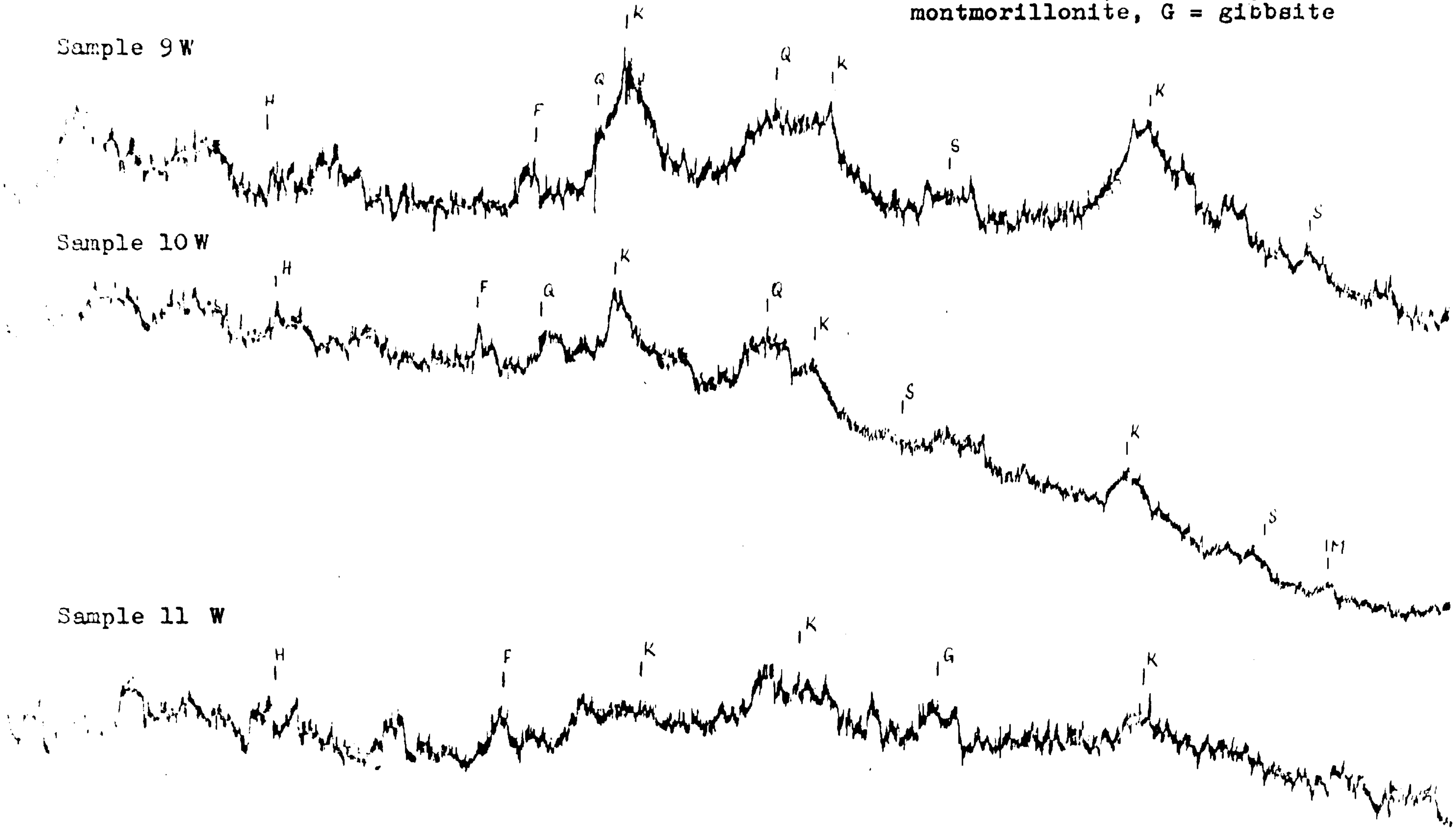
Sample 7 W

Sample 8 W



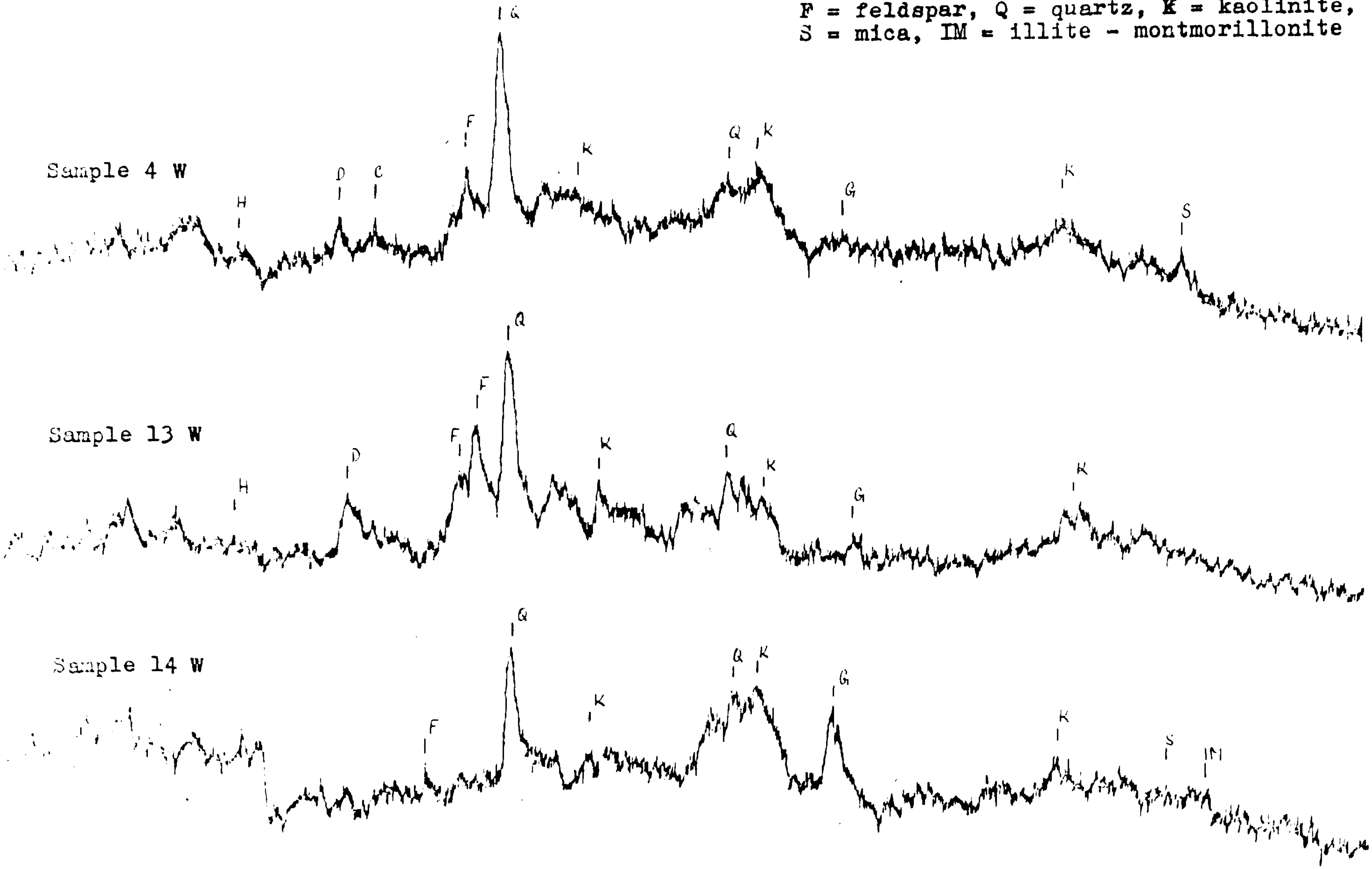
Graph 21 <u>X-ray photographs of Samples 9W,10W,11W</u>

H = hematite, F = feldspar, Q = quartz, K = kaolinite, S = mica, IM = illite - montmorillonite, G = gibbsite



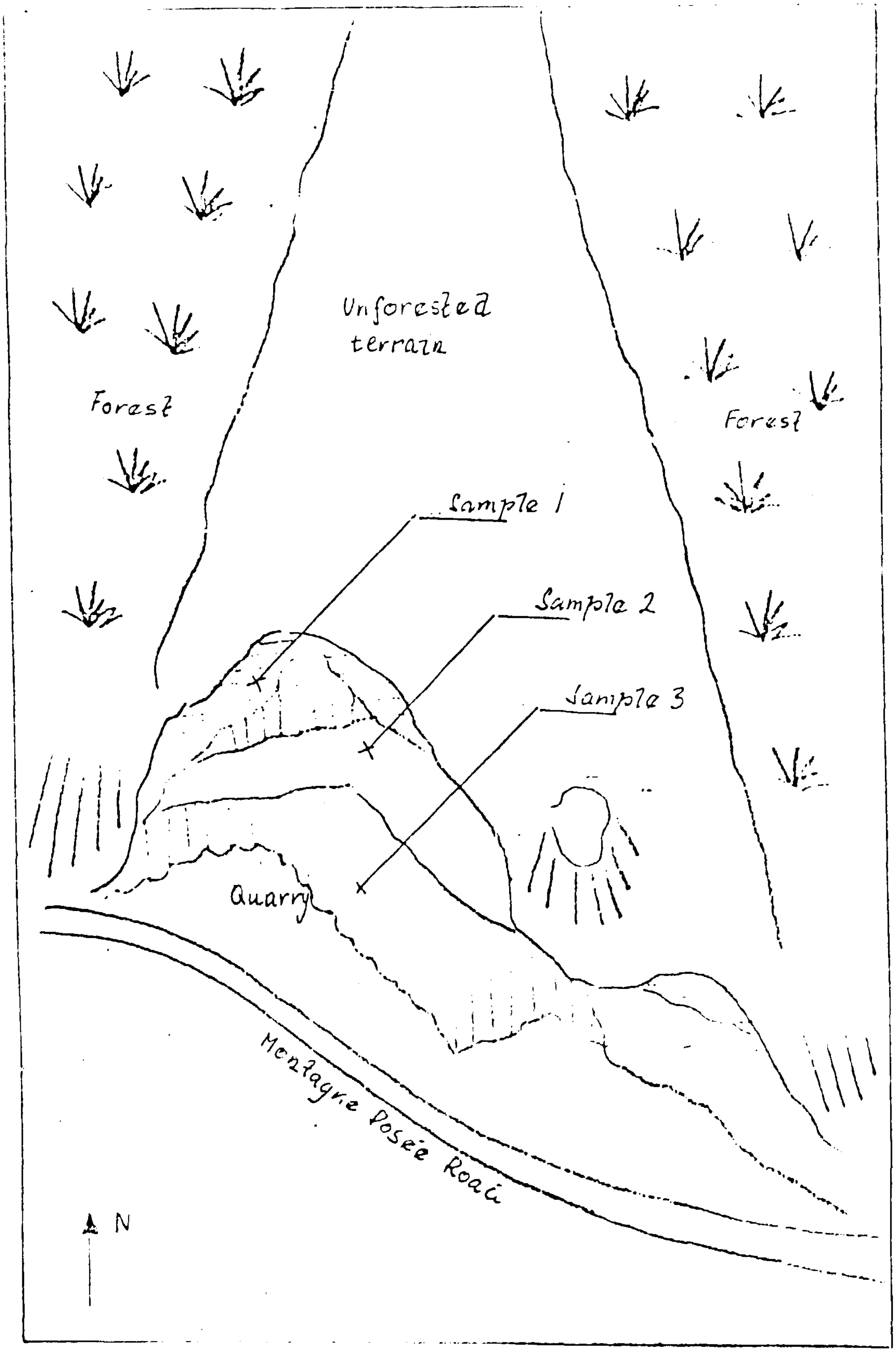
Graph 22 X-ray photographs of Samples 4W,13W,14W

H = hematite, D = dolomite, C = calcite,
F = feldspar, Q = quartz, K = kaolinite,
S = mica, IM = illite - montmorillonite



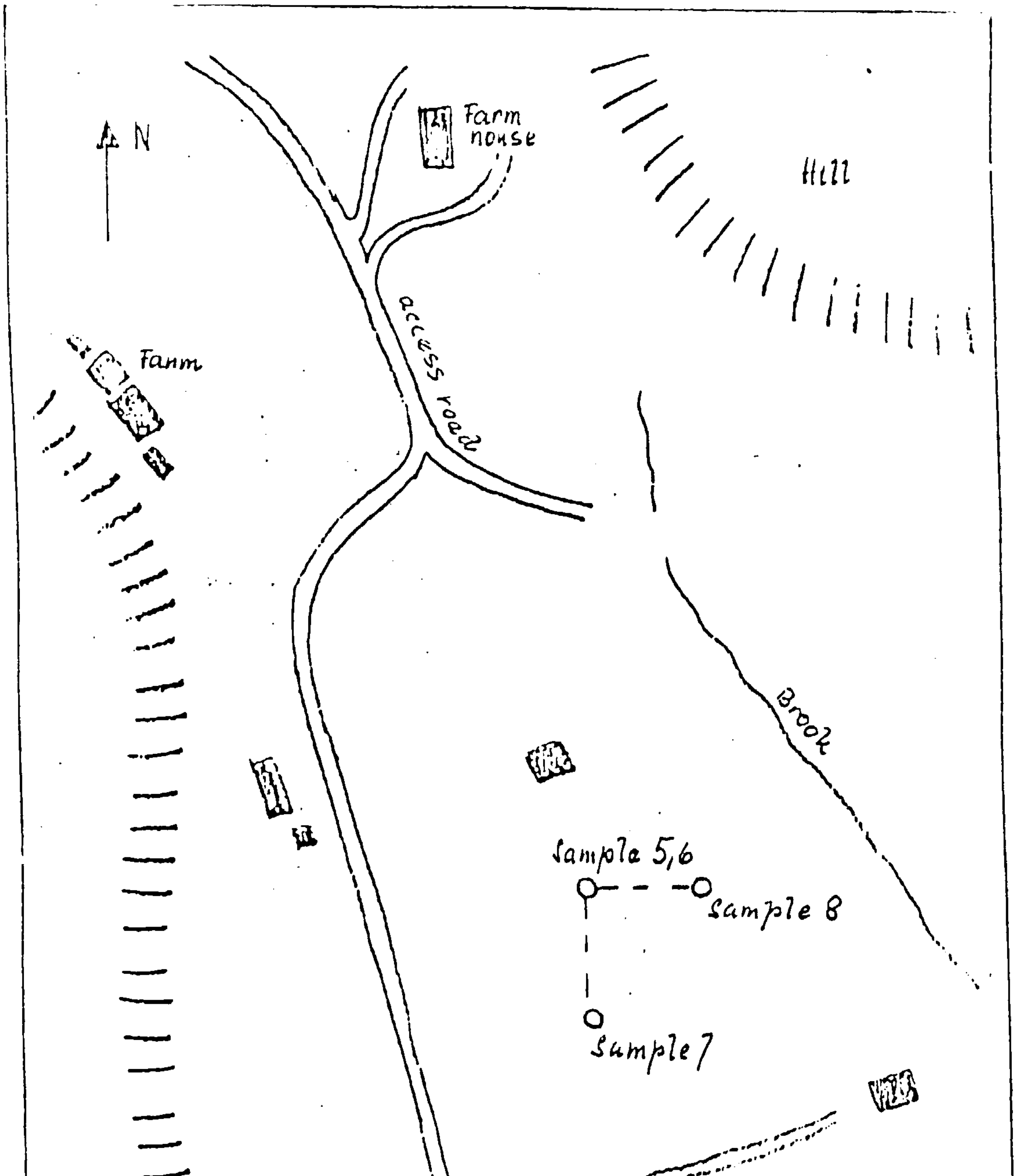
Picture 1 - Montagne Posée Road - Situation of Sample Takings

cadastre 3479 co-ordinates 343-344E, 799-798N



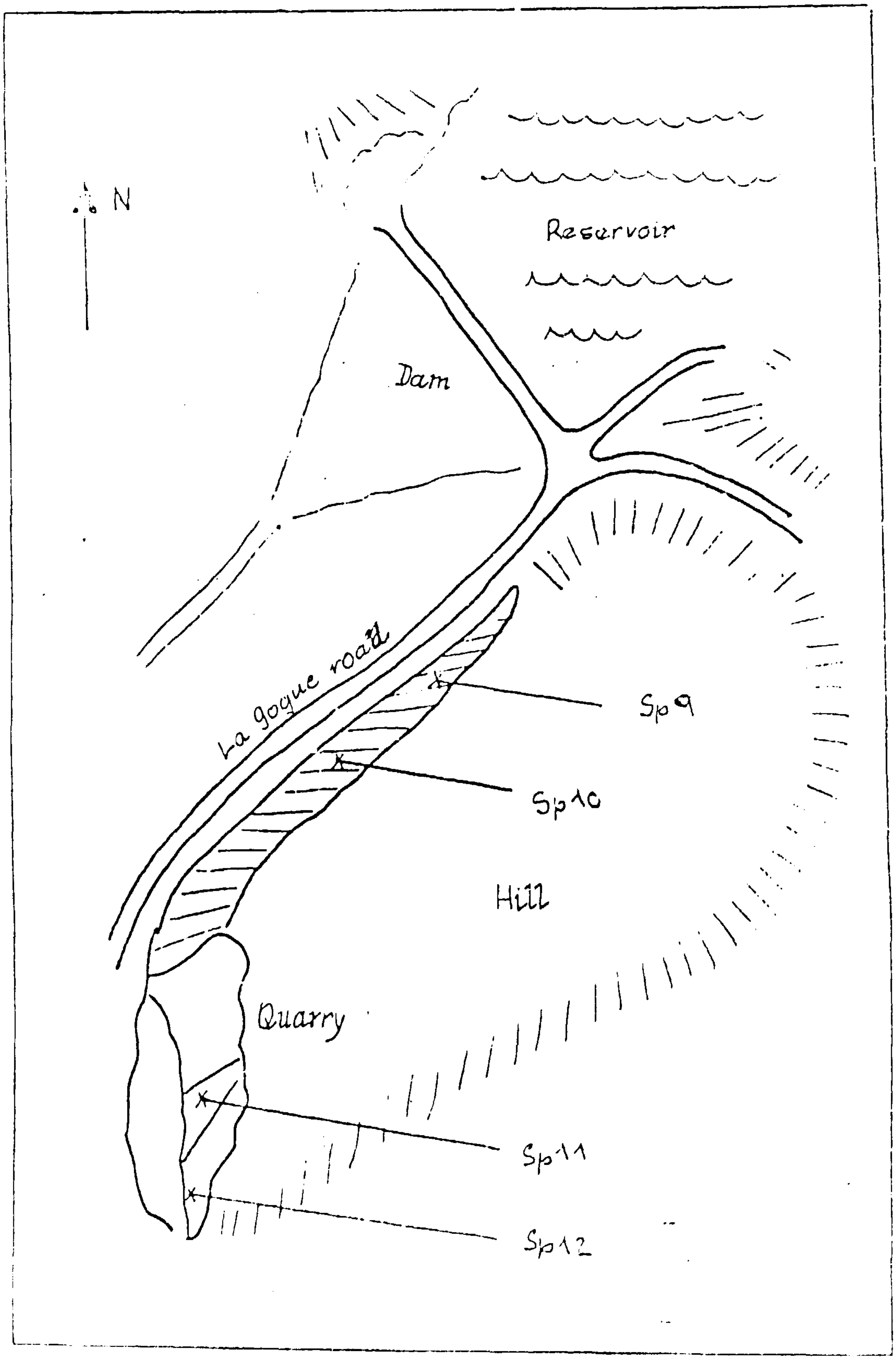
Picture 2 - Val d'Inder Estate - Situation of Sample Takings

cadastre 3273-3473   co-ordinates 339-341E, 733-735N



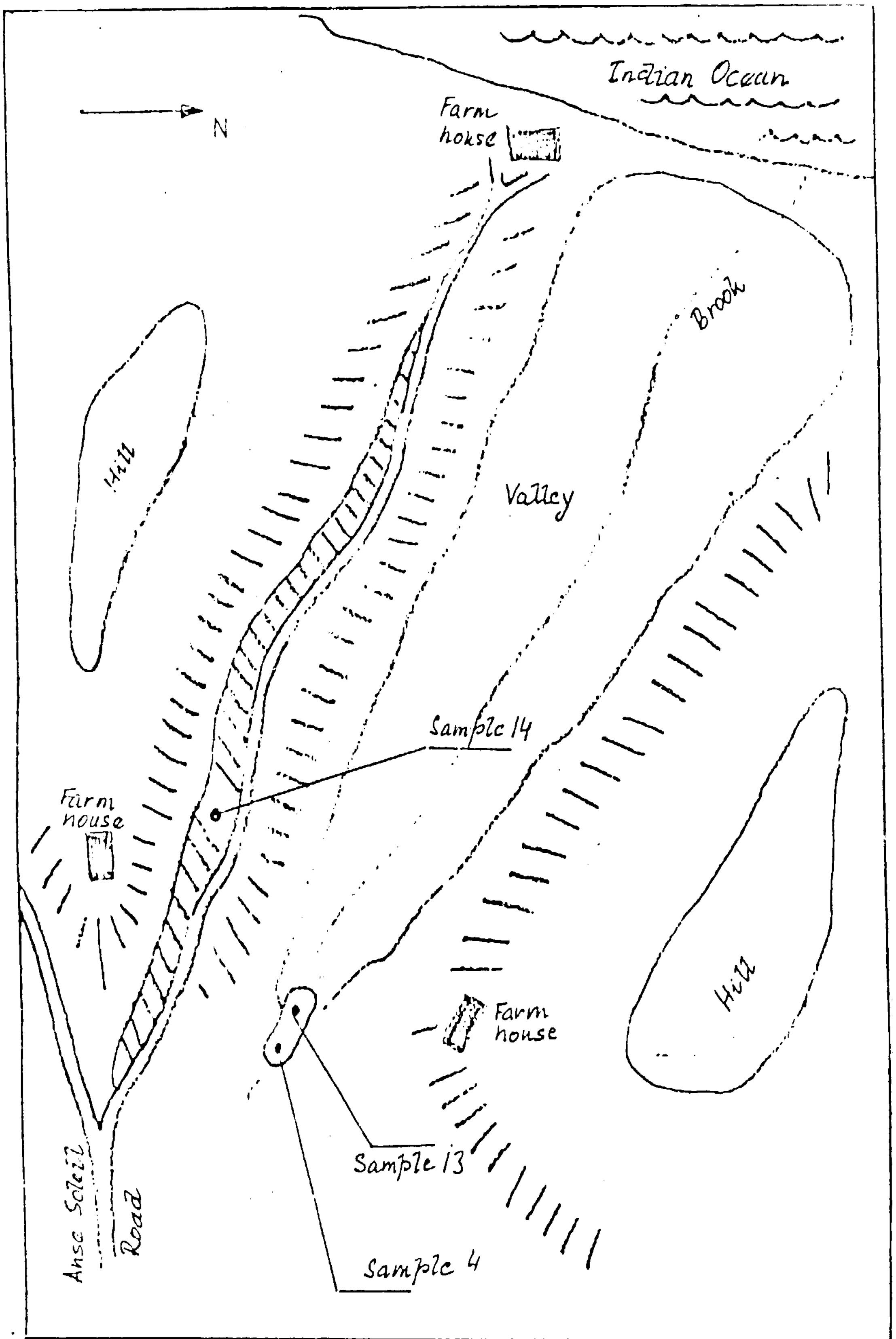
Picture 3 - La gogue - Situation of Sample Takings

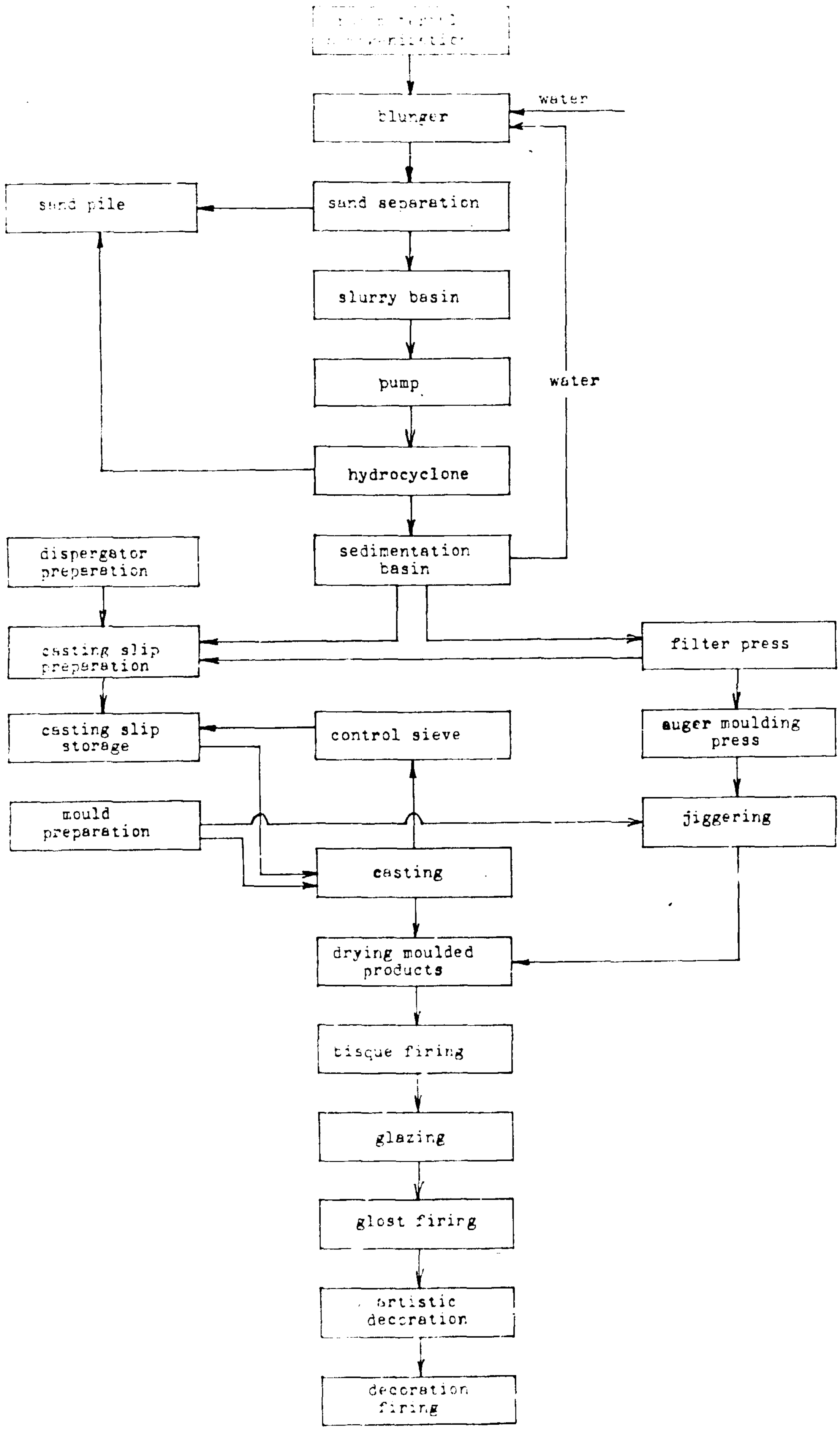
cadastre 2692

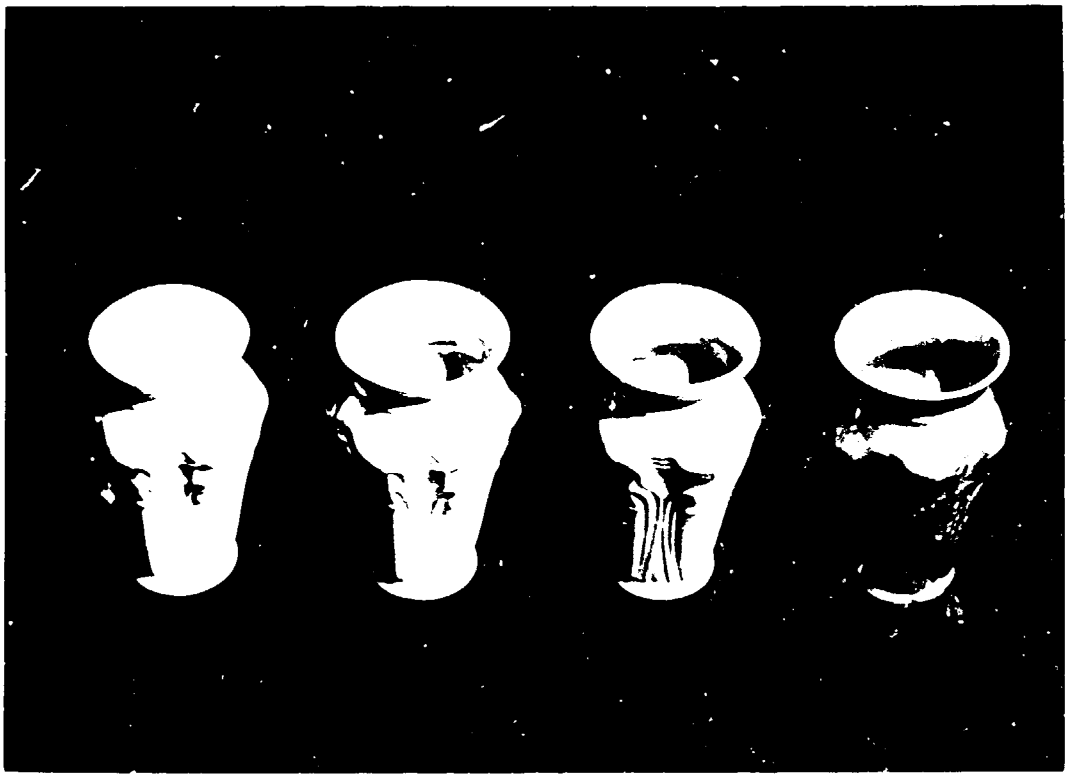


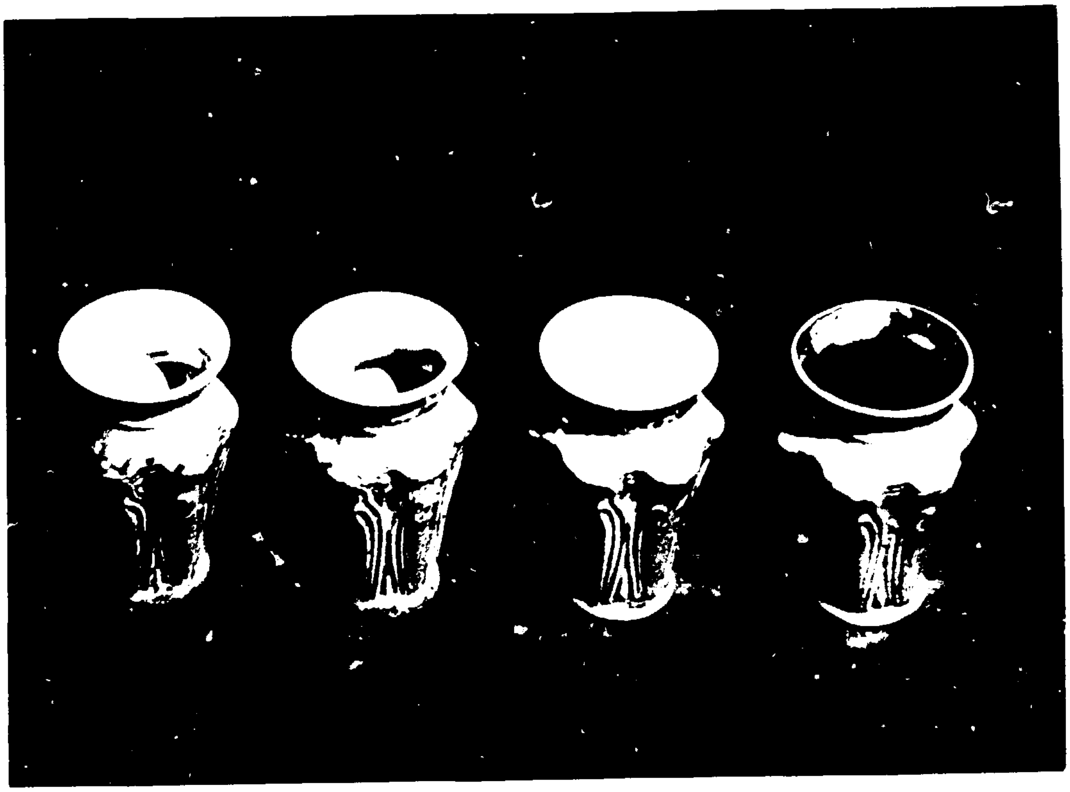
Picture 4 - Anse Soleil Road - Situation of Sample Takings

cadastre 2875   co-ordinates 297-300E, 755-758N

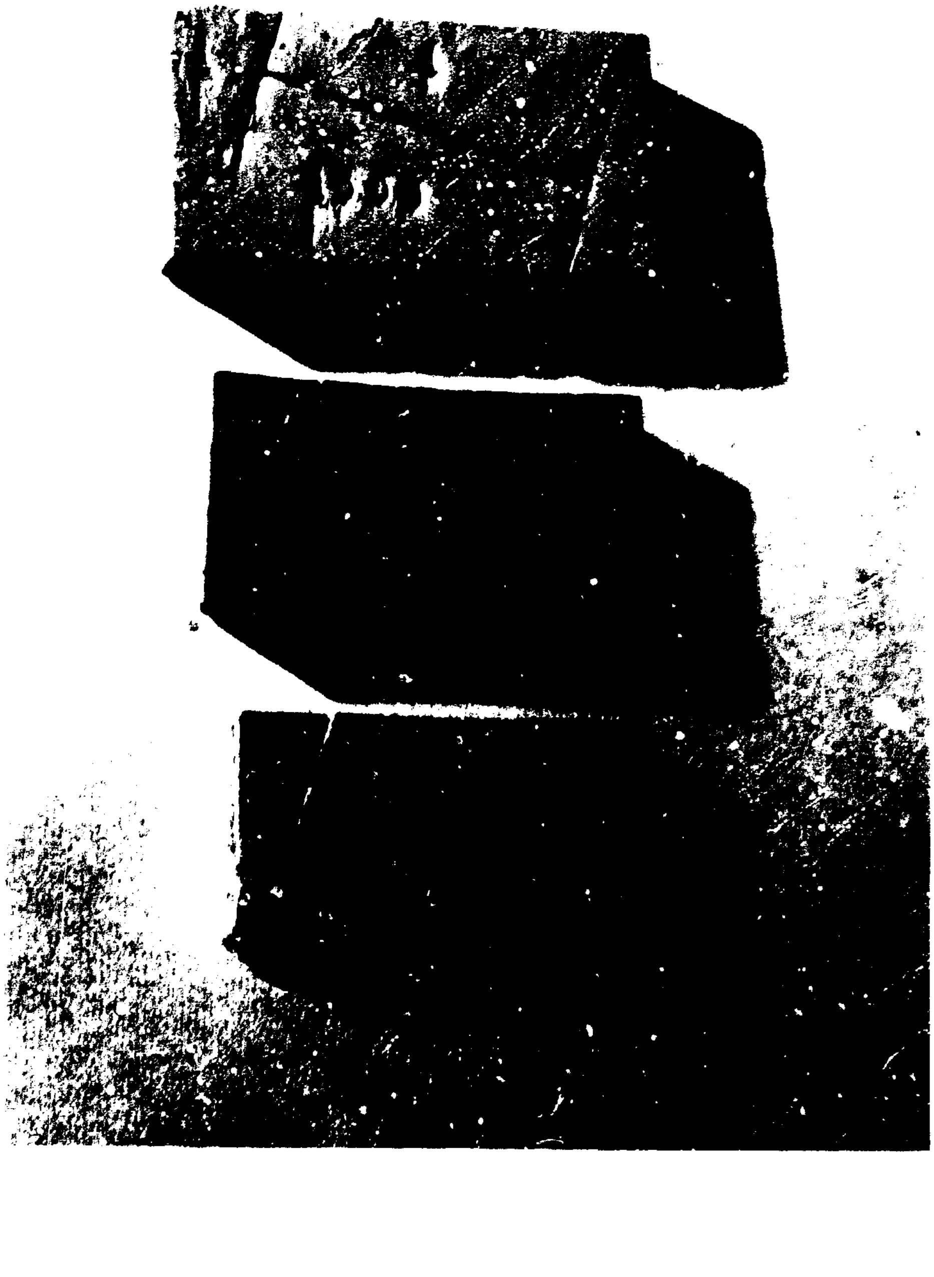


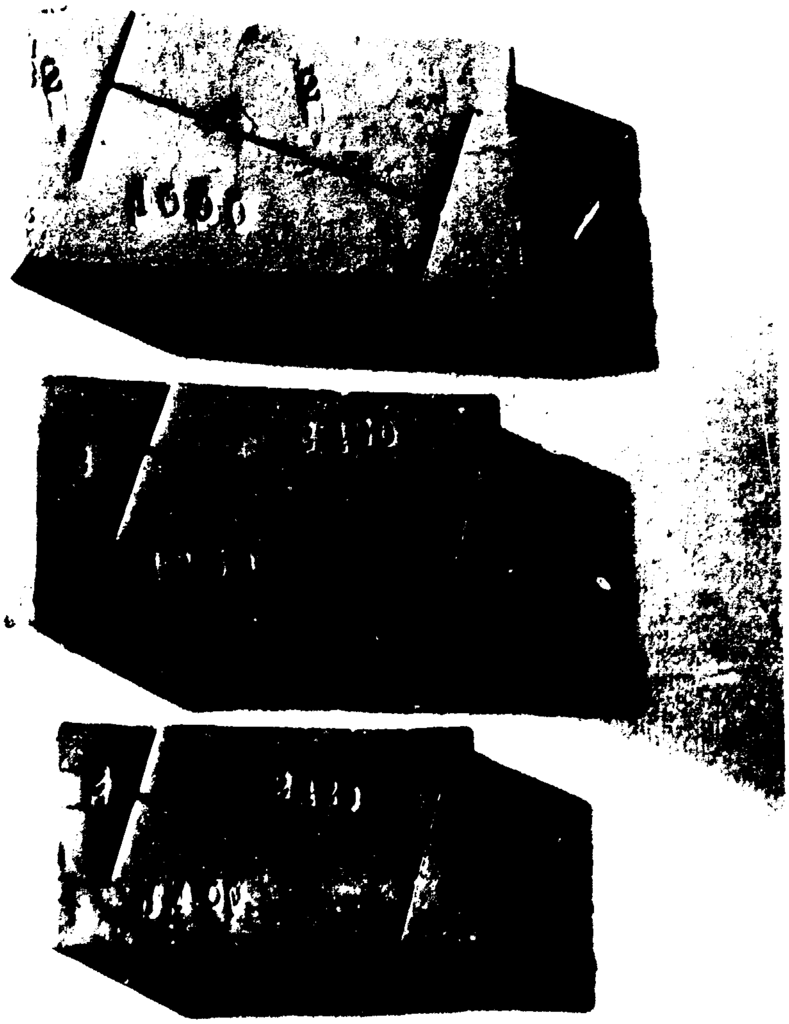

water
blunger
sand separation
sand pile
slurry basin
pump
water
hydrocyclone
dispergator preparation
sedimentation basin
casting slip preparation
filter press
casting slip storage
control sieve
auger moulding press
mould preparation
jiggering
casting
drying moulded products
bisque firing
glazing
glost firing
artistic decoration
decoration firing





[redacted]





Photograph 11 [illegible] - red clay

Fired at (from above) [illegible], [illegible] and [illegible]