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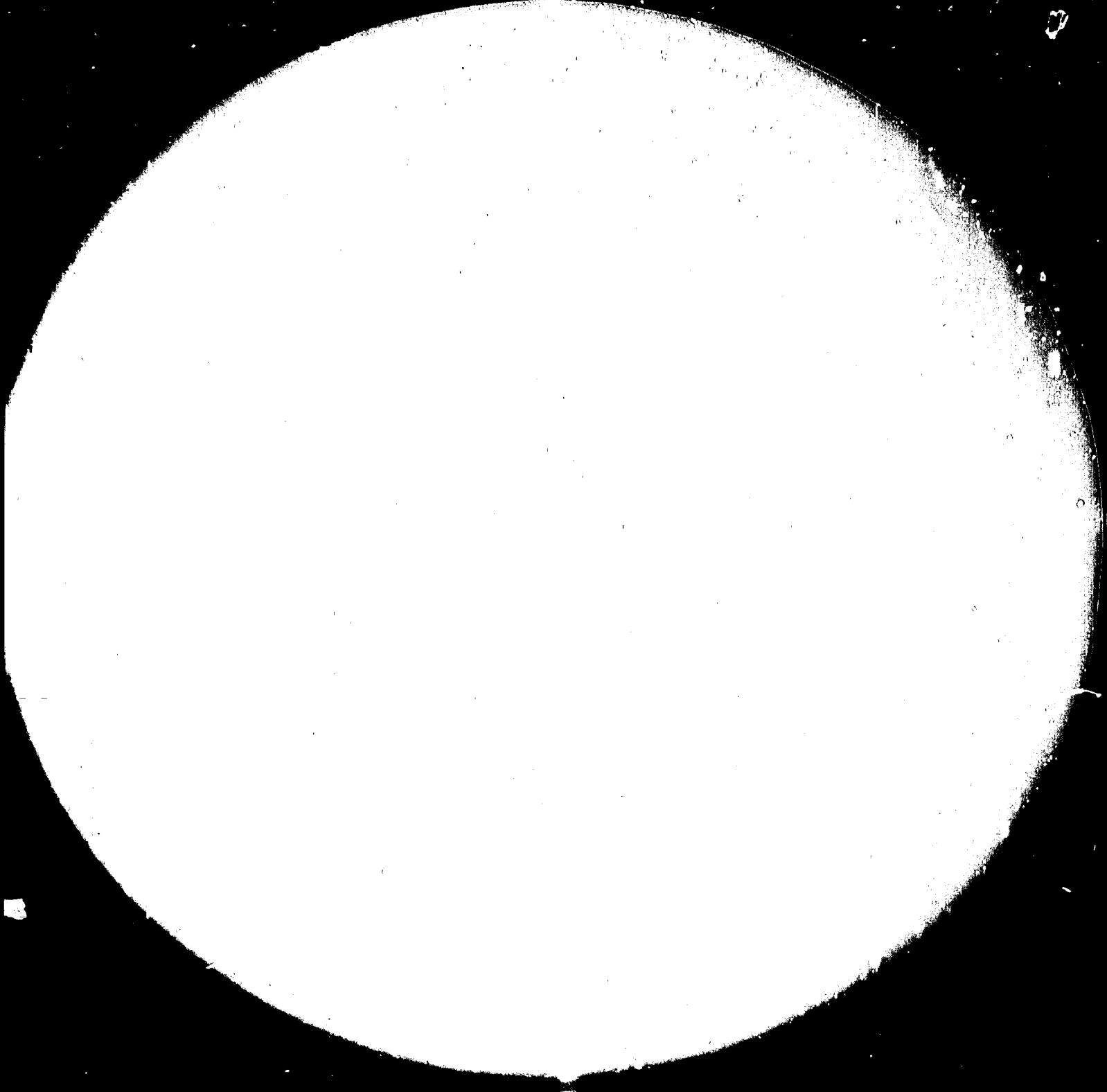

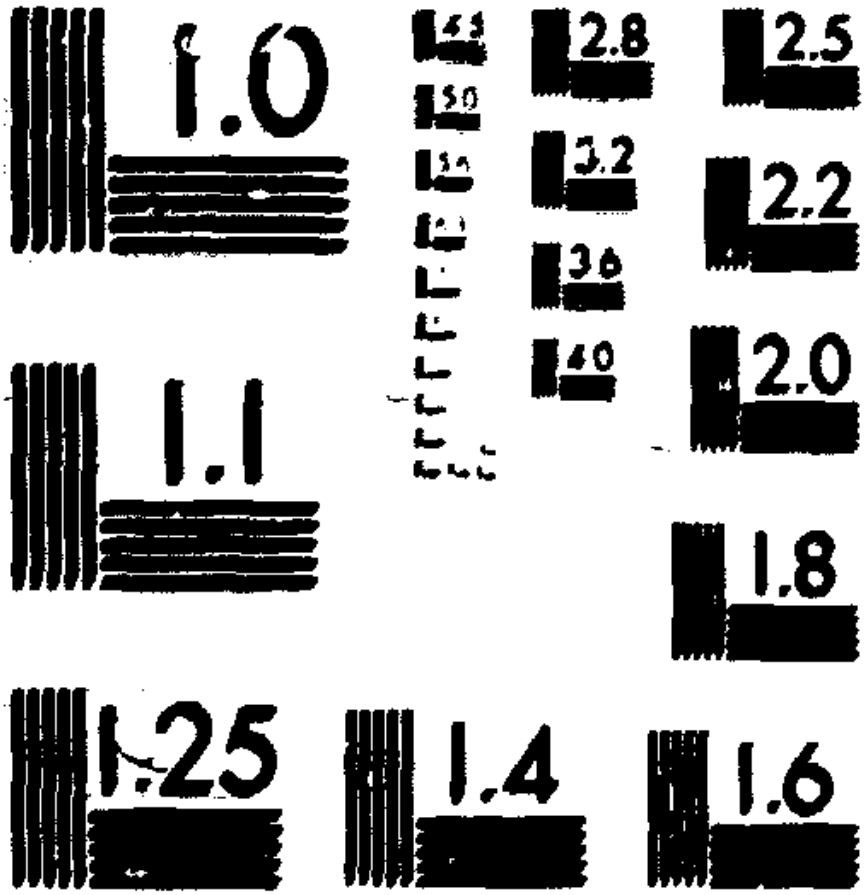

UNIDO-CZECHOSLOVAKIAN JOINT PROGRAMME FOR THE INTERNATIONAL CO-OPERATION IN THE FIELD OF CERAMICS, BUILDING MATERIALS AND NON-METALLIC MINERALS BASED INDUSTRIES AT THE INSTITUTE FOR CERAMICS, REFRACTORIES AND RAW MATERIALS IN HORNÍ BŘÍZA

Clay Samples from the Caribbean Area,

Technological Evaluation

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

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (hereinafter referred to as "UNIDO") requested by the letter of Mr. G.P.Veliky, Director, Industrial Operations Division, ref. OA 321 CAR 3 dated 20 January 1978 and addressed to Mr. Josef Belacik, Counsellor, Alternate Permanent Representative Permanent Mission of the Czechoslovak Socialist Republik to the International Organization in Vienna, the testing of a few clay samples from Caribbean area.

Testing of clay samples was carried out in the Institute for Ceramics, Refractories and Raw Materials in Horní Bříza prior the establishment of the Joint Programme for International Co-Operation in the Field of Ceramics, Building Materials and Non-Metallic Based Industries, attached to the mentioned Institute.

The main objective of this assignement was to specify the most suitable clay samples for the manufacture of fired clay bricks or for some other products.

C O N T E N T S

I. Conclusions and Recommendations

All eight samples of raw materials from the Caribbean area were investigated by usual laboratory tests.

It was found on the basis of series of results that most suitable samples are raw materials marked 1/3 and 4/5. For industrial use it is recommended to mix both raw materials together.

The results give presumption to exploit these materials not only for production of ordinary brickware but for production of higher standard building materials.

Further it is recommended to verify the homogenity of mining pits, to take higher quantity of samples and determine the technology by pilot tests.

II. Description and Properties of Raw Clay Samples

Eight samples were sent by air for the testing. The weight of samples was from 0,8 kg to 3,0 kgs. Samples were properly wrapped and marked subsequently :

1/3 (6 - 8 ft)
1/8 (16 - 18 ft)
2/2 (3 - 6 ft)
2/5 (12 - 14 ft)
3/2 (10 - 15 ft)
4/2 (3,6 - 8,6 ft)
4/5 (18,6 - 23,6 ft)

No map was enclosed, therefore this report do not specify the place where the samples were taken.

The colour of samples does not differ very. Samples 2/5, 3/2, 3/3, 4/2 and 4/5 are brown, samples 1/3 and 2/2 are dark brown and the last sample 1/8 is light brown. Samples 2/5, 3/2, 4/2 and 4/5 have a good plasticity. Sample 2/2 is very coarse with low plasticity. The low plasticity is characteristic for samples 1/3 and 1/8, while sample 3/3 is very hard and its workability is rather difficult.
The results of wet sieve analyses are given in following table No 1.

Table No 1.
Wet sieve analyses of Caribbean area samples

Sample	1/3	1/8	2/2	2/5	3/2	3/3	4/2	4/5
Rest on the sieve 4900 op/cm^2 / % /	25,6	2,0	36,4	6,0	17,6	18,0	10,4	8,4

The results are very different, with the minimum rest on the sieve 4 900 openings/cm^2 2 % and with the maximum rest 36,4 %.

III. X-ray, DTA and Chemical Analyses

All eight samples were subjected to X-ray analysis. It was proved that all samples contained substantial quantity of quartz and felspar. The mineral of montmorillonite type was found out in samples 4/2, 2/2, 2/5, 1/3 and rather more significant quantity in sample 4/5. Kaolinite is present in samples 3/2, 2/5, 4/2 and 4/5, however in negligible quantity. Iron oxides and hydroxides were not proved. Thecharacteristic of X-ray analyses enables a hypothesis that iron and aluminium are both bound in the form of alumogel and hematogel.

Sample 4/5, having the highest content of montmorillonite, was subjected to DTA and GTA also.

Results of X-ray analyses show that main components of all samples create quartz and felspar. Only the sample 1/3 and namely the 4/5 contain rather significant quantity of clay mineral montmorillonite and can be considered a suitable material for ceramic production.

X-ray analyses copies of all eight samples are enclosed as Appendix No 1. The copie of DTA and GTA of sample 4/5 is enclosed as Appendix No 2.

The sample 4/5 having highest content of clay mineral montmorillonite was subjected to chemical analysis also.

Chemical analysis of sample 4/5 :

SiO_2	63,14 %
Al_2O_3	15,10 %
TiO_2	1,04 %
Fe_2O_3	7,17 %
MgO	1,72 %
CaO	2,28 %
Na_2O	3,13 %

Li_2O 0,45 %
L. on I. 4,90 %

Chemical composition of sample 4/5 corresponds with average composition of brick clays. All values are within the usual range. The content of Na_2O and K_2O enables a good sintering.

IV. - Technological Tests

The aim of technological tests is to determine important technological properties, what enables to classify tested clay samples.

As the most important properties were chosen : water of plasticity, shrinkage wet-dry, shrinkage wet-fired, water absorption and volume weight. The sound of samples and presence of cracks were appreciated after firing, too.

1. Preparation of small laboratory bricks

All samples were at first adjusted in pieces approximately 2 cm in size and were dried by room temperature. Individual samples were then milled in a small laboratory mill and ceramic bodies were prepared by addition of water. Water of plasticity was determinated by usual method. The values of required water of plasticity are as follows:

Sample	Water of plasticity
1/3	25,2 %
1/8	21,8 %
2/2	22,9 %
2/5	30,4 %
3/2	27,7 %
3/3	24,4 %
4/2	25,6 %
4/5	29,4 %

Small laboratory bricks were prepared manually. The dimension were 70 x 35 x 15 mm. Small bricks were at first dried by room temperature, after 48 hours were given in laboratory drying chamber and were dried by 110 °C for 36 hours. No cracks occurred after drying. The drying was done very carefully, all samples were turned down during drying in the air. Samples showed tendency to twist even in such a careful drying. Samples 1/3 and 2/2 showed relatively the smallest drying troubles.

Shrinkage wet-dry was then determinated and the values are as follows:

Sample	Shrinkage wet-dry
1/3	11,5 %
1/8	14,8 %
2/2	8,8 %
2/5	14,2 %
3/2	13,2 %
3/3	11,1 %
4/2	12,1 %
4/5	14,7 %

2. Firing and properties of small laboratory bricks

The determination of firing temperature is a very important technological point. Laboratory gradient kiln is often used to determine suitable firing temperature by using small samples only. This laboratory firing process is relatively quick and advantageous.

Specimens, in the shape of small beams, were prepared from bodies 1/3 and 4/5. They were dried in usual way and then put into laboratory gradient kiln which enables to fire particular parts of specimen by different temperatu from 840° - 1120 °C.

The small beams were evaluated after firing and the firing temperature 940 - 1000 °C was determinated.

After the determination of firing temperature, all small laboratory bricks were fired in factory tunnel kiln by temperature 960 - 980 °C. The lenght of the tunnel kiln is approximately 100 m, firing cycle 18 hours, 30 minutes at highest temperature.

The values of technological properties brings table No 2.

Table No 2. Technological properties of laboratory bricks

Sample	Shrinkage dry-fired	Water absorption	Volume weight	Sound of bricks	Remarks
1/3	0,22 %	15,7 %	1,92 g.cm^{-3}	bright	
1/8	3,10 %	6,6 %	2,04 g.cm^{-3}	hoarse	cracks
2/2	0,58 %	16,3 %	1,91 "	bright	
2/5	2,25 %	10,0 %	1,96 "	hoarse	cracks
3/2	1,53 %	10,8 %	1,90 "	hoarse	cracks
3/3	0,52 %	14,5 %	1,83 "	bright	
4/2	1,05 %	12,3 %	1,99 "	bright	
4/5	0,55 %	13,6 %	1,87 "	bright	

The colour of all small fired bricks is red with small differencies in shade only.

Bodies with the highest dry-fired shrinkage e.g. 1/8, 2/5 and 3/2 had cracks after firing.

In order to complete technological properties laboratory bodies for determination of bending strenght were prepared. They were fired by the same conditions as all testing bricks e.g. by 960 - 980 °C. The bending strenght was then measured and the values are as follows :

Sample	Bending strenght /kp.cm^{-2}/
1/3	61
1/8	37
2/2	46
2/5	56
3/2	54
3/3	52
4/2	53
4/5	94

Values in Table No 2., results of wet-dry shrinkage and renelts of bending strenght determination show that samples 1/3 and 4/5 are the most suitable from all tested samples. Samples 1/3 and 4/5 had the highest bending strenght, very low dry-fired shrinkage, water absorption and volume weight corresponding to requirments on brickware. They had bright sound and no cracks.

In order to facilitate the decision on the selection of suitable clay deposit, glazed samples from bodies 1/3 and 4/5 were prepared by double firing process. Bodies glazed with ordinary white glaze were fired by temperature 960 - 980 °C in the same factory tunnel kiln as unglazed small laboratory bricks. The glazed surface of both samples was quite good which shows that also other ceramic products than ordinary red bricks could be produced from tested bodis.

V. Summary

Eight samples from Caribbean area were tested in Institute for Ceramics, Refractories and Raw Materials in Horní Bříza as an introductory work of UNIDO - Czechoslovakian Joint Programme.

All eight samples were subjected to X-ray analyses, DTA, GTA and chemical analysis was also done on sample 4/5. The series of technological values comprising wet sieve analysis (4900 op/cm^2), water of plasticity, wet-dry shrinkage, dry-fired shrinkage, water absorption, volume weight and bending strenght was determined. Appearence, sound and presence of cracks of small fired bricks were also evaluated.

The survey of technological properties brings table No 3.

Table No 3. Survey of technological properties

Property	Sample 1/3	1/8	2/2	2/5	3/2	3/3	4/2	4/5
Sieve analysis / % /	25,6	2,0	36,4	6,0	17,6	18,0	10,4	8,4
Water of plasticity / % /	25,2	21,8	22,9	30,4	27,7	24,4	25,6	29,4
Shrinkage wet-dry / % /	11,5	14,8	8,8	14,2	13,2	11,1	12,1	14,7
Shrinkage dry-fired / % /	0,22	3,10	0,58	2,25	1,53	0,52	1,05	0,55
Water absorption / % /	15,7	6,6	16,3	10,0	10,8	14,5	12,3	13,6
Wolume weight /g.cm^{-3}/	1,92	2,04	1,91	1,96	1,90	1,83	1,99	1,87
Bending strenght /kp.cm^{-2}/	61	37	46	56	54	52	53	94
Sound	bright	hoarse	bright	hoarse	hoarse	bright	bright	bright
Cracks	no	yes	no	yes	yes	no	no	no

Samples 1/3 and 4/5 can be considered to be the best for the production of red bricks. For the industrial using it is recommendable to mix both clays together.

It is very probable that both mentioned clays 1/3 and 4/5 coulde be also usable for the production of higher quality products like facing bricks and facing strips glazed or unglazed, floor tiles glazed or unglazed. The production of glazed materials can be considered as possible because ordinary glazes correspond with tested bodies.

VI. Final Note

The submitted laboratory evaluation of Caribbean area raw materials fulfilled the requirments and determined two localities as the most suitable ones for further exploration. These localities give on the basis of submitted laboratory and research results, presumption for industrial use not only in the brickware manufacture by plastic technology but in the building materials industry for the production of glazed and unglazed materials by dry pressing process as well.

For programming further work it is necessary to verify the homogenity of mining pits, to take higher quantity of samples and make pilot tests. The proper technology for brickware and for higher standard building materials can be then determined on the basis of pilot tests.

VII. REFERENCES :

1. Engelthaler Z.A. : Technological Research and In-Plant Trials with Jordanian Ceramic Raw Materials - Amman, October 1969

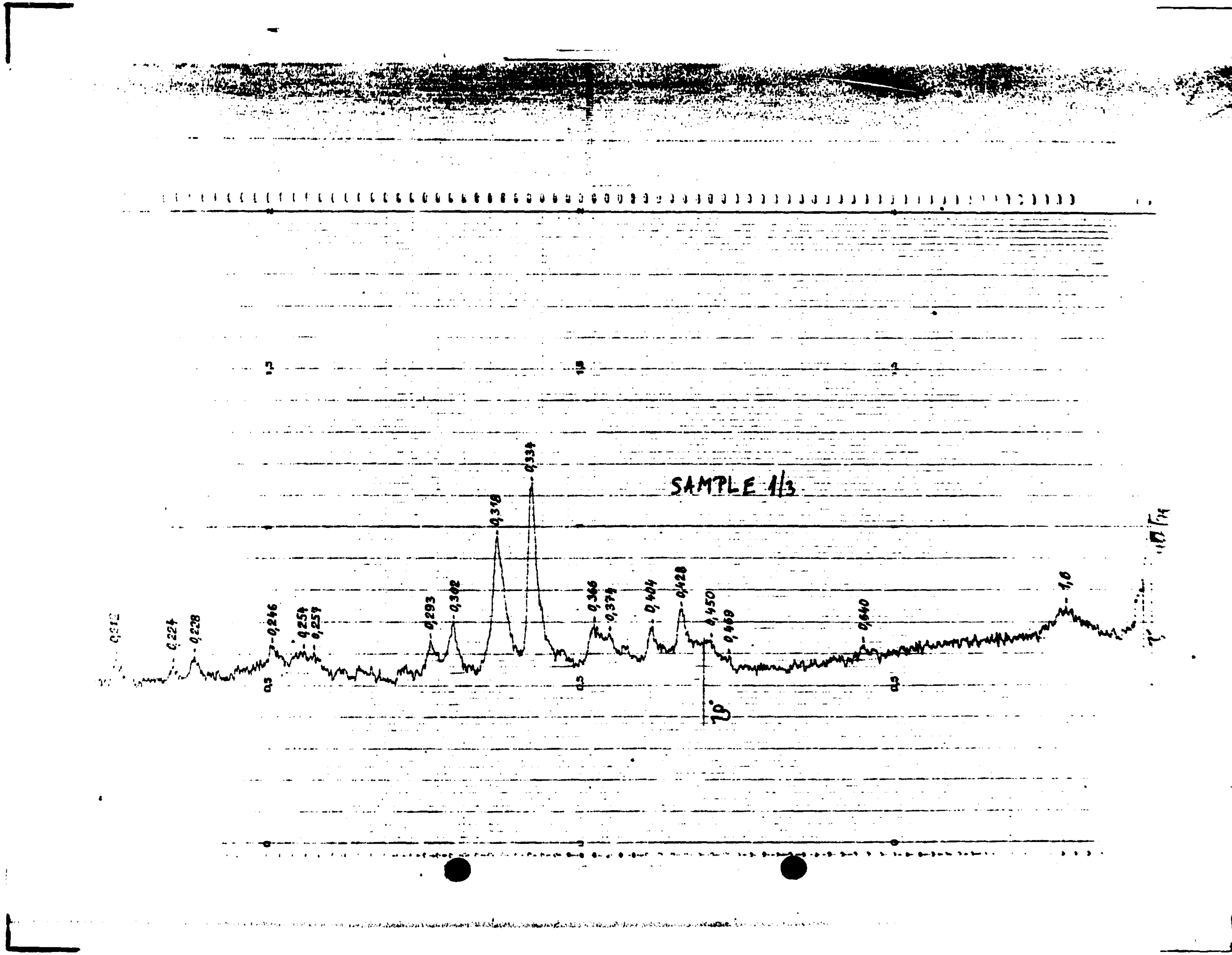
2. Dřevo J., Franče J., Stockert H. : Assistance in the Establishment of Clay Products and Non-Metallic Materials Industries in Botswana - Horní Bříza, September 1977

3. Tchoichvili L., Caviglia P.J. : Laterite - a Raw Material for Building Ceramics - Interceram, Volume 26, No 2. 1977

VIII. [redacted]

APPENDIX No 1.

X-ray analyses of samples
from Smallbeam area.



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0,254
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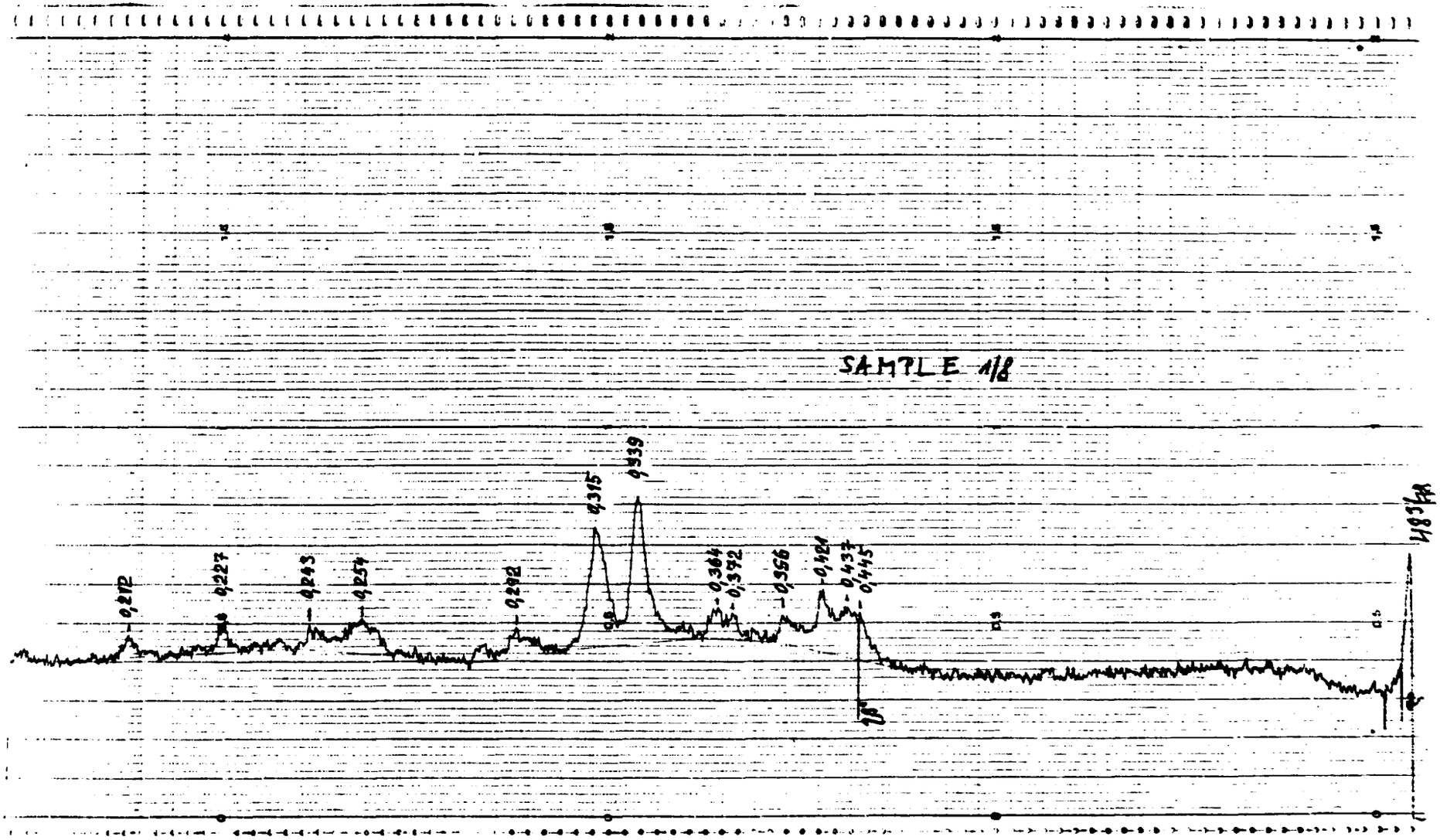
10°
0,5
1,0
1,5
2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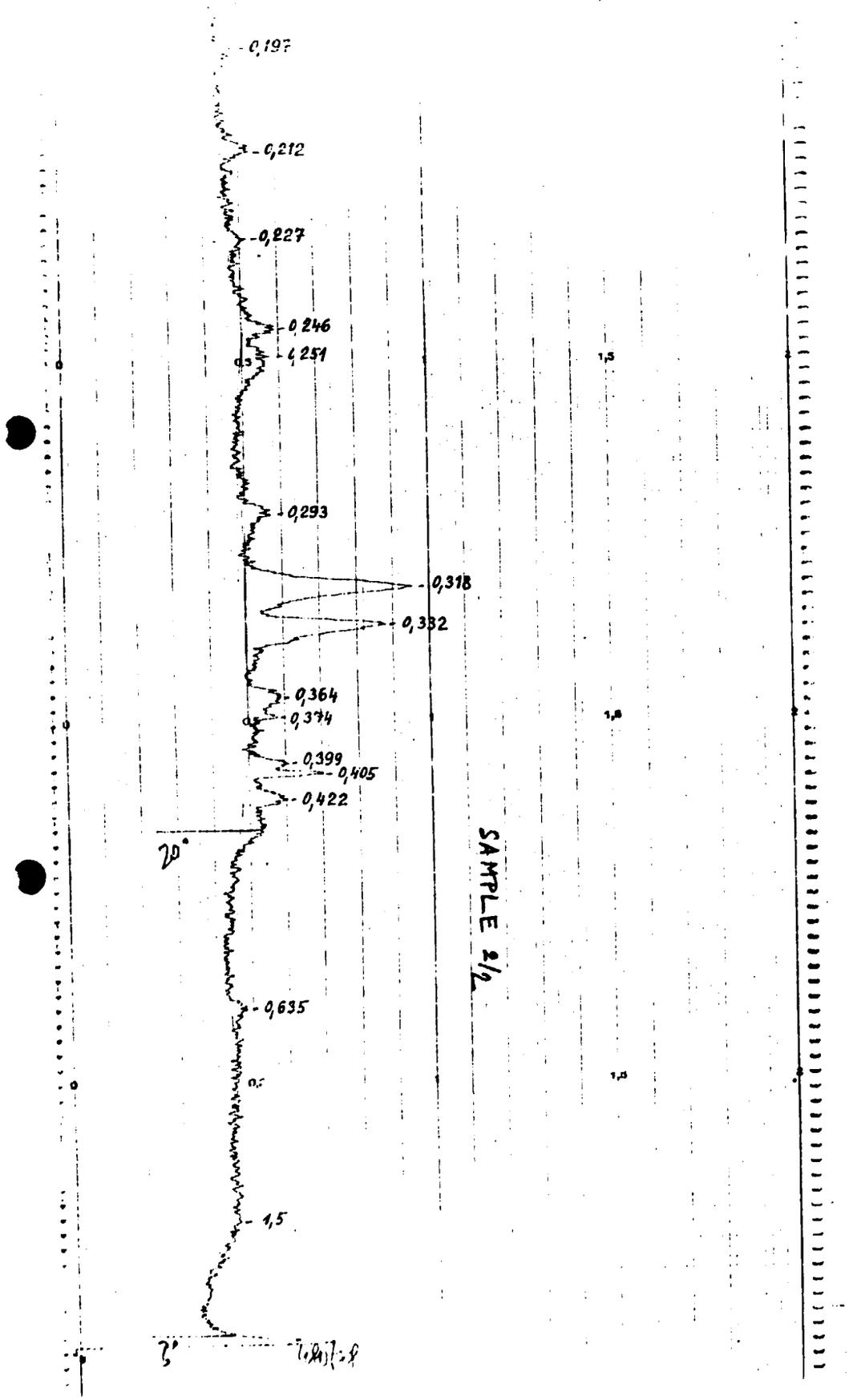
0,445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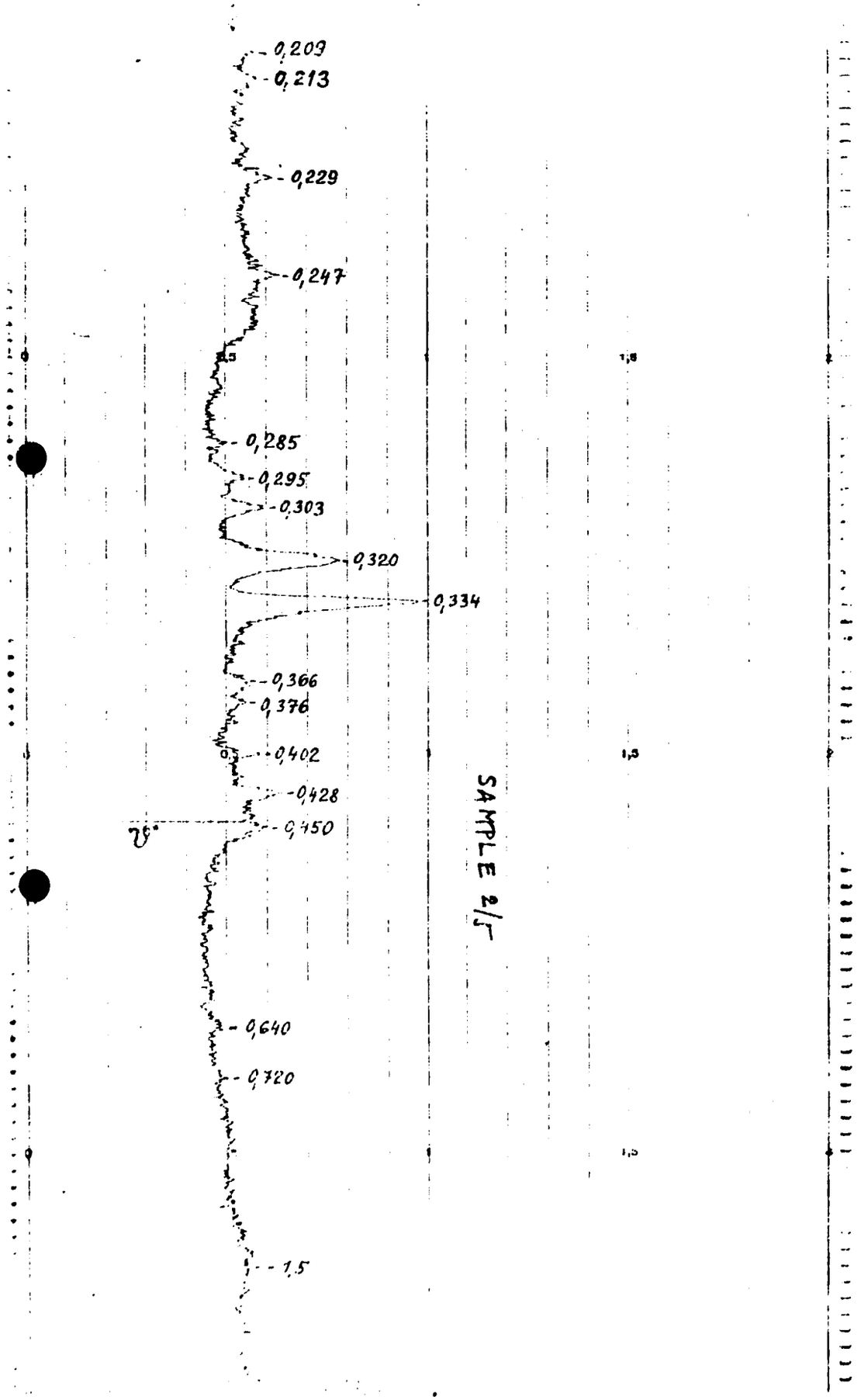
0,635
1,5
3°
SAMPLE 2/2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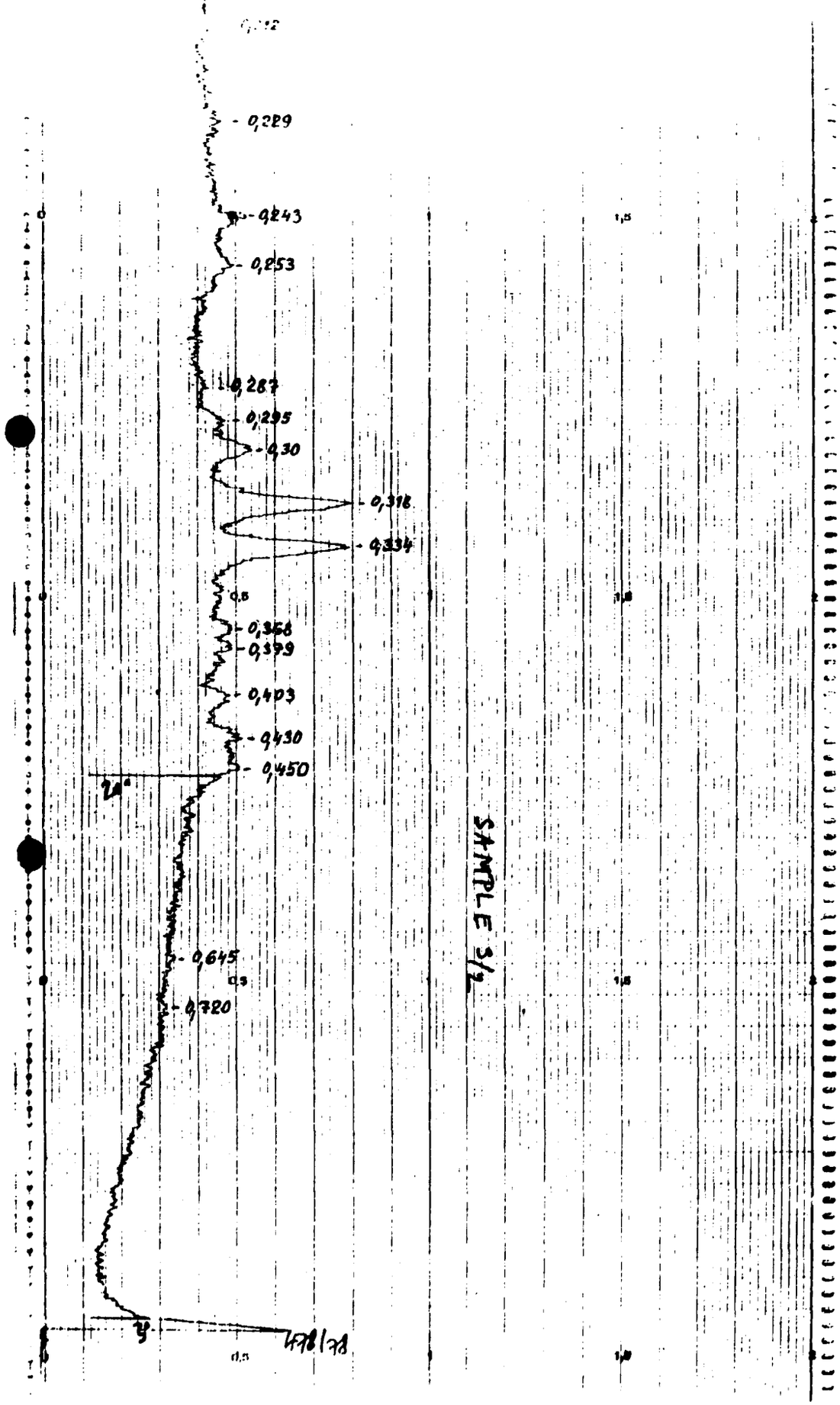
SAMPLE 2/5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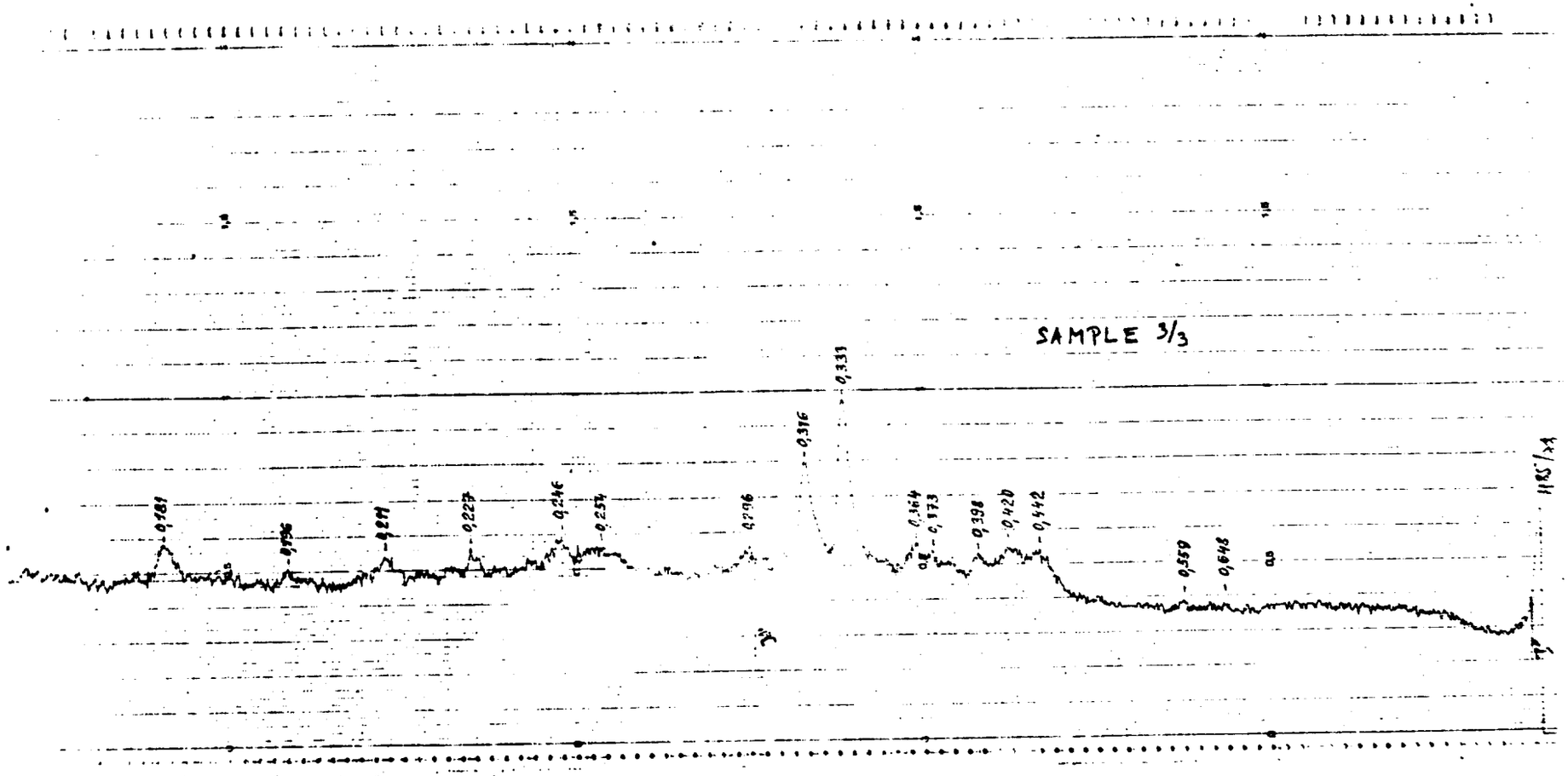
0,645
0,720
SAMPLE 3/2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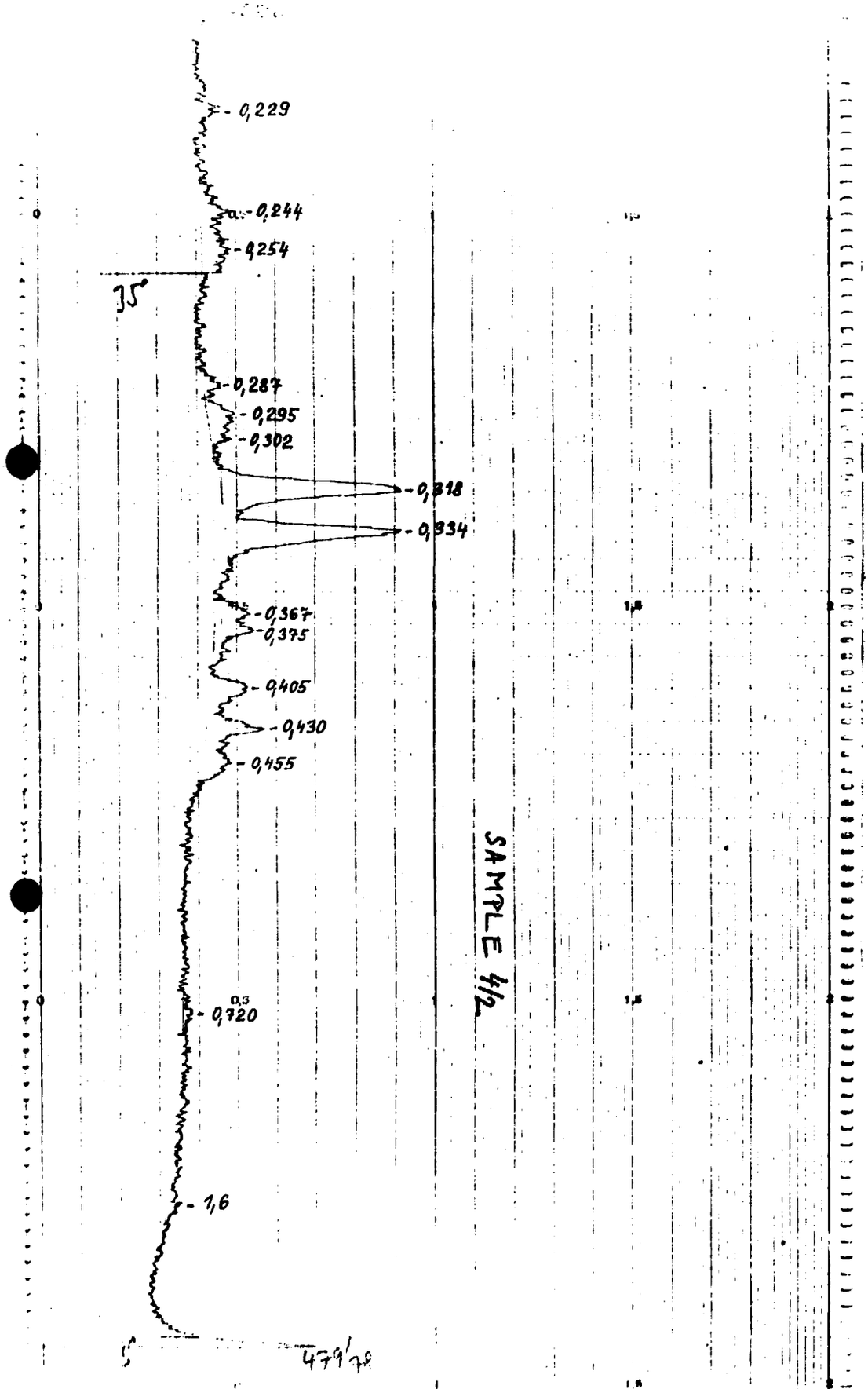
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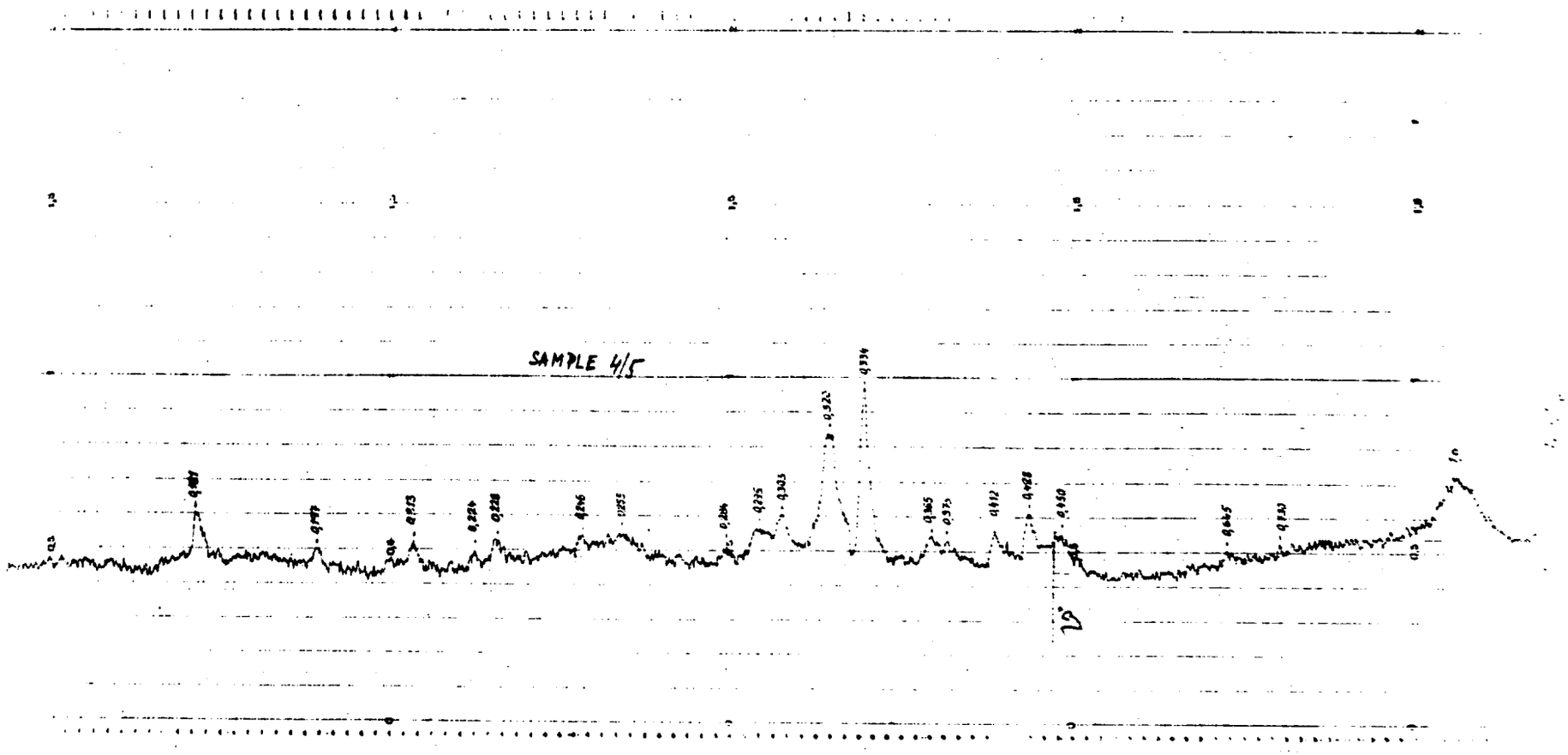
SAMPLE 4/2
479/78


SAMPLE 4/5

APPENDIX No 2.

DRA and CRA of sample 4/5

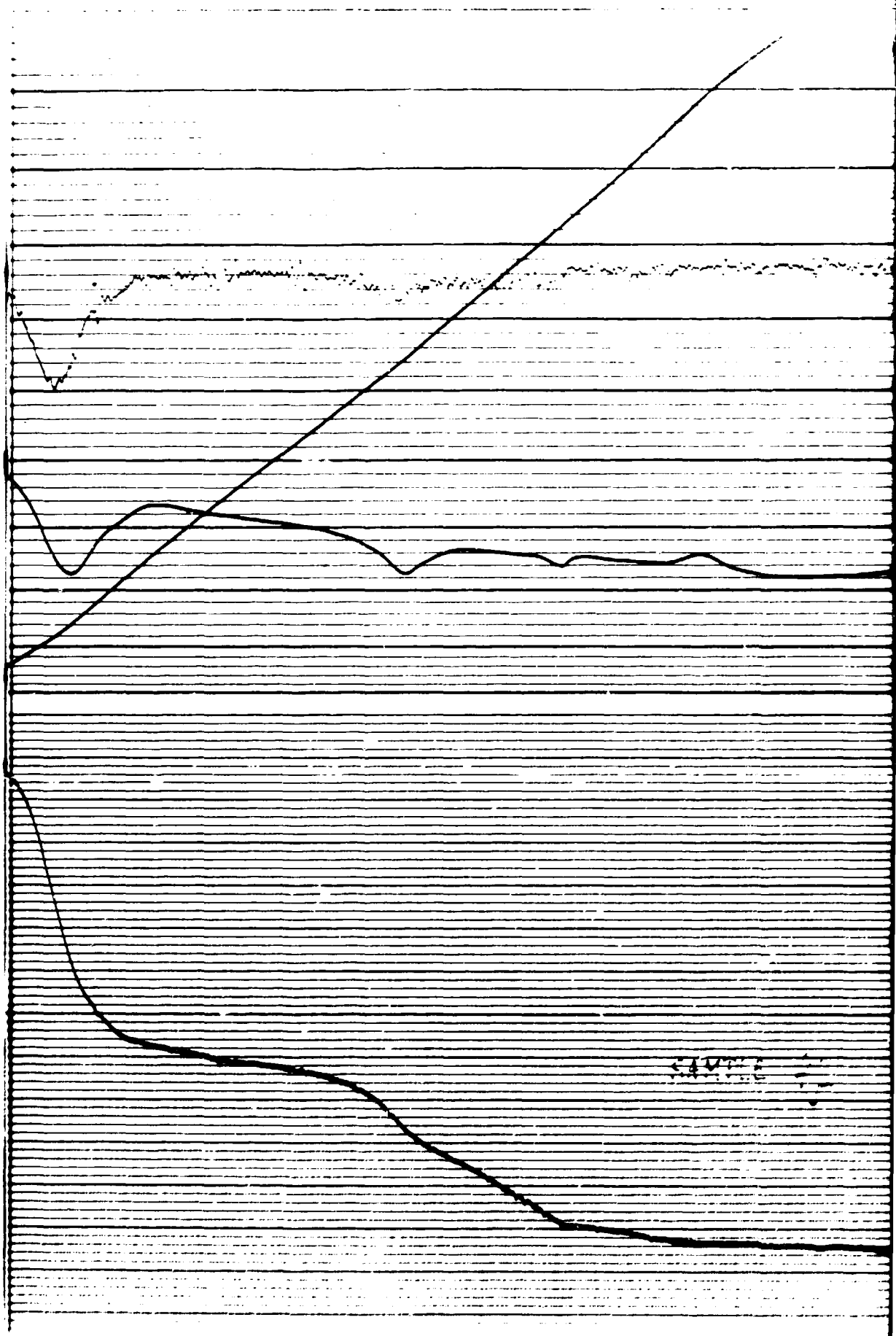


EXHIBIT 1

Preparation of small laboratory bricks

EXHIBIT 2

Small laboratory bricks drying at the air

EXHIBIT 3

Laboratory gradient kiln

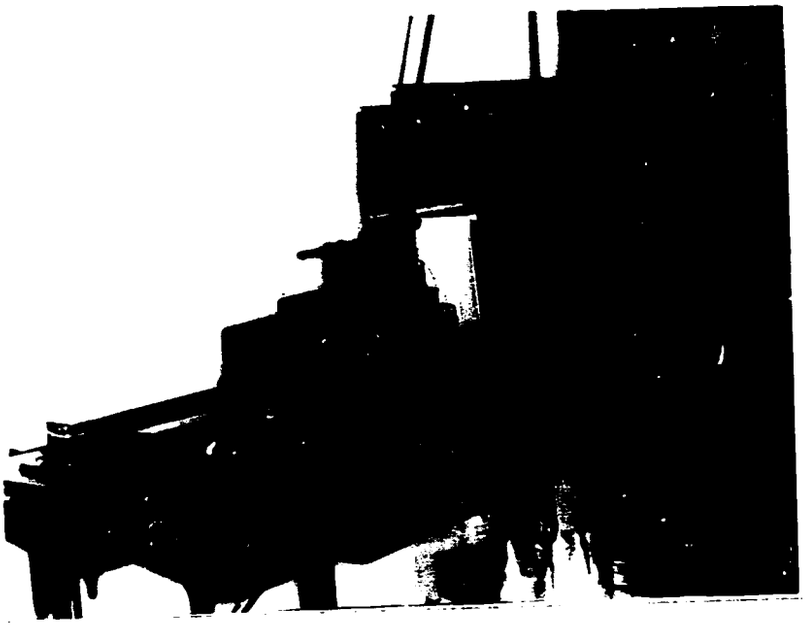


EXHIBIT 4

Small laboratory fired bricks