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LOOKING FOR CHROMIUM IN 19TH-CENTURY CERAMIC COLOURS

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Part I: Discussion

In the early 1970s, ceramic researchers at Parks Canada somehow acquired the knowledge that certain underglaze colours were "chrome colours"; that is, chromium oxide was deliberately used in their recipes. How we acquired this knowledge is mystifying. No discussion of chromium colours was found in the vast literature on historic ceramics[1]. While the chemical content of decorations was not a pressing problem, this discrepancy between our knowledge and our memories was bothersome, and last year I proposed to discover whether we were suffering from delusion or amnesia.

I selected samples of sherds that I felt were probably decorated with chromium as well as smaller samples of sherds with similar colours that I felt were probably not decorated with chromium. The distinction between the two was made not only on the basis of colour but also on the date of the items. All examples suspected of being "chrome colours" were on whiteware and thus dated after 1820. All the examples suspected of not being "chrome colours" were on pearlware or creamware and thus probably dated before 1830. We had reason to believe that the introduction of several new colours took place some time in the 1820s. Underglaze pinks and reds were simply not seen on earlier datable objects; this was true also for certain purples and greens. The same colours were common on objects dating after about 1830. Historical confirmation for these observations comes from Simeon Shaw. In 1829 he wrote

> Very recently several of the most eminent Manufacturers have introduced a method of ornamenting Table and Dessert Services, similarly to Tea Services, by the Black Printers using red, brown, and green colours, for beautiful designs of flowers and landscapes;[2]

Test Results

The tests for chromium were designed and conducted by Joy Moyle of the Conservation Division, Parks Canada. She describes the test procedures and the detailed results in Part 2 of this report. The following is a summary of the results as well as observations on certain groups of objects.

In general, the test results were gratifying. Significant amounts of chromium were found in all the examples that were suspected to be "chrome colours" and, with the exception of one sherd, insignificant amounts of chromium were found in all the examples that were suspected not to be chrome colours.

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Observations on Examples with Pink and Red Decoration (See Part II: Table 3)

All of the examples had significant amounts of chromium: from 15 to 64 micrograms per square centimeter. Unless otherwise indicated, all quantities of chromium discussed here represent the difference between the amount of chromium found on a decorated part of the sherd and the amount found on an undecorated part of the sherd.

Neither the hue nor the intensity of the colour was dependant on the amount of chromium alone. For example, two plates had pink-painted decorations which were visually distinct from each other (Munsell value 10RP4/8 and a paler 10RP6/6)[3] but whose chromium content was almost the same (24 and 22 micrograms per square centimeter). Conversely, examples decorated in the same colour had widely different amounts of chromium. For example, red transfer-printed items of Munsell value 2.5R3/6 ranged in chromium content from 25 to 64 micrograms per square centimeter, almost the entire range of the sample.

Observations on Examples with Purple Decoration (See Part II: Table 4)

Underglaze purple decoration is rarely found on creamware or pearlware. Only two pearlware examples were tested and the chromium content in both their decorations was negligible. The colours on these two sherds (7.5RP2/2 and 10R3/4) are unlike the colours on any of the whiteware sherds.

Of the twelve whiteware sherds tested, eleven had quantitied of chromium ranging from 13 to 92 micrograms per square centimeter. The remaining sherd had a low tested value for chromium, 5 micrograms/ square centimer, but the decoration of this sherd is unusual in that the pigment has separated into blue and red. I do not know whether or not to consider the decoration on this sherd as an example of a "chrome colour".

Like the red or pink decoration, the hue and intensity of the purple did not depend on the amount of chromium alone. Examples with the same colour decoration (5RP3/6) had chromium values ranging from 13 to 92 micrograms per square centimeter, almost the entire range of the sample.

Observations on Examples with Green Decoration (See Part II: Table 2)

The test results on green decoration were more difficult to interpret than those on the red or purple. There appeared to be a continuous range of chromium values from 0 to 901 micrograms per square centimeter with the creamware and pearlware examples at the low end (0 to 16) and the whiteware examples ranging from 34 to 901 micrograms per square centimeters.

Small amount of chromium (0 to 26) were found on the <u>undecorated</u> parts of most sherds regardless the type of decoration on them. In other words, chromium occurred naturally as an invisible impurity in the fabric or glaze and presumably in non-chrome pigments as well. I hypothesized that chromium in decorations on the pearlware and creamware examples was just such contamination while chromium in decorations on the whiteware examples occurred in significantly higher amounts, thus actively contributing to the colour. I divided the test results into four groups:

1. chromium content from a decorated part of creamware and pearlware sherds.
2. chromium content from an undecorated part of the same sherds.
3. chromium content from a decorated part of the whiteware sherds.
4. chromium content from an undecorated part of the same sherds.

Standard statiscal tests were applied to the data. One-way analysis of variance determined whether or not statistically significant differences existed among the mean chromium values of any of the groups. Least-significant-difference revealed where any differences occurred. A significance level of 99.9% was applied.

The results of the statistical tests showed that three groups were not significantly different from each other and one group, number three, was different from all the rest. Thus, the various shades of green on whiteware were all "chrome colours" while various shades of green on pearlware and creamware were not.

As with the other colours, the amount of chromium alone did not change the hue or intensity of the green decoration. In fact, there were examples of green "non-chrome colours" that had exactly the same Munsell value as some green "chrome colours."

Identifying Chromium Colours Visually

The pinks and reds are the only colours that can easily be identified as containing chromium; these colours, in any shade, all contained significant amounts of chromium.

While examples exist of underglaze purple decorations made without chromium, they are relatively rare and have only been noted on pearlware and creamware. On the other hand, examples of purple decoration containing chromium are common on 19th-century ceramics and have only been noted on whiteware. With caution, I would venture that any shade of underglaze purple decoration on whiteware is a "chrome colour" while any shade of purple decoration on pearlware or creamware is not.

The green decoration did not divide as tidily as the pink or purple decorations. In general, green decoration on whiteware contained chromium whereas green decoration on pearlware and creamware did not. However, one of the tested examples was a pearlware sherd with green decoration that contained a large amount of chromium. There is no reason to believe that this is a unique example and it seems likely that there was a period when certain factories were still producing pearlware but had introduced chromium-based pigments for their decorations.

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This project was meant to answer the question: are certain underglaze ceramic colours that appear for the first time after about 1830 "chrome colours", that is, made with chromium oxide. The answer is yes. The very good reason why we wanted to know the answer was curiosity. We were all familiar with the use of metallic oxides as colourants on historic-period ceramics, and the sudden appearance of colours we could not explain technically was disturbing. Knowledge of the technical manufacturing method enhances our understanding generally of the ceramics. It is easier to appreciate objects in terms of the age in which they were produced, their relative cost, and even their aesthetic value if they can be seen against an intelligible background of manufacturing technique.

References Cited

Munsell Color Company
Munsell Book of Color. Baltimore, 1929.

Shaw, Simeon
History of the Staffordshire Potteries. G. Jackson, Hanley, 1829.

Endnotes

1. The literature referred to here is comprised of the secondary sources meant primarily for collectors and amateur scholars. Our education in ceramics

history is based largely on these illustrated books and articles. I have recently found some references to chromium for ceramic colours in technical sources. While these sources indicate that chromium-based colours were known to the pottery industry in the 19th century, their not being illustrated nor even very descriptive makes them unhelpful in identifying 19th-century chromium decoration.

2. Simeon Shaw, History of the Staffordshire Potteries, p. 234.
3. Munsell Color Company, Munsell Book of Color.

Part II: Analysis

Purpose

The aim of this experiment was to analyze 63 sherds to determine whether the coloured underglaze decoration on a sherd contained a significantly higher concentration of chromium than the uncoloured portion of the same sherd. The underglaze colours analyzed were red, green and purple.

Background

Vauquelin discovered the elment chromium in 1797 (Weast 1980, B-7) and since then chromium in the oxide form has become a very common pigment in ceramic glazes. A very versatile colourant, it can produce green, red, pink, purple, orange, brown and black underglaze colours when combined with one or more of the following metal oxides: tin, cobalt, nickel, manganese, iron, zinc, aluminium and alkaline earths. The metal oxides used with chromium oxide to produce the underglaze colours analyzed in this report are discussed in the following paragraphs.

Different hues of green are produced when metal oxides in varying amounts are added to chromium oxide. Table I illustrates the oxides used and the shades of green produced.

Table 1
The Hues of Green produced when various metal oxides are added to chromium oxide

Metal Oxide	Result
Cobalt	0.4% brightens chromium green 0.4% bluish green
Nickel	olive or bronze green
Iron	brownish green
Maganese	olive or brownish green
Calcium or other alkaline earths	bright green (Victoria green)
Zinc	greyish green
Aluminium	lightens chromium green

References (Panicken 1945, 77; Parmelee 1951, 430; Seger 1902, 656).

The production of most of the colours requires the addition of very small amounts of the oxides to the chromium oxide. All of the green chromium colours are more brilliant when they are fired in a strongly reducing kiln.

Chromium will produce a "red" colour with either tin oxide or aluminium oxide (Norton 1970, 218-219; Parmelee 1951; 434-435). Aluminium oxide produces salmon, flesh and pastel pink chromium colours while tin oxide-chromium colours can vary from maroon to pink to violet.

The chrome-tin colour is the most widely used modern underglaze red (Parmelee 1951, 434) and the nature of the pigment has been studied extensively. The red colour is produced when finely divided chromic oxide deposits on tin oxide. The chromic oxide first vaporizes then condenses on a stable tin sphene (CaO-SnO_2-SiO_2) crystal (Norton 1970, 218) and since the tin is essentially insoluble in most glazes, it retains the pink or maroon colour. The calcium oxide and silica are required to stabilize the colour at elevated temperatures and are also used to brighten the red colour. Up to 25% calcium oxide can be used, but over 25% destroys the colour. Very low concentrations of lime can result in violet and lilac shades. The colour is mainly dependent on the ratio of chromium oxide to tin oxide, if the ratio is 1:5 the colour is green; 1:15 purple, 1:17 to 1:20 red or maroon and 1:25 pink (Hurd 1961, 11). The chrome-tin colours require an oxidizing condition during firing since they are destroyed by reduction.

The nature and behavior of the chrome-aluminium colour is probably analoglous to the chrome-tin colour, but, this has not been confirmed (Norton 1970, 219).

Chromium oxide is an important underglaze colourant due to the diversity of colours it can produce. Green, red, pink, purple, orange, brown and black colours all can be produced when this colourant combines with one or more metal oxides. The underglaze colours analyzed in this report were red, green and purple.

Sample Description

Sixty-three coloured underglaze samples were analyzed. These sherds were separated by colour into three main groups: green, purple and red. See Figures 1, 2 and 3. The underglaze decoration on each sherd had been applied by one of four techniques: transfer, hand painting, stamp and sponge. See figures 3, 4, 5, and 6. The ceramics were of three different types - creamware, pearlware and whiteware.

Method

(Appendix I contains detailed sampling, dissolution and analysis procedures)

The sherds were sampled by using a drill press with a tungsten carbide drill bit. Each sherd was sampled in two areas: the most heavily coloured and the non-coloured. See figure 7. The drill hole diameters were measured by calipers under a microscope and the sample areas were calculated from these measurements.

The method used to dissolve the samples was a modified version of the procedure developed by W.J. Price. The W.J. Price method (Price and Whiteside, 1977, 669) was modified by increasing the heating periods and by excluding the ionization buffer.

The grade of chemicals used in the dissolution method are in Appendix II.

The analyses of the samples were performed on a Perkin Elmer atomic absorption spectrophotometer model 460 with a graphite furnace accessory. The volume of sample used in the analysis was 100 microlitres (μl) or less depending on the sample concentration.

Results

The results are in Table 2, 3 and 4. The amount of chromium responsible for the colour is the difference between the coloured and non-coloured areas. Concentrations of chromium were expressed in micrograms chromium per square centimeter ($\mu g/cm^2$). The results are interpreted and discussed by Lynne Sussman in Part I of this paper.

Discussion of Method

The concentration of chromium used in underglaze colourants is in the microgram per square centimeter range. One microgram (μg) is 0.000001 or one millionth of a gram and significant contamination can easily occur. The main sources of contamination that were encountered were reagents and implements used in sampling. Contamination occured when reagent grade hydrofluoric acid was used in the dissolution procedure. It had to be replaced by ultra pure hydrofluoric acid that contains only 0.0003 micrograms per millilitre ($\mu g/ml$) chromium. Contamination also occurred when a stainless steel scalpel blade was used to remove sample dust from the drill holes. A bone instrument was fashioned and used instead. All known sources of contamination were minimized.

Ideally the analysis should have been done in triplicate, however, this would have been far too time consuming. Each sherd had a non-coloured sample removed which also acted as a control. Contamination would have shown up in the non-coloured sample results.

Two results, 2E16Z1 and 3T30G1-3, are listed in table 2 as approximate. Sample 2E16Z1 had a vine pattern which required several small drill holes. See figure 8. The amount of green vine taken in each drill hole had to be estimated and therefore the actual concentration of chromium is approximate. The atomic absorption readings for sample 3T30G1-3 were not stable. For photograph of sherd see figure 1. A constituent of the coloured sample produced unstable readings since stable readings returned when the non-coloured portion, other samples and standards were analyzed.

One sample, 9G1B14-13, was analyzed twice with very different results, 71 μg Cr/cm^2 and 129 μg Cr/cm^2. This discrepancy was due to varying concentrations of pigment per surface area. Samples were taken from the most heavily pigmented area, however, in a sample like 9G1B14-13, these areas are very small and the drilled samples visually contained different amounts of pigment. If the samples from sherd 9G1B14-13 contained approximately the same amount of pigment per unit area then the results would have been similar.

This method of analyzing underglaze colourants involves

1) grinding off the sample from the sherd.
2) dissolving in a hydrofluoric acid pressure vessel
3) analyzing the solution using a graphite furnace attached to an atomic absorption spectrophotometer.

This is obviously a time consuming and delicate method, however, it is also a highly specific and sensitive technique..

References

Bleininger, A.V. (ed.)
1902
The Collected Writings of Hermann August Seger. Easton, PA: The Chemical Publishing Company.

Hurd, B.
1961
Chrome-Tin Pinks and Maroons. American Ceramics Society Bulletin 40, no. 1:11-12.

Norton, F.H.
1970
Fine Ceramics - Technology and Applications. New York: McGraw-Hill.

Panicker, M.K.N.
1945
Faults Found with Various Types of Chrome Greens and the Methods Obviating Them. Trans. Ind. Cer. Soc. V, no. 2:76-78.

Parmelee, C.
1951
Ceramic Glazes. Harmen, C. (ed.). 1973. Boston: Cahners Publishing Company, Inc.

Price, W.J., and P.J. Whiteside
1977
General Method for Analysis of Siliceous Materials by Atomic-absorption Spectrophotometry and Its Application to Macro- and Micro-samples. Analyst 102, 664-671.

Rhodes, D.
1974
Clay and Glazes for the Potter. Revised edition. Radnor, Pa.: Chiton Book Company.

Weast, R. (ed.).
1980.
CRC Handbook of Chemistry and Physics. 60th edition. Boca Raton, Florida: CRC Press, Inc.

Appendix I

Detailed Sample Preparation and Analysis

A. Sampling Procedure

The following is the detailed procedure that was used to sample every undercolour glaze sherd. Initially the sherd was wiped with a damp kimwipe then examined to determine the best sampling locations. The sample was drilled using a tungsten carbide drill bit that had been previously rinsed with distilled water, dryed with a fresh kimwipe and dusted using "phfft" aerosol duster. The drilling was done slowly and steadily thereby minimizing the amount of airborne sample dust. The sample dust was then knocked and then scraped into the digestion bomb (teflon lined - Parr acid digestion bomb) using a bone "knife". The remaining sample dust on the sherd and on the "knife" was washed into the digestion bomb with one millilitre (ml) of distilled water. The sherd was wiped with a kimwipe and dusted using the aerosol. The sample remaining on the drill bit was knocked into the bomb and then any sample still adhered to the drill bit was washed into the digestion bomb with 1 ml of distilled water. The drill bit was then cleaned using a kimwipe and aerosol. The diameter of the drill holes were measured under a stereomicroscope using calipers and the sample area was calculated.

B. Dissolution Procedure

This is the detailed procedure for dissolving the undercolour glaze sample that was sampled by the method already described. All volumes were measured using an Eppendorf pipette.

In a fume hood, 0.5 ml of reagent grade nitric acid (HNO_3) was added to the digestion bomb, followed by 0.5 ml of ultra pure hydrofluoric acid (HF). The digestion bomb was then placed in an oven for approximately 1.5 hours at 160°C. After 1.5 hrs the bomb was removed and cooled by either placing it in the freezer or by running cold water over it. When the container was cool, it was opened and 3 mls of 4% boric acid were added. The bomb was placed back in the oven for approximately 1 hour at 160°C. The bomb was removed and cooled then the contents were transferred to a 50 ml volumetric flask and diluted to that volume. The samples were analyzed as quickly as possible.

C. Sample Analysis

All samples were analyzed for chromium using a graphite furnace attachment model 2100 on a Perkin Elmer model 460 atomic absorption spectrophotometer. Each set of analysis was comprised of 7 samples, coloured and non-coloured samples from 3 sherds and a chemical blank. The chemical blank was prepared by using the dissolution procedure with 2 ml of distilled water instead of the sample and water solution prepared in the sample preparation. Four chromium standards were prepared for each set of analysis, 0.005 ppm, 0.02 ppm and 0.03 ppm. These standards were prepared by diluting 1000 ppm Baker Analyzed Chromium standard with the prepared chemical blank. The standards in 100 ml aliquots, were analyzed by atomic absorption spectrophotometry and the resulting absorbances versus their concentration were plotted to form a calibration curve.

Eppendorf pipettes were used to measure and inject all samples and standards into the graphite furnace. The initial sample volume for all samples was 100 ml, however, this volume had to be reduced for samples with high absorbances could be plotted on the linear portion of the calibration curve.

Appendix II

Description of chemicals and equipment:

- Boric acid - H_3BO_3 Fisher certified A.C.S. cat. A-74
- Chromium 1000 ppm standard Baker analyzed reagent cat. 6926-1
- Hydrofluoric acid - HF Baker Ultrex Ultrapure reagent Cat. 4804
- Nitric acid - NHO_3 Fisher reagent A.C.S. cat. A-200
- Cameron Precision Engineering Co. drill press
- Eppendorf pipettes series 3130
- Nikon stereomicroscope SMZ-10
- Parr acid digestion bomb - teflon lined No 4745
- Peacook hardened stainless steel calipers
- Perkin Elmer
    - atomic Absorption Spectrophotometer model 460
    - graphite furnace model 2100

TABLE 2
Chromium Analysis OF Sherds Containing Green Underglaze Pigments

Provenience No.	Description of Sherd	Munsell Colour	Concentration of Chromium $\mu g/cm^2$ non-coloured area	green coloured Area	Difference
9G24D1	creamware saucer	10Y 7/6	0	0	0
19H8B4	pearlware cup	10Y 5/4	0	0	0
19H10D1	creamware bowl	10Y 5/6	0	0	0
19H17A3	pearlware saucer	7.5GY 4/4	5	7	2
19H8L2	pearlware cup	2.5GY 5/6	2	5	3
9G5B1	pearlware plate	10BG 5/4	4	8	4
19H17A2-4	pearlware saucer	7.5GY 6/4	5	10	5
19H8V1	pearlware saucer	5GY 5/6	8	15	7
2E16R30-35	pearlware bowl	7.5G 2/4	4	11	7
19H12A1	pearlware saucer	7.5GY 4/4	1	9	8
19H7D6-20	pearlware plate	2.5G 4/8	4	14	10
9G11V3	creamware saucer	2.5GY 4/4	2	17	15
9G24D1	pearlware cup	5GY 4/6	0	16	16
9G31B1-81	whiteware plate	5GY 3/4	6	40	34
9G22K1-28	whiteware plate	7.5GY 4/4	0	61	61
*9G1B14-13 (A)	whiteware plate	7.5BG 3/4	7	78	71
9G1B30-64	whiteware sherd	2.5BG 3/4	4	96	92
3T19Z1	bone china saucer	10G 4/8	3	98	95
3T33V3-1	whiteware sherd	10G 3/6	11	119	108
*9G1B14-13 (B)	whiteware plate	7.5BG 3/4	20	149	129
9G25B1-51	whiteware sherd	7.5GY 4/4	2	143	141
9G1B28-29	whiteware plate	7.5BG 3/4	14	166	152

9G15B4-17	whiteware sherd	$\frac{5GY}{3/4}$	15	169	154
9G22L2-39	whiteware saucer	$\frac{7.5GY}{4/4}$	1	168	167
3T30G1-4	whiteware cup	$\frac{2.5BG}{3/4}$	0	190	190
9G9H2-23	whiteware plate	$\frac{7.5GY}{4/4}$	0	214	214
9G1B2-14	whiteware cup	$\frac{2.5BG}{3/4}$	0	227	227
9G6C1-58	whiteware saucer	$\frac{7.5GY}{4/4}$	1	241	241
9G39B1-432	whiteware plate	$\frac{7.5GY}{3/2}$	13	261	248
2E16Z1	whiteware ewer	$\frac{7.5GY}{4/6}$	approx. 1	approx. 308	approx. 307
9G1B1-45	whiteware sherd	$\frac{10GY}{4/6}$	5	348	343
9G8G14-16	whiteware hollowware	$\frac{7.5GY}{4/6}$	6	354	348
19H2E1	pearlware cup	$\frac{10GY}{3/4}$	2	358	356
3T30G1-3	whiteware plate	$\frac{2.5BG}{3/4}$	approx. 11	approx. 381	approx. 370
9G39B1-431	whiteware sherd	$\frac{7.5GY}{5/8}$	0	569	569
IU1A1-103	whiteware hollowware	$\frac{10GY}{6/6}$	26	760	734
1K40E2-2	whiteware cup	$\frac{10GY}{3/4}$	2	903	901

* two separate analysis (A) & (B)

TABLE 3
Chromium Analysis OF Sherds Containing Red Underglaze Pigments

Provinence No.	Description of Sherd	Munsell Colour	Concentration of Chromium $\mu g/cm^2$ non-coloured area	Red coloured Area	Difference
3T30J2-4	whiteware sherd	$\frac{2.5R}{4/8}$	5	20	15
9G1B17-20	whiteware plate	$\frac{10RP}{4/6}$	1	18	17
2E17K3-162	whiteware plate	$\frac{10RP}{6/6}$	0	22	22
9G1B20	whiteware teapot lid	$\frac{2.5R}{3.5/8}$	7	29	22
2E17B2-118	whiteware plate	$\frac{10RP}{4/8}$	3	27	24
9G15D3-28	whiteware sherd	$\frac{2.5R}{3/8}$	4	28	24
9G15N3-398	whiteware saucer	$\frac{2.5R}{3/6}$	0	25	25
9G15L3	whiteware hollowware	$\frac{2.5R}{3/6}$	8	38	30
9G15N3-397	whiteware saucer	$\frac{2.5R}{3/6}$	0	31	31
9G22L2-38	whiteware plate	$\frac{2.5R}{3/8}$	8	43	35
3T30F1-11	whiteware saucer	$\frac{2.5R}{3/8}$	0	38	38
9G15D3-29	whiteware teapot	$\frac{7.5RP}{3/6}$	1	53	52
9G5M3-108	whiteware plate	$\frac{25R}{3/6}$	0	64	64

TABLE 4
Chromium Analysis OF Sherds Containing Purple Underglaze Pigments

Provinence No.	Description of Sherd	Munsell Colour	Concentration of Chromium $\mu g/cm^2$ non-coloured area	Purple coloured Area	Difference
2E17C2-51	pearlware saucer	7.5RP/2/2	0	0	0
2E23D16-5	pearlware saucer	10R/3/4	2	7	5
9G15H3-149	whiteware ewer	--	0	5	5
2E15C4-4	whiteware sherd	5RP/3/6	0	13	13
9G1B29-39	whiteware plate	5RP/3/6	5	19	14
9G38A1-98	whiteware sherd	5RP/3/4	7	26	19
9G1B29-40	whiteware saucer	5RP/3/6	3	23	20
9G15A1-15	whiteware sherd	5RP/3/6	2	25	23
9G15C3-37	whiteware saucer	5RP/3/6	3	29	26
1K1P1-66	whiteware cup	10PB/3/6	0	29	29
9G32A1-34	whiteware plate	5RP/3/4	0	35	35
9G5E1-18	whiteware saucer	5RP/3/6	0	51	51
9G13D1-11	whiteware sherd	5RP/3/4	3	66	63
9G7B3-81	whiteware platter	5RP/3/6	4	96	92

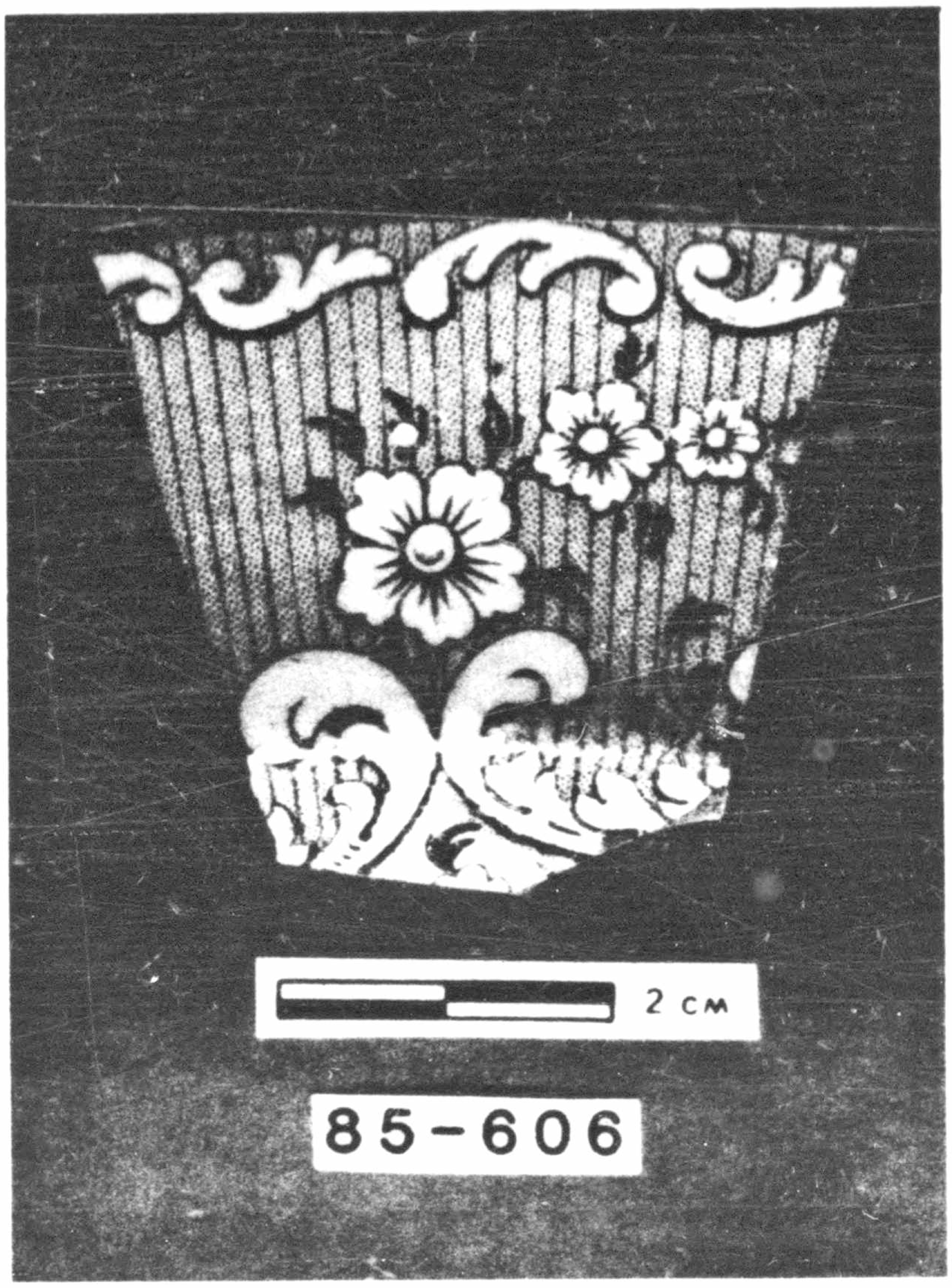

Figure 1. Green transfer plate

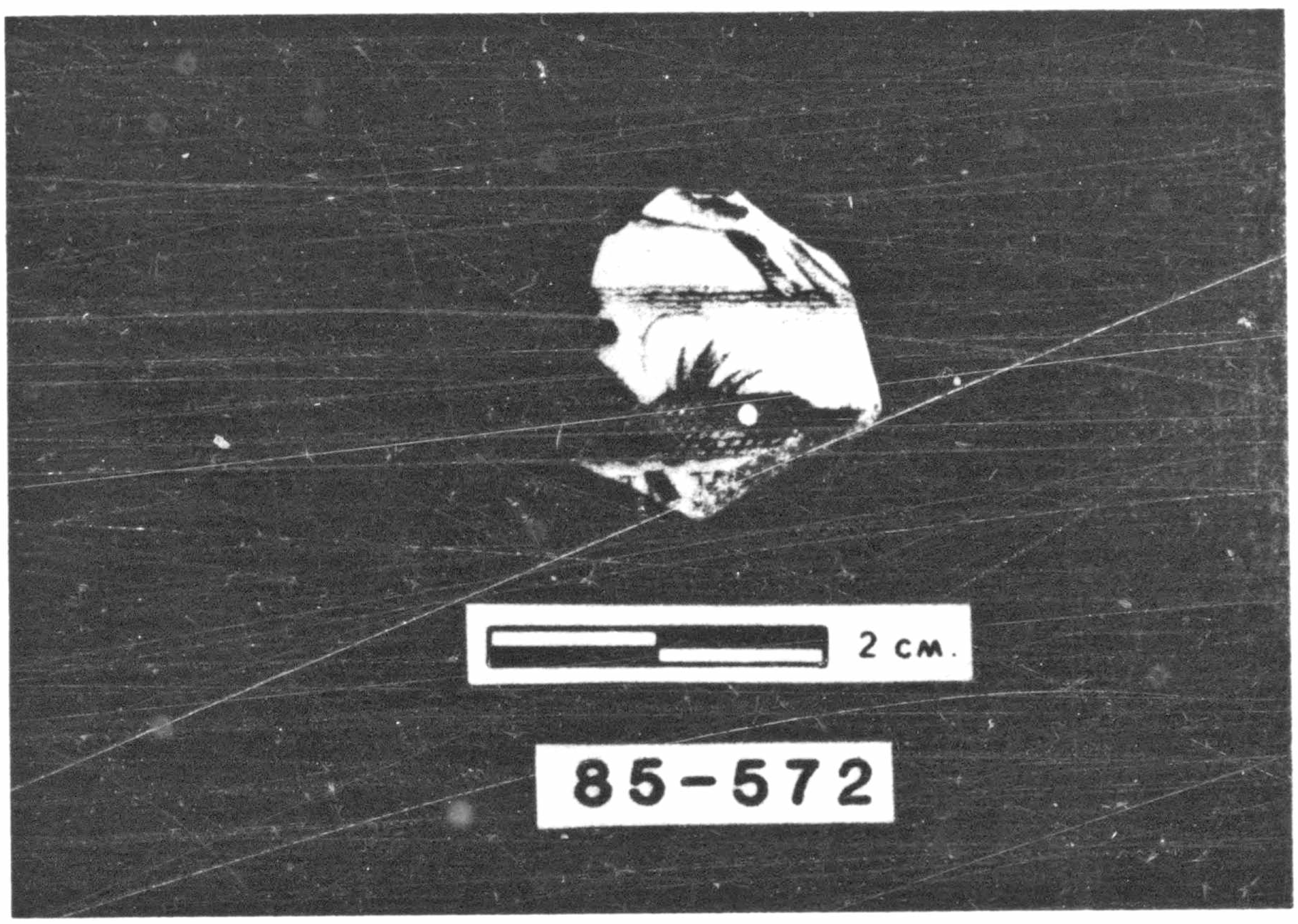

Figure 2. Purple transfer saucer

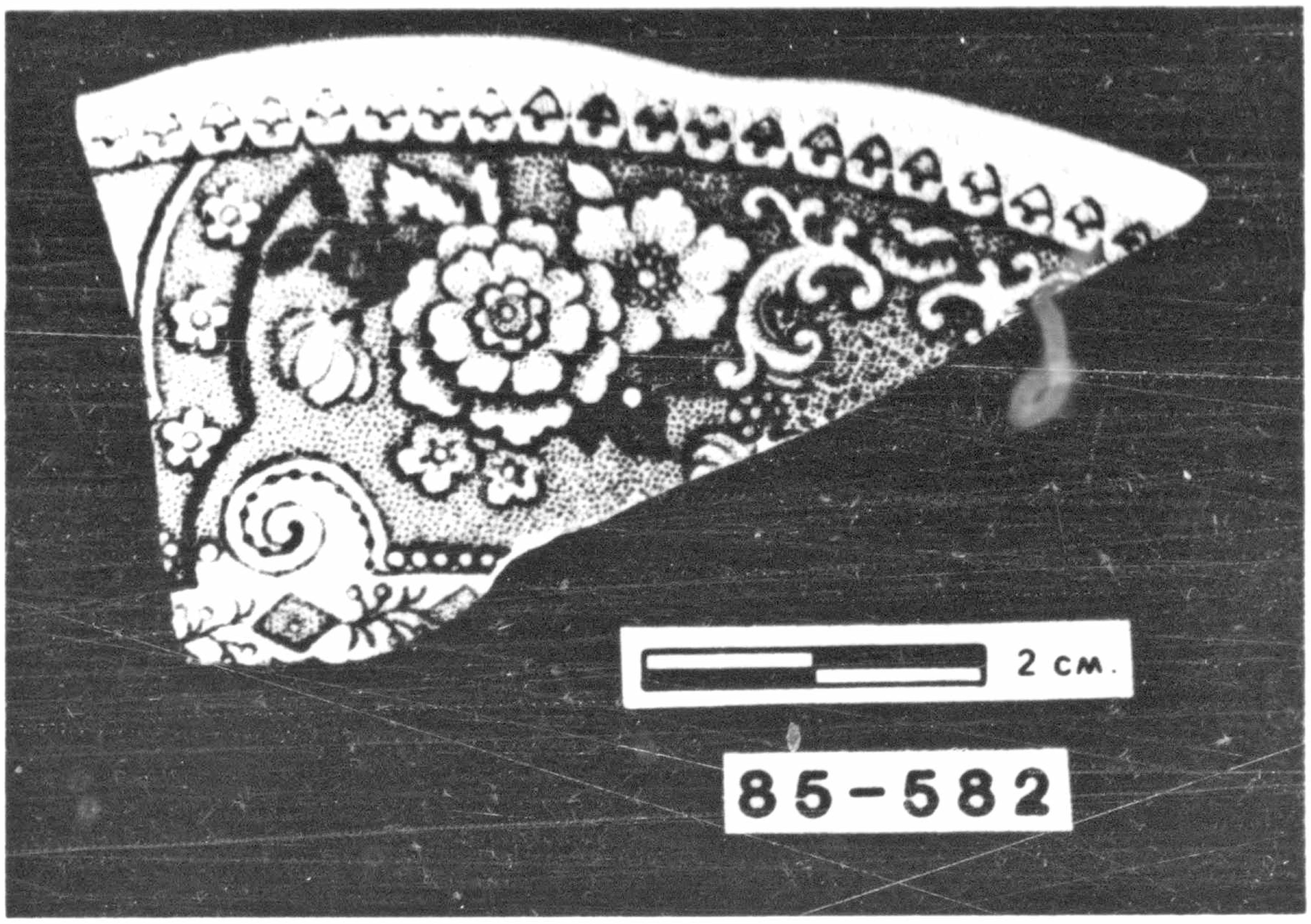

Figure 3. Red transfer plate

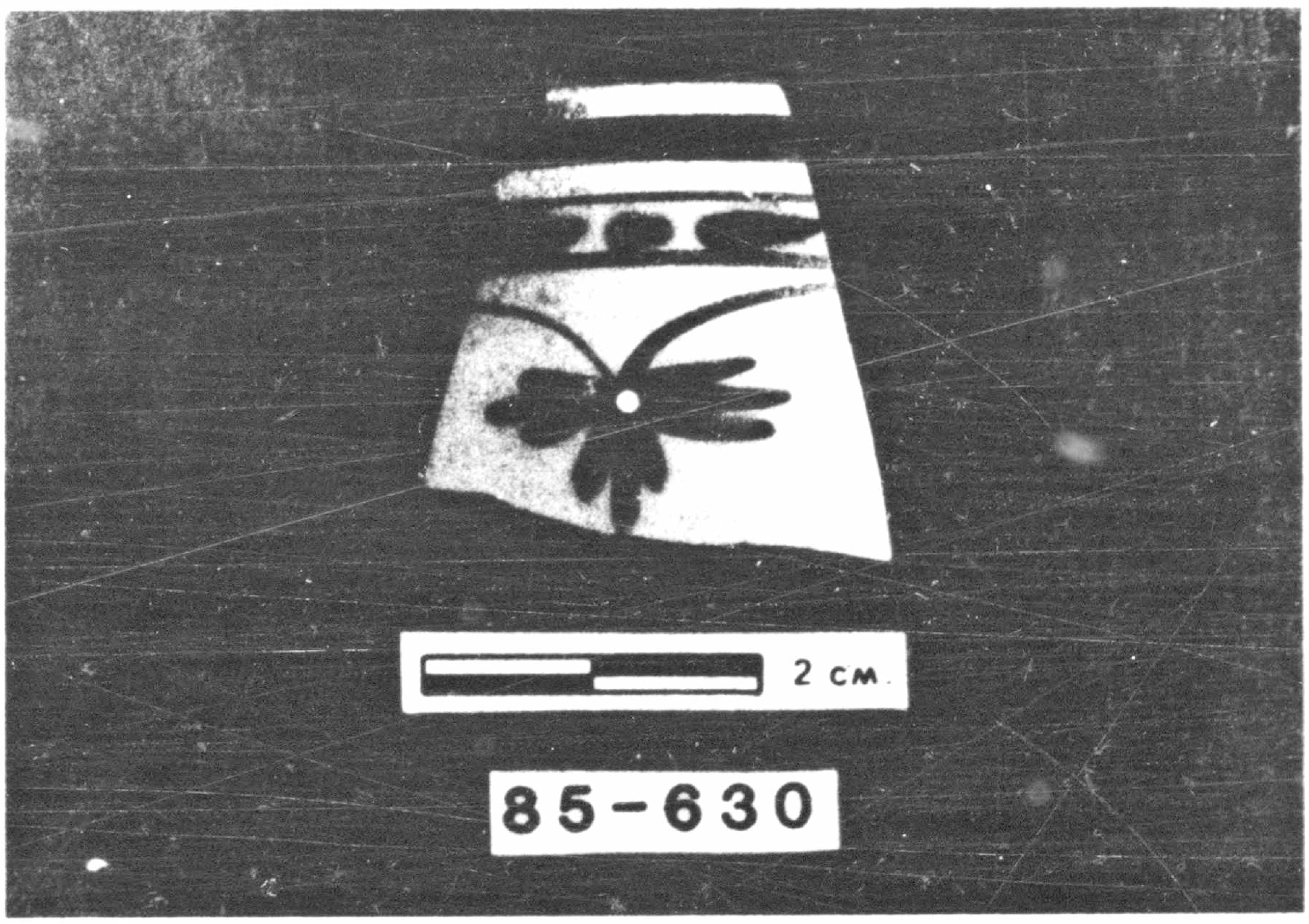

Figure 4. Handpainted pearlware cup

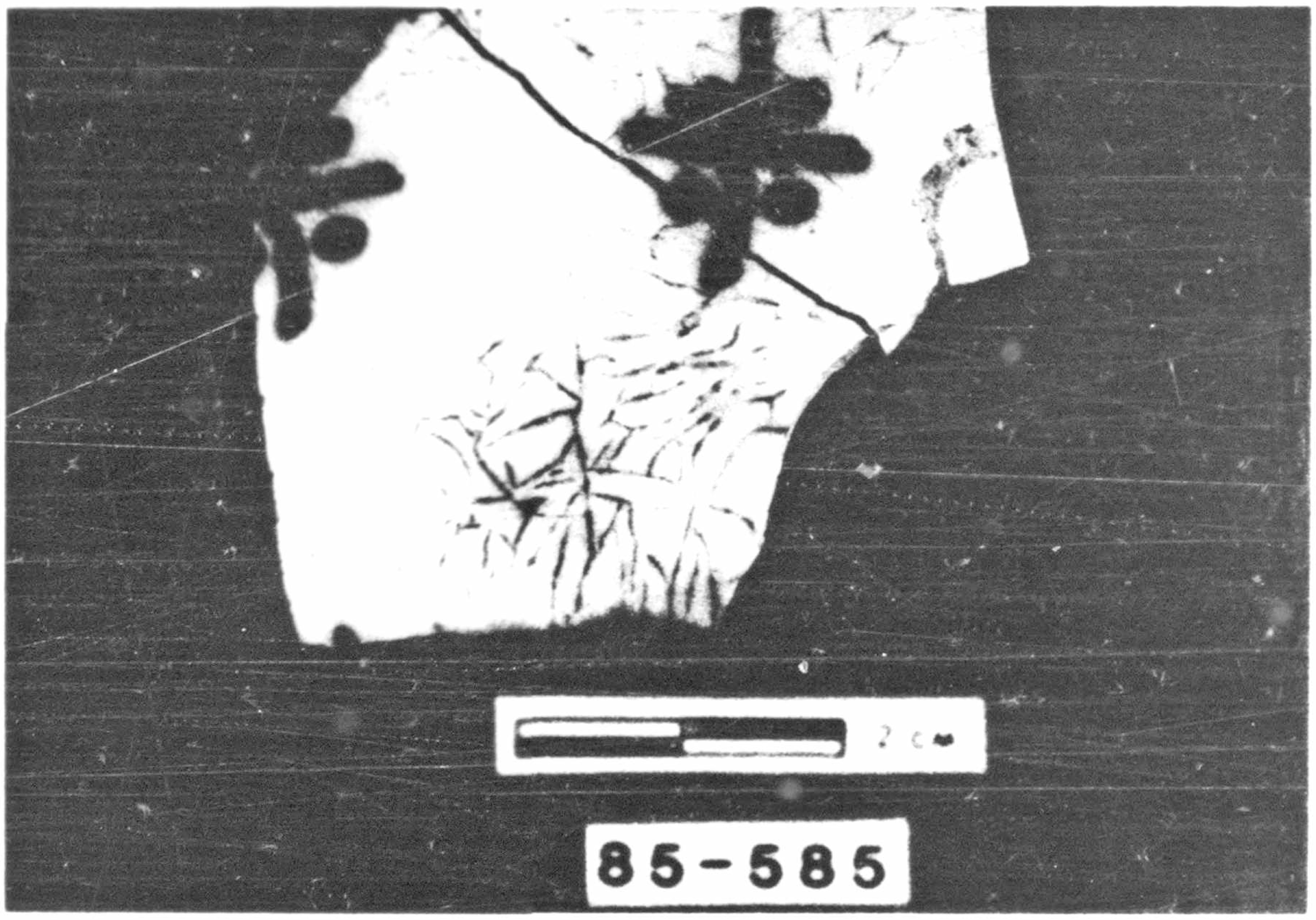

Figure 5. Stamped saucer

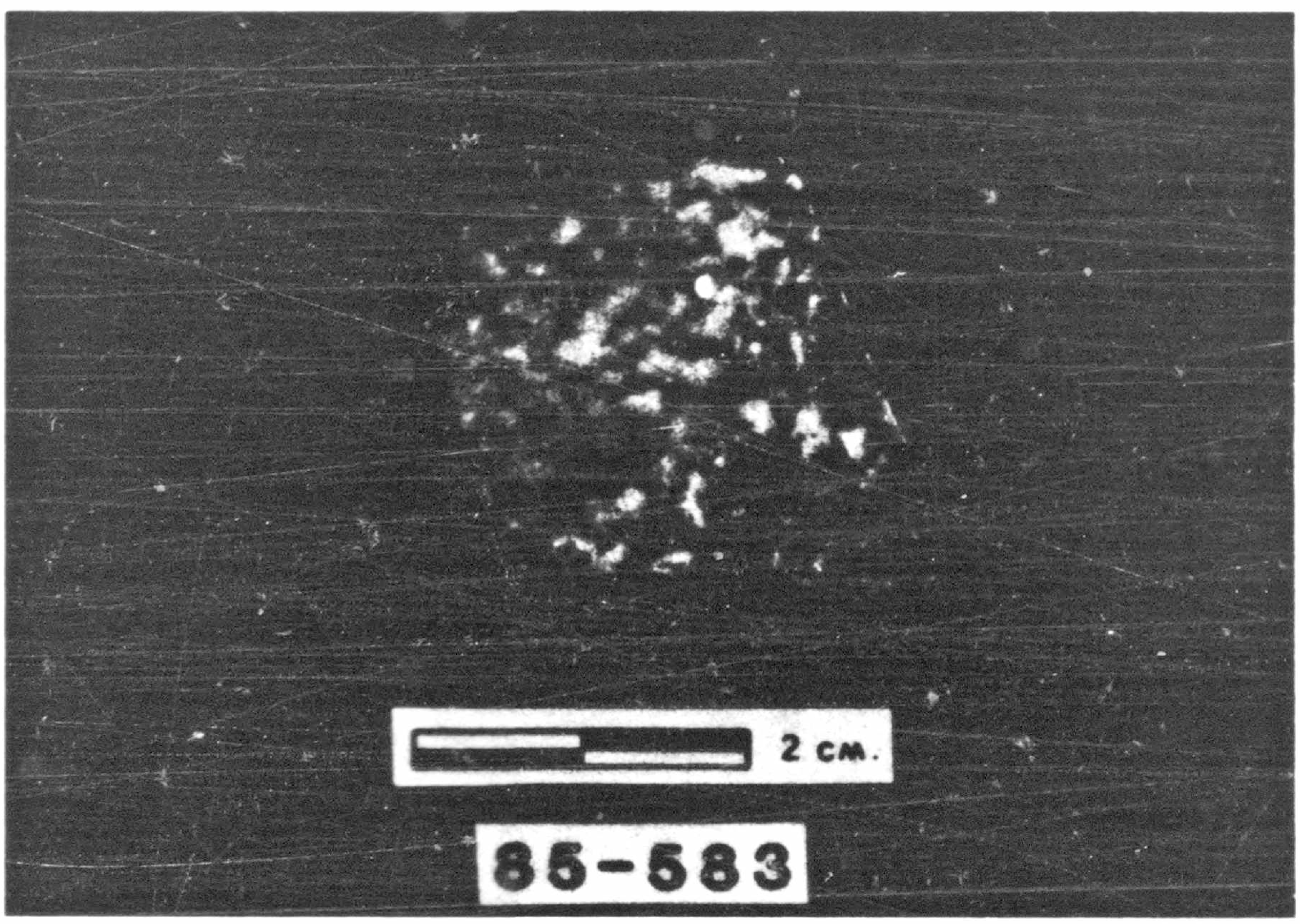

Figure 6. sponged hollowware

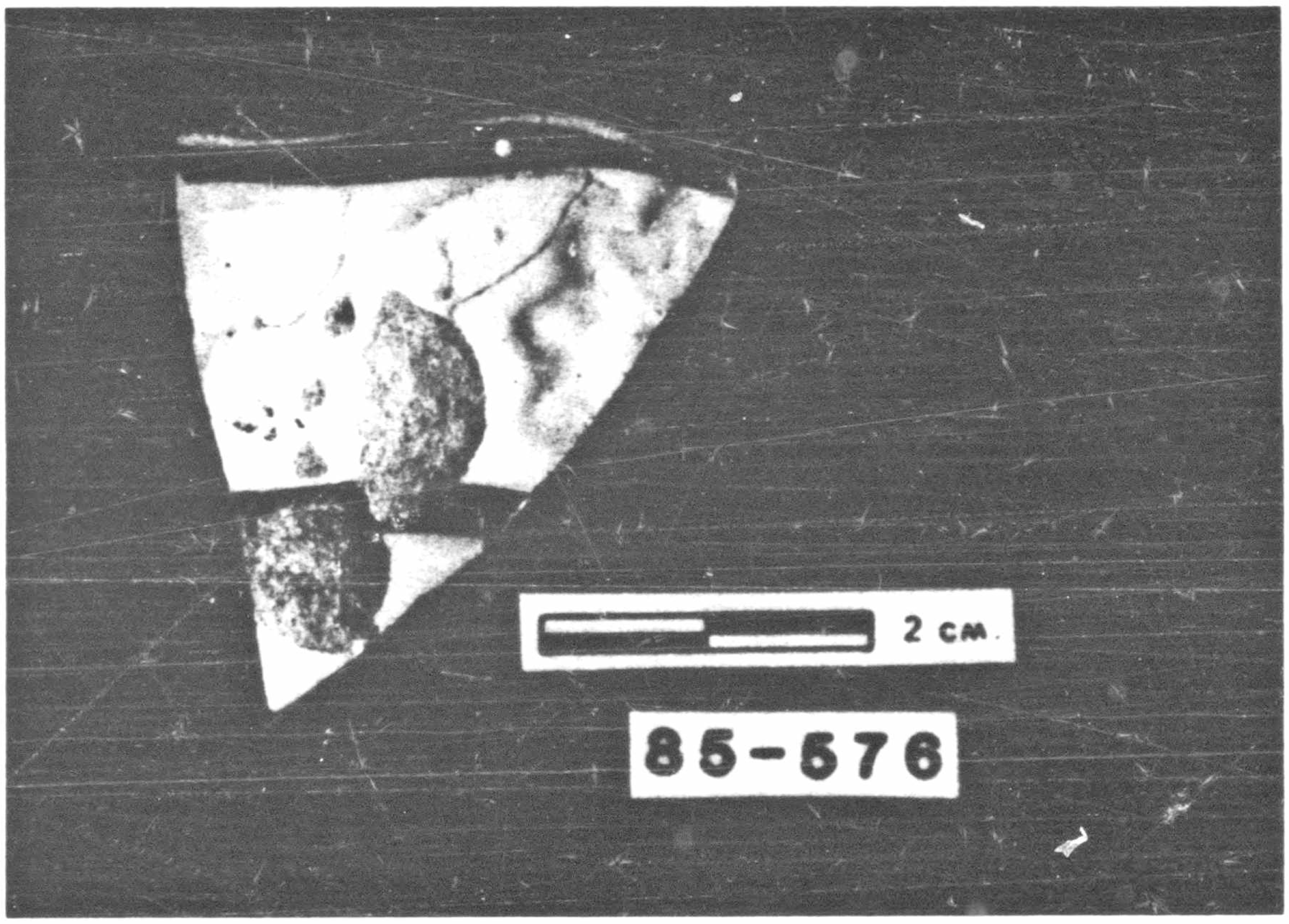

Figure 7. Photograph illustrating sample drill holes.

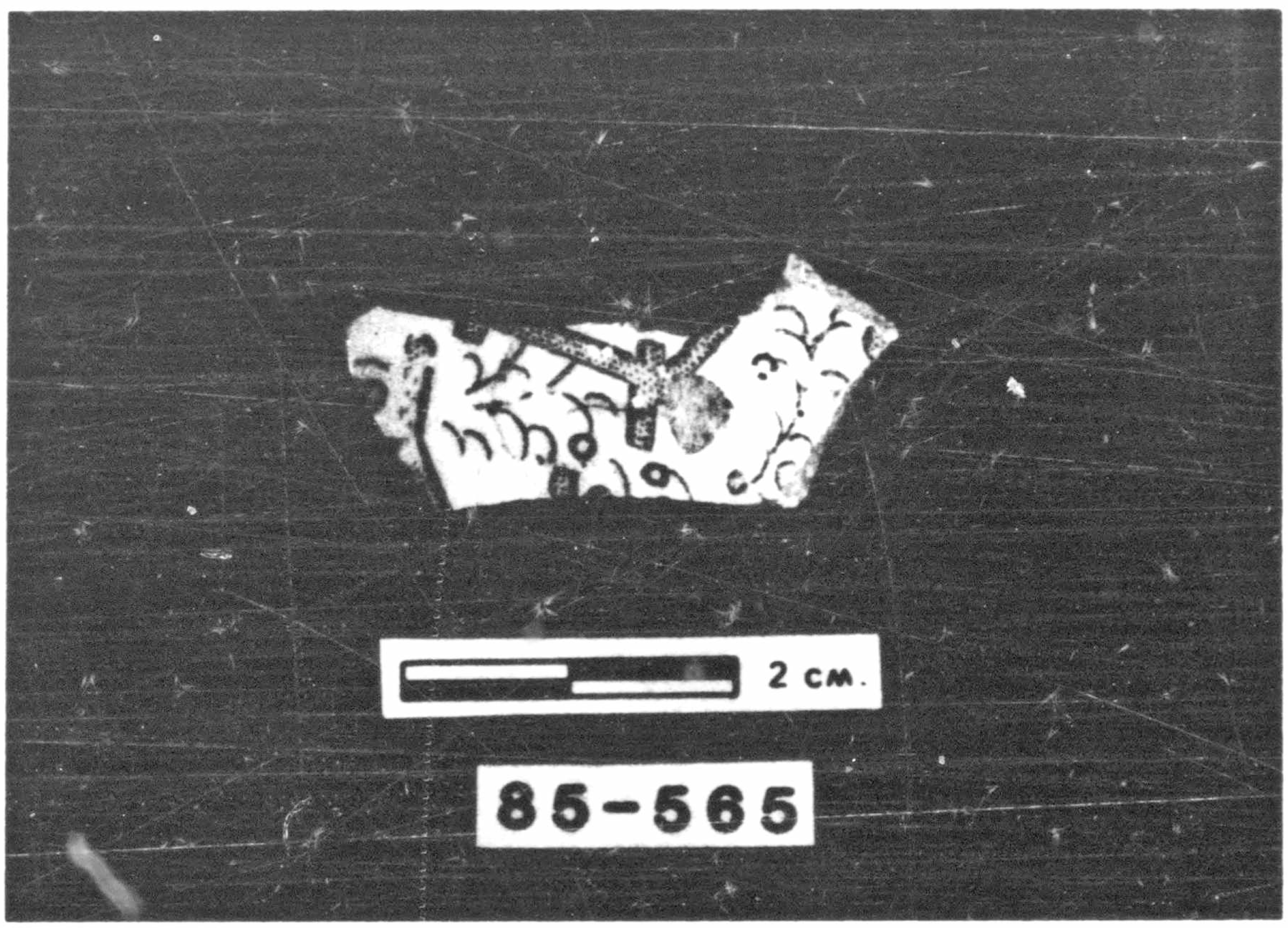

Figure 8. Photograph of sherd illustrating numerous sample drill holes.

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