City Hall Rehabilitation Archaeology Project 2010-2011
Volume 4

Alyssa Loorya
Daniel Eichinger
Meta F. Janowitz
Matthew Brown
Christopher Ricciardi

Prepared for: Mayor's Fund to Advance New York City

Chrysalis Archaeology - Brooklyn, New York
URS Corporation - Burlington, New Jersey

Alyssa Loorya and Christopher Ricciardi, Editors

City Hall Park
2010-2011 Excavation Report

Appendix L:

Chester Higgins Images

CACchm002: northeast vault area, F. 8 (well), 9, 10, 11 (drains) in the foreground.

CACchm004: northeast vault area, F. 8 (well), 9, 10, 11 (drains) in the foreground.

CACchm006: northeast vault area, F. 8 up close, F. 9, 10, 11 (partial).

CACchm007: northeast vault area, F. 11 (drain) south profile view, F. 8 (partial).

CACchm008: northeast vault area, F. 3.

CACchm009: northeast vault area, F. 4, and F. 7 (small well) Plan View.

CACchm011: northeast vault area, F. 2 cistern, top view.

CACchm016: northeast vault area, F. 2 cistern, SW corner of F. 4 NW.

CACchm019: northeast vault area, F. 3 interior, top view.

CACchm020: northeast vault area, F. 11 (drain).

CACchm021: northeast vault area, F. 11 (drain) intersection with F. 8 well.

CACchm022: northeast vault area, F. 8 (well) plan view, F. 9, 10, 11 (partial).

CACchm023 northeast vault area, F. 8 (well) plan view, F. 9, 10, 11 (partial).

CACchm026: northeast vault area, F. 8 (well) and
F. 11 profile view where drain enters well.

CACchm032: northeast vault area, F. 9 (drain) and F. 8 well intersection, F. 11 drain in background.

CACchm033: northeast vault area, F. 9 (drain) and F. 8 well intersection, F. 11 drain in background.

CACchm035: northeast vault area, F. 8 well southern interior, view from inside F. 10.

CACchm039 northeast vault area, F. 8 (well) western interior, beneath opening of F. 11 drain.

CACchm040: northeast vault area, F. 8 well southern interior wall.

CACchm041: northeast vault area, F. 8 well southeast interior wall.

CACchm042: northeast vault area, F. 8 (well) northern interior, beneath opening of F. 10 drain.

CACchm050: northeast vault area, F. 8 (well) and F. 10 profile view where drain enters well.

CACchm052: northeast vault area, F. 11 entrance to F. 8 well.

CACchm056: northeast vault area, retaining wall (F. 1).

CACchm058: northeast vault area, F. 11 interior, view from inside well.

CACchm059: northeast vault area, F. 3 east wall, exterior and corridor along retaining wall.

CACchm061: northeast vault area, easternmost end of retaining wall, where it meets East Path.

CACchm064: northeast vault area, F. 8 (well) and F. 9 profile view where drain enters well.

CACchm070: northeast vault area, drain west of F. 3, collapsed segment.

CACchm071: northeast vault area, F. 3 east wall, exterior.

CACchm073: northeast vault area, F. 3 east wall, exterior and view of interior.

CACchm075: northeast vault area, F. 3 SE corner and south wall interior.

CACchm077: northeast vault area, F. 3 east wall exterior abutting retaining wall.

CACchm080: northeast vault area, F. 3 interior facing west wall,
partial view of north and south walls.

CACchm083: northeast vault area, F. 3 SW corner and south wall interior, view of segment of retaining wall as well.

CACchm084: northeast vault area, F. 3 south wall interior along retaining wall.

CACchm085: northeast vault area, F. 4 exterior of east wall,
eastern half of F. 7 (small well).

CACchm088: northeast vault area, F. 3 an interior corner.

CACchm092: northeast vault area, F. 4 exterior of east wall,
eastern half of F. 7 (small well).

CACchm094: northeast vault area, F. 4 exterior of east wall,
eastern half of F. 7 (small well).

CACchm095: northeast vault area, F. 4 northeast corner interior
and plan view of F. 7 west half.

CACchm096: northeast vault area, F. 4 interior view from NE corner above F. 7.

CACchm097: northeast vault area, F. 4 interior view from west wall.

CACchm098: northeast vault area, F. 2 cistern plan view.

CACchm100: northeast vault area, F. 2 northern exterior, profile view of stepped dome.

CACchm101: northeast vault area, F. 2 northern exterior, profile view of stepped dome.

CACchm102: northeast vault area, F. 2 northern exterior, close up of stepped dome and F. 4 SW corner abutting F. 2 exterior.

CACchm105: northeast vault area, F. 2 cistern plan view, view of other features to the east.

CACchm108: northeast vault area, view of F. 4 SW corner abutting F. 2 exterior.

CACchm111: northeast vault area, F. 4 interior view from SW corner.

CACchm113: northeast vault area, F. 4 plan view of south wall
and northern part of F. 2 cistern.

CACchm115: northeast vault area, F. 2 cistern in back ground,
F. 4 south wall in foreground.

CACchm117: northeast vault area, F. 7 interior, also F. 4 interior NE corner.

CACchm119: northeast vault area, F. 2 cistern in background,
F. 4 south wall in foreground.

CACchm120: northeast vault area, F. 4 interior profile of south wall.

CACchm123: City Hall basement, interior room.

CACchm126: City Hall basement, interior room.

CACchm130: northeast vault area, F. 8 and F. 11 in foreground, retaining wall and City Hall in background.

CACchm131: northeast vault area, F.3 in foreground, retaining wall and City Hall exterior in background.

CACchm133: northeast vault area, F.3, 4 and 2 plan view in foreground, City Hall exterior in background.

CACchm135: northeast vault area, F. 4 and 2 plan view.

CACchm136: northeast vault area, F. 4 and 2 plan view, other features and NE area in background.

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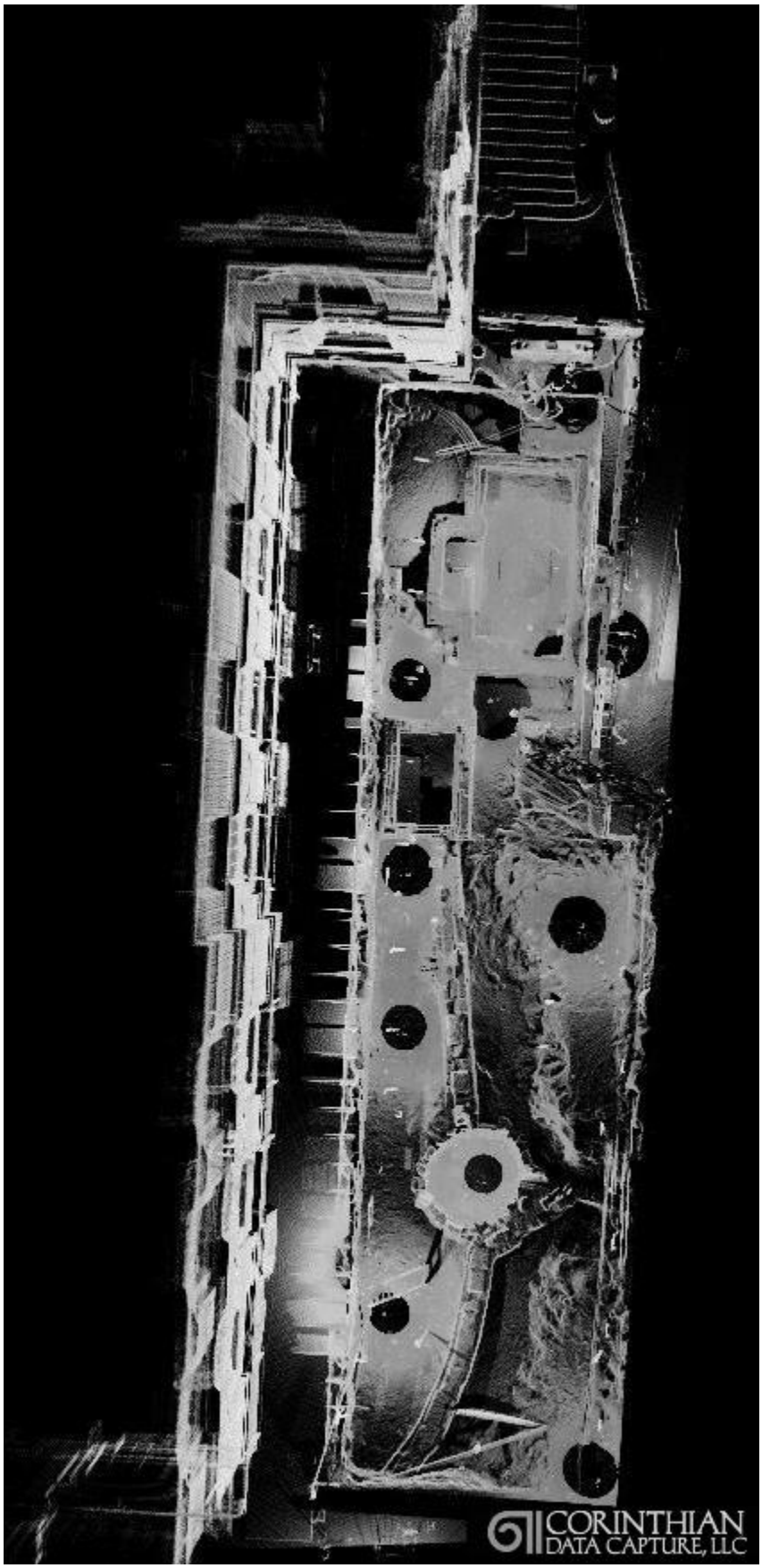
2010-2011 Excavation Report

Appendix M:

The Northeast Field – Three Dimensional Image Scans 2010

Z
Y
CORINTHIAN
DATA CAPTURE, LLC

CORINTHIAN
DATA CAPTURE, LLC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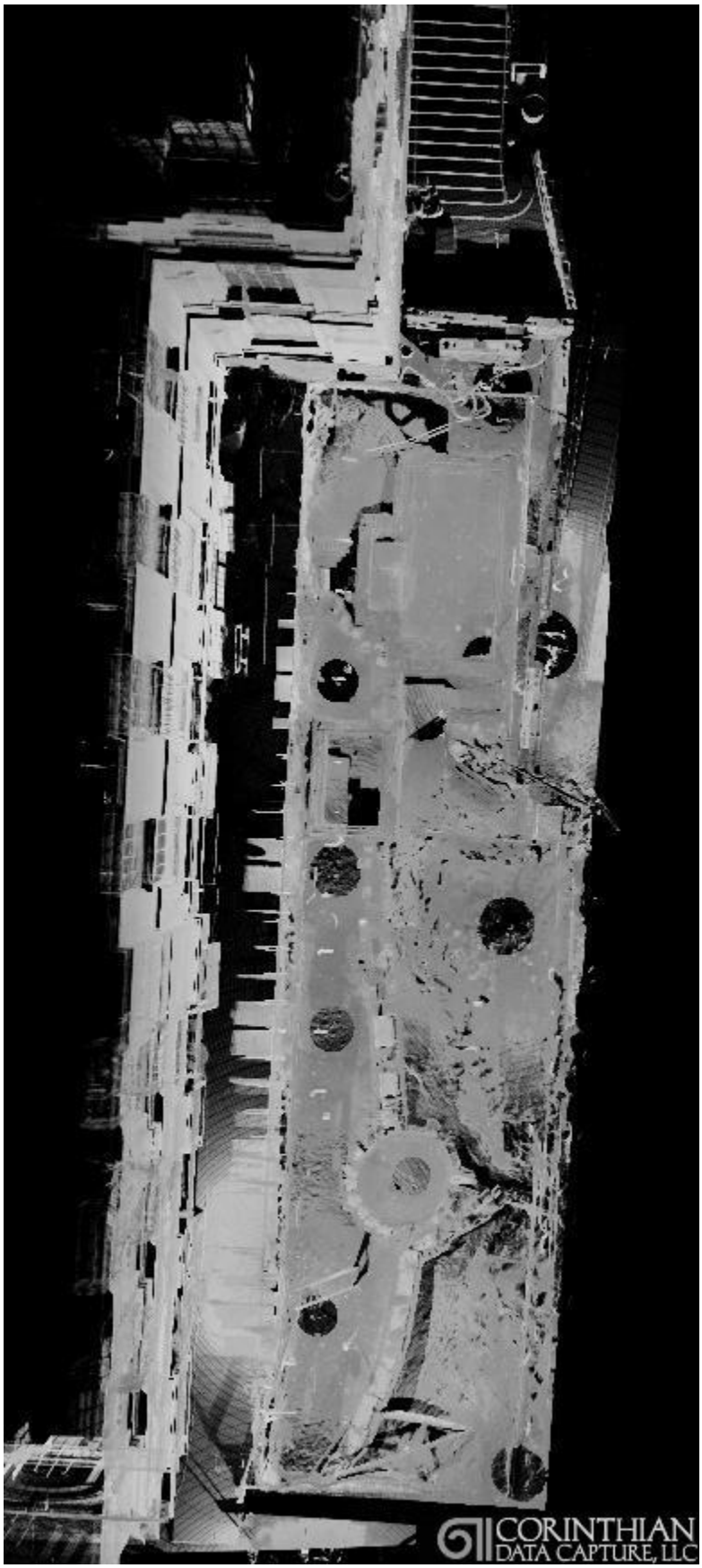
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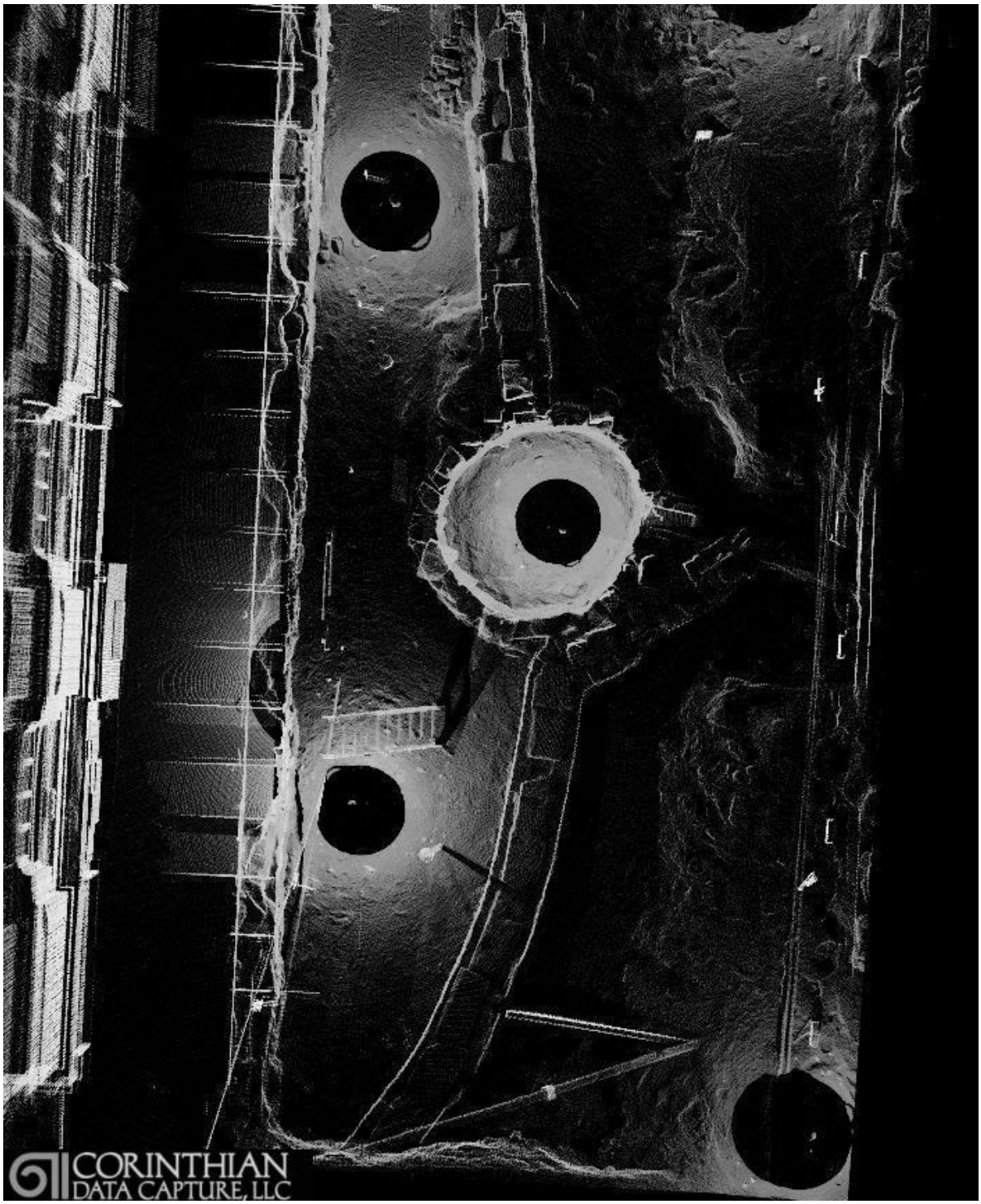
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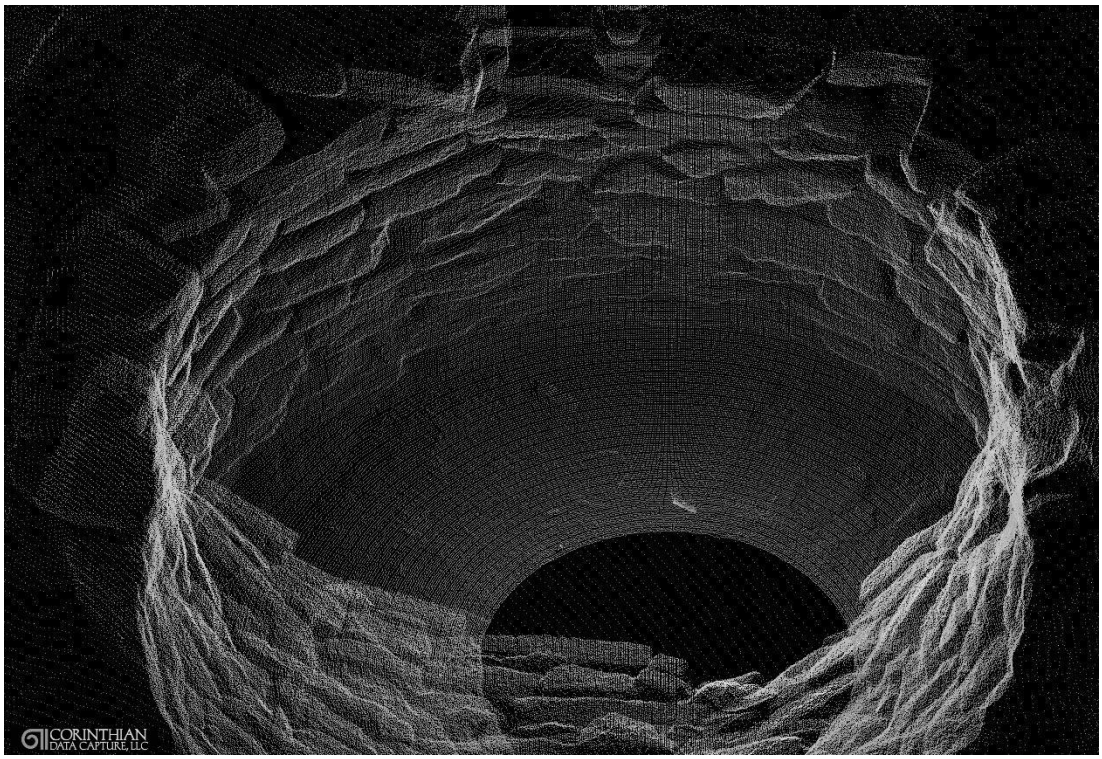
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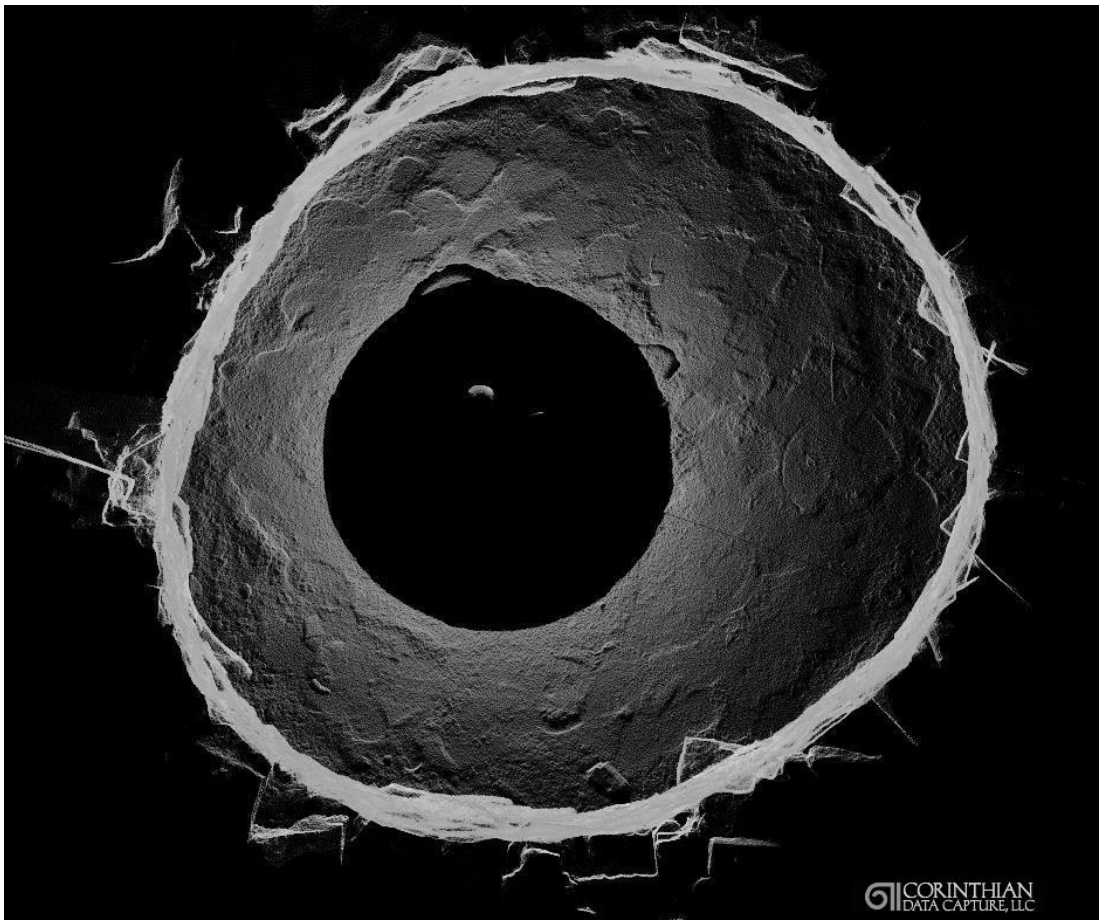
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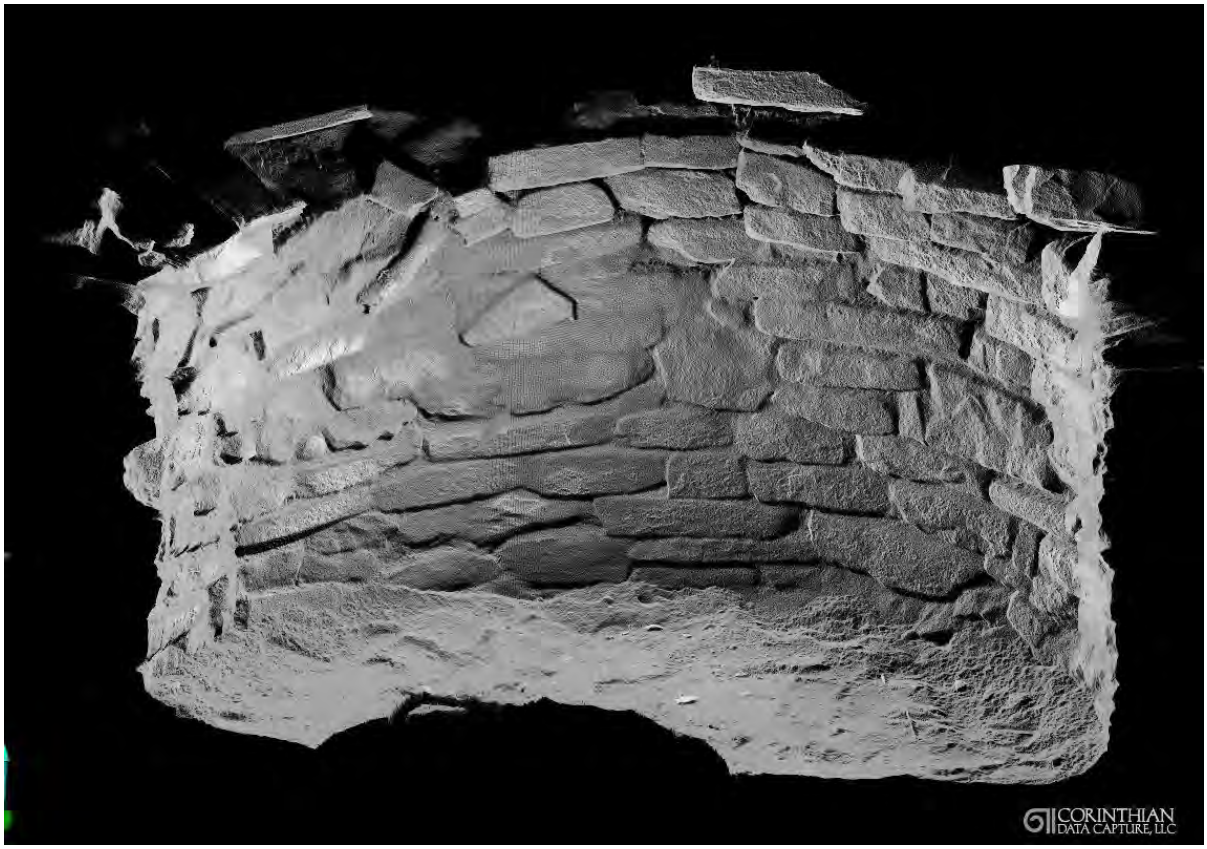
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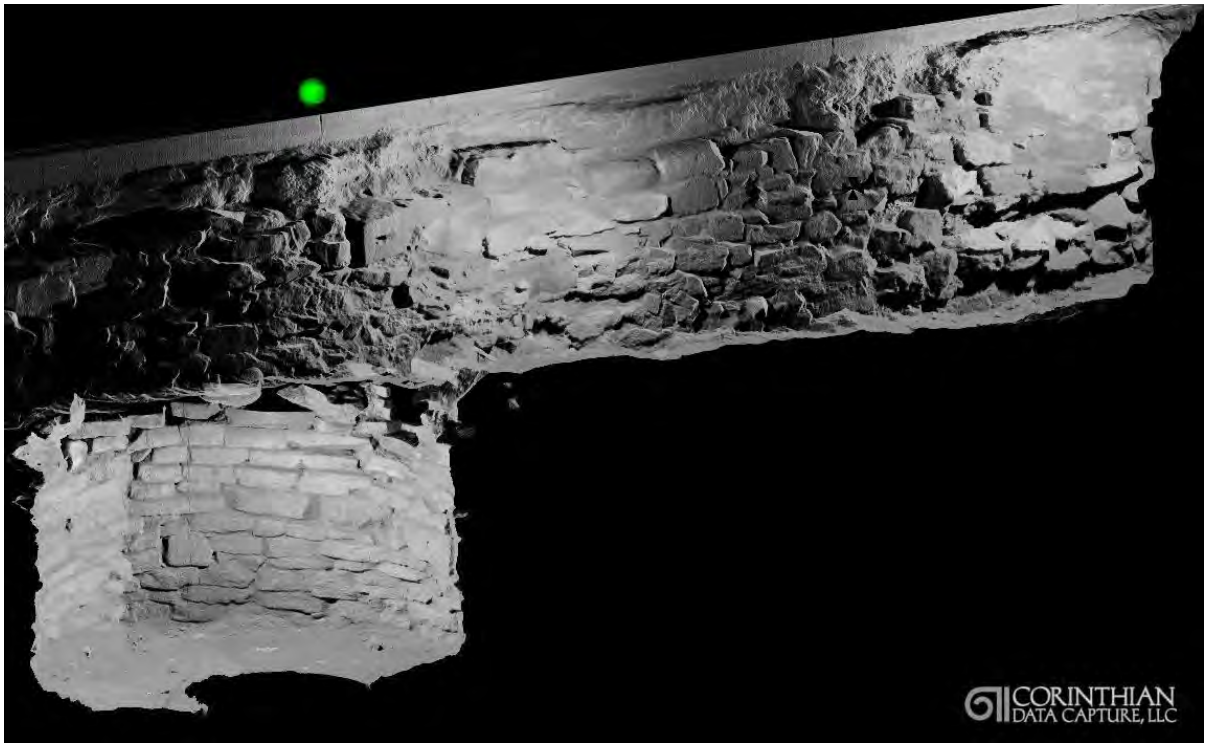
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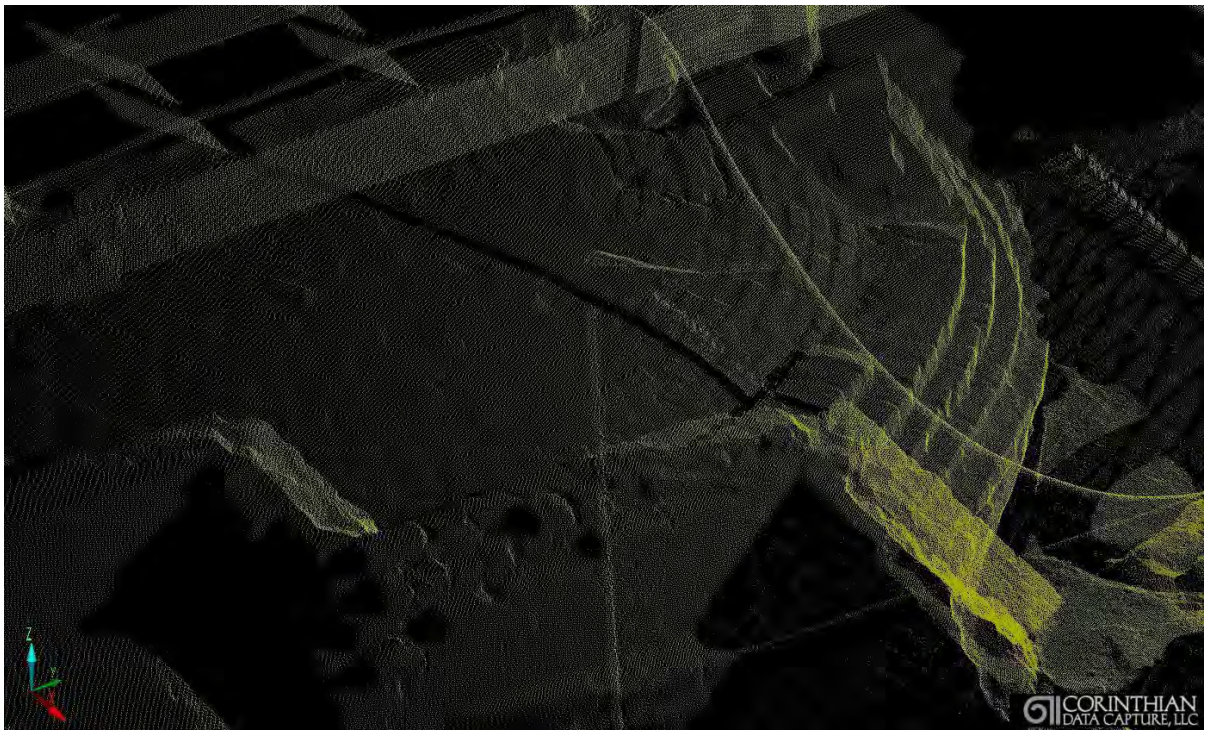
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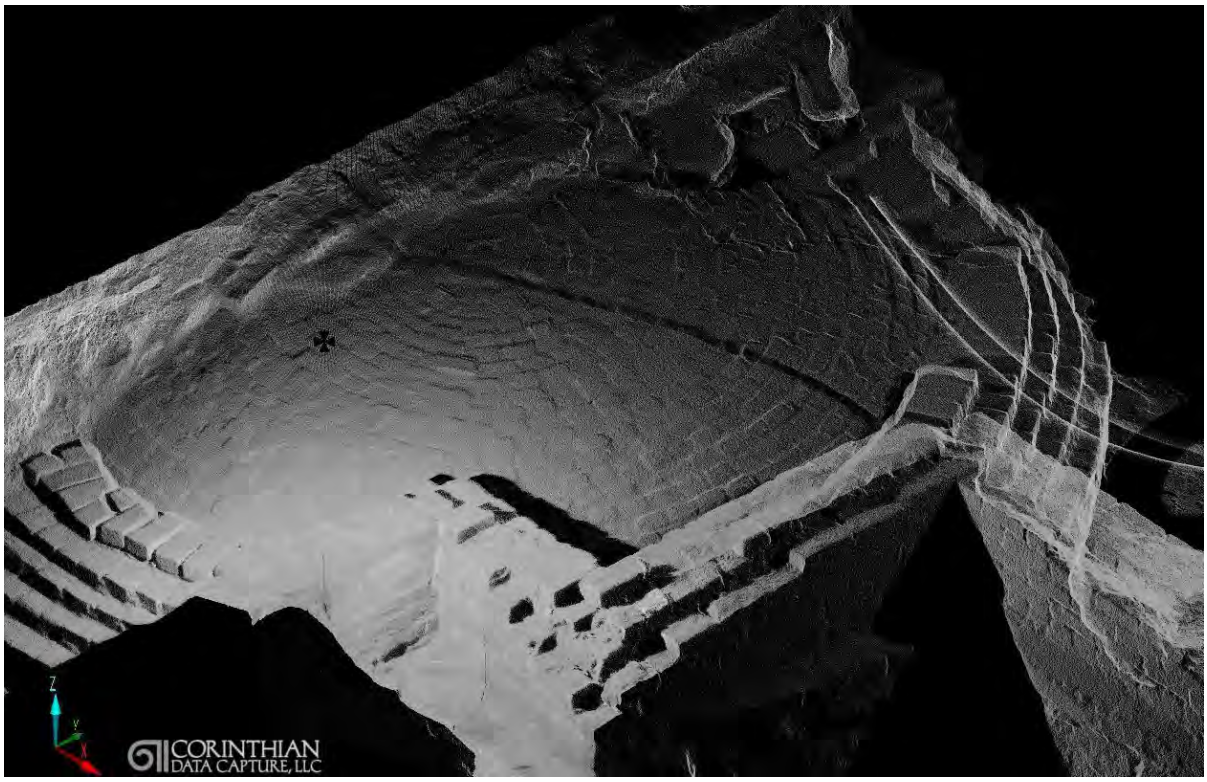
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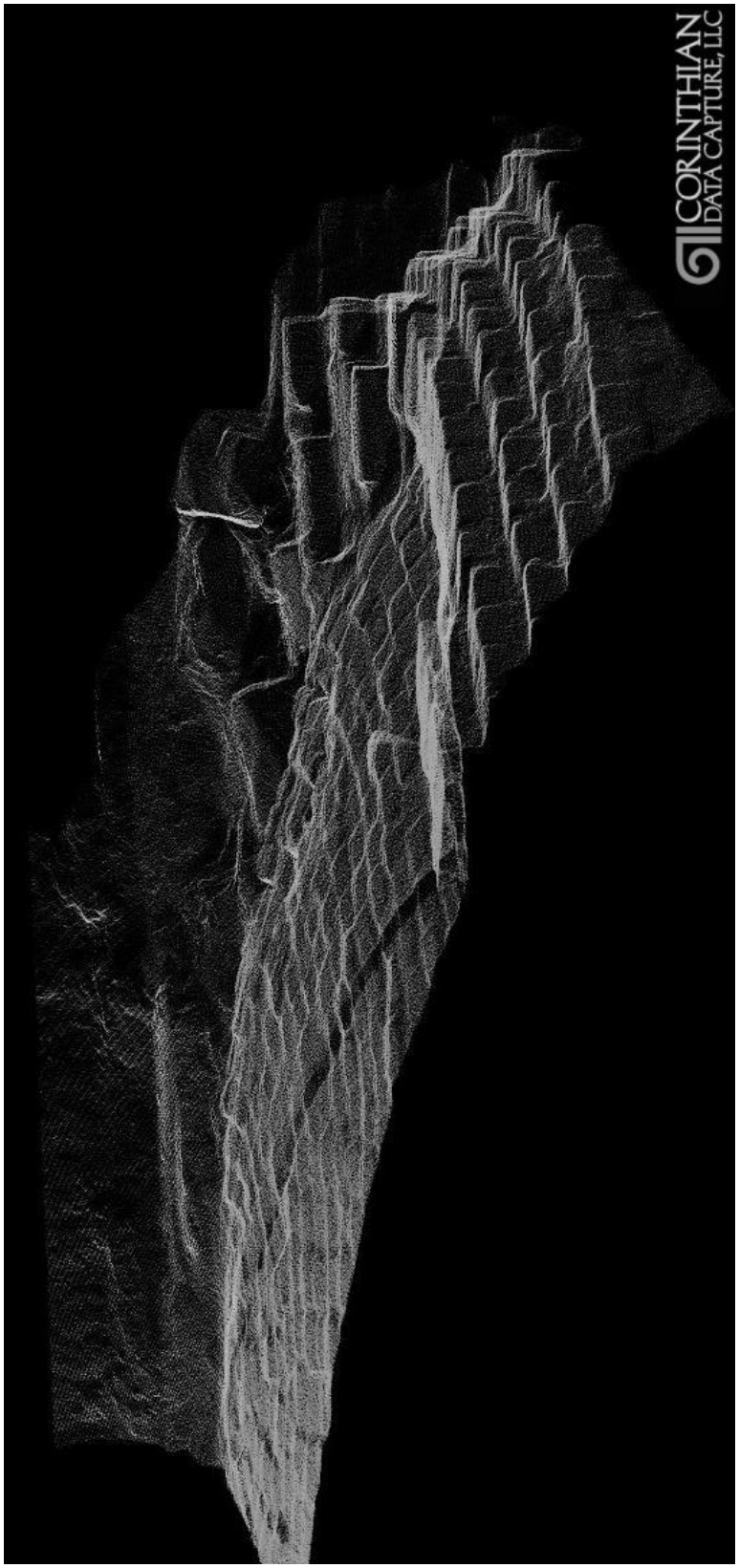
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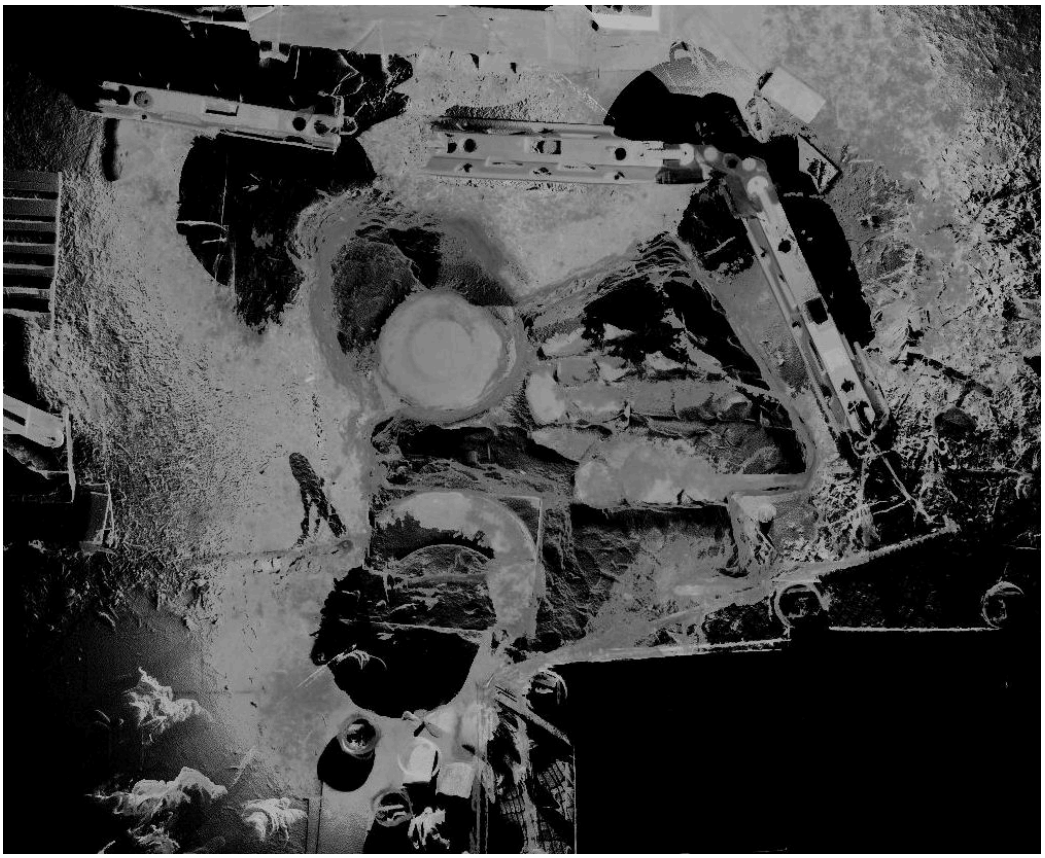
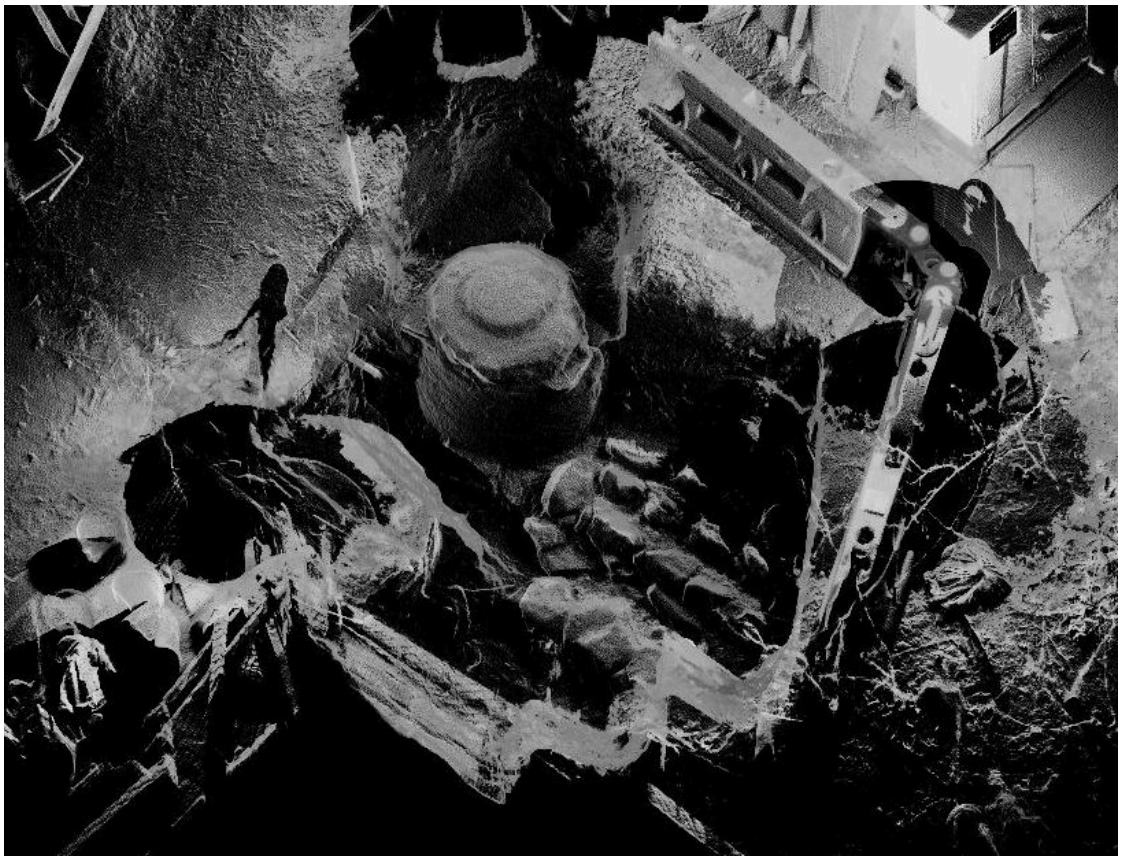
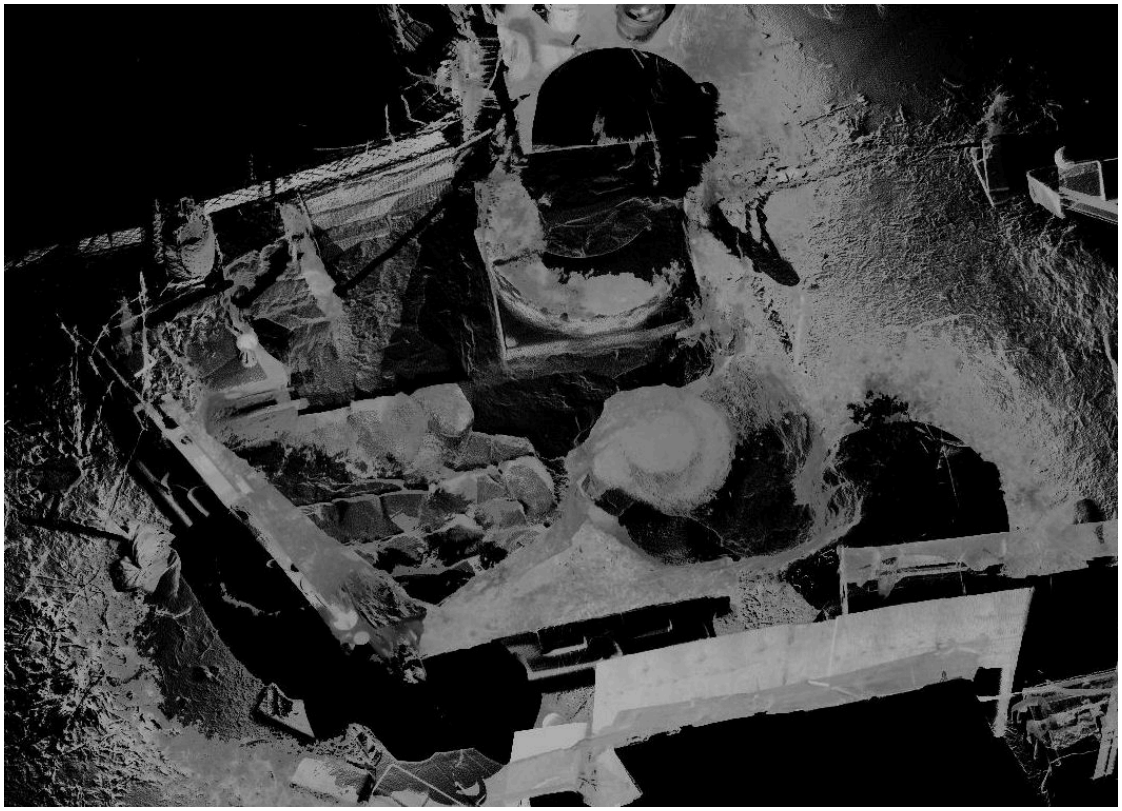
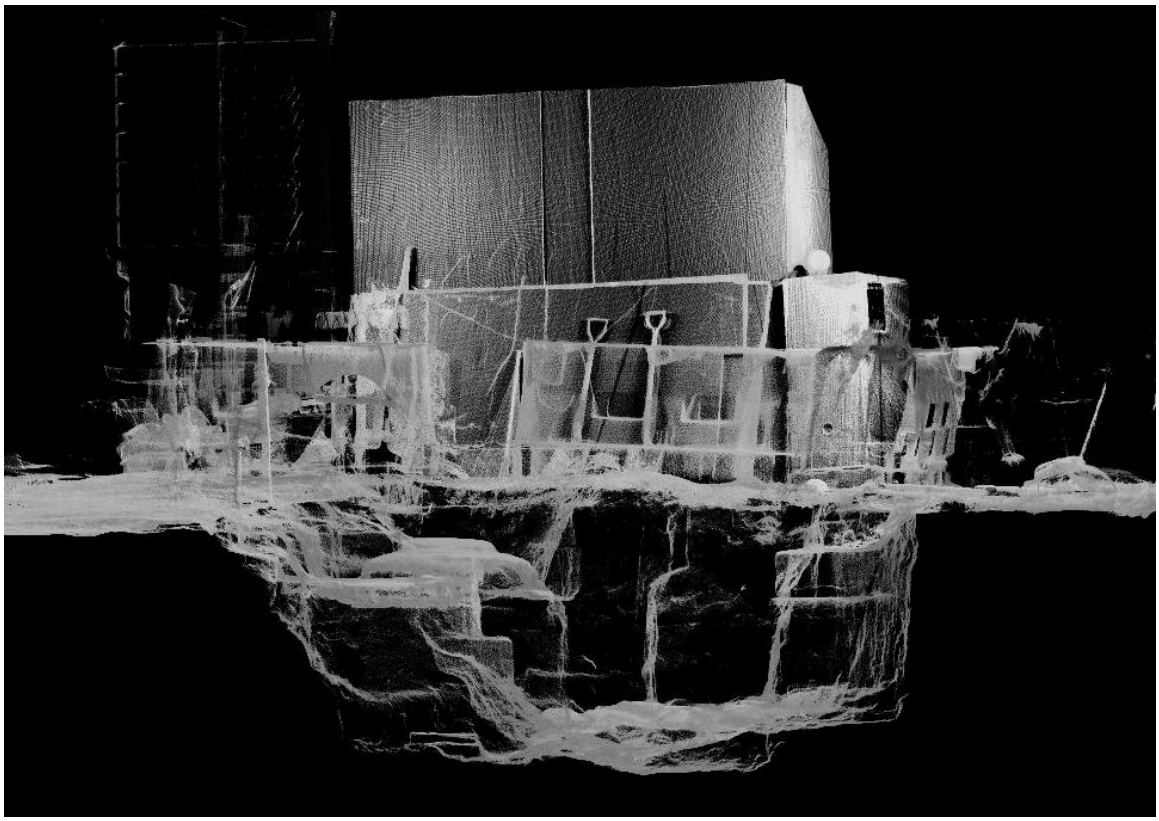
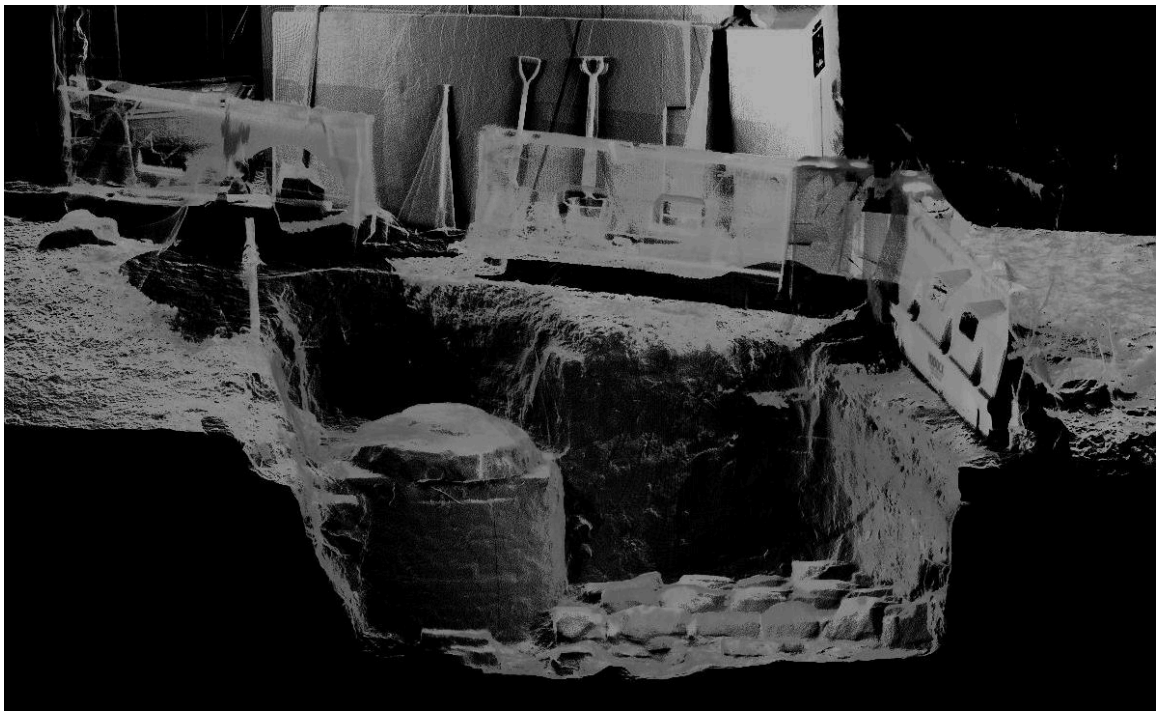








Z
Y
X



YODOCK

City Hall Park
2010-2011 Excavation Report

Appendix N:

Conservation Work

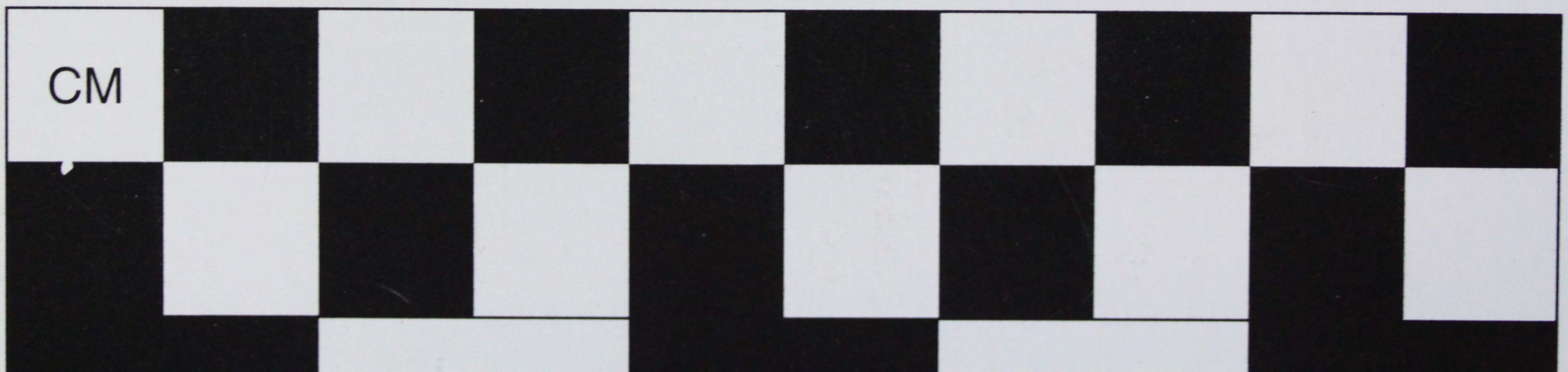
Image #	Object	FS#:Entry#
1	button	209:52
2	Copper alloy knob	7:5
3	Drawer pull	51:16
4	Key	200:1
5	Furniture part	316:3
6	key	199:1
7	Knife handle	447:8
8	Coin (shield nickel)	56:49
9	Button	413:1
10	Powder horn tip	460:10
11	French military button	353:8
12	Copper alloy buckle	37:12
13-15	2 copper alloy buttons w/ NY State seal	71:50
16	spoon	225:45
17	button	321:9
18	Bone brush	401:47
19	Buckle	409:3
20	Pocket knife w/bone grips	376:127
21-22	Bone hair comb	376:159
23	Painted glass	
24-25	2 Iron restraints	404:65 & 409:4
26	Bone handle (dagger) w/ carved X	376:128
27	Bone cap	376:143
28	Coin (perforated)	209:51
29	Straight pins	225:40
30	Bone handle	376:129
31-32	8 – 10 bone buttons and 2 button blanks	376:various
33	Iron andiron	30:59
34	Bone handled utensil	23:115
35-39	Coin (perforated) x-ray images	209:51

1

ENTRY 52

FS 209

ENTM52



NYCHP

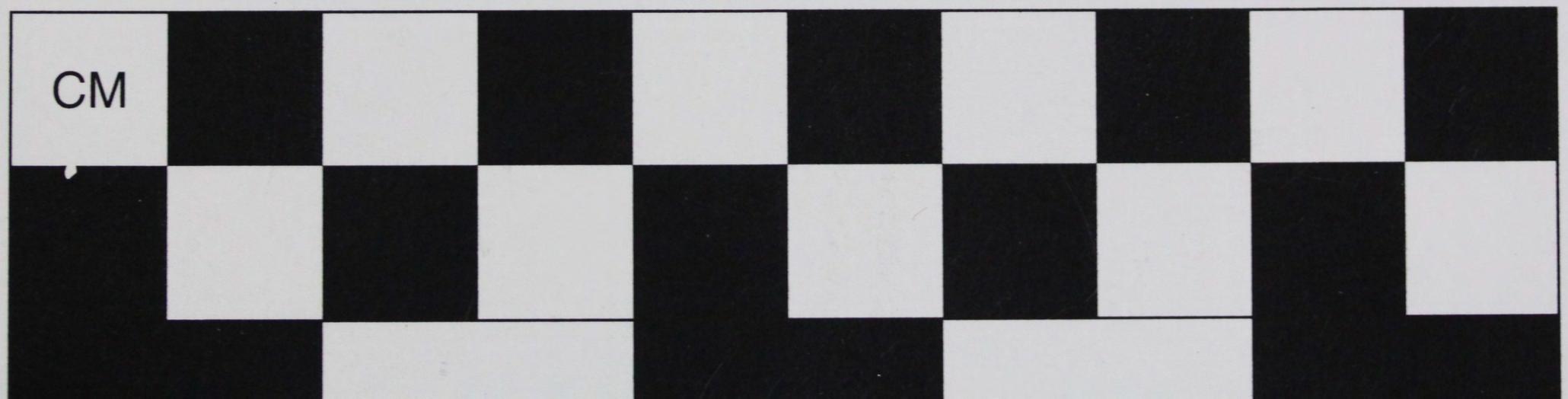
FS# 7.5

CM

ENTRY 16

FS 51

ENTRY 16



ENTRY 1
FS 200

ENTRY 3

FS 316

CM

1

entrg 1

FS 199

CM

NYCHP
TWEED MAN HOLE
FEATURE 30
EASTERN HALF
STRAT I (LV. 1)
11/11/10

ENTRY 8

HANDLE
(KNIFE (SWORD?))

enthu 49

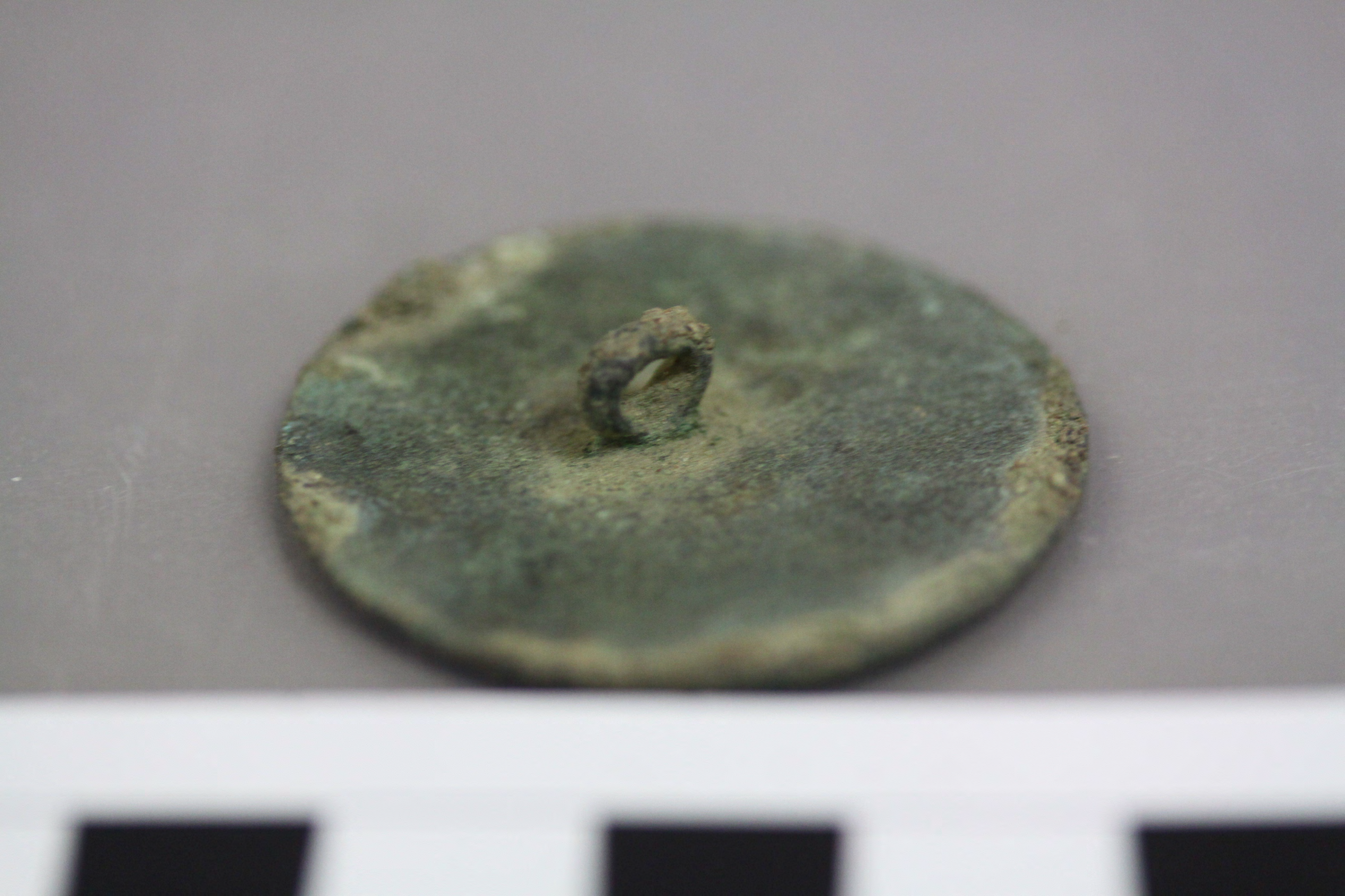
75 SF

95 St

ENTRY 1

FS 413

CM



NYCHP

NE VAULT AREA

TJ 29 SOUTHERN EXTENSION

FEA. 35

12-9-10

F.S. 460

ENTRY 10

POWDERHORN TIP

CM

Entry 8

FS 353

QUATRIEME REGIMENT

NYCHP

PS 37

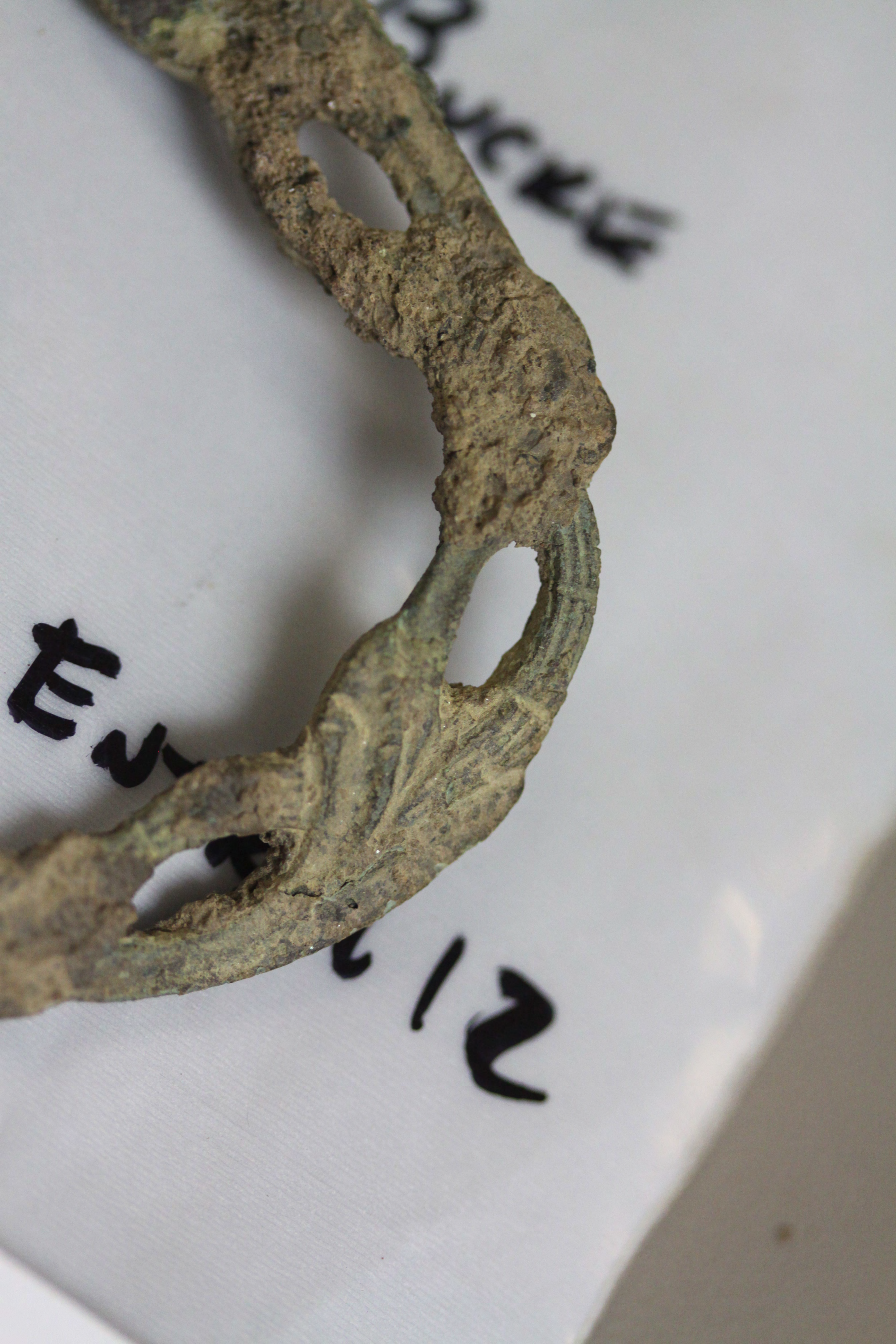
TU 6

LU 4

6[illegible]-10

BUCKLE

ENTRY 12


E 2
2/2

NYCHP

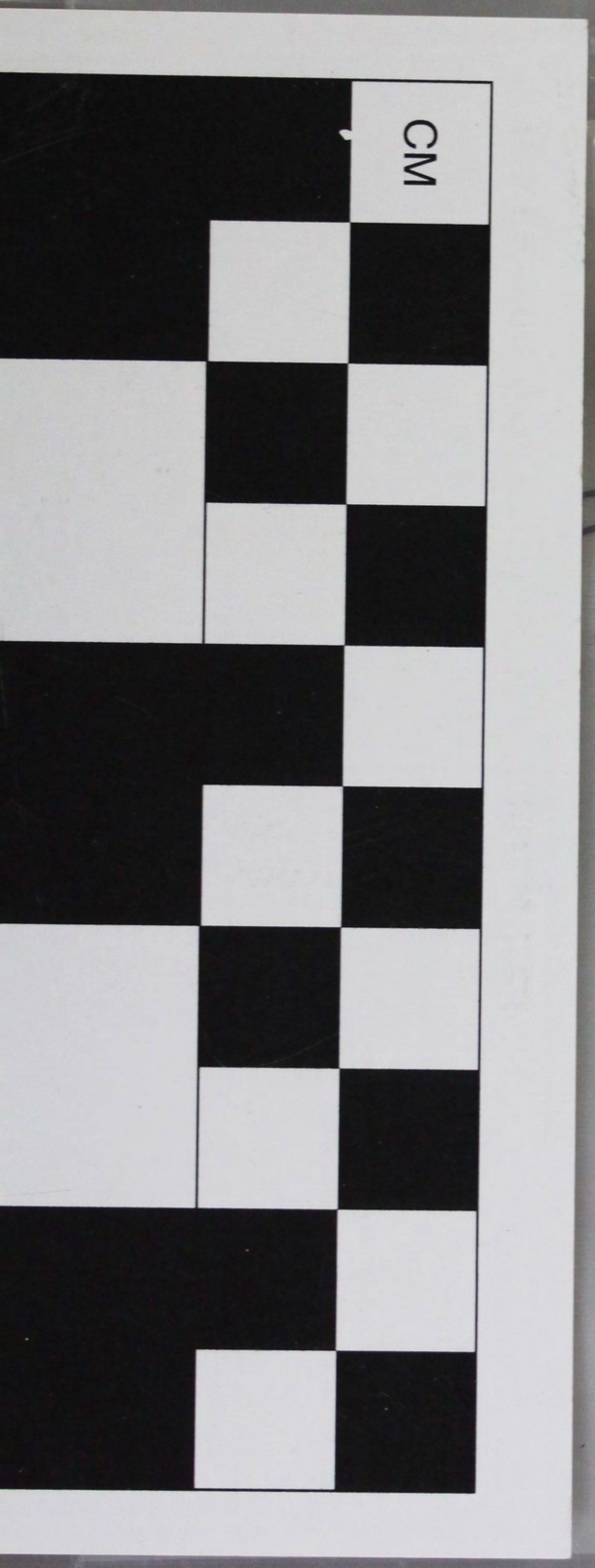
FS 71
entry 50

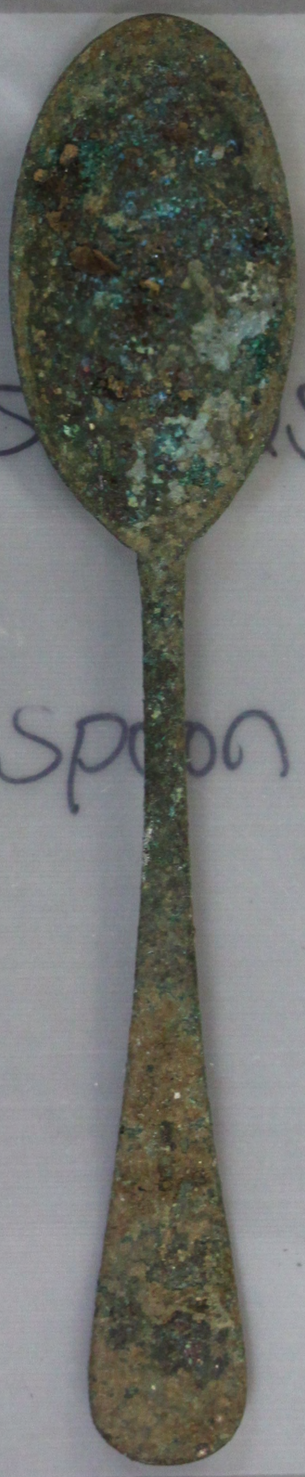
N.Y. Buttons

CM

CM

Entry 45





FS 225

spoon

FS 225

CM

1

ENTRY 9

FS 321

CM
ENTRY 4
FS 40

CM
ENTRY 4
FS 40

NYCHP

ENTRY 3

FS 409

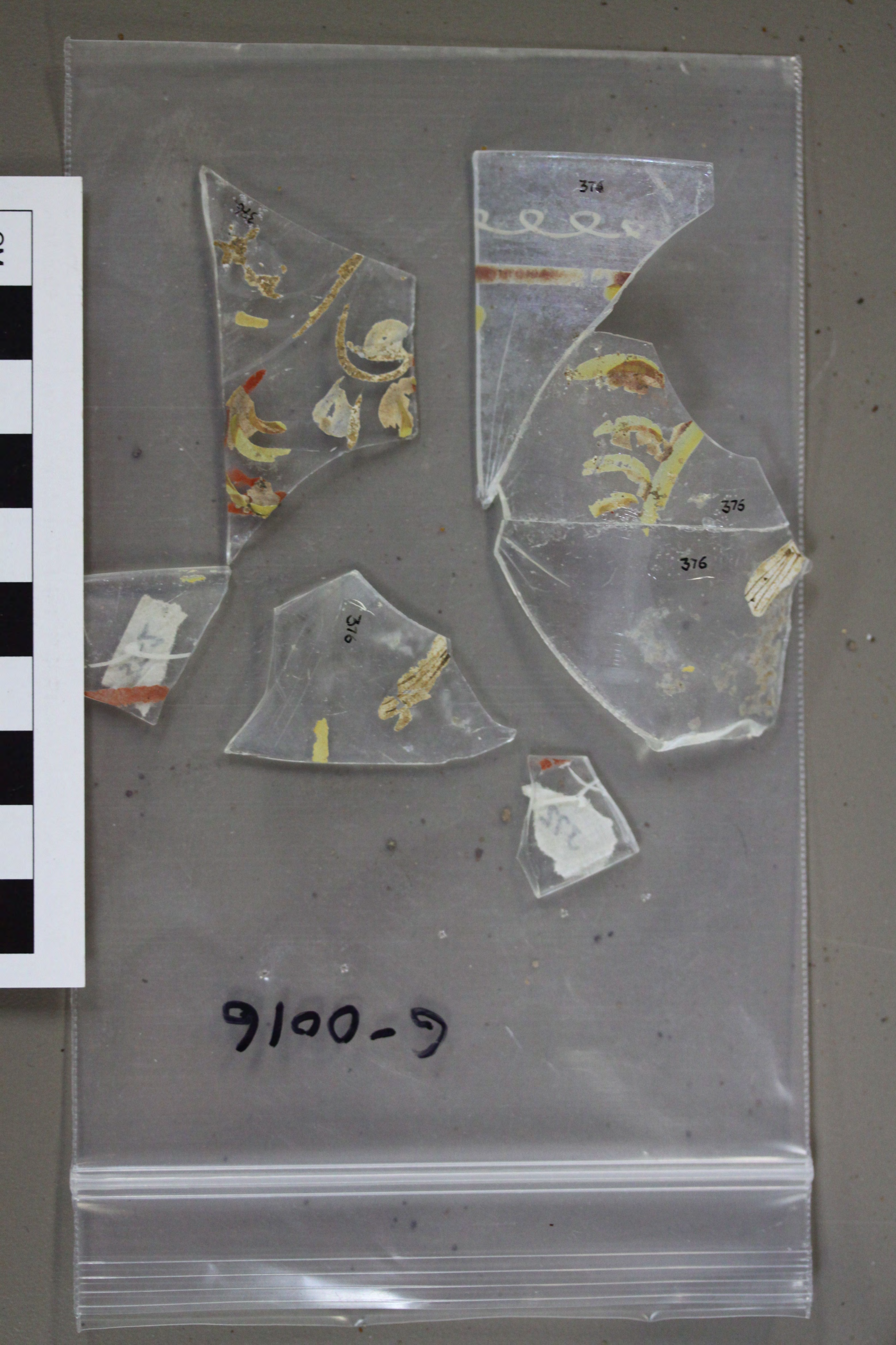
BUCKLE

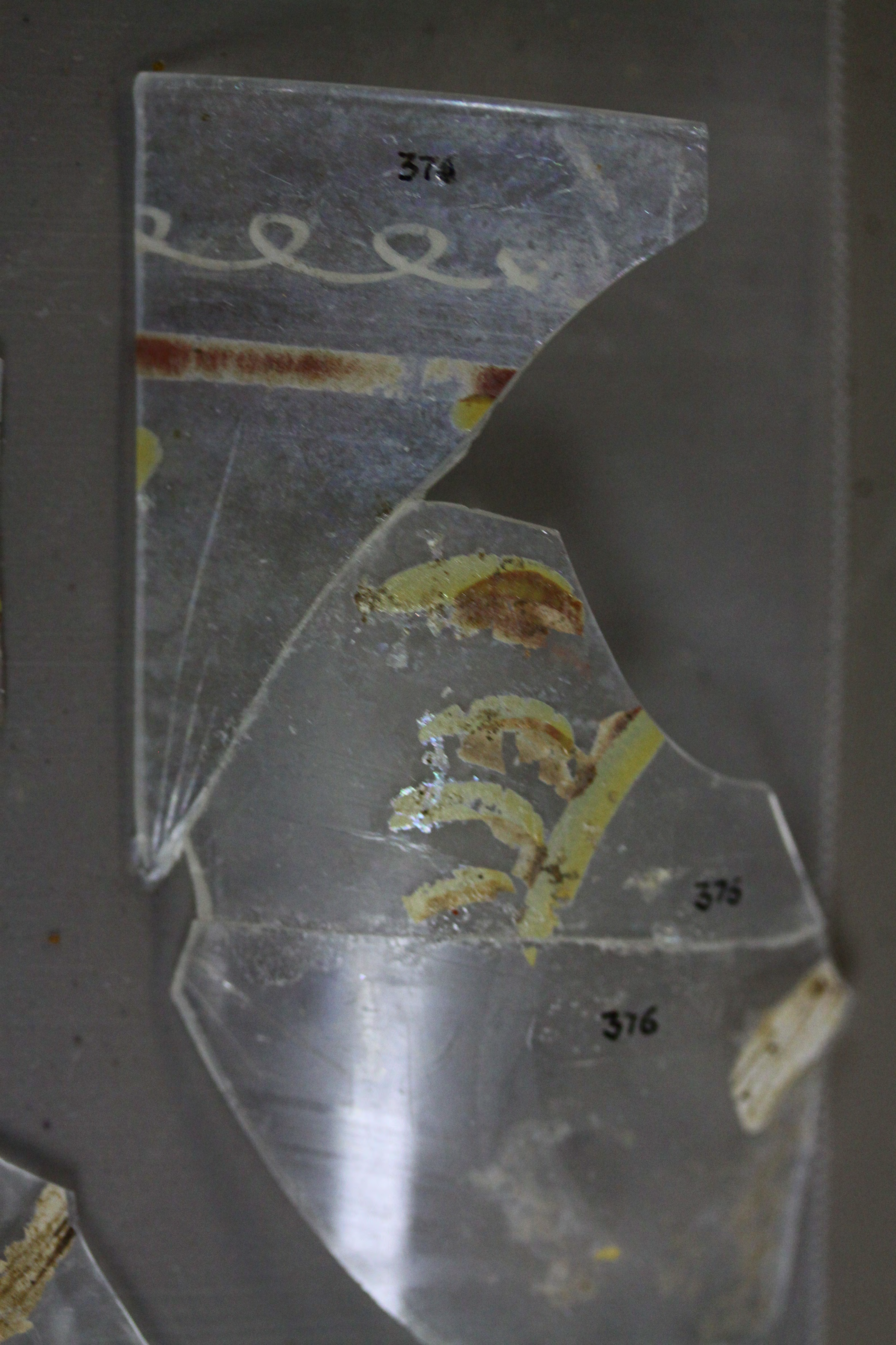
NMCHP
30'x30' MANHOLE
FEATURE 28
LEVEL 2
10/16/10

FS 376
ENTRY 127

POCKET KNIFE
W/ BONE GRIPS

CM


376
374
376
376
376
9100-9


374
375
376

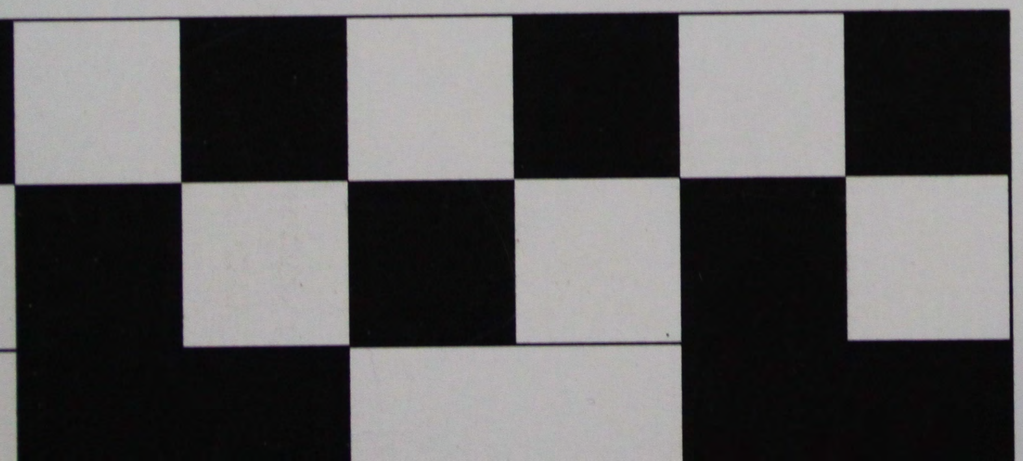
FS 404
ENTRY 65

POSSIBLE RESTRAINT

POSSIBLE RESTRAINT

ENTRY 4

POSSIBLE RESTRAINT



FS 409

CM
FS 409

D
O MANHOLE
LE 28

FS 376
ENTRY 128

BONE HANDLE INCISED
"X" ¿DAGGER?

LEVEL 2

10/16/18

BONE HANDLE INCISED

"M" ¿DAGGER?

ENTRY 143
FS 376

CM

NYCHP
ROOM 8C T.U.5
STRAT III
19 JULY 2010

FS 209

ENTRY 51

?3 PENCE
GEORGE II?

E2 552

FS 376

ENTRY 129

FS #376

BONE
HANDLE
UTENSIL, CROSS
HATCHE

CM

376.235
0.76
376.239
B
0.115
0.067
0.108
376.242
0.064
0.108
376.240
0.46
0.059
0.114
376.
E01.P025

376.238

0.475

0.064

HOLE 0.07

FS 80.55
CM

XSYCHP
TU4 NE
LVI
6/3/10
CM

City Hall Park
2010-2011 Excavation Report

Appendix O:

Mortar Analysis

MORTAR ANALYSES
ARCHAEOLOGICAL SITE
CITY HALL
NEW YORK, NY

Prepared for:
Beyer Blinder Belle
Architects and Planners
41 East 11th Street
New York, NY 10003

Prepared by:
Jablonski Building Conservation, Inc.
40 West 27th Street, Suite 1201
New York, NY 10001

September 8, 2010

INTRODUCTION

Jablonski Building Conservation, Inc. (JBC) was retained by Beyer Blinder Belle Architects to conduct analyses of mortar samples taken from the archaeological features found to the north of New York City Hall. Samples were taken from the Rubble Wall (A1), the Brick Feature located in the Middle of the Pit (A2), the Cistern (A3), and the Brick Feature Adjacent to the Cistern (A4). The purpose of the analyses is to characterize the mortars and possibly determine their dates of installation. A sample was also taken from the rubble wall in the basement of City Hall (B1), and the infill around the Federal Measures plaque (B2). These mortars were installed at a known date and were analyzed to compare against the unknown mortars from the archaeological site. Photographs showing sampling locations are included in Appendix A.

METHODOLOGY

The six mortar samples were analyzed in JBC's laboratory using wet, gravimetric analysis. The spreadsheet of the data collected is included in Appendix C. Portions of the samples were examined under magnification. Using natural daylight, the binder in the sample was matched to a color standard of the Munsell Color Chart (as per ASTM 1535, "Specifying Color by the Munsell System"). The examination also included separating the sample into three components: the acid-soluble fraction, the "fines" (i.e. pigment, clay or cement residue), and the aggregate or sand fraction. Separation was accomplished via wet-chemical techniques. The acid-soluble fraction was removed by digestion with 3M hydrochloric acid. Levigation and filtration were then used to separate the fines from the aggregate (sand). Percent weights were calculated for further assessment. The color of the fines was matched to the Munsell Soil Color Chart. Predominating colors and shapes of sand grains were noted during examination of the aggregate fractions.

Sieve analysis was also performed on the extracted sand fractions. The grading was compared to ASTM C144 Standard Specification for Aggregate for Masonry Mortar which defines the limits of a well-graded sand and states that no more than 50 percent of the sand shall be retained between any two consecutive sieves, and not more than 2 percent between the #50 and #100 sieves.

Portions of the six mortars were also sent to Highbridge Materials Consulting, Inc. (Highbridge) for petrographic and chemical examination in order to identify original components, assess material qualities and estimate proportions. A copy of the Highbridge report is included in Appendix D.

FINDINGS

In order to provide the most complete description of each mortar, the flowing discussion of the findings is a combination of the observations and wet gravimetric analyses performed by JBC, and the petrographic and chemical analyses performed by Highbridge.

Archaeological Site: Rubble Wall (Sample A1)

Visual Observations

While light brown and weathered on the surface, in cross section, the mortar from the rubble wall is pinkish gray (Munsell 7.5YR 7/2) in color. Petrographic examination of the sample revealed extremely fine-grained crystals within the matrix. They are likely iron-oxide based which could be the result of iron leaching from the red sandstone grains in the aggregate. This suggests that the mortar was originally bright white in color and turned pink in service.

The mortar is relatively hard and well-consolidated. The mortar is coarse-textured with lime blebs dispersed throughout the sample, but no shells or organic material was noted. The texture suggests a "hot mix" where the lump lime was mixed with the sand while slaking and placed in the wall shortly thereafter. The matrix has a high capillary porosity typical of high lime mortars with air content estimated between 6 and 12 percent by volume. Recrystallization of calcium carbonate was observed within the pores, which is indicative of moisture moving through the mortar. This has not affected the strength of the mortar.

Acid Solubles

According to the gravimetric analysis performed by JBC, the sample contains approximately 20.8 percent of acid soluble material by weight. A vigorous reaction with medium fizzy bubbles occurred upon the addition of 3M hydrochloric acid.

The lime is believed to have been burned from an impure marble. Most of the lime grains retain the sugary texture of the original marble rock. Some hydraulicity is indicated due to the abundance of burned silicate impurities and the relative hardness of the mortar. It is possible that this hydraulicity was an accidental result of using an impure lime. No cement or pozzolans were detected. Given the location of the site, it is most likely that Inwood Marble is source. However the low magnesium content in the lime is not typical for limes burned from Inwood Marble. The burning of the lime appears to have been inconsistent as both under and over-burned grains are present.

Fines

The gravimetric analysis showed that 9.9 percent of the sample by weight contained fine material. The fines are brown in color (between Munsell colors 7.5YR 6/3 and 5/3). The fines are most likely a combination of the burned silicate impurities from the lime portion, the super-fine portion of the aggregate, and the iron-oxide based crystallizations from the leaching sandstone grains.

Aggregate

The gravimetric analysis showed that the sample contains approximately 69.3 percent of aggregate by weight. The sand is generally brown in color (Munsell 7.5YR 5/3). The aggregate is a natural sand consisting predominantly of quartz and feldspars with red sandstones, iron-rich

mudstones, and diabase—all associated with materials weathered from the Newark Basin rocks in New Jersey. The particles are sub-angular to sub-rounded in shape and generally medium to very coarse grained (1/4mm to 1cm in diameter). A sieve analysis of the sand is included below. According to ASTM C144, the sand is too coarse with only 95.85 percent passing the #4 sieve and 89.31 percent passing the #8.

Sieve #	% Retained	% Passing	C144 % Passing
#4	4.2%	95.9%	100%
#8	6.5%	89.3%	95% to 100%
#16	17.1%	72.2%	70% to 100%
#30	32.3%	39.9%	40% to 75%
#50	27.8%	12.1%	10% to 35%
#100	8.6%	3.5%	2% to 15%
#200	2.7%	0.8%	0% to 5%
Pan	0.8%	0.0%	

Estimated Proportions

Chemical analysis was performed by Highbridge to estimate the original lime to sand ratio in the sample. Due to the texture of the mortar, it was suggested that the mortar was originally proportioned using lump lime and sand in a hot mix. If this is the case, the original lime to sand ratio is estimated at 1:4 by weight. The equivalent ratio of hydrated lime to sand is 1:2 by volume. A lime putty to sand ratio is approximately 1:3 by volume.

Archaeological Site: Brick Feature Mid Pit (Sample A2)

Visual Observations

The mortar is pale brown in color (Munsell Color 10YR 6/3). The mortar is soft and friable. Several voids are observable with an air content of approximately 3 to 4 percent by volume. No internal microscopic shrinkage cracks were observed. Some secondary recrystallization of calcium carbonate was found but was relatively minor. Patchy carbonation of natural cement was observed throughout the entire thickness of the sample, though this is a natural function of the cement curing.

The matrix is clay-based with fine grained sand and silt. Dolomitic natural cement is present in minor amounts and is used to stabilize the clay binder. A few lumps of clay were found petrographically and the clay is well-dispersed throughout the mortar.

Acid Solubles

Gravimetric analysis showed that the mortar contains only 7.3 percent acid solubles by weight. The binder matrix is sparse, porous and weakly hydraulic. While the cemetitious binder is natural cement, the cement contains grains with a relatively high lime (acid soluble) content.

The natural cement contains calcined dolomite grains with rims of iron product and dispersed combined quartz silt and clinkered material (not acid soluble) in addition to the trace grains with a high lime content. The cement has a lower magnesium content than Rosendale cement, but a magnesium content too high to suggest European natural cements.

Fines

Gravimetric analysis showed that the mortar contains 13.6 percent fines. The fines are brown in color (between Munsell 10YR 5/3 and 6/3). The fines portion contains mostly the clay used as the binder with some cement particles, and the fine portion of the aggregate.

Aggregate

The gravimetric analysis showed that the aggregate content is approximately 79.2 percent by weight. The sand is generally brown in color (Munsell 10YR 5/3). The aggregate is a predominantly quartz with minor amounts of amphibolites, arkosic sandstone, and feldspar. The sub-angular to sub-rounded in shape and generally medium to very coarse grained (1/4mm to 1cm in diameter). A sieve analysis of the sand shows that the sand is too coarse and too narrowly graded with 66.4 percent retained in the #30 and #50 sieves.

Sieve #	% Retained	% Passing	C144 % Passing
#4	1.0%	99.0%	100%
#8	5.8%	93.2%	95% to 100%
#16	28.8%	64.4%	70% to 100%
#30	37.6%	26.8%	40% to 75%
#50	19.5%	7.3%	10% to 35%
#100	4.8%	2.5%	2% to 15%
#200	1.4%	1.1%	0% to 5%
Pan	1.1%	0.00%	

Estimated Proportions

Chemical analysis was performed by Highbridge in order to estimate the original proportions of the mortar. The ratio of cement binder to sand/clay is estimated at 1:14 by weight. Conversion to the volumetric ratio is 1:13. While this mix appears to be oversanded, the clay portion is actually part of the binder. It is possible that the sandy clay mixture had a higher density than an equivalent volume of sand which could result in a volume ration 10 to 20 percent lower.

Archaeological Site: Cistern (Sample A3)

Visual Observations

The mortar from the cistern is white in color (Munsell 5Y 8/1). The matrix is soft, friable and water permeable. The mortar is coarse-textured with relatively large undispersed lime blebs distributed throughout the sample. This texture is suggestive of a hot mix where the lump lime is

mixed with sand while slaking and placed in the wall shortly thereafter. The air content is estimated between 6 and 10 percent by volume.

Minor cracking was detected but it was localized and not typical shrinkage cracks. The mortar matrix is mostly carbonated which is a desirable result of mortar curing. There was minor carbonatate precipitation in the air voids, suggesting a small amount of water passing through the mortar. This is expected, as the feature was buried.

Acid Solubles

Gravimetic analysis showed that the sample contains approximately 30.09 percent of acid soluble material. A vigorously effervescent reaction with large, foamy bubbles occurred upon the addition of 3M hydrochloric acid to the crushed sample.

Most of the lime grains retain the sugary texture of the original marble rock. The lime is interpreted as being burned from an impure marble similar, but not identical to the marble used in the rubble wall mortar. The lime burning appears to have been relatively consistent. Though the levels of impurities are high, they are not high enough to impart any detectable hydraulicity. The impurities are however sufficient enough to have produced a lean or meager lime—a lime that is weaker as a result of its impurities.

The lime has a moderate dolomitic component. This, coupled with the inherent impurities in the source marble, suggests that Inwood Marble is the possible source.

Fines

Gravimetric analysis showed that 13.4 percent of the sample contains fine material. The fines are light gray in color (Munsell 10YR 7/2). The fines are most likely a mixture of the fine portion of the sand, some clay, and the impurities from the lime source.

Aggregate

Gravimetric analysis showed that the mortar contains approximately 56.5 percent aggregate by weight. The overall color of the sand is pinkish gray (Munsell color 7.5YR 6/2). The aggregate is a natural sand consisting predominantly of quartz with some feldspar and minor amounts of aluminous metamorphic rocks all commonly found in New York sands. Other lithic particles include red sandstones, iron-rich mudstones and diabase, all associated with materials weathered from Newark Basin rocks in New Jersey. The sandstones impart a pinkish tone to the aggregate which is responsible for the pinkish tone of the mortar. The sand grains are sub-angular to sub-rounded in shape and medium to very coarse grained (1/4mm to 5mm). A sieve analysis of the sand shows that it is narrowly graded with the majority of sand retained in the #30, #50 and #100 sieves.

Sieve #	% Retained	% Passing	C144 % Passing
#4	0.0%	100.0%	100%
#8	6.0%	94.0%	95% to 100%
#16	7.9%	86.1%	70% to 100%
#30	31.1%	55.1%	40% to 75%
#50	36.1%	19.0%	10% to 35%
#100	13.8%	5.2%	2% to 15%
#200	4.2%	1.1%	0% to 5%
Pan	1.1%	0.0%	

Estimated Proportions

Chemical analysis was performed by Highbridge in order to estimate the original lime to sand ratio. The weight proportion of the original lime to sand ratio, assuming that the mortar was originally proportioned using lump lime and sand in a hot mix, is 1:2. Hydrated lime to sand ration is equivalent to 1:1 by volume. Lime putty to sand ration is approximately 1:1 by volume. In whichever form the ratio is given, the mortar is undersanded. It is possible that the mortar was originally undersanded to counteract the lower lime yield of the lean lime.

Archaeological Site: Brick Feature adjacent to Cistern (Sample A4)

Visual Observations

The mortar is light yellowish brown in color (Munsell Color 2.5Y 6/3). The mortar is moderately soft and somewhat permeable with and air content of between 8 and 10 percent by volume. There is little cracking or significant signs of distress observed.

The mortar is a natural cement and sand mixture.

Acid Solubles

Gravimetric analysis showed that the mortar contains only 13.9 percent acid solubles by weight. As the petrographic analysis identified the mortar as a natural cement-sand mix with no acid soluble aggregate, the acid soluble content is from the cement.

Fines

Gravimetric analysis showed that the mortar contains 18.2 percent fines. The fines are light yellowish brown in color (Munsell 2.5Y6/3). The fines are most likely a combination of the fine, silt portion of the aggregate and the insoluble residues of the natural cement. The chemistry of the cement is similar to that of Rosendale cement.

Aggregate

The gravimetric analysis showed that the aggregate content is approximately 67.9 percent by weight. The sand is generally brown in color (between Munsell 10YR 5/3 and 5/4). The aggregate is predominantly quartz with minor amounts of granitic grains. The particles are sub-angular to sub-rounded in shape and generally medium to very coarse grained (1/4mm to 5cm in diameter). The sieve analysis of the sand shows that the sand is narrowly graded with too much sand retained by the #16, #30, #50 and #100 sieves.

Sieve #	% Retained	% Passing	C144 % Passing
#4	0.00%	100.0%	100%
#8	4.7%	95.3%	95% to 100%
#16	20.5%	74.9%	70% to 100%
#30	33.6%	41.3%	40% to 75%
#50	26.5%	14.8%	10% to 35%
#100	11.2%	3.6%	2% to 15%
#200	2.8%	0.8%	0% to 5%
Pan	0.8%	0.0%	

Estimated Proportions

Chemical analysis was performed by Highbridge in order to estimate the original natural cement to sand ratio. Assuming the typical bulk densities of natural cement and damp, loose sand, the ratio is approximately 1:4 by volume. By today's standards, this mortar is over-sanded, where a typical ratio is around 1:3. Historically, the mortar is very over-sanded where a typical natural cement to sand ratio is around 1:2.

City Hall Basement: Rubble Wall Probe (Sample B1)

Visual Observations

The mortar is off-white in color (Munsell Color 10YR 8/1). The mortar is moderately soft and water permeable, with an air content between 8 and 12 percent by volume. The mortar is coarse-textured with lime blebs dispersed throughout the sample. No shells or organic material was noted. The texture suggests a "hot mix" where the lump like was mixed with the sand while slaking and placed in the wall shortly thereafter.

Acid Solubles

According to the gravimetric analysis performed by JBC, the sample contains approximately 24.8 percent by weight of acid soluble material. A vigorous reaction with medium fizzy bubbles occurred upon the addition of 3M hydrochloric acid.

According to the analysis performed by Highbridge, the lime is dolomitic with a very feeble hydraulicity. The lime could have been burned from the local Inwood Marble, or from a

dolomitic limestone like those located in the Hudson Valley. The weak hydraulicity is the result of burning an impure limestone or marble.

Fines

The gravimetric analysis showed that 15.5 percent of the sample by weight contained fine material. The fines are white in color (Munsell 10YR 8/1). The fines are most likely a combination of the burned silicate impurities from the lime portion and the super-fine portion of the aggregate.

Aggregate

The gravimetric analysis showed that the sample contains approximately 59.8 percent of aggregate by weight. The sand is generally pinkish gray in color (Munsell 7.5YR 6/2). The aggregate is a natural sand consisting predominantly of quartz and granitic grains with red sandstones. The minor rock types are typical of those found in the New York City area with the sandstone originating in the Newark Basin of New Jersey. The sandstone particles impart a slight pinkish tone to the mortar. The sand particles sub-angular to sub-rounded in shape and generally medium to very coarse grained (1/4mm to 1cm in diameter). The sieve analysis of the sand shows that the sand is narrowly graded with the majority of sand retained in the #16, #30, and #50 sieves.

Sieve #	% Retained	% Passing	C144 % Passing
#4	1.0%	99.0%	100%
#8	3.5%	95.6%	95% to 100%
#16	17.1%	78.5%	70% to 100%
#30	43.7%	34.9%	40% to 75%
#50	27.8%	7.0%	10% to 35%
#100	6.5%	0.5%	2% to 15%
#200	0.5%	0.0%	0% to 5%
Pan	0.0%	0.0%	

Estimated Proportions

Chemical analysis was performed by Highbridge to estimate the original lime to sand ratio in the sample. Due to the texture of the mortar, it was suggested that the mortar was originally proportioned using lump lime and sand in a hot mix. If this is the case, the original lime to sand ratio is estimated at 1:3 by weight. The equivalent ratio of hydrated lime to sand is 1:1 by volume. The lime putty to sand ratio is approximately 1:2 by volume.

City Hall Basement: Probe Adjacent to Federal Measure Plaque (Sample B2)

Visual Observations

The mortar is light brownish gray in color (Munsell Color 10YR 7/2). The mortar is moderately mard and water permeable, with an air content between 12 and 15 percent by volume. The mortar is identified as a natural cement and sand mix.

Acid Solubles

According to the gravimetric analysis performed by JBC, the sample contains approximately 30.7 percent by weight of acid soluble material. A vigorous reaction with medium fizzy bubbles occurred upon the addition of 3M hydrochloric acid. As no lime or acid soluble aggregate was found in the petrographic analysis of the sample, the acid soluble content is from the natural cement.

Fines

The gravimetric analysis showed that 8.1 percent of the sample by weight contained fine material. The fines are light yellowish brown in color (Munsell 10YR 6/3). The fines are most likely a combination of the insoluble cement residues and the super-fine portion of the aggregate. According to Highbridge's analysis the cement has a high magnesium content, which is typical of American natural cements. The chemistry of the cement is most similar to those produced in Louisville, KY or Cement, GA.

Aggregate

JBC's gravimetric analysis showed that the sample contains approximately 61.2 percent of aggregate by weight. The sand is generally light grayish brown in color (Munsell 2Y 6/3). The aggregate is a natural sand consisting predominantly of quartz with minor amounts of granitic and aluminious metamorphic grains. The aggregate is typical of sand found in the New York City area. The sand particles are sub-angular in shape and generally medium to very coarse grained (1/4mm to 1/2cm in diameter). The sieve analysis of the sand shows that the sand is narrowly graded with the majority of sand retained in the #16, #30, and #50 sieves.

Sieve #	% Retained	% Passing	C144 % Passing
#4	0.0%	100.0%	100%
#8	2.6%	97.4%	95% to 100%
#16	13.9%	83.5%	70% to 100%
#30	50.3%	33.2%	40% to 75%
#50	22.1%	11.1%	10% to 35%
#100	9.8%	1.3%	2% to 15%
#200	1.3%	0.0%	0% to 5%
Pan	0.0%	0.0%	

Estimated Proportions

Chemical analysis was performed by Highbridge to estimate the original natural cement to sand ratio in the sample. The original natural cement to sand ratio is estimated at 1:2 by weight, which is typical of historic natural cement-based mortars.

Summary Chart

The following chart outlines and summarizes the findings of the analyses of the six mortar samples.

	Rubble wall	**Brick Feat. Mid-pit**	**Cistern**	**Brick Feat. Adj. to Cistern**	**City Hall Rubble Wall**	**City Hall probe Adj. to Fed. Meads.**
Binder	Lime	Natural cement & clay	Lime	Natural cement	Lime	Natural cement
Binder to Sand ratio (lime estimated as a hydrate)	1:2	1:15 (Sand proportion includes clay)	1:1	1:4	1:1	1:2
Binder source	Impure dolomitic marble	Dolomitic American cement	Impure dolomitic marble	Dolomitic American cement, poss. Rosendale, NY	Impure dolomitic marble or limestone	Dolomitic American cement, poss. Louisville, KY or Cement, GA

CONCLUSIONS

Based on the analyses of the mortars, samples A1 (the Rubble Wall), A3 (the Cistern) and B1 (the probe in the rubble wall of the basement) are lime-sand mixes. Samples A4 (Brick Feature Adjacent to the Cistern) and B2 (probe adjacent to Federal Measure plaque in the basement) are natural cement and sand mixes. Sample A2 (Brick Feature Mid-pit) is a natural cement stabilized earthen mortar.

Natural cement was first discovered in America in 1817 in Fayetteville, NY during the construction of the Erie Canal and commercial production of natural cement began in 1819. Therefore, the Brick Feature Mid-pit and the Brick Feature Adjacent to the Cistern cannot predate c.1817. However, the brick used in the mid-pit feature is pressed brick, which would date that feature to about c.1860. The brick used in the feature adjacent to the cistern is common brick, which has a broader timeline.

The binder in the mortar from the Brick Feature Mid-Pit (A2) is actually a natural cement stabilized earthen mortar. The dolomitic natural cement is present as a stabilizer, while the clay is the principal binder. Clay mortars were typically used in exterior structures that were protected from moisture. The clay in this mortar could have been used as an extender for the more expensive cement.

The mortar taken from the probe adjacent to the Federal Measure plaque (B2) was analyzed to compare a mortar from a known date (1903) to the mortars of unknown vintage. The analysis found that while it has a natural cement binder like that found in the brick features in the archaeological site. However, the natural cement in B2 is most likely from Louisville, KY or Cement, GA while the other natural cements are more consistent with Rosendale cement. Also, the sand portion is completely different than the sand from the other mortars. The mortar from this probe is most likely the youngest mortar analyzed.

Samples A1, A3, and B1 are lime-sand mixes. The three mortars have some characteristics in common. All three mortars are coarsely mixed with lime blebs distributed throughout the samples. This suggests that all three mortars were prepared as a hot mix—sand is added to quicklime and the lime is slaked upon the addition of water to the mix and placed in the wall shortly after mixing. The mineralogy and grading of the sand in the mortars are also similar.

Despite the similarities, there are differences in the chemistry of the lime that suggests these were installed at different times. The lime in sample A1 (Rubble Wall) is hydraulic due to the impurities present in the source rock. The lime in sample A3 (Cistern) contains more magnesium and has no hydraulicity. The lime in B1 (Rubble Wall in City Hall basement) is purely dolomitic with very minimal hydraulicity.

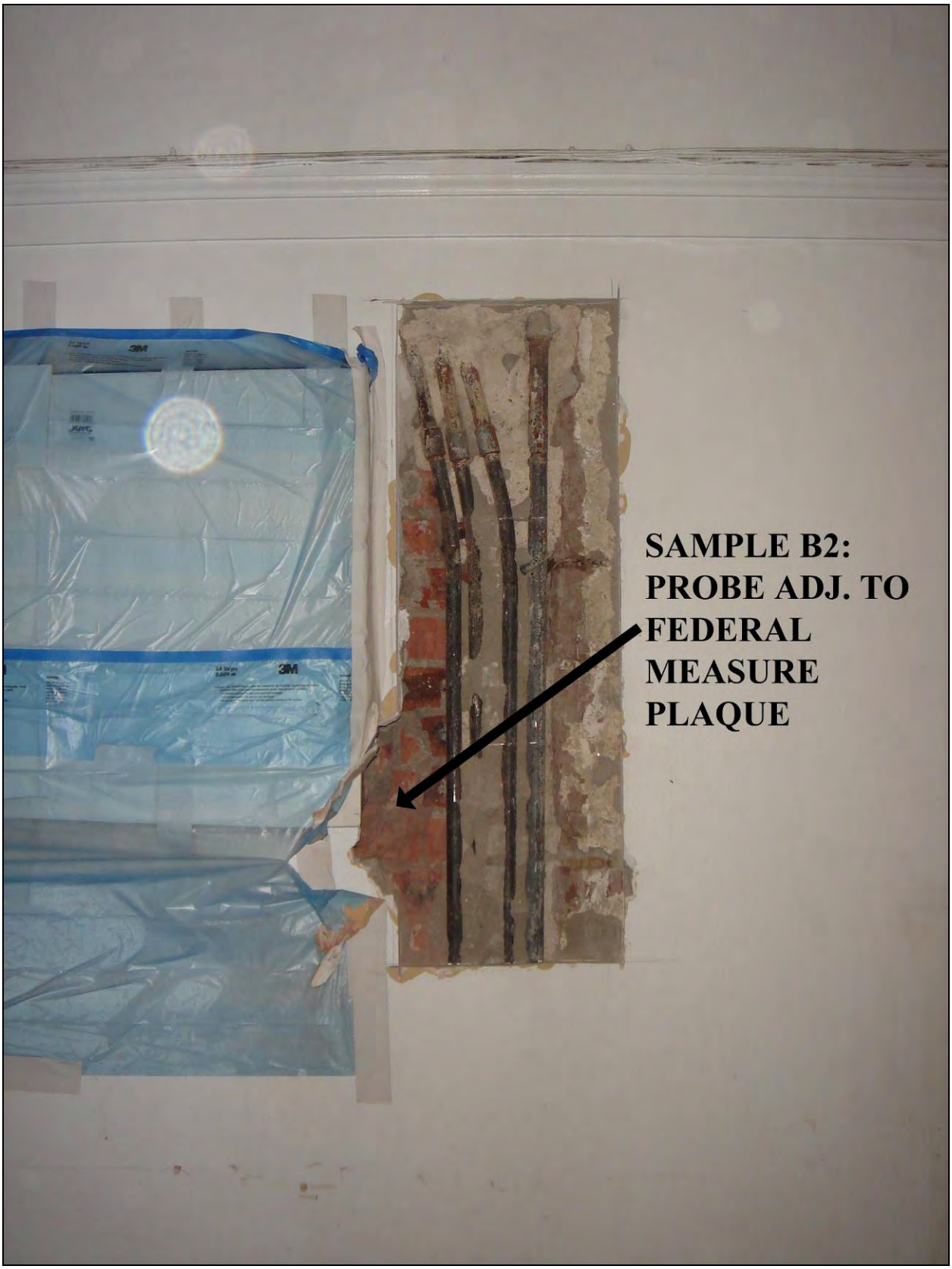
Unfortunately, lime mortars have a very broad timeline of use from colonial times up through the early 19th century. Lime mortars are even used today in restoration work. It is therefore difficult to pinpoint exactly when the Rubble Wall and the Cistern in the archaeological site were built based on an analysis of the mortars alone. Construction techniques, the juxtaposition of

elements, and historic research is also required. (The mortar from the rubble wall in the City Hall basement is most likely c.1811, the completion date for City Hall.)

APPENDIX A: SAMPLE LOCATIONS

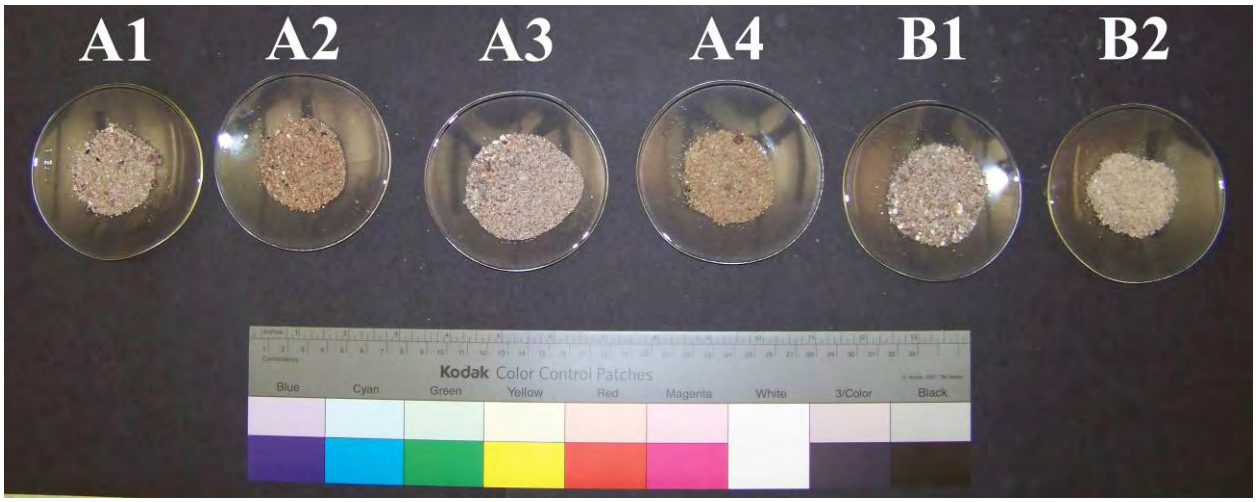
SAMPLE A3:
CISTERN
SAMPLE A4:
BRICK
FEATURE ADJ.
TO CISTERN
SAMPLE A2:
BRICK
FEATURE
MID-PIT
SAMPLE A1:
RUBBLE WALL

SAMPLE A3:
CISTERN
SAMPLE A4:
BRICK FEATURE
ADJ. TO CISTERN

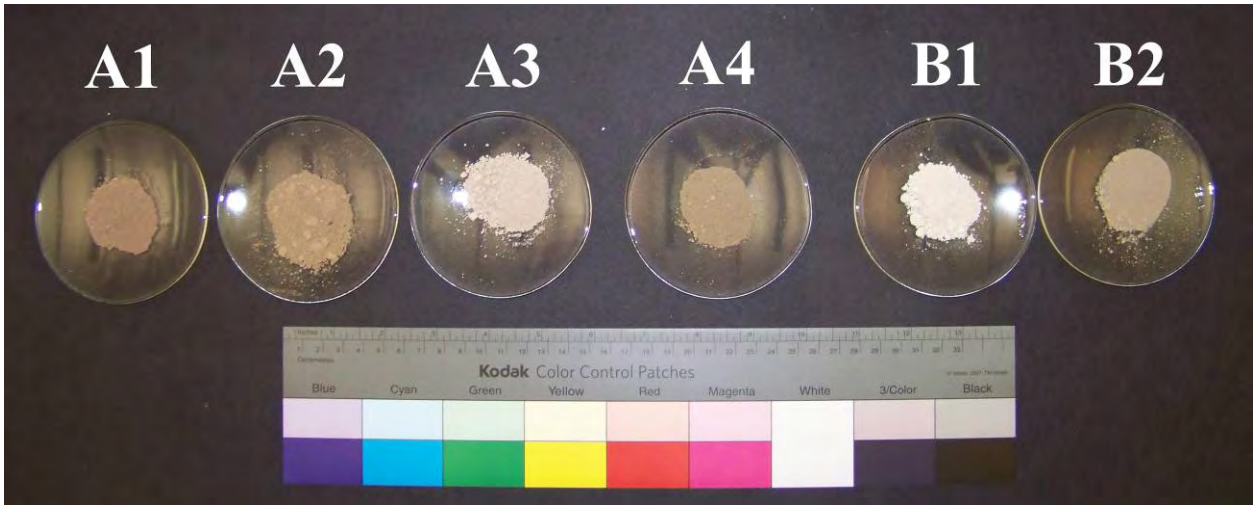

SAMPLE B2:
PROBE ADJ. TO
FEDERAL
MEASURE
PLAQUE

APPENDIX B: MORTAR COMPONENTS

Samples



Sands



Fines

APPENDIX C: JBC MORTAR ANALYSIS SPREADSHEET

CITY HALL MORTARS FROM ARCHAEOLOGICAL SITE

Sample	Rubble wall			Brick feature mid pit (icehouse)			Cistern			Brick feature adj. to cistern			CH S. basement wall (c.1810)			CH N. basement wall (c.1903)		
Description	Pinkish binder, a few lime blebs observed, a few brown flecks-looks left behind after sand grains fell out. Binder has irridescent sheen, microcracks. No shell or organic material.			Brown binder. Not well consolidated. Many voids. Dark aggregate. No shells or organic material.			White, chalky appearance to binder. Not well consolidated, voids, cracks. Some lime blebs. Difficult to determine the presence of shell materials.			Brown binder. Not well consolidated. May voids. No shells or organic material. Dark aggregate.			Off-white binder with lime blebs. Chalky appearance, soft, voids.			Brown binder, well-consolidated. Several small voids.		
Color	pinkish gray 7.5YR 7/2			pale brown 10YR 6/3			white 5Y 8/1			pale brown 10YR 6/3			white lighter than 10YR 8/1			light gray 10YR 7/2		
Hardness (1 to 5)	3			1			1			3.5			3			4		
Beaker wt.	135.9			133.91			139.56			132.63			139.58			132.63		
Beaker + Sample wt.	163.21			175.45			160.93			171.59			220.16			147.33		
Filter Paper wt.	4.88			4.86			4.88			4.91			14.8			4.95		
Filter Paper + Fines wt	7.59			10.49			7.75			11.99			27.25			6.14		
Beaker + Sand wt.	154.83			166.8			151.63			159.09			187.73			141.63		
Reaction Description	vigorous with medium fizzy bubbles			vigorous with large foamy bubbles that rose to the top of the beaker			vigorous with large foamy bubbles that rose to the top of the beaker			vigorous with large foamy bubbles			vigorous with small fizzy bubbles			vigorous with small fizzy bubbles		
Sample Wt.	27.31			41.54			21.37			38.96			80.58			14.70		
Sand Wt.	18.93	69.32%		32.89	79.18%		12.07	56.48%		26.46	67.92%		48.15	59.75%		9.00	61.22%	
Fines Wt.	2.71	9.92%		5.63	13.55%		2.87	13.43%		7.08	18.17%		12.45	15.45%		1.19	8.10%	
Acid Solubles Wt.	5.67	20.76%		3.02	7.27%		6.43	30.09%		5.42	13.91%		19.98	24.80%		4.51	30.68%	
Fines Color	brown between 7.5YR 6/3 and 5/3			brown between 10YR 6/3 and 5/3			light gray 10YR 7/2			light yellowish brown 2.5Y 6/3			white 10YR 8/1			light yellowish brown 10YR 6/3		
Sand Color	brown 7.5YR 5/3			brown 10YR 5/3			pinkish gray 7.5YR 6/2			brown between 10YR 5/3 and 5/4			pinkish gray 7.5YR 6/2			light yellowish brown 2Y 6/3		
Sand Description	mostly clear and rose quartz with brownstone and a few dark volcanic rocks.			Overall tone is yellowed probably from staining from clay. Mostly clear and rose quartz with brownstone and a few dark volcanic rocks.			mostly clear and rose quartz with brownstone and a few dark volcanic rocks.			Overall tone is yellowed probably from staining from clay. Mostly clear and rose quartz with brownstone and a few dark volcanic rocks.			mostly clear and rose quartz with brownstone and a few dark volcanic rocks.			Mostly clear quartz		
Sand Shape	sub-angular to sub-rounded			sub-angular to sub-rounded			sub-angular to sub-rounded			sub-angular to sub-rounded			sub-angular to sub-rounded			sub-angular		
Sand Size Range	v.coarse to med. (1cm to 1/4mm)			v.coarse to med. (1cm to 1/4mm)			v.coarse to med. (5mm to 1/4mm)			v.coarse to med. (5mm to 1/4mm)			v.coarse to med. (1cm to 1/4mm)			coarse to med (1/2mm to 1/4mm)		
Sieve Analysis	**Wt.**	**% Ret**	**% Pass**	**Wt.**	**% Ret**	**% Pass**	**Wt.**	**% Ret**	**% Pass**	**Wt.**	**% Ret**	**% Pass**	**Wt.**	**% Ret**	**% Pass**	**Wt.**	**% Ret**	**% Pass**
#4	0.78	4.15%	95.85%	0.32	0.97%	99.03%	0.00	0.00%	100.00%	0.00	0.00%	100.00%	0.47	0.98%	99.02%	0.00	0.00%	100.00%
#8	1.23	6.54%	89.31%	1.92	5.83%	93.20%	0.72	5.98%	94.02%	1.23	4.66%	95.34%	1.67	3.47%	95.56%	0.24	2.62%	97.38%
#16	3.21	17.07%	72.23%	9.48	28.80%	64.40%	0.95	7.89%	86.13%	5.40	20.48%	74.86%	8.21	17.05%	78.51%	1.27	13.86%	83.52%
#30	6.08	32.34%	39.89%	12.38	37.61%	26.79%	3.74	31.06%	55.07%	8.85	33.56%	41.30%	21.02	43.65%	34.86%	4.61	50.33%	33.19%
#50	5.22	27.77%	12.13%	6.41	19.47%	7.32%	4.34	36.05%	19.02%	6.99	26.51%	14.79%	13.40	27.82%	7.04%	2.02	22.05%	11.14%
#100	1.62	8.62%	3.51%	1.58	4.80%	2.52%	1.66	13.79%	5.23%	2.94	11.15%	3.64%	3.13	6.50%	0.54%	0.90	9.83%	1.31%
#200	0.51	2.71%	0.80%	0.47	1.43%	1.09%	0.50	4.15%	1.08%	0.74	2.81%	0.83%	0.26	0.54%	0.00%	0.12	1.31%	0.00%
Pan	0.15	0.80%	0.00%	0.36	1.09%	0.00%	0.13	1.08%	0.00%	0.22	0.83%	0.00%	0.00	0.00%	0.00%	0.00	0.00%	0.00%

APPENDIX D: HIGHBRIDGE MATERIALS CONSULTING, INC. REPORT

HIGHBRIDGE MATERIALS CONSULTING, INC.

47 Hudson Street
Ossining, NY 10562
Phone: (914) 502-0100
Fax: (914) 502-0099
jwalsh@highbridgematerials.com

MORTAR ANALYSIS REPORT

Client:	Jablonski Building Conservation, Inc.	**Client ID:**	JABL001
Project:	New York City Hall Mortars	**Report #:**	SL0097-01
Location:	New York, NY	**Date Received:**	07/19/10
Sample Type:	Mortar	**Report Date:**	08/09/10
Delivered by:	Client (Helen Thomas-Haney)	**Chemist:**	M. Malaj
		Petrographer:	J. Walsh
		Page 1 of 42	

Report Summary

- Six mortar samples from New York City Hall and adjacent archaeological sites are examined petrographically and chemical in order to identify original components, assess material qualities, and estimate proportions. Extraction of graded sand samples are excluded from the analyses.
- A sample labeled "City Hall Archaeological Site: Rubble Wall" is identified as a sanded lime mortar. The lime exhibits some minor hydraulic property. The sand is well graded and the binder to sand ratio is estimated at 1 : 1.8 when normalized to the equivalent of a modern dry lime hydrate.
- A sample labeled "City Hall Archaeological Site: Brick Feature Mid-Wall" is identified as an earthen mortar stabilized with natural cement. Traces of "limier" material are detected though the presence of a lime addition is not certain. The primary component is a mixture of clay, silt and sand. The cementitious material is present at no more than 10% by volume of the total.
- A sample labeled "City Hall Archaeological Site: Cistern" is identified as a sanded, non-hydraulic lime mortar. The lime is estimated to have been a meager lime with some dolomitic content as well as siliceous impurities. The sand is well graded and the binder to sand ratio estimated at 1 : 0.8 when normalized to the equivalent of a modern dry lime hydrate.
- A sample labeled "City Hall Archaeological Site: Brick Feature Adjacent to Cistern" is identified as a sanded natural cement mortar. The cement is a high magnesian American product. The sand is well graded though overabundant and the binder to sand ratio is estimated at 1 : 4.4 by volume.
- A sample labeled "City Hall Basement: Rubble Wall" is identified as a feebly hydraulic dolomitic lime mortar. The sand is somewhat narrowly graded. The binder to sand ratio is estimated at 1 : 1.1 when normalized to the equivalent of a modern dry lime hydrate.
- A sample labeled "City Hall Basement: Probe Adjacent to Federal Measure" is identified as a sanded natural cement mortar. The cement is a high magnesian American product. The sand is well graded and the binder to sand ratio is estimated at 1 : 2.1 by volume.
- A more detailed discussion of these findings may be found in the "Petrographic Findings and Discussion" section on page 5 of this report.

1. Introduction

On July 19, 2010, Highbridge received six mortar samples from Ms. Helen Thomas-Haney of Jablonski Building Conservation, Inc. reported to have been sampled from New York City Hall and adjacent archaeological sites. At the client's request, a petrographic examination and chemical analysis is performed on each sample. Excluded from the analysis is an extraction and gradation of the sand portion. The samples are identified as follows. For convenience of sample management and reporting, the laboratory has assigned arbitrary sample identifications using a prefix of "A" for mortars from archaeological features adjacent to the building and "B" for mortars taken at basement walls of City Hall.

Lab ID	Client Description
A1	City Hall Archaeological Site: Rubble Wall
A2	City Hall Archaeological Site: Brick Feature Mid-Wall
A3	City Hall Archaeological Site: Cistern
A4	City Hall Archaeological Site: Brick Feature Adjacent to Cistern
B1	City Hall Basement: Rubble Wall
B2	City Hall Basement: Probe Adjacent to Federal Measure

2. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within *ASTM C 1324: Standard Test Method for Examination and Analysis of Hardened Masonry Mortar*. Data collection is performed by a degreed geologist who by nature of his/her education is qualified to operate the analytical equipment employed. Analysis and interpretation is performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 3 of *ASTM C 856*.

Chemical analysis was conducted according to the procedures outlined in *ASTM C 1324: Standard Test Method for Examination and Analysis of Hardened Masonry Mortar*. Water, carbon dioxide and aggregate weight percentages are determined gravimetrically. Oxide weight percentages are determined by atomic absorption spectroscopy. The methods are modified when accounting for dolomitic lime. Rather than approximating lime through DTA with possible errors due to carbonated lime, dolomitic lime is instead calculated directly from the chemical analysis by simultaneous equations based on typical dolomitic lime chemistry.

3. Summary of Samples as Received

Sample ID	**A1 (City Hall Archaeological Site: Rubble Wall)**
Description	The sample consists of four irregular mortar pieces weighing a total of 129.5 g. The largest piece is approximately 2.75” x 1.5” x 1” in dimensions.
Surfaces	No bedding or pointing surfaces are obvious. The surfaces are irregular in shape with a relatively continuous weathering crust. The weathered surfaces are coarse and sandy-textured with a dull luster and brownish color.
Hardness / Friability	Moderately hard and non-friable.
Appearance	Fresh surfaces have a waxy luster and are pinkish white in color (Munsell color code approximately 5YR 7.5-8/2).
Other Details	Variously sized white binder grains are common throughout the sample and are found to sizes as large as approximately one centimeter. Very fine coal fragments are visible under low powered magnification. No brick fragments are detected. Only some very minor contour scaling is observed in one sample piece. Otherwise, no significant cracks are detected. No efflorescence is visible. However, very fine-grained, fibrous, white mineral deposits are detected in air-voids.

Sample ID	**A2 (City Hall Archaeological Site: Brick Feature Mid-Wall)**
Description	The sample consists of several small mortar pieces and abundant loose powder weighing a total of 63.5 g. Assuming the samples represent bedding fragments, the bed thickness is approximately 0.5”
Surfaces	No pointing surfaces are obvious. Bed surfaces are mostly compact, smooth and planar.
Hardness / Friability	Soft and friable.
Appearance	Fresh surfaces have a dull and earthy luster and are pale brown in color (Munsell color code approximately 10YR 6/3).
Other Details	No binder grains are other inclusions are visible in hand sample. No mineral deposits or efflorescence is detected. Cracking cannot be discussed due to the fragmentary nature of the sample.

Sample ID	**A3 (City Hall Archaeological Site: Cistern)**
Description	The sample consists of two irregular mortar pieces weighing a total of 38.5 g. The largest piece is approximately 2” x 1” x 1” in dimensions.
Surfaces	One piece is irregular with no obvious surfaces. The other has two well compacted planar surfaces. Minor soiling is observed.
Hardness / Friability	Soft and friable.
Appearance	Fresh surfaces have a dull luster and are nearly white in color (Munsell color code approximately 7.5YR 8/1).
Other Details	Variously sized white binder grains are moderately common throughout the sample and are found to sizes as large as several millimeters. A very low abundance of wood fiber is found in one area. No brick fragments or other inclusions are detected. No significant cracking or efflorescence is observed.

Sample ID	**A4 (City Hall Archaeological Site: Brick Feature Adjacent to Cistern)**
Description	The sample consists of four bedding mortar pieces weighing a total of 151.0 g. Pieces range in size from 1.5” - 3” in length with apparent bed thicknesses ranging from 3/8” to 1”.
Surfaces	No pointing surfaces are obvious. Some pieces are blocky and somewhat irregular in shape. Where bed surfaces are apparent these are mostly compact and planar. Some surfaces exhibit a slight grayish soiling.
Hardness / Friability	Moderately soft and non-friable.
Appearance	Fresh surfaces have a dull luster and are light brownish gray in color (Munsell color code approximately 10YR 6/2.5).
Other Details	No obvious binder grains or other inclusions are visible in hand sample. One of the four pieces exhibits several hairline cracks oblique to the bedding surface. No efflorescence or secondary mineral deposits are observed.

Sample ID	**B1 (City Hall Basement: Rubble Wall)**
Description	The sample consists of several small irregular mortar pieces weighing a total of 32.5 g. The pieces are generally less than 1” in dimension.
Surfaces	Surfaces are mostly irregular and well consolidated.
Hardness / Friability	Moderately soft and non-friable.
Appearance	Fresh surfaces have a dull luster and are nearly white in color (Munsell color code approximately 2.5Y 8/1).
Other Details	Variously sized white binder grains are common throughout the sample and are found to sizes as large as a centimeter or so. No brick fragments or other inclusions are detected. No efflorescence or mineral deposits are observed. Cracking is difficult to assess due to the sample size.

Sample ID	**B2 (City Hall Basement: Probe Adjacent to Federal Measure)**
Description	The sample consists of four irregularly shaped mortar pieces weighing a total of 29.0 g.
Surfaces	No bedding or pointing surfaces are obvious. The mortar is well consolidated.
Hardness / Friability	Moderately hard and non-friable.
Appearance	Fresh surfaces have a moderately dull luster and are light gray in color (Munsell color code approximately 10YR 7/1.5).
Other Details	No obvious binder grains or other inclusions are visible in hand sample. No cracking, efflorescence or secondary mineral deposits are observed.

4. Petrographic Findings and Discussion

General Discussion

Six samples are provided for analysis. Three of these represent pure lime mortars (Samples A1, A3, and B1), two represent pure natural cement mortars (Samples A4 and B2), and one is a cement-stabilized earthen mortar (Sample A2).

The three lime mortars are similar in that they are all coarsely mixed with relatively large lime inclusions dispersed throughout the matrix. This type of texture may be associated with the preparation of the mortar as a hot mix. This is one in which the lime slaking and blending with sand occurs simultaneously as construction proceeds with the mortar placed shortly after mixing. All three lime types are determined to have been burned from a rock source. The lime in Samples A1 and A3 is clearly derived from a marble while the lime in B1 may have been burned from either a marble or an even-grained dolomitic limestone. The estimated binder to sand ratios are discussed in the individual mortar sections below as well as presented in table format in Section 5 of this report. Samples A3 and B1 are considered undersanded.

While the preparation and lime source appear similar, there are enough subtle differences that make it difficult to state that the mortars are contemporaneous. Most notable is the variation in lime chemistries. The lime in Sample A1 appears to have a distinct hydraulicity due to impurities in the lime source. The lime in Sample A3 while texturally similar is a bit richer in magnesium and exhibits virtually no hydraulic character. The lime in Sample B1 is different still being purely dolomitic with only a very feeble hydraulic quality. The first two samples could be from a similar vintage if the lime were being supplied from a marble source with a high degree of layer to layer variation. The weak hydraulicity may be responsible for the slightly more indurate character of Samples A1 and B1. Sample A3 with the higher purity lime is softer and more friable.

It is understood that two of the mortars are from archaeological sites adjacent to City Hall and the author assumes that the original construction dates are uncertain. Unfortunately, it is difficult to estimate vintage for lime mortars as they are ubiquitous from colonial times right up through the early twentieth century. The crude mixing might suggest an earlier date though this is speculative. While the presence of rock lime as opposed to shell lime might suggest an approximately post-1830 vintage in the southeastern United States, this rule of thumb cannot be used in the New York City area. The author has encountered marble lime in New York as far back as the early eighteenth century. The local Inwood Marble may have been considered a convenient source. The applications may be more informative. Sample A3 is described as a cistern sample. If the sample was recovered from a cistern lining, the absence of a more hydraulic or cementitious mortar might be telling. European Roman cements may have been available as early as the first decade of the nineteenth century. Certainly American natural cements were ubiquitous by the 1830's and would have been a logical choice for any waterproofing application.

Samples A4 and B2 are pure natural cement mortars. Both have high magnesium chemistries typical of American natural cements. The binder in B2 appears more typical of cements such as those produced in Rosendale, NY while that in A4 exhibits a little more variation. Sample A4 is considered quite oversanded with a binder to sand ratio estimated at 1 : 4.4 by volume. Sample B2 has a more typical mix proportioning at approximately 1 : 2.1 by volume. The matrix in this sample has characteristics indicative of a dry, stiff original mix. The resulting granularity of the binder is responsible for a moderate permeability.

Sample A4 is understood to have been sampled from an archaeological feature. Given the natural cement binder, the construction date cannot be earlier than ca. 1820 and is probably later than ca. 1830. The author is not aware of the relationship between this sample and Sample A3. If the field relationship indicates they are clearly contemporaneous, then the argument suggested above may be flawed. Sample B2 is reported by the client to have a vintage ca. 1903. The presence of natural cement is not at odds with this date though natural cement was certainly in decline by the first decade of the twentieth century.

Sample A2 is identified as an earthen mortar stabilized with natural cement. Traces of lime are detected though it is not certain if an intentional lime addition is present as well. Nevertheless, the clay, silt, and sand dominate the mix and the binder represents less than 10% of the volume. The soft, porous mortar may then be considered similar to an adobe. This mortar is also reported to have been sampled from an archaeological feature. Again, the natural cement addition sets an earliest possible construction date of 1818.

Sample A1 (City Hall Archaeological Site: Rubble Wall): (Figs. 1 through 6)
Sample A1 is identified as a sanded lime mortar. Some notable hydraulicity is indicated though no cement or pozzolanic additions are detected. The original weight ratio of unslaked lump lime to aggregate is estimated at about 1 : 4. Normalizing the quantity of original lime and sand to the equivalent of a modern dry hydrate results in a binder to sand ratio estimated at 1 : 1.8 by volume. However, it should be understood that the lime would not have been mixed in this way. The mortar is coarse-textured with very large undispersed lime grains distributed throughout the matrix. The texture is suggestive of a hot mix or one in which the lump lime was mixed with the sand while slaking and placed in the wall shortly thereafter. Though roughly mixed, the mortar is relatively well consolidated with an air content estimated between 6% and 12% by volume. While dull brown and weathered on the surface, the fresh mortar is light pink in color (Munsell color code approximately 5YR 7.5-8/2). The matrix is relatively hard and non-friable for a lime mortar though the matrix appears to be moderately water permeable.

The aggregate is a siliceous natural sand consisting predominantly of quartz with minor feldspar. Other minor mineralogies are those commonly found in New York sands including aluminous metamorphic rocks. Also observed are red sandstones, iron-rich mudstones, and dark volcanics (diabase) all associated with materials weathered from Newark Basin rocks in New Jersey. While not predominant, the sandstones impart a distinct pinkish tone to the aggregate. A sand extraction was not requested for the mortar samples. Nevertheless, a small-scale acid digestion was performed to help explain unusual chemical analysis results. A moderate abundance of fines were recovered at approximately 5% of the total aggregate. No clay lumps are detected in thin section but it is likely that some clay is dispersed throughout the matrix. The sand is sharp-textured with most grains being subangular and equidimensional in shape. Grains as large as 3/8” are found in hand sample though the majority of the gradation is much finer grained. The effective nominal top size in most areas of the mortar appears in the range of the No. 16 sieve and the gradation curve is broad below this mesh.

The lime is interpreted to have been burned from an impure marble. Given the location, the Inwood Marble is the most likely source. Lime grains are found in moderately high abundance petrographically. The most common texture is one retaining the sucrosic or “sugary” texture of the original marble rock indicating crystal sizes on the order of 250 to 500 µm. The burning appears to have been inconsistent and both underburned and overburned grains are found. Burned silicate impurities are relatively common some of which have been fused to a vesicular glass. In cases where one binder type is present it is generally possible to estimate the original chemistry from the chemical analysis. The estimates for the lime-based mortars in the sample suite are given in Table 5.2 below. In this case, the resulting estimate is quite unusual. First, the lime has a low magnesium content and this is rare for limes burned from the Inwood Marble. Most Inwood layers are dolomitic in part or in full. Even more unusual is that the resulting chemistry is calculated to be almost exactly that of a modern portland cement with an indicated hydraulicity higher than that of an eminently hydraulic lime. Much of this is interpreted to be the result of leached elements from the aggregate producing a significant measurement interference. Evidence of this is found in the relatively high iron content as the Inwood Marble is generally deficient in this element. Therefore, the estimate of the lime chemistry is considered erroneous. Still, the abundance of burned silicate impurities and the relative hardness of the binder indicates that the lime did in fact have some hydraulic property. It is possible that this hydraulicity was an accidental consequence of an anomalous layer in the lime source rock and not intentionally sought after.

The mortar has a distinct pinkish coloration which might suggest that some intentional additive is present. Given the hardness of the mortar, it might be suspected that brick dust was added as a pozzolan. However, no such addition is detected and the hardness of the mortar is attributed to a combination of some hydraulicity in the original lime as well as recrystallization of calcium carbonate in service. Also absent is any type of powdered pigment. The coloration might be attributed to the red sandstone component of the aggregate. Certainly the sand exerts some influence on the appearance. However, all three examined lime mortars contain similar aggregate and only A1 has a pinkish hue. Microscopic observations of A1 reveal extremely fine-grained dendritic crystallizations within the lime matrix that are likely iron-oxide based. These most likely represent leaching of red sandstone grains in service. Sample A1 does exhibit the highest degree of secondary chemical effects of the three lime mortars. If this is the case, then the mortar represented by Sample A1 was originally bright white in color with the coloration developing later in service.

Chemical analysis was performed on the mortar in order to estimate the original lime to sand ratio and these estimates are presented in Table 5.3 and 5.4 below. It is suggested here that the mortar was originally proportioned using lump lime and sand in a hot mix. If that is the case, it is difficult to convert the weight proportions to volumes without knowing the size of the lime particles and the original bulk weight. Nevertheless, the weight proportion of the raw materials may be calculated and the original lime to sand ratio is estimated at 1 : 4.3 by weight. Additional ratios may be calculated from this more robust estimate. If one were to convert this amount of lime to an equivalent weight of modern dry lime hydrate with typical bulk density, the hydrated lime to sand ratio is equivalent to 1 : 1.8 by volume. One could also convert this same amount of lime

to a putty assuming that a given mass of dry lime hydrate will lose approximately 40% of its volume when mixed to putty consistency. This results in a lime putty to sand ratio of approximately 1 : 3.0 by volume.

Generally, the matrix has a high capillary porosity as is typical of high lime mortars. However, many areas exhibit reduced porosity due to recrystallization of calcium carbonate in the pores. Secondary calcium carbonate precipitation as distinguished from lime carbonation is fairly extensive in Sample A1. While indicative of moisture movement in service, the secondary minerals are not necessarily considered deleterious to the mortar. In fact, the recrystallization has served to strengthen the matrix and enhance its durability. The phenomenon of autogenous healing in lime mortars or the healing of shrinkage cracks with secondary carbonation is quite often overstated. However, in this particular case, the carbonate has healed microscopic polygonal cracks that are attributed to the early shrinkage of the mortar.

Sample A2 (City Hall Archaeological Site: Brick Feature Mid-Wall): (Figs. 7 through 11)
Sample A1 is identified as a cement stabilized earthen mortar. The matrix is clay based with fine-grained sand and silt. Dolomitic natural cement is present in minor abundance as a binder and stabilizer. The original ratio of cement to clay and sand is estimated at approximately 1 : 15 by weight. The mortar is dull and earthy lustered and pale brown in color (Munsell color code approximately 10YR 6/3). The material is soft, friable, and permeable. The mortar is well consolidated with an air content estimated at 3% to 4% by volume.

The majority of the material is a mixture of clay and sand. The coarser sand and silt components that can be identified petrographically consist predominantly of quartz with minor amphibolite, arkosic sandstone, and feldspar. Trace minerals include aluminous metamorphic rock fragments. Few lumps of silty clay are found petrographically and the clay is otherwise well dispersed throughout the matrix. Thin clay coatings are relatively common on around sand grains. The sand is mostly sharp-textured with subangular shapes on average and equidimensional aspects. The nominal top size is estimated at the No. 8 sieve and the gradation curve is broad.

The binder matrix is sparse, porous, and weakly hydraulic. Residual cementitious binder is detected in moderately low abundance. Natural cement is clearly the main component. However, only a low percentage of residual grains have the typical internal textures found in the more common American cements such as those from Rosendale, NY or Louisville KY. These include calcined dolomite grains with distinctive rims of iron product and dispersed combined quartz silt. The majority of grains while still cementitious have a greater variety of textures. Some of these include vitrified or clinkered material. There also trace grains with higher lime content though it is possible these are simply “limier” portions of the cement. The estimated binder chemistry is presented in Table 5.6 below. If lime is present, there is room in the chemistry for a maximum of about one half part lime per part cement. However, this is calculated assuming the most extreme chemistries of natural cement and lime. The chemistry is just as easily explained by a pure natural cement with lower typical magnesium content. The magnesium content is not as high as a “Rosendale-type” cement but is still too high to suggest a European cement. As American cements were introduced in 1818, this represents an earliest possible vintage. While admittedly speculative, the observations could perhaps place a fairly tight time bracket on the construction as Rosendale cements were not introduced until about 1828 at the earliest. However, given the “economical” nature of the mortar there is no obvious reason to discount the use of one of the lower quality cements even if Rosendale were already available.

Chemical analysis was performed in order to estimate original material proportions and these estimates are presented in Table 5.7 below. The sand and clay are combined together as one component as a sand extraction was not requested for the sample. The ratios of cement binder to sand/clay are estimated at 1 : 14.2 by weight. Using typical conversion factors for cement and sand densities yields a volume ratio of 1 : 13. However, it might be expected that the sandy clay mixture had a higher density than an equivalent volume of sand. This could result in a volume ratio anywhere from 10% to 20% lower than reported here.

While soft and friable, the mortar appears to have been volume stable in service as larger pieces contain no internal microscopic shrinkage cracks. Some secondary recrystallization of calcium carbonate is found but is relatively minor. The entire bed thickness exhibits the typical patchy carbonation of natural cement and this is considered a natural consequence of the cement curing.

Sample A3 (City Hall Archaeological Site: Cistern): (Figs. 12 through 16)
Sample A3 is identified as a sanded, non-hydraulic lime mortar. The original weight ratio of unslaked lump lime to aggregate is estimated at 1 : 2. The mortar mix is considered binder rich and normalizing the quantity of original lime and sand to the equivalent of a modern dry hydrate results in a binder to sand ratio estimated at 1 : 0.8 by volume. However, it should be understood that the lime would not have been mixed in this way. The mortar is coarse-textured with relatively large undispersed lime grains distributed throughout the matrix. As discussed for Sample A1, the texture is suggestive of a hot mix or one in which the lump lime was mixed with the sand while slaking and placed in the wall shortly thereafter. Though roughly mixed, the mortar is relatively well consolidated with an air content estimated between 6% and 10% by volume. On fresh surfaces the mortar is dull-lustered and nearly white in color (Munsell color code approximately 7.5YR 8/1). The matrix is soft, friable and water permeable.

The aggregate is a siliceous natural sand qualitatively similar to that found in Sample A1. The sand consists predominantly of quartz with minor feldspar. Other minor mineralogies are those commonly found in New York sands including aluminous metamorphic rocks. Also observed are red sandstones, iron-rich mudstones, and dark volcanics (diabase) all associated with materials weathered from Newark Basin rocks in New Jersey. While not predominant, the sandstones impart a distinct pinkish tone to the aggregate. This coloration is responsible for the very faint pinkish tone of the mortar. It should be noted that the color is significantly fainter than observed in Sample A1. A sand extraction was not requested for the mortar samples. Nevertheless, a small-scale acid digestion was performed to provide additional information. A moderate abundance of fines were recovered at approximately 5% of the total aggregate. No clay lumps are detected in thin section but it is likely that some clay is dispersed throughout the matrix. The sand is sharp-textured with grains being subangular in shape on average and equidimensional in aspect. The nominal top size is estimated at the No. 8 sieve and the gradation curve is estimated to be broad below this mesh.

The lime is interpreted to have been burned from an impure marble similar but not identical to that of Sample A1. Given the location, the Inwood Marble is the most likely source. Lime grains are found in moderately high abundance petrographically. The most common texture is one retaining the sucrosic or “sugary” texture of the original marble rock indicating crystal sizes on the order of 250 to 500 µm. The lime burning appears to have been more consistent than that observed in Sample A1 though there are still burned silicate impurities present. Some of these are positively identified as pyroxene and amphibole and this confirms the marble source. The original lime chemistry was estimated from the chemical analysis and the results presented in Table 5.2 below. In this case, the chemistry indicates a fairly typical meager lime. The levels of impurities are high though not high enough to have produced a detectable hydraulicity. A hydraulic index is calculated at 0.06 and feebly hydraulic limes typically have minimum indices of approximately 0.10. However, the impurities are considered sufficient to have produced a lean lime or one that would be expected to exhibit less bulking behavior on slaking. If this meager quality was expected by the original masons, the lower sand content may have been intentional to counteract the lower lime yield. Also indicated by the chemistry is a moderate dolomitic or magnesian component. Again, this is expected of lime burned from the Inwood Marble. It is notable that a higher abundance of uncarbonated lime grains are present in this sample as compared to Sample A1. This would be explained by the higher magnesium content as the carbonation reaction is much more sluggish in magnesium limes.

Chemical analysis was performed on the mortar in order to estimate the original lime to sand ratio and these estimates are presented in Table 5.3 and 5.4 below. It is suggested here that the mortar was originally proportioned using lump lime and sand in a hot mix. If that is the case, it is difficult to convert the weight proportions to volumes without knowing the size of the lime particles and the original bulk weight. Nevertheless, the weight proportion of the raw materials may be calculated and the original lime to sand ratio is estimated at 1 : 2.0 by weight. Additional ratios may be calculated from this more robust estimate. If one were to convert this amount of lime to an equivalent weight of modern dry lime hydrate with typical bulk density, the hydrated lime to sand ratio is equivalent to 1 : 0.8 by volume. One could also convert this same amount of lime to a putty assuming that a given mass of dry lime hydrate will lose approximately 40% of its volume when mixed to putty consistency. This results in a lime putty to sand ratio of approximately 1 : 1.3 by volume. In whichever form the estimates are given it is clear the mortar is undersanded.

Despite the low sanding and expected volume instability, microscopic shrinkage cracking is minimal in Sample A3. Minor cracking is detected but these are more localized than typical polygonal lime shrinkage cracks. Aside from larger lime grains discussed above, the mortar matrix is mostly carbonated and this is an expected and desirable result of mortar curing. The sample is identified as being associated with a cistern. However, evidence of water ingress is also quite minimal. There is some coarser-grained carbonate precipitation in air-voids but these are not particularly abundant. No significant deleterious reactions are identified in the sample provided.

Sample A4 (City Hall Archaeological Site: Brick Feature Adjacent to Cistern): (Figs. 17 through 20)
Sample A4 is identified as a pure natural cement mortar with an original binder to sand ratio estimated at 1 : 4.4 by volume. The mortar is moderately well consolidated with an air content estimated between 8% and 10% though the mix is considered quite oversanded for a natural cement mix. The matrix is moderately soft and somewhat water permeable. On fresh surfaces, the mortar is dull lustered and light brownish gray in color (Munsell color code approximately 10YR 6/2.5).

The aggregate is a siliceous natural sand consisting predominantly of quartz with lesser granitic grains. Minor mineralogies include aluminous metamorphic rock types and graywacke sandstone. Trace dolomitic limestone found may actually represent underburned portions of the cement. The rock types are common in sands of the New York City area though the sand is slightly different in detail than in the previously described samples. A sand sample was not extracted and the color and texture of the sand is not discussed. However, the brownish color of the matrix is more strongly influenced by the color of the binder than that of the sand. The sand is sharp-textured with grains being subangular in shape on average and equidimensional in aspect. The nominal top size is estimated at the No. 8 sieve. The aggregate appears well graded with only a minor abundance of fines.

The hydraulic matrix has a moderate capillary porosity with a moderate to moderately low abundance of natural cement residuals. These fine- to medium-sized relict grains contain textures consistent with the low temperature firing of an argillaceous dolomitic limestone. Most of the textures are consistent with the more common natural cements such as those from Rosendale, NY though some grains appear a bit lower in iron. Nevertheless, the cement chemistry is estimated from the chemical analysis (see Table 5.6 below) and the cement in A4 is more typical of Rosendale than the other two natural cement samples. The magnesium content is high and this is also indicative of most American natural cements. Only a minor abundance of underburned cement residuals are identified and no overburned grains are found. The binder is well hydrated and the original mix water content appears to have been moderate.

Chemical analysis was performed on the mortar in order to estimate the original cement to sand ratio and the estimate is presented in Table 5.7 below. Assuming typical bulk densities of natural cement and damp, loose sand, the ratio is approximately 1 : 4.4 by volume. This would be considered oversanded by today's standards and quite oversanded for a historical natural cement mortar where typical sandings did not generally exceed two parts sand per one part cement. Still the mortar is not poorly consolidated largely due to an adequate sand gradation. A narrower gradation would likely have resulted in a grittier, more friable mortar given the low binder content.

The mortar is partially carbonated throughout with a microscopically patchy carbonation typical of natural cement mortars. Primary hydroxides from the cement hydration are consumed as a result of the carbonation and this is considered a normal consequence of natural cement mortar aging. Little microscopic cracking is detected in the sample and there is no evidence for any significant physical distress in service. There is evidence for a moderate degree of water ingress as secondary carbonate deposits are common throughout the sample. These appear as medium- to coarse-grained sparry to blocky crystals in voids.

Sample B1 (City Hall Basement: Rubble Wall): (Figs. 21 through 24)
Sample B1 is identified as a sanded, dolomitic lime mortar with a feebly hydraulic quality. The original weight ratio of unslaked lump lime to aggregate is estimated at approximately 1 : 3. As with Sample A3, the mortar mix is considered binder rich and normalizing the quantity of original lime and sand to the equivalent of a modern dry hydrate results in a binder to sand ratio estimated at 1 : 1.1 by volume. However, it should be understood that the lime would not have been mixed in this way. As found with Samples A1 and A3, the mortar is coarsely mixed and coarse-grained lime particles are common in the matrix. The mortar was likely hot mixed. Still, the mortar is relatively well consolidated with an air content estimated between 8% and 12% by volume. On fresh surfaces, the mortar is dull-lustered and nearly white in color (Munsell color code approximately 2.5Y 8/1). The matrix is only moderately soft and the slightly indurate nature likely the result of the weak hydraulicity. Nonetheless, the mortar is considered moderately water permeable.

The aggregate is a siliceous natural sand qualitatively similar to that found in other samples. The sand consists predominantly of quartz with minor granitic, aluminous metamorphic, and arkosic sandstone grains. As noted before, these minor rock types are typical of those in the New York City area with the sandstone deriving from Newark Basin bedrock. No significant clay mineralogies are identified. While not predominant, the sandstones impart a distinct pinkish tone to the aggregate. This coloration as well as that from the other minor lithologies is responsible for the overall warm tone of the mortar. The distinctly pinkish color viewed in Sample A1 is not present in Sample B1. The sand is sharp-textured with

grains being subangular in shape on average and equidimensional in aspect. The nominal top size is estimated at the No. 16 sieve in thin section though grains as coarse as the No. 8 mesh may be present. A sand extraction was not performed and a quantitative gradation curve cannot be provided. However, petrographic observations suggest the gradation curve is somewhat narrow with a large majority of grains found within the range of the No. 30 and No. 50 sieves and a very minor quantity of fines.

The binder matrix has a high capillary porosity with little petrographic indication of any hydraulic character. The binder is identified as a purely dolomitic lime with a very feebly hydraulic character. The lime was burned from either a dolomitic marble such as the local Inwood Marble, or a dolomitic limestone such as those located further north in the Hudson Valley. Undispersed lime grains are found in high abundance petrographically. Most contain relict internal textures from the original rock source. The most common are "ghosts" of original dolomite grains with an equidimensional sucrosic texture. Unlike Samples A1 and A3 the original grain size is finer and ranges from approximately 100 µm to 250 µm. Larger grains are often dotted with fine-grained fully combined silicates. While these could represent a fine-grained marble with evenly dispersed quartz, the finer-grained textures are also common in dolomitic limestone. Larger irregular inclusions of glass and possibly some very fine-grained inert aluminate minerals may have derived from the burning of some clay impurities.

The original lime chemistry was estimated from the chemical analysis and the results presented in Table 5.2 below. The calcium oxide to magnesium oxide ratio of the binder is 1.5 and just slightly more calcium rich than the theoretical minimum for a pure dolomite (1.4). As with Sample A1, some larger lime inclusions exhibit areas that have not yet carbonated and this is attributed to the slower carbonation rate of dolomitic limes. Also noted in the chemical analysis is a feeble degree of hydraulicity. A hydraulic index is calculated at 0.18 and in this case not believed to represent any interference from the aggregate. A typical feeble hydraulic lime might have an index of between 0.1 and 0.2. However, the index does not take into account the magnesium content. This adds more "lime" to the calculation and reduces the actual hydraulicity. It should be noted that true hydraulic limes are rarely dolomitic. It is interpreted here that whatever little hydraulicity was present was not intentional. Nevertheless, the trace hydraulic components may have strengthened the matrix slightly and Sample B1 is clearly on the more indurate side of the scale for common lime mortars.

Chemical analysis was performed on the mortar in order to estimate the original lime to sand ratio and these estimates are presented in Table 5.3 and 5.4 below. Again, it is suggested here that the mortar was originally proportioned using lump lime and sand. If that is the case, it is difficult to convert the weight proportions to volumes without knowing the size of the lime particles and the original bulk weight. Nevertheless, the weight proportion of the raw materials may be calculated and the original lime to sand ratio is estimated at 1 : 2.9 by weight. Additional ratios are again calculated from this more robust estimate. If one were to convert this amount of lime to an equivalent weight of modern dry lime hydrate with typical bulk density, the hydrated lime to sand ratio is equivalent to 1 : 1.1 by volume. Calculating as a lime putty as discussed previously results in a ratio of 1 : 1.8 by volume. This estimate is subject to greater error than the other two. In any case, the mixture is considered undersanded for a lime mortar.

Despite the low sanding, narrow gradation, and expected volume instability, microscopic shrinkage cracking is minimal in Sample B1. Polygonal shrinkage cracking is mostly restricted to within larger lime particles. The binder matrix itself is mostly free from shrinkage cracking. Of course, the lime particles themselves may be considered to behave as sand particles counteracting the volume instability. The mortar matrix is mostly carbonated and this is an expected and desirable result of mortar curing. Evidence of water ingress is minimal and virtually no secondary mineral deposits are identified.

Sample B2 (City Hall Basement: Probe Adjacent to Federal Measure): (Figs. 25 through 27)
Sample B2 is identified as a pure natural cement mortar with an original binder to sand ratio estimated at 1 : 2.1 by volume. The mix ratio is considered typical of historical natural cement mortars. The mortar is moderately well consolidated with an air content estimated between 12% and 15%. The binder has a microscopically granular texture that is likely the result of a low original water content. Still, the mortar appears to be moderately water permeable. The matrix is moderately hard. On fresh surfaces, the mortar is dull lustered and light gray in color (Munsell color code approximately 10YR 7/1.5).

The aggregate is a siliceous natural sand consisting predominantly of quartz with minor granitic and aluminous metamorphic grains. Traces of arkosic sandstone are present though less so than in other mortars examined in the suite. The sand represents a typical New York City mineral assemblage. A sand sample was not extracted and the color and texture of the sand is not discussed. However, the brownish color of the matrix is more strongly influenced by the color of the binder than that of the sand. The sand is sharp-textured with grains being subangular in shape on average and equidimensional in aspect.

The nominal top size is estimated at the No. 16 sieve. The aggregate appears well graded with only a minor abundance of fines.

The hydraulic matrix has a moderate to moderately high capillary porosity with a high abundance of natural cement residuals. In this case, the porosity is not due to a sparser cementitious hydrate resulting from high water content. Instead, the cementitious hydrate is dense and compact and the porosity is due to the granularity of closely packed cement residuals. These textures are indicative of a mortar mixed in a relatively dry, stiff condition. Nonetheless, the mortar is considered adequately hydrated and cohesive. The residual cement grains have textures consistent with the low temperature burning of an argillaceous dolomitic limestone. Of the three cement mortars in the sample suite, Sample B2 exhibits the most consistent cement textures like those of the high magnesian American cements such as those from Rosendale, NY. There is one cement clot identified petrographically that includes clinkered grains some of which appear to represent aluminate assemblages. There were natural portland cements produced in Syracuse, NY representing intentionally overburned natural cement. However, the majority of textures are not consistent with Syracuse cements and the clinkered area is likely a trace bit of unintentionally overburned natural cement. The original cement chemistry is estimated as well and is presented in Table 5.6 below. The calcium content is higher and the silica content lower than most Rosendale cement and the chemistry is more similar to those of either the Louisville, KY or Cement, GA districts. Nevertheless, the cement is high in magnesium and not considered atypical of the higher quality American natural cements. The client reports a construction date of ca. 1903 for this mortar. This places the construction during a time period where natural cement usage was rapidly declining in the United States. The author is not familiar with the exact years when manufacturing ceased for each of the natural cement manufacturing districts. However, it would seem likely that by this date there is a higher probability that the cement came from one of the larger centers.

Chemical analysis was performed on the mortar in order to estimate the original cement to sand ratio and the estimate is presented in Table 5.7 below. Assuming typical bulk densities of natural cement and damp, loose sand, the ratio is approximately 1 : 2.1 by volume. Historically, a 1 : 2 ratio was a common choice for natural cement mortars as opposed to 1 : 3 for portland cement mortars later in the nineteenth century.

The mortar is partially carbonated throughout with a microscopically patchy carbonation typical of natural cement mortars. Primary hydroxides from the cement hydration are consumed as a result of the carbonation and this is considered a normal consequence of natural cement mortar aging. Little microscopic cracking is detected in the sample and there is no evidence for any significant physical distress in service. There is no evidence for any significant degree of water ingress and no secondary mineral deposits are identified aside from those of normal carbonation.

Respectfully submitted,

John J. Walsh
President/ Senior Petrographer

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5. Chemical Analysis

Table 5.1: Chemical Analysis Results (Lime-Based Mortars)

SAMPLE ID	**A1**	**A3**	**B1**
Component (wgt. %)			
SiO_2	4.02	0.62	1.61
CaO	10.95	21.39	11.48
MgO	0.24	2.76	7.58
Al_2O_3	1.15	0.69	0.47
Fe_2O_3	0.63	0.41	0.40
Insoluble residue	73.24	52.68	61.43
LOI %, to 110°C (Free water)	1.66	2.10	0.95
LOI %, 110°C-550°C (Combined water)	2.99	2.83	8.34
LOI %, 550°C-950°C (Carbon dioxide)	5.29	15.94	7.92
Measured Totals	**100.16**	**99.43**	**100.18**

Notes:
1) The sample preparation was modified from those outlined in ASTM C 1324 in order to better partition the binder and sand. A room temperature acid digestion was substituted in order to more fully capture dolomitic and hydraulic components. The base digestion was neglected so as to minimize the leaching of sand components.

Table 5.2: Estimated Original Lime Chemistries (Lime-Based Mortars)

SAMPLE ID	**A1**	**A3**	**B1**
Component (wgt. %)			
SiO_2	23.4	2.4	7.4
CaO	63.8	81.8	52.8
MgO	1.4	10.6	34.8
Al_2O_3	6.7	2.6	2.2
Fe_2O_3	3.7	1.6	1.8
Other	1.0	1.0	1.0
CaO/MgO ratio	46.1	7.7	1.5
Hydraulicity Index	**0.47**	**0.06**	**0.18**
Cementation Index	**1.15**	**0.11**	**0.24**

Notes:
1) As only one binder is found in each sample, it was possible to estimate the original lime chemistry from the chemical analysis. The measured values are normalized to 99% assuming that other unmeasured oxides represent approximately 1% of the total. Hydraulicity index is calculated by dividing the sum of silica and alumina by the measured calcium. Note that this neglects the contribution of magnesium to the lime and tends to overestimate the potential hydraulicity in dolomitic limes. Cementation index is calculated by dividing the “hydraulic elements” by the “lime elements” after multiplying each by coefficients normalizing them to their molecular rather than weight contribution.

Table 5.3: Calculated Lime and Sand Weights (Lime-Based Mortars)

SAMPLE ID	**A1**	**A3**	**B1**
Component (wgt. %)			
Lump lime (wgt. %)	19	33	26
Sand (wgt. %)	81	67	74
Lump lime : sand ratio (by weight)	1 : 4.3	1 : 2.0	1 : 2.9

Notes:
1) The lime and sand weights are taken directly from the chemical analysis on a non-volatile basis assuming that all measured oxides derive from the lime and the acid insoluble residue from the sand. The lime is reported in unslaked or lump form. Weights are normalized to 100%.

Table 5.4: Calculated Components (Lime-Based Mortars)

SAMPLE ID	**A1**	**A3**	**B1**
Component			
Portland cement (wgt. %)	Not detected	Not detected	Not detected
Natural cement (wgt. %)	Not detected	Not detected	Not detected
Lime expressed as dry hydrate (wgt. %)	22	39	32
Pozzolans (wgt. %)	Not detected	Not detected	Not detected
Pigment (wgt. %)	Not detected	Not detected	Not detected
Sand (wgt. %)	78	61	68
Lime : sand ratio (by volume with lime as a dry hydrate)	1 : 1.8	1 : 0.8	1 : 1.1
Lime : sand ratio (by volume with lime as a putty)	1 : 3.0	1 : 1.3	1 : 1.8

Notes:
1) Lime weights are calculated by converting the measured calcium oxide and magnesium oxide by molecular weight conversion to the equivalent weight of calcium hydroxide and magnesium hydroxide. Due to the high impurities in the original lime, silica, aluminum, and iron are added to this weight as their oxides. All weights are then expressed as dry hydrates and not putty as this is considered a more robust and accurate calculation even though the lime was not added in this form. Sand weights are calculated directly from the acid-insoluble residue. Weight percentages are then normalized to 100% to return the values to original dry components. Component volume ratios are given as dry hydrate for the binder and damp, loose sand for the aggregate. Volumetric ratios are calculated assuming bulk densities for dry lime hydrate and damp loose sand of 40 lb./cu. ft. and 80 lb./cu. ft. respectively. Another volume ratio is estimated for the lime as a putty. This assumes that a volume of dry bulk lime will lose approximately 40% of its volume when mixed with water to the consistency of a putty. The sand volume then increases for the same weight of lime. This calculation is considered less accurate due to uncertainties in the density characteristics of the original lime.

Table 5.5: Chemical Analysis Results (Cement-Based Mortars)

SAMPLE ID	**A2**	**A4**	**B2**
Component (wgt. %)			
SiO_2	1.58	4.12	6.46
CaO	2.81	5.64	12.31
MgO	0.61	2.70	4.50
Al_2O_3	0.54	1.17	1.18
Fe_2O_3	0.25	1.23	1.00
Insoluble residue	89.23	75.92	61.26
LOI %, to 110°C (Free water)	0.76	1.42	1.01
LOI %, 110°C-550°C (Combined water)	2.07	2.71	6.06
LOI %, 550°C-950°C (Carbon dioxide)	2.87	5.53	5.13
Measured Totals	**100.72**	**100.45**	**98.91**

Notes:
1) The sample preparation was modified from those outlined in ASTM C 1324 in order to better partition the binder and sand. A hot acid digestion was substituted in order to more fully capture cement components. A base digestion was performed on the insoluble residue in order to dissolve silica gel released from the acid digestion of the natural cement.

Table 5.6: Estimated Original Cement Chemistries (Cement-Based Mortars)

SAMPLE ID	**A2**	**A4**	**B2**
Component (wgt. %)			
SiO_2	25.1	25.5	23.3
CaO	44.7	34.9	44.5
MgO	9.6	16.7	16.3
Al_2O_3	8.6	7.3	4.3
Fe_2O_3	3.9	7.6	3.6
Other	8.0	8.0	8.0
MgO / SiO_2 Ratio	**0.38**	**0.66**	**0.70**
Cementation Index	**1.42**	**1.45**	**1.08**

Notes:
1) As only one binder is suspected in each sample, it was possible to estimate the original cement chemistry from the chemical analysis. The measured values are normalized to 92% assuming that other unmeasured oxides and volatiles represent approximately 8% of the total for a typical natural cement. Note that there is a possibility of a lime addition in Sample A2 in which case the reported chemistry is actually a combination of the two components. Hydraulicity index is calculated by dividing the sum of silica and alumina by the measured calcium. Cementation index is calculated by dividing the "hydraulic elements" by the "lime elements" after multiplying each by coefficients normalizing them to their molecular rather than weight contribution.

Table 5.7: Calculated Components (Cement-Based Mortars)

SAMPLE ID	**A2**	**A4**	**B2**
Component			
Portland cement (wgt. %)	Not detected	Not detected	Not detected
Natural cement (wgt. %)	7	18	31
Lime expressed as dry hydrate (wgt. %)	Not detected	Not detected	Not detected
Pozzolans (wgt. %)	Not detected	Not detected	Not detected
Pigment (wgt. %)	Not detected	Not detected	Not detected
Sand (wgt. %)	93	82	69
Binder : sand ratio (by volume)	1 : 13	1 : 4.4	1 : 2.1

Notes:
1) Natural cement is calculated assuming that all five measured oxides belong to this component. Sand is calculated directly from the acid insoluble residue. Note that the reported sand for Sample A2 includes all clay and silt representing the earthen component of the mortar. Weight percentages are then normalized to 100%. Volumetric ratios are calculated assuming bulk weights for natural cement and sand of 75 lb./cu. ft. and 80 lb./cu. ft. respectively. The sand and clay density may be underestimated for Sample A2.

Appendix I: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic reflected light microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The overlays presented in the photomicrographs (e.g., text, scale bars, and arrows) are prepared as layers in Adobe Photoshop and converted to the jpeg format. Digital processing is limited to those functions normally performed during standard print photography processing. Photographs intended to be visually compared are taken under the same exposure conditions whenever possible.

The following abbreviations may be found in the figure captions and overlays and these are defined as follows:

cm	centimeters	PPL	Plane polarized light
mm	millimeters	XPL	Crossed polarized light
µm	microns (1 micron = 1/1000 millimeter)		
mil	1/1000 inch		

Microscopical images are often confusing and non-intuitive to those not accustomed to the techniques employed. The following is offered as a brief explanation of the various views encountered in order that the reader may gain a better appreciation of what is being described.

Reflected light images: These are simply magnified images of the surface as would be observed by the human eye. A variety of surface preparations may be employed including polished and fractured surfaces. The reader should note the included scale bars as minor deficiencies may seem much more significant when magnified.

Plane polarized light images (PPL): This imaging technique is most often employed in order to discern textural relationships and microstructure. To employ this technique, samples are milled (anywhere from 20 to 30 microns depending on the purpose) so as to allow light to be transmitted through the material. In many cases, TLI also employs a technique whereby the material is impregnated with a low viscosity, blue-dyed epoxy. Anything appearing blue therefore represents some type of void space (e.g.; air voids, capillary pores, open cracks, etc.) Hydrated cement paste typically appears a light shade of brown in this view (with a blue hue when impregnated with the epoxy). With some exceptions, most aggregate materials are very light colored if not altogether white. Some particles will appear to stand out in higher relief than others. This is a function of the refractive power of different materials with respect to the mounting epoxy.

Crossed polarized light images (XPL): This imaging technique is most often employed to distinguish components or highlight textural relationships between certain components not easily distinguished in plane polarized light. Using the same thin sections, this technique places the sample between two pieces of polarizing film in order to determine the crystal structure of the materials under consideration. Isotropic materials (e.g.; hydrated cement paste, pozzolans and other glasses, many oxides, etc.) will not transmit light under crossed polars and therefore appear black. Non-isotropic crystals (e.g.; residual cement, calcium hydroxide, calcium carbonate, and most aggregate minerals) will appear colored. The colors are a function of the thickness, crystal structure, and orientation of the mineral. Many minerals will exhibit a range of colors due to their orientation in the section. For example, quartz sand in the aggregate will appear black to white and every shade of gray in between. Color difference does not necessarily indicate a material difference. When no other prompt is given in the figure caption, the reader should appeal to general shapes and morphological characteristics when considering the components being illustrated.

Chemical treatments: Many chemical techniques (etches and stains typically) are used to isolate and enhance a variety of materials and structures. These techniques will often produce strongly colored images that distinguish components or chemical conditions.

Figure 1: Sample A1 as received by Highbridge for analysis. The sample is identified as "City Hall Archaeological Site: Rubble Wall".

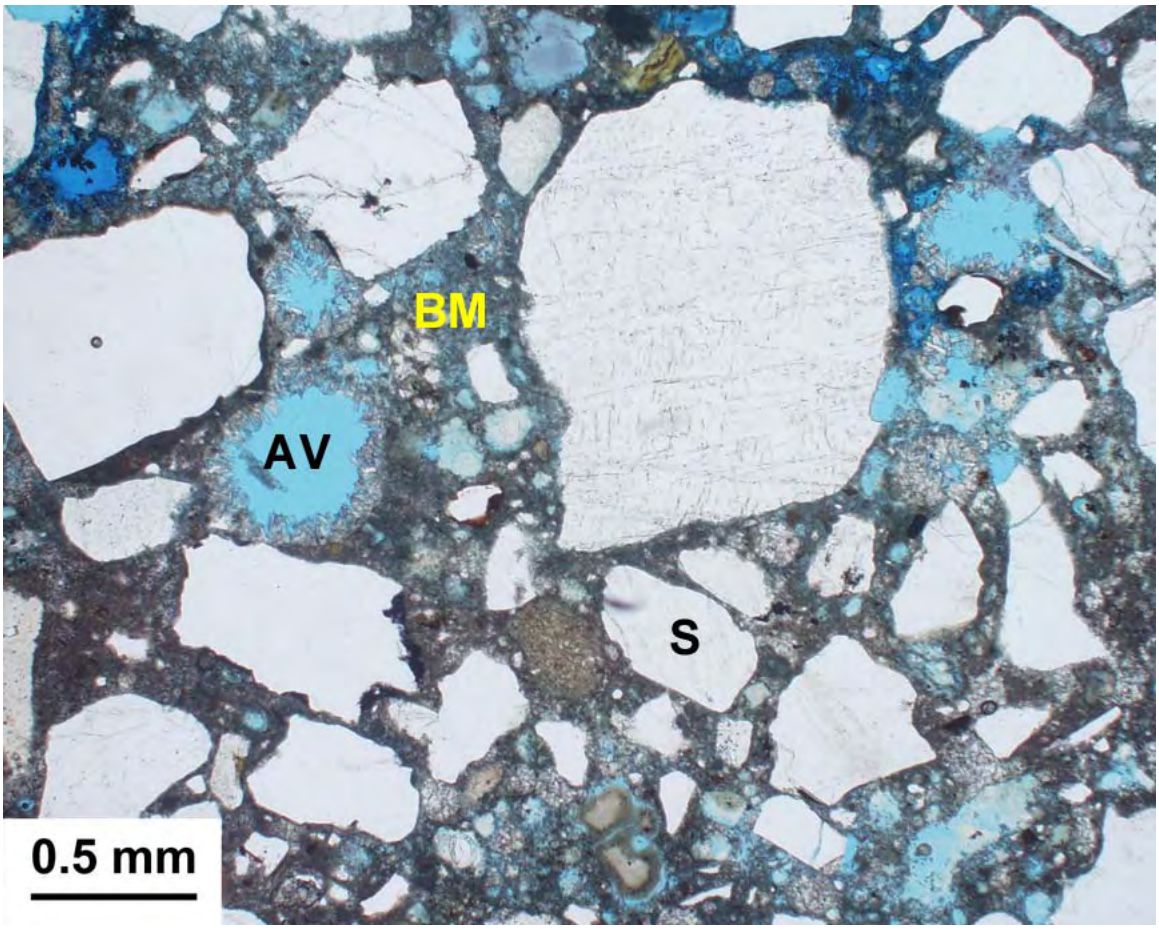


Figure 2: PPL photomicrograph illustrating the overall microtexture of Sample A1. The binder matrix (BM) has a variable capillary porosity as indicated by the absorption of blue-dyed epoxy used in the sample preparation. Generally, the porosity is high though recrystallization of calcium carbonate has reduced the porosity in some areas. The sand (S) is well graded and adequately coated with binder. The aggregate is moderately abundant. The mortar is relatively well consolidated and air-voids (AV) are not excessive.

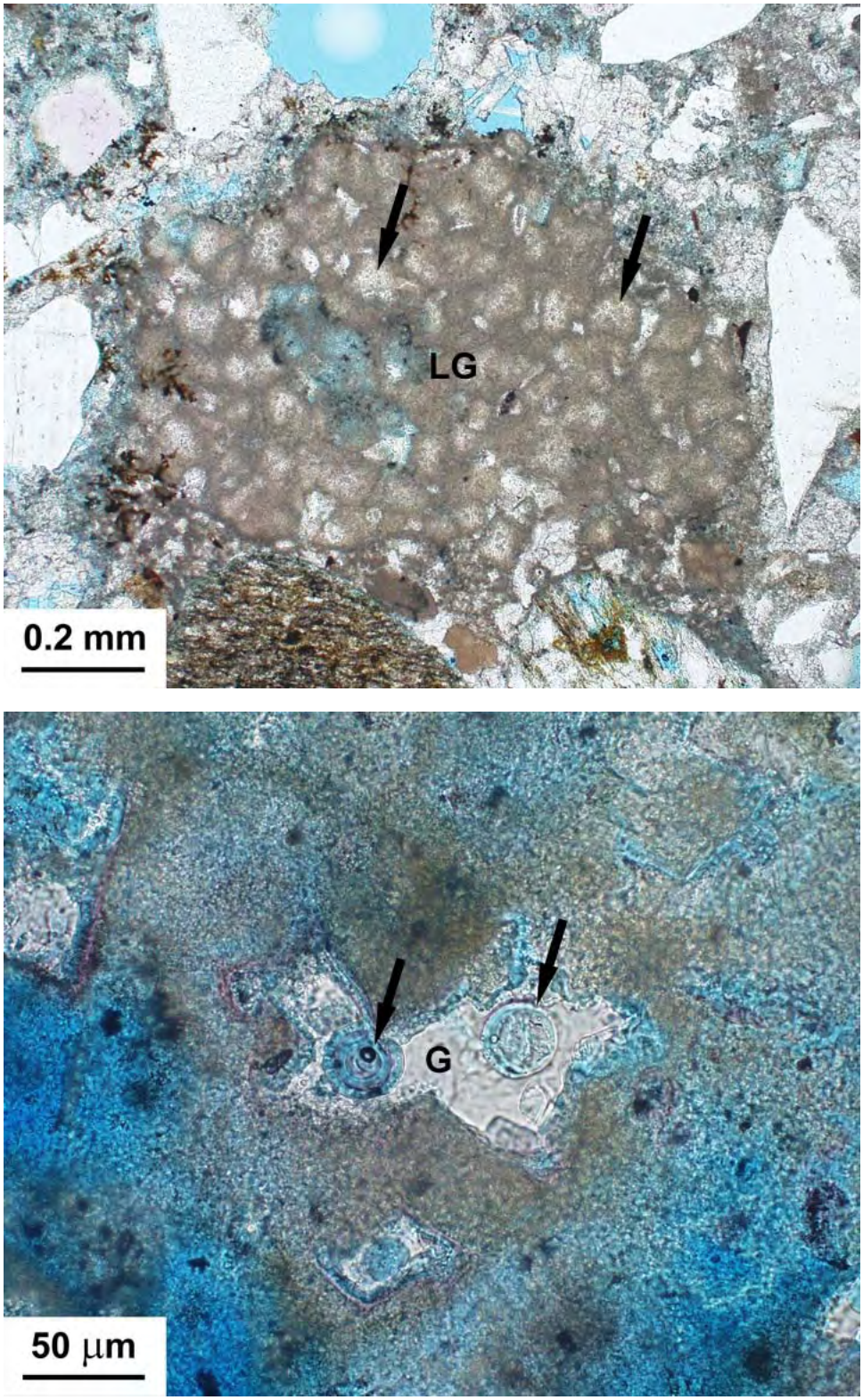


Figure 3: PPL photomicrographs illustrating some properties of the lime binder in Sample A1. (Top) Most grains exhibit textures as in the lime grain depicted (LG). The arrows illustrate "ghosts" of original carbonate crystals as they were found in the source rock. The texture is sucrosic or "sugary". The size of these original sugary crystals is typical in marble. (Bottom) Impurities are present and some of these overburned. A glassy area (G) is shown within a lime grain. The arrows show small vesicles or air bubbles formed from gases escaping during the fusing of the glass in the kiln. The glass represents some overburned silicate material and in this case not considered hydraulic.

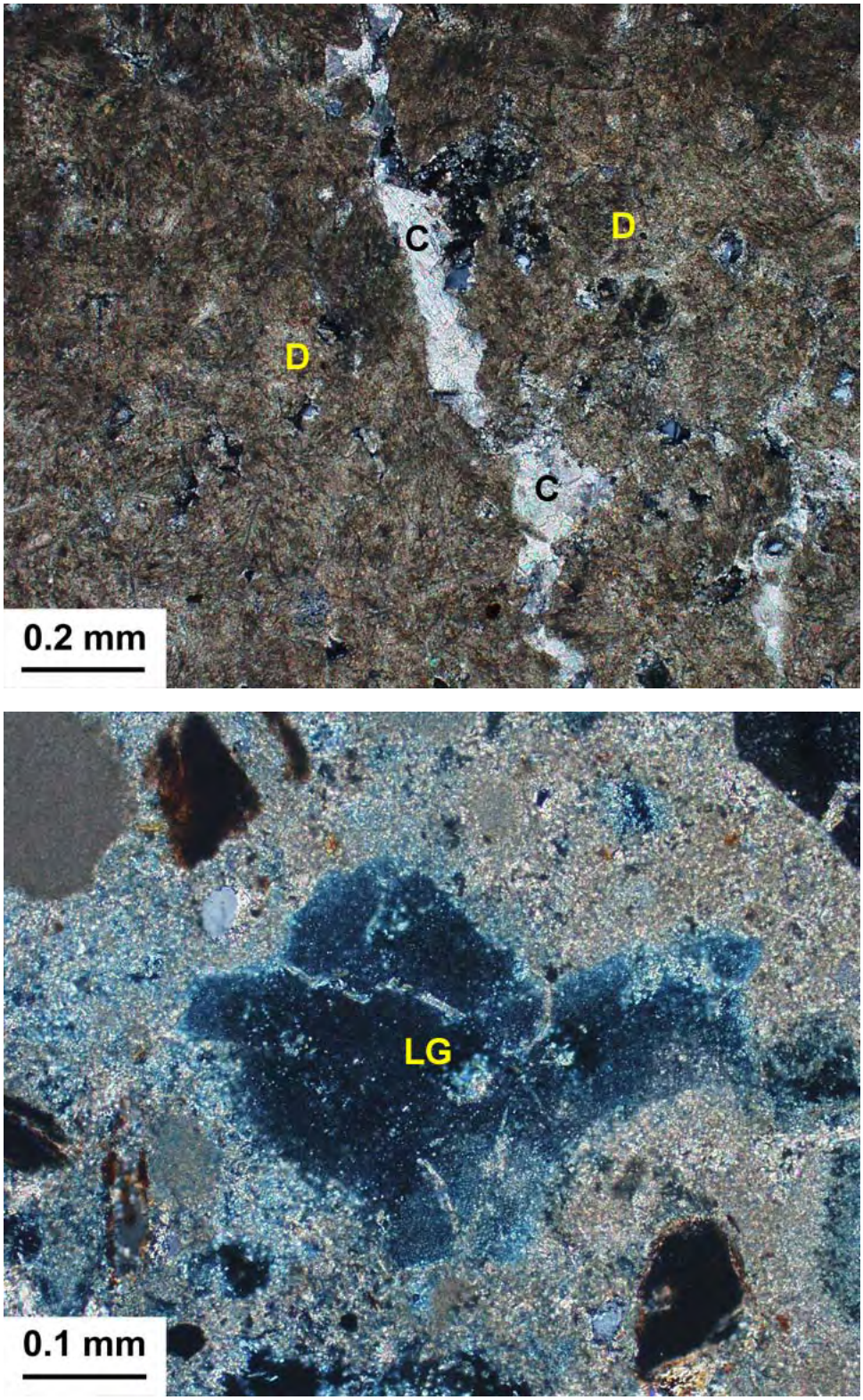


Figure 4: XPL photomicrographs illustrating additional properties of the lime binder in Sample A1. These images show grains with a higher dolomitic content though these are not the norm. (Top) This image illustrates a lime grain that is approximately one centimeter in diameter. The particle is underburned and most of the matrix is composed of weakly fired dolomite (D). An original calcite vein (C) is completely unburned as calcite has a higher calcining temperature than dolomite. (Bottom) Note the more gray color of this lime grain under crossed polars (LG). The colors indicate that the grain is uncarbonated. Dolomitic lime carbonates more slowly than high calcian limes. Nevertheless, Sample A1 has the lowest dolomite content of the three examined lime mortars.

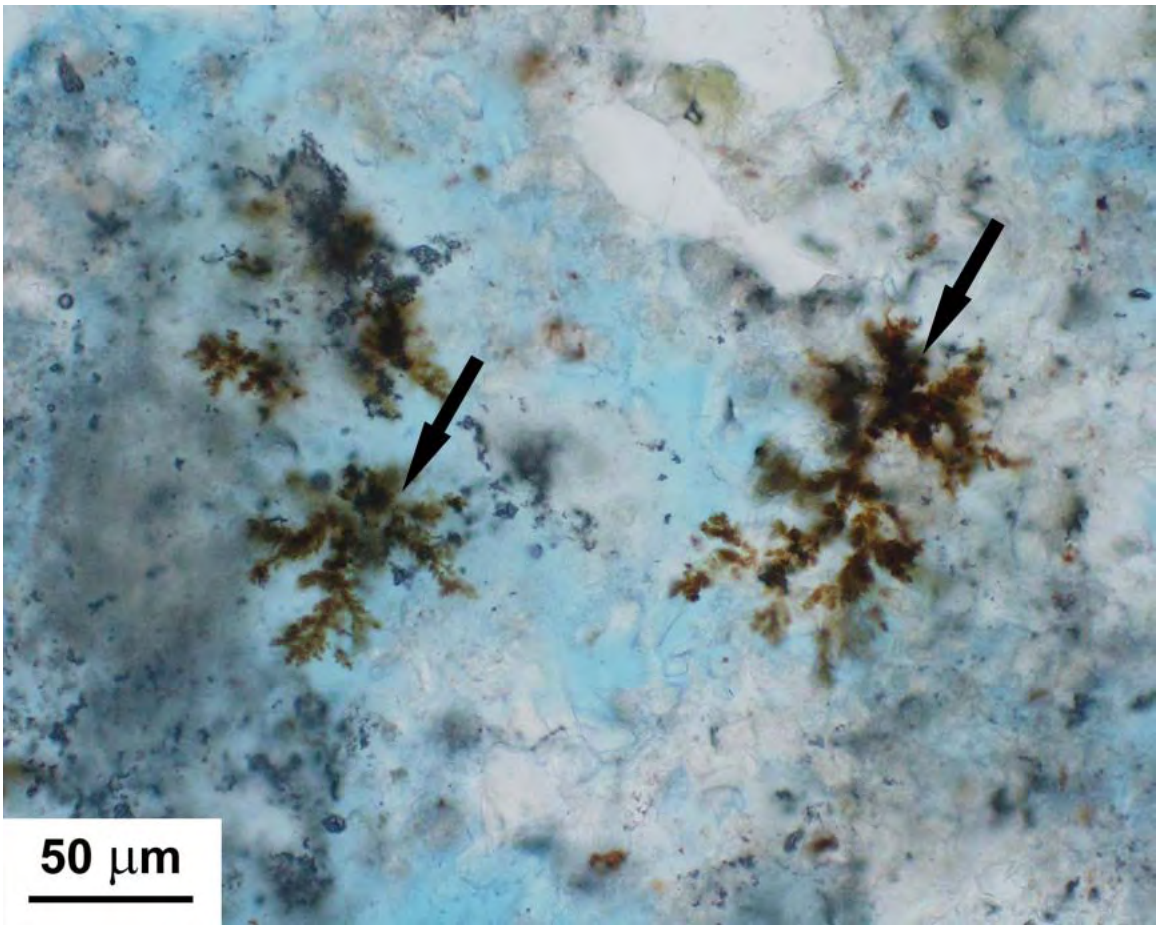


Figure 5: PPL photomicrograph of Sample A1 taken under conoscopic illumination. The illumination methods causes the image to appear blurry but this is a trade off to bring finer materials into better view. The arrows indicate very fine-grained dendritic crystals that are believed to be iron-bearing. These may relate to leaching of iron from the aggregate and may be responsible for the weak pinkish pigmentation of the mortar. No other pigmenting sources are identified in Sample A1.

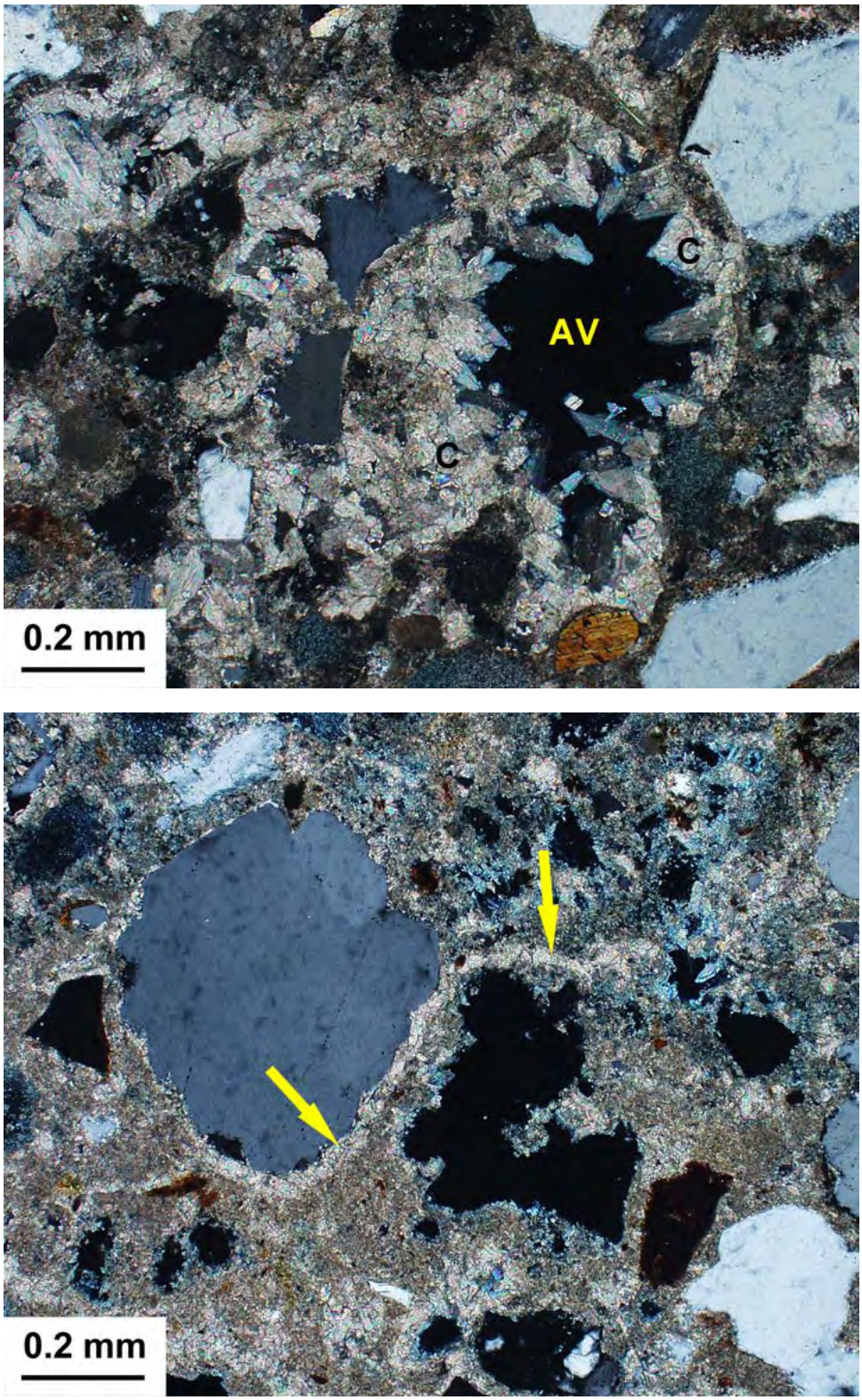


Figure 6: XPL photomicrographs of Sample A1. There is evidence for significant moisture movement and recrystallization in this sample. (Top) Carbonate deposits (C) are common in air-voids (AV). (Bottom) Carbonate has also crystallized within original shrinkage cracks (arrows) in a process called autogenous healing.

Figure 7: Sample A2 as received by Highbridge for analysis. The sample is identified as "City Hall Archaeological Site: Brick Feature Mid-Wall".

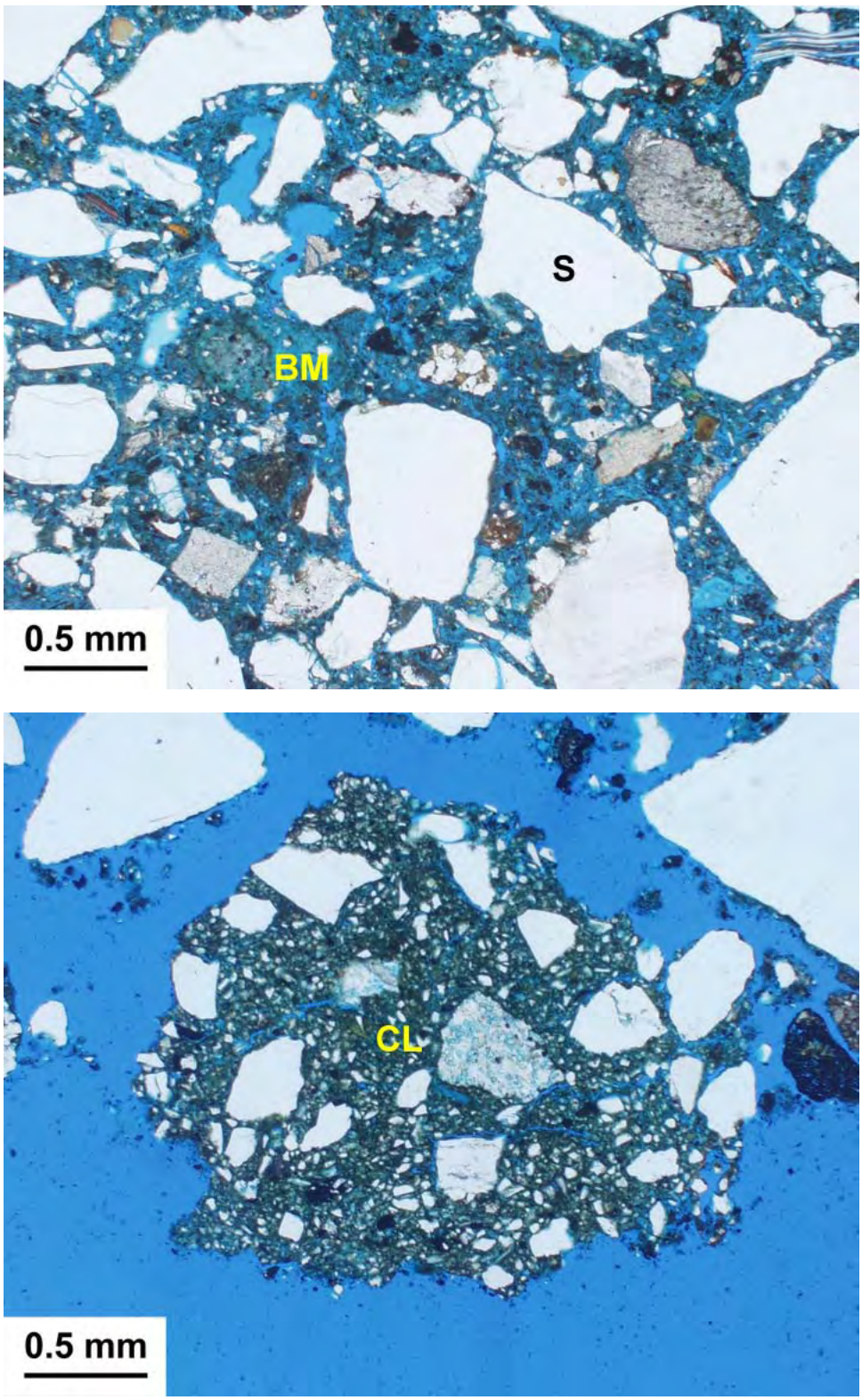


Figure 8: PPL photomicrographs illustrating the overall microtexture of Sample A2. (Top) The binder matrix (BM) has a high porosity as indicated by the high absorption of blue-dyed epoxy used in the sample preparation. The matrix is composed mostly of silty clay. Sand grains (S) are also distributed throughout the matrix and may have been part of the original clay source and not necessarily a separate addition. (Bottom) A silty clay lump (CL) is shown. These are not abundant and the clay is well dispersed. Nevertheless, these few grains are probably indicative of the original clay source before other additions.

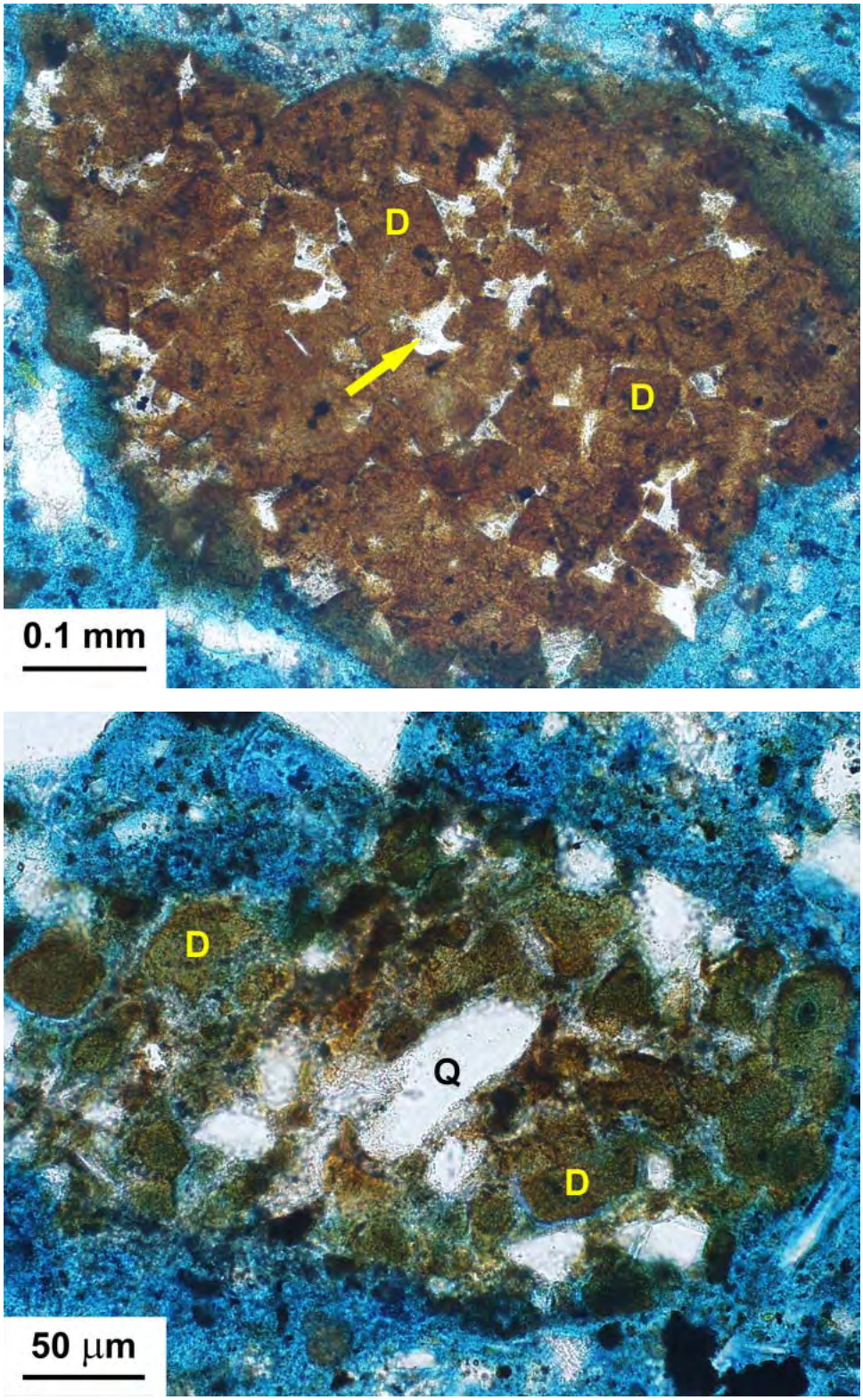


Figure 9: PPL photomicrographs illustrating properties of the cement in Sample A2 added as a stabilizer to the earthen mortar. (Top) A natural cement grain typical of those from Rosendale, NY is shown. Common features include calcined dolomite grains (D) containing abundant iron-bearing product. Interspersed throughout the cement matrix are grains of partly combined quartz silt (arrows). This type of cement grain is not particularly common in the sample. (Bottom) There is a high degree of variation in the cement textures. A residual grain is shown here where calcined dolomite grains (D) are less sharply defined and contain less iron product. Quartz silt (Q) is coarser grained and less equidimensional in shape. These are not common features in either Rosendale or Louisville cements.

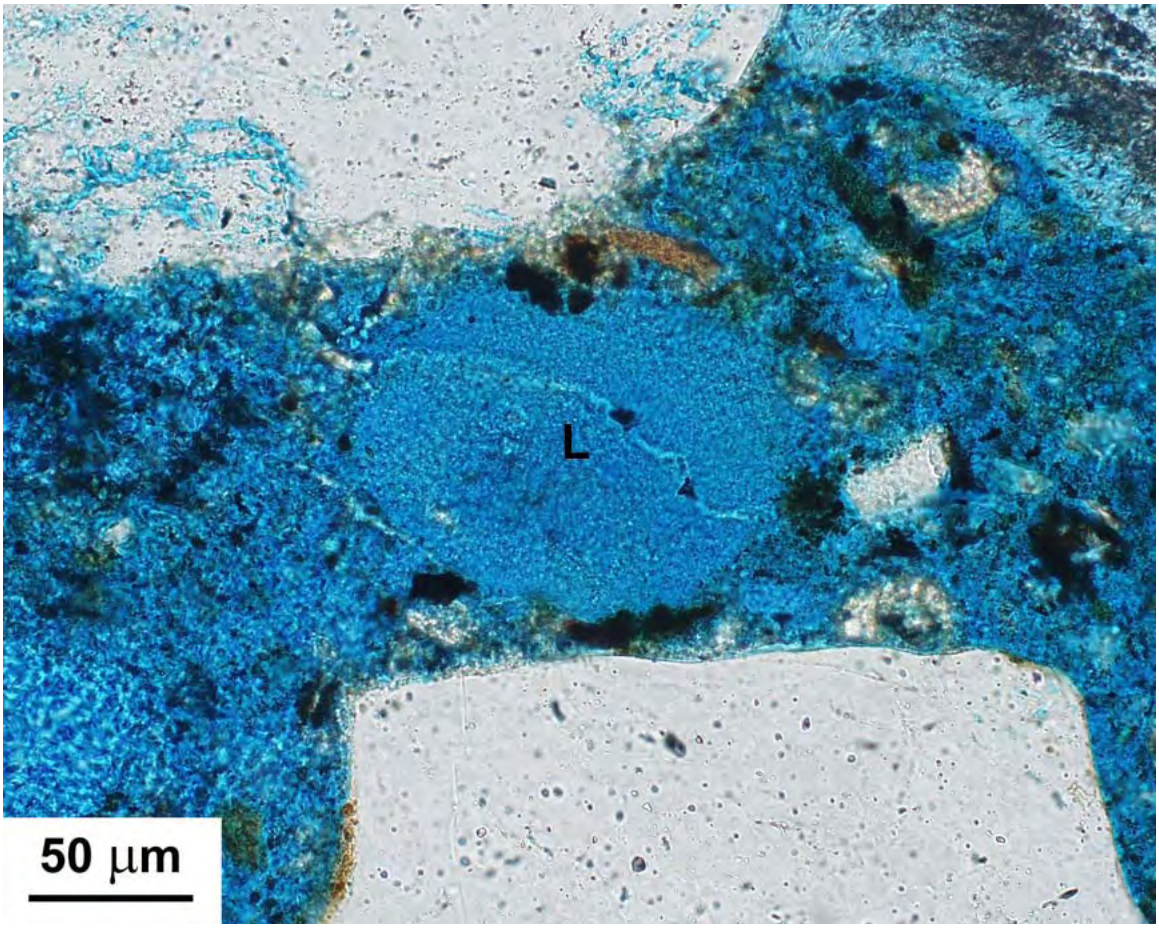


Figure 10: PPL photomicrograph of sample A2. Trace "limier" areas are also found (L). These could represent a minor lime addition. However, it is also possible these simply represent more calcium-rich areas of the natural cement.

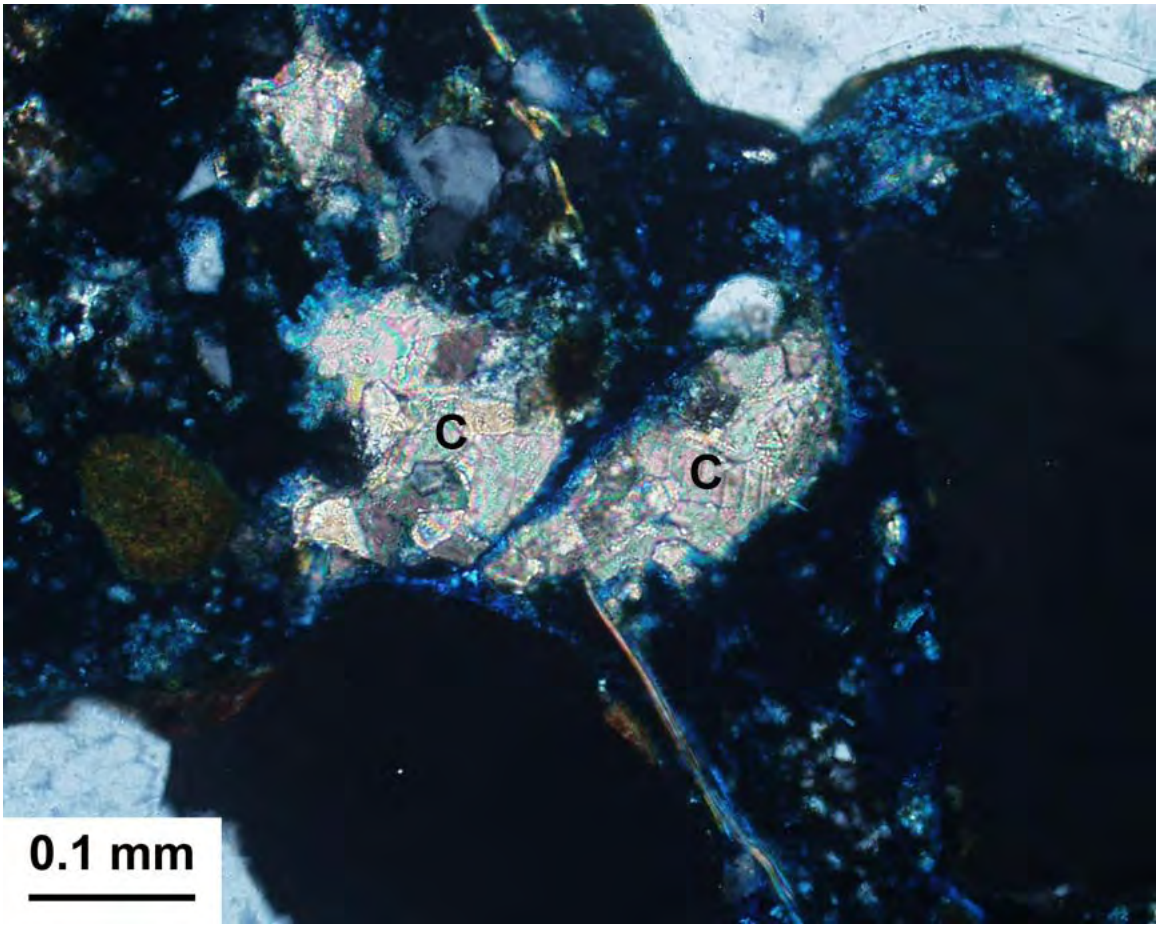


Figure 11: XPL photomicrograph of Sample A2. Minor carbonate deposits are found in air-voids (C). These are not particularly abundant in this sample.

Figure 12: Sample A3 as received by Highbridge for analysis. The sample is identified as "City Hall Archaeological Site: Cistern".

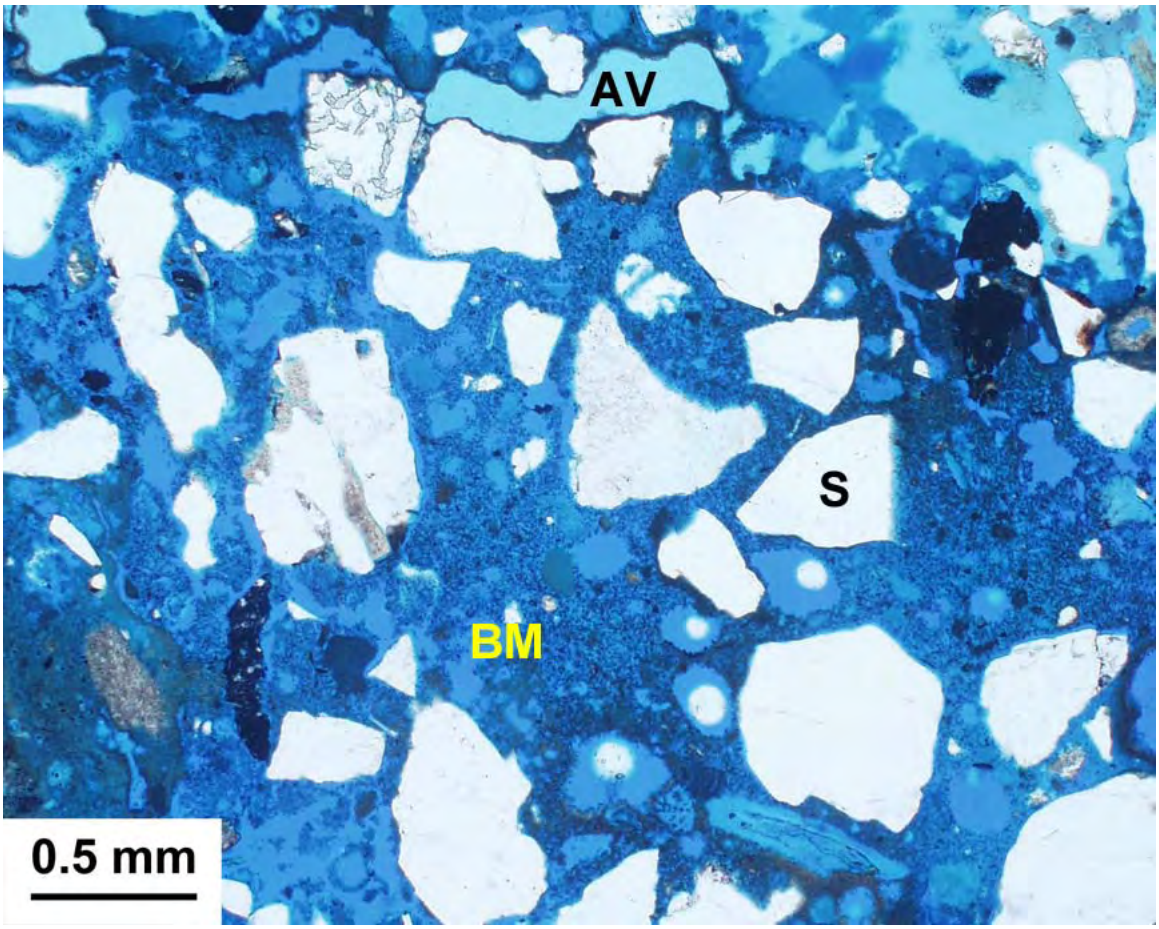


Figure 13: PPL photomicrograph illustrating the overall microtexture of Sample A3. The binder matrix (BM) has a high capillary porosity as indicated by the strong absorption of blue-dyed epoxy used in the sample preparation. The porosity is typical of a high lime mortar. The sand (S) is well graded and adequately coated with binder. The aggregate content is quite low as shown by the wide spacing between individual sand grains. The mortar is relatively well consolidated and air-voids (AV) are not excessive.

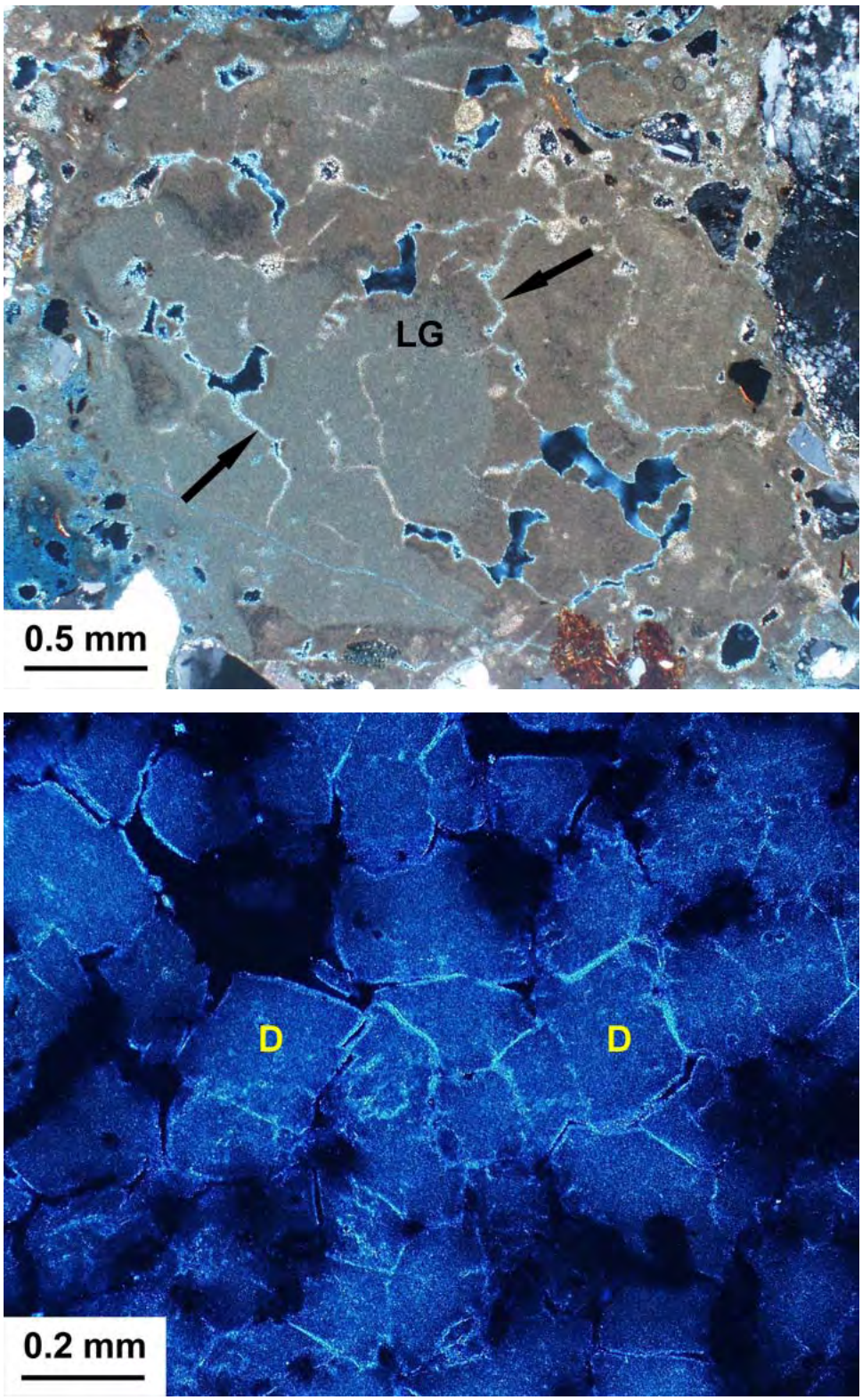


Figure 14: XPL photomicrographs illustrating some properties of the lime binder in Sample A3. (Top) A lime grain is shown (LG) containing fine polygonal cracks (arrows). As with Sample A1, these features represent relicts from the original source rock. These indicate a relatively coarse-grained "sugary" crystal texture characteristic of marble. This particular grain is fully carbonated. (Bottom) The grain shown here more clearly exhibits the rhombic shapes of the original dolomite (D). The bluish gray colors under crossed polars indicate the grain has remained uncarbonated.

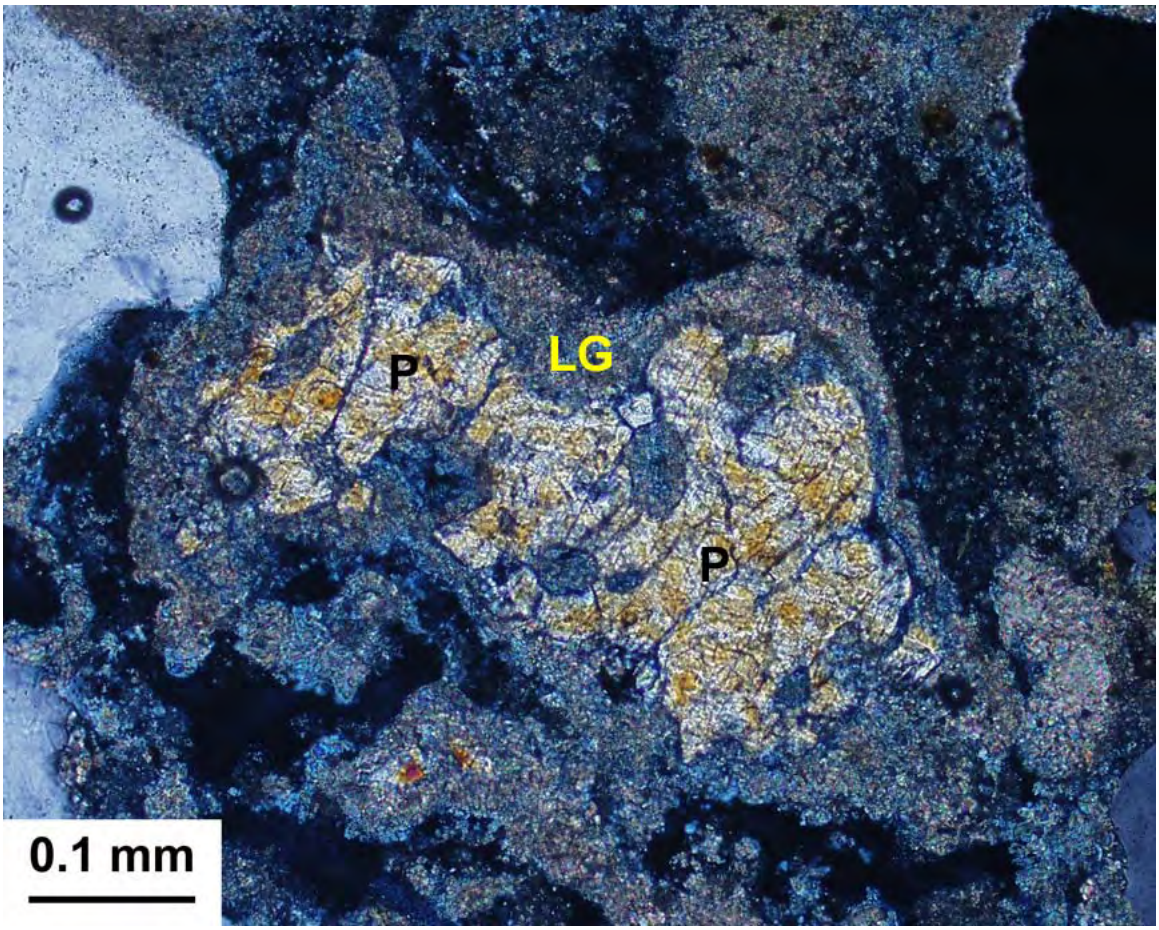


Figure 15: XPL photomicrograph of another lime grain (LG) in Sample A3. A partially burned crystal of pyroxene (P) is contained within the core of the lime particle. Pyroxene is a silicate mineral common in marble but not in limestone. The lime is clearly burned from a dolomitic marble and the local Inwood Marble is the most likely source.

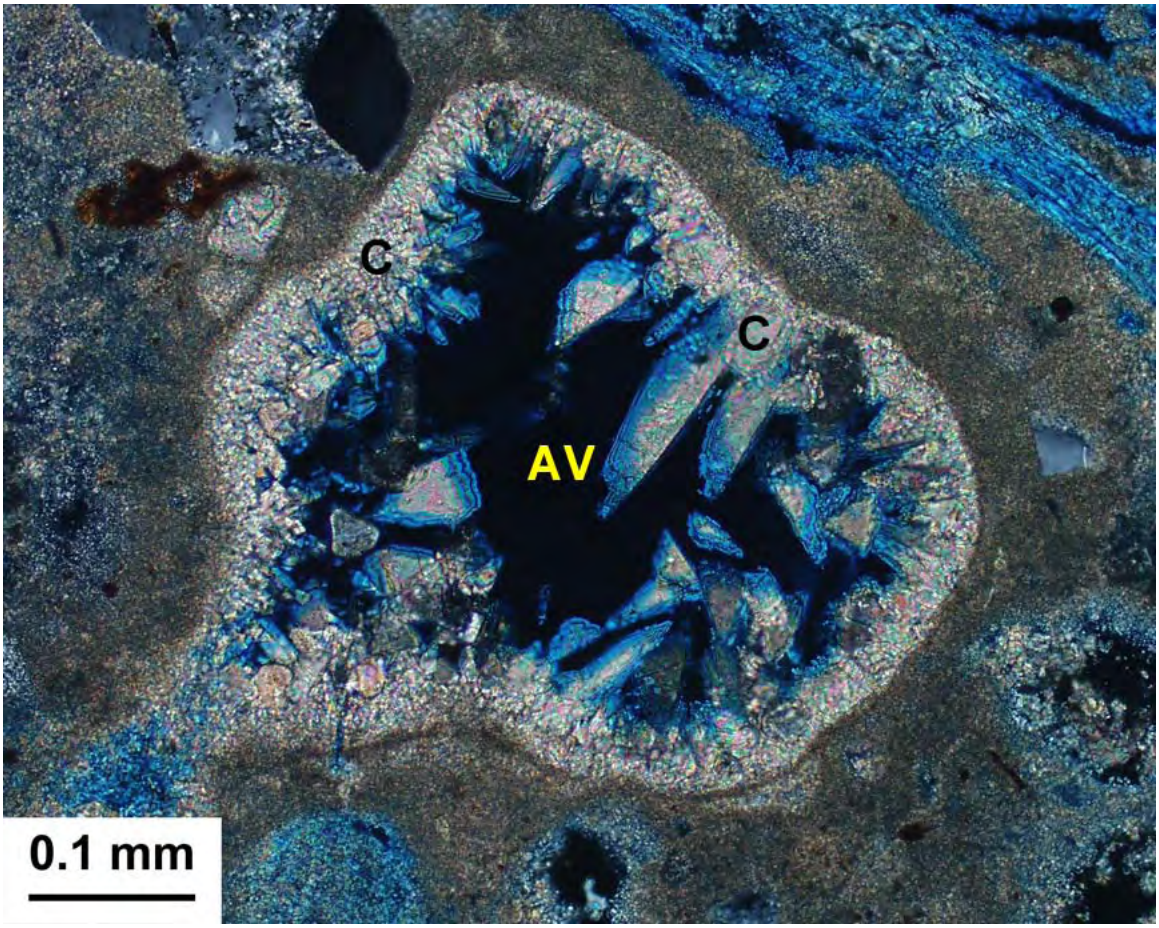


Figure 16: XPL photomicrograph of Sample A3. Minor carbonate deposits (C) are found in air-voids (AV). These are not particularly abundant in this sample.

Figure 17: Sample A4 as received by Highbridge for analysis. The sample is identified as "City Hall Archaeological Site: Brick Feature Adjacent to Cistern".

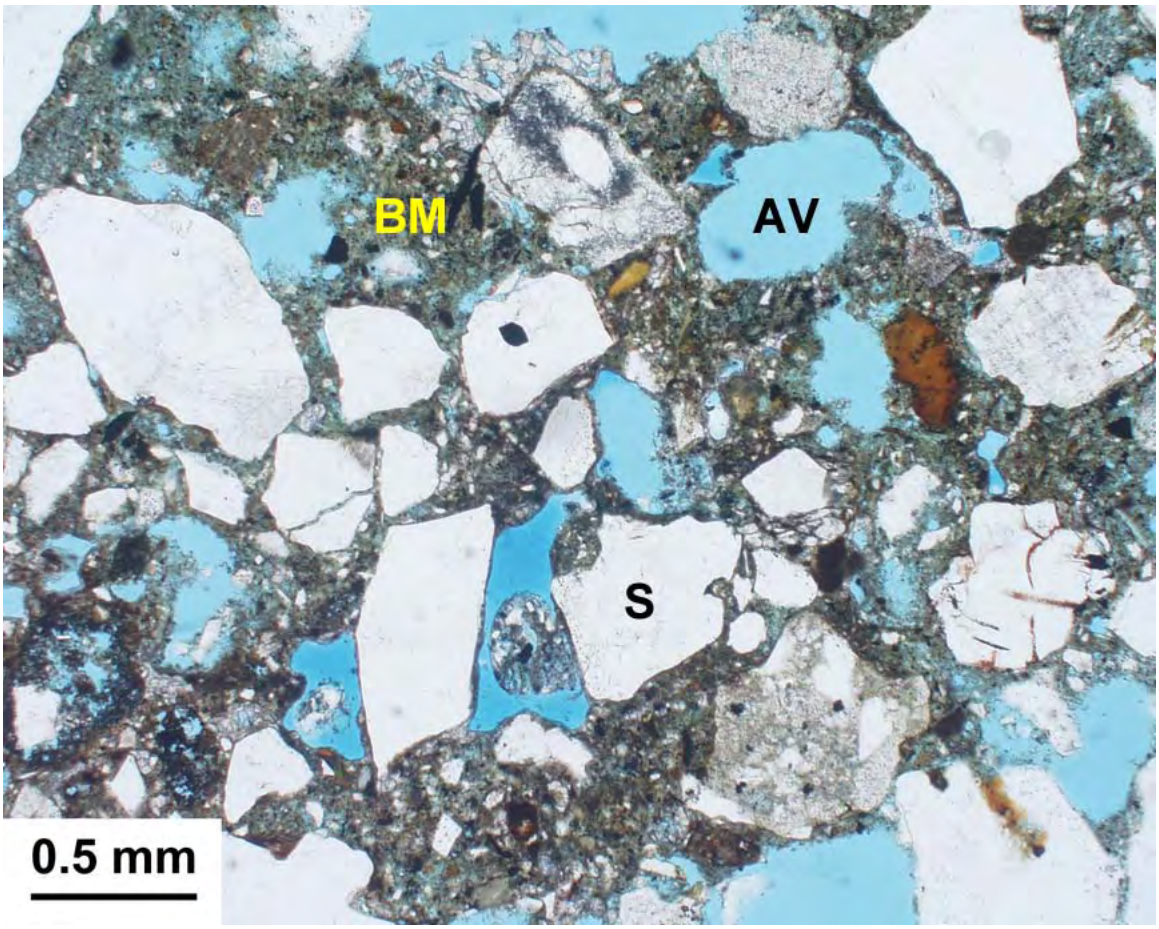


Figure 18: PPL photomicrograph illustrating the overall microtexture of Sample A4. The binder matrix (BM) has a moderate capillary porosity as indicated by the absorption of blue-dyed epoxy used in the sample preparation. The brown colored matrix is composed of cementitious hydrates. Sand grains (S) are densely distributed throughout the matrix and are mostly well coated with binder. The mortar is considered quite oversanded for a typical historical natural cement mortar. Air-voids (AV) are abundant.

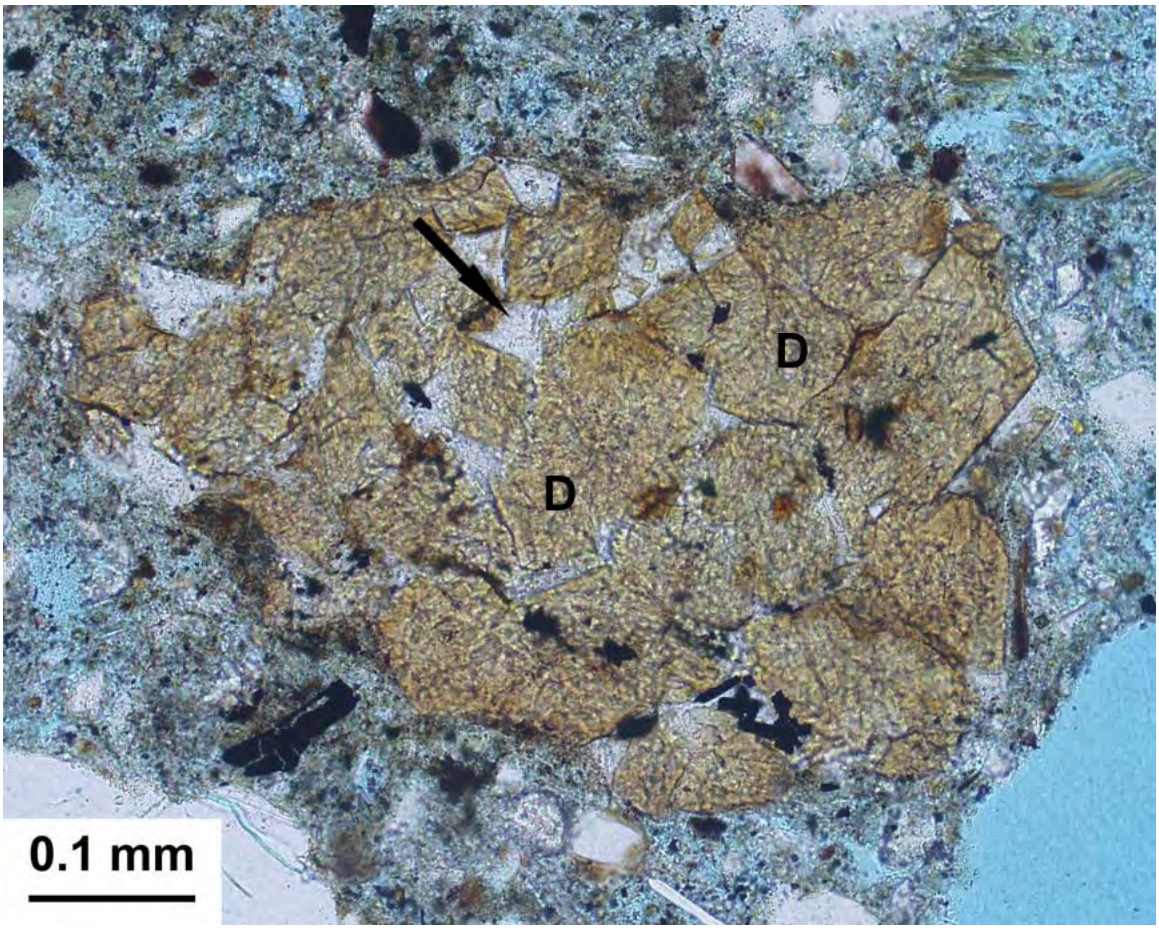


Figure 19: PPL photomicrograph illustrating properties of the cement in Sample A4. A natural cement grain with features typical of those from Rosendale, NY is shown. Common features include calcined dolomite grains (D) containing abundant iron-bearing product. Interspersed throughout the cement matrix are grains of partly combined quartz silt (arrows). This type of residual grain is relatively common within the mortar matrix.

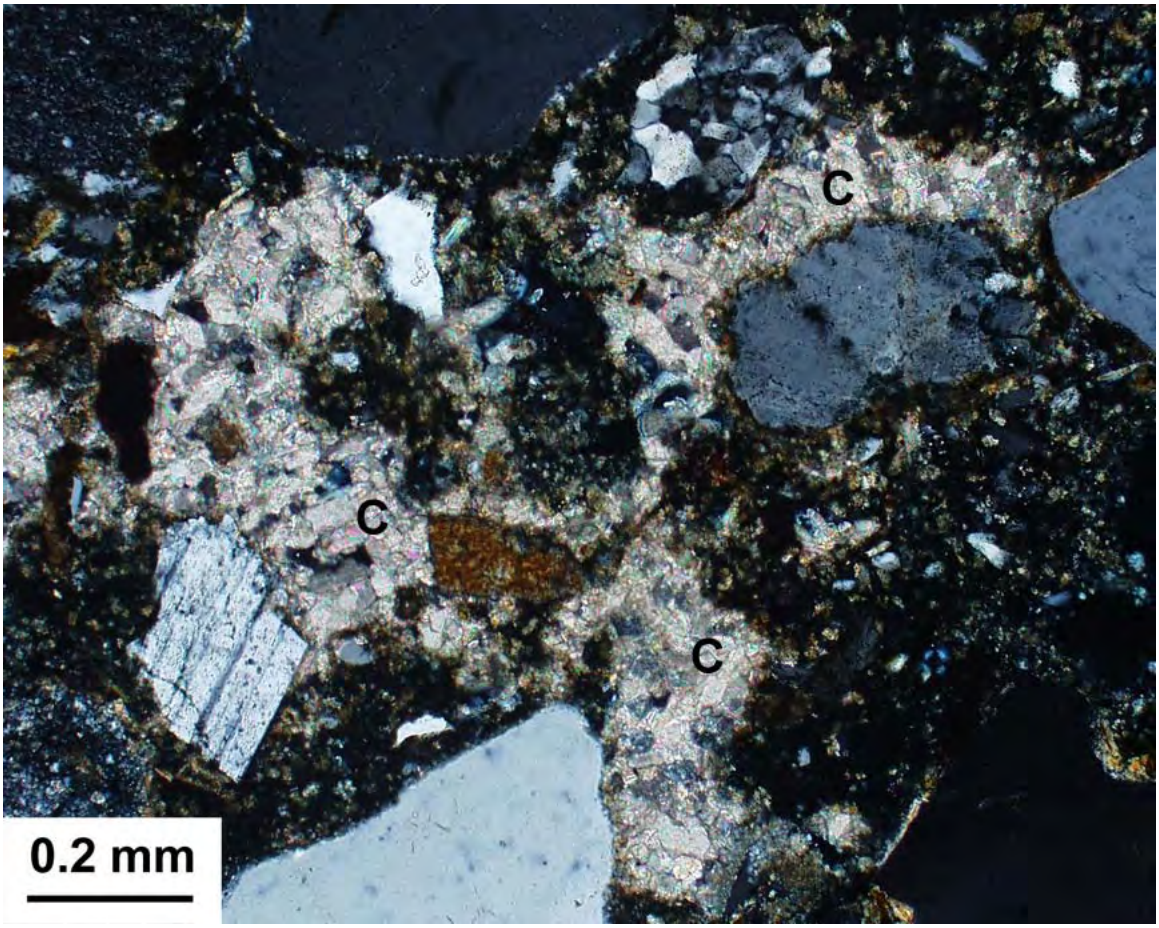


Figure 20: XPL photomicrograph of Sample A4. There is evidence for moderate moisture movement and recrystallization in this sample. Carbonate deposits (C) are common in air-voids and these are the result of calcium leaching from the cementitious binder.

Figure 21: Sample B1 as received by Highbridge for analysis. The sample is identified as "City Hall Basement: Rubble Wall".

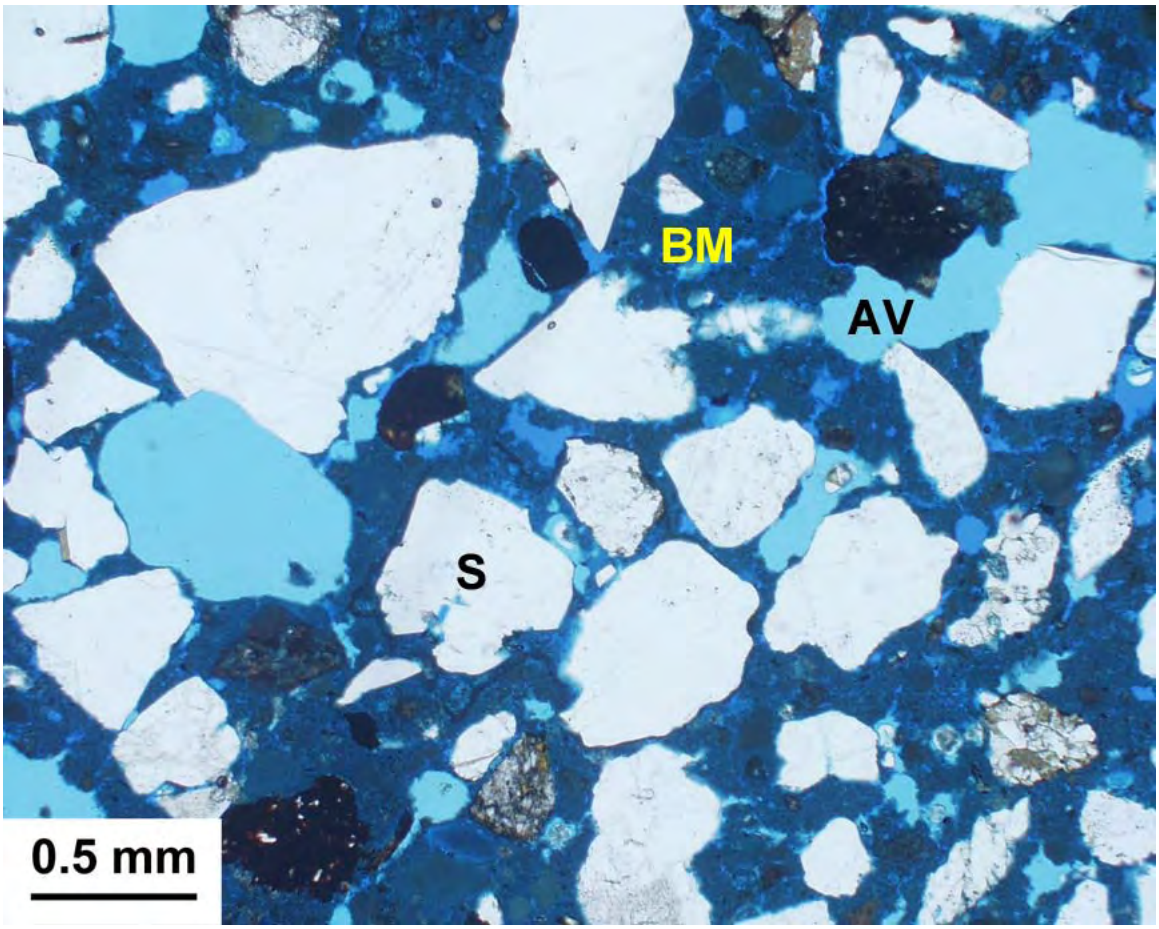


Figure 22: PPL photomicrograph illustrating the overall microtexture of Sample B1. The binder matrix (BM) has a high capillary porosity as indicated by the strong absorption of blue-dyed epoxy used in the sample preparation. The porosity is typical of a high lime mortar. The sand (S) is narrowly graded and adequately coated with binder. Note the rather limited size range of the sand grains. The aggregate content is quite low as shown by the wide spacing between individual grains. The mortar is relatively well consolidated and air-voids (AV) are not excessive.

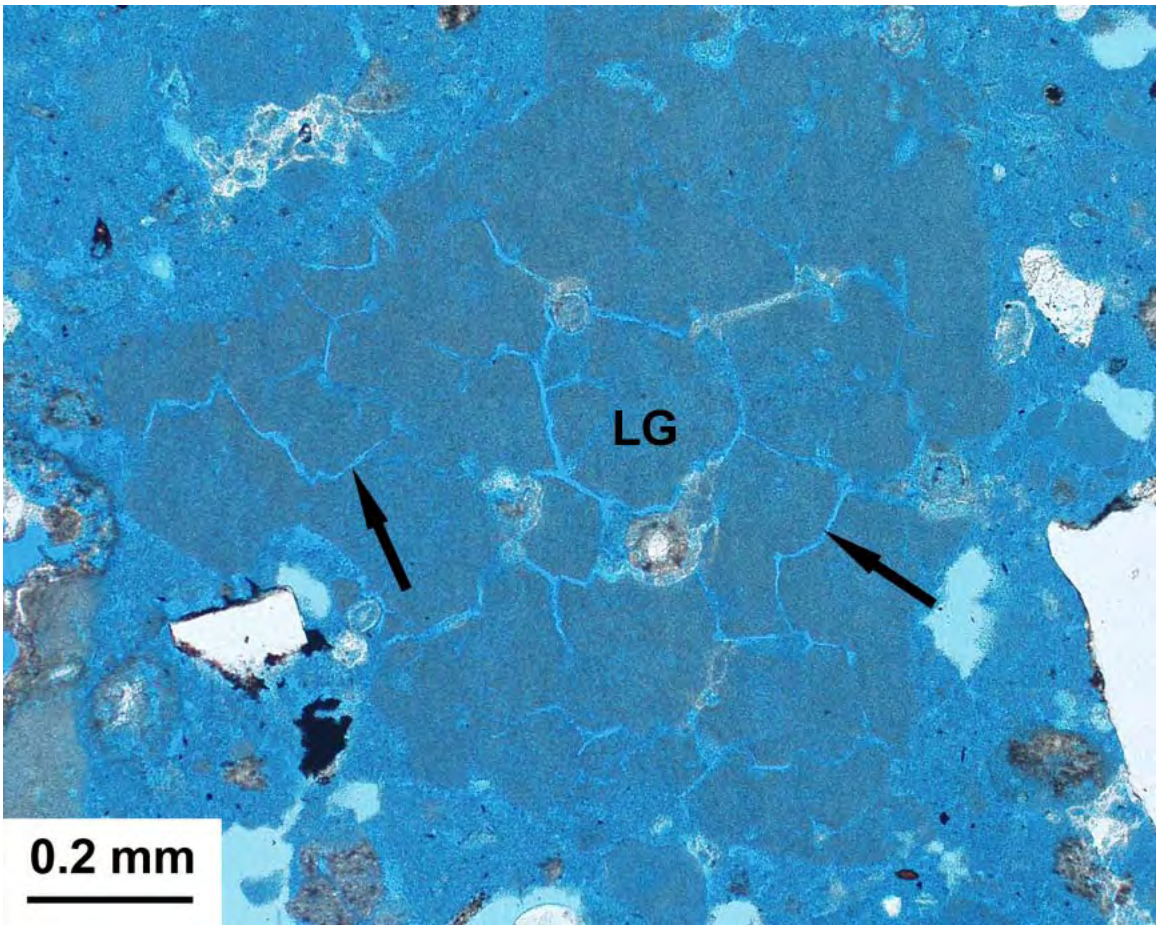


Figure 23: PPL photomicrograph illustrating some properties of the lime binder in Sample B1. A lime grain is shown (LG) containing fine polygonal cracks (arrows). As with the other lime mortars, these features represent relicts from the original source rock. These indicate a relatively fine-grained "sugary" crystal texture. The grain size shown here is on the larger end of the range for this sample. The size range could represent either a marble or a dolomitic limestone. This particular grain is fully carbonated.

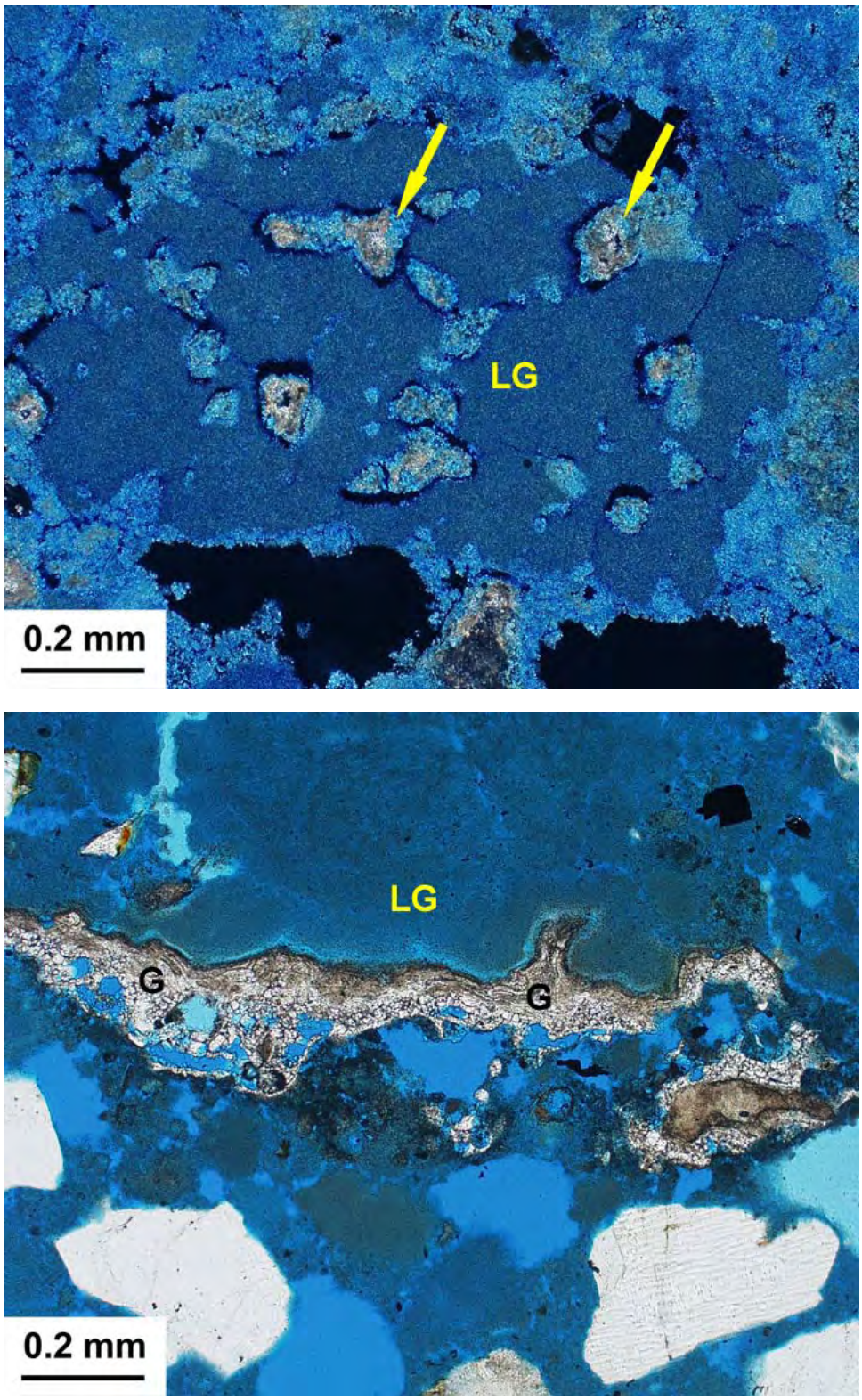


Figure 24: Photomicrographs illustrating other lime textures in Sample B1. (Top) XPL image of a lime grain (LG). The arrows indicate fine "spots" representing quartz in the original rock that has combined during calcination. The combination has resulted in a feeble hydraulicity. This particular grain is dolomitic and remains uncarbonated. (Bottom) PPL image of a glass inclusion (G) in another lime grain (LG). The glass likely represents some overburning of siliceous or aluminous impurities in the original lime source. These features still do not help distinguish the lime source as they could represent silicates from either a marble or a dolomitic limestone.

Figure 25: Sample B2 as received by Highbridge for analysis. The sample is identified as "City Hall Basement: Probe Adjacent to Federal Measure".

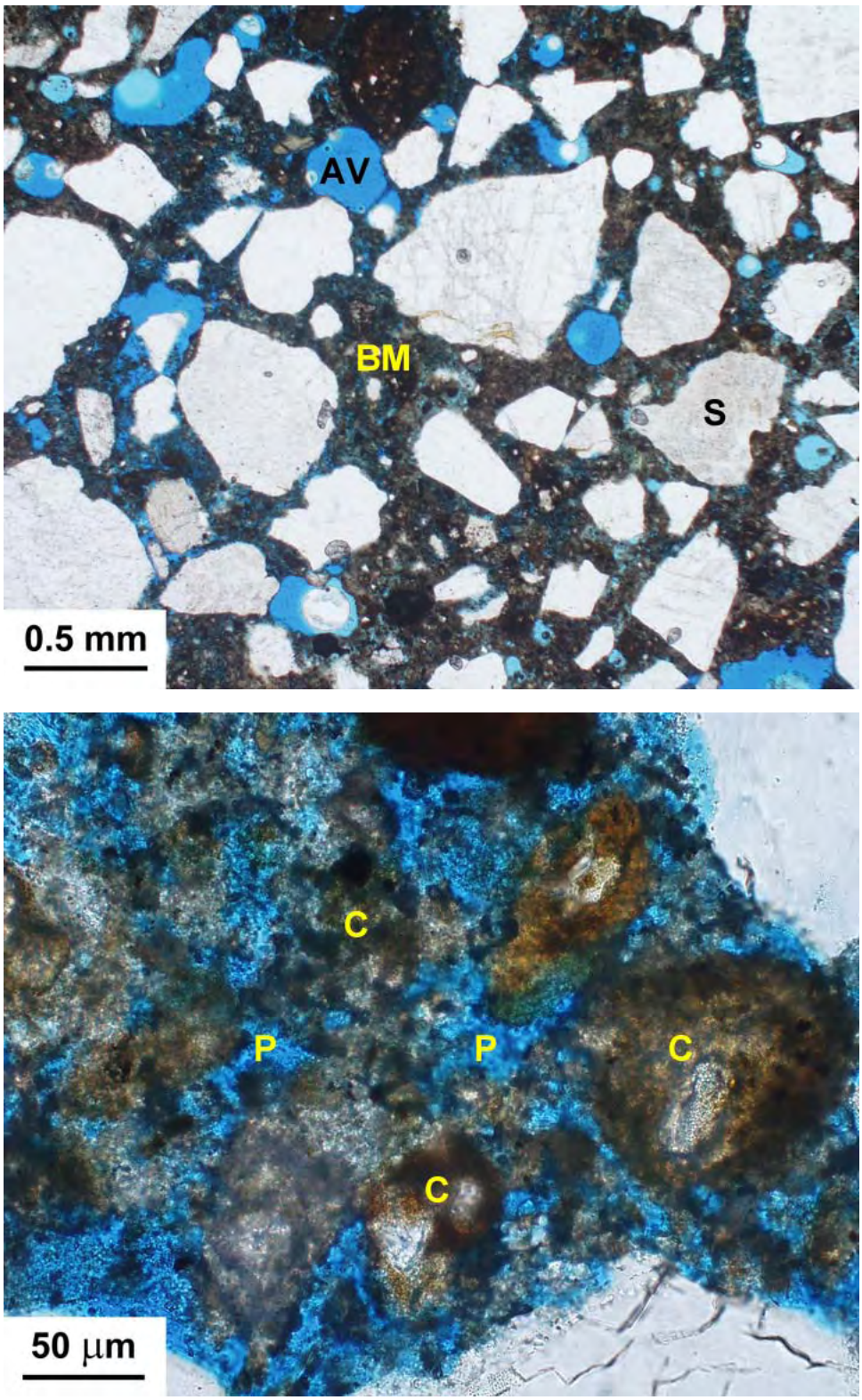


Figure 26: PPL photomicrographs illustrating the overall microtexture of Sample B2. (Top) The binder matrix (BM) has a moderate capillary porosity as indicated by the absorption of blue-dyed epoxy used in the sample preparation. The brown colored matrix is composed of cementitious hydrates. Sand grains (S) are evenly distributed throughout the matrix and are well coated with binder. Air-voids (AV) are not excessive. (Bottom) The pores in the matrix (P) are the result of closely spaced cement grains (C). This granular texture is indicative of a low original water content.

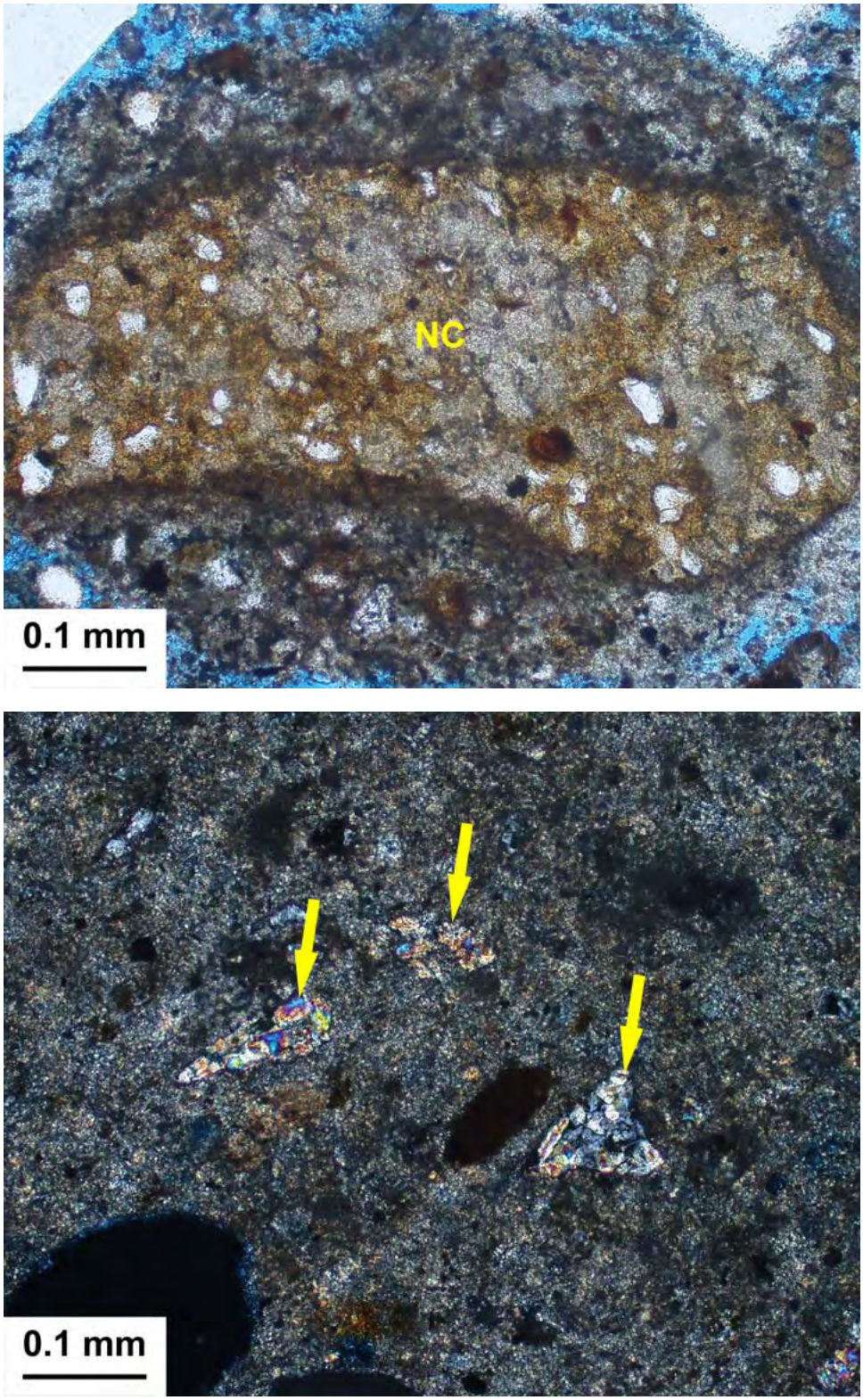


Figure 27: Photomicrographs illustrating properties of the cement in Sample B2. (Top) PPL image. A natural cement grain (NC) with features typical of those from Rosendale, NY is shown. Common features include calcined dolomite grains containing abundant iron-bearing product. Interspersed throughout the cement matrix are grains of partly combined quartz silt. This type of residual grain is very common within the mortar matrix. (Bottom) XPL image. A small cement clot is identified petrographically. The clot includes clinkered cement residuals (arrows). These contain a variety of mineralogies including inert aluminates. The grains are not consistent with a portland cement and likely represent trace amounts of overburned natural cement.

City Hall Park
2010-2011 Excavation Report

Appendix P:

Rockmore Construction Award

Chrysalis Archaeological Consultants
Cultural Resource Specialists

To: Anne-Marie Cantwell, Professional Archaeologists of New York City
From: Alyssa Loorya and Chris Ricciardi - Chrysalis Archaeological Consultants, Inc.
Date: March 11, 2011
Re: PANYC's Outstanding Non-Archaeologist Contribution Nomination for 2011

Dear Ms. Cantwell and the Members of the Nomination Committee:

On behalf of Chrysalis Archaeological Consultants, Inc. (Chrysalis), I would like to make the following nomination for the Professional Archaeologists of New York City (PANYC) 2011 Outstanding Contribution to New York City Archaeology by a Non-Archaeologist.

Chrysalis nominates Rockmore Contracting Corporation (Rockmore) of Smithtown, New York for their outstanding contribution to the overall Cultural Resource Management (CRM) (Archaeological) Project at City Hall from April through December 2010.

Rockmore, led by the President of the Corporation, Mr. Sean Finn, and their Project Manager, Mr. Fred Weiss, and a consistent crew of at least six (6) workers, provided outstanding assistance to Chrysalis throughout the field portion of the City Hall project. Rockmore's crew was courteous, respectful, inquisitive, helpful, understanding and, by the end of the project, dedicated to the cause of preservation and archaeology.

Due to the directives put in place by The City of New York – Landmarks Preservation Commission's Director of Archaeology (LPC), Rockmore's crew was required to undertake a majority of the archaeological excavation. Although this doubled their work load, the crew did so without a complaint. Instead, they asked the archaeologists on site for "training" so that they could better understand what they were doing and why. They always excavated with care.

The crew, at times, used trowels and whisk brooms to assist the archaeologists when it came time for "delicate" work. There were many instances where the archaeologists would ask, "What happened to our trowels?" only to find the construction crew using them to carefully uncover a feature.

When the archaeologists were not on site, the crew would stop working if they found something that they did not understand and wait for the archaeologists before proceeding with work. Once again, due to the directive of the LPC, archaeological monitoring was not required in several areas of the project. However, the crew did not let that stop them from halting their work and calling the archaeologists in when something was in question.

4110 Quentin Road Brooklyn, New York 11234-4322
Phone/Fax: (718) 645-3962 • Mobile: (347) 922-5581
info@chrysalisarchaeology.com • www.chrysalisarchaeology.com

We have worked in the field of archaeology for almost two decades. We have worked with many construction crews. To be fair, most have been respectful of the archaeologists and the archaeological process. However, none were as dedicated and considerate as the Rockmore crew.

It is, we believe, due to the leadership and business philosophy of Mr. Finn and Mr. Weiss that the Rockmore team acted in the manner that they did during this project. Rarely in archaeology do you hear of one praising the construction crew for their efforts – but in this case it is warranted.

It goes without saying that City Hall and City Hall Park is one of the most significant archaeological sites within the City of New York and is the subject of PANYC's 2011 Public Program. We could not have done as good as a job as was accomplished at City Hall without the incredible assistance from the Rockmore team, notably: Fred Weiss, Brien Weiss, Greg Alexander, Anthony Schiarno, Domenic, Elvin, Ronny, Cliff, Ben, Eddie and the entire crew. Chrysalis Archaeology whole-heartedly recommends that Rockmore Contracting Corporation receive the 2011 PANYC Outstanding Contribution to New York City Archaeology award.

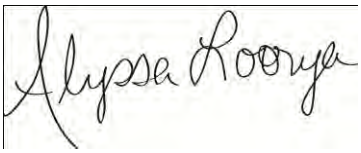
For your records, the contact information for Rockmore is:

Sean Finn, President
Rockmore Contracting Corporation
26 Loft Road
Smithtown, New York 11787
Phone: (631) 366-6200
Email: sfinn@rockmorecontracting.com

Fred Weiss, Project Manager
Rockmore Contracting Corporation
26 Loft Road
Smithtown, New York 11787
Cell: (516) 315-4787
Email: fweiss@rockmorecontracting.com

Thank you for the consideration of this nomination letter. If you have any questions, I would be happy to provide any information necessary.

Sincerely,



Alyssa Loorya, President

PROFESSIONAL ARCHAEOLOGISTS OF NEW YORK CITY

A-M. Cantwell
14 Stuyvesant Oval, #5C
NY, NY 10009
212 677-7209
email acantwel@andromeda.rutgers.edu

Mr. Sean Finn, President
Mr. Fred Weiss, Project Manager
Rockmore Contracting Corporation
26 Loft Road
Smithtown, New York 11787

Dear Messrs. Finn and Weiss,

It is my pleasure to inform you that Professional Archaeologists of New York City (PANYC) has awarded Rockmore Contracting Corporation the SPECIAL PANYC AWARD FOR OUTSTANDING CONTRIBUTIONS MADE BY A NON ARCHAEOLOGIST TO NEW YORK CITY ARCHAEOLOGY. This award is presented from time to time to individuals or organizations for their work in preserving and understanding the city's archaeological past. Rockmore is being recognized for its outstanding work on the City Hall Project. The nomination was initially made to the Awards Committee by Chrysalis Archaeological Consultants.

The award will be presented at PANYC's Annual Symposium on the Archaeology of New York City to be held on May 1, 2011 at the Museum of the City of New York, Fifth Avenue at 103rd Street. The program starts at 1 PM and the award will probably be presented sometime between 1:30 and 2:00. The program's theme this year, as it turns out, is "The History and Archaeology of the Commons: New York's City Hall Park."

I look forward to presenting the award to you or your representative at the Symposium on May 1st. If you need any further information, please contact me.

Congratulations and many thanks for your efforts on behalf of New York's archaeological past!

Sincerely,

Anne-Marie Cantwell
Chair, PANYC Awards Committee

cc :Alyssa Loorya, Chris Ricciardi

Professional Archaeologists of New York City

Recognition Award

Outstanding Contribution to New York City Archaeology
for their work on the City Hall Renovation Project

Rockmore Construction

May 2011

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Lynn Rakos, President