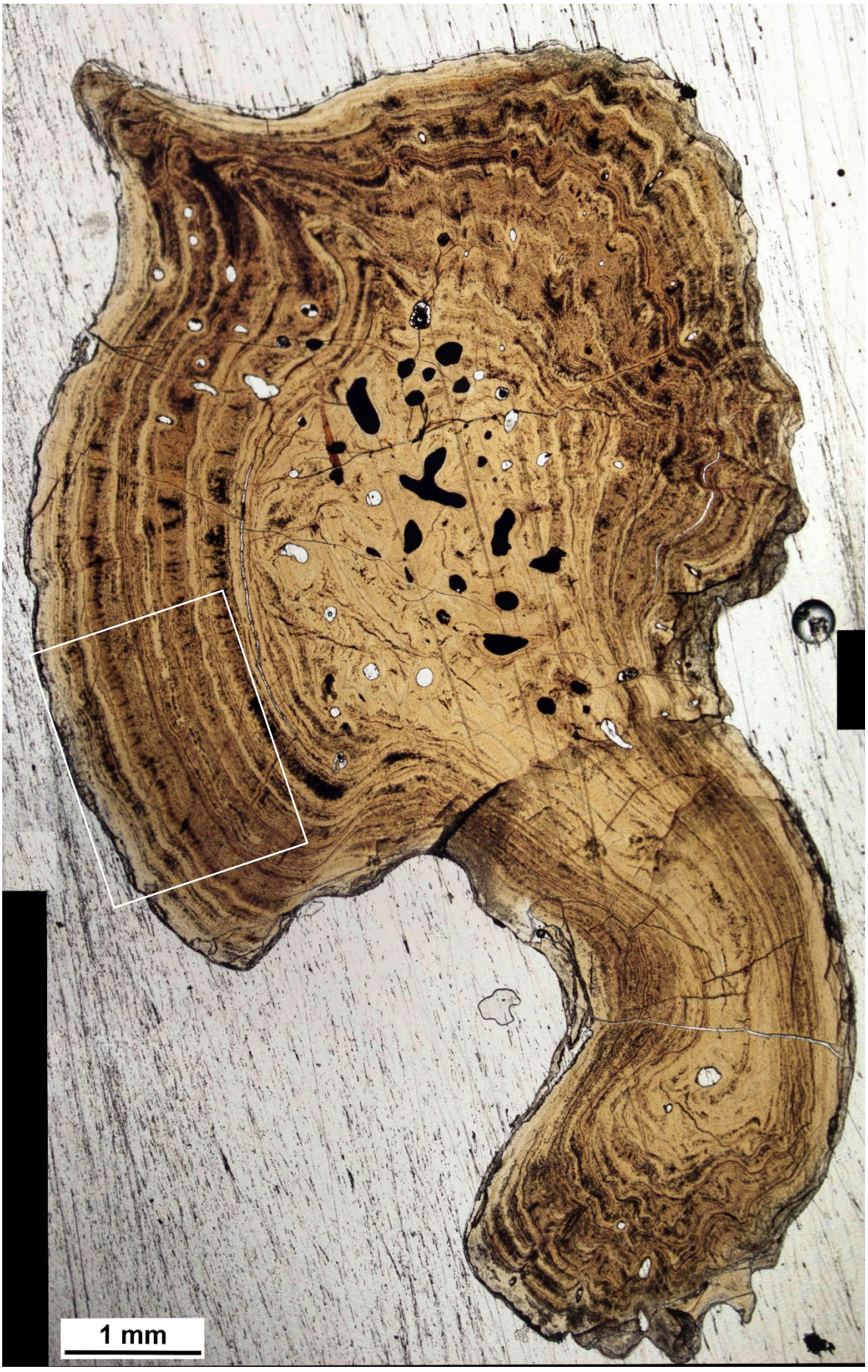
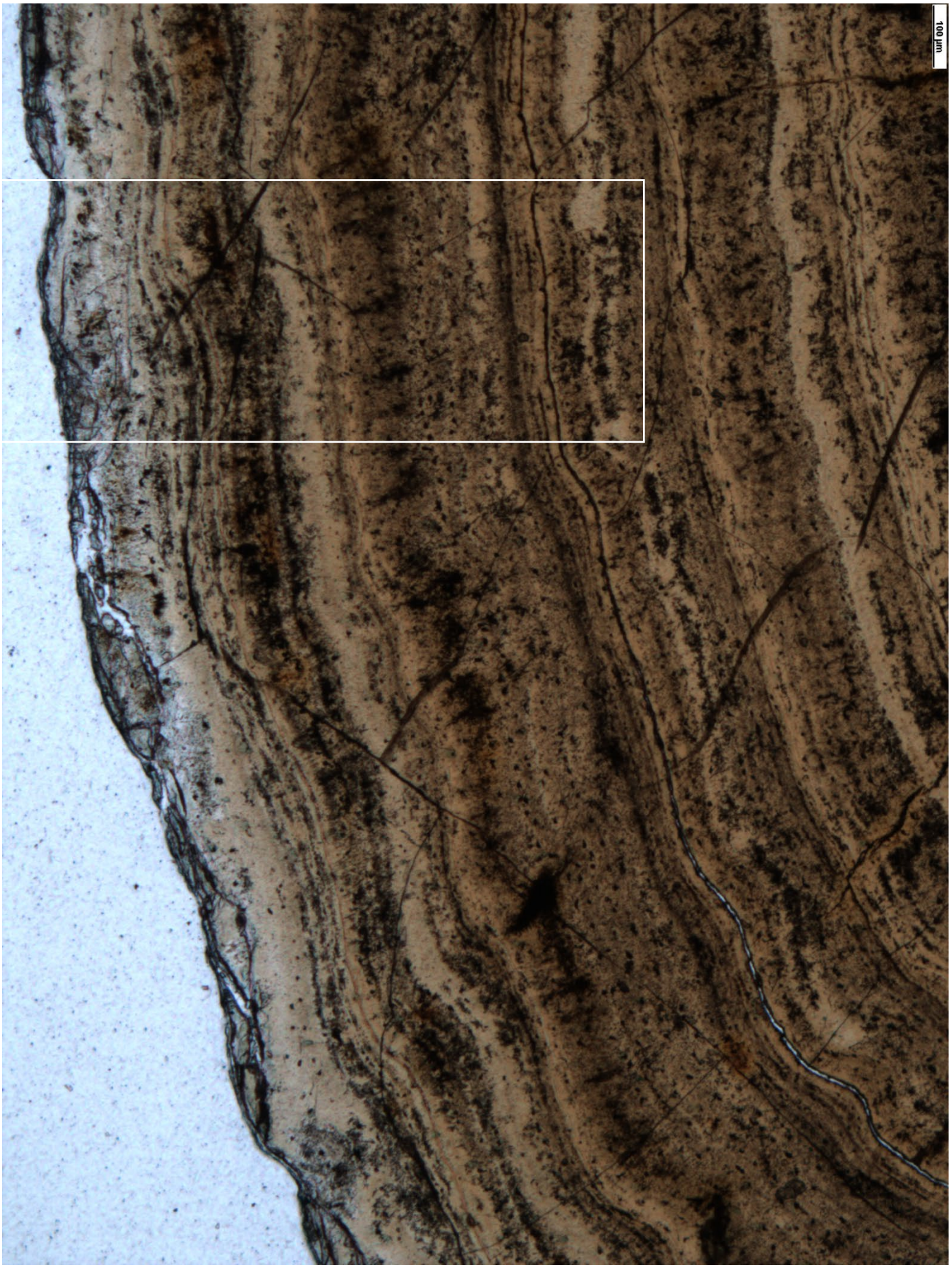
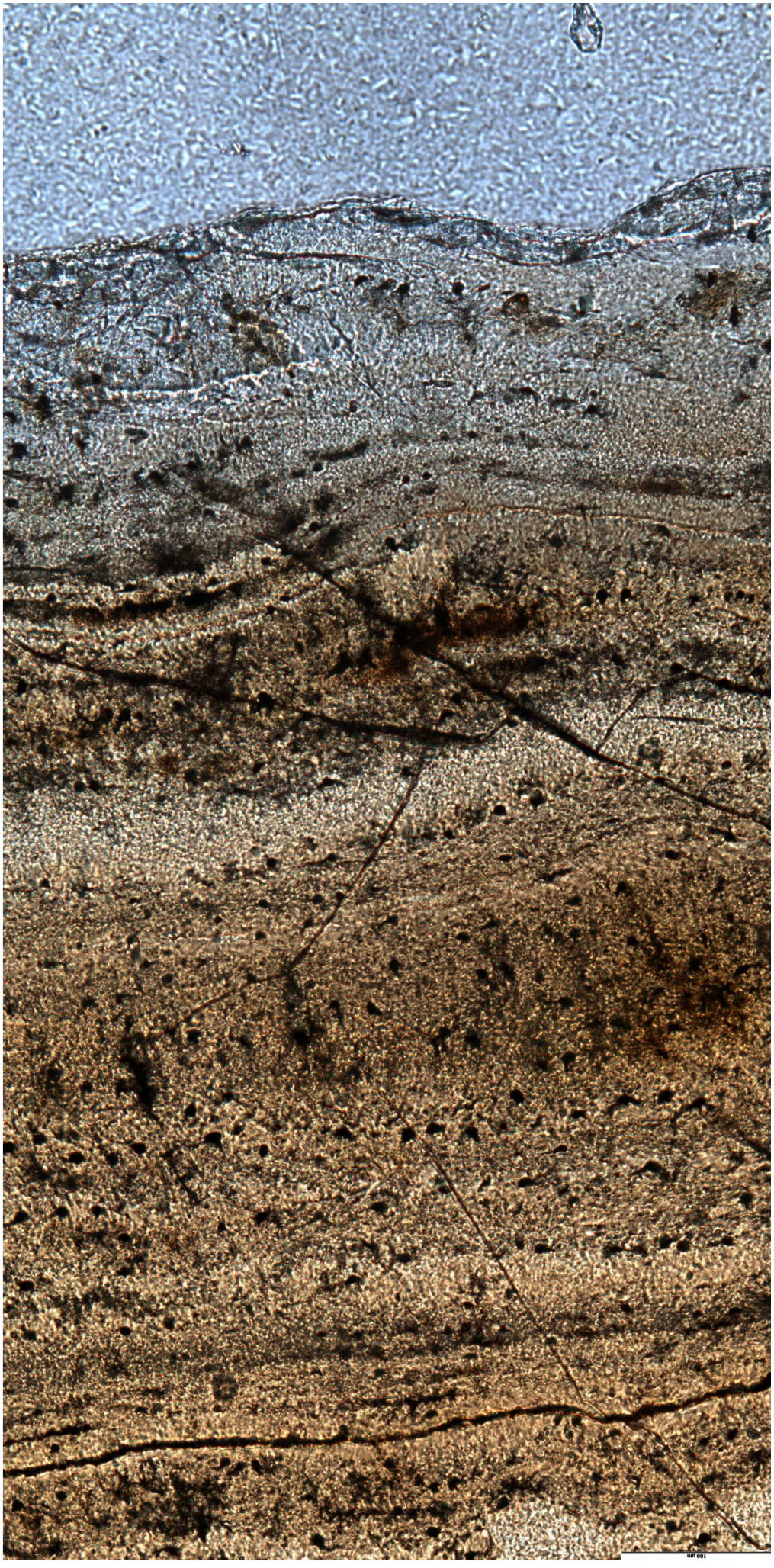
Supplementary information

1. Osteohistological thin sections

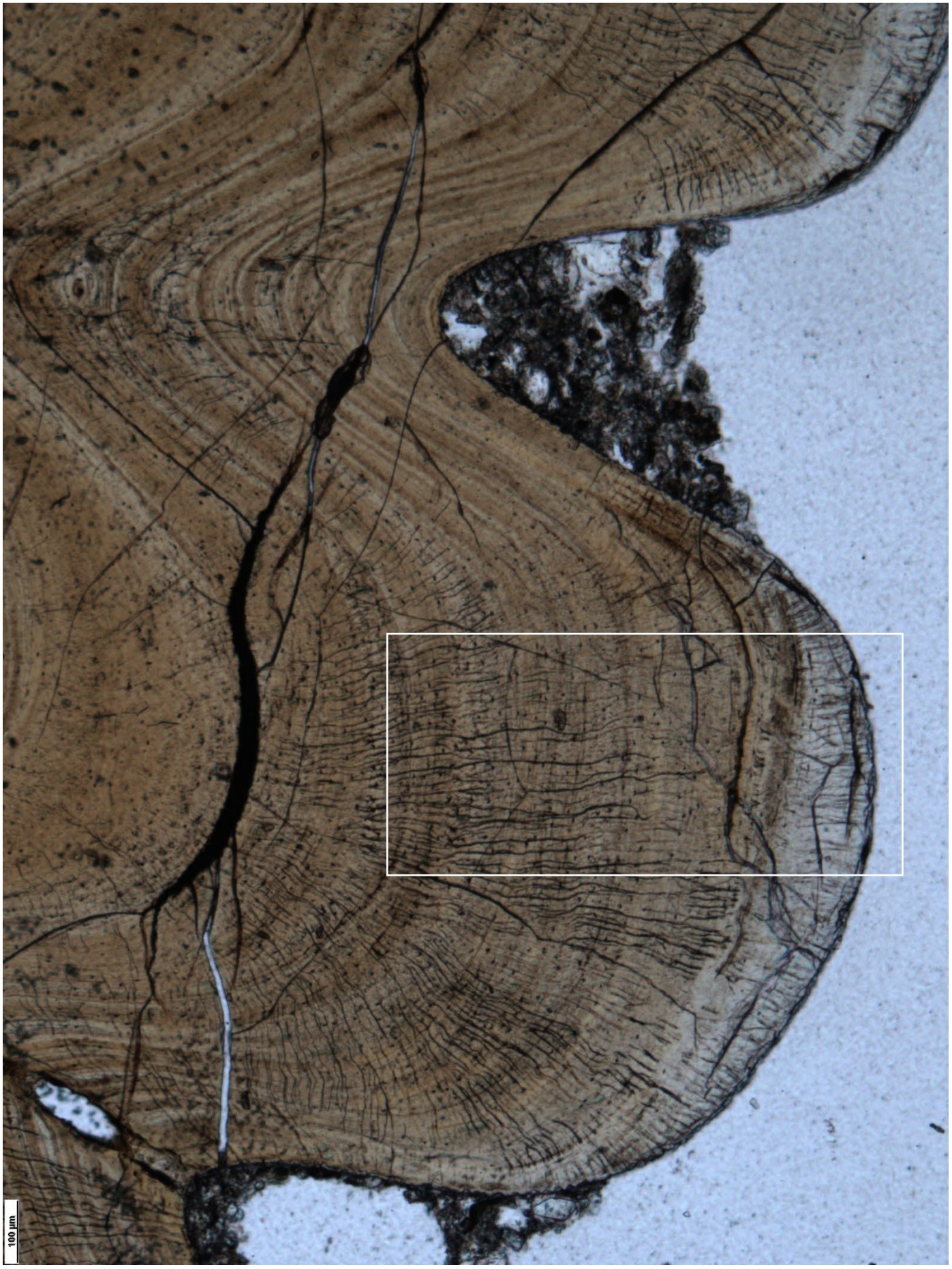
1.1 Thin sections of X-2724 at multiple resolutions




100 µm

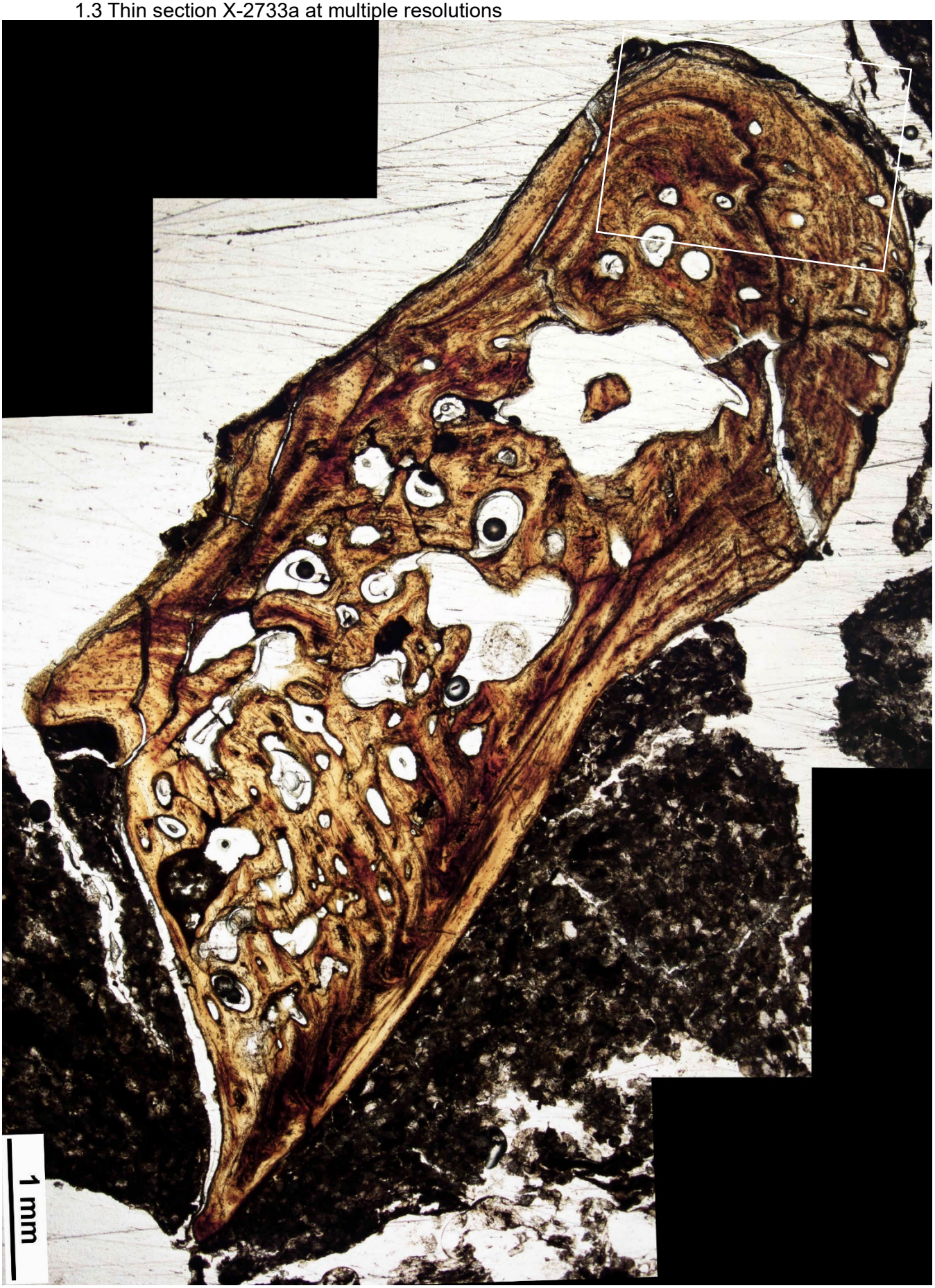


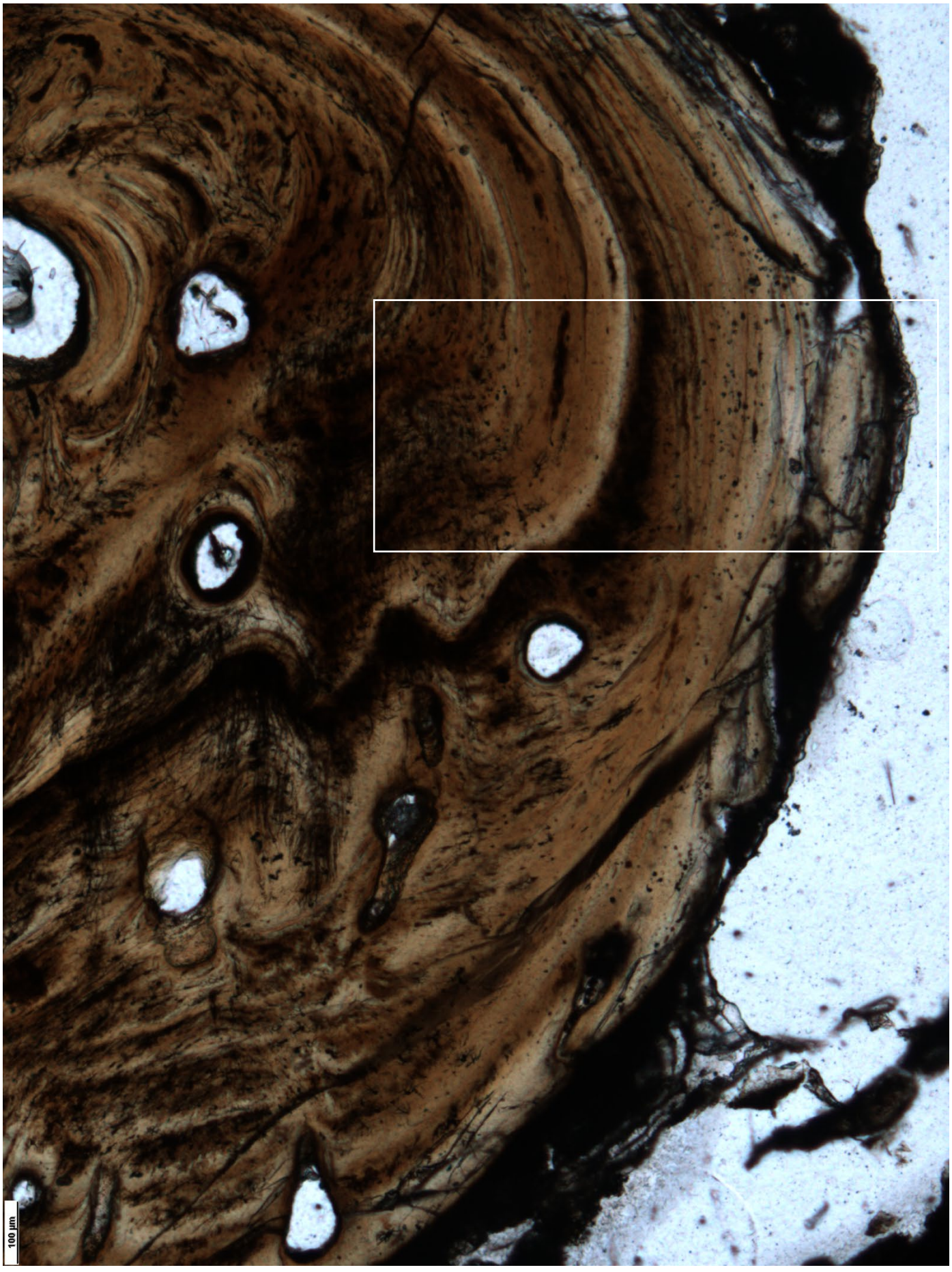
1.2 Thin section MDX-3 at multiple resolutions

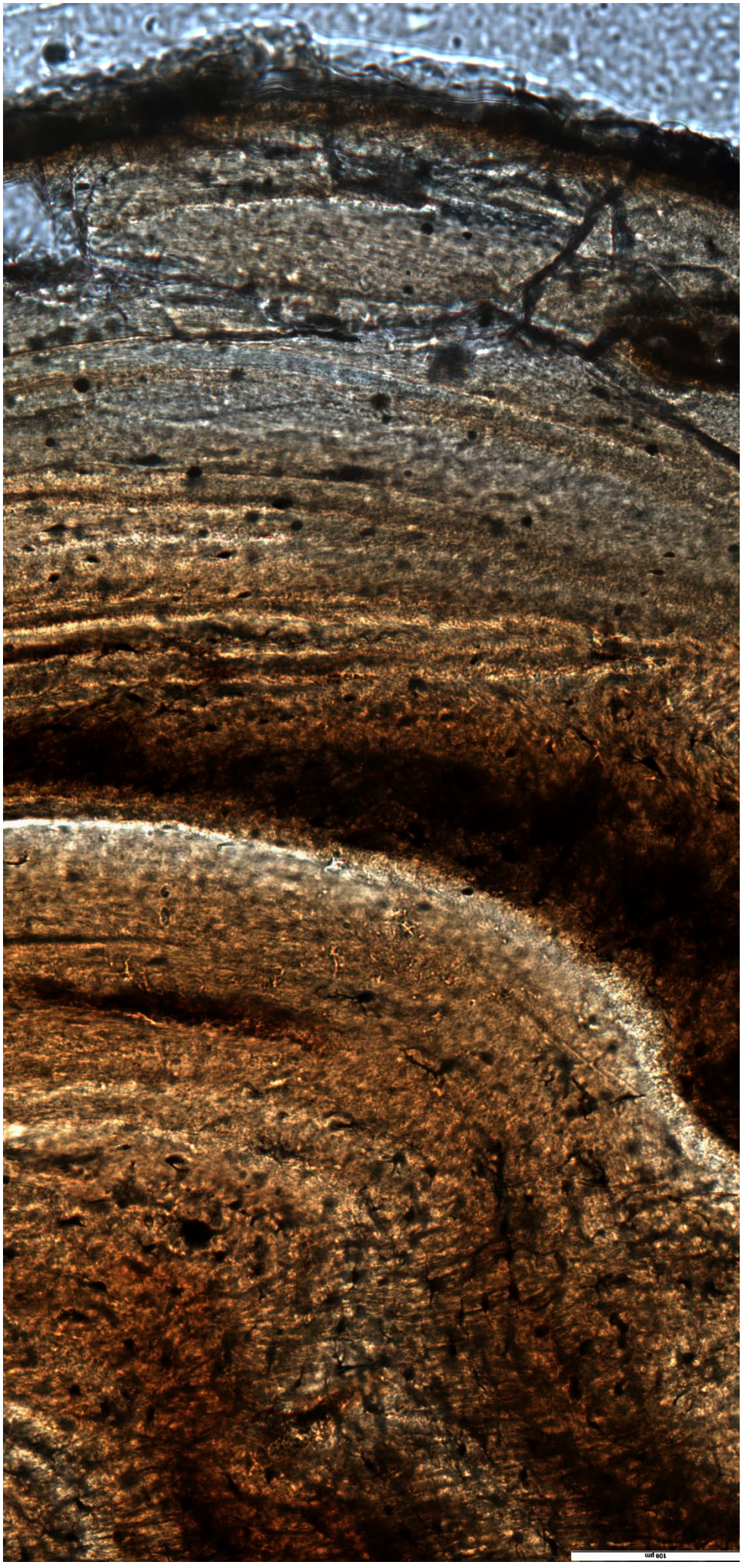

100 µm


100 µm

1.3 Thin section X-2733a at multiple resolutions

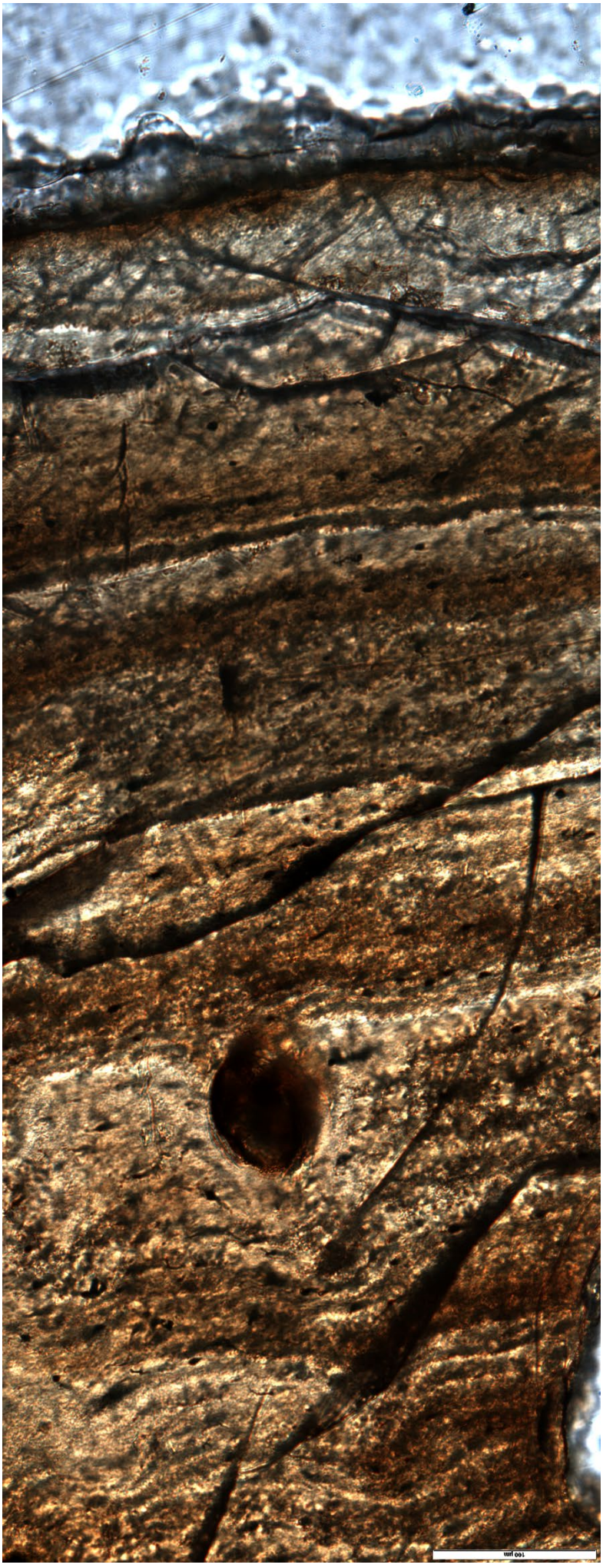



100 µm

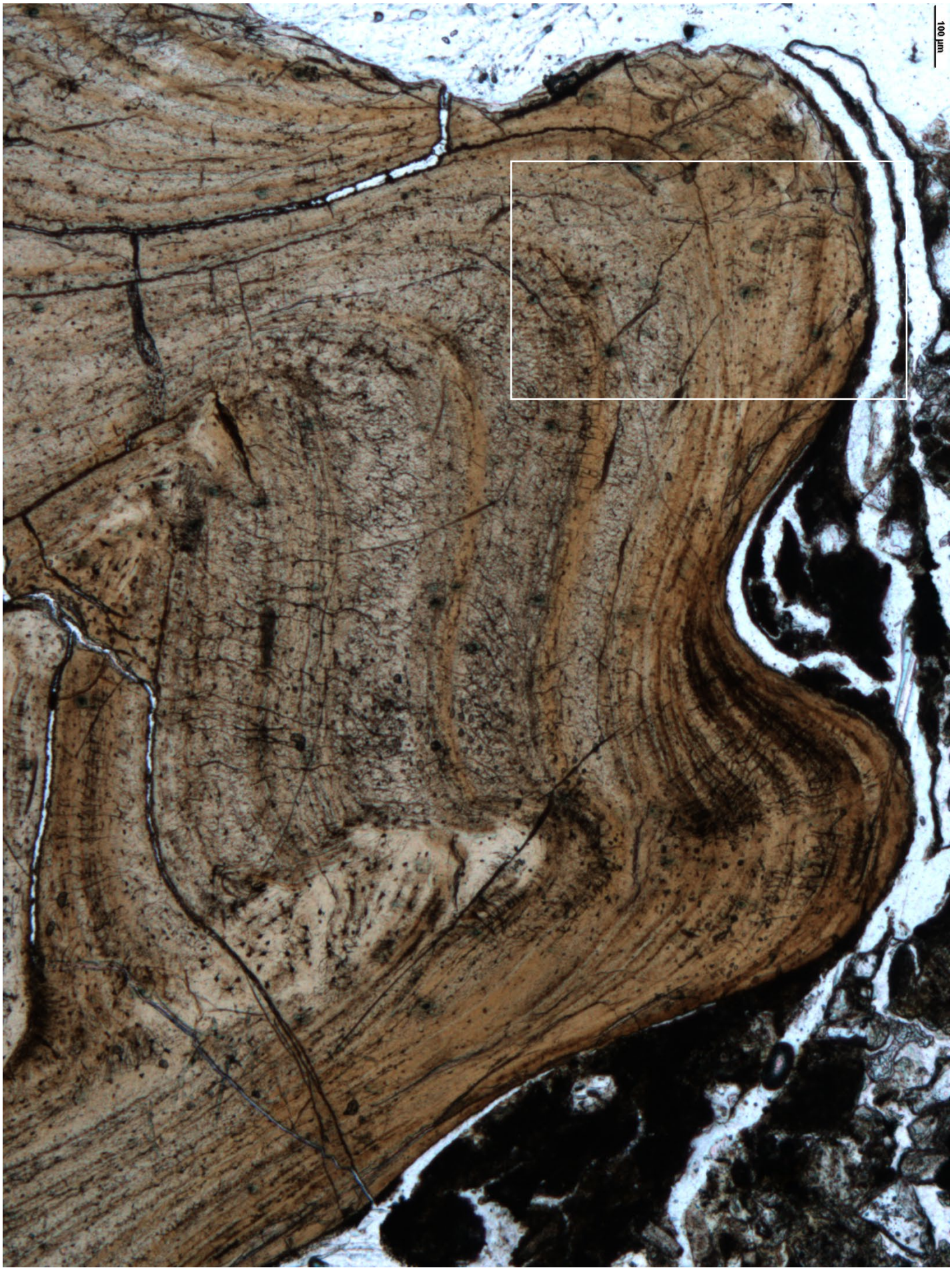

100 µm

1.4 Thin section X-2733b at multiple resolutions


100 µm

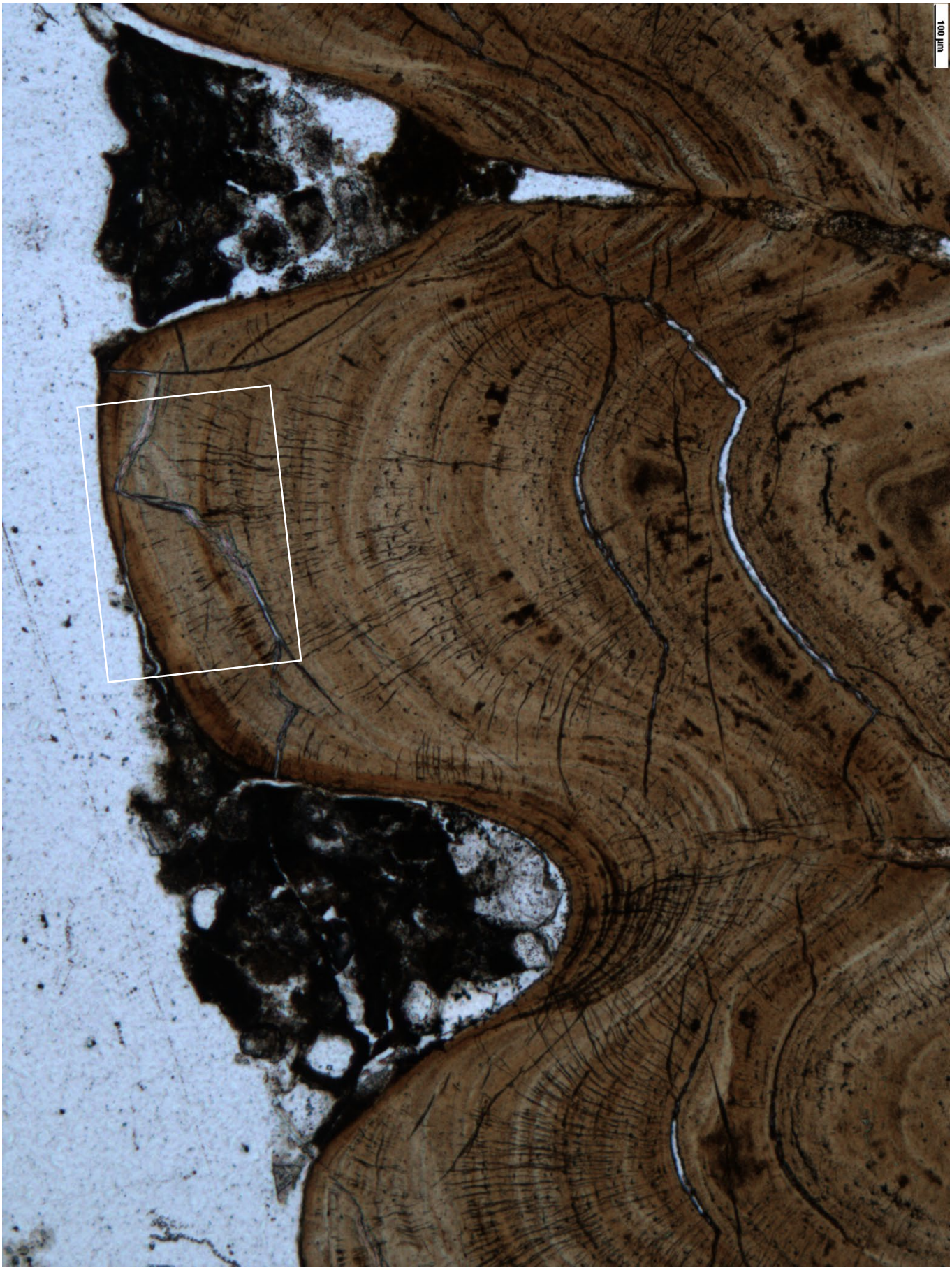


1.5 Thin section X-2743M at multiple resolutions


100 µm


100 µm

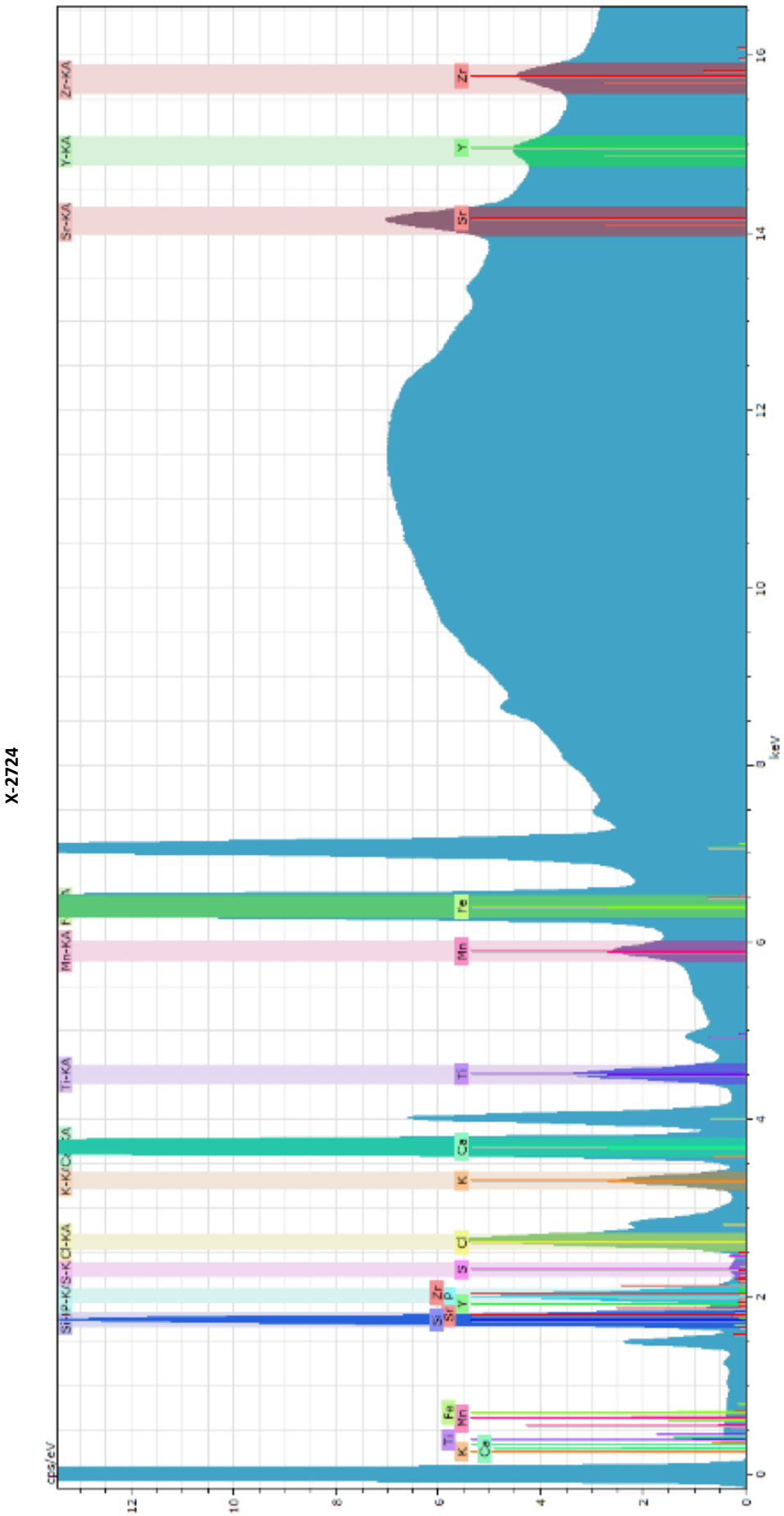
1.6 Thin section X-2744M at multiple resolutions


100 µm

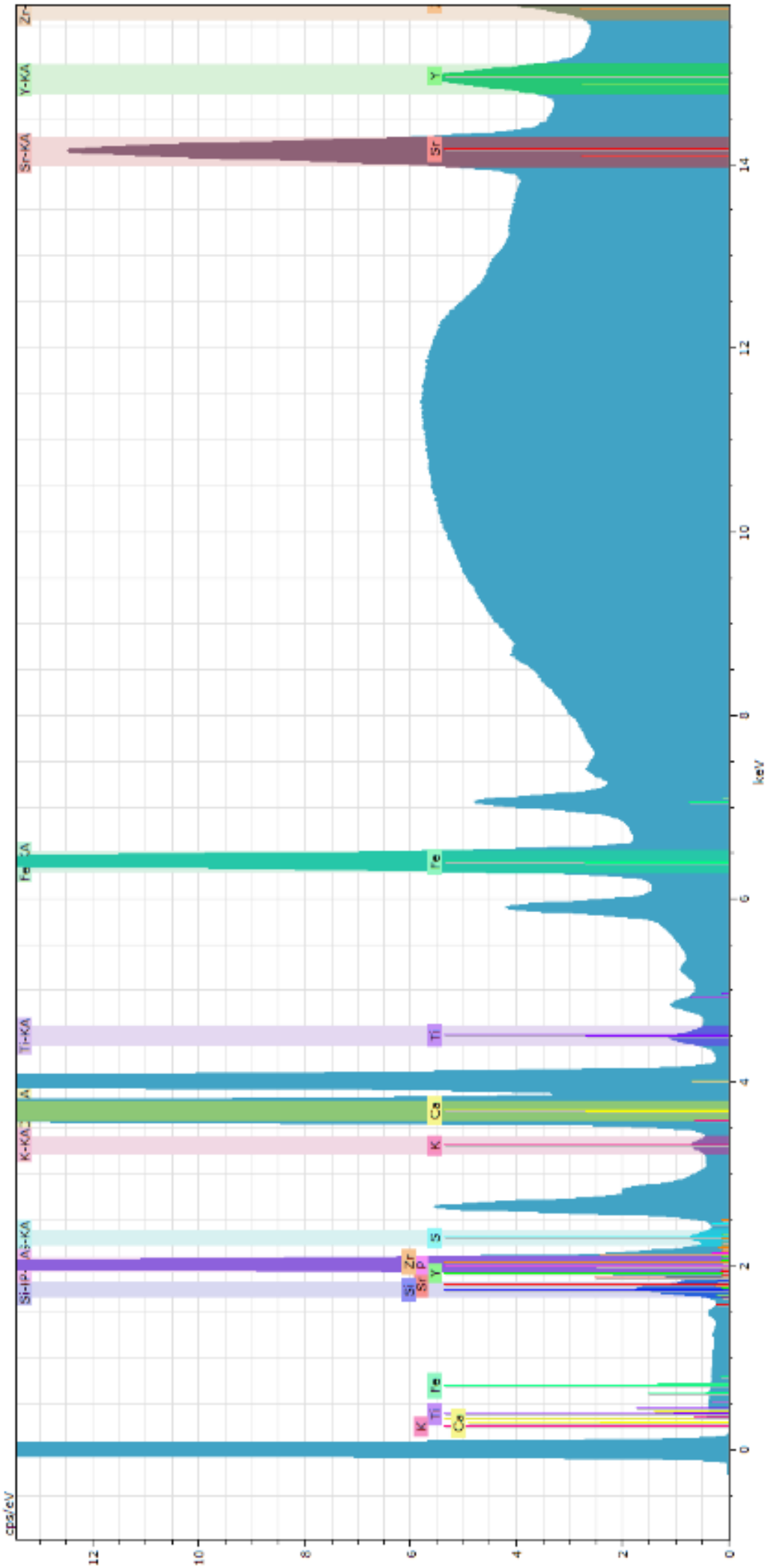

100 µm

2. Micro X-ray fluorescence

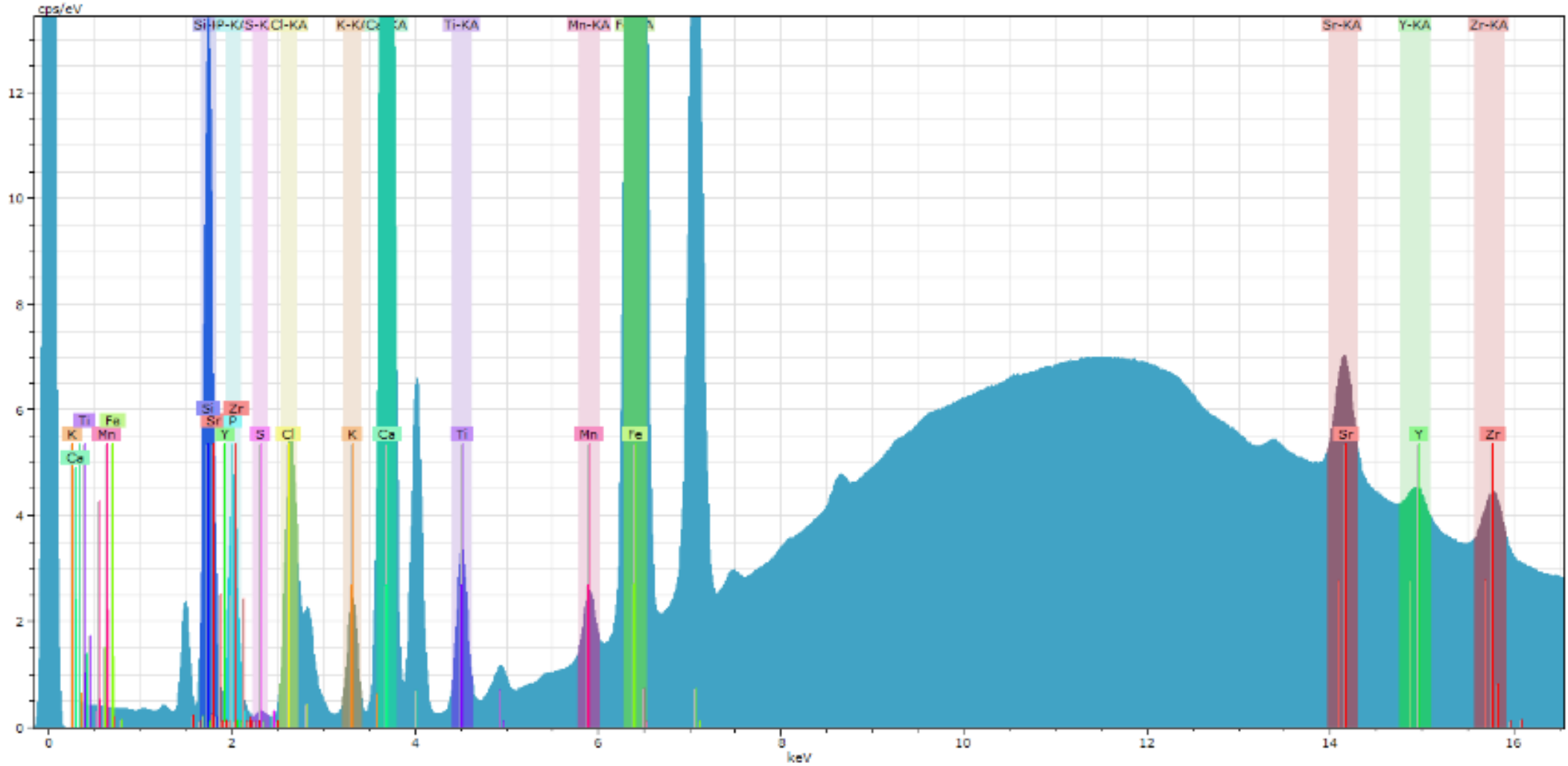
2.1 Elemental spectrum for each specimen



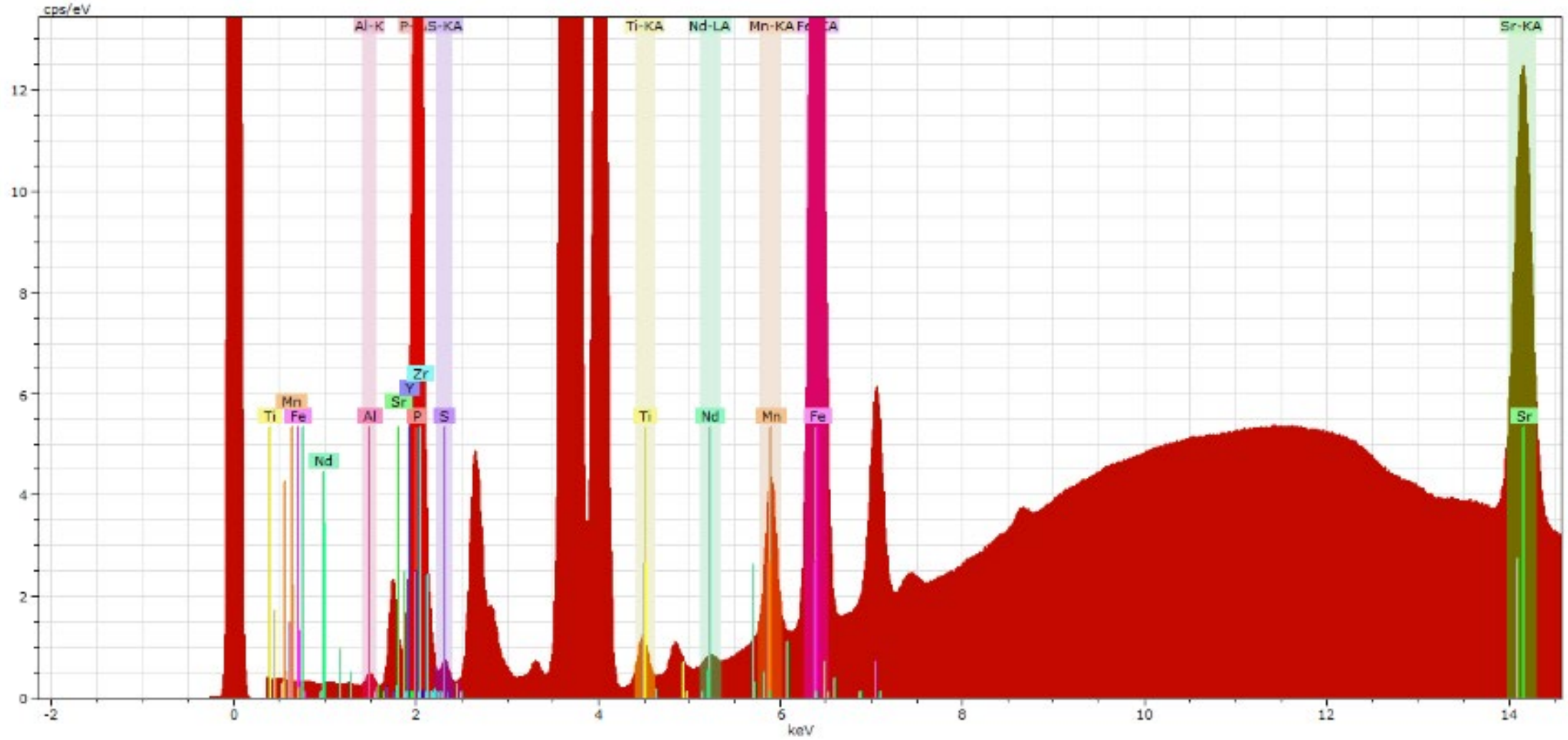
MDX-3

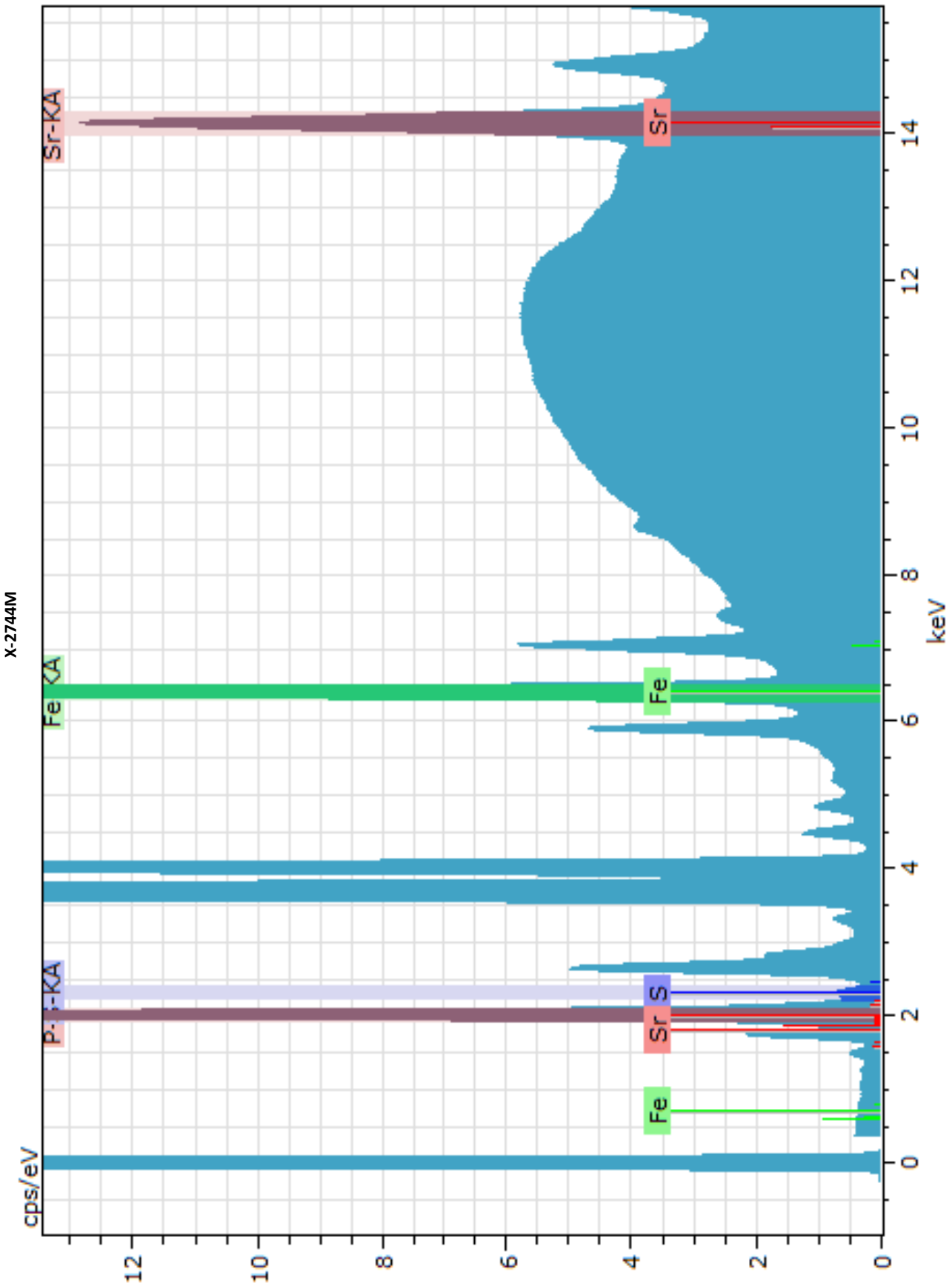

cps/eV
kev
Zr
Y-KA
Sr-KA
Fe-KA
Ti-KA
Ca-KA
K-KA
As-KA
Si-KA
Sr
Y
Fe
Ti
Ca
K
S
Zr
Si
P

X-2733a, plus sediment and X-2733b

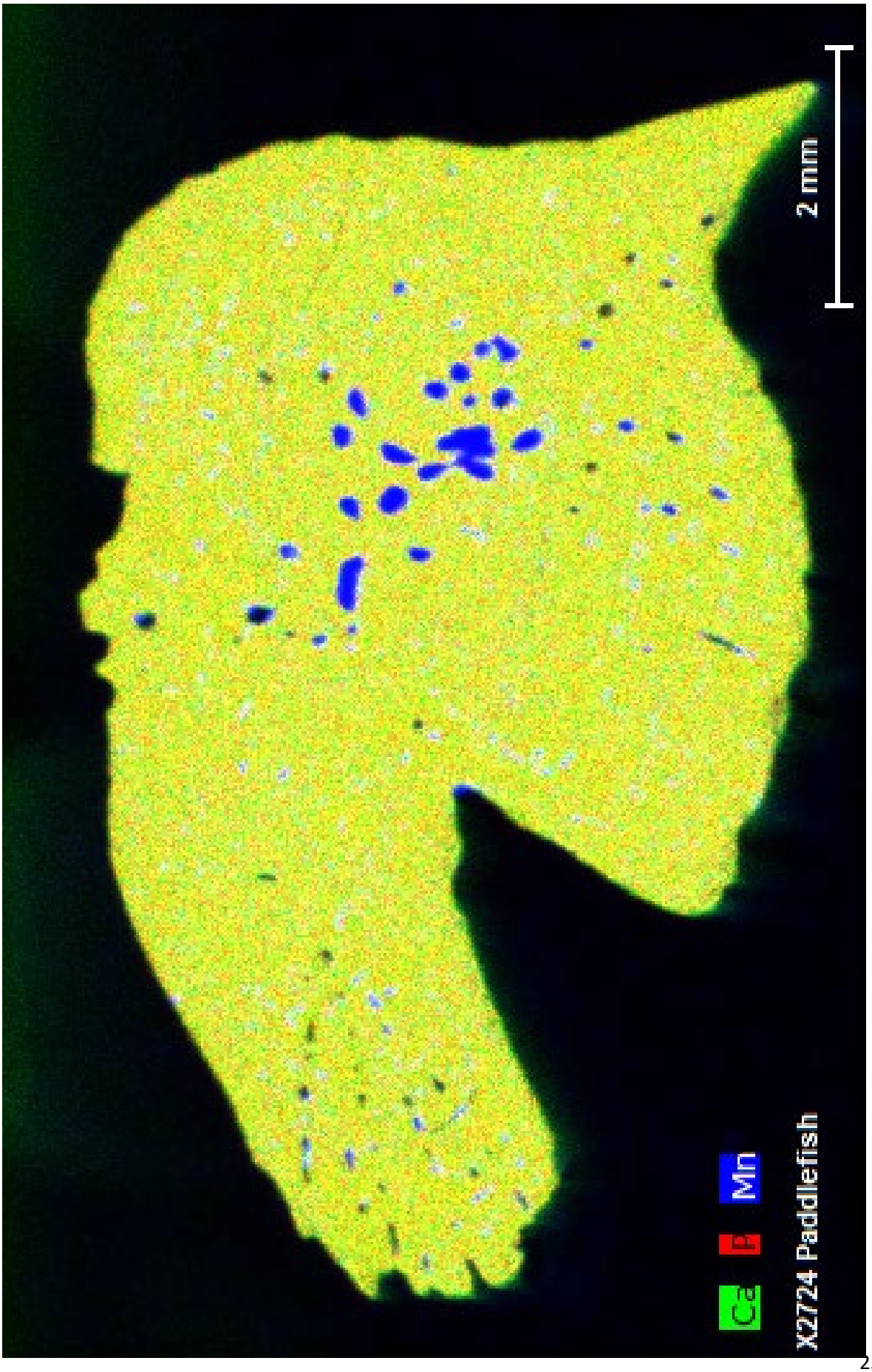


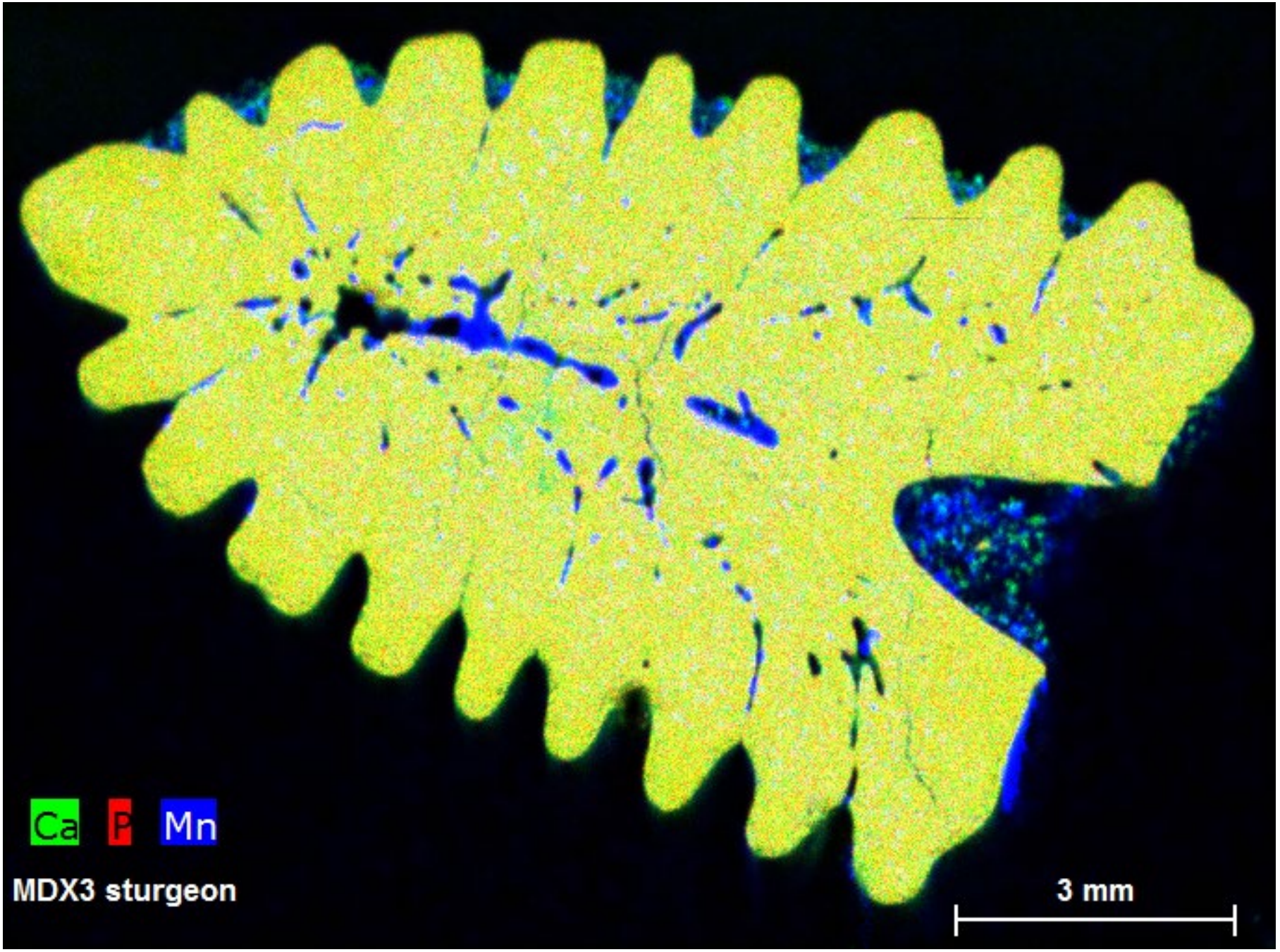
X-2743M

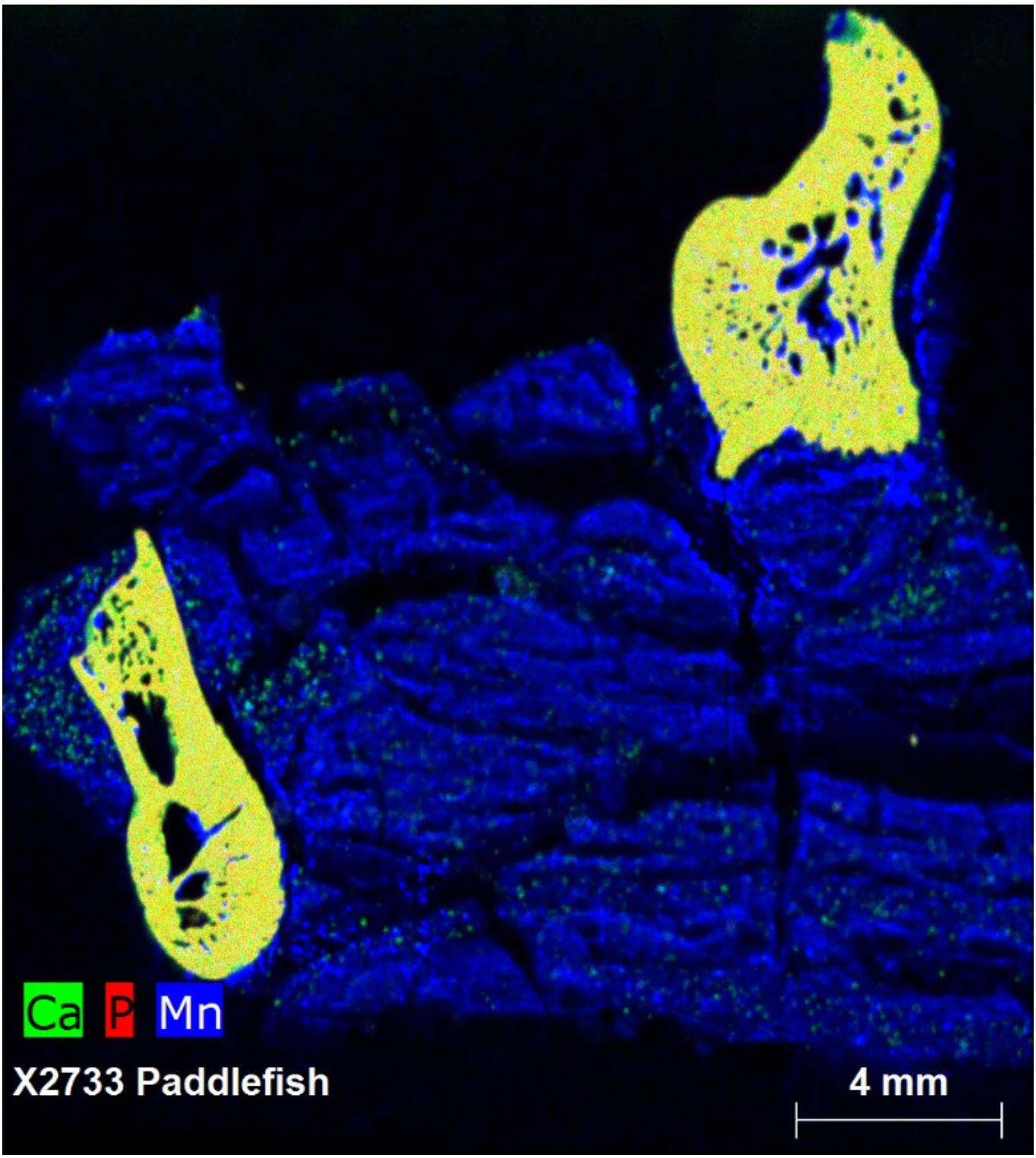


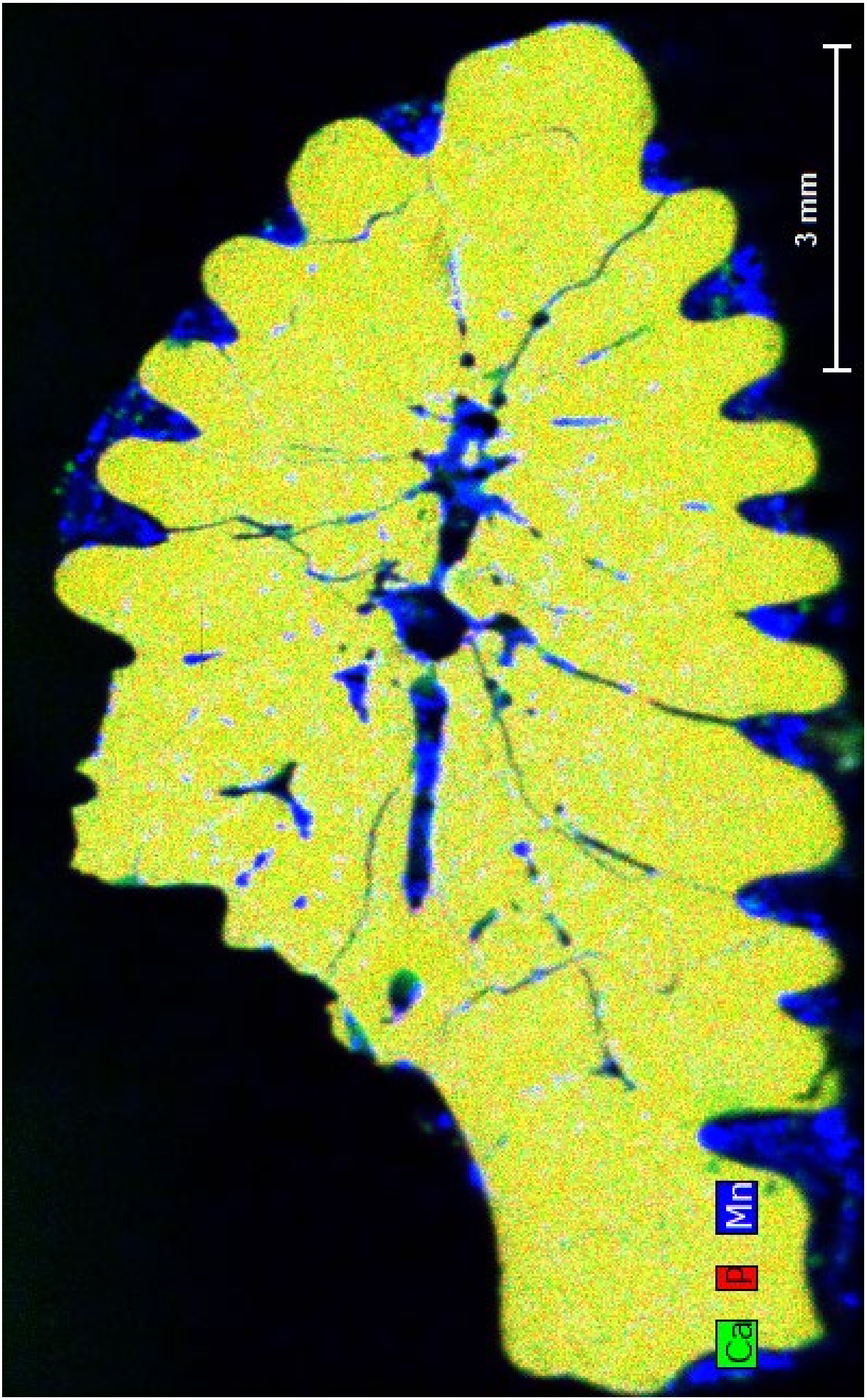

X-2744M
cps/eV
keV
Sr-KA
Fe KA
Sr
Fe
Sr
S
Fe

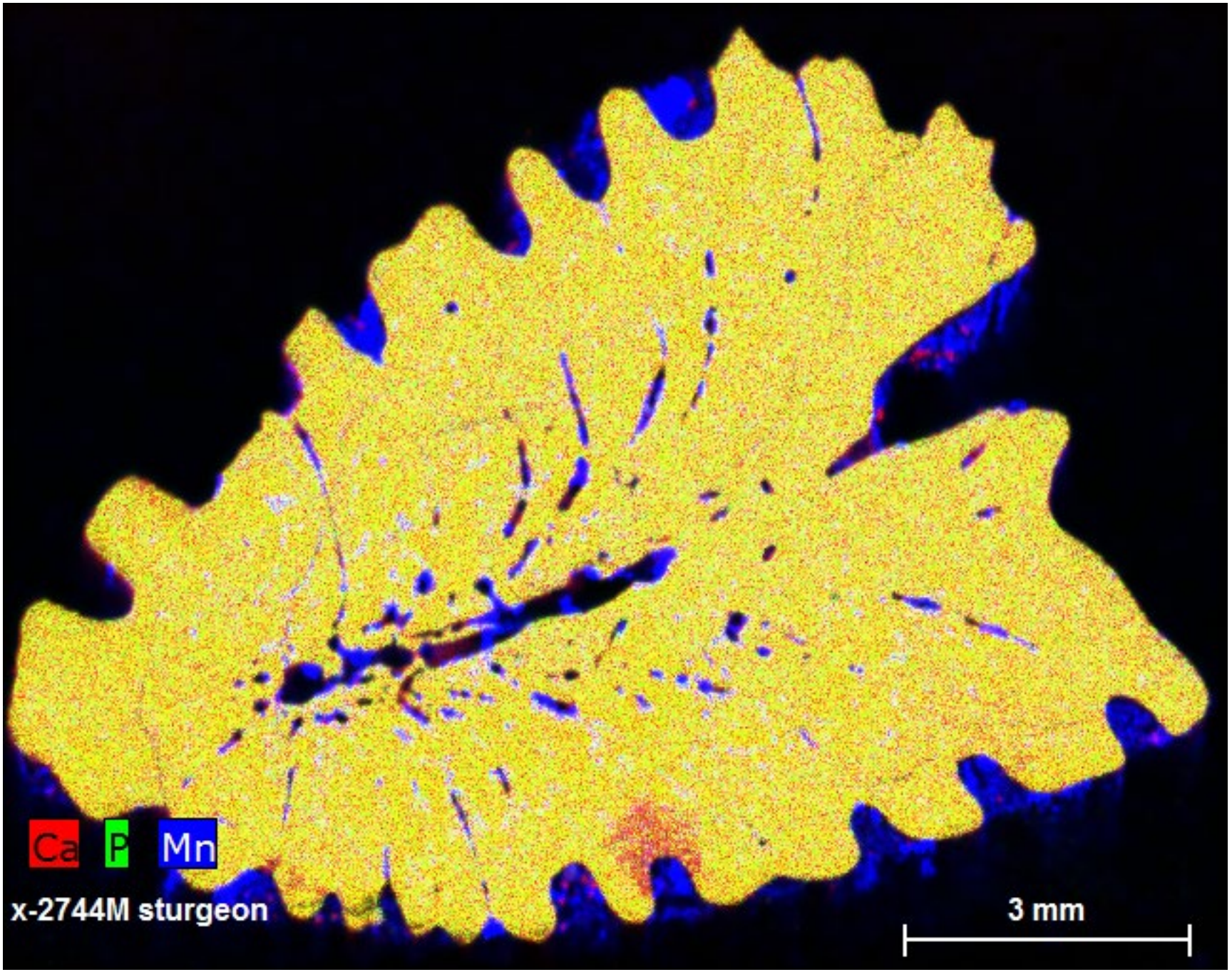
2.2 Elemental distribution map of Ca, P and Mn for each specimen



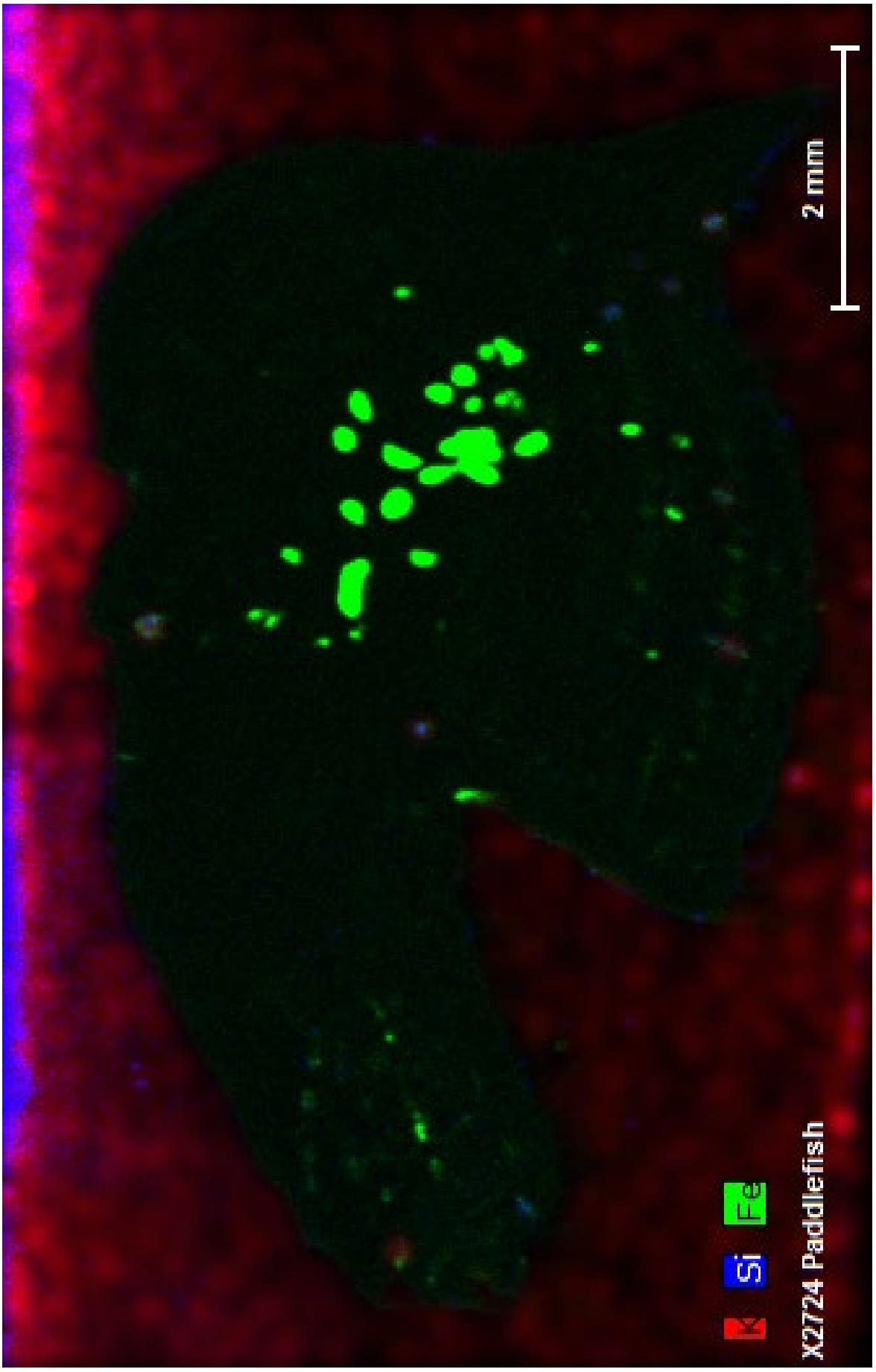

Ca
P
Mn
MDX3 sturgeon
3 mm

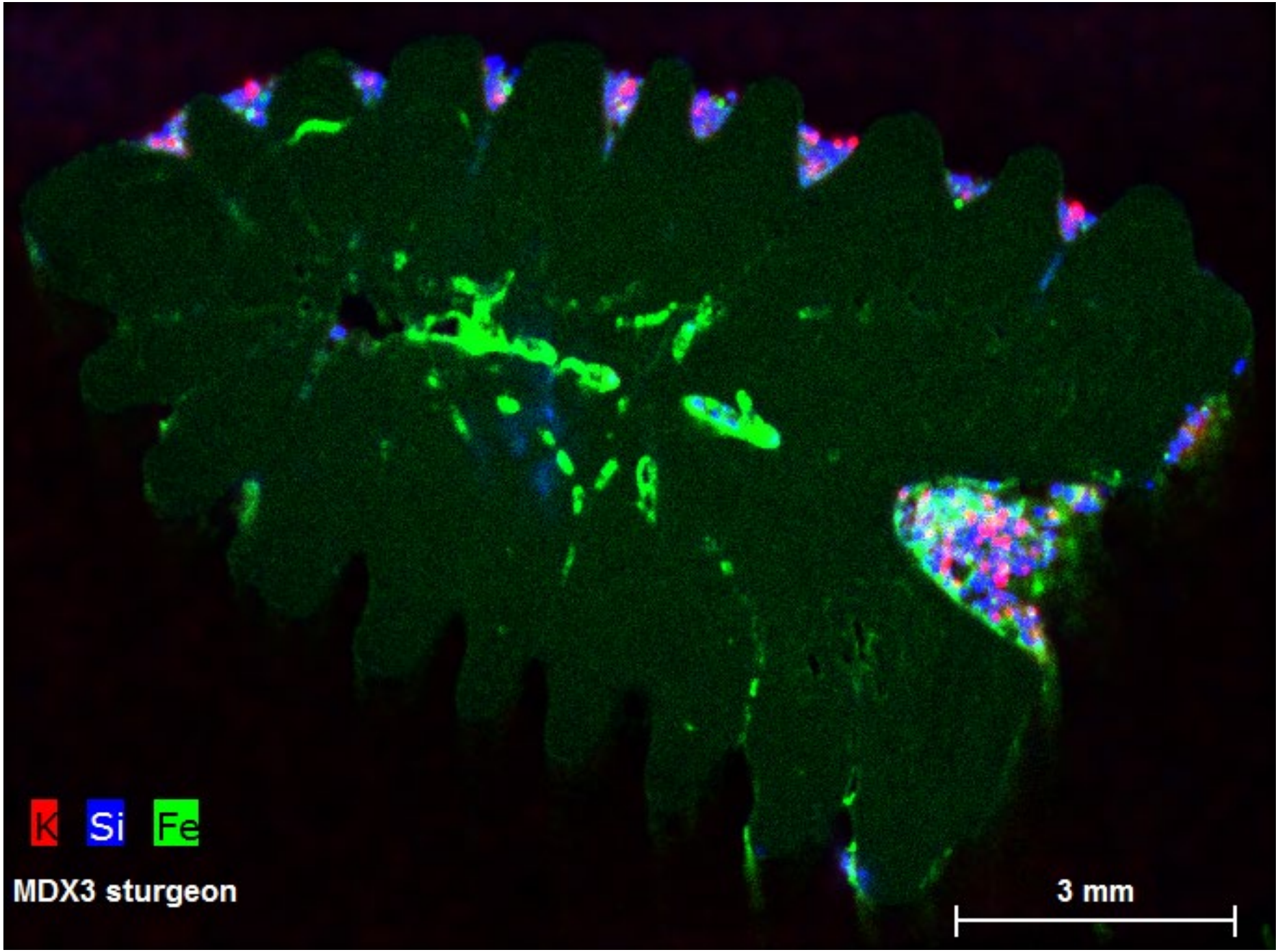

Ca P Mn
X2733 Paddlefish
4 mm

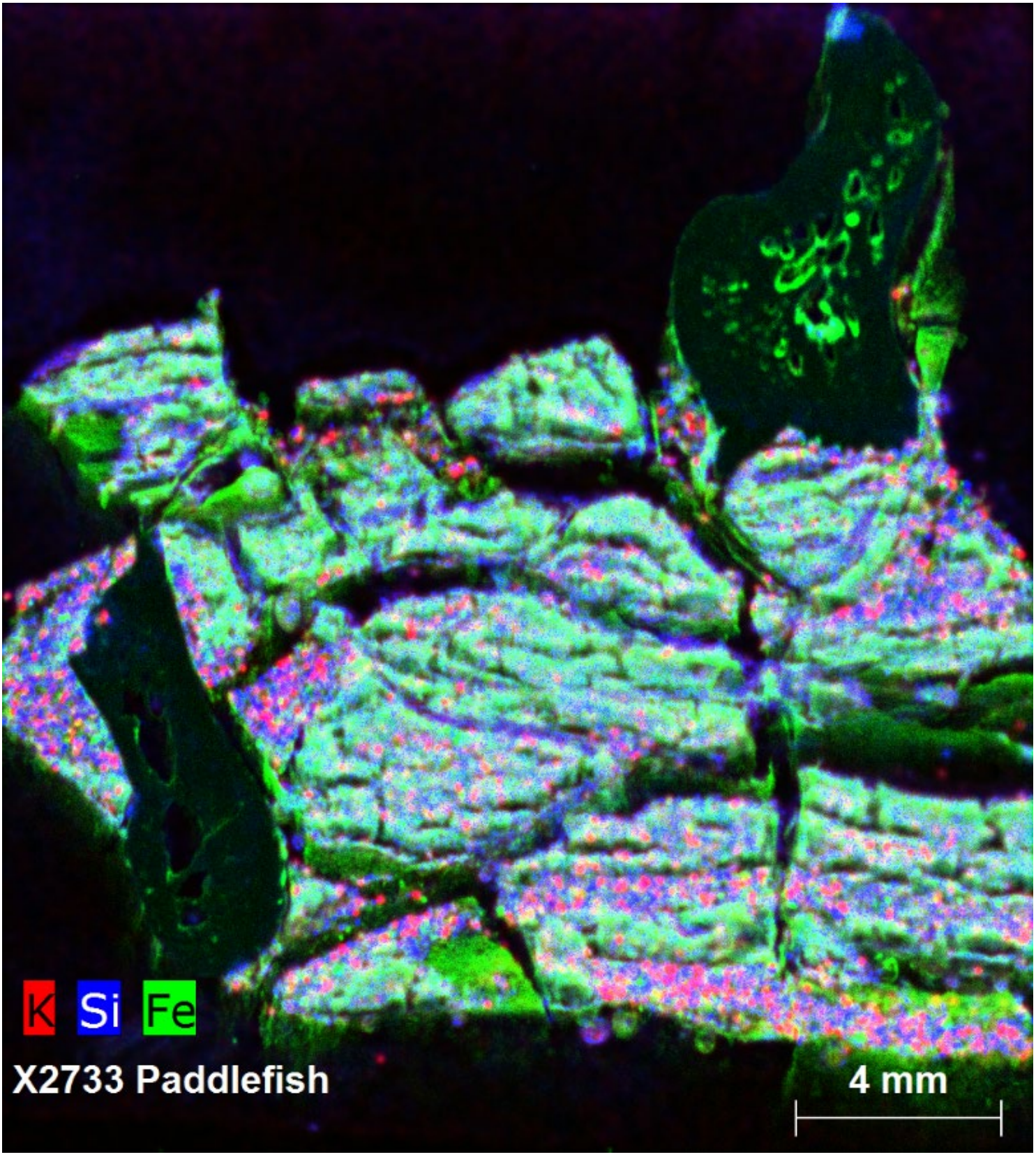

3 mm
Mn
B
Ca

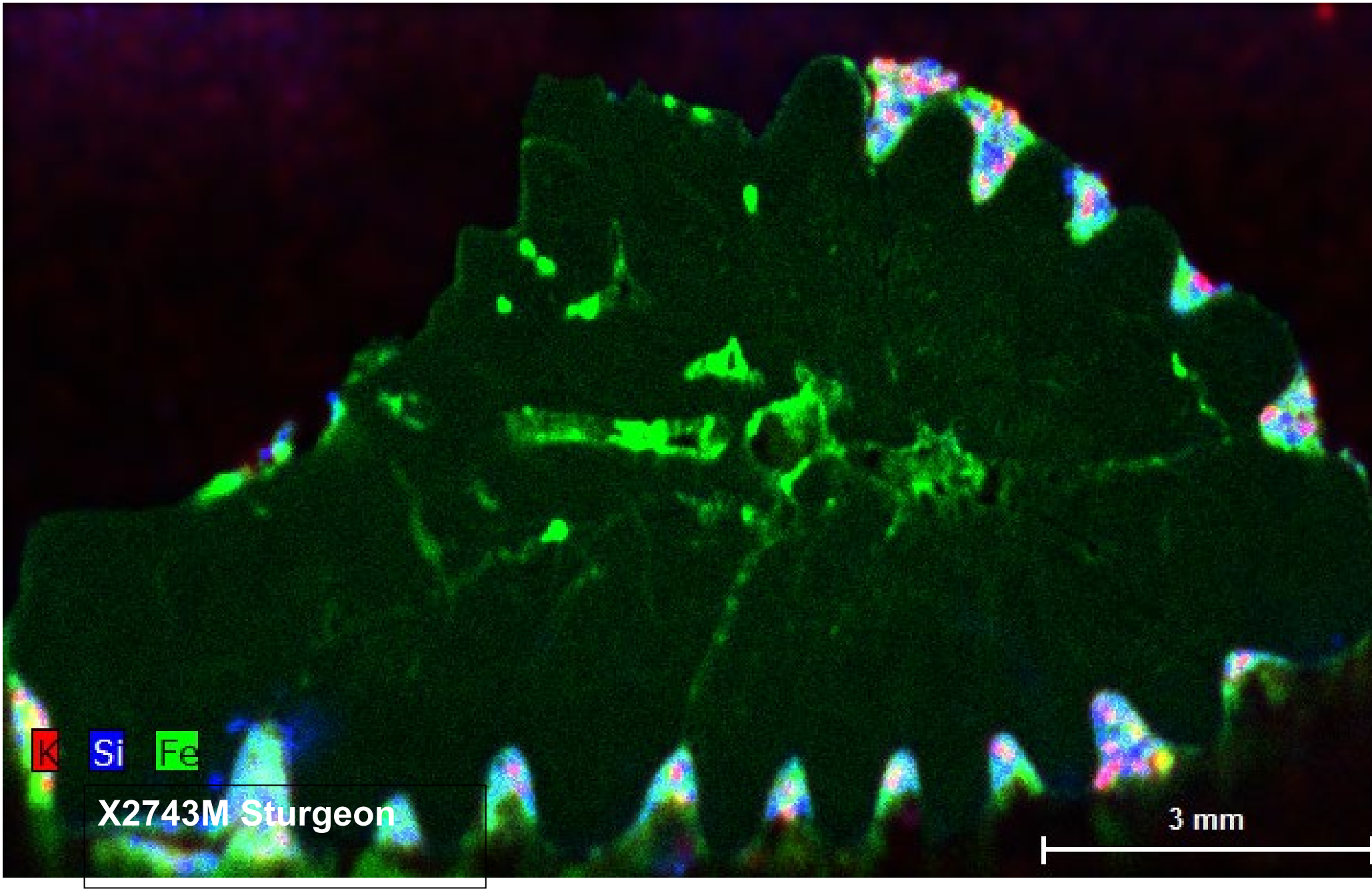

Ca
P
Mn
x-2744M sturgeon
3 mm

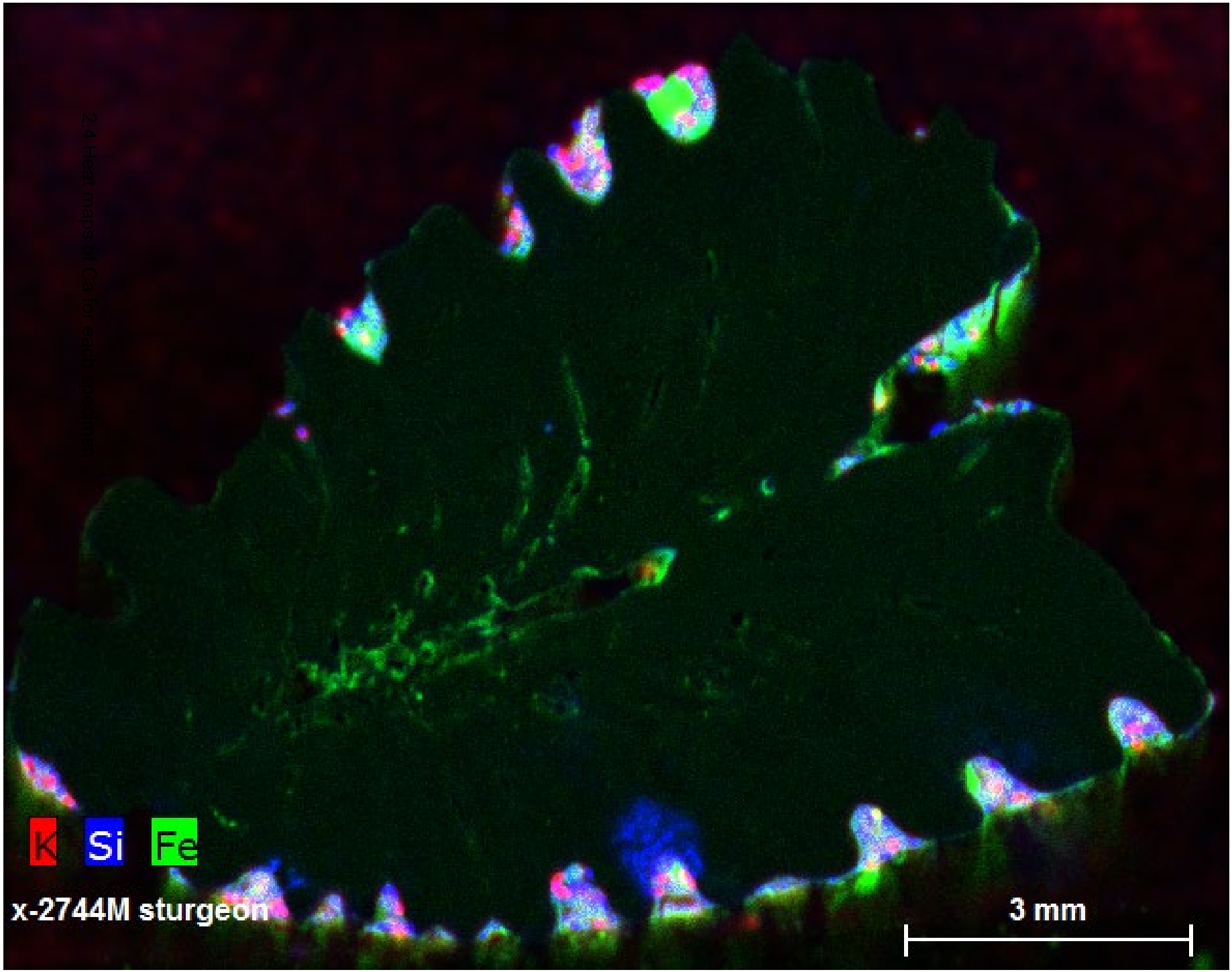
2.3 Elemental distribution map of K, Si and Fe for each specimen



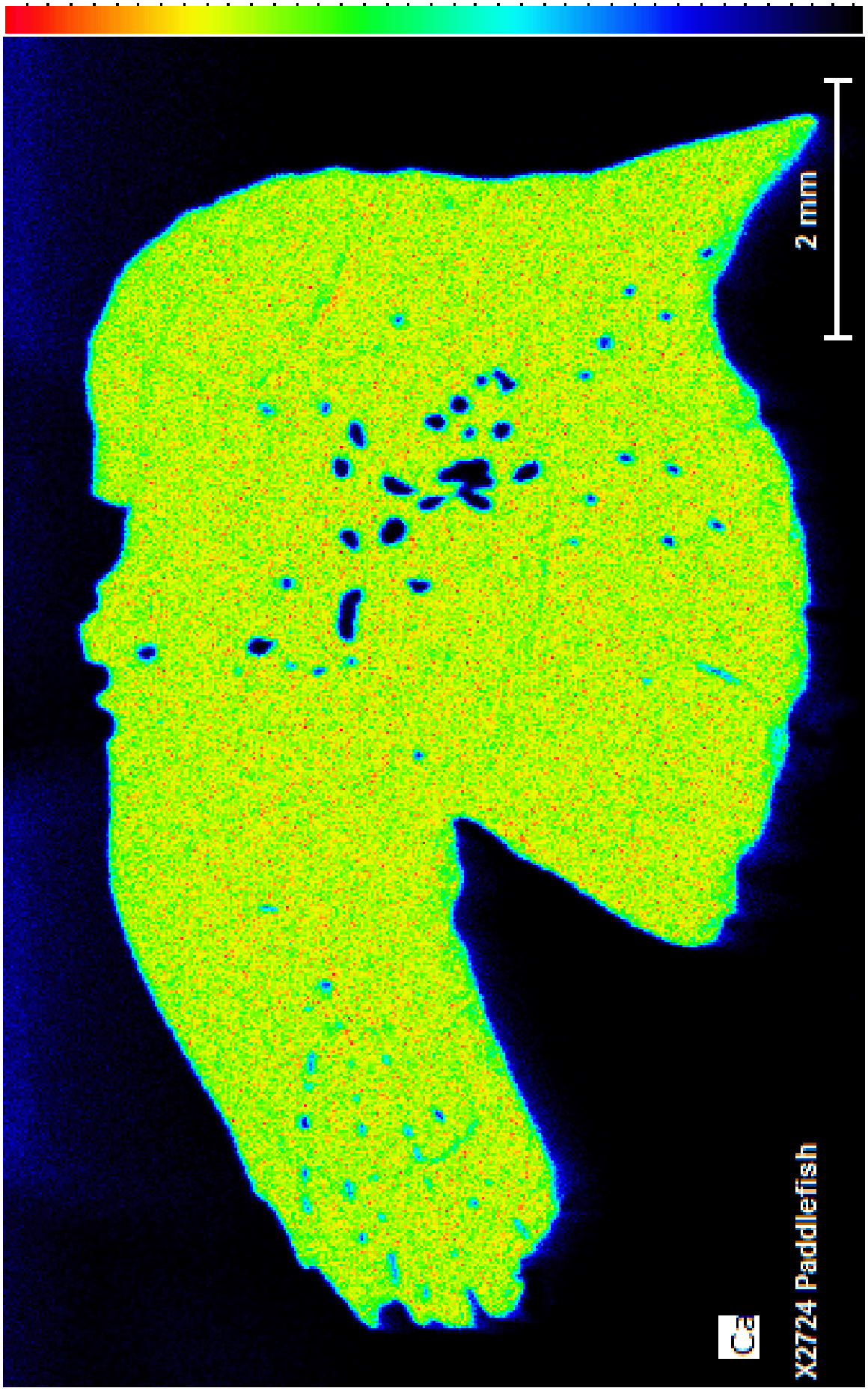

K
Si
Fe
MDX3 sturgeon
3 mm

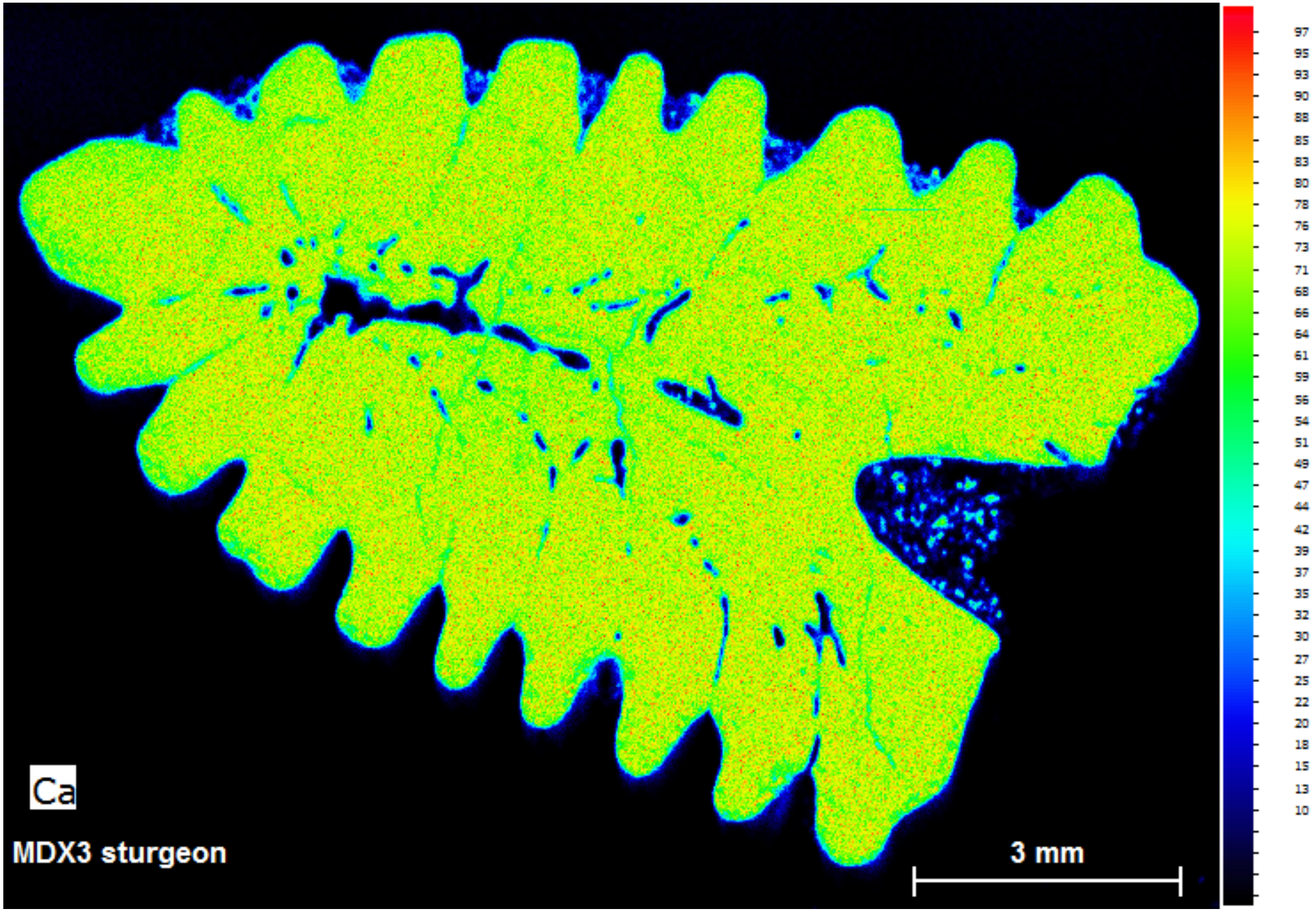

K Si Fe
X2733 Paddlefish
4 mm

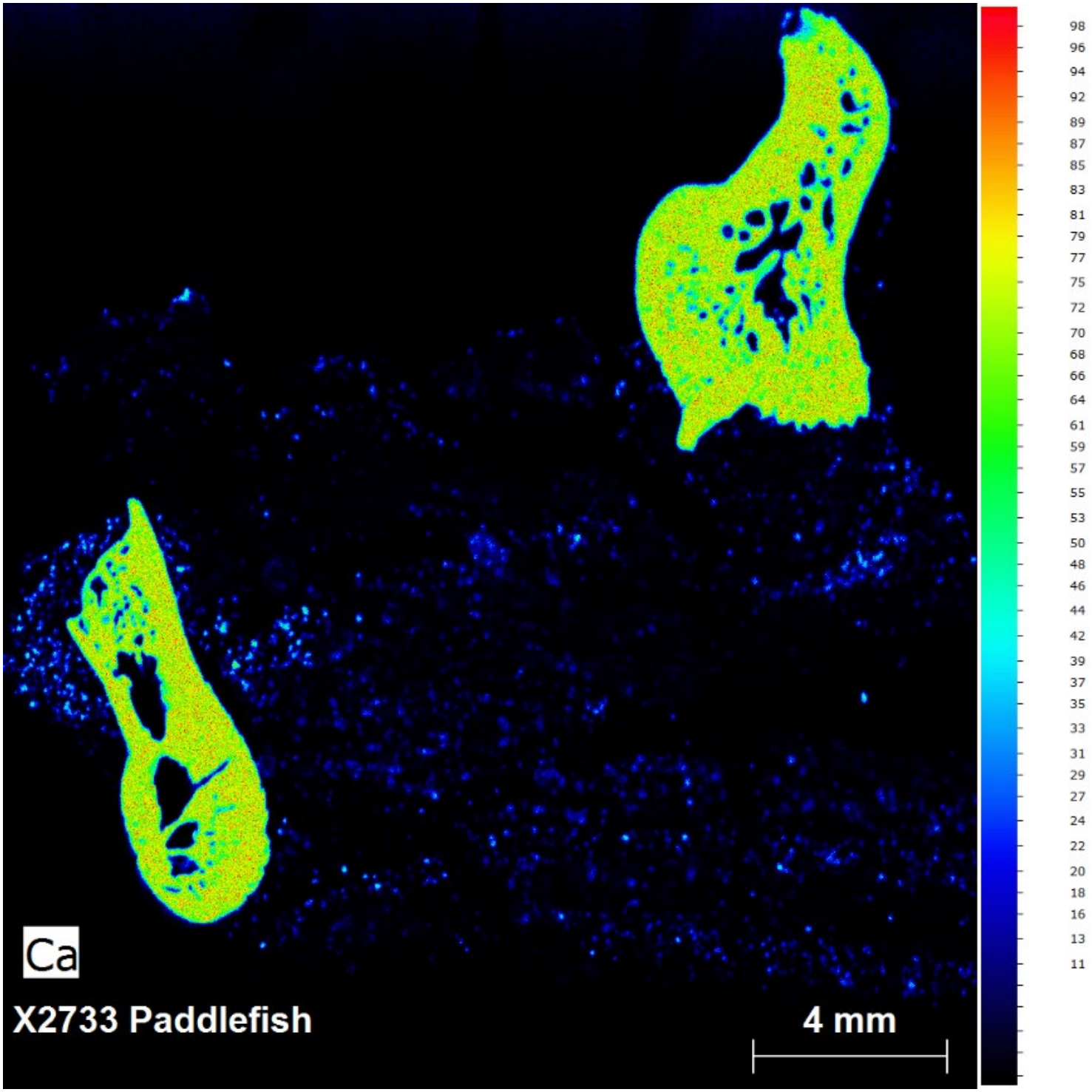

K
Si
Fe
X2743M Sturgeon
3 mm

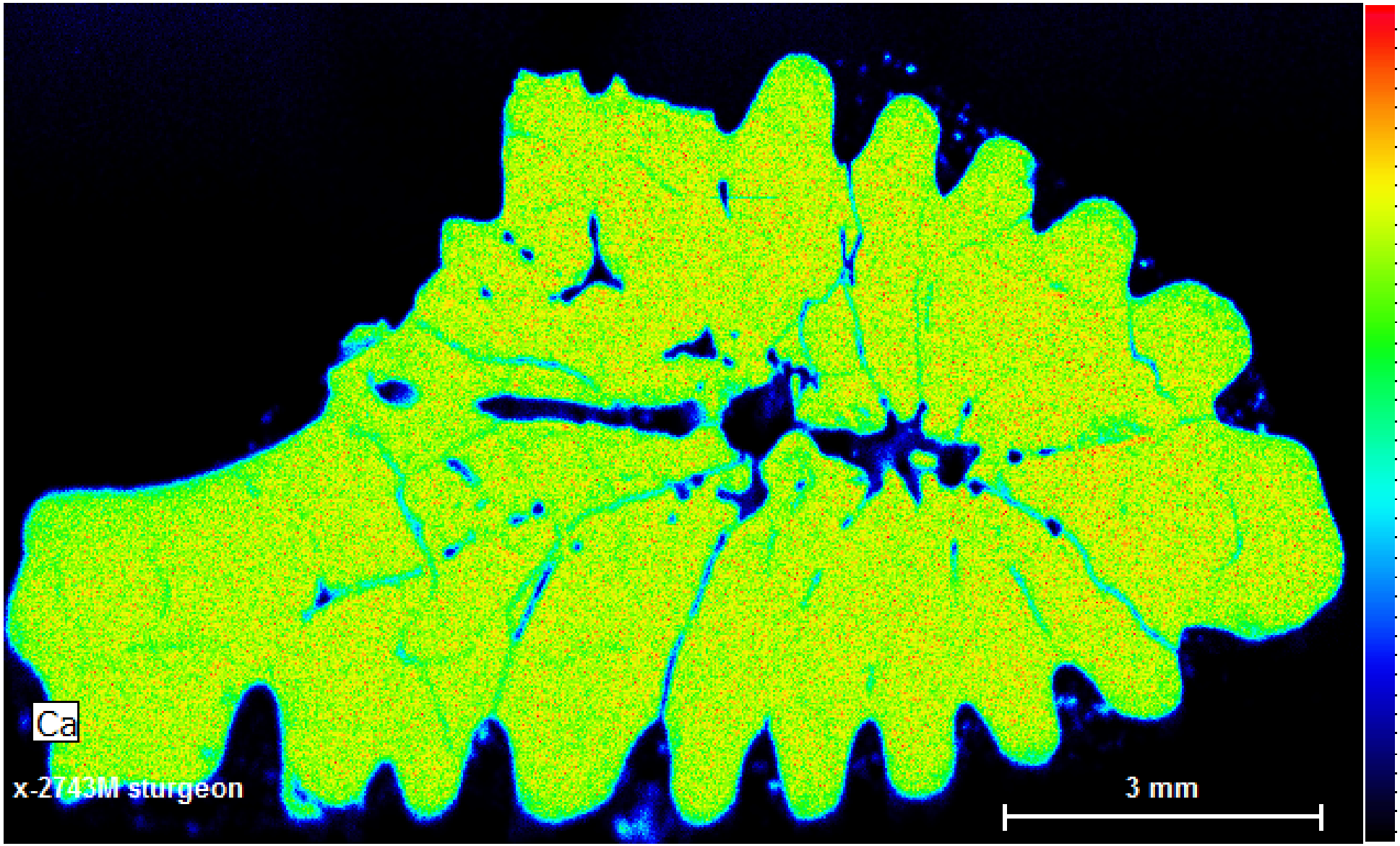


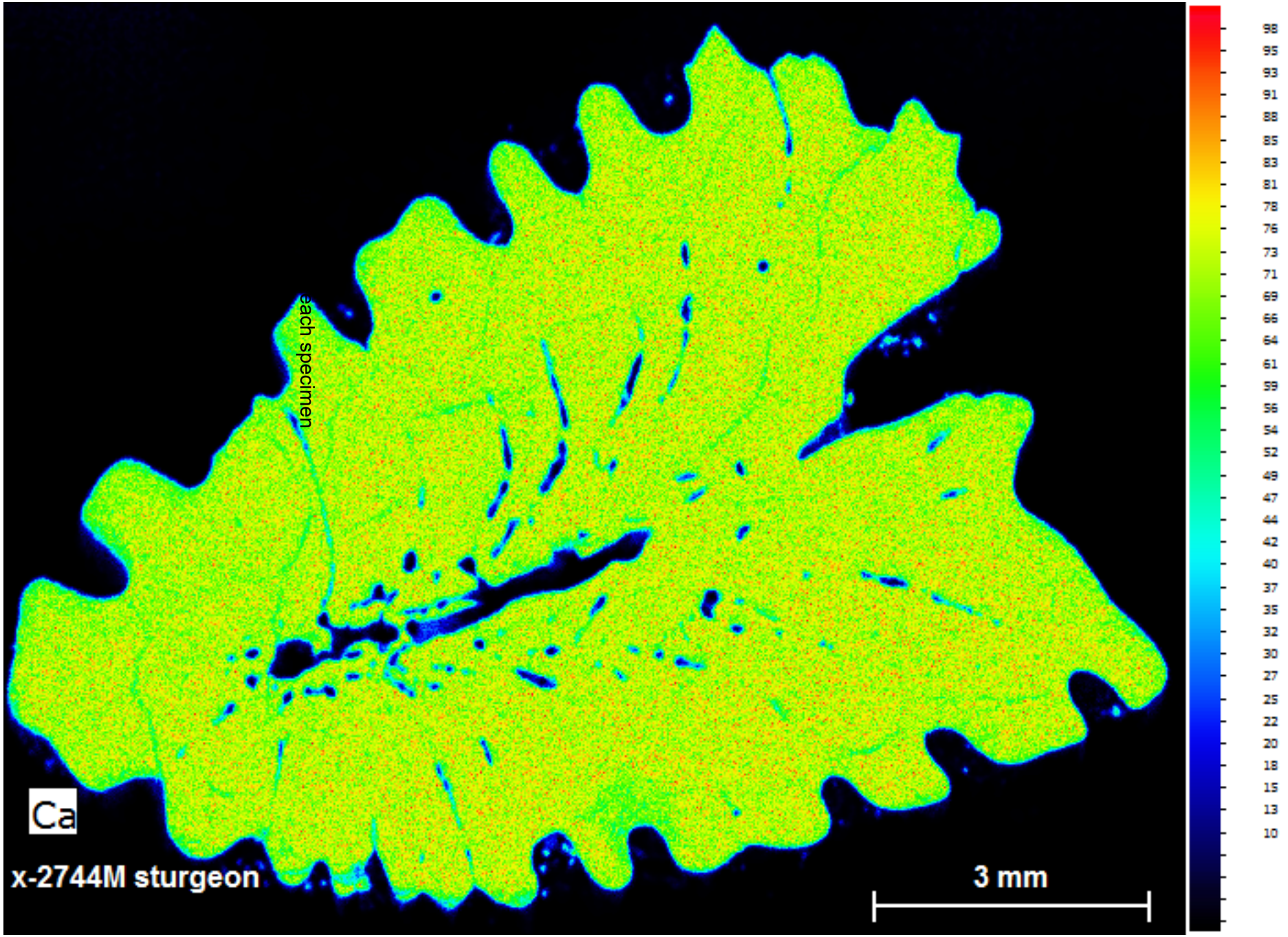
2.4 Heat maps of Ca for each specimen

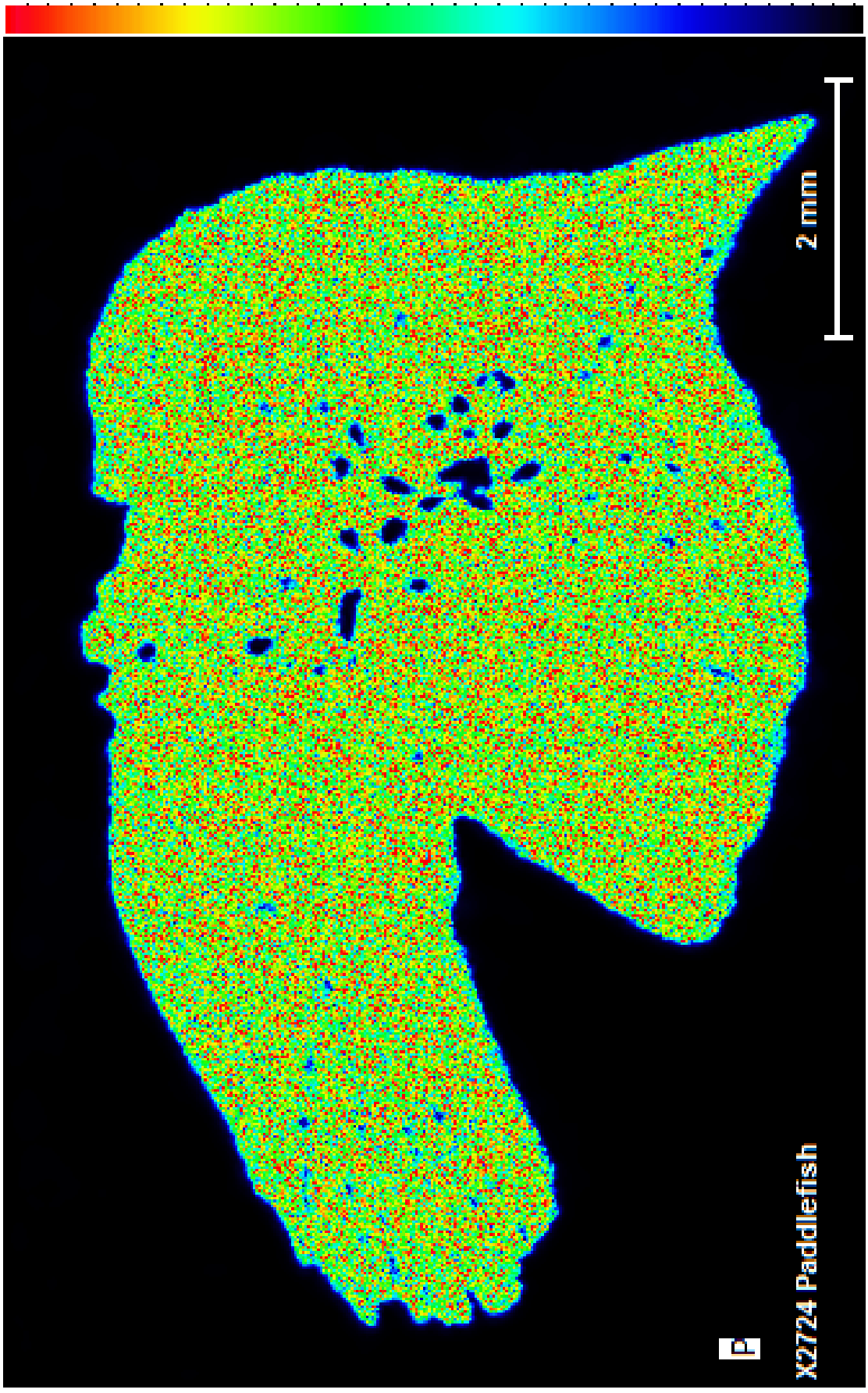

2 mm
X2724 Paddlefish
Ca

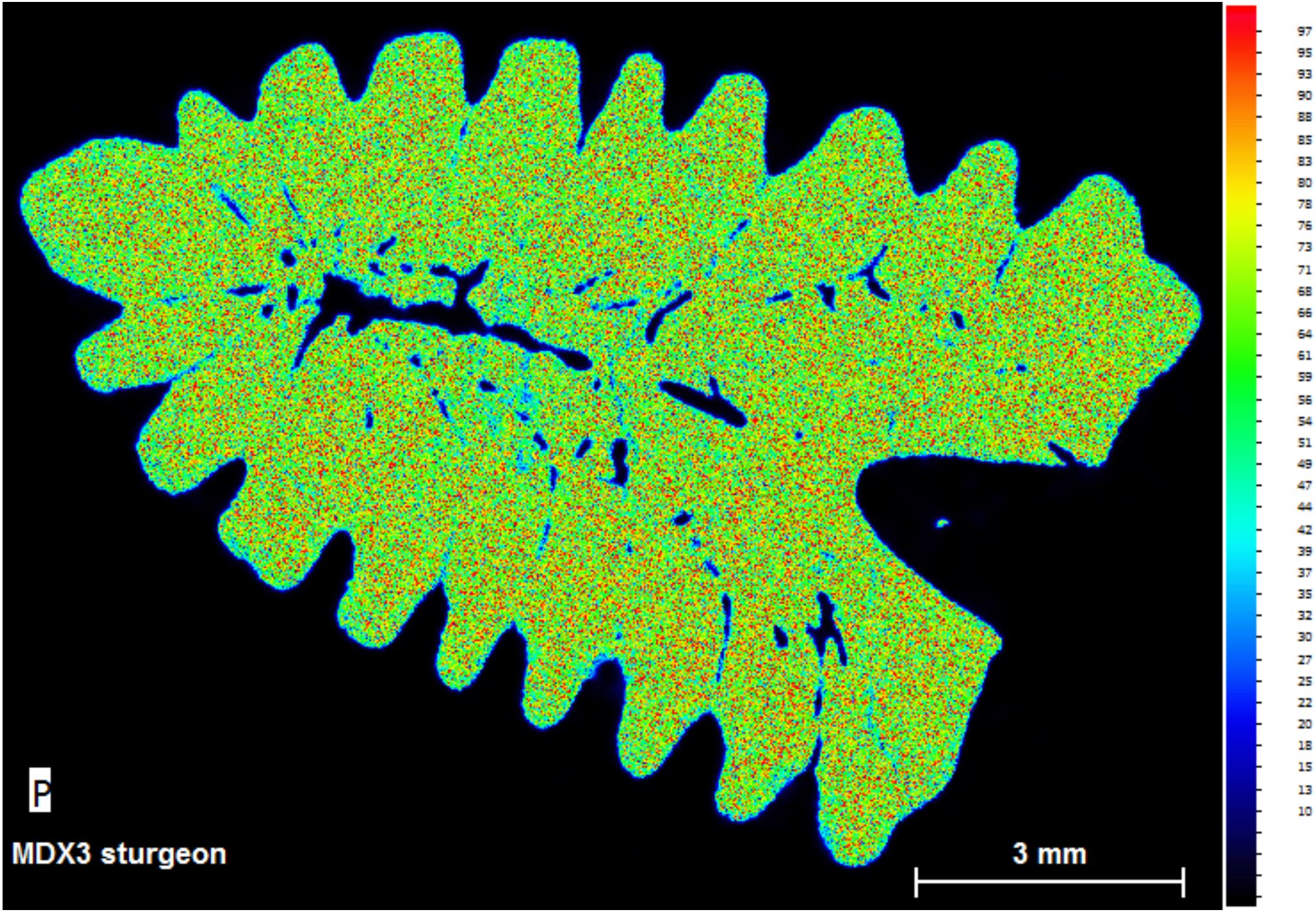

Ca
MDX3 sturgeon
3 mm
97
95
93
90
88
85
83
80
78
76
73
71
68
66
64
61
59
56
54
51
49
47
44
42
39
37
35
32
30
27
25
22
20
18
15
13
10


98
96
94
92
89
87
85
83
81
79
77
75
72
70
68
66
64
61
59
57
55
53
50
48
46
44
42
39
37
35
33
31
29
27
24
22
20
18
16
13
11
Ca
X2733 Paddlefish
4 mm


Ca
x-2743M sturgeon
3 mm


each specimen
Ca
x-2744M sturgeon
3 mm
98
95
93
91
88
85
83
81
78
76
73
71
69
66
64
61
59
56
54
52
49
47
44
42
40
37
35
32
30
27
25
22
20
18
15
13
10


2 mm
F
X2724 Paddlefish


P
MDX3 sturgeon
3 mm
97
95
93
90
88
85
83
80
78
76
73
71
68
66
64
61
59
56
54
51
49
47
44
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32
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27
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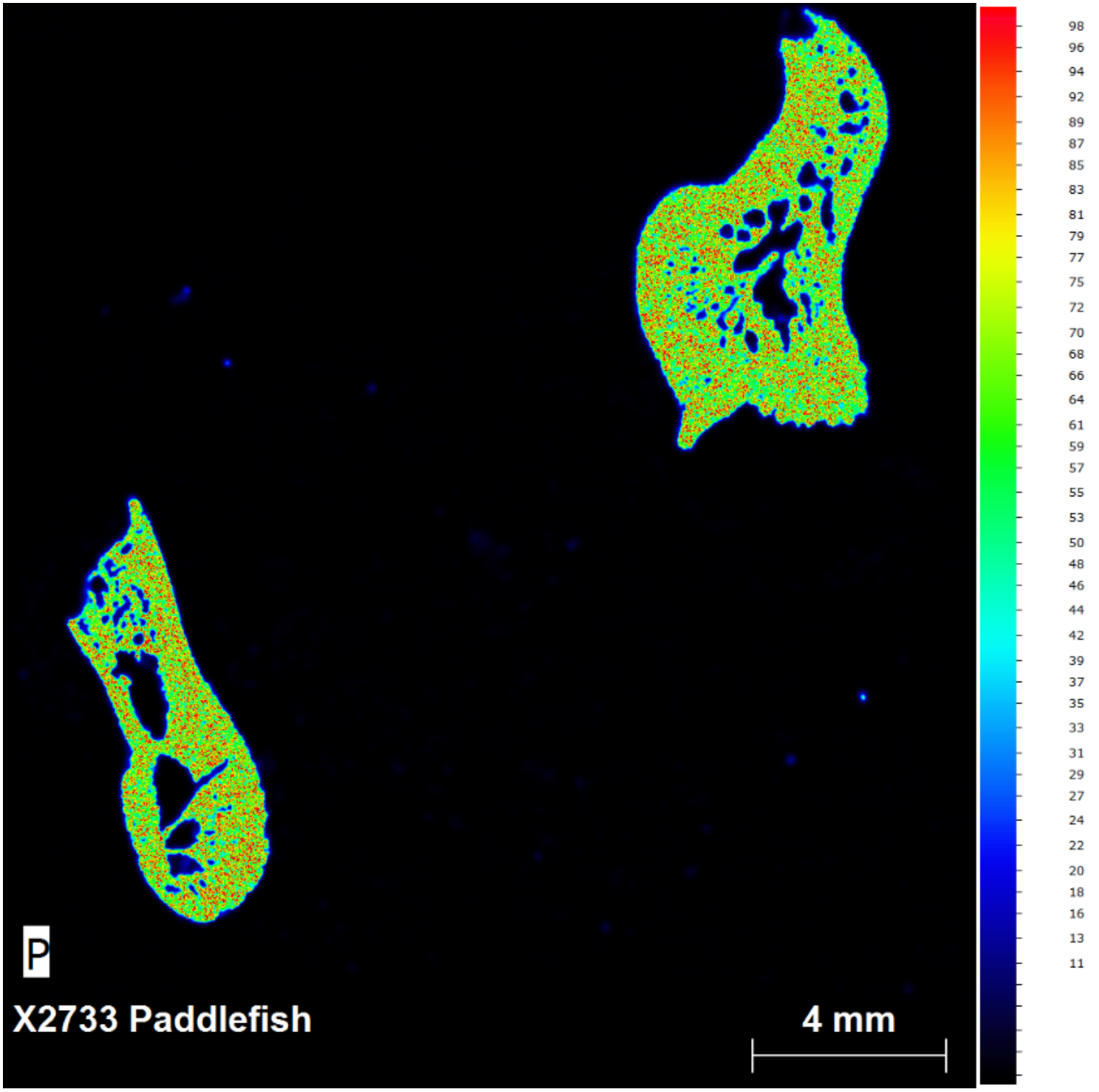
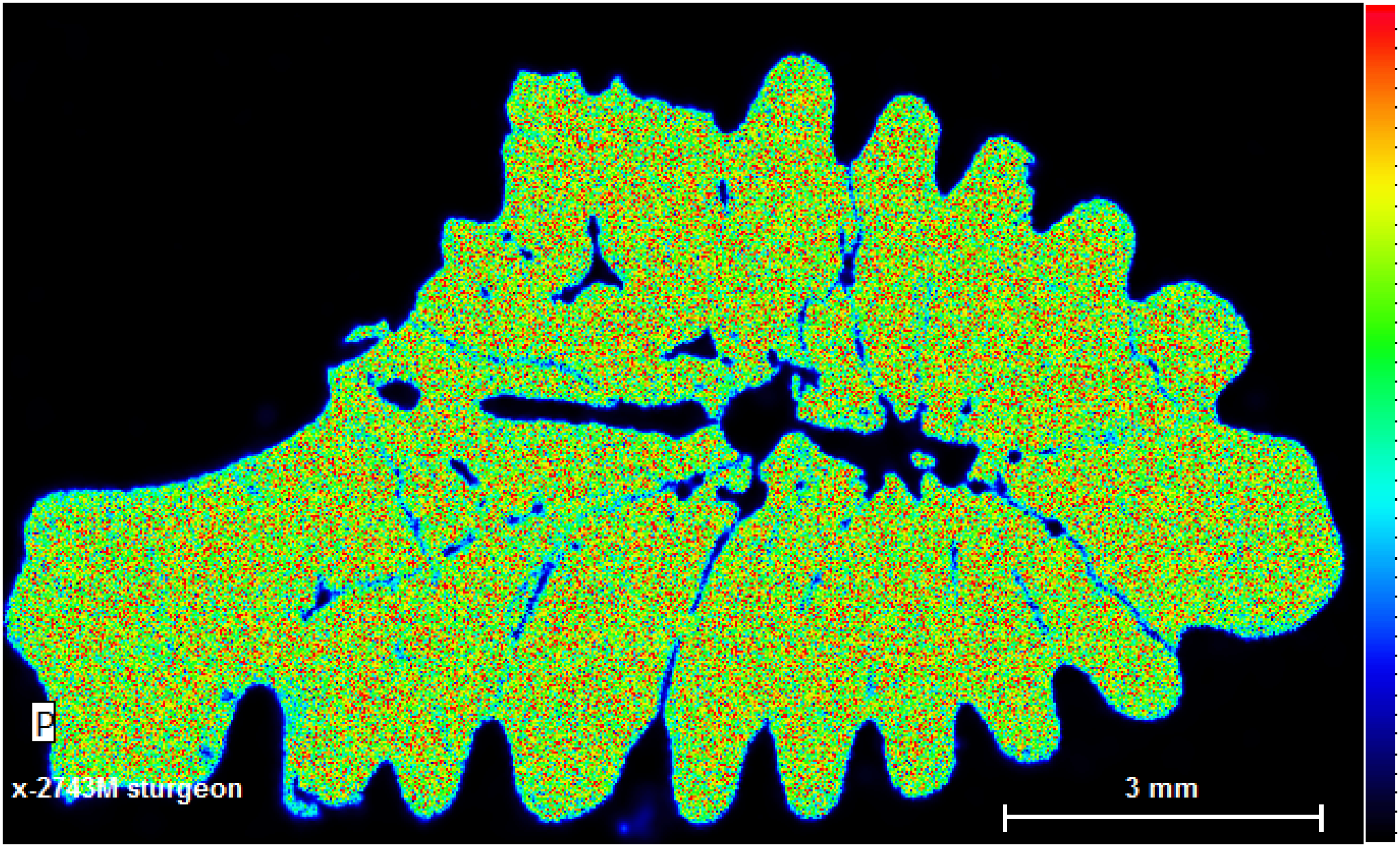
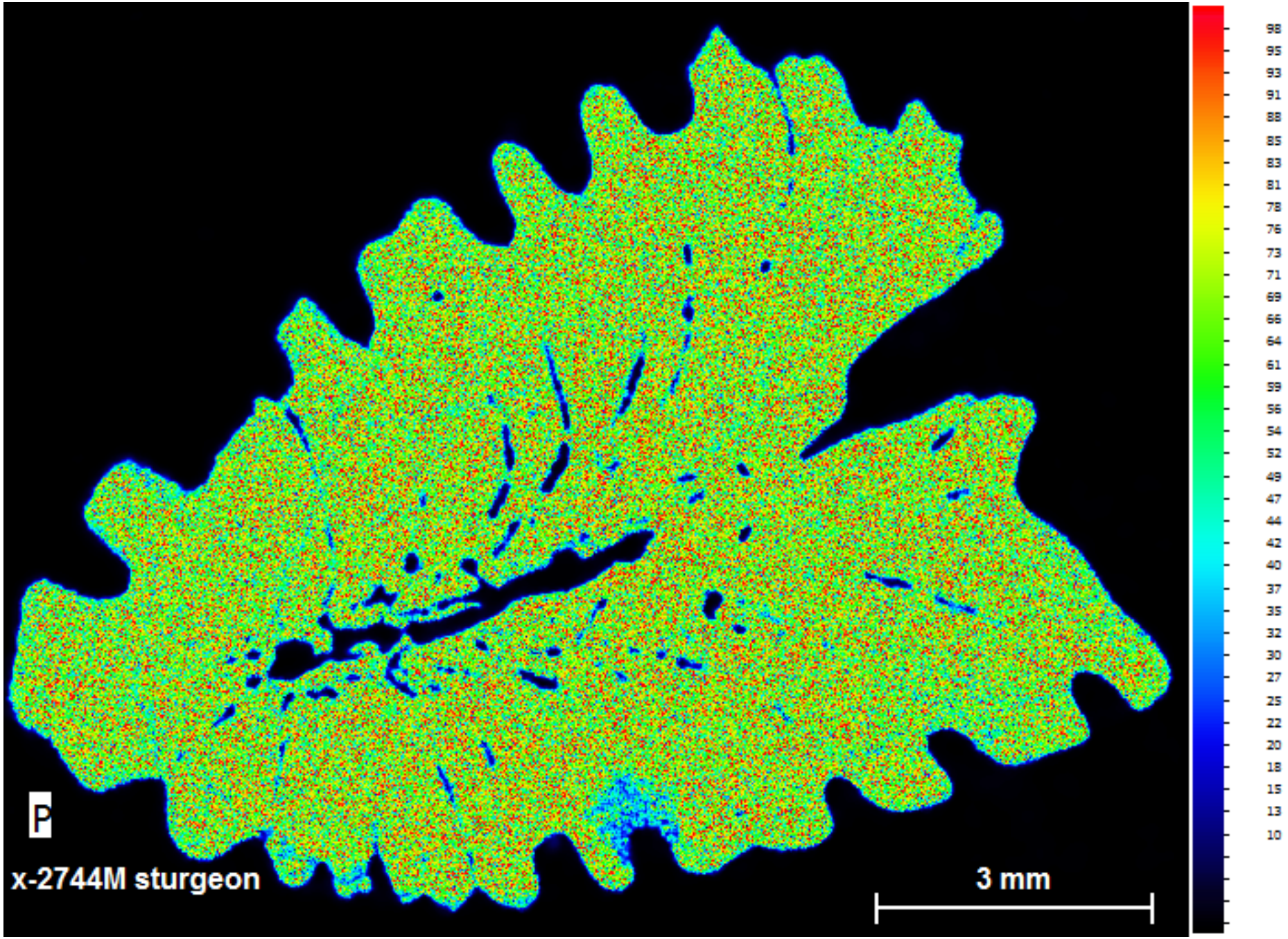
22
20
18
15
13
10


98
96
94
92
89
87
85
83
81
79
77
75
72
70
68
66
64
61
59
57
55
53
50
48
46
44
42
39
37
35
33
31
29
27
24
22
20
18
16
13
11
P
X2733 Paddlefish
4 mm


P
x-2743M sturgeon
3 mm


P
x-2744M sturgeon
3 mm
98
95
93
91
88
85
83
81
78
76
73
71
69
66
64
61
59
56
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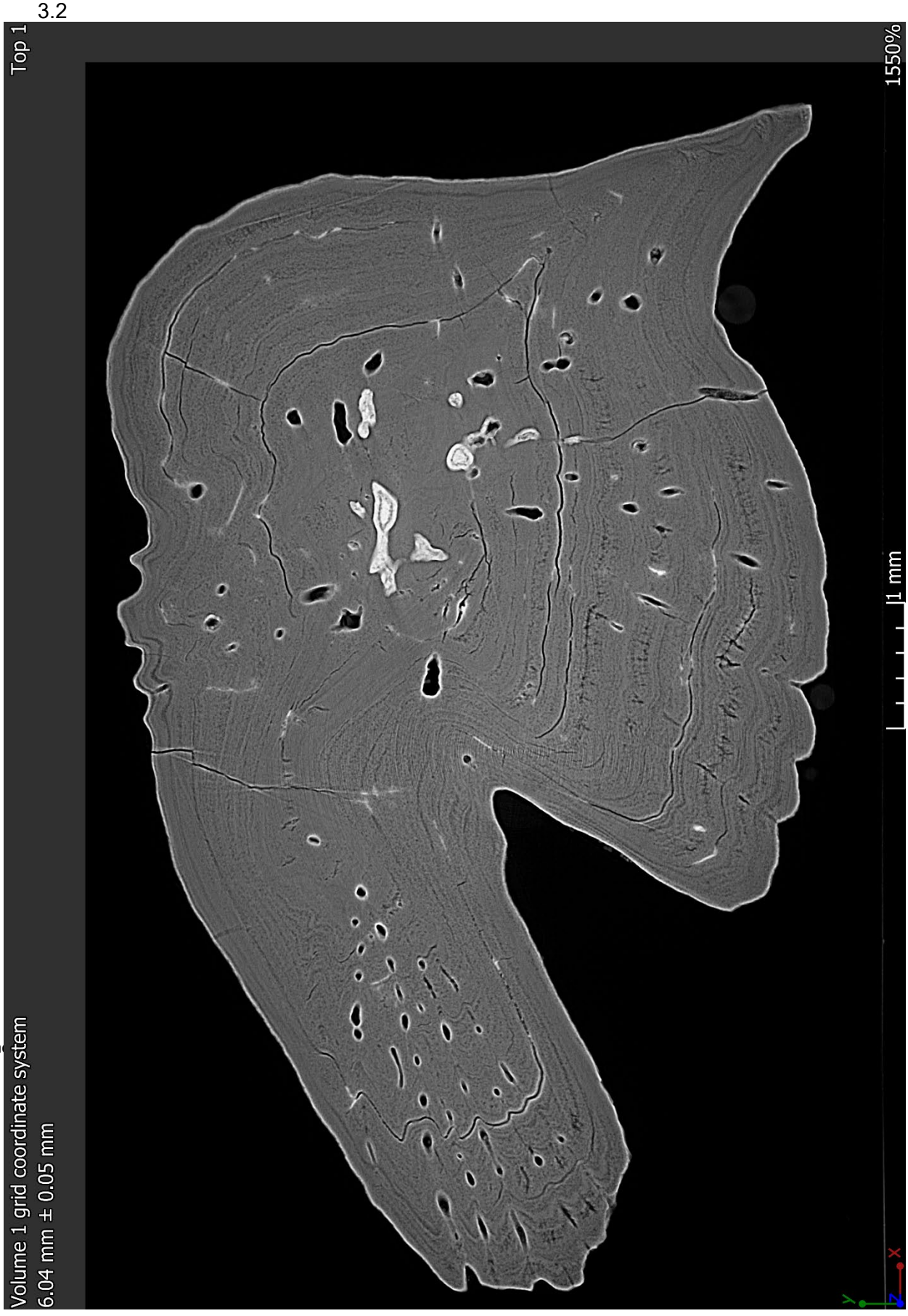
10

3. Propagation-based phase contrast synchrotron radiation micro computed tomography

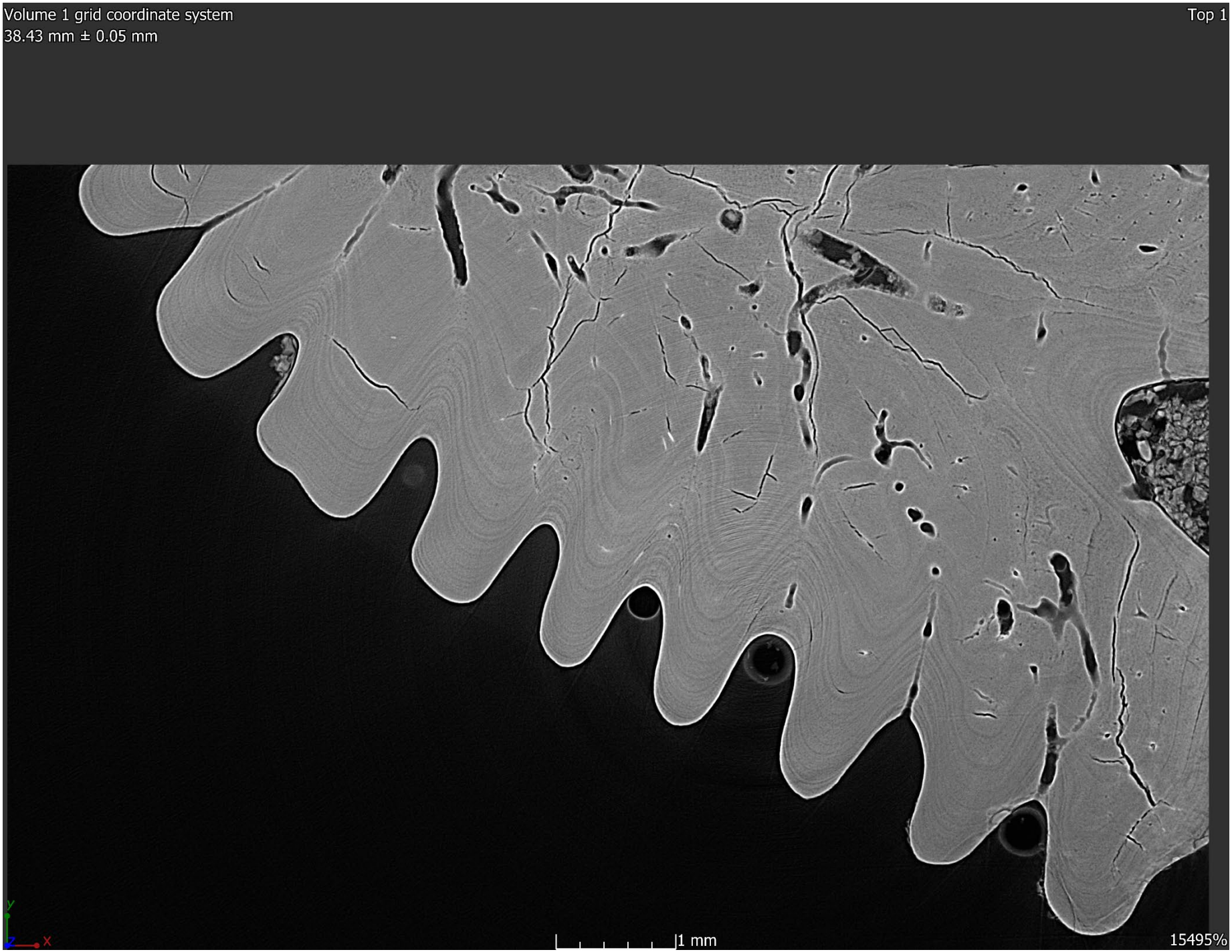
3.1 Thick slab (virtual thin sections) of X-2724, MDX-3, X-2743M and X-2744M

3.2

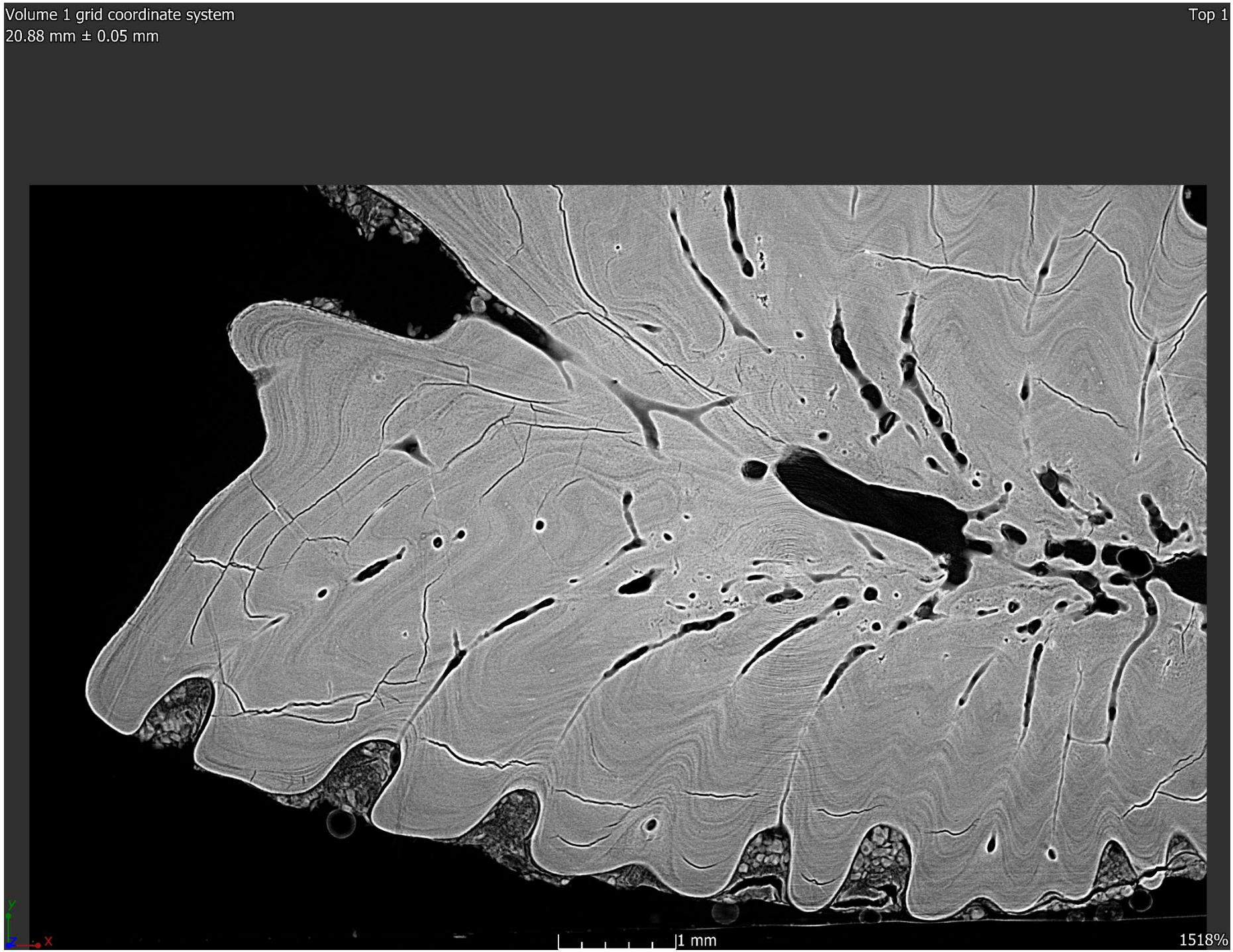


Ca ıylla

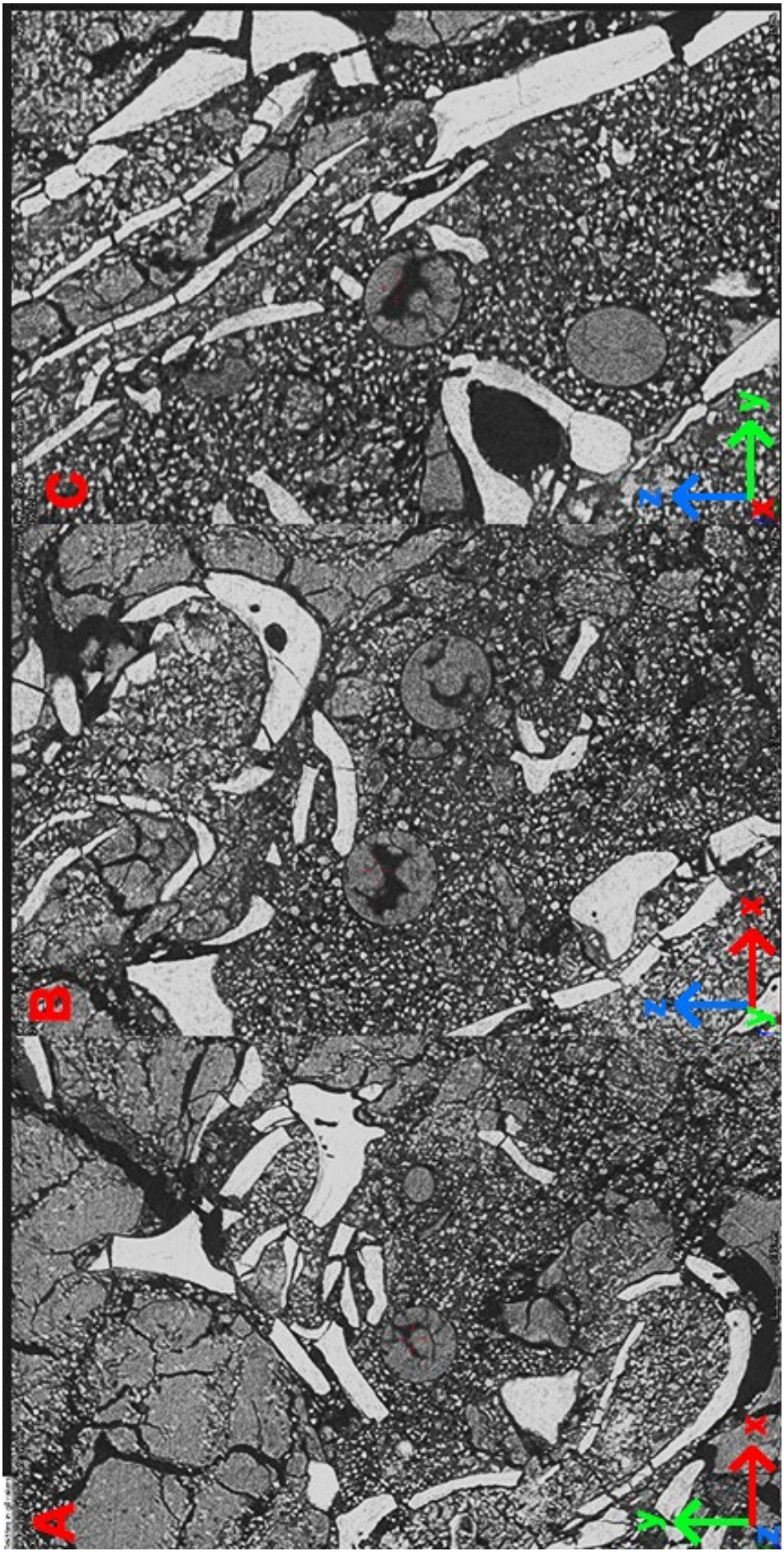
X-2724

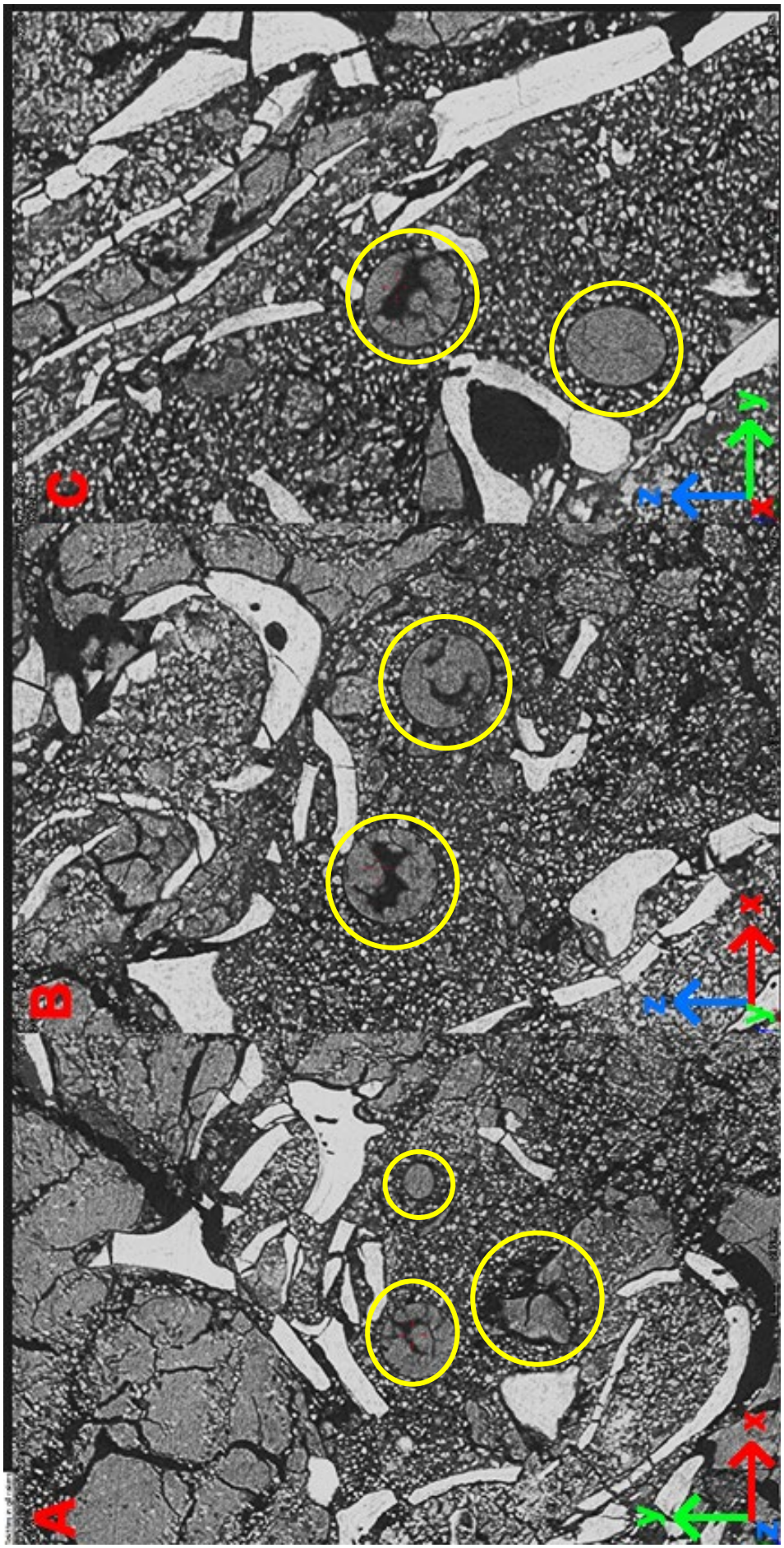

Volume 1 grid coordinate system
38.43 mm ± 0.05 mm
Top 1
y
x
1 mm
15495%


Volume 1 grid coordinate system
20.30 mm ± 0.05 mm
Top 1
y
x
1 mm
1518%


Volume 1 grid coordinate system
20.88 mm ± 0.05 mm
Top 1
1 mm
1518%

4.1 Thick slab (virtual thin sections) of FAU.DGS.ND.161.4559.T with the impact spherules in the gill rakers (tektites indicated on next page)




C
B
A

3.1 Thick slabs (virtual thin sections) of the membranous non-mineralized sidewalls of the cranial cavity of FAU.DGS.ND.161.4559.T with locations indicated on the 3D model of the specimen.