



Troubleshooting Inadequately Cured Concrete or Why Did my Concrete Scale?

Iowa Better Concrete Conference

Iowa State University

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American Engineering Testing, Inc.

Reasons for Scaling of Exterior Concrete Flatwork

1. Poor overall air content

- a. No air entrainment
 - batching error
 - wrong mix delivered
- b. extended time before placement

Reasons for Scaling of Exterior Concrete Flatwork



2. Poor finishing practices

- a. Over-finishing
- b. Working water into the surface
- c. Retempering/excessive w/cm
- d. Inadequate curing
 - Late
 - Incomplete

Reasons for Scaling of Exterior Concrete Flatwork



3. Late season placements (premature service) – lack of durability strength
4. Exposure to Salt hastens distress
 - a. Lowers freezing temp of water
 - b. Critical saturation due to osmosis
 - c. Produces a specific environmental condition
 - d. Who's fault?
 - e.concrete was already compromised



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SUPERINTENDENT

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PARKING
♿

RESERVED
PARKING
♿

RESERVED
VISITORS

RESERVED
VISITORS



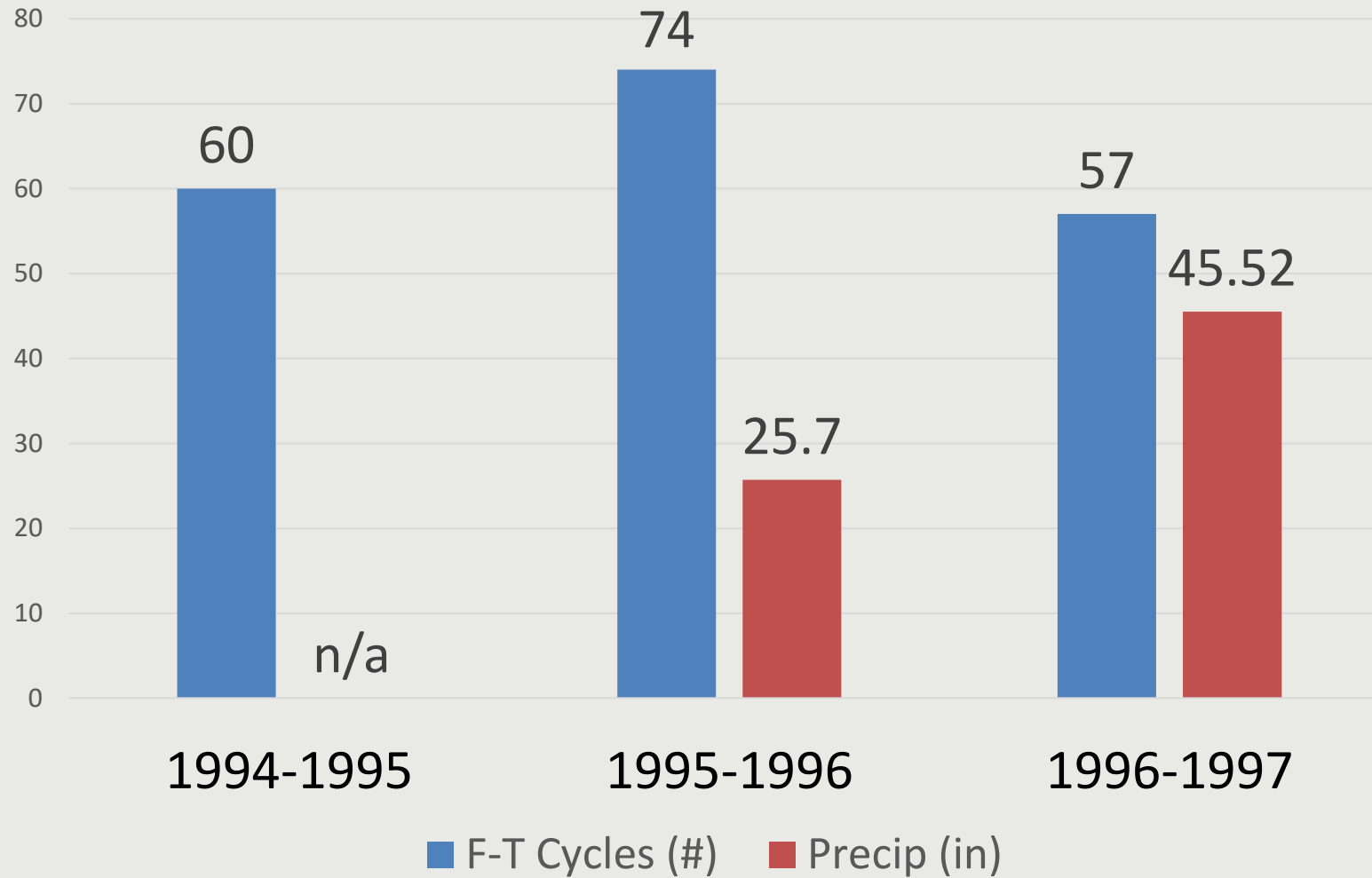


SECRETARY



1994-1997 Freeze-Thaw Cycles & Precipitation

Cycle Low temp ≤ 28
Precip. only Oct Nov Dec

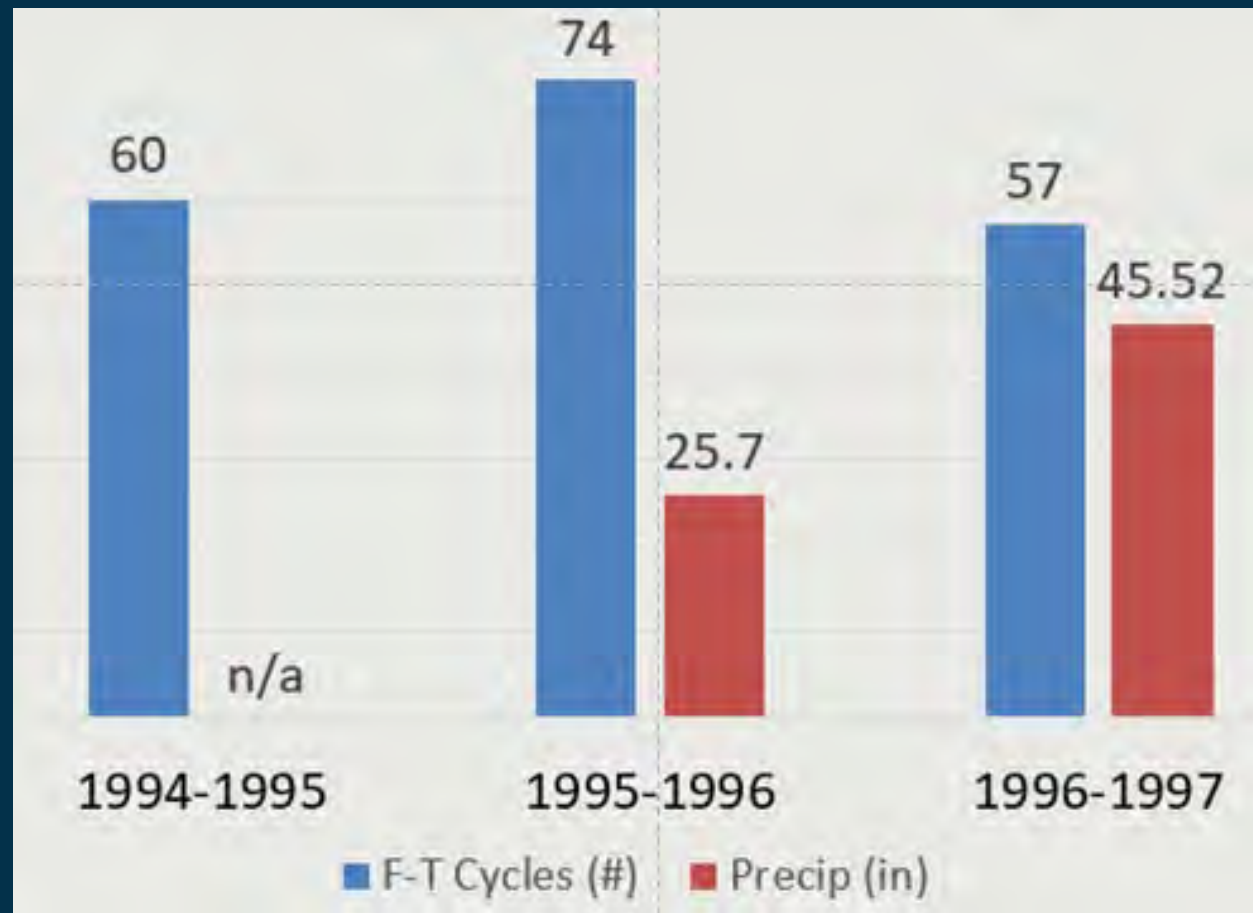


1998 ARMMN Study After 96-97

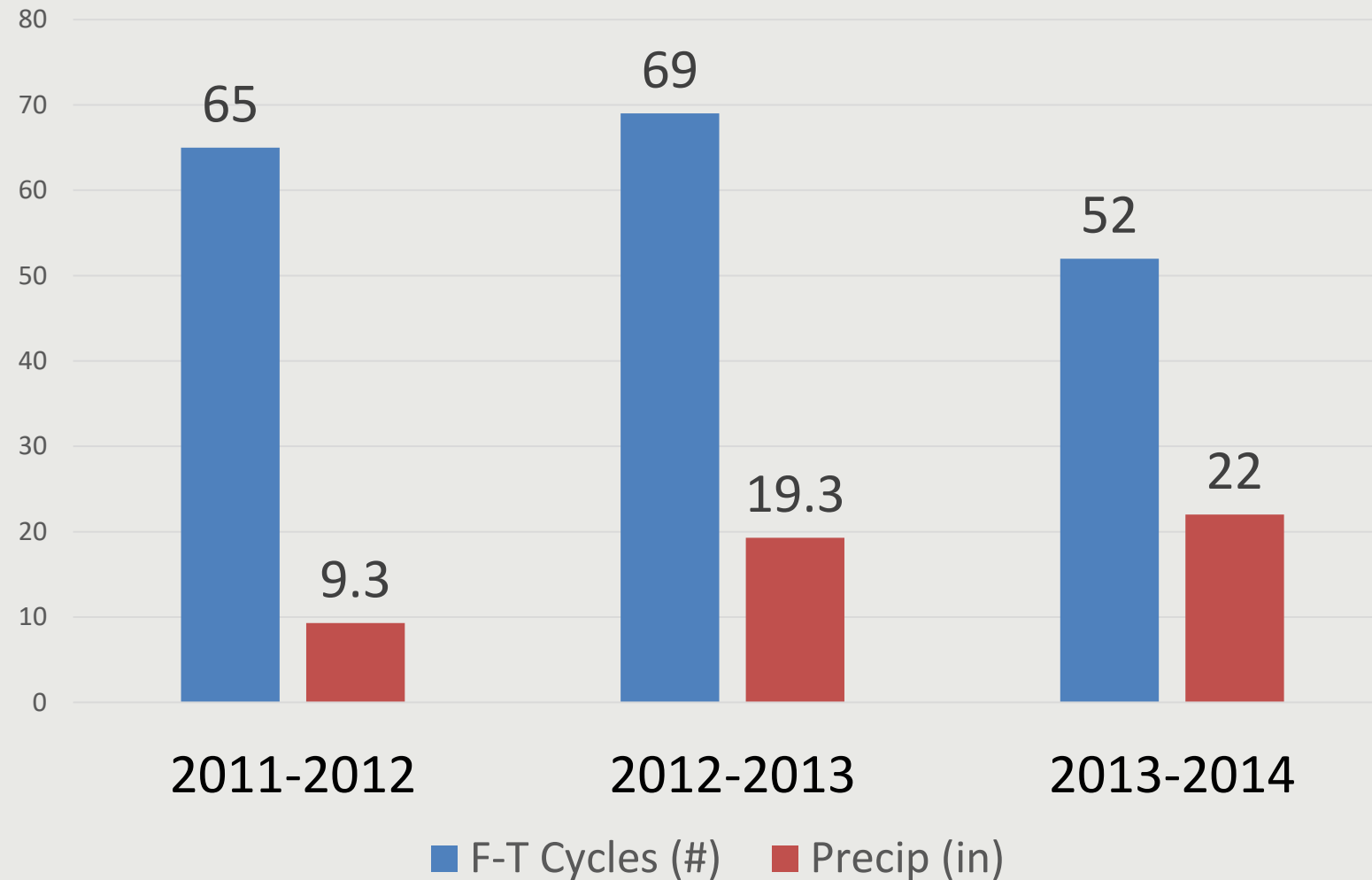
33 Core Samples

Air Problems	21% total
Low air	15%
No air	6%
Over-finishing	48%
Inadequate Curing	61%
Long Haul Time (>45min)	42%
High w/cm (>0.45)	39%
Late Season Placement	15%

1994-1997 Freeze-Thaw Cycles & Precipitation



2011-2014 Freeze-Thaw Cycles & Precipitation

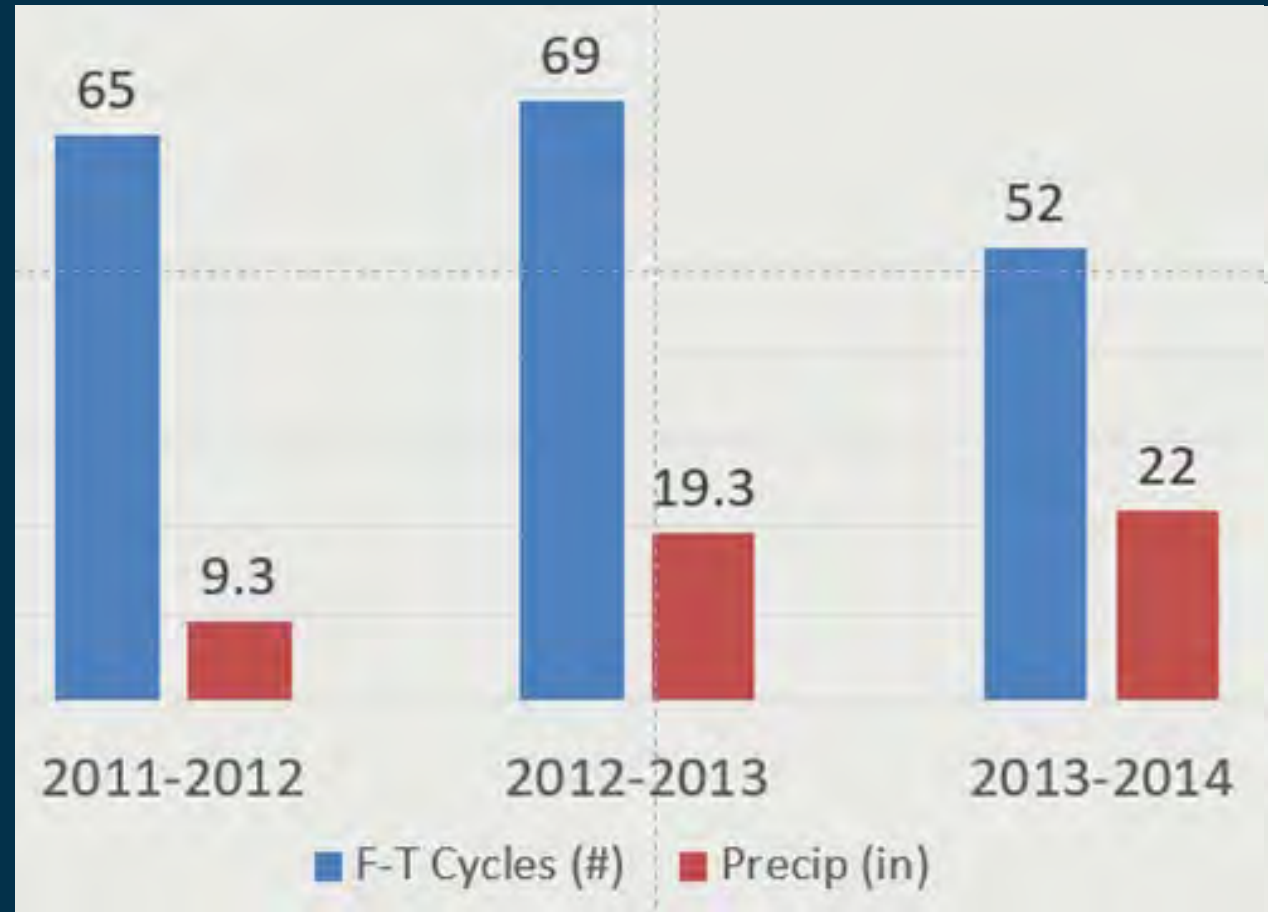


2015 ARM Study After 13-14

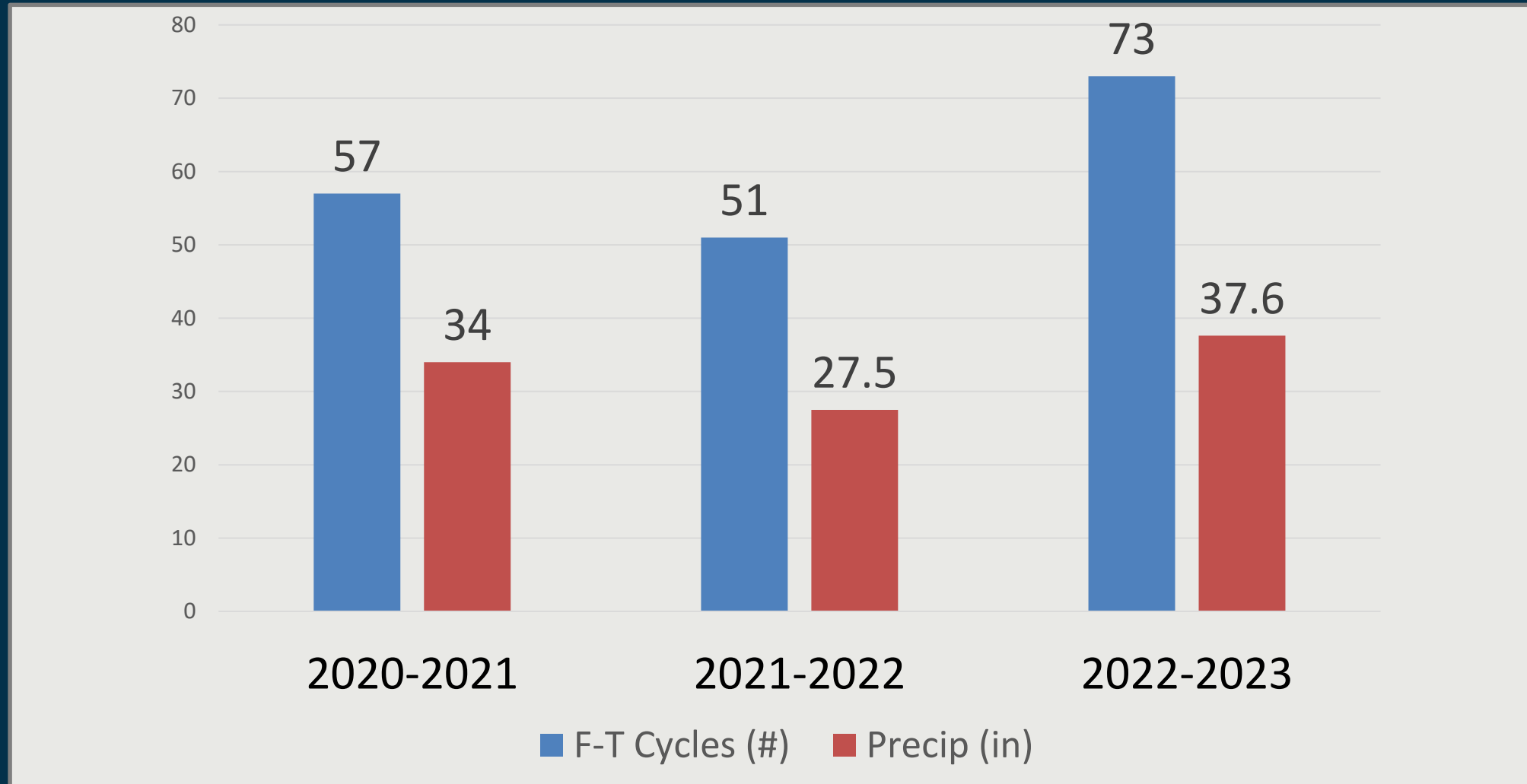
16 Core Samples

Low air	13%
Over-finishing	13%
Inadequate Curing	44%
w/cm <0.45	100%
Late Season Placement	31%

2011-2014 Freeze-Thaw Cycles & Precipitation



2020-2023 Freeze-Thaw Cycles & Precipitation







PETROGRAPHY

Microscopical
analysis of concrete
and aggregates

PETROGRAPHY

ASTM's

C856

C457

C1723



PETROGRAPHY

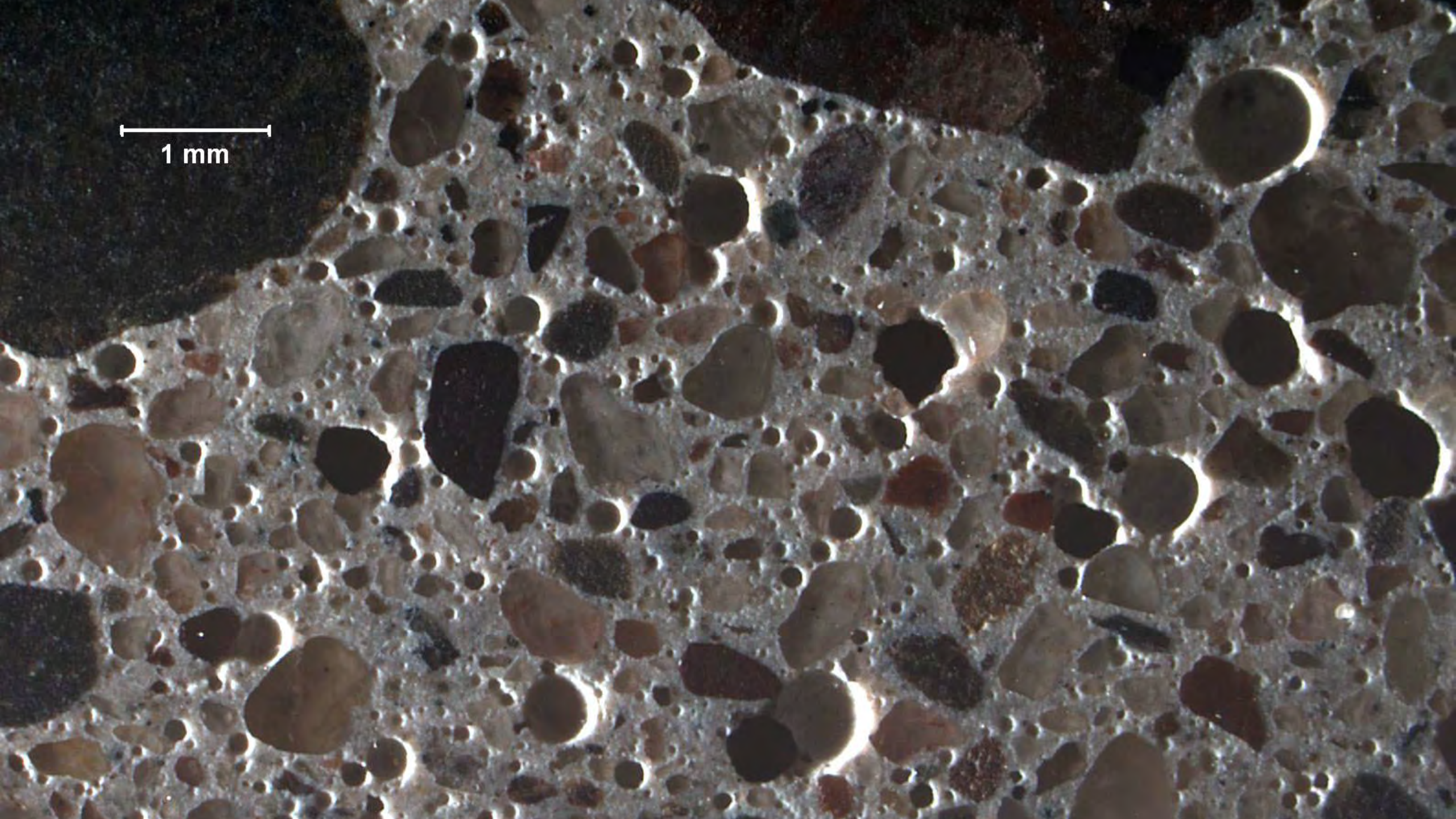
Core Sampling

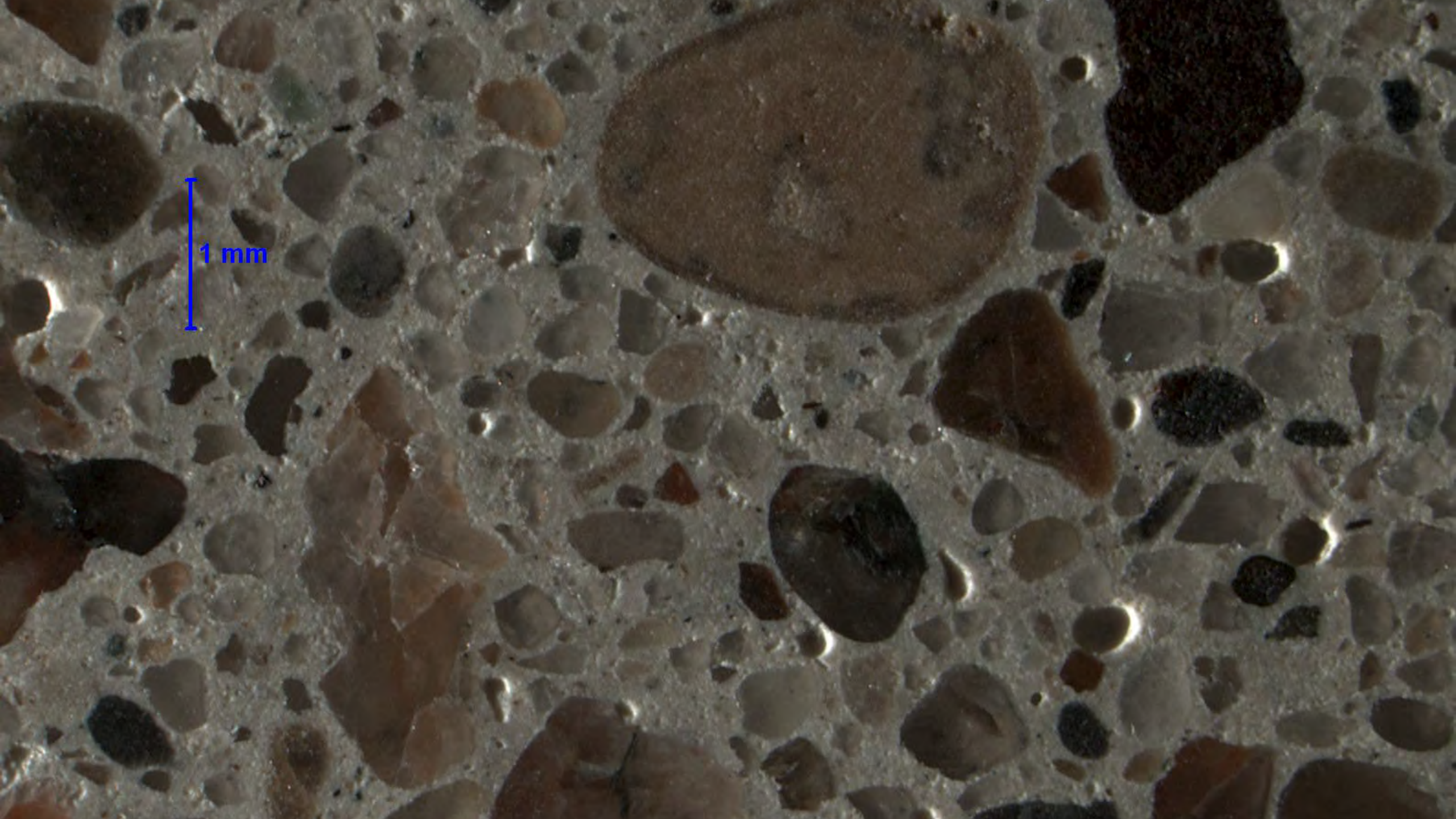
Preparation of lapped
and thin sections

Various microscopes



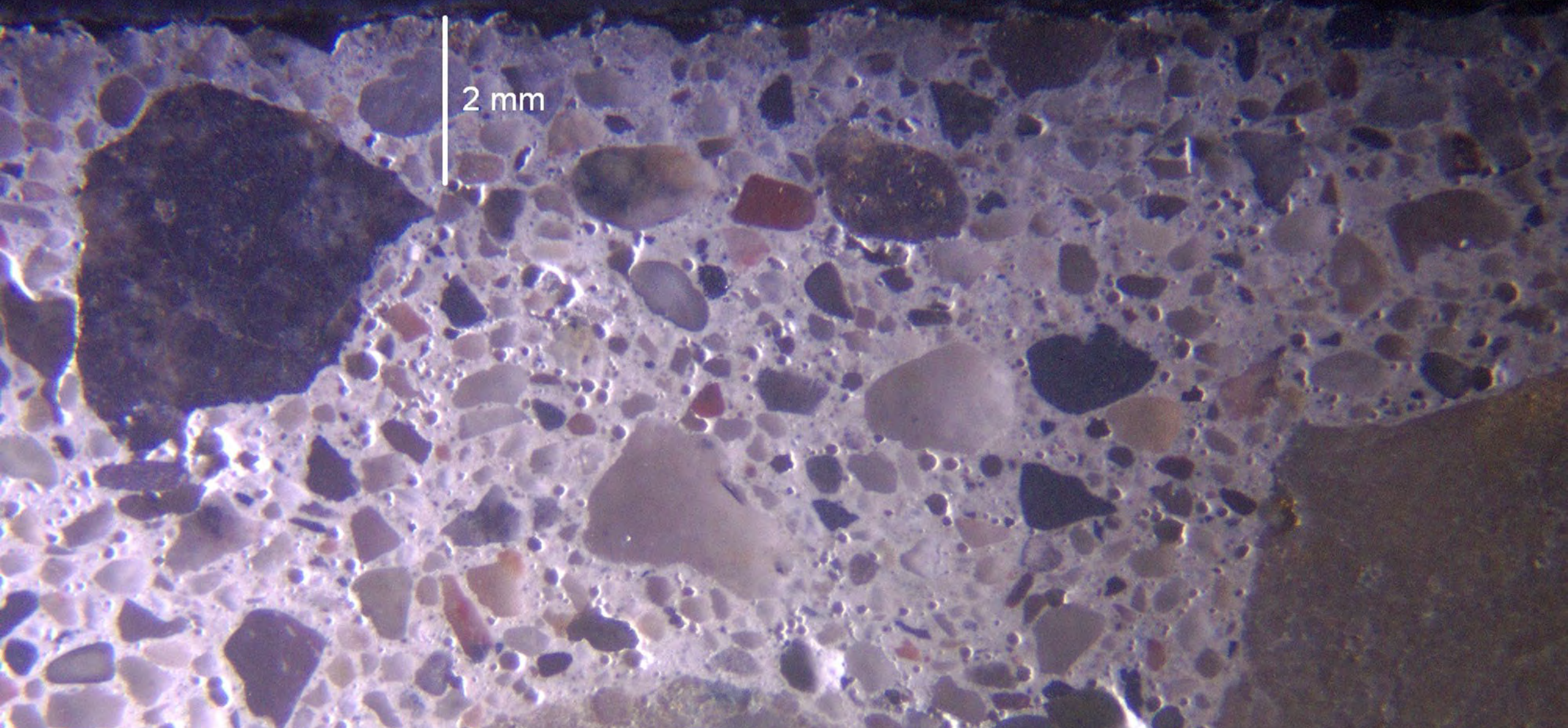




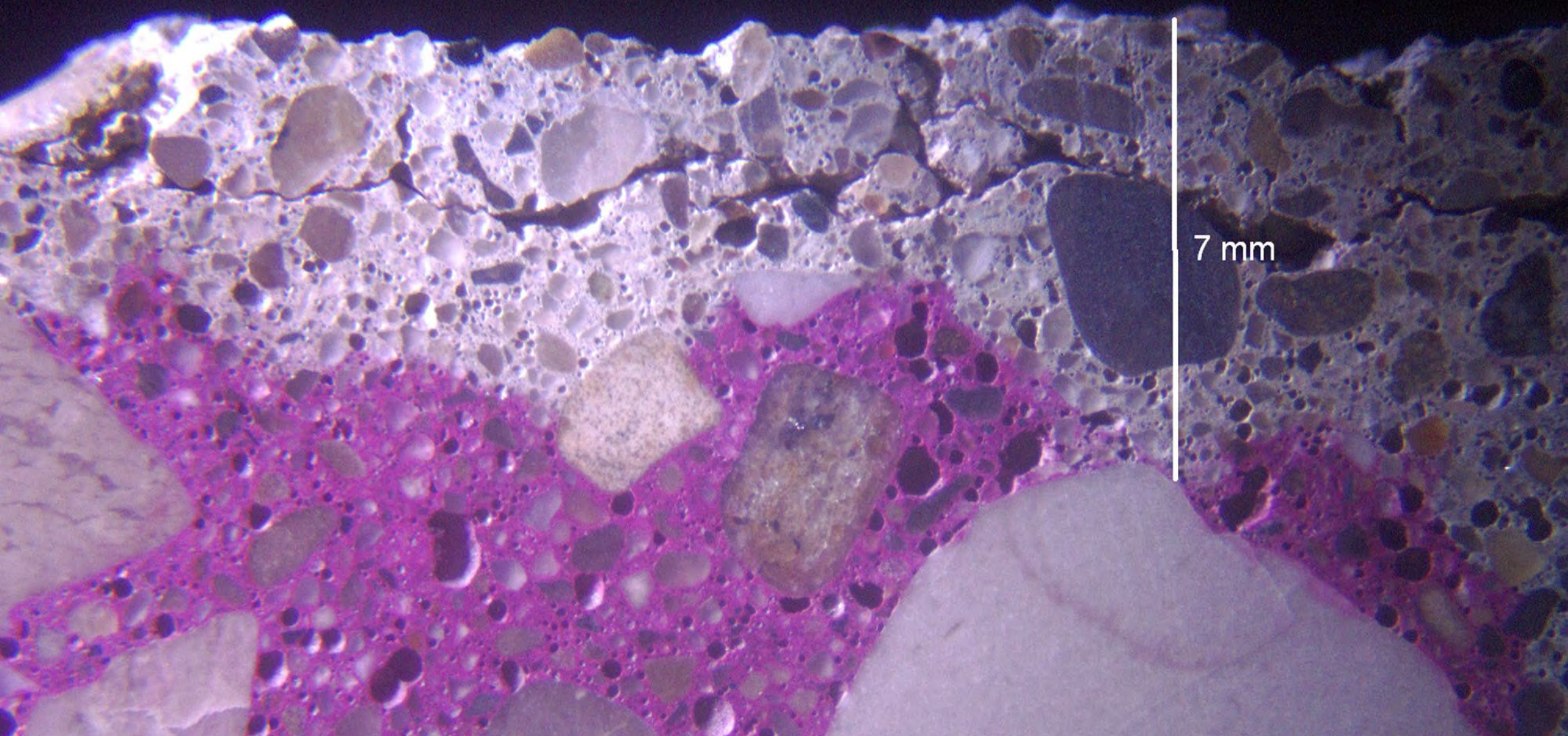


1 mm

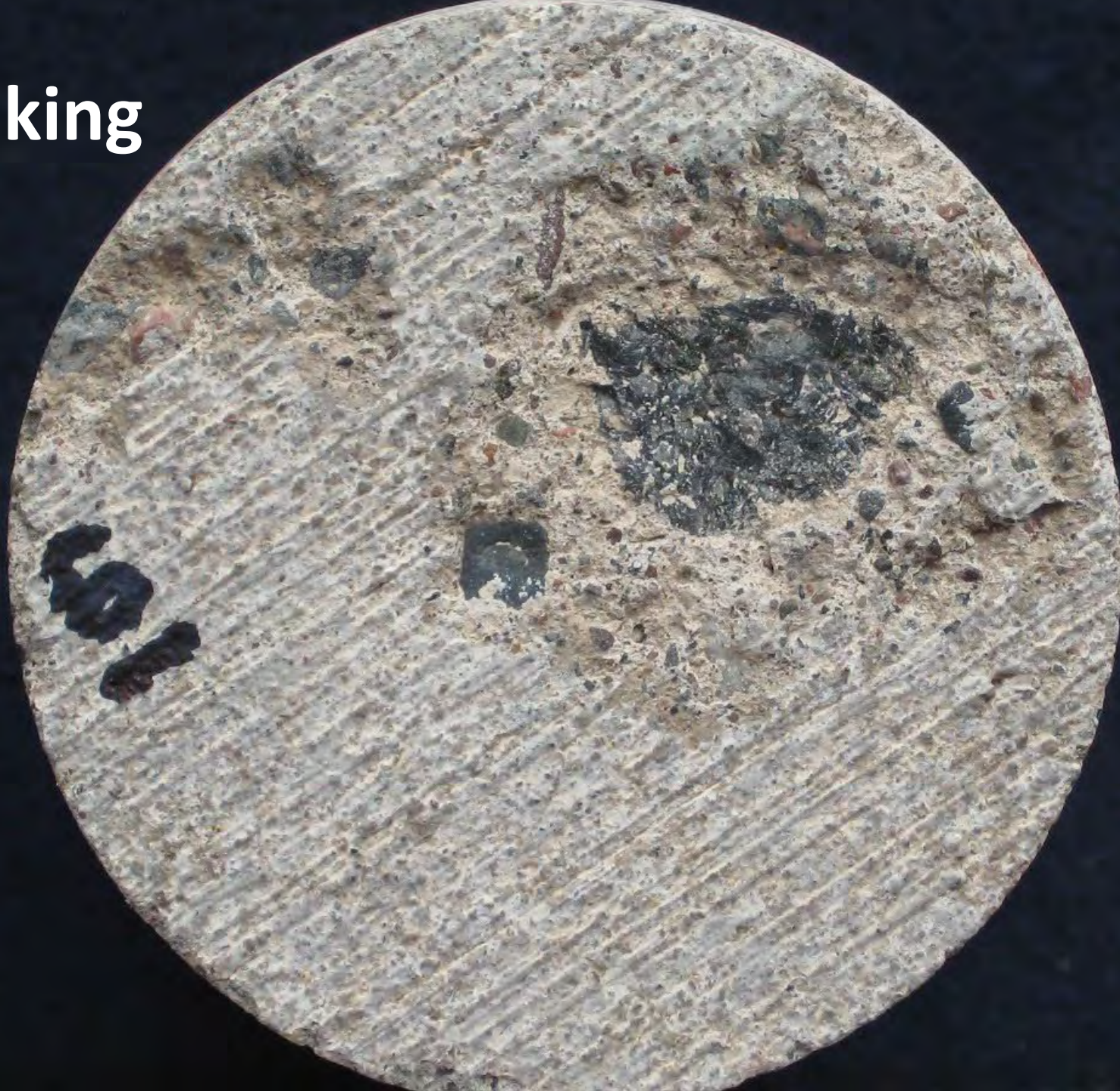
Over-finishing



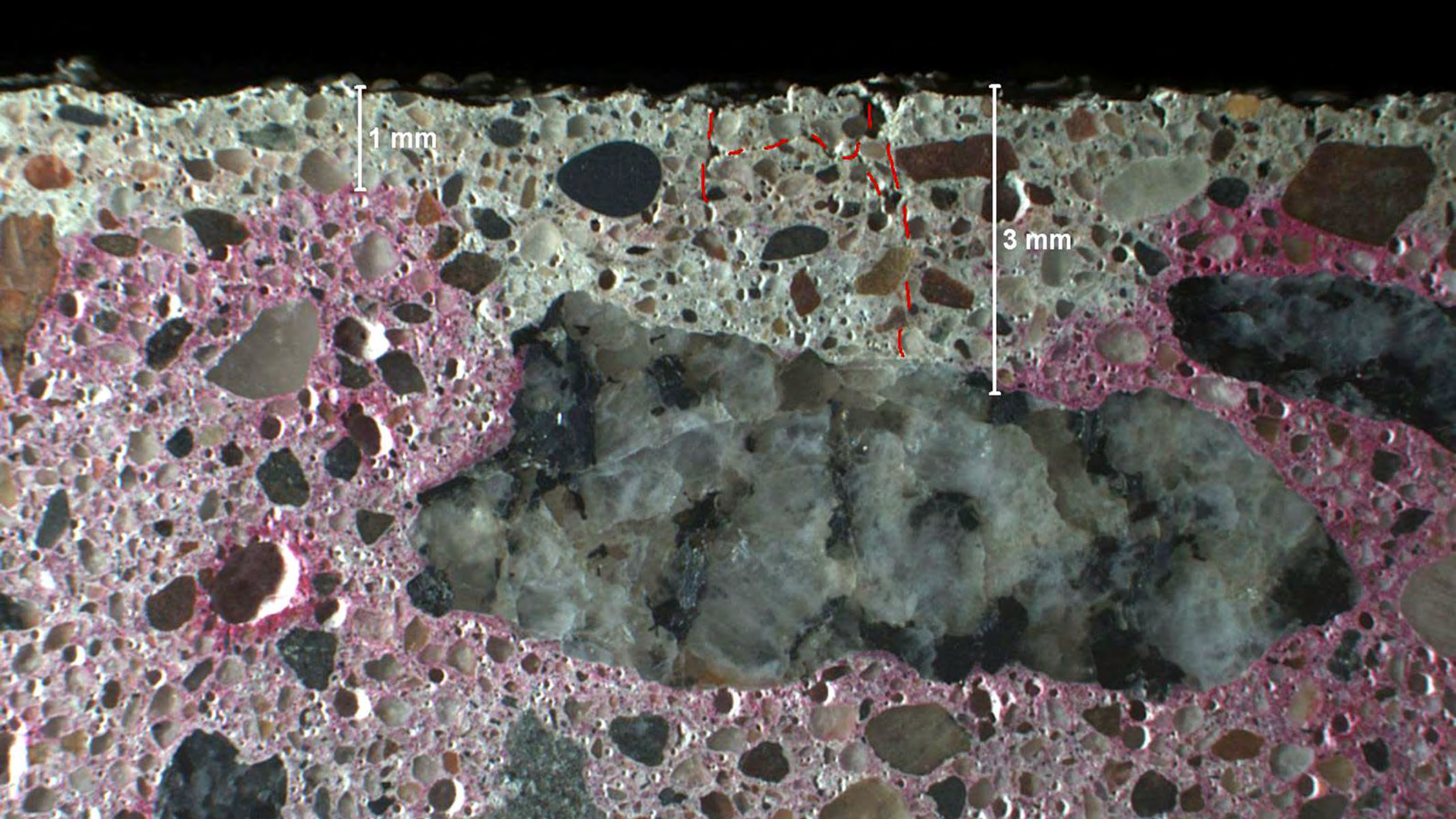
Carbonation and Scaling

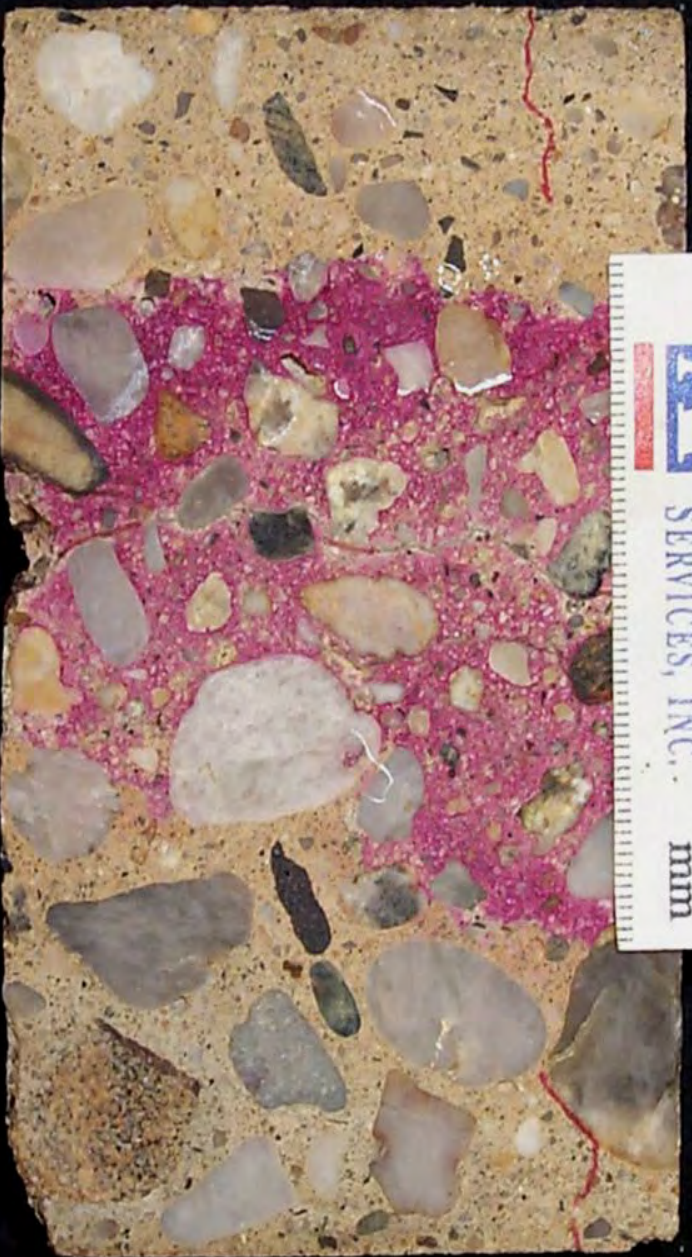


Mortar Flaking









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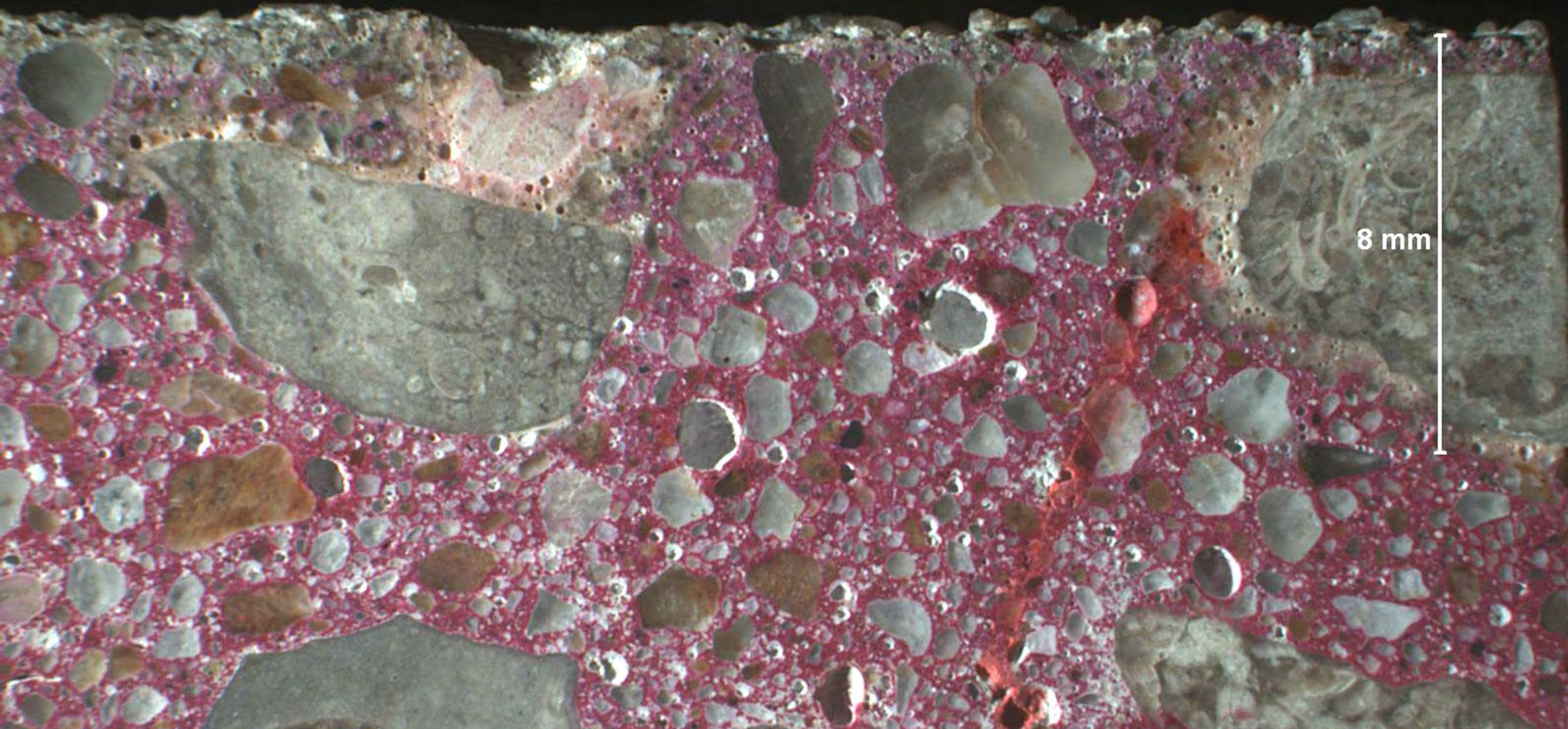
mm



University Sports Field Risers



40 year old airfield pavement

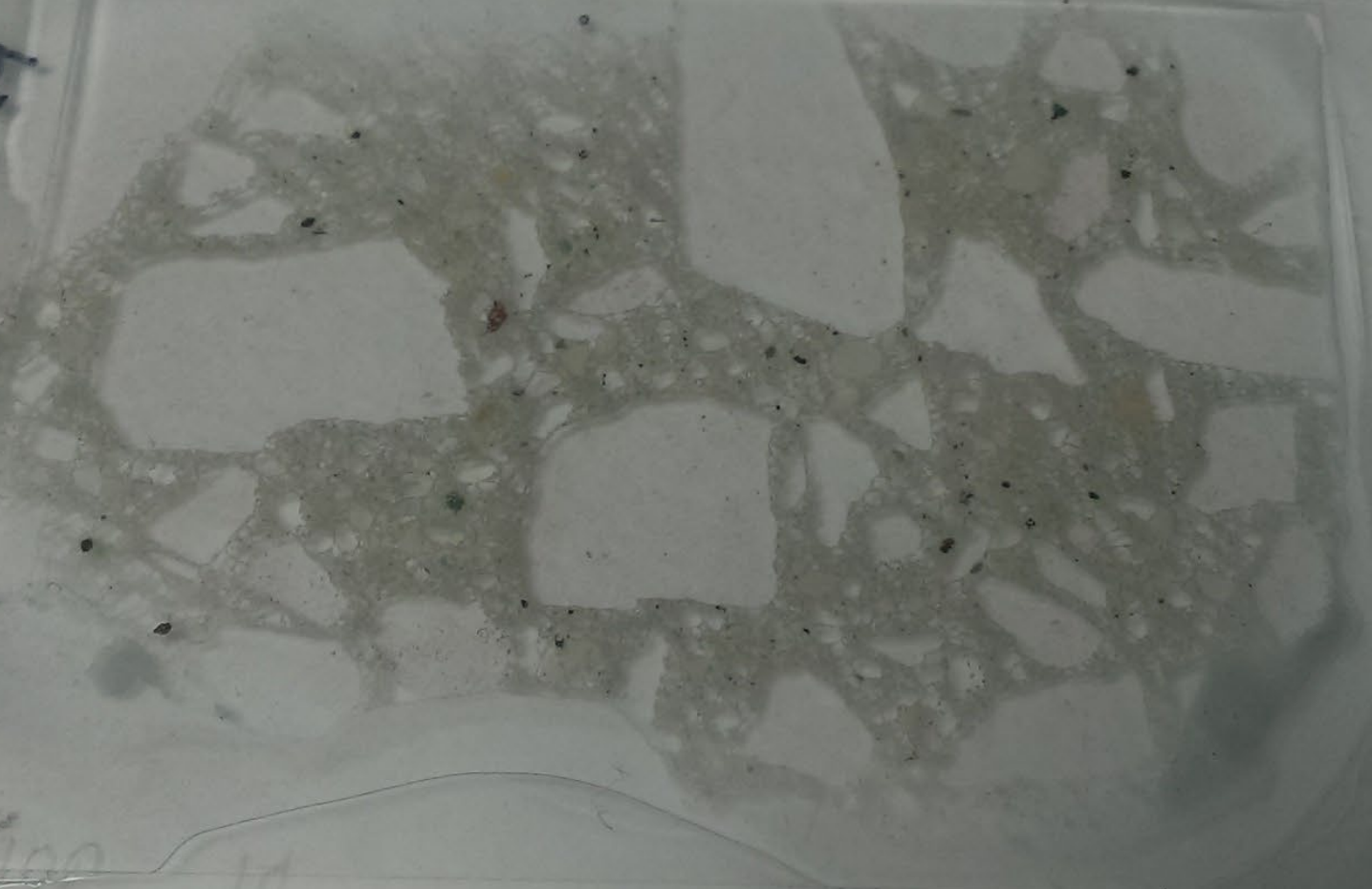


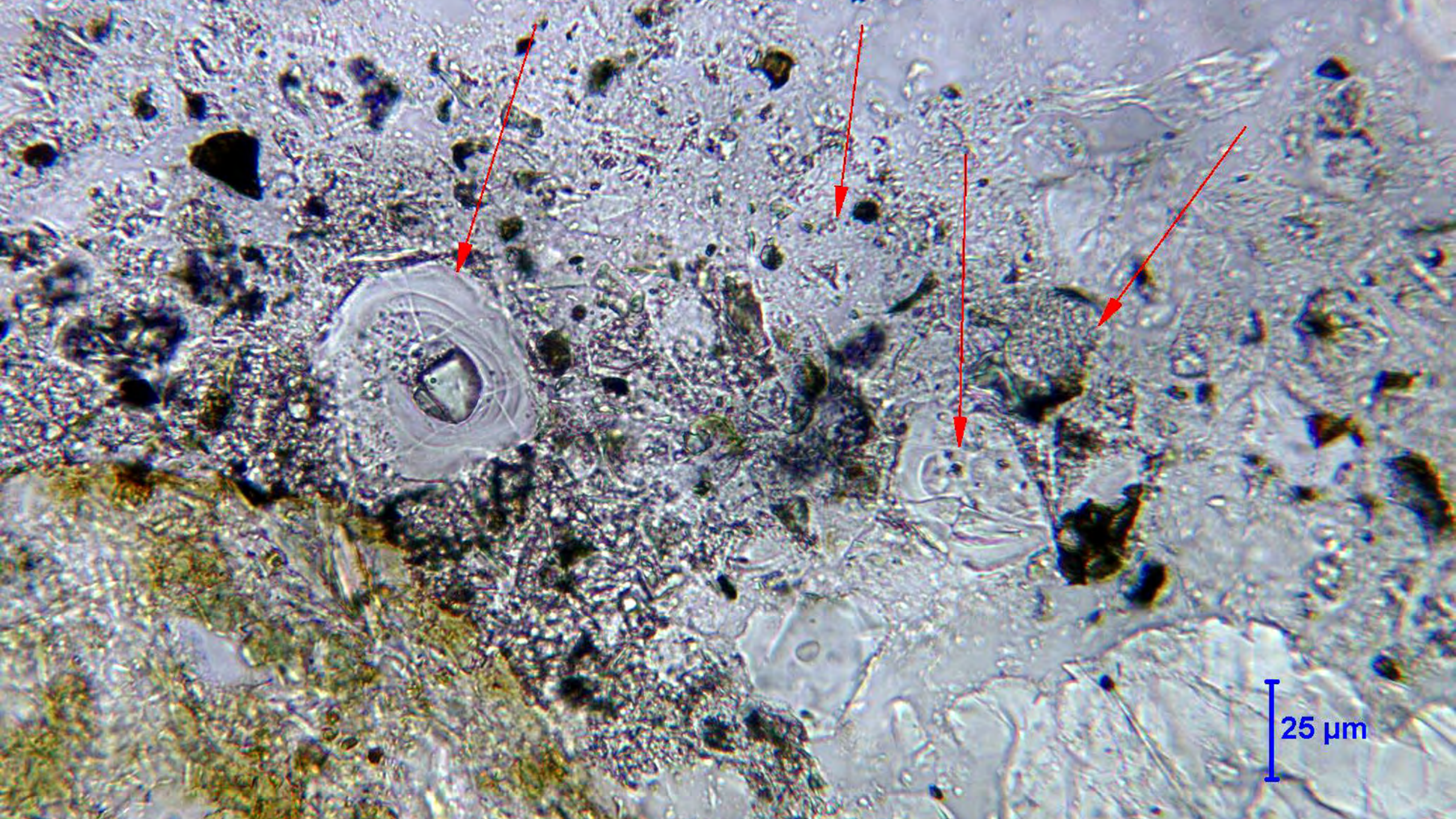
8 mm



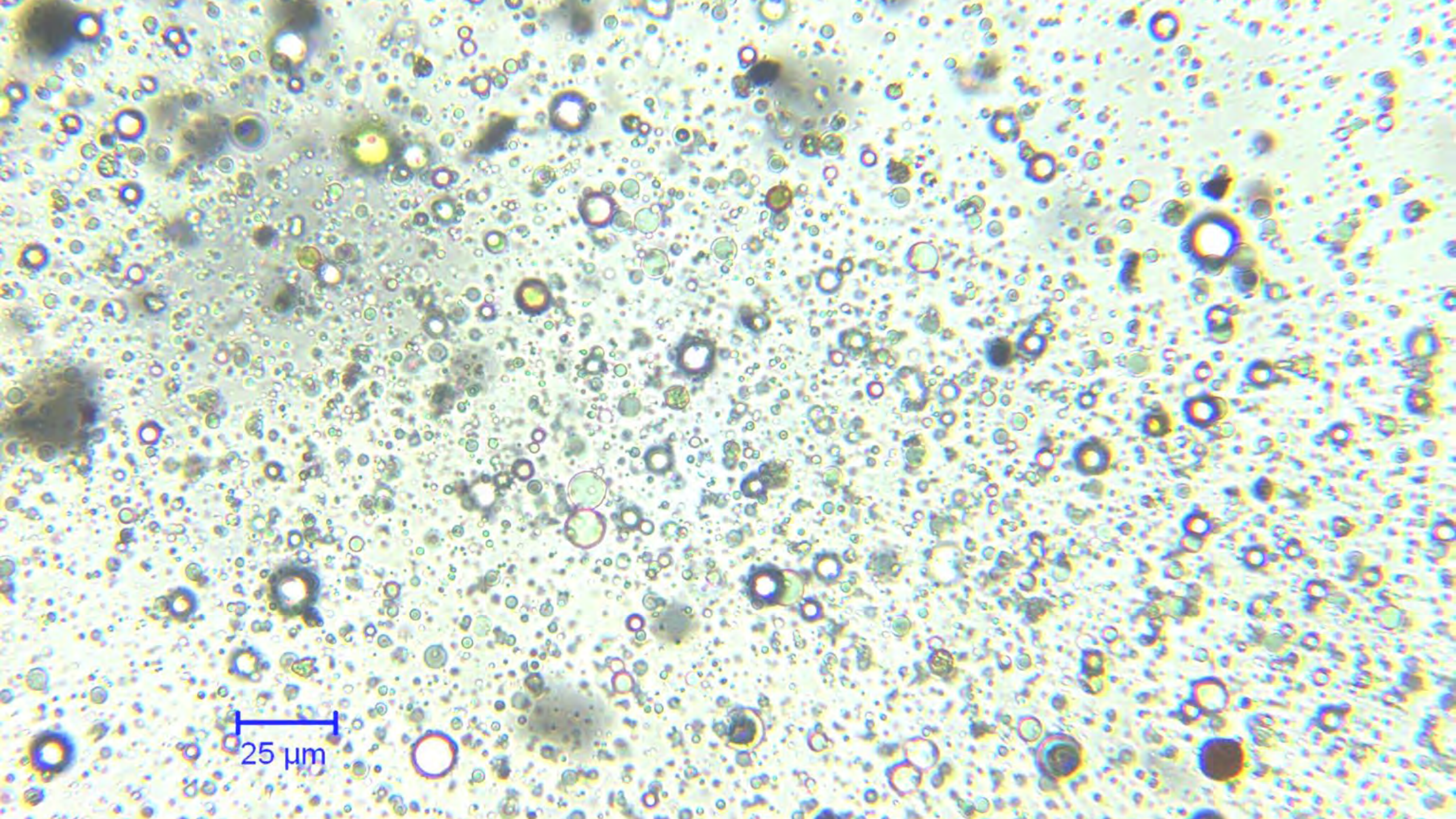
901104-2

h1

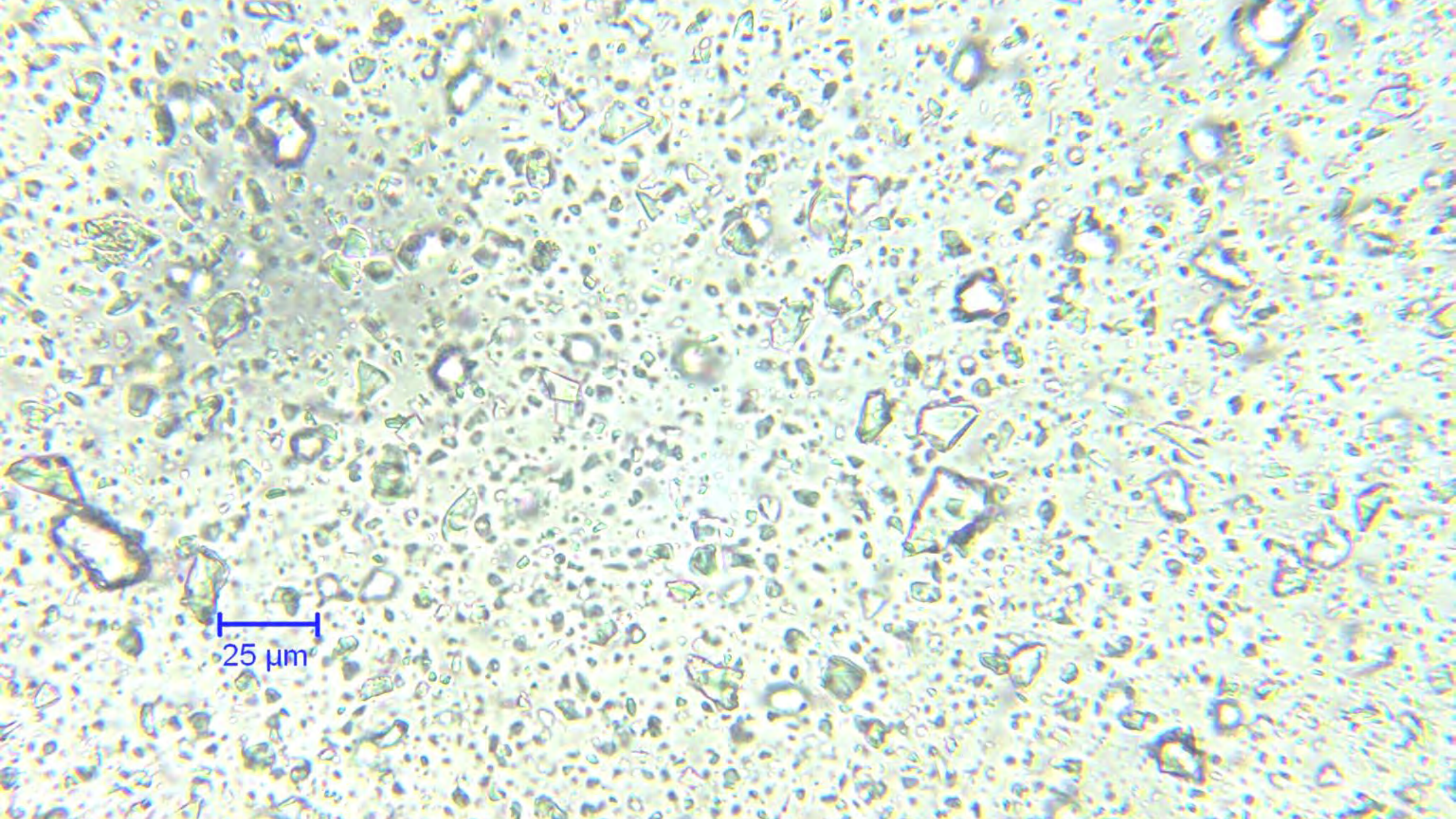




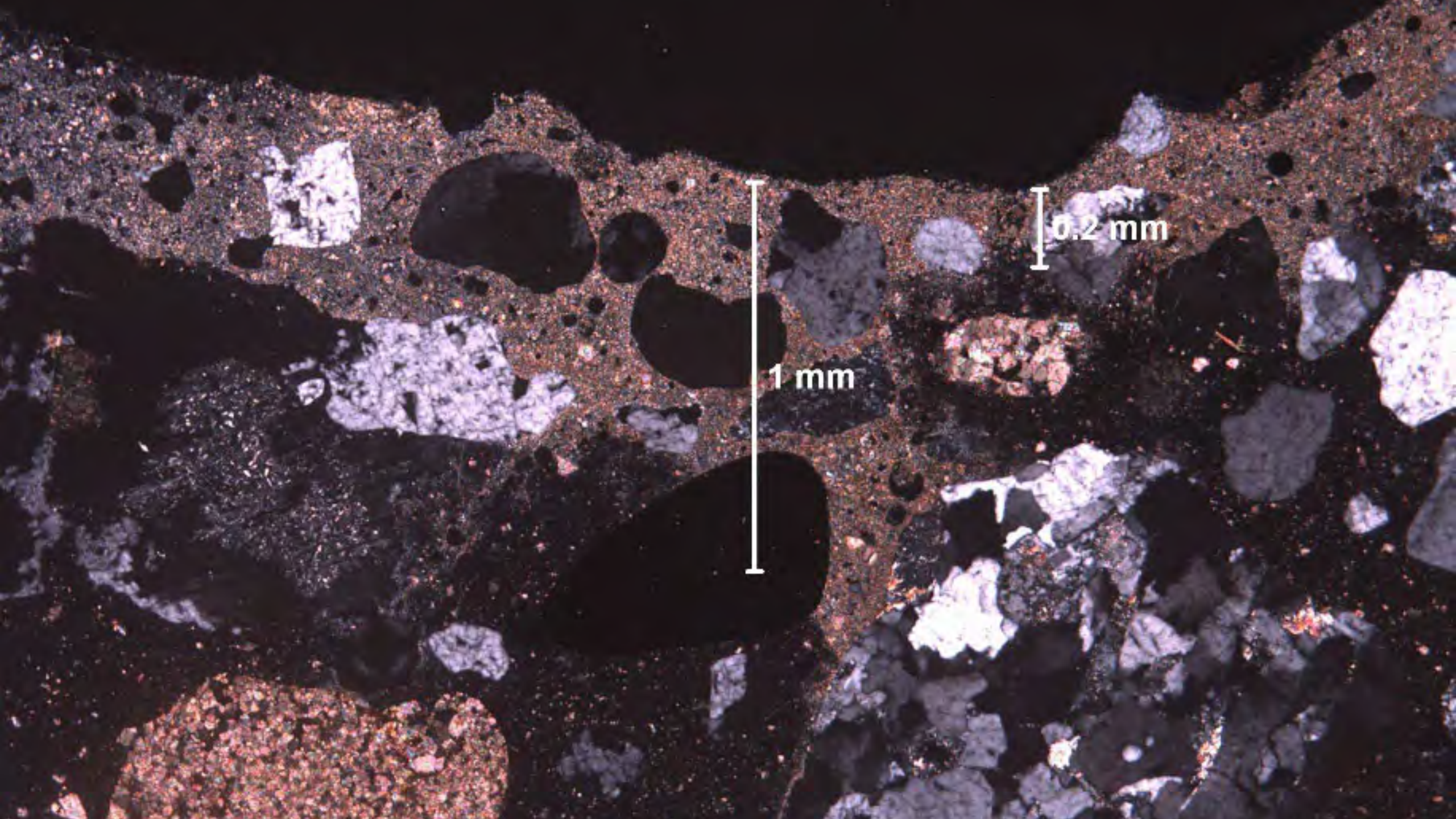
25 μm



25 μm

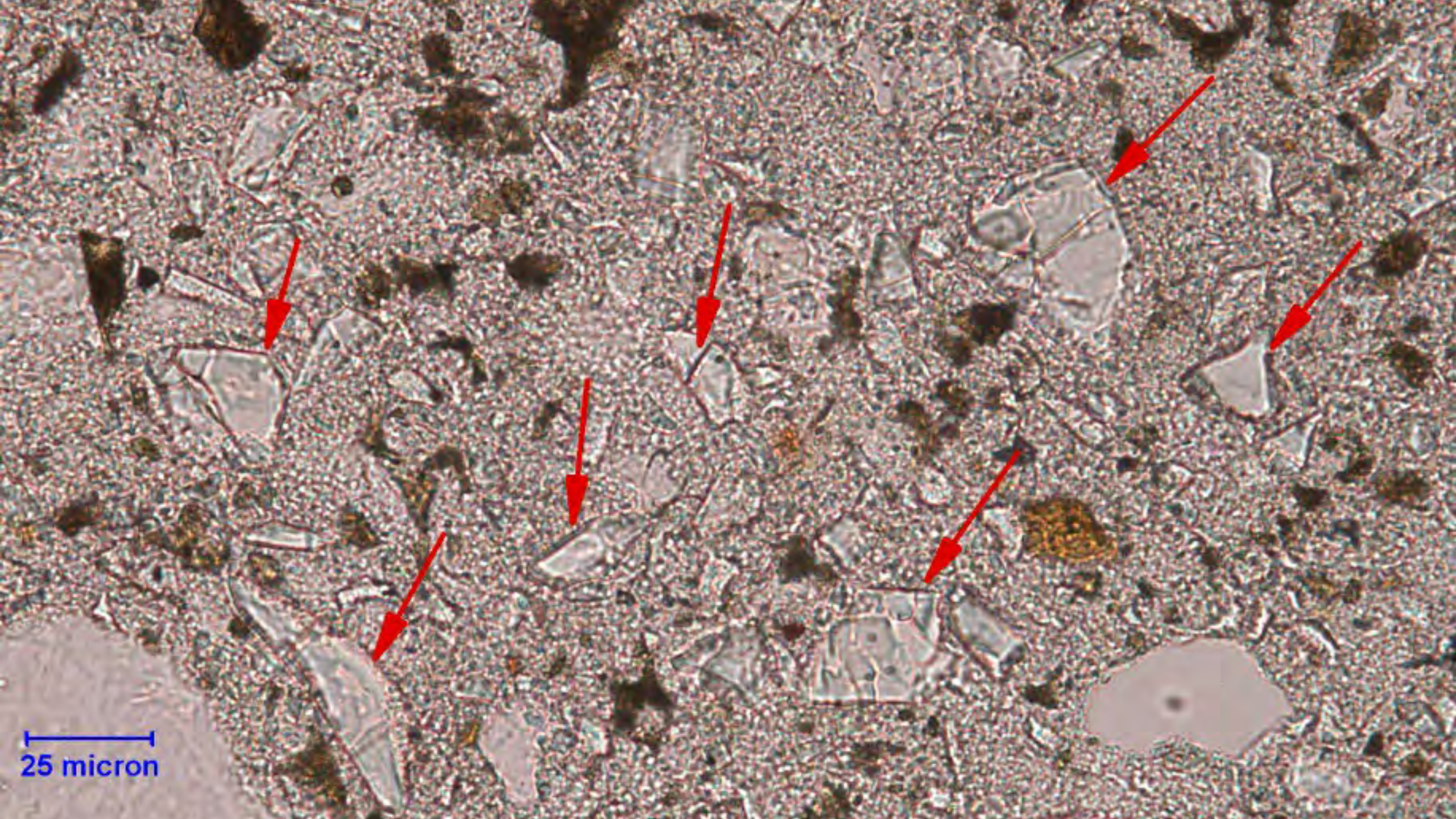


25 μm

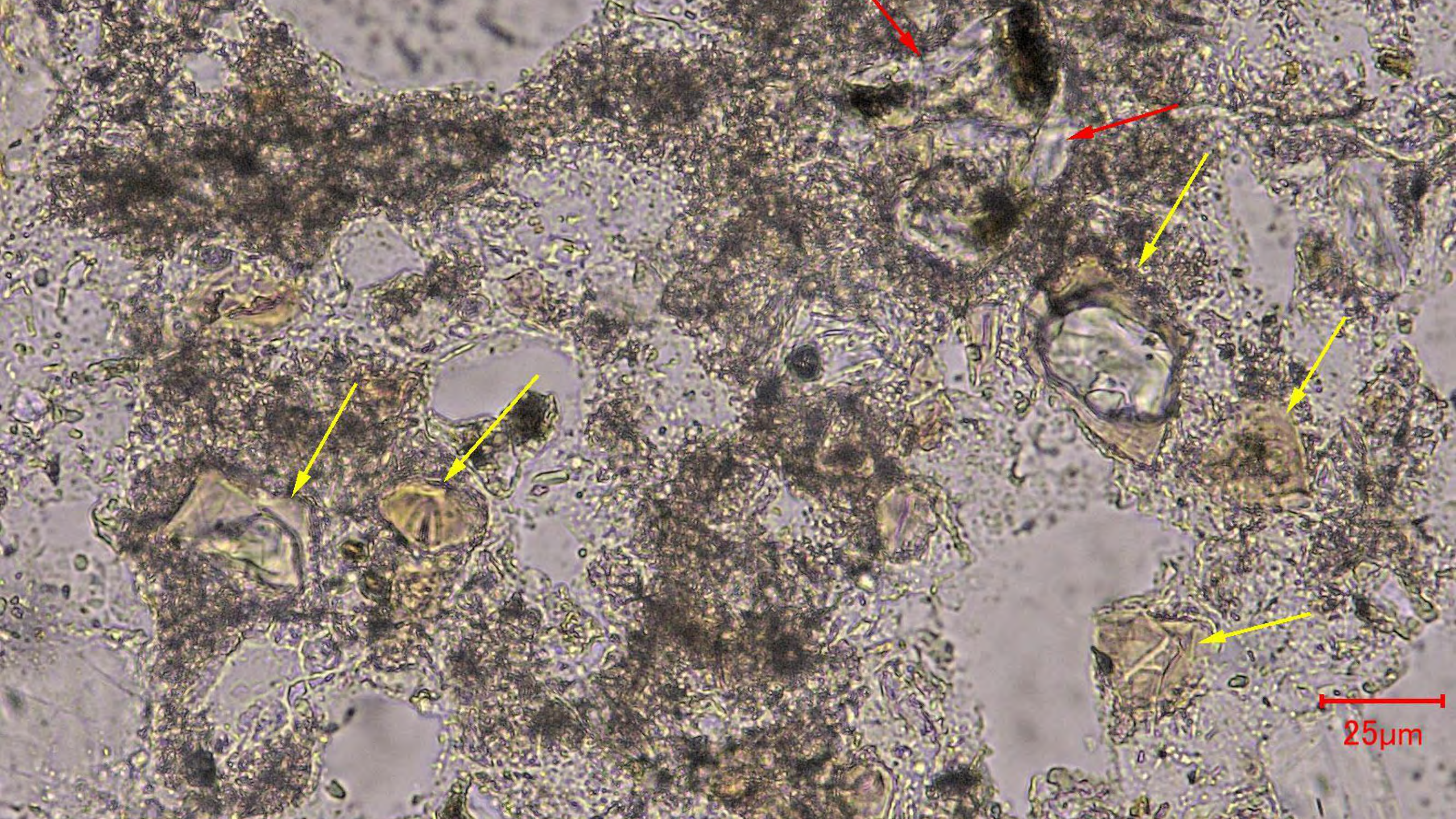


0.2 mm

1 mm



25 micron



25µm

SEM ANALYSIS

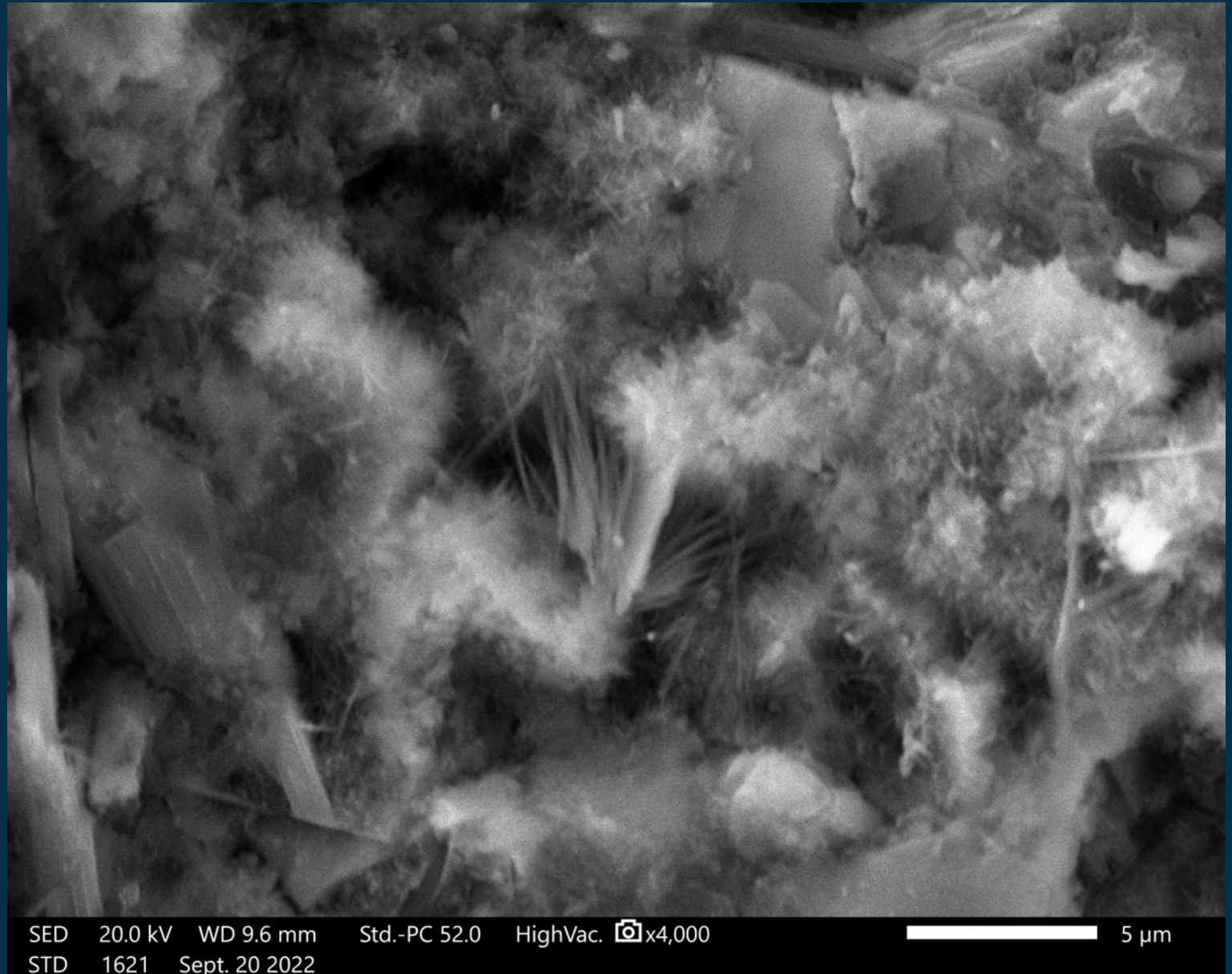
OPC Paste

CSH (fuzzy)

Ettringite (needly)

Ca(OH)₂ (tabular crystals)

Pore solutions > pH11



SEM ANALYSIS

Carbonated Paste

Completely different microstructure

CaCO₃ like material

..with residual Si, Al, Fe

Very little ettringite

Pore solutions close to neutral pH 7

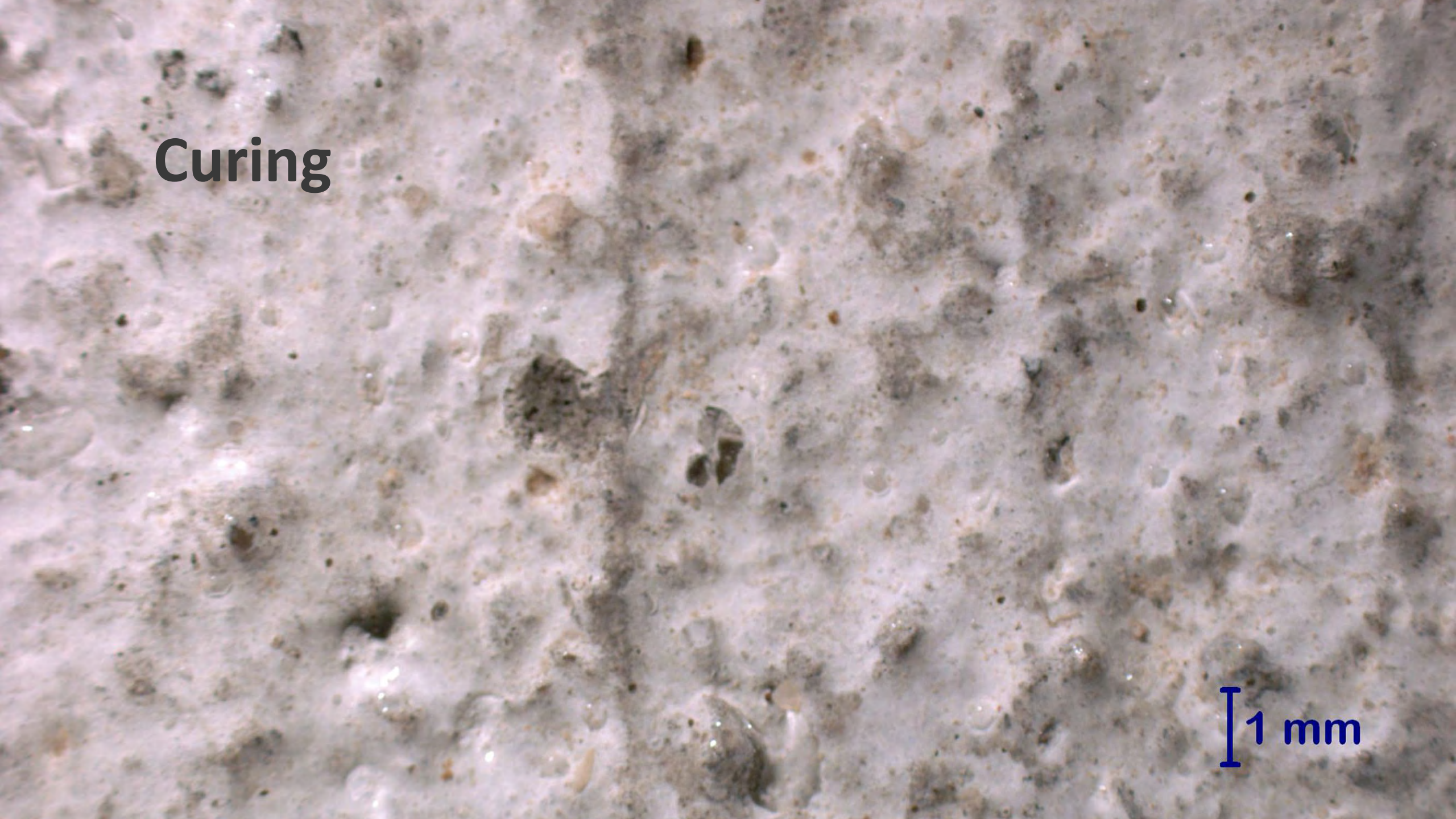


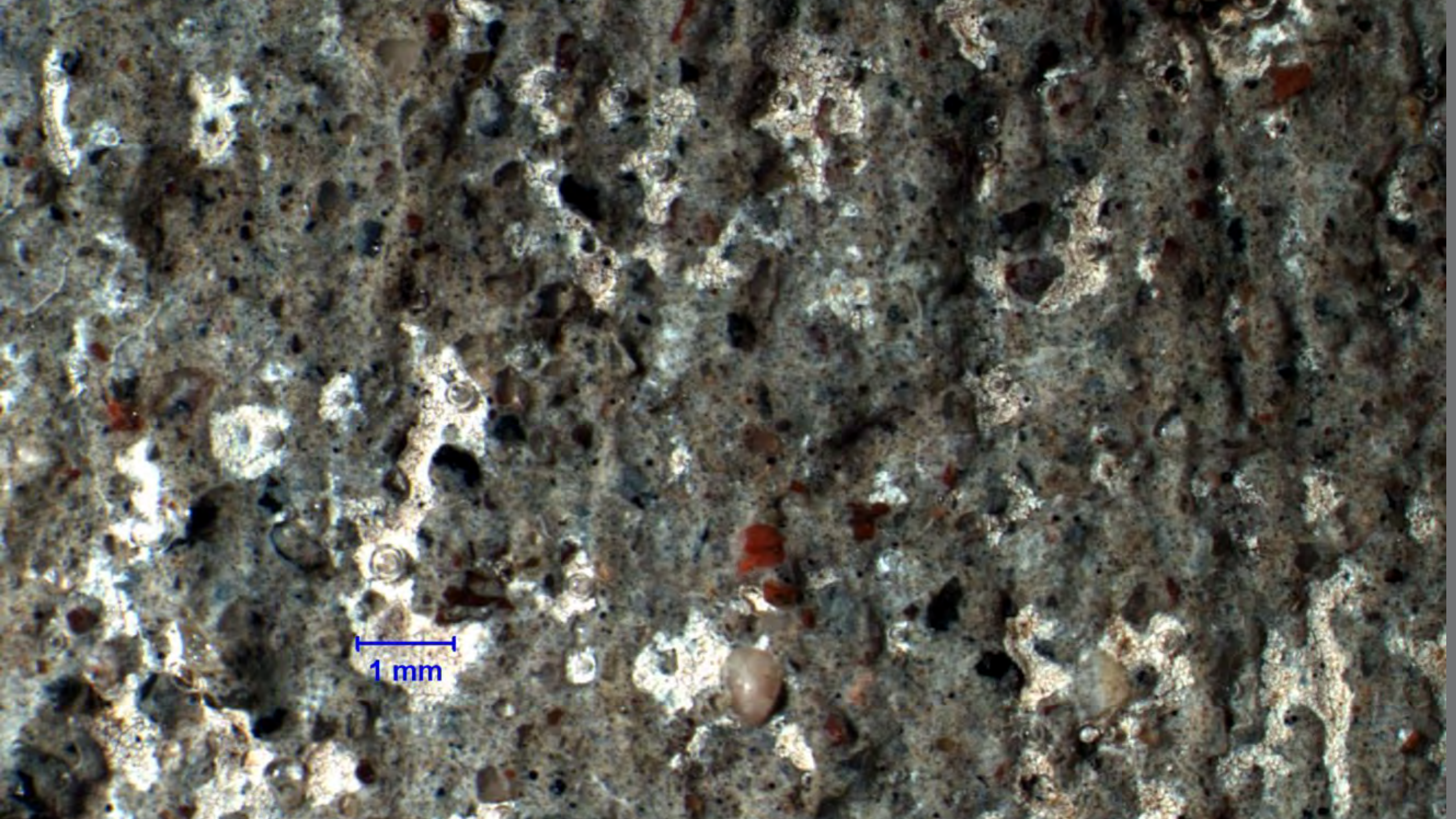
SED 20.0 kV WD 10.2 mm Std.-PC 52.0 HighVac. x4,000
STD 1634 Sept. 20 2022

5 μm

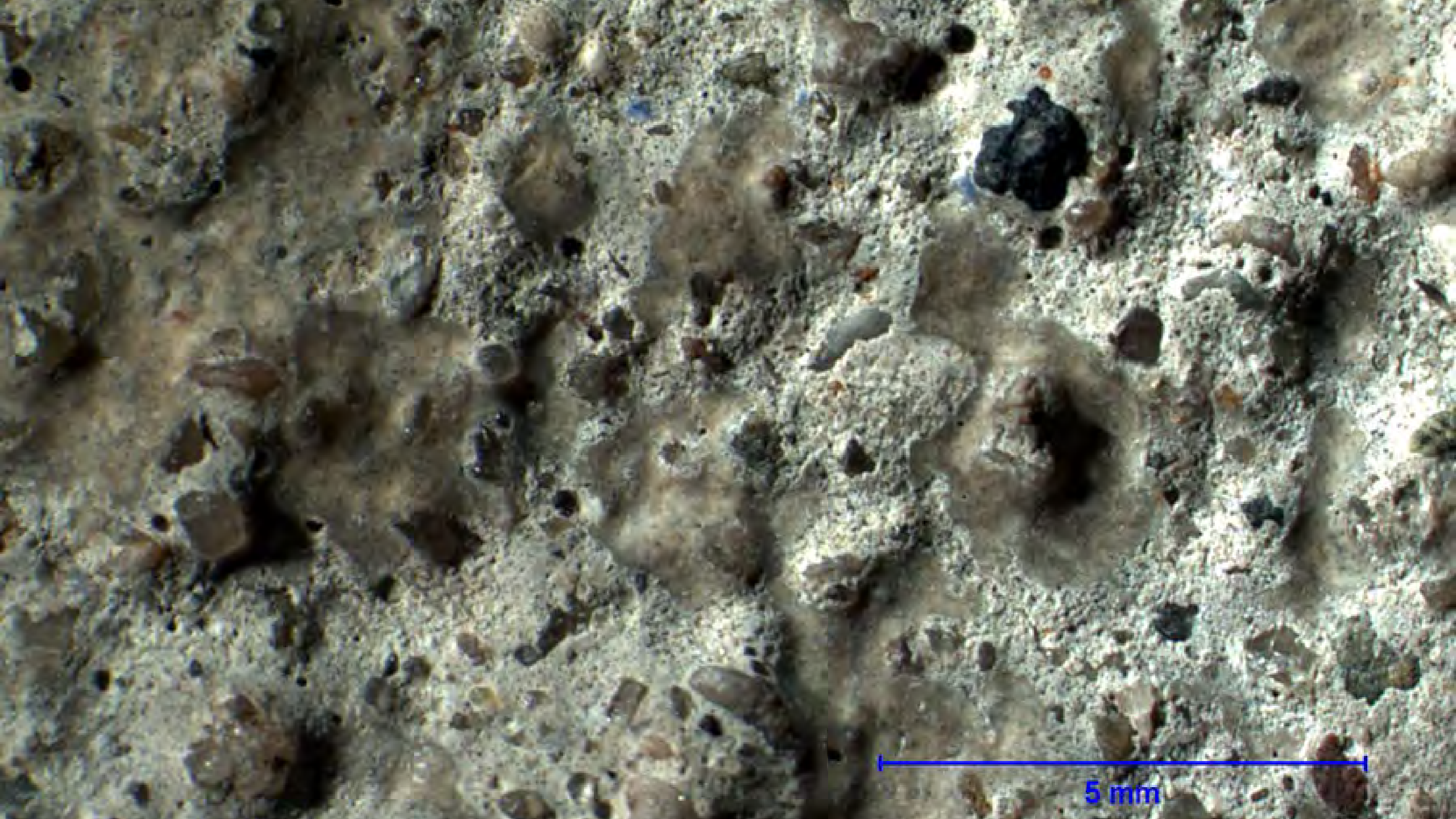
Curing

1 mm

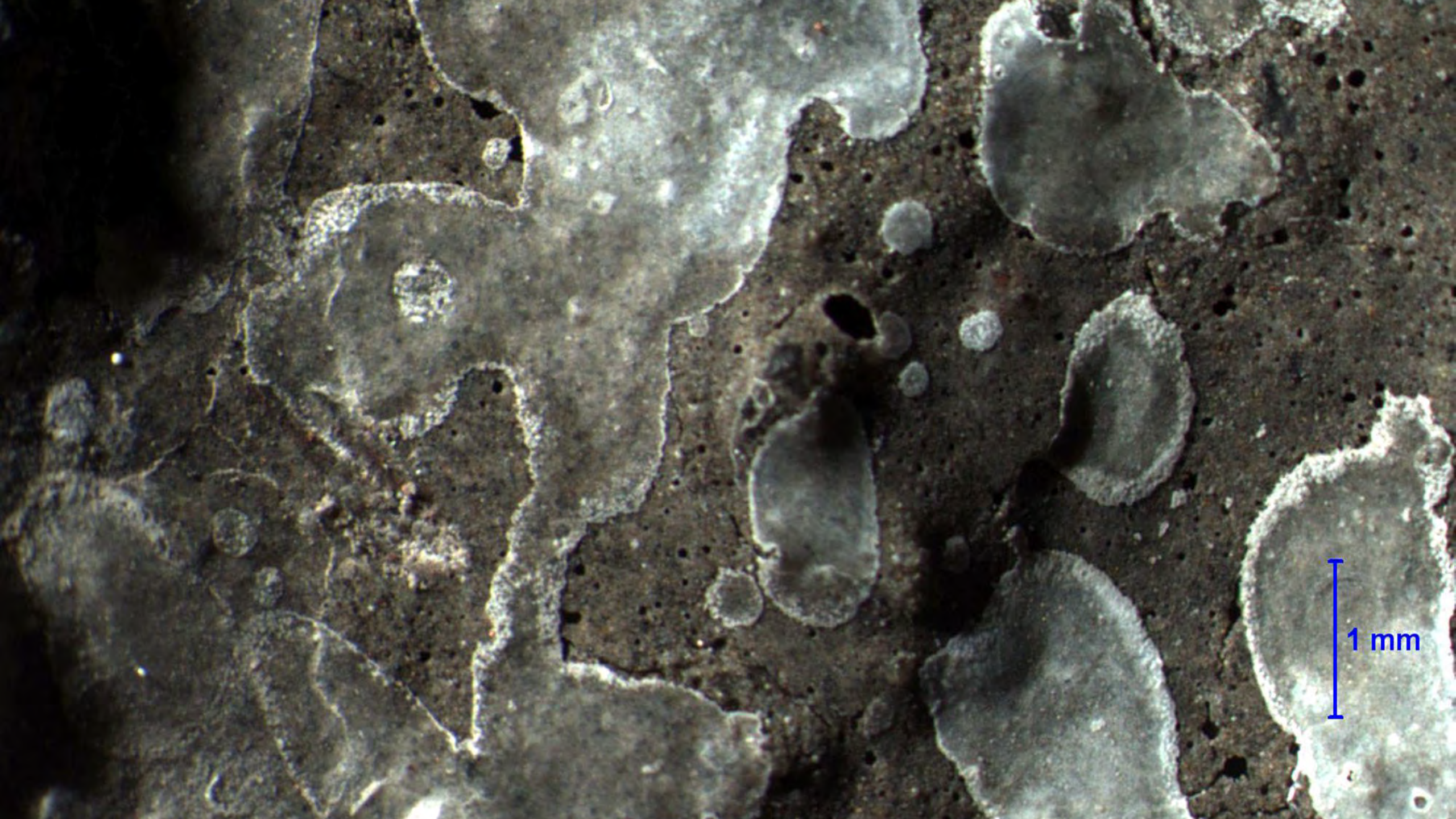




1 mm



5 mm

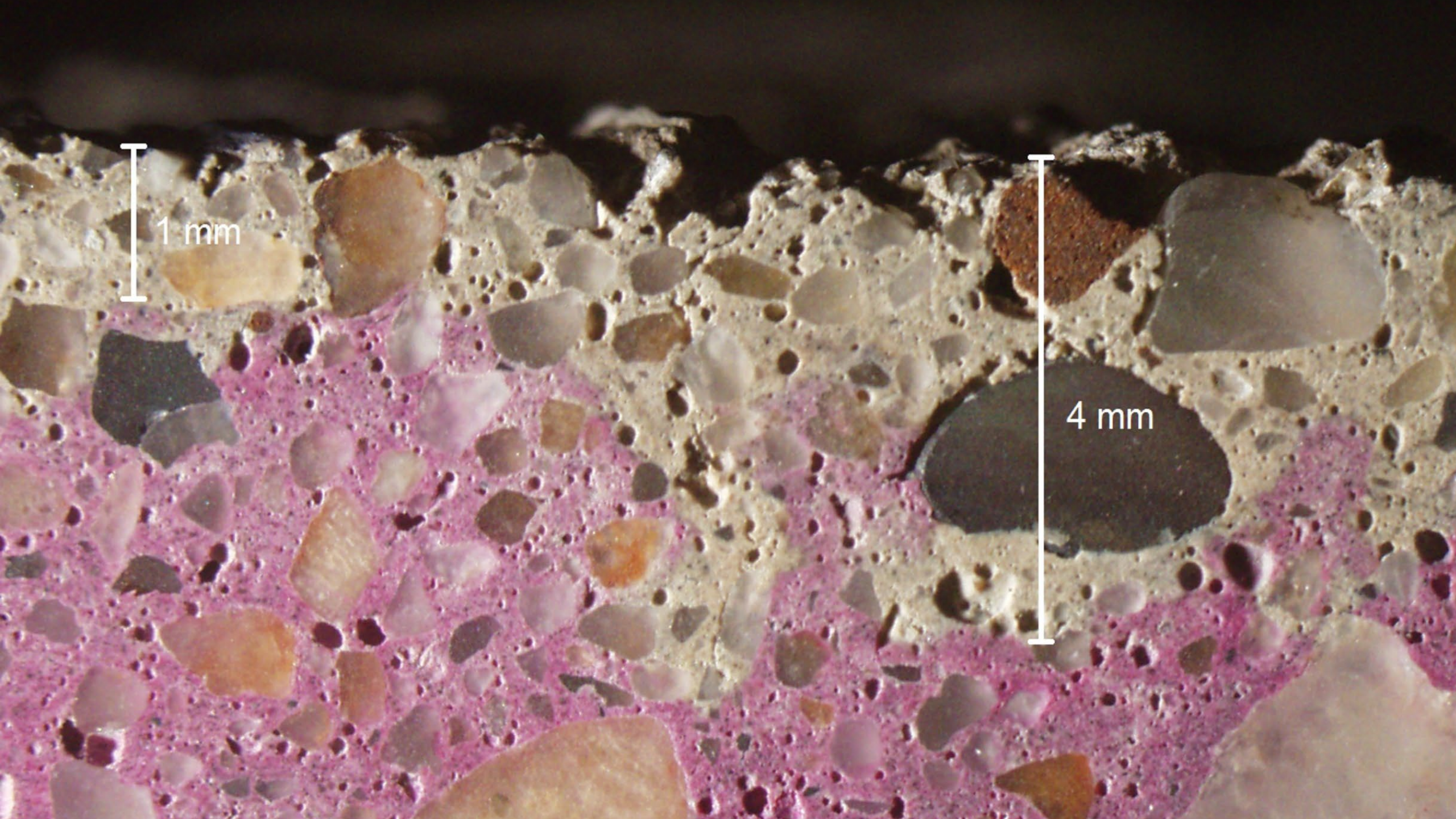




North Dakota, 2016



2 mm



1 mm

4 mm

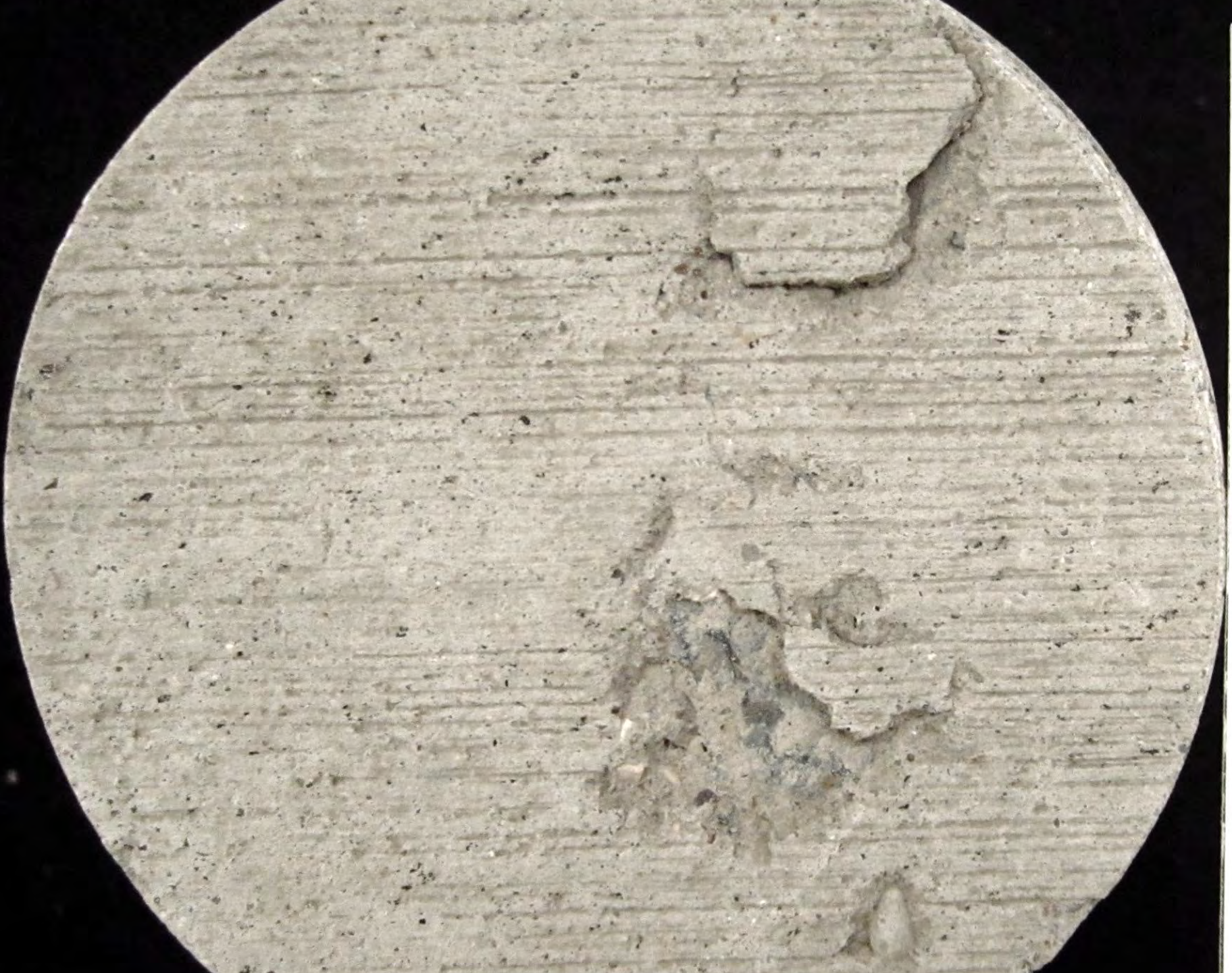


North Dakota, 2013

CM

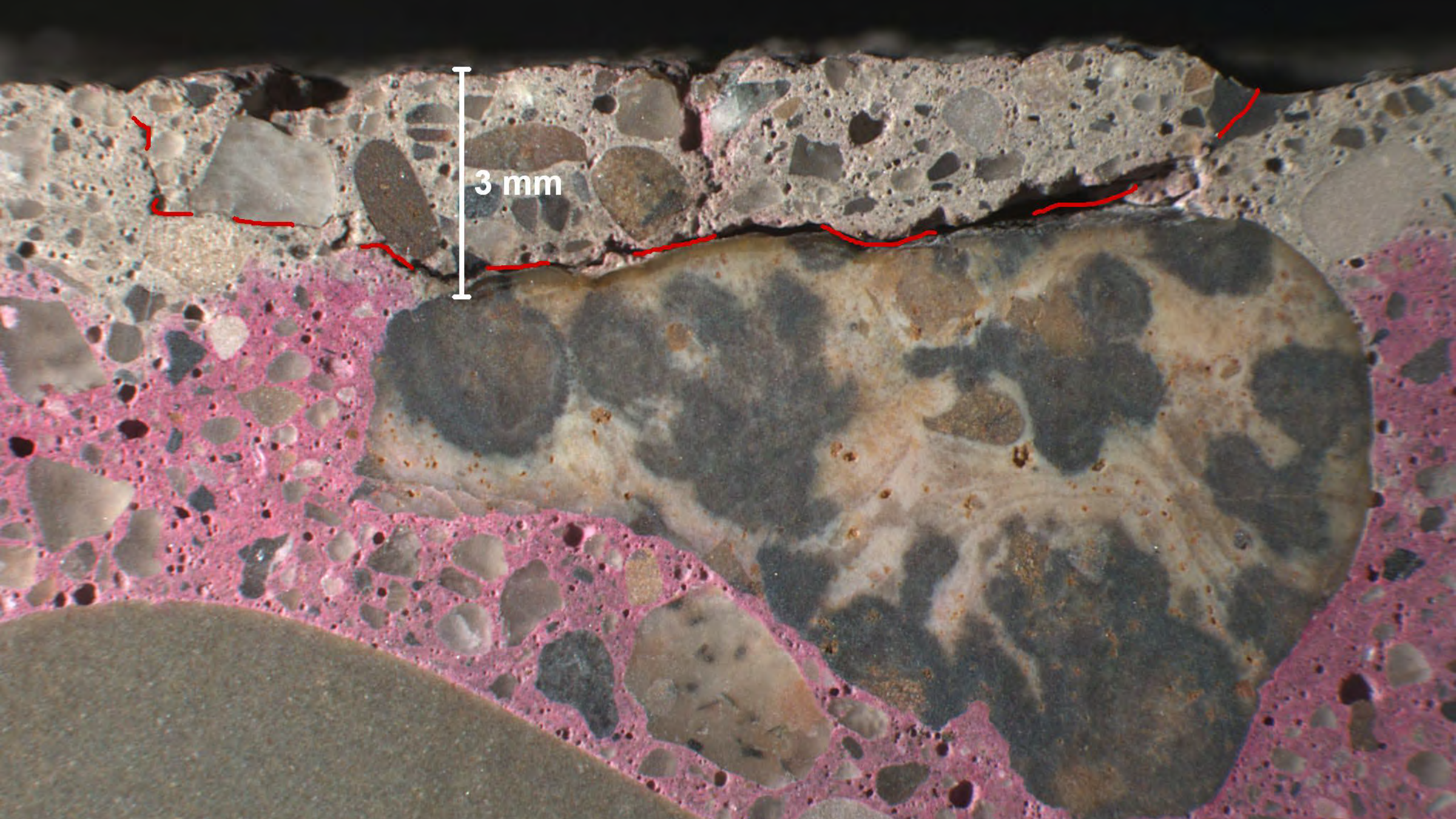


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5 mm

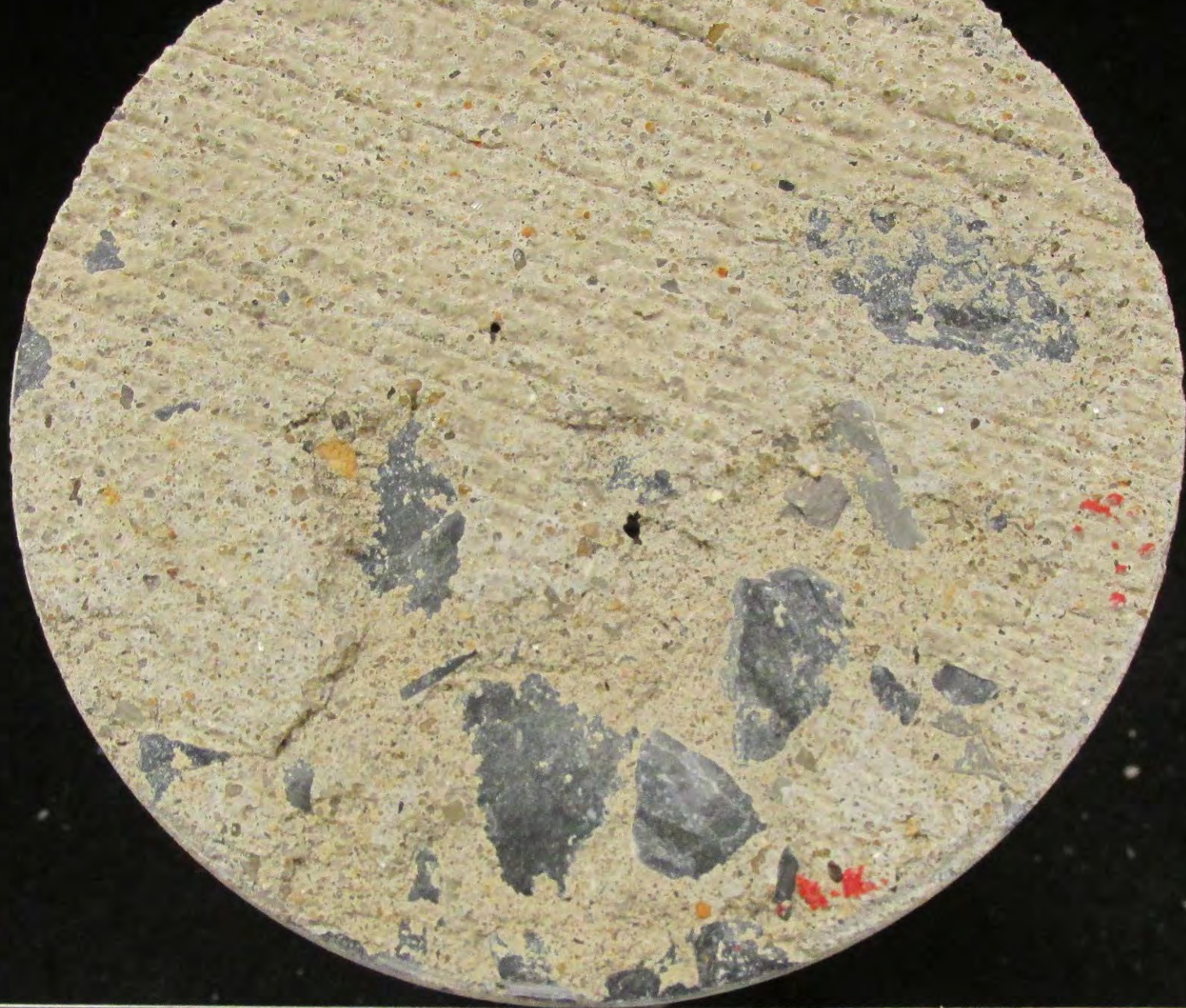


3 mm

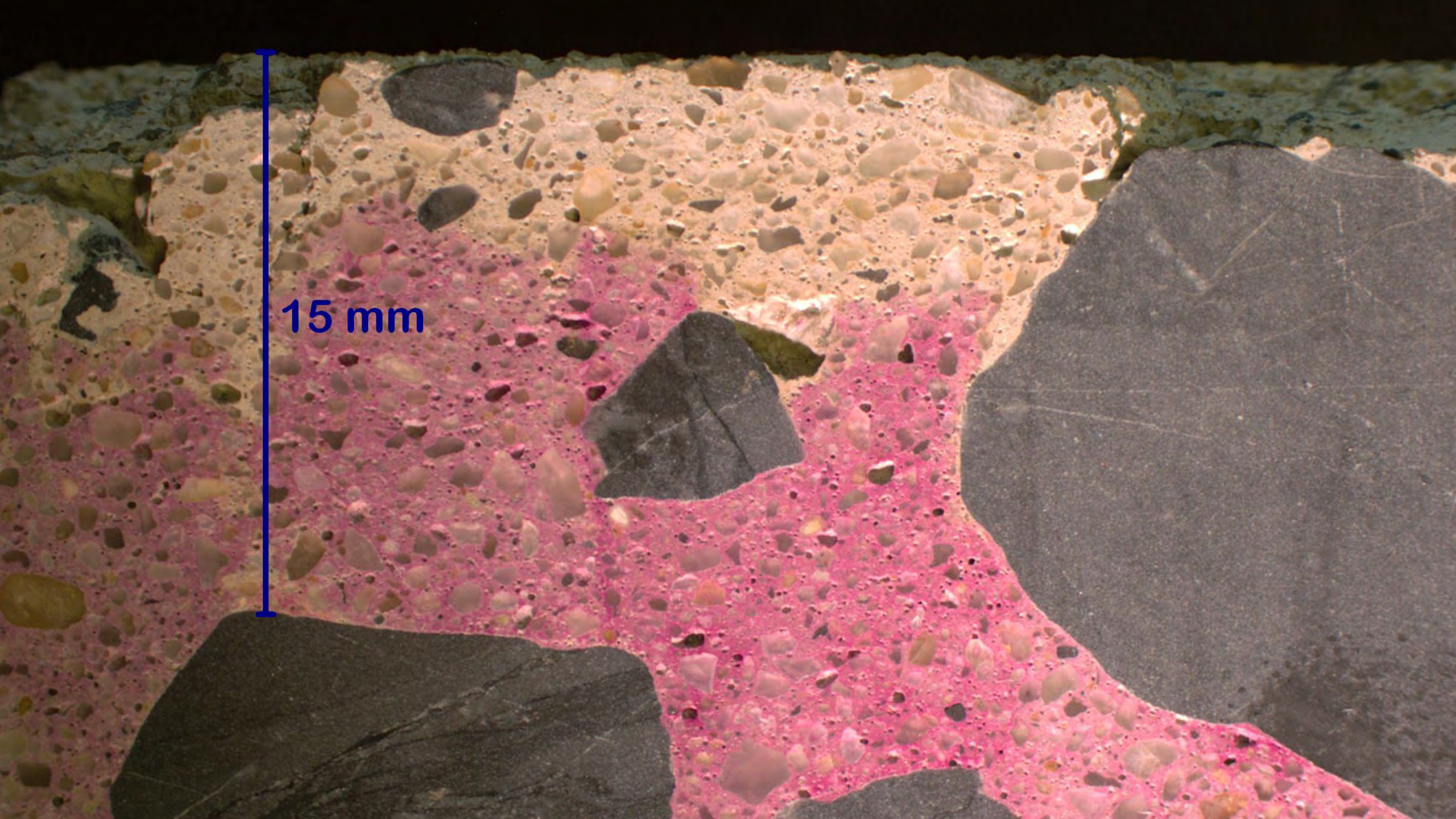


Baltimore, MD, subdivision, 2016









15 mm

Heavy Civil Paving

Lower w/cm

Comprehensively enforced

Timely

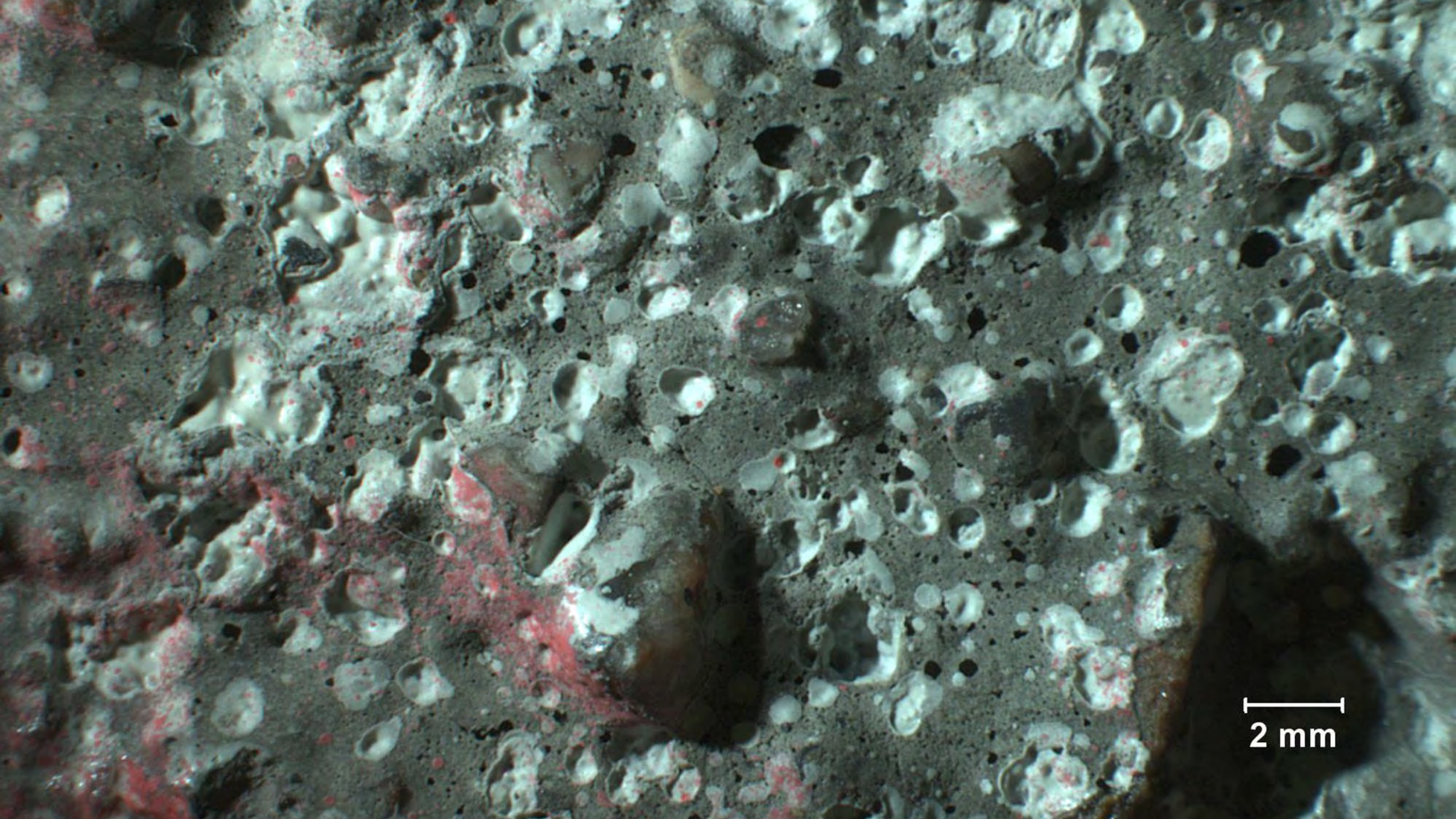
Curing method



Midwest 2012








2 mm

New Bridge – NE USA Spring 2014





30/30/40





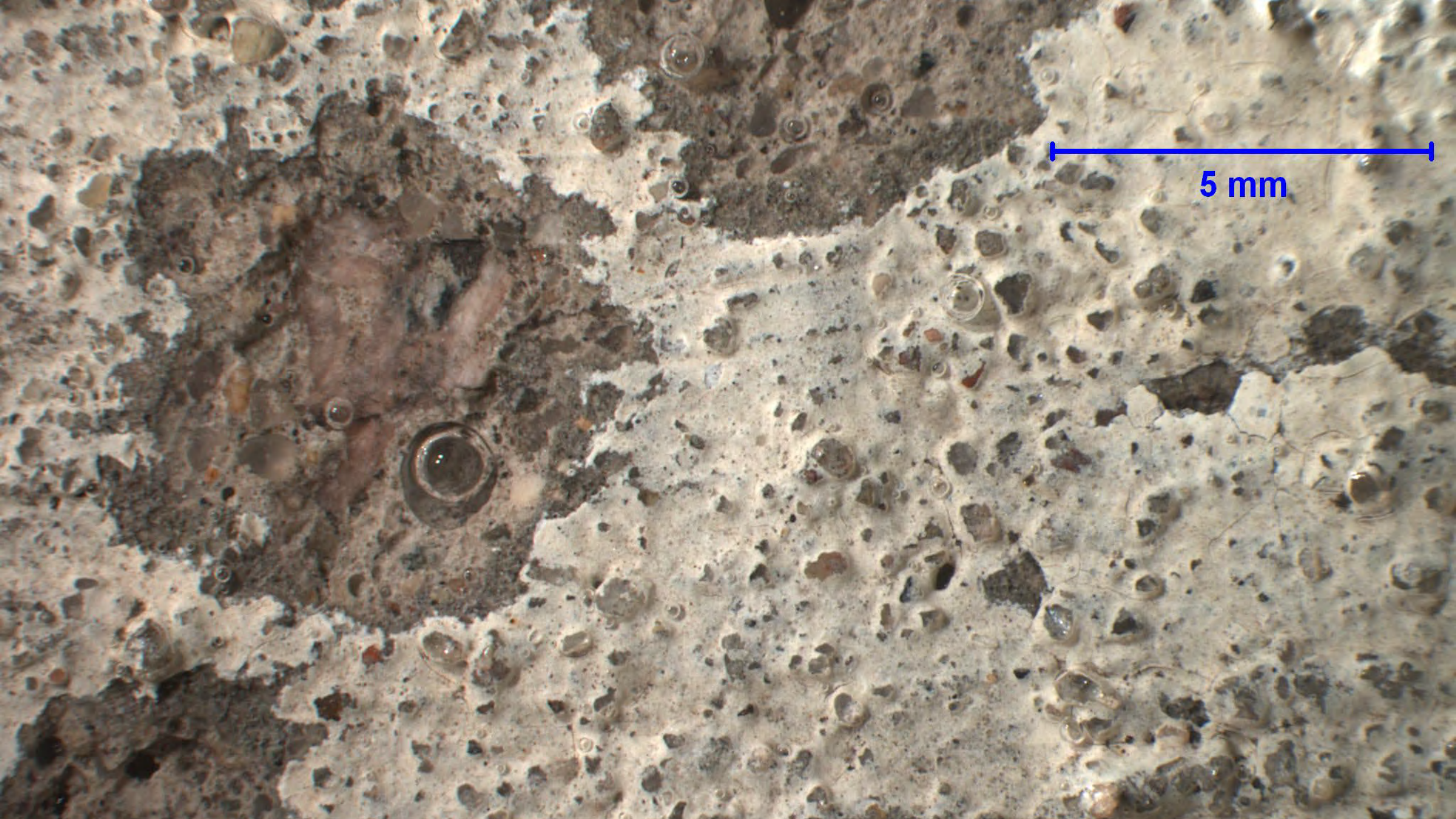


4B

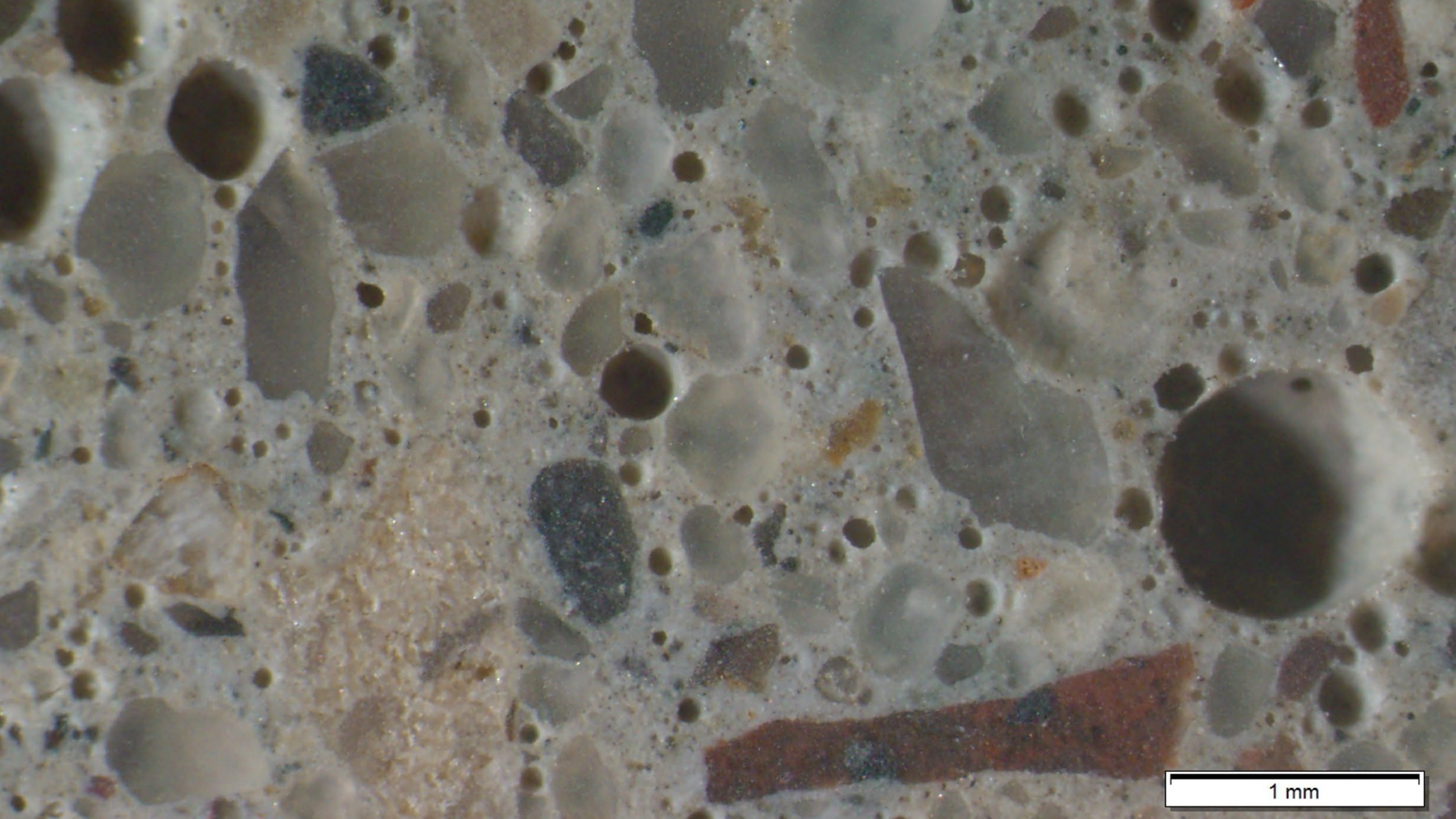


4C

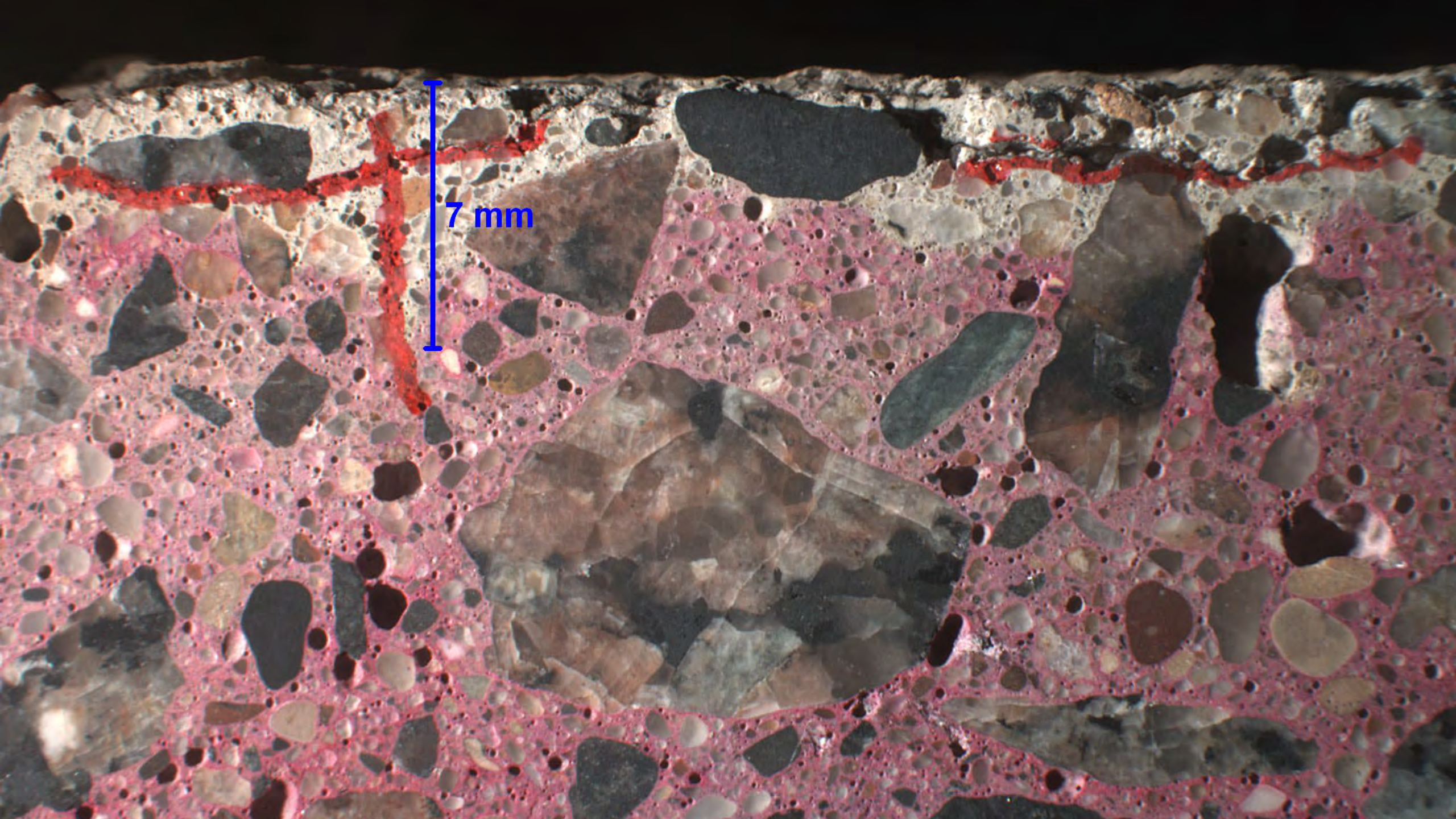




5 mm



1 mm

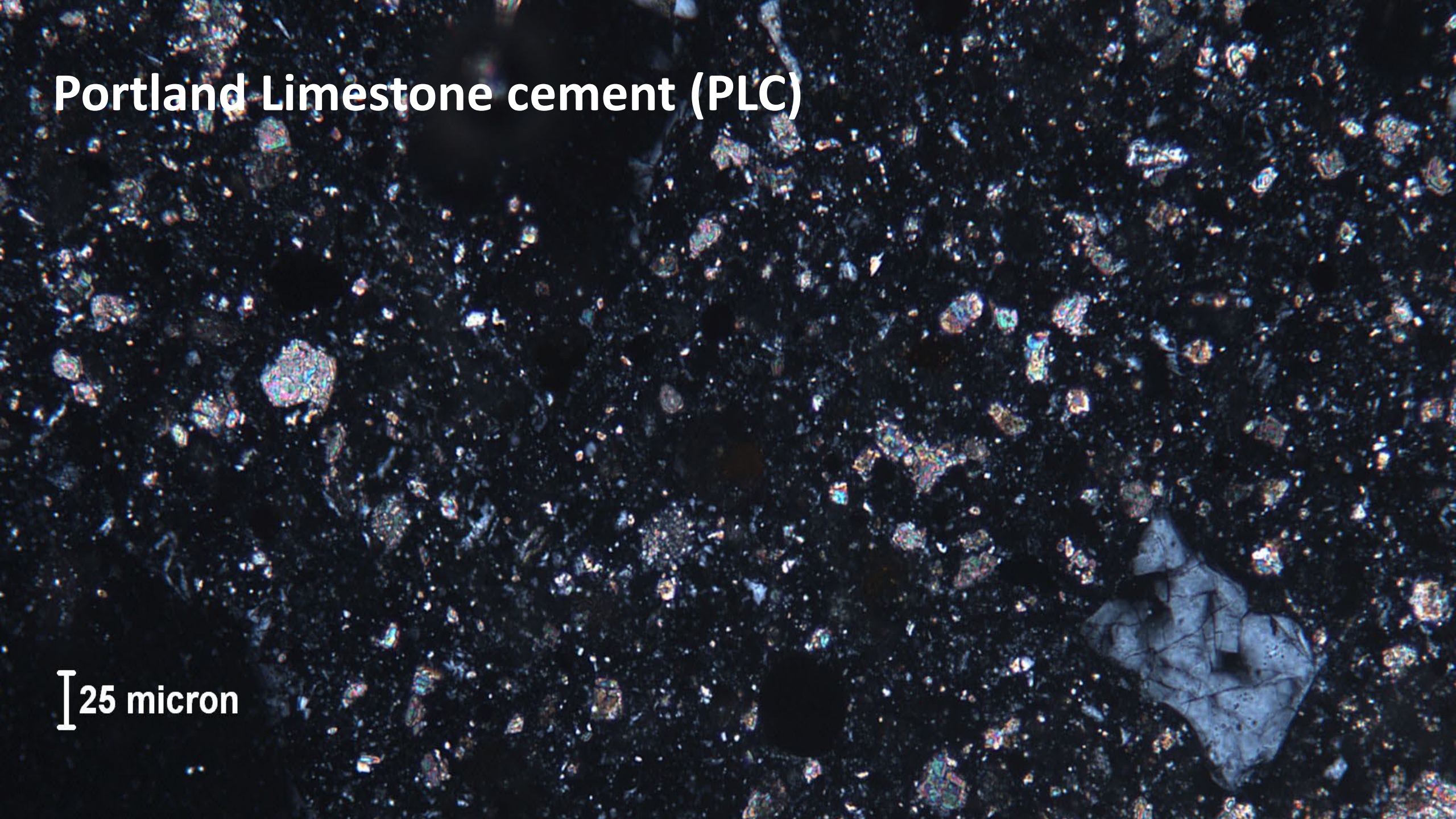


7 mm

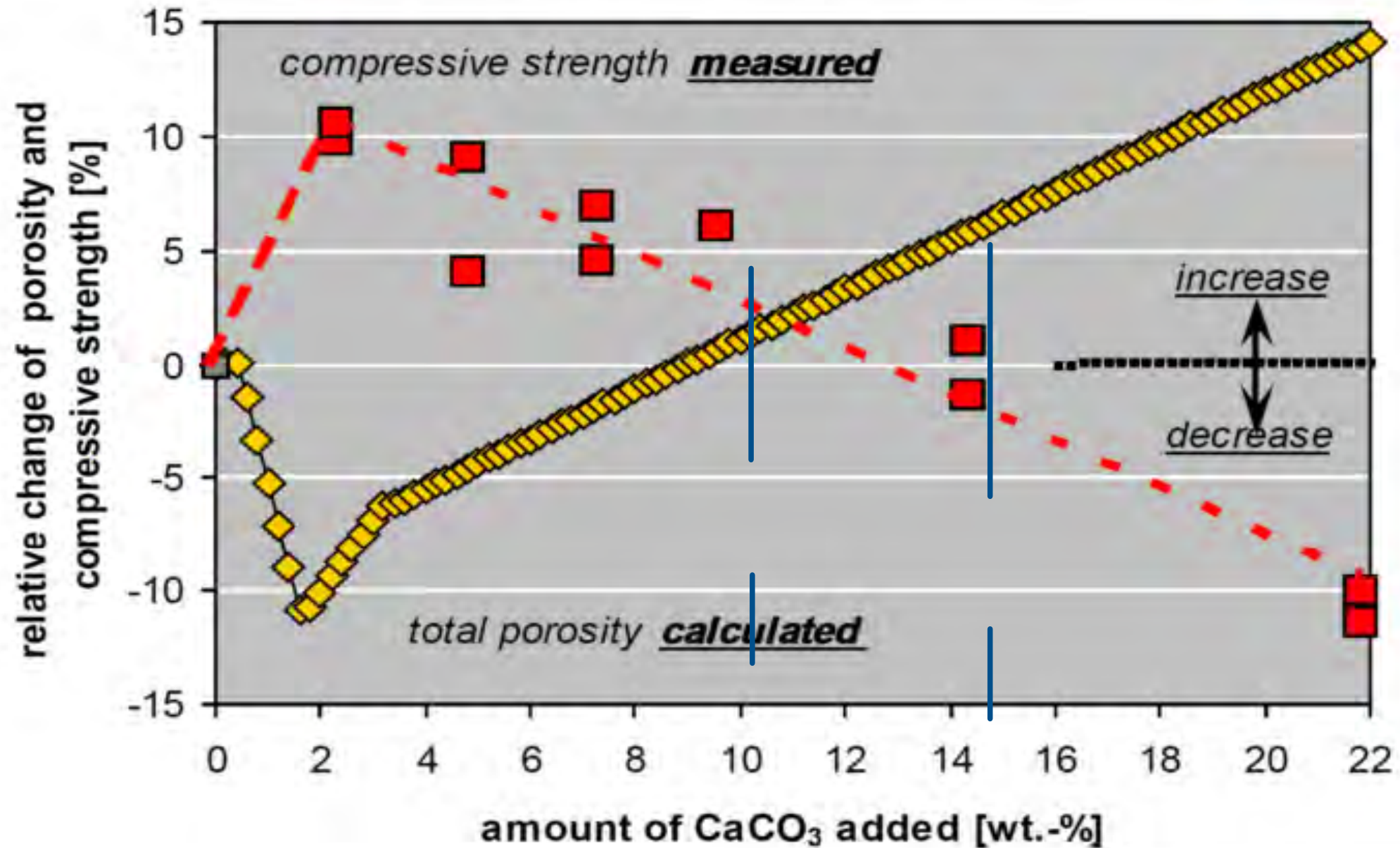


Portland Limestone cement (PLC)

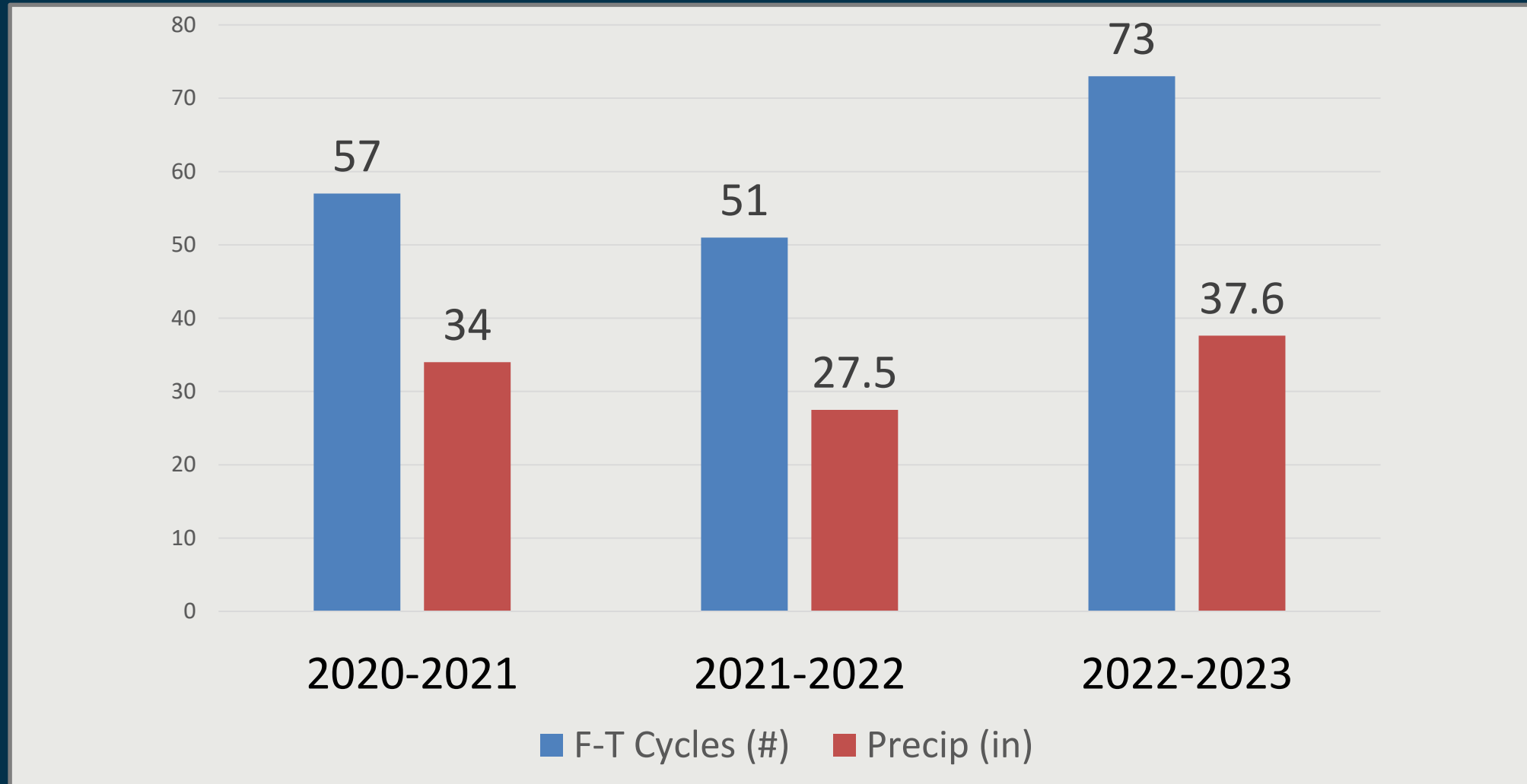
25 micron



Correlation: Porosity – Compressive Strength (exp. Data by D. Herfort, Aalborg cement)



2020-2023 Freeze-Thaw Cycles & Precipitation





Thank you!



Exposure Conditions

Twin Cities - SW Metro

Spring 2013

