Near Surface Aggregate Reactivity (NSAR): What We Know

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American Engineering Testing, Inc.

What is petrography?

Geologic term applied to the microscopic analysis of concrete, mortar, CMU's, grout, stucco, plaster, and other cementitious materials

ASTM Committee C9
Sub-Committee C9.65

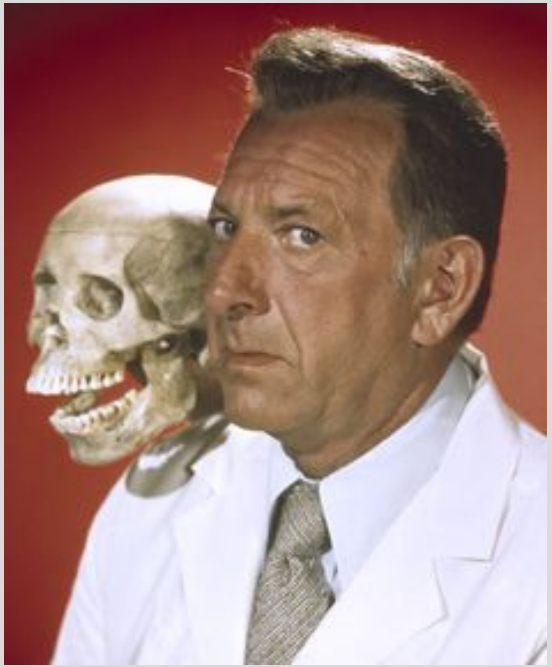
- **ASTM:C856**
- **ASTM:C457**
- **ASTM:C295**
- **ASTM:C1324 (C12.02)**

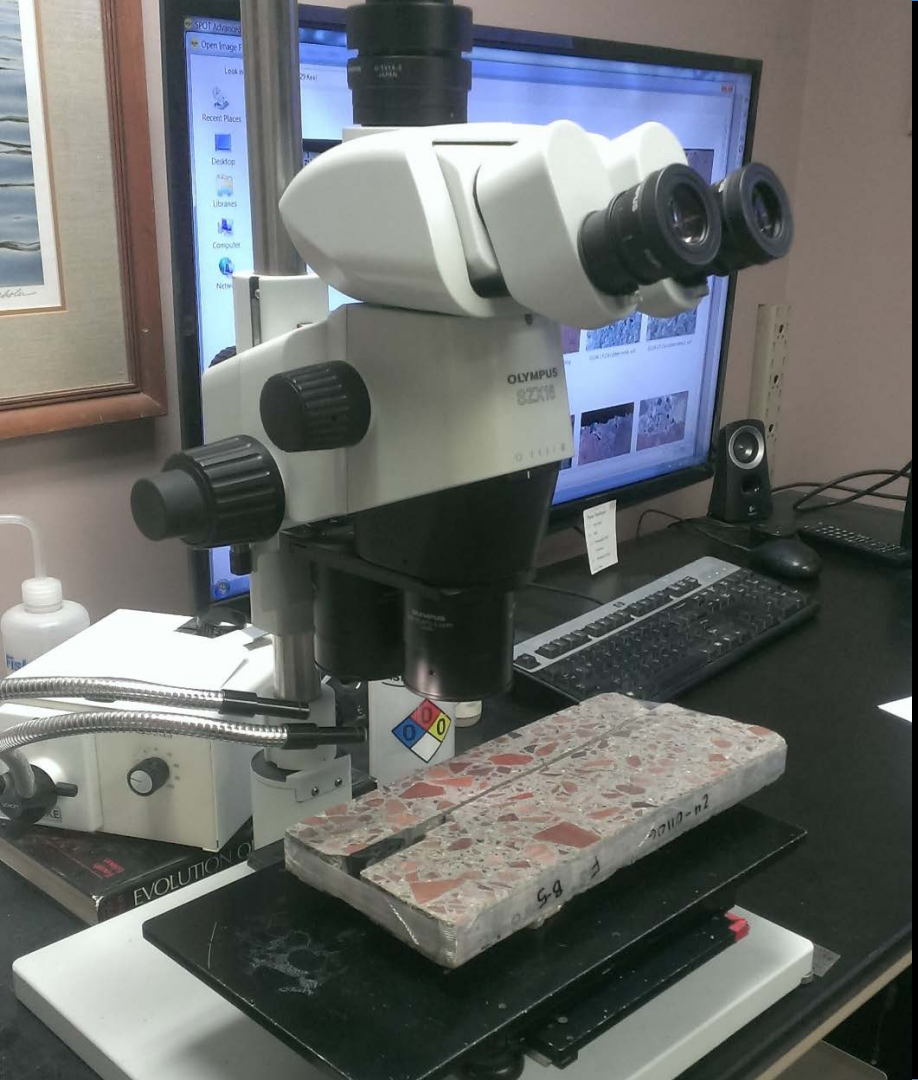
Why use petrography?

- **Trouble Shooting Hardened Concrete and Masonry Problems**
- **QA or QC**
- **Condition Survey/Restoration**
- **Reverse Engineer**

Outline

- Petrography Primer
- Define ASR
- Examples
- Define NSAR
- An Upper Midwest NSAR enigma
- Surface prep
- The new age of NSAR
- Moisture sensitive flooring and NSAR
- Brief Case studies




OLYMPUS
SZX16


METRIC


OLYMPUS
OLYMPUS


240106
14

Alkali-Silica Reaction (ASR)

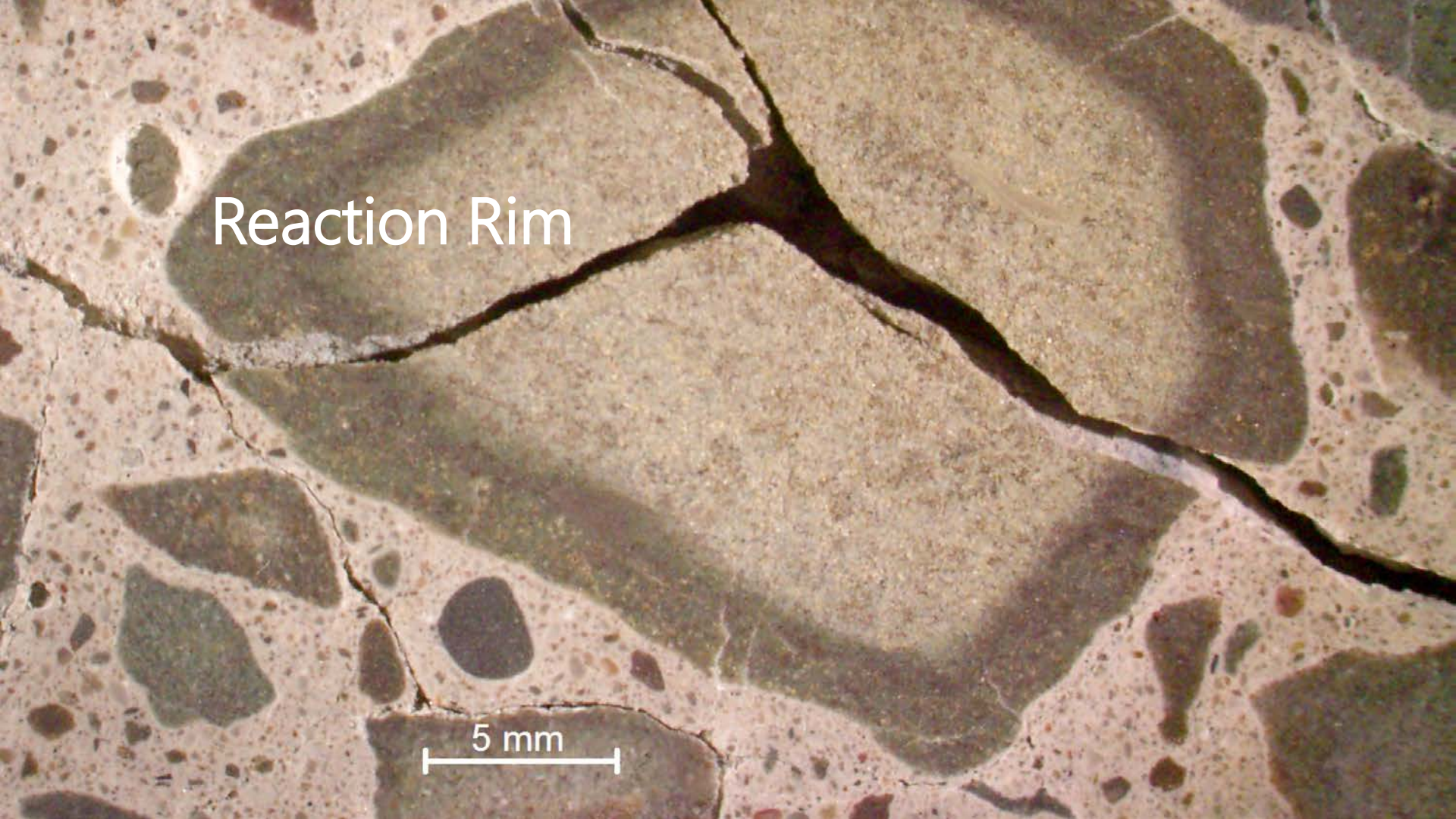
A reaction between water in capillaries and pores in concrete paste, alkalis and hydroxyl ions (OH-) in solution, and unstable silicon dioxide in aggregates.

ASR produces a hygroscopic gel product.

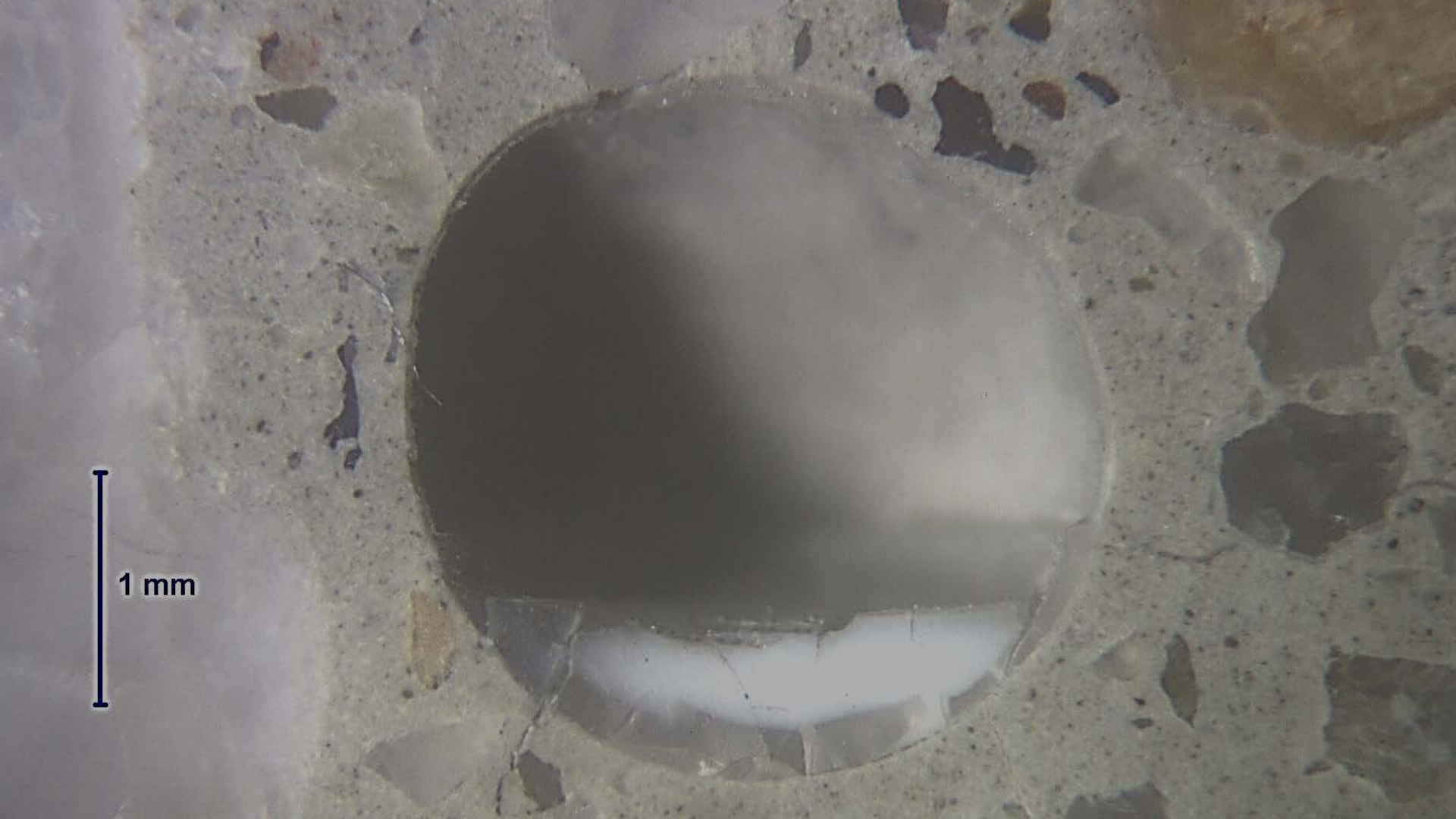
Ramps and Bridges

Water Control Structures

Pavements


Reaction Rim
5 mm


1 mm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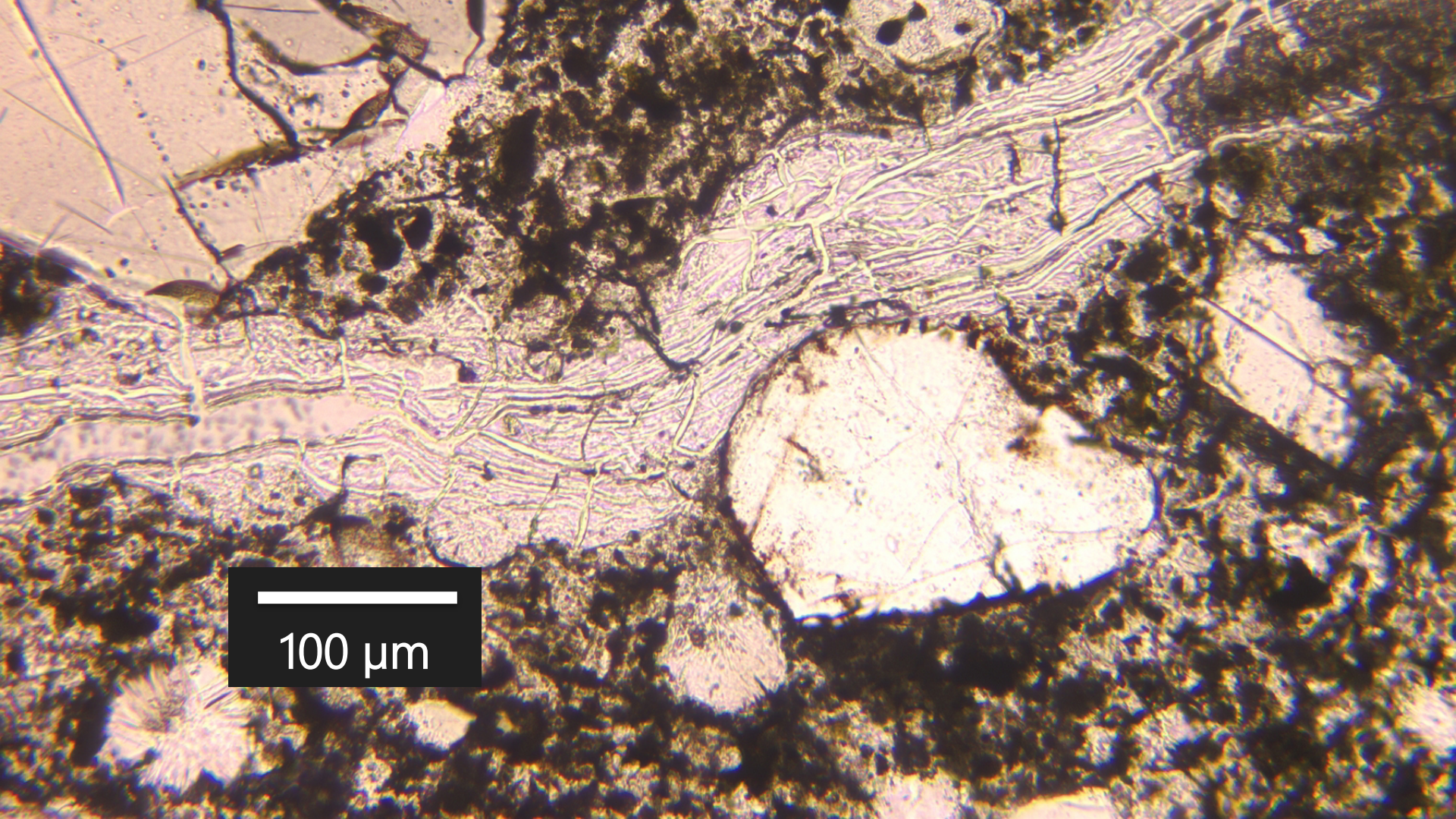

100 µm


0.25mm
gel
chert
chert

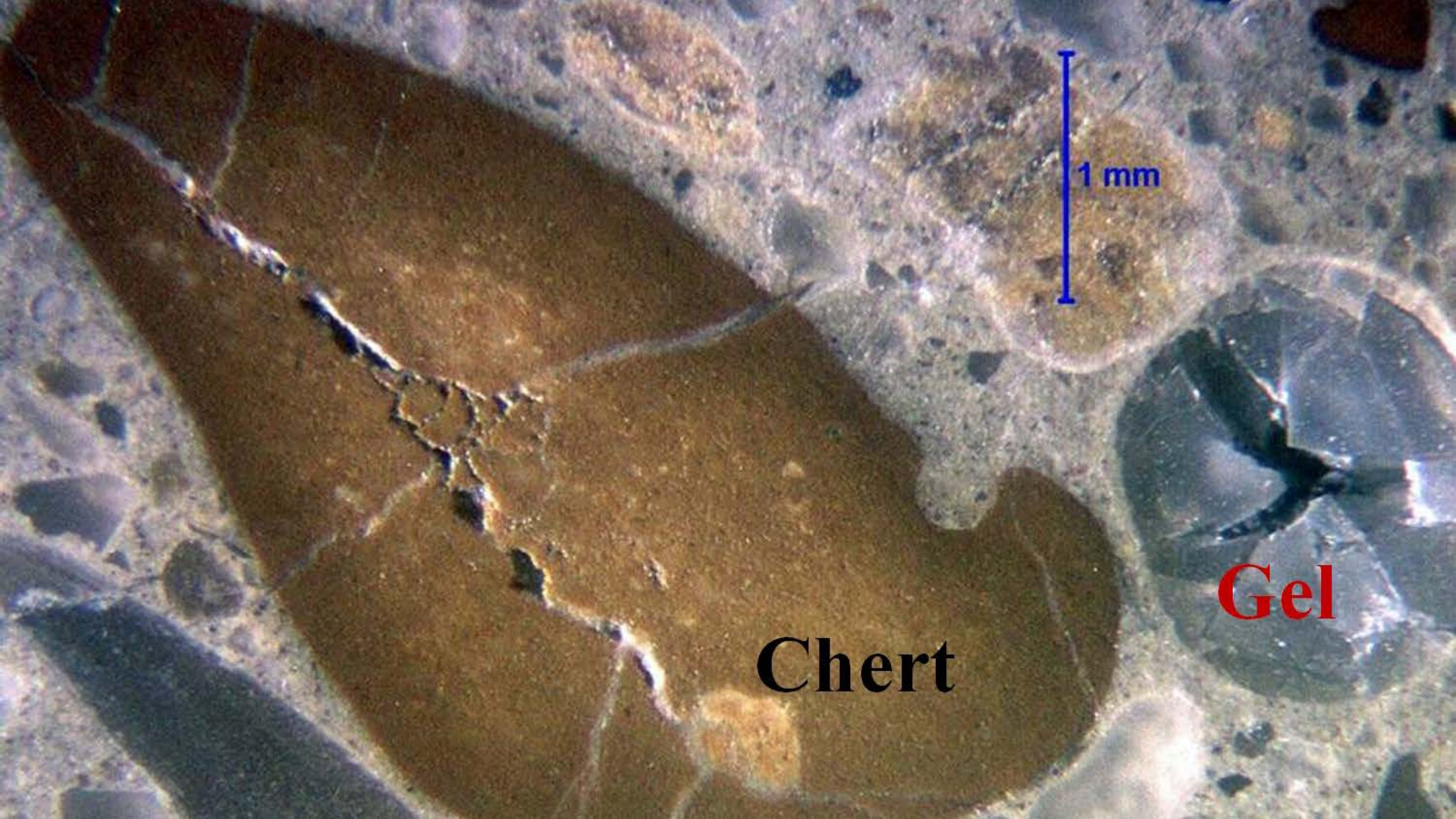
Alkali-Silica Reaction (ASR)

“Fast” Reactors

- **Shales**
- **Some cherts**
- **Glassy volcanics**

“Slow” Reactors

- **Metamorphic lithologies**
- **Argillites**
- **Silicified carbonates**
- **Quartzite**

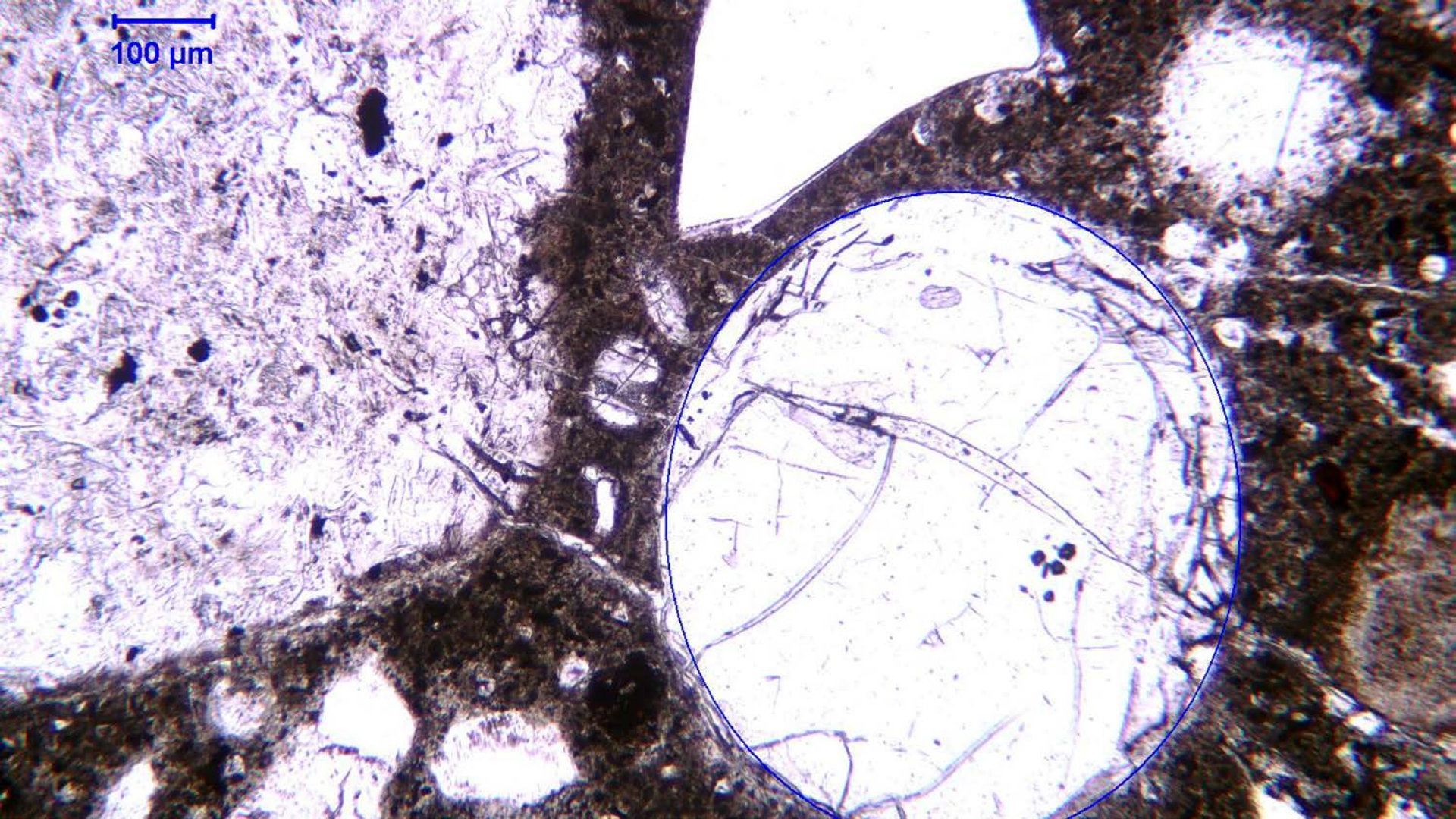

1 mm
Gel
Chert


Volcanic Gravel
Arizona Airport


SERVICES, INC.
METRIC 1 2 3 4 5 6 7

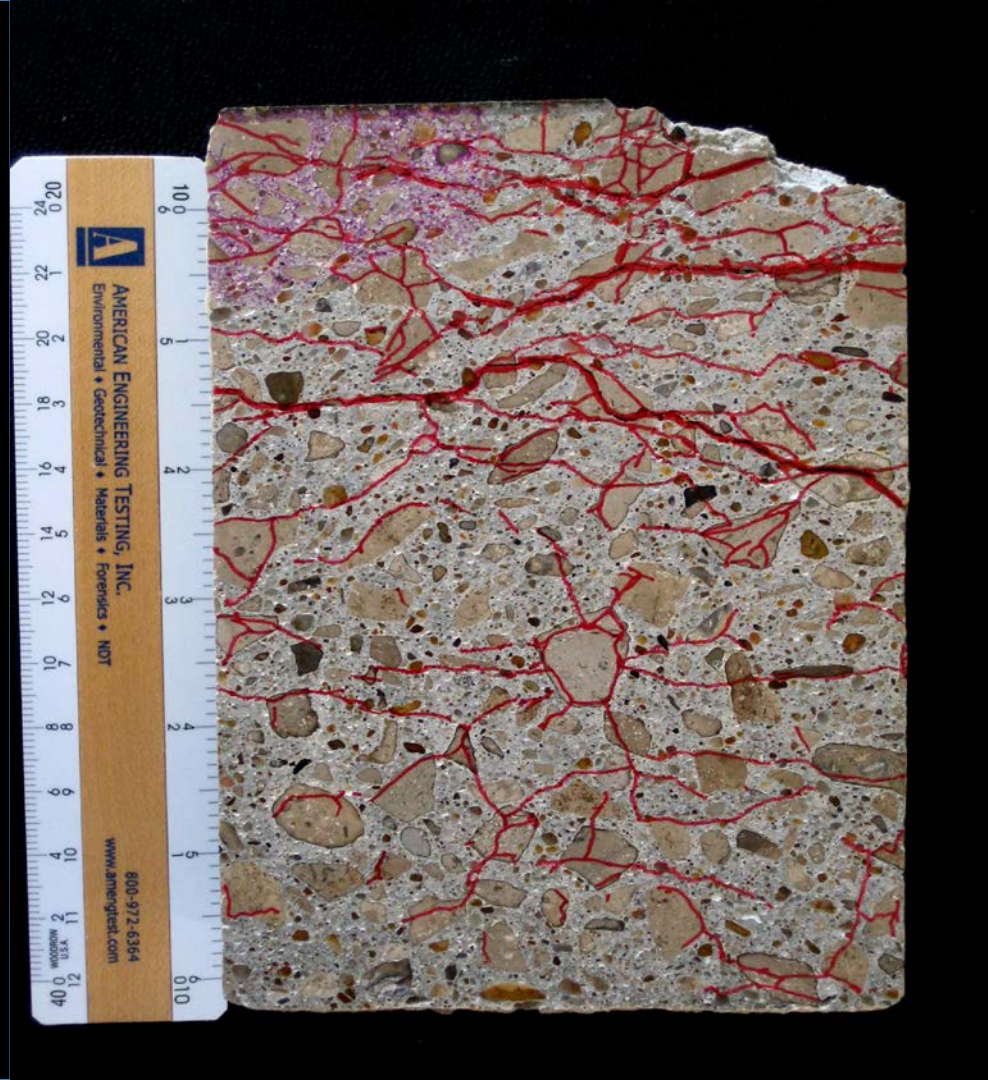
AMERICAN PETROGRAPHIC SERVICES, INC.


1 mm

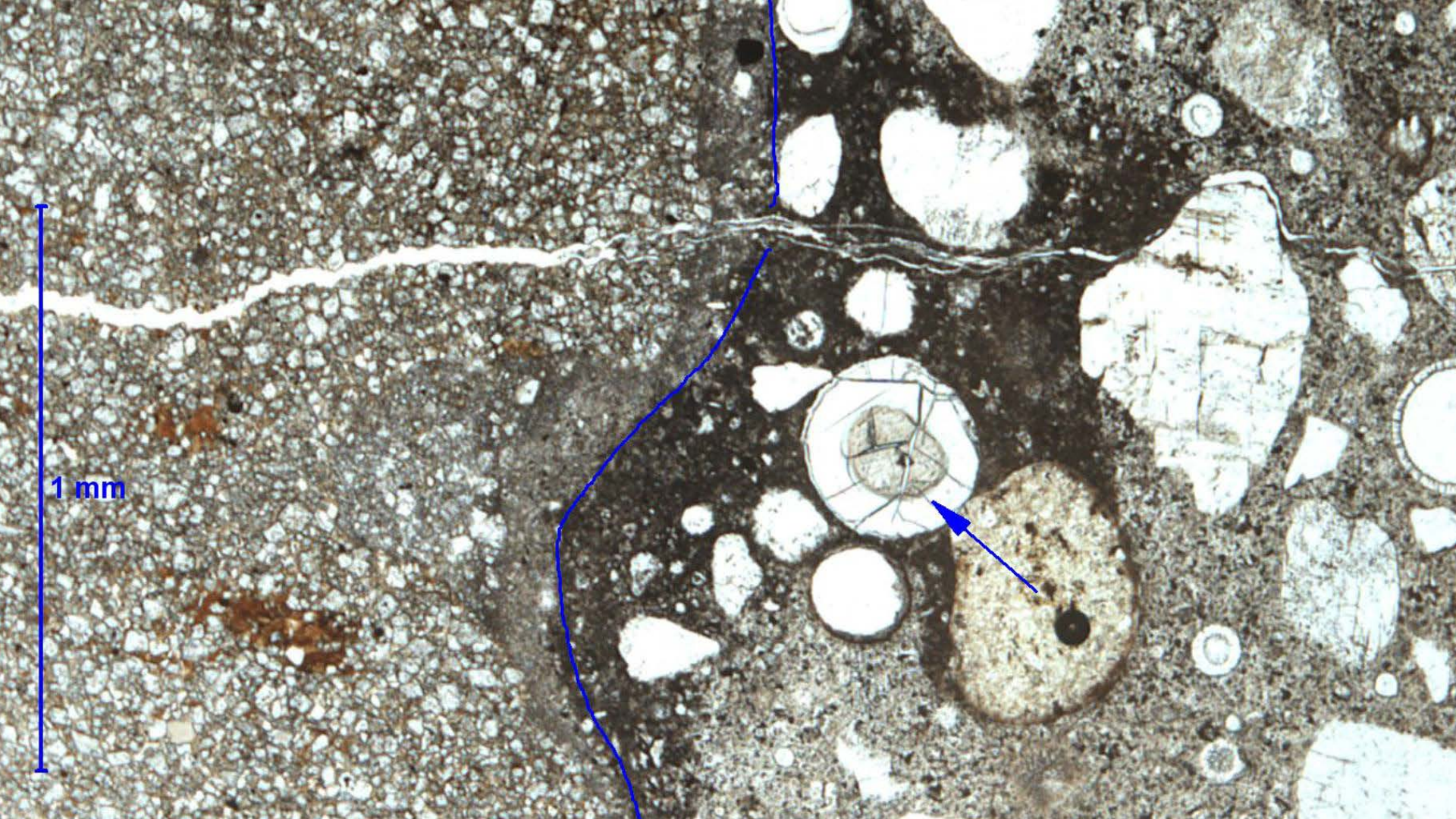

100 µm


Distribution Center
Pavement - Kansas

Silicified Carbonate



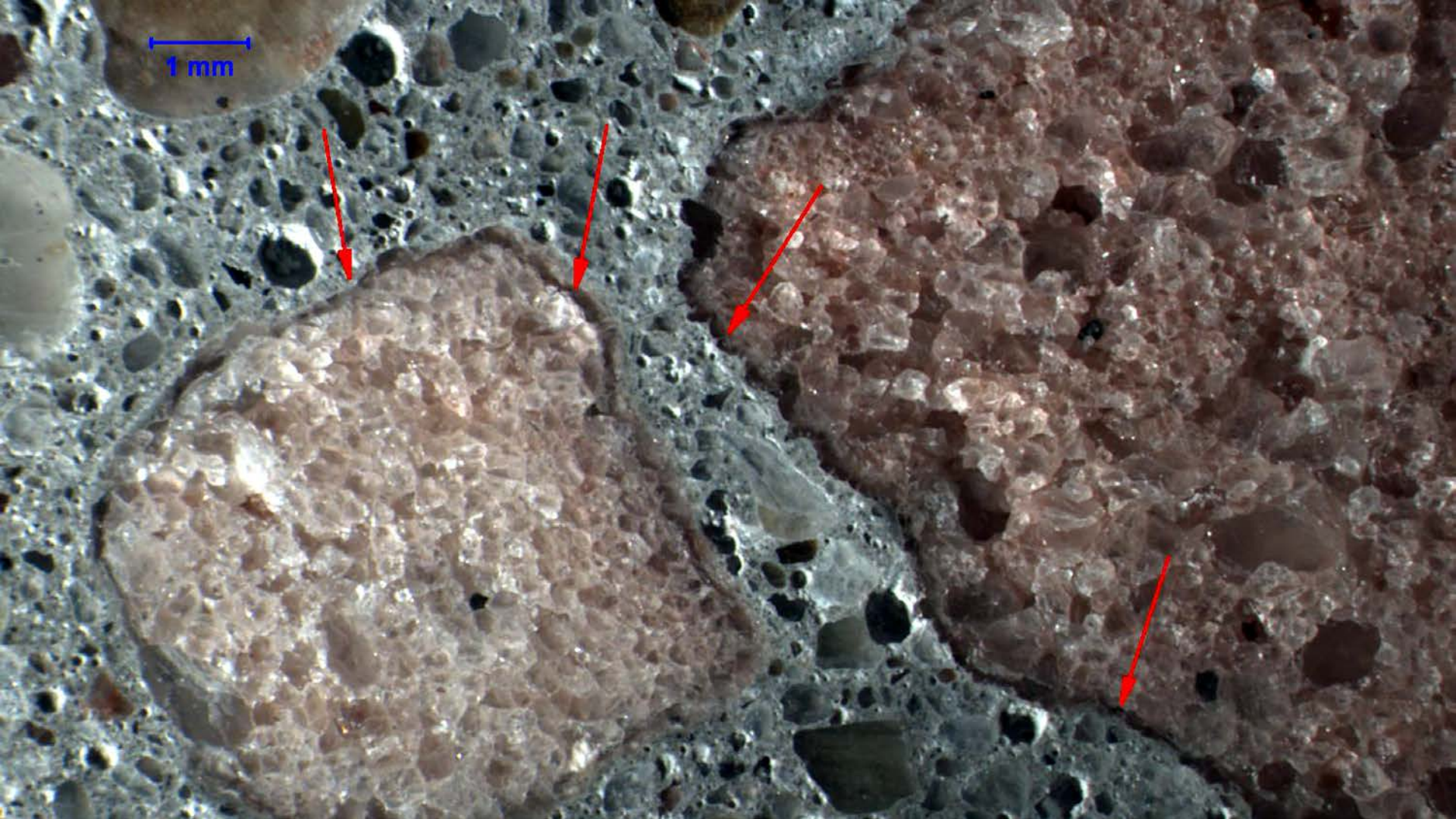

1 mm


1 mm

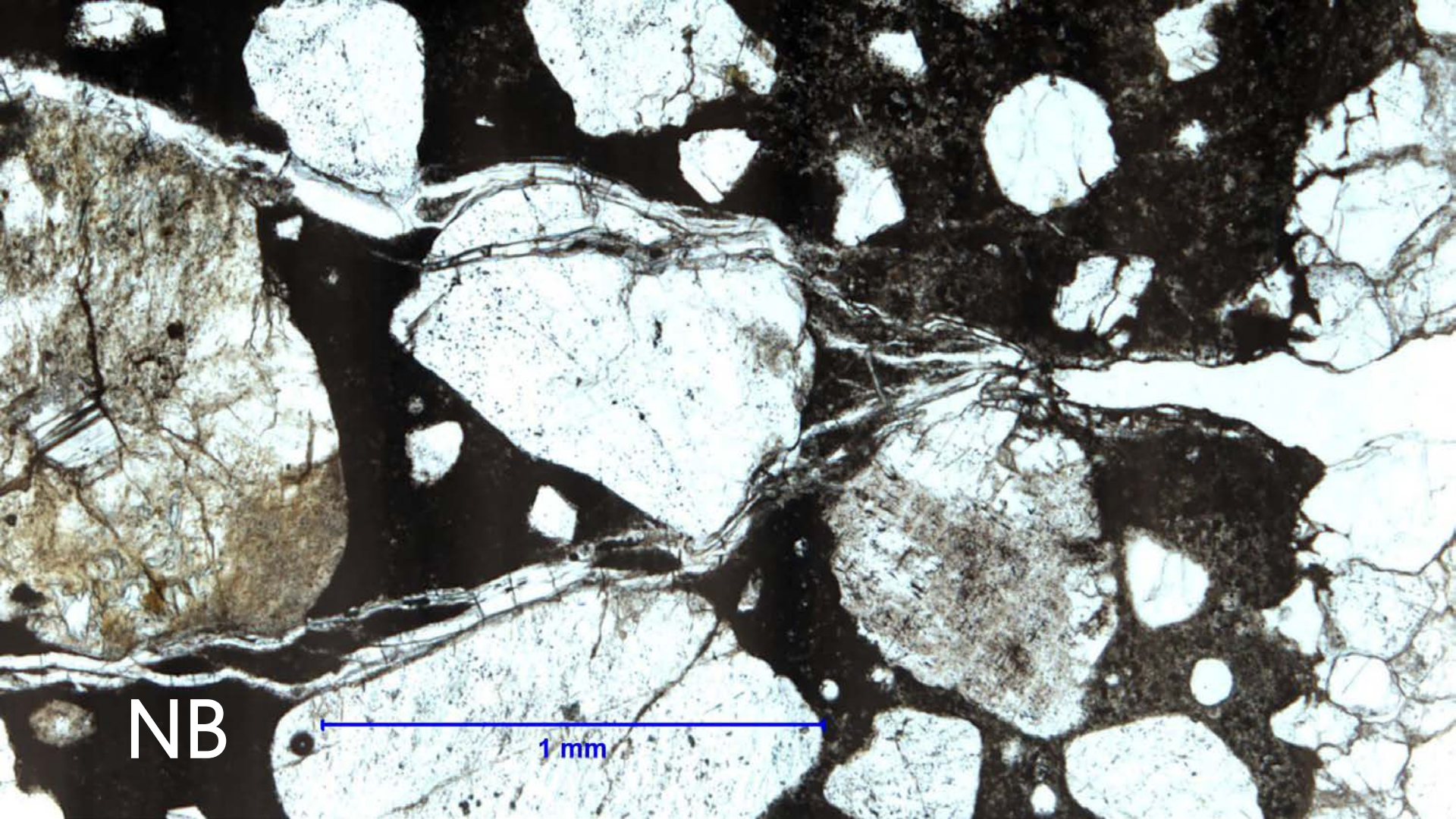
South Dakota

Quartzite


1 mm


1 mm


NB
1 mm


NB
1 mm

Near Surface Aggregate Reactivity

- ASR in the near surface concrete only
- Induced beneath M-S floorings by:
  - high RH
  - conc. of alkalis and OH-
- Produces a defect in flooring bond
- Allows osmotic pressure to produce a liquid-filled blister

NSAR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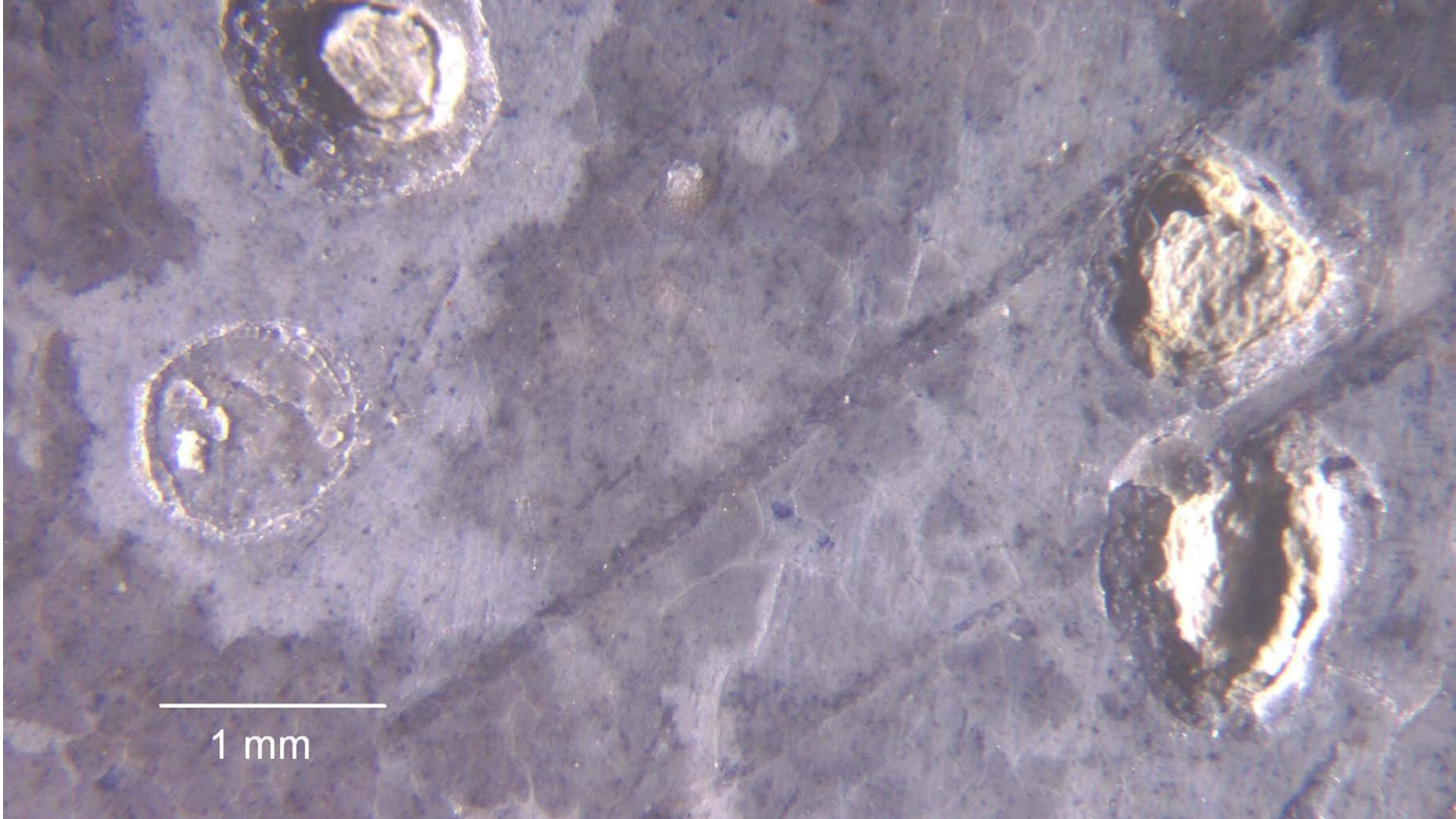
PETROGRAPHIC
SERVICES, INC.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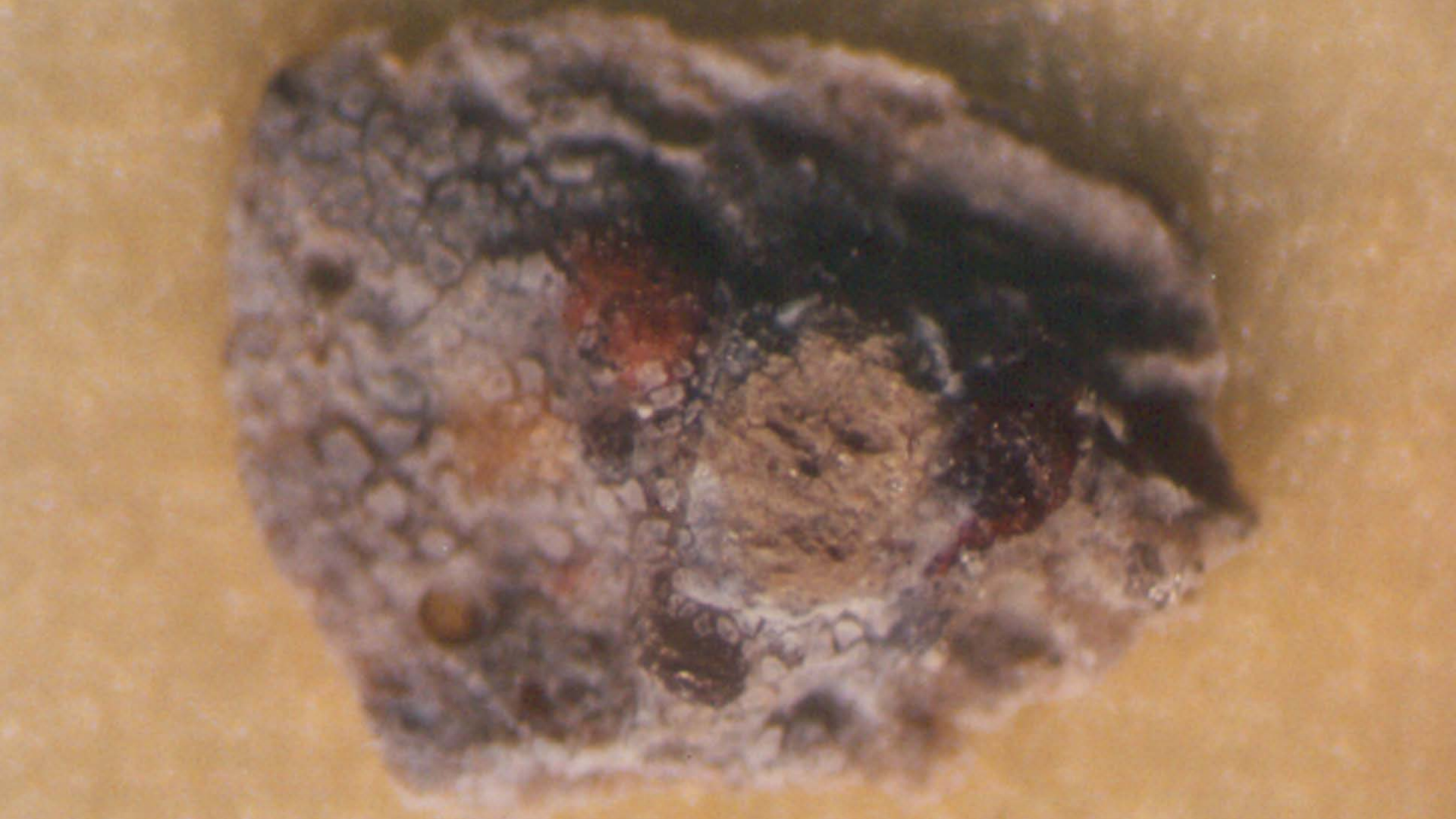
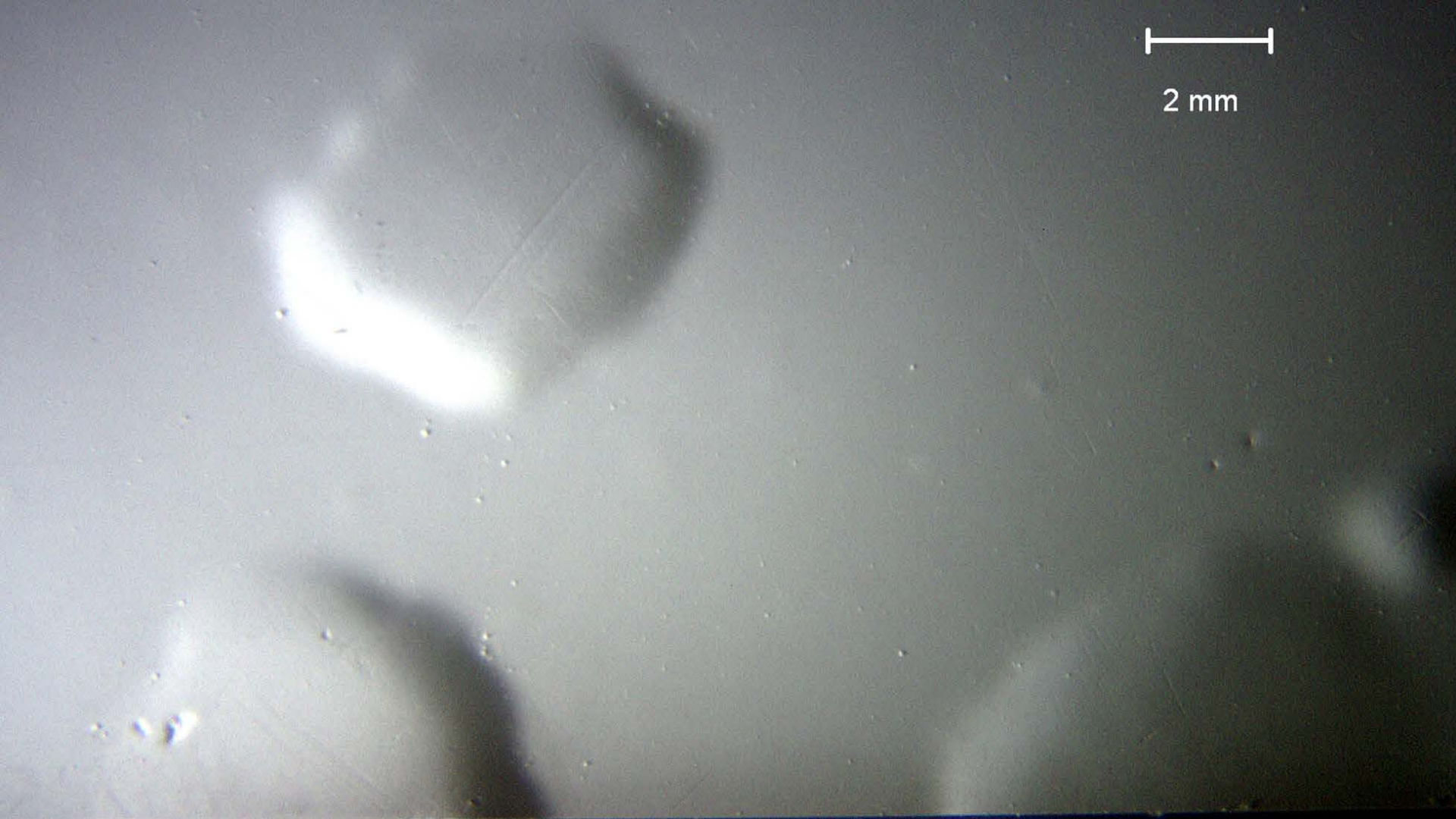
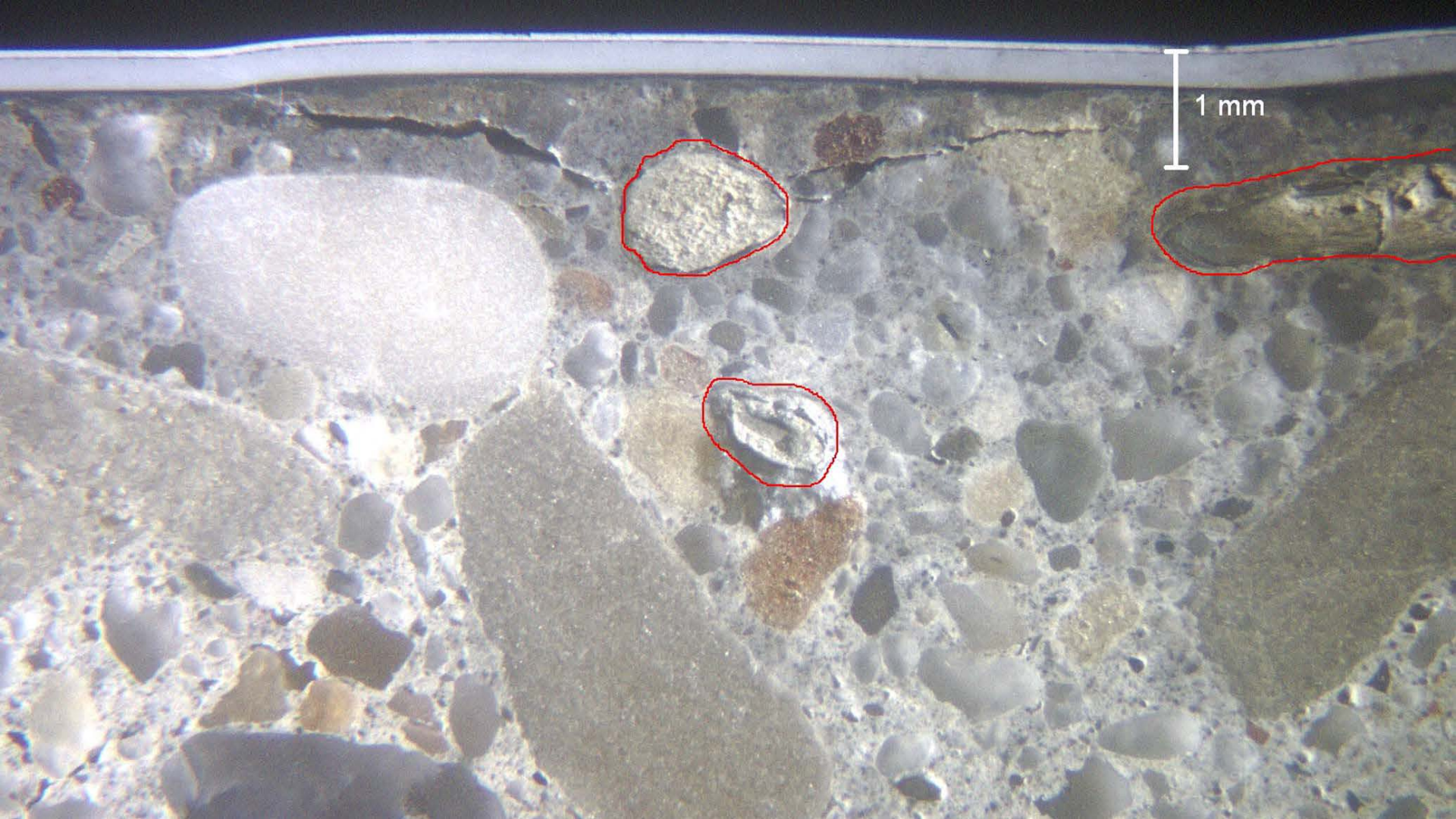



2 mm


1 mm

Pierre Shale

- Highly porous and absorptive
- Amorphous opaline silica (zooplankton) 100ma
- Mixed layer clays

Grey Drift

Red Drift

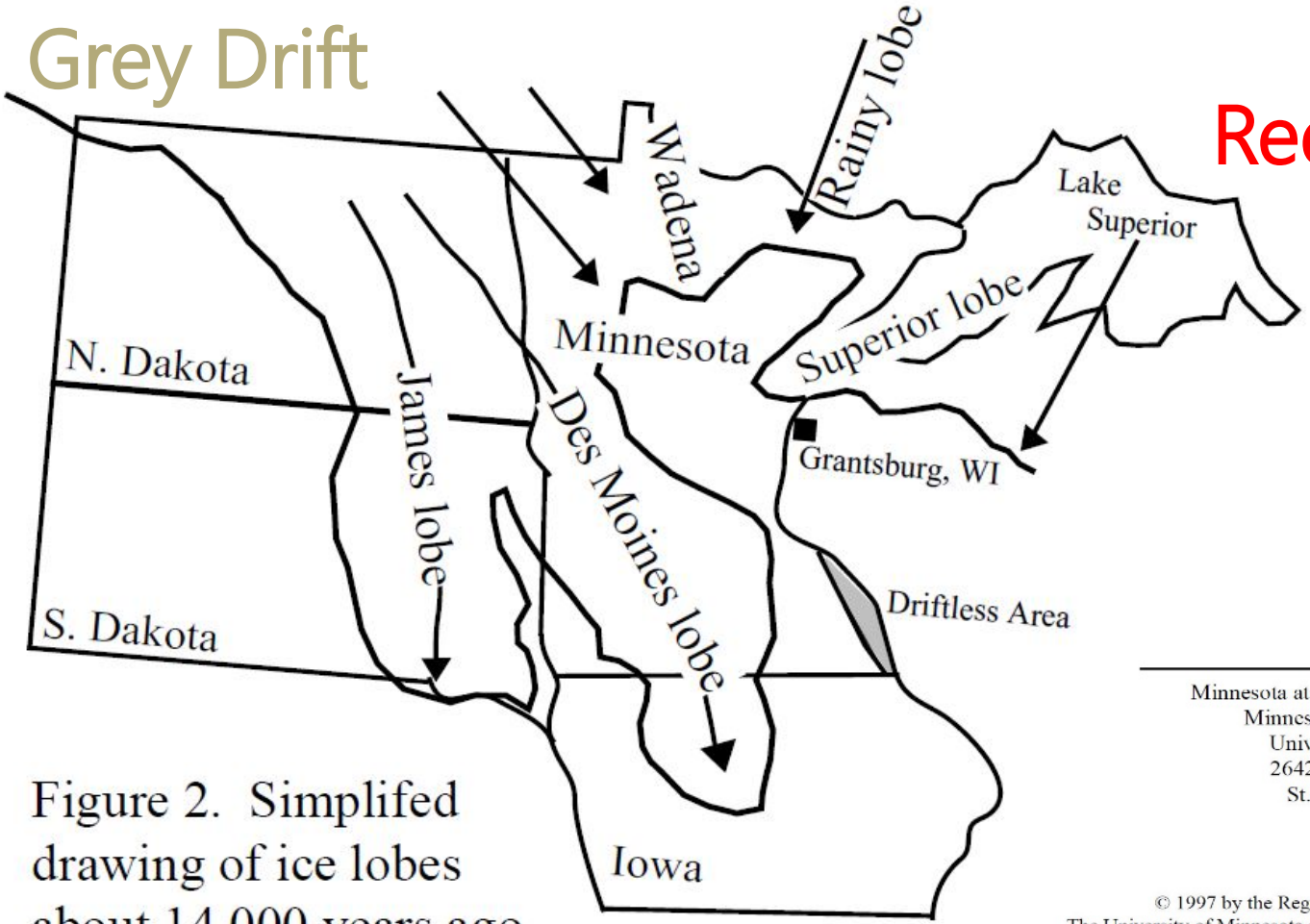
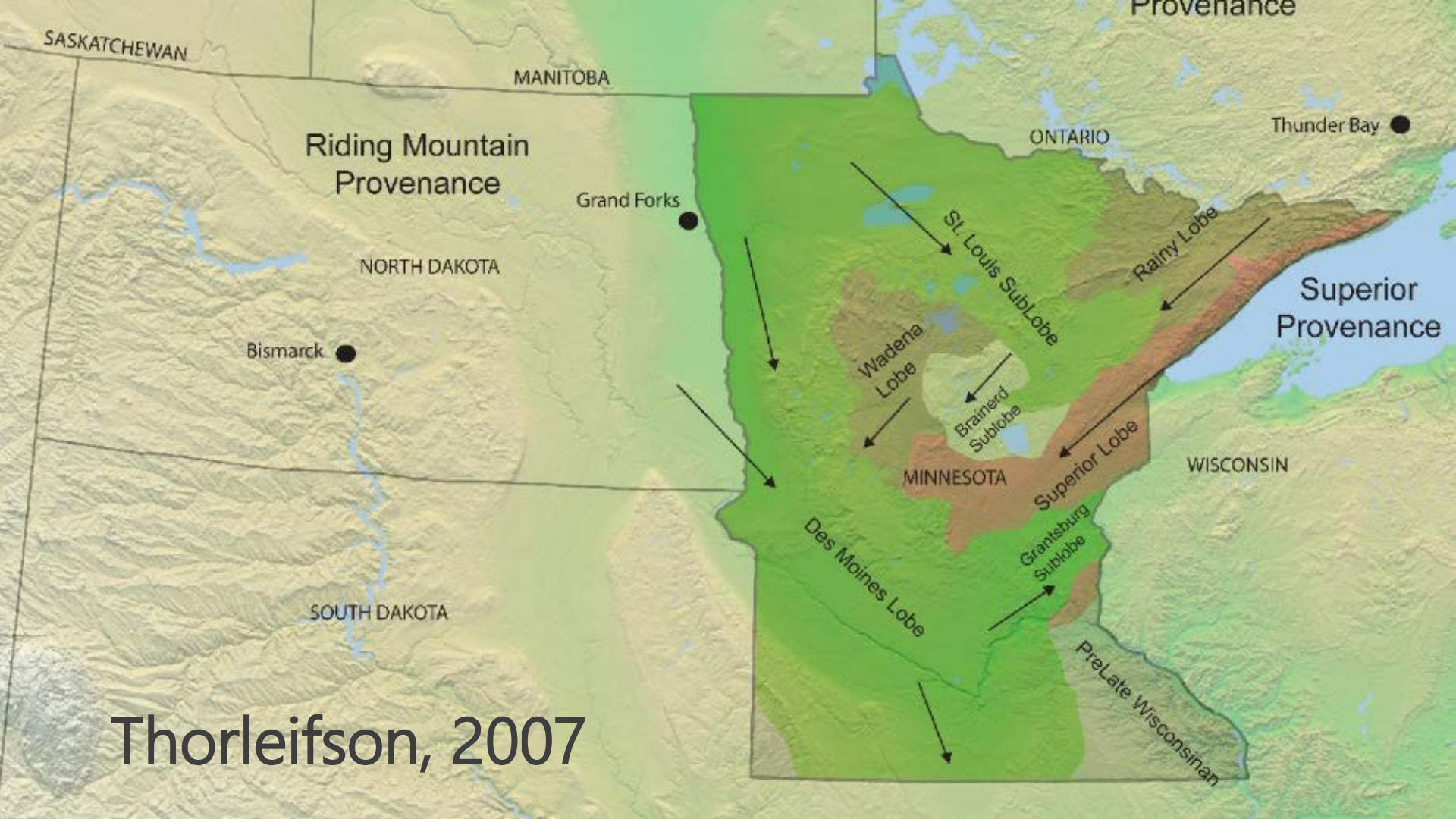


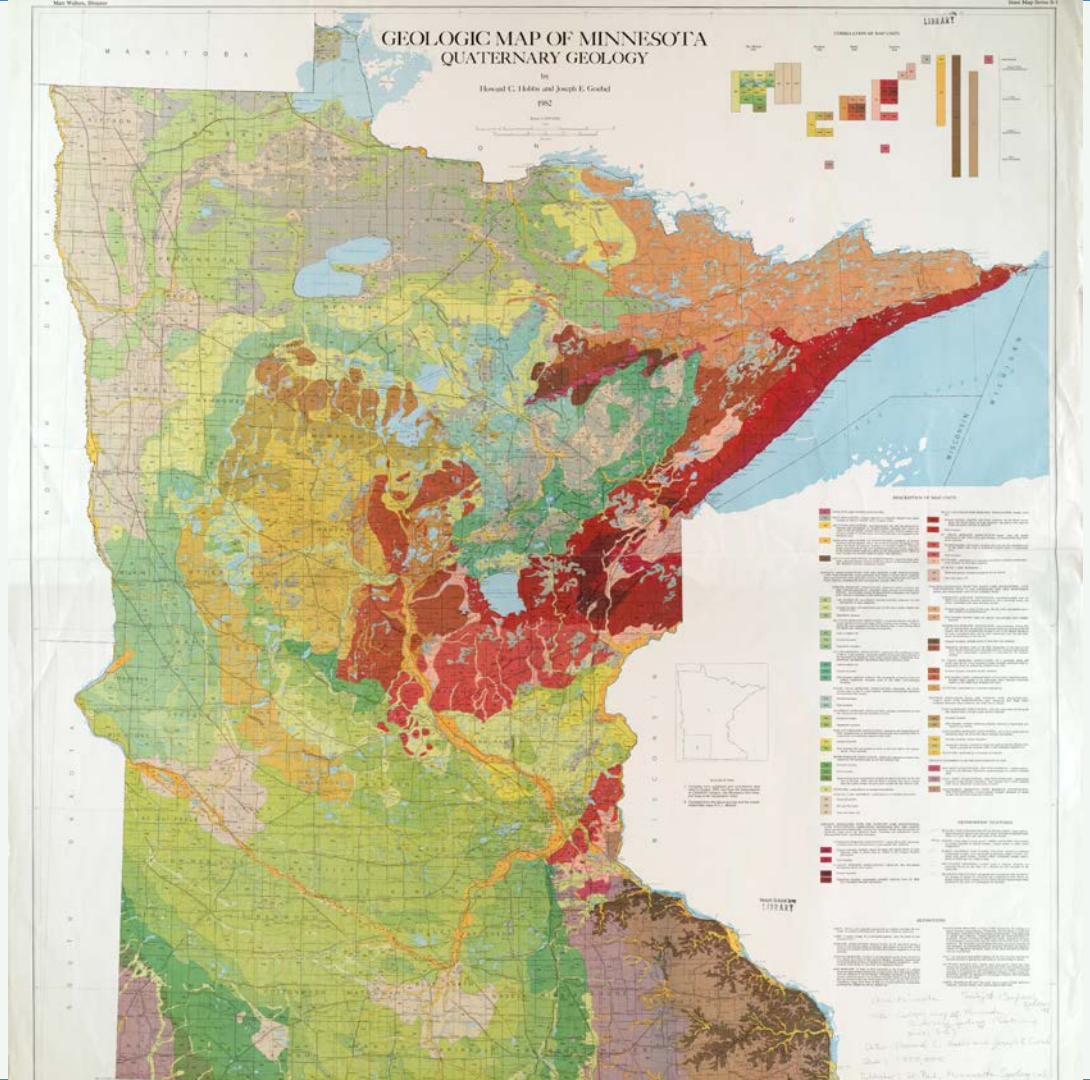
Figure 2. Simplifed drawing of ice lobes about 14,000 years ago.

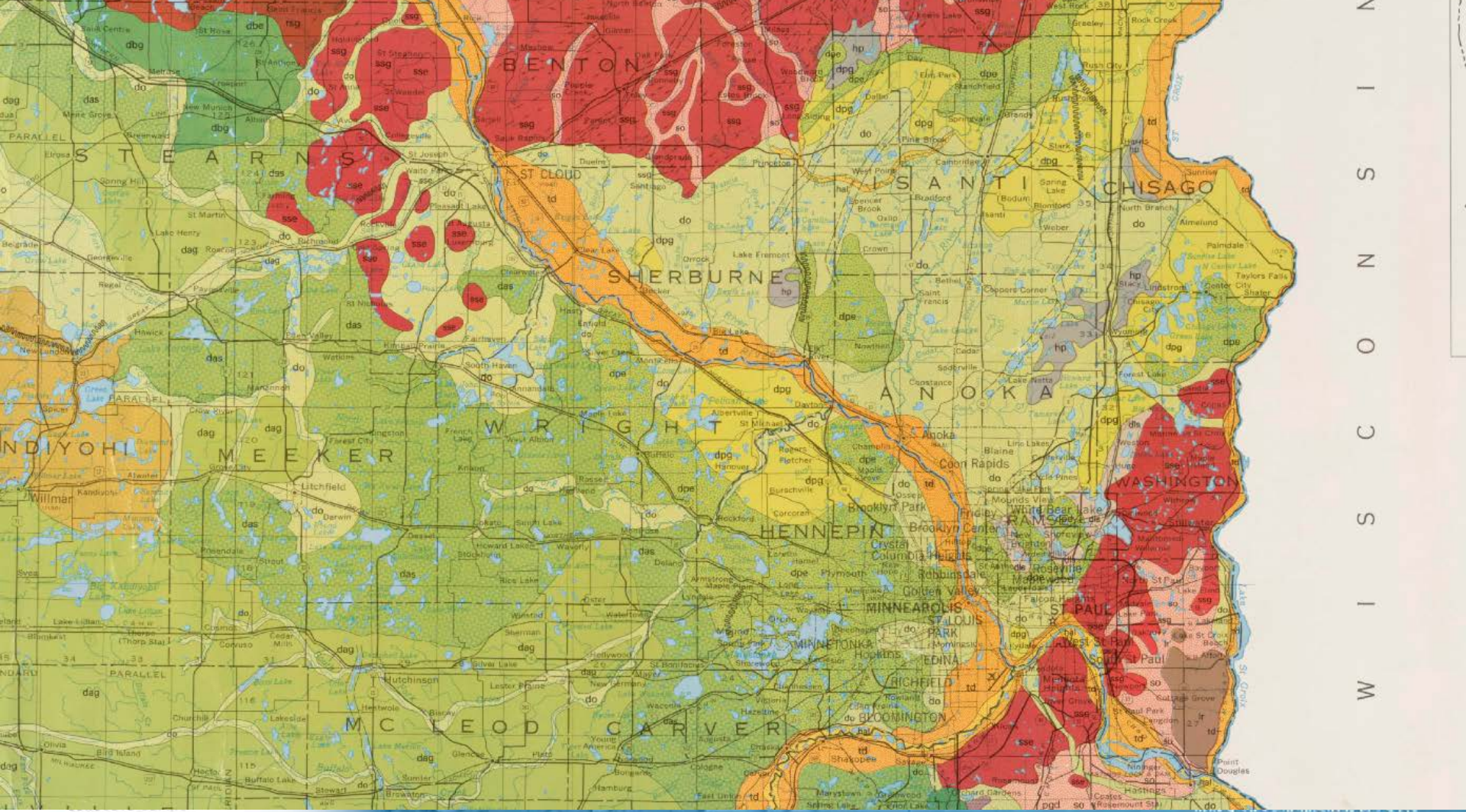
Minnesota at a Glance is produced by the
Minnesota Geological Survey
University of Minnesota
2642 University Avenue
St. Paul, MN 55114

B.A. Lusardi, 1994;
revised March 1997



Thorleifson, 2007


GEOLOGIC MAP OF MINNESOTA
QUATERNARY GEOLOGY
by
Howard C. Hobbs and Joseph E. Goebel
1982
MANITOBA
LIBRARY


BENTON
STEARNS
ST CLOUD
SHERBURNE
ISANTI
CHISAGO
ANOKA
WRIGHT
MEEKER
HENNEPIN
WASHINGTON
RAMSEY
MINNEAPOLIS
ST PAUL
MINNETONKA
EDINA
RICHFIELD
BLOOMINGTON
MCLEOD
CARVER
WISCONSIN

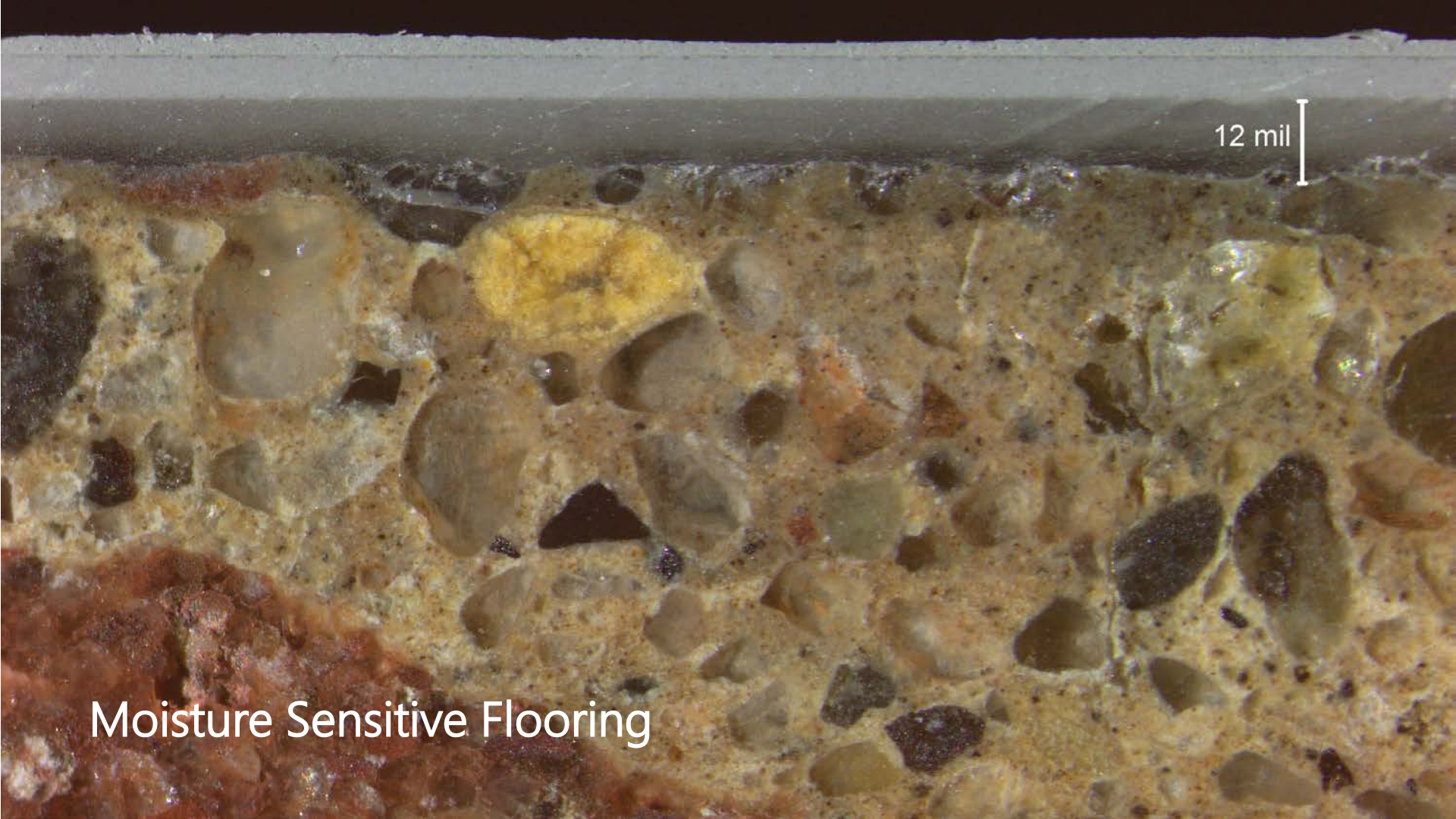

C123 -2.4spg
1 mm


C123 -2.4spg
2 mm

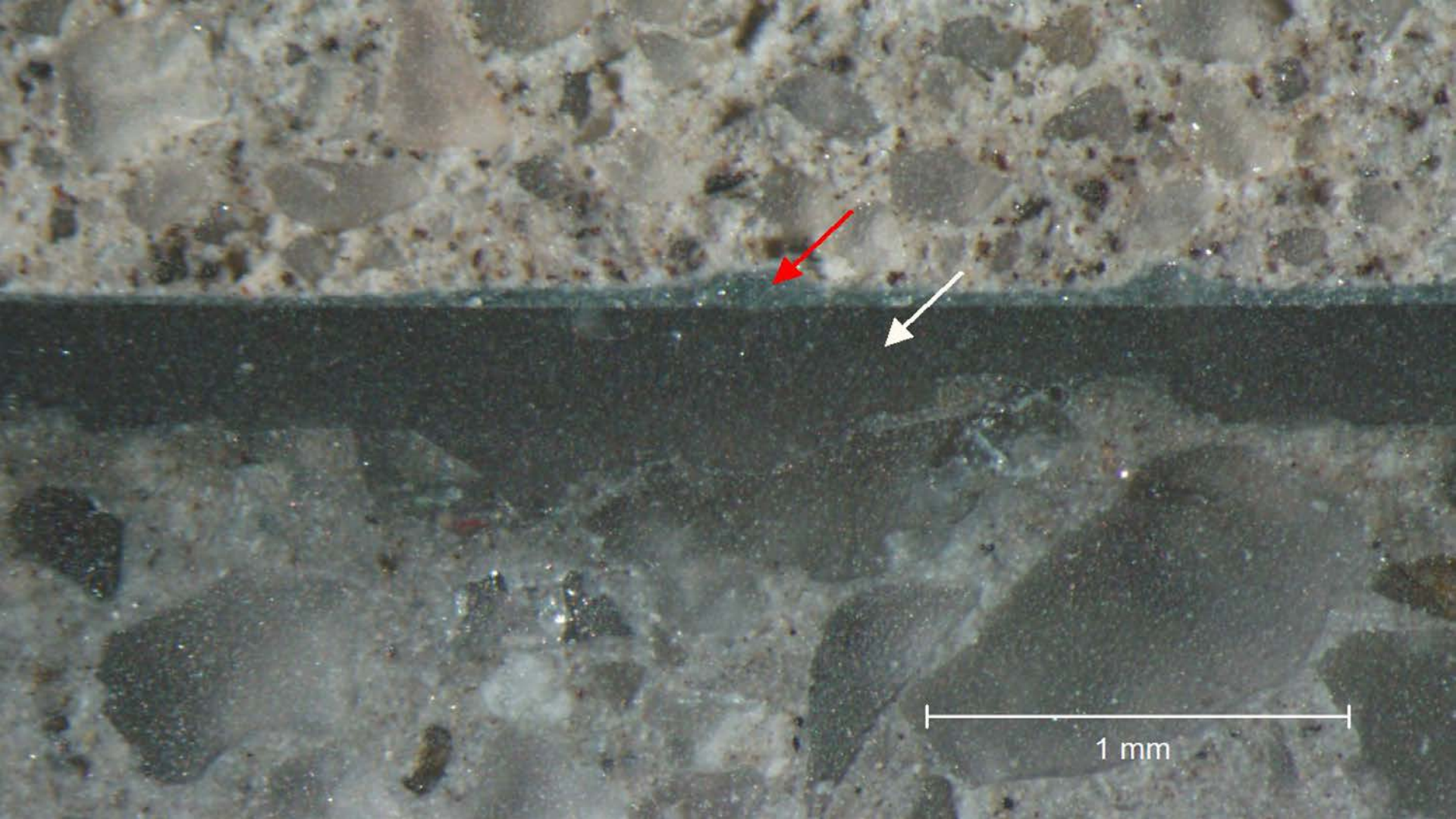
ASTM C33 Aggregate Quality

TABLE 2 Limits for Deleterious Substances in Fine Aggregate for Concrete

Item	Mass Percent of Total Sample, max
Clay lumps and friable particles	3.0
Coal and lignite:	
Where surface appearance of concrete is of importance	0.5
All other concrete	1.0



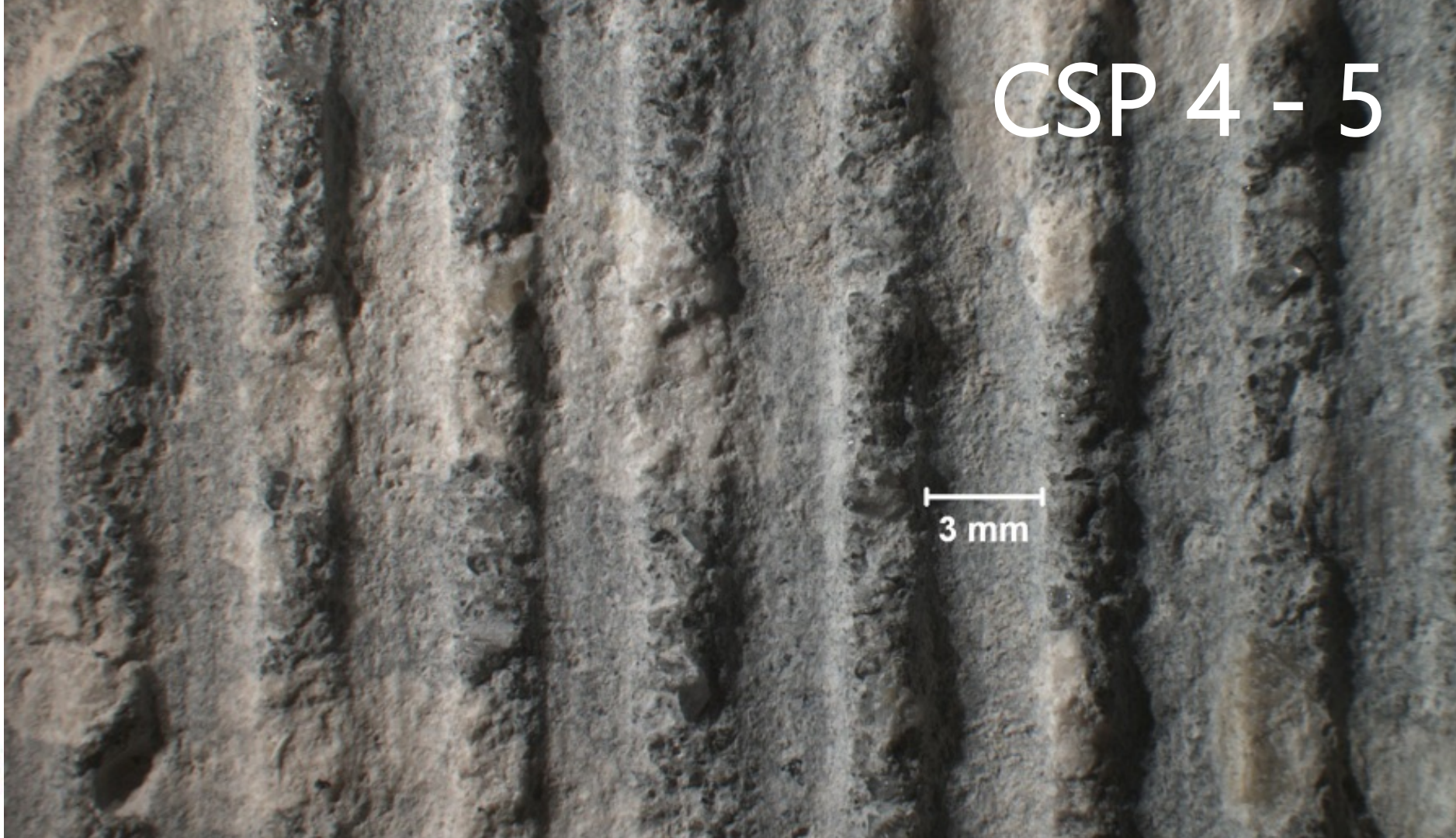
Moisture Sensitive Flooring


1 mm

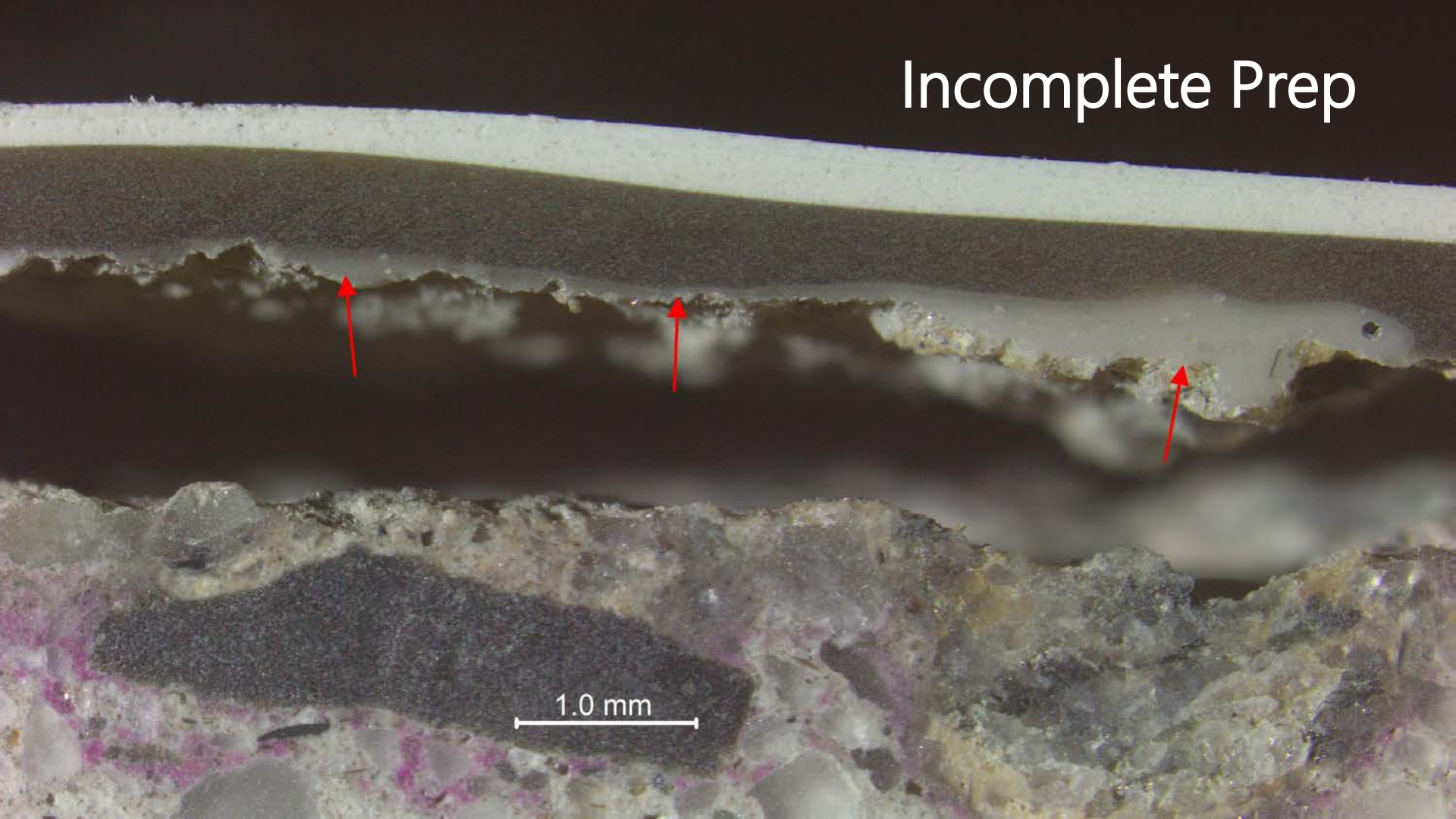
Surface Prep

ICRI CSP “chips”


CSP 3
1 mm


CSP 4 - 5
3 mm

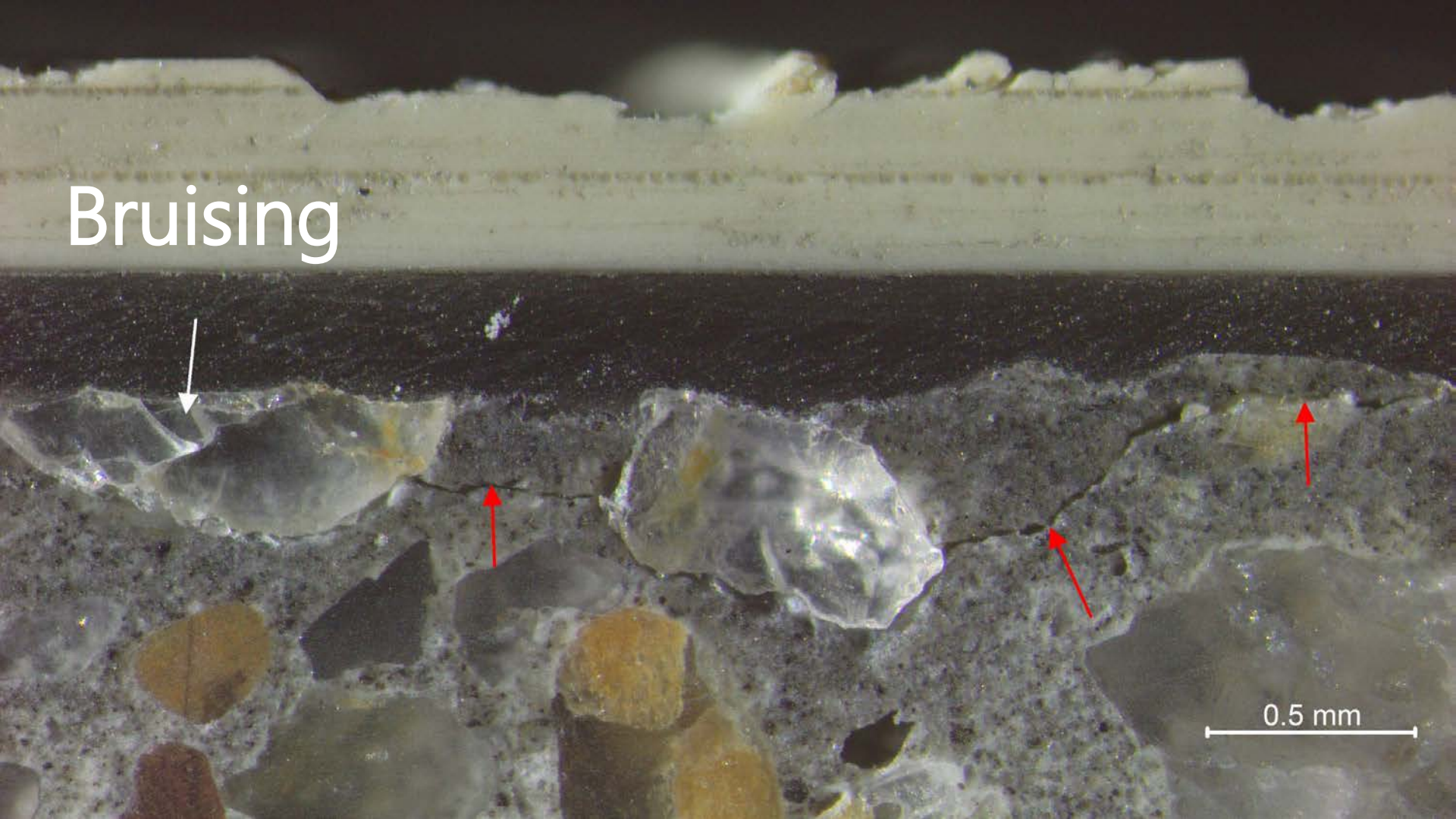
Incomplete Prep



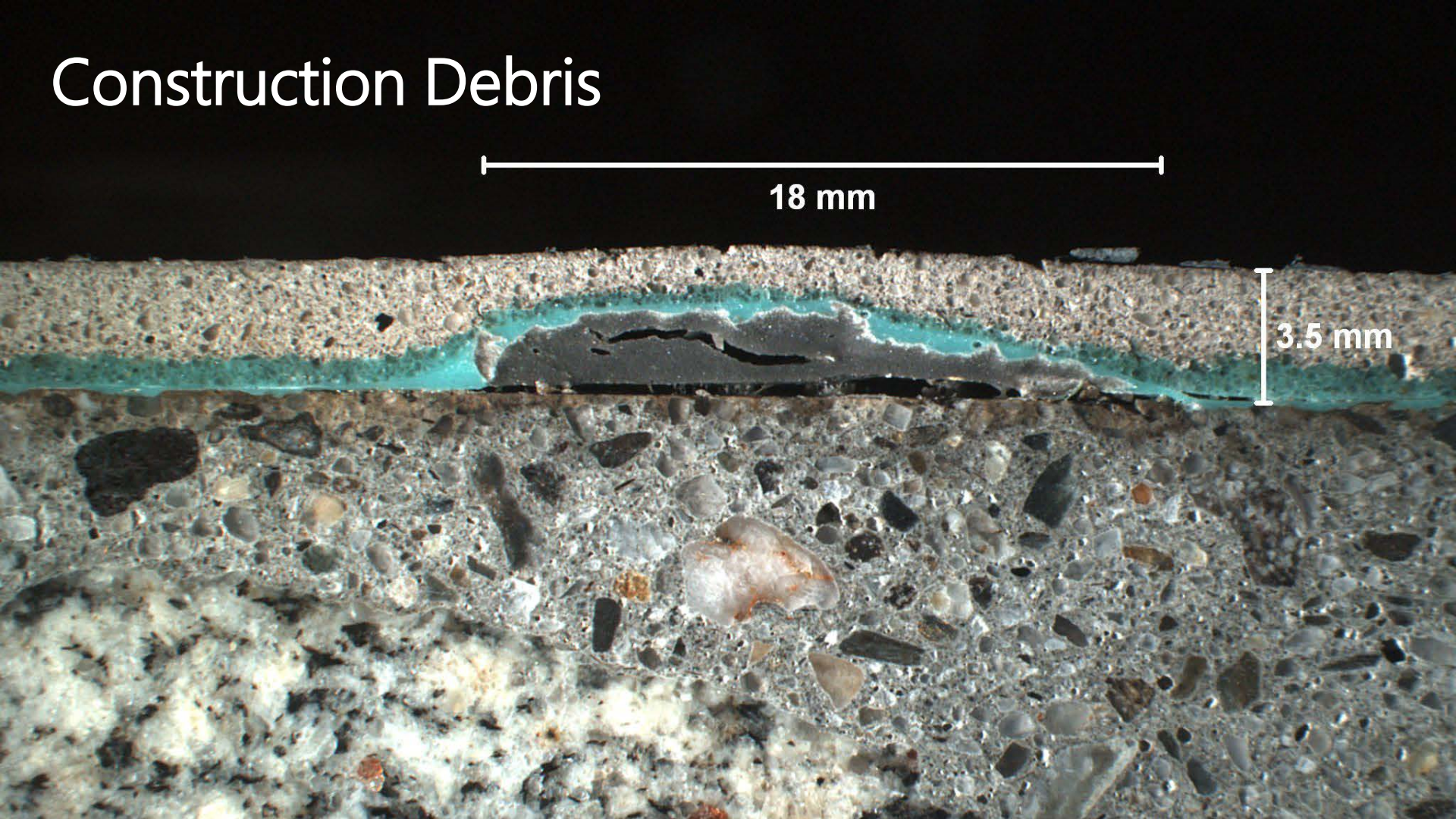

Incomplete Prep
-Curing Compound
1 mm

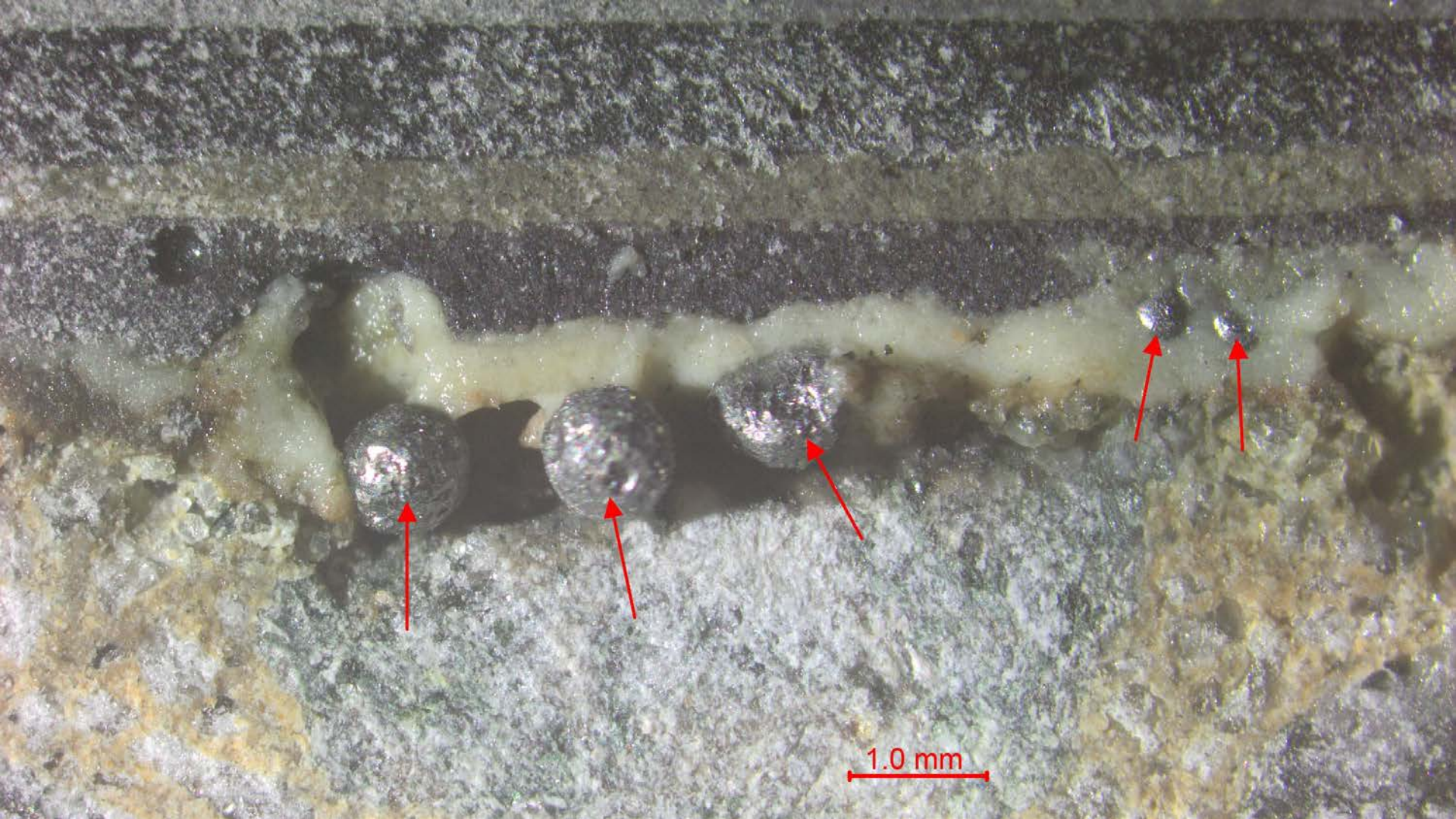

Incomplete Prep
-penetrating sealer
1 mm

Bruising

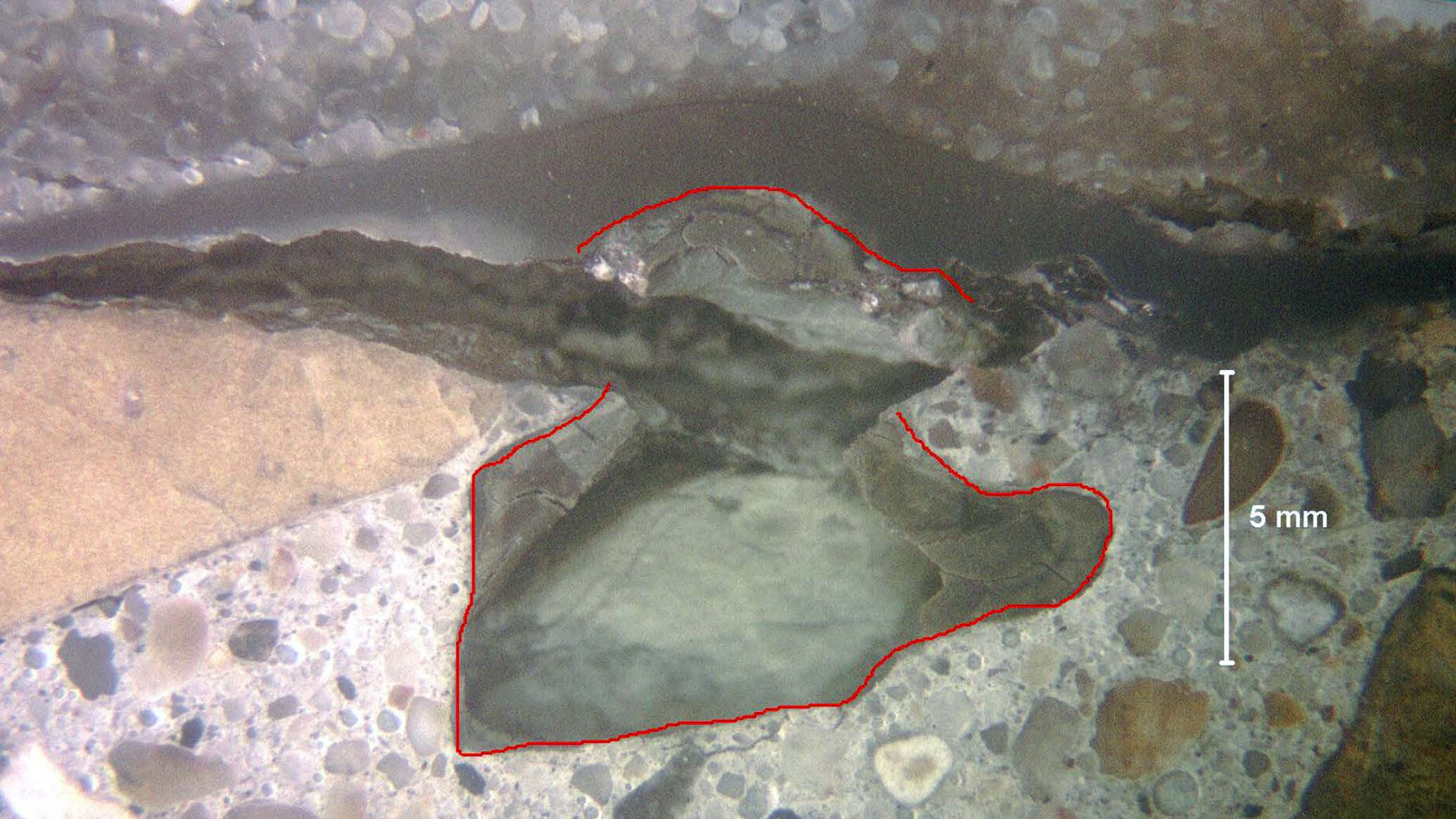


Construction Debris




1.0 mm

Hangar Floor
MN


5 mm

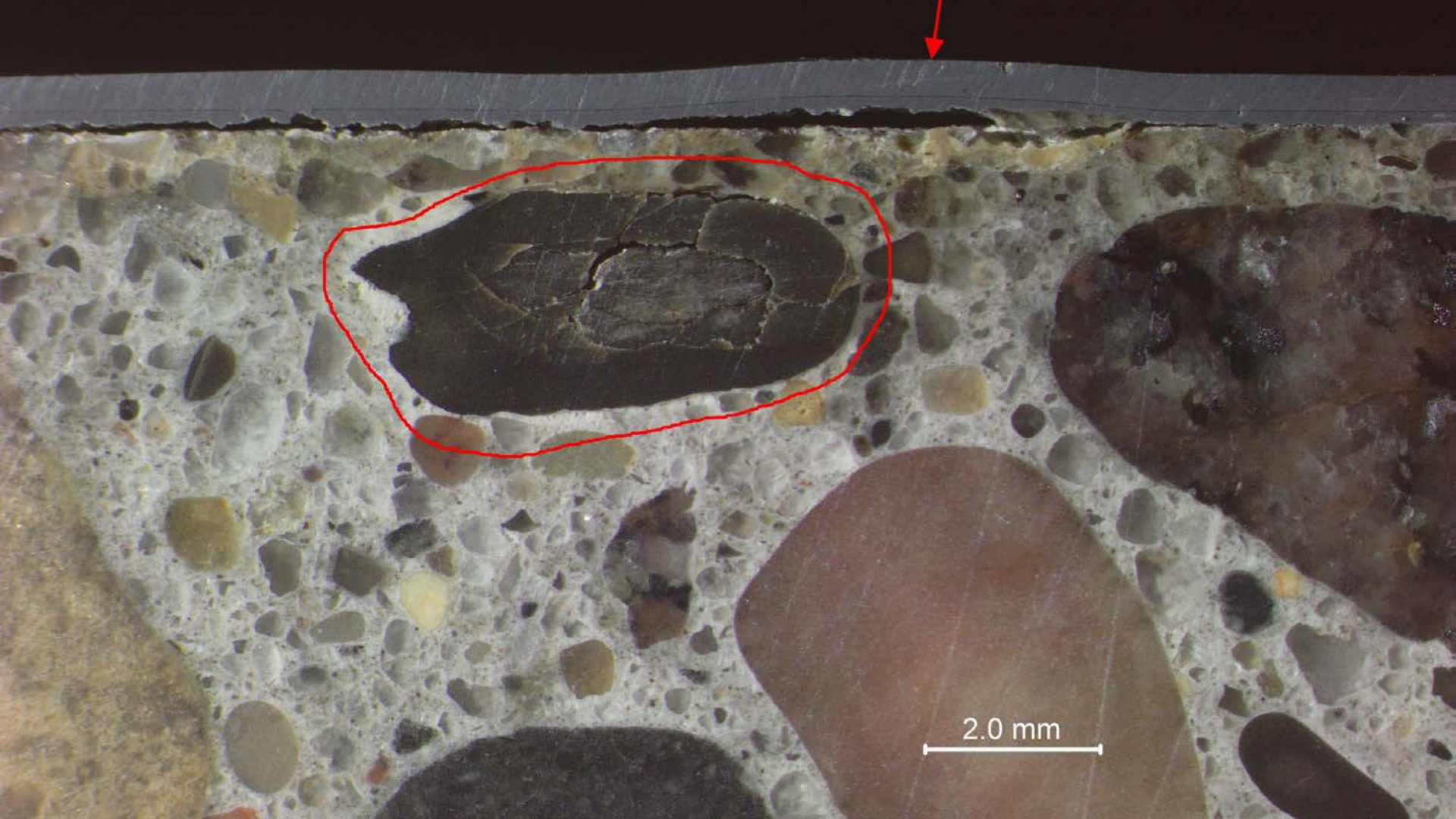

Defects in Bond may = Osmotic Blisters
Local Commercial Floor

Local Commercial Floor – preexisting

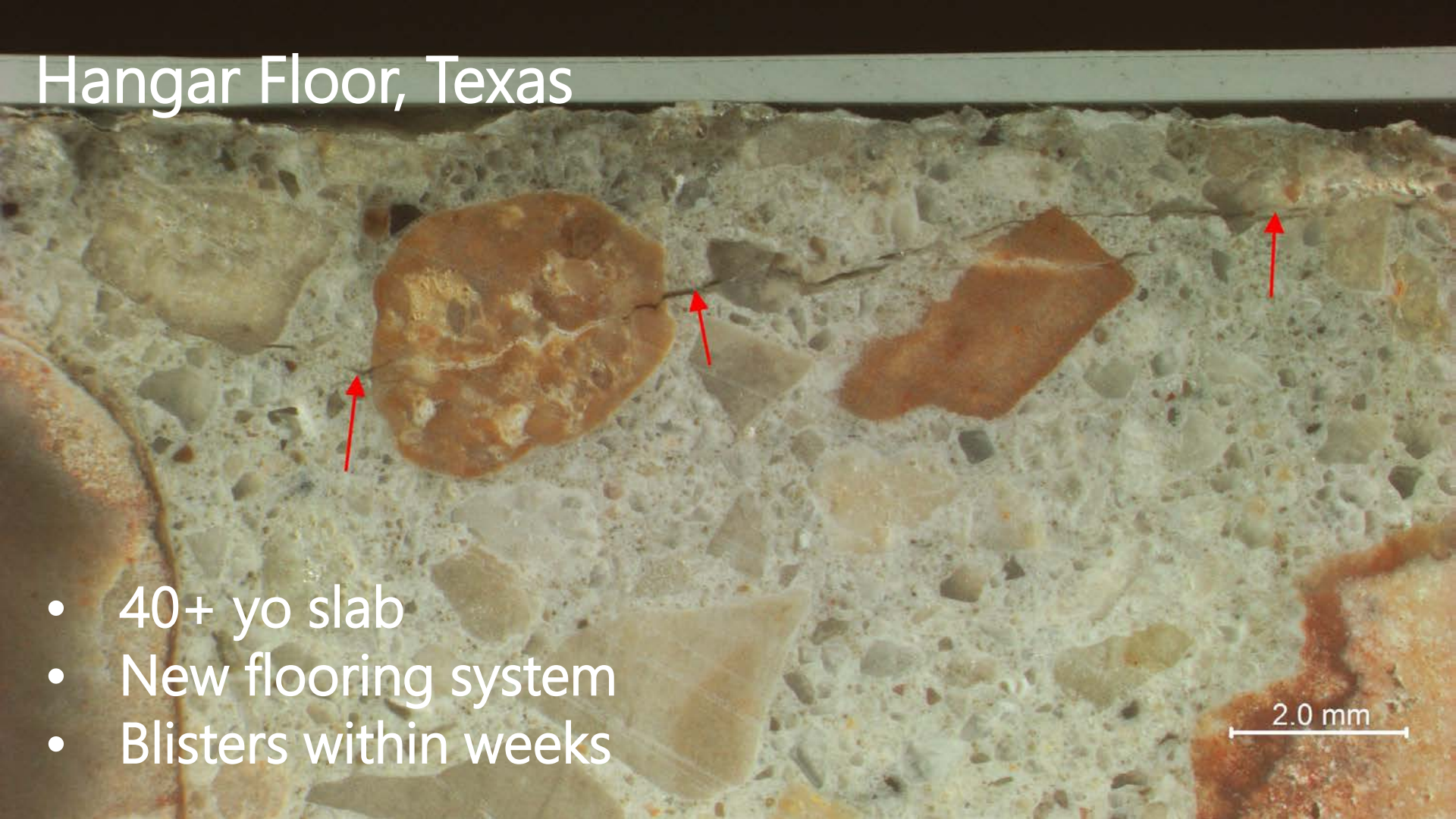

New Epoxy Flooring – 2 months


CM
AMERICAN

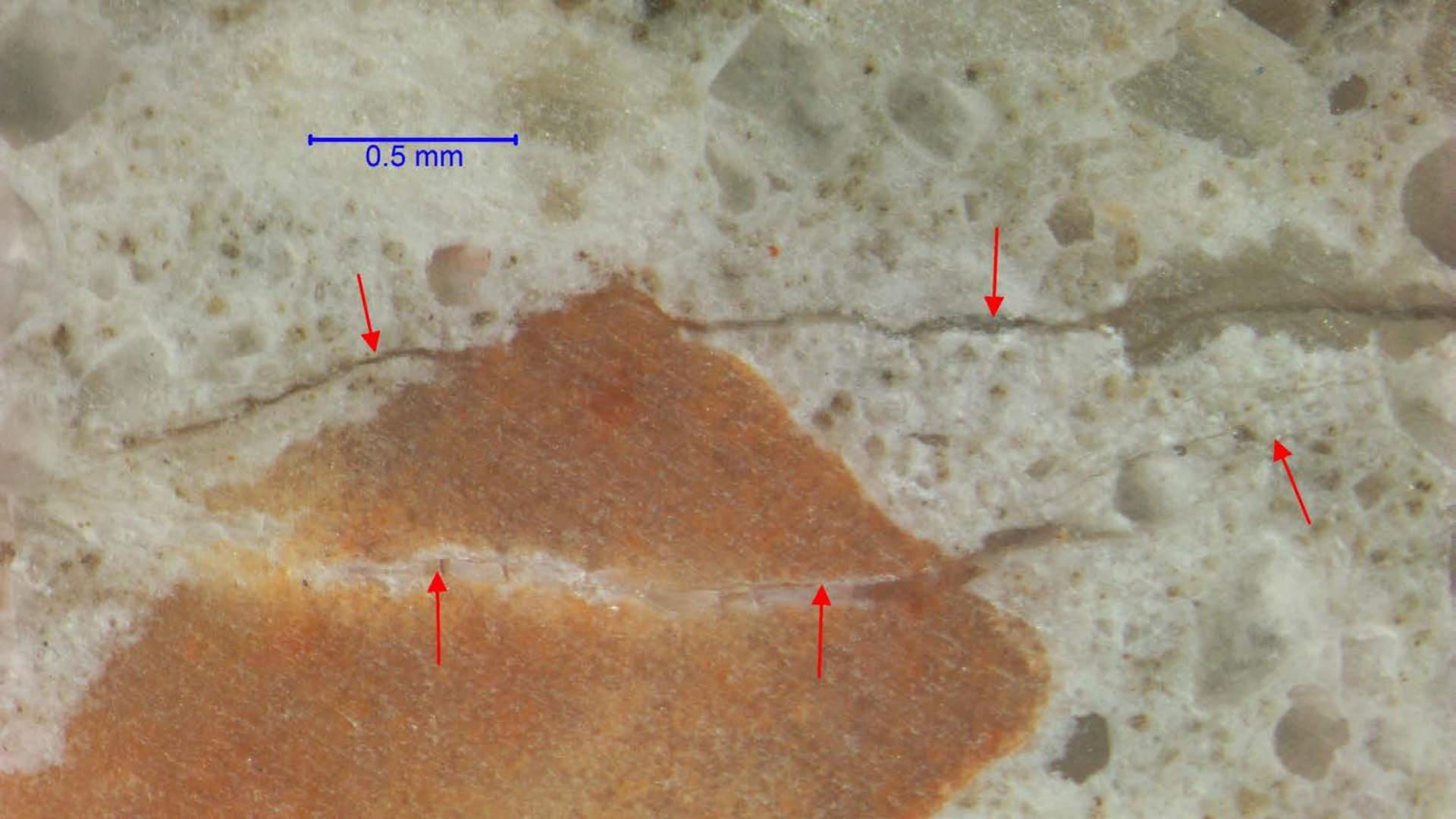

5.0 mm


2.0 mm

Hangar Floor, Texas

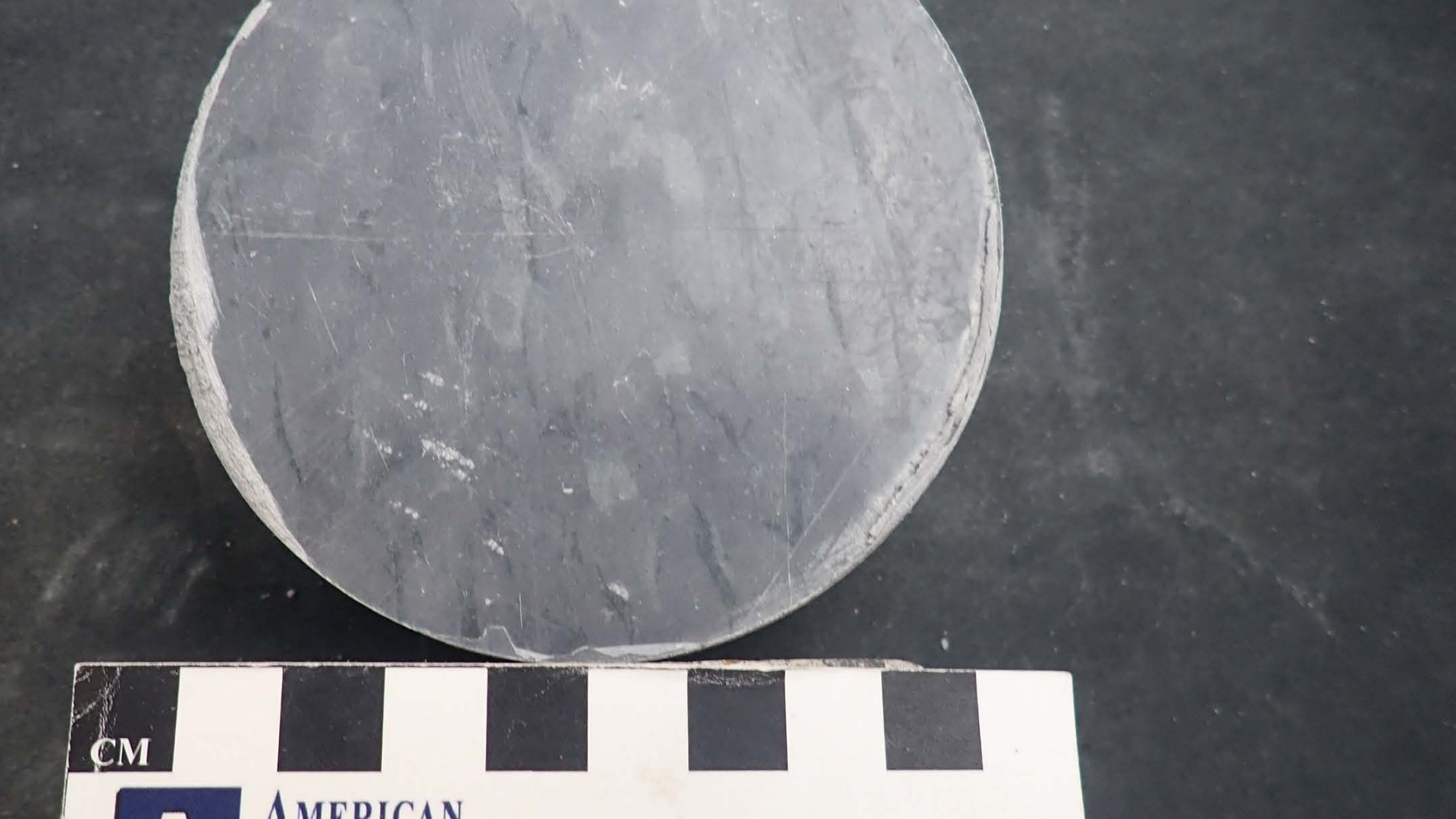


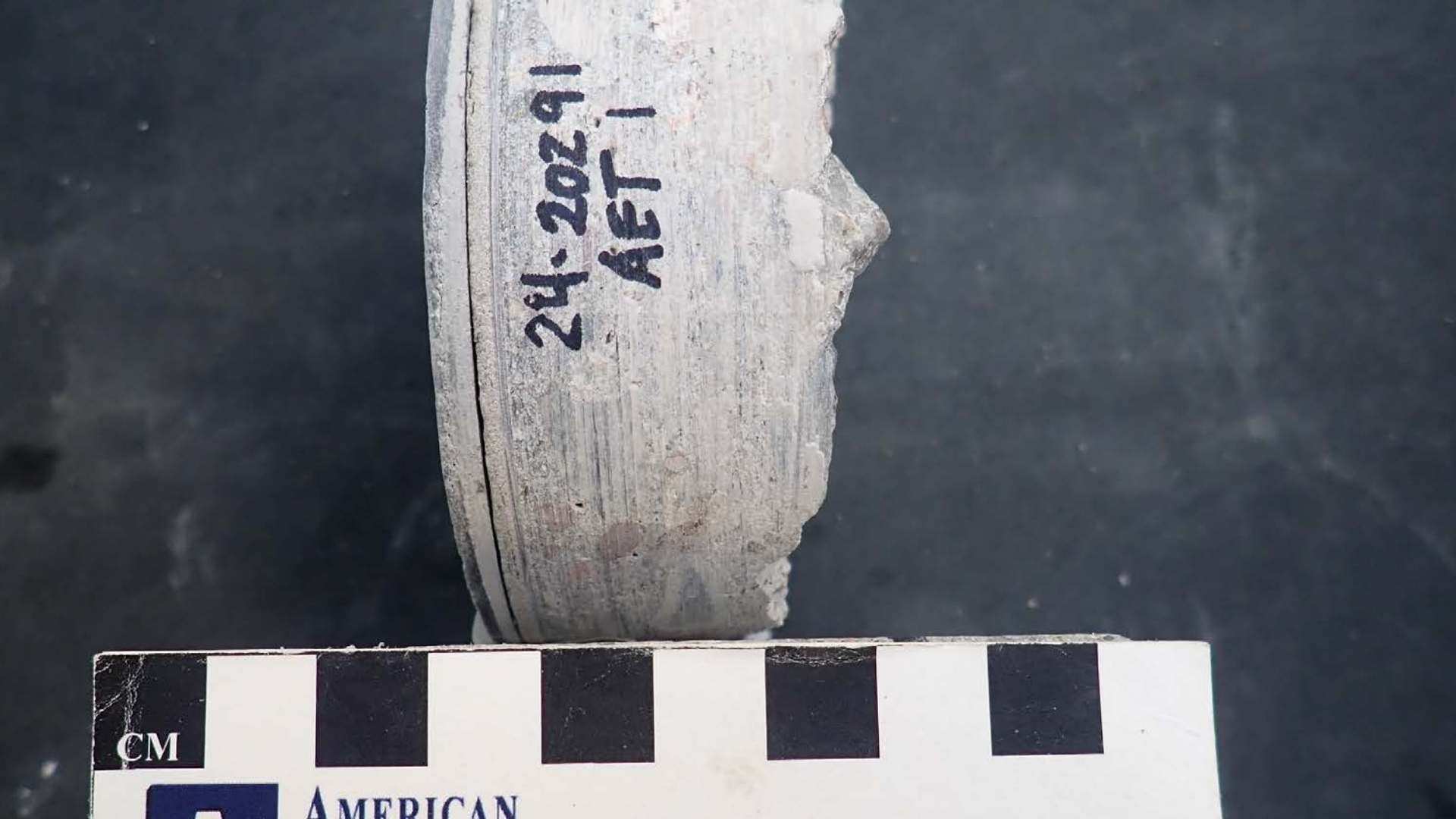
- 40+ yo slab
- New flooring system
- Blisters within weeks

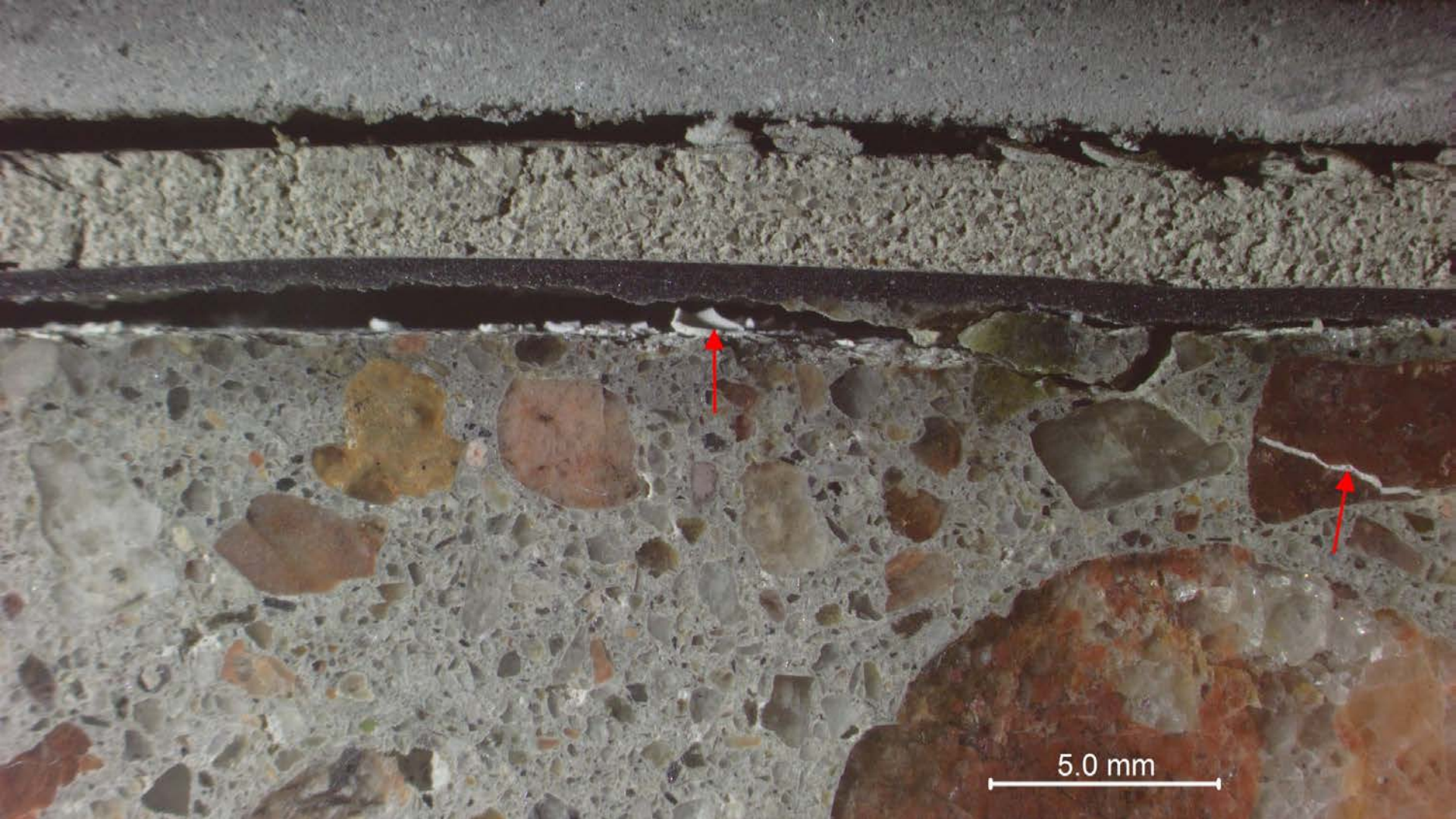

0.5 mm

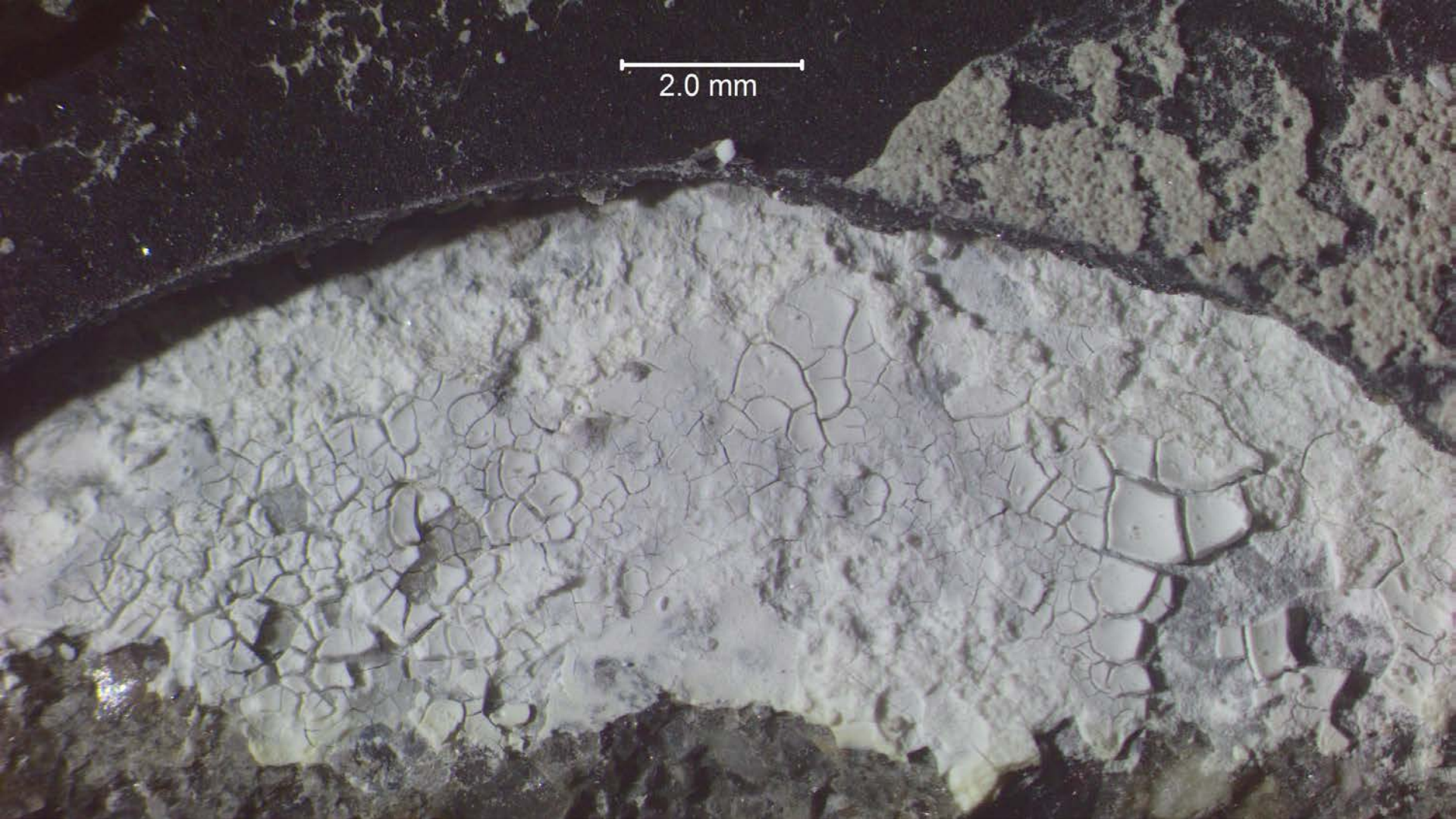
Commercial VCT installation – Colorado

- Installed resin for moisture mitigation and and underlayment Oct 2017
- Liquid-filled blisters July 2018

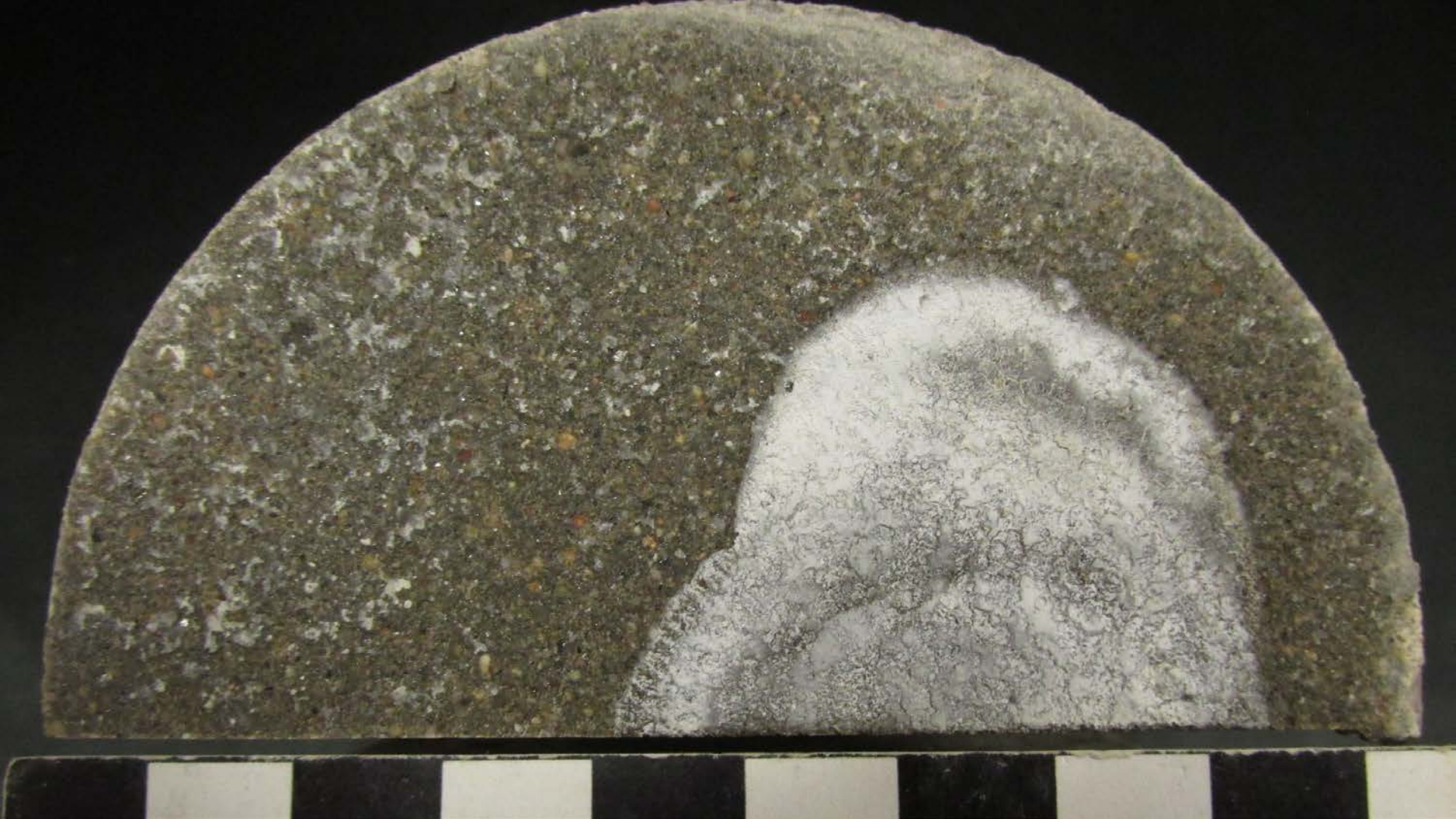

CM
AMERICAN

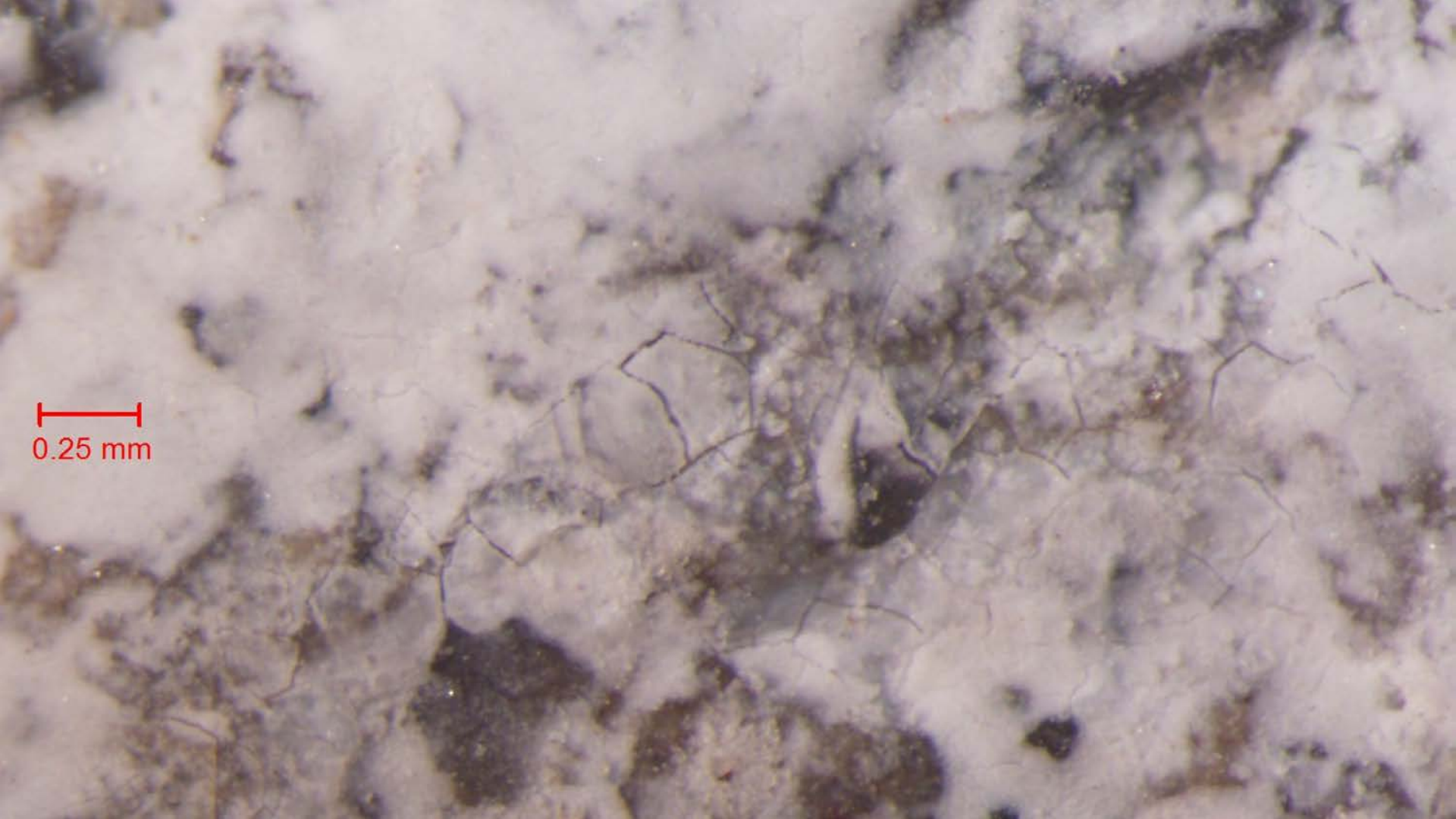

24-2029
AET 1
CM
AMERICAN

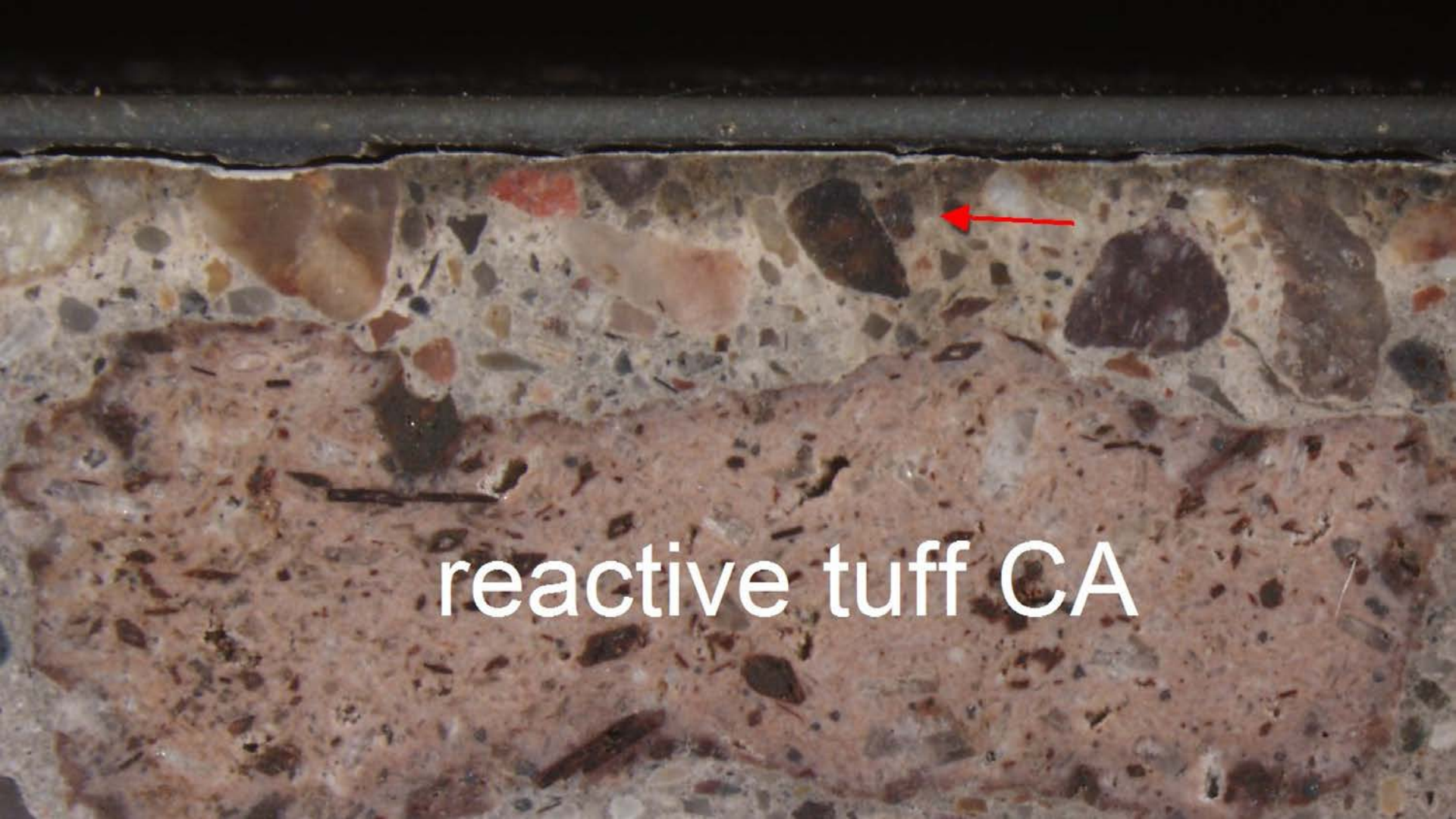

5.0 mm


2.0 mm


Bank
Arizona



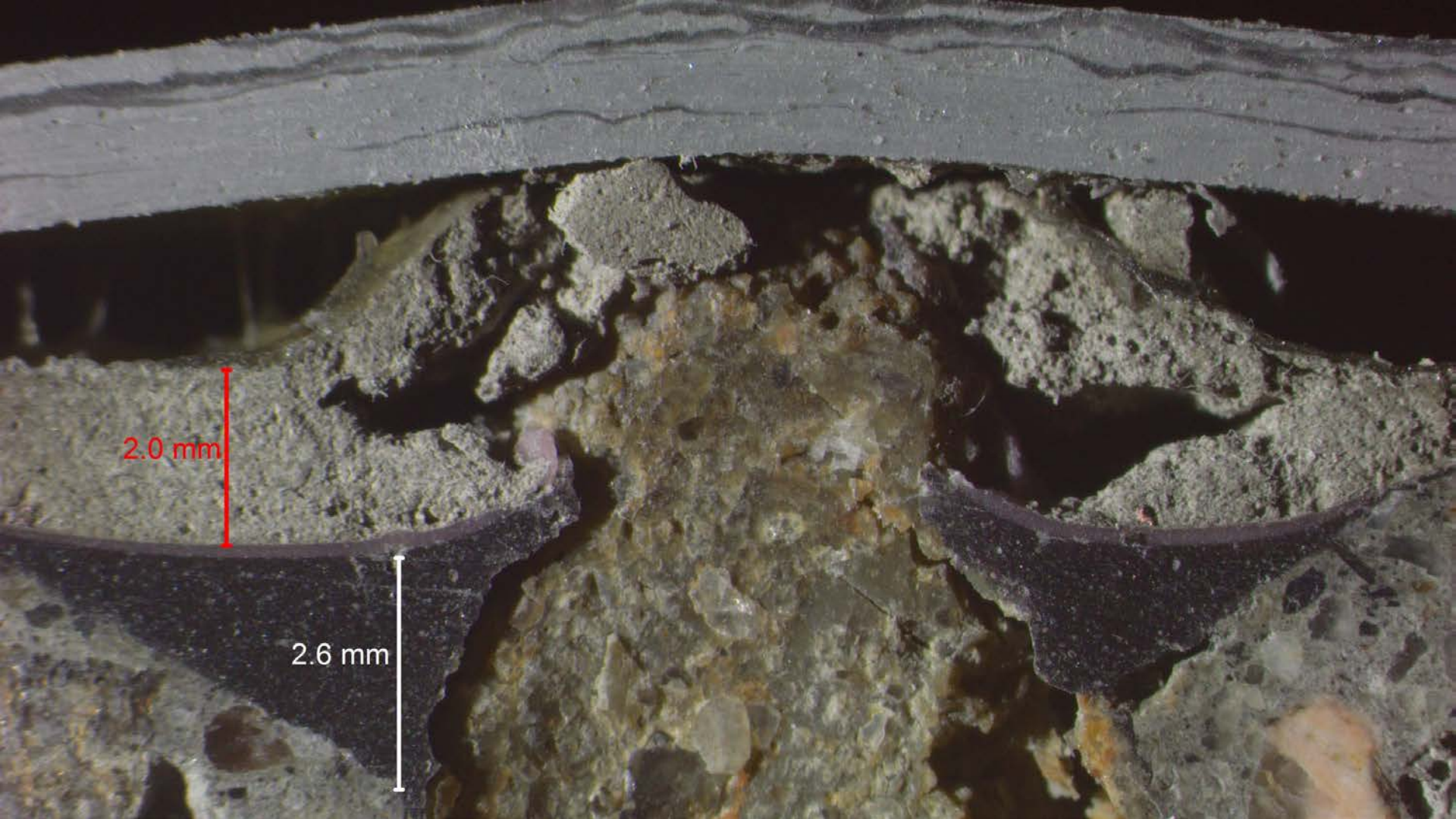

0.25 mm


reactive tuff CA

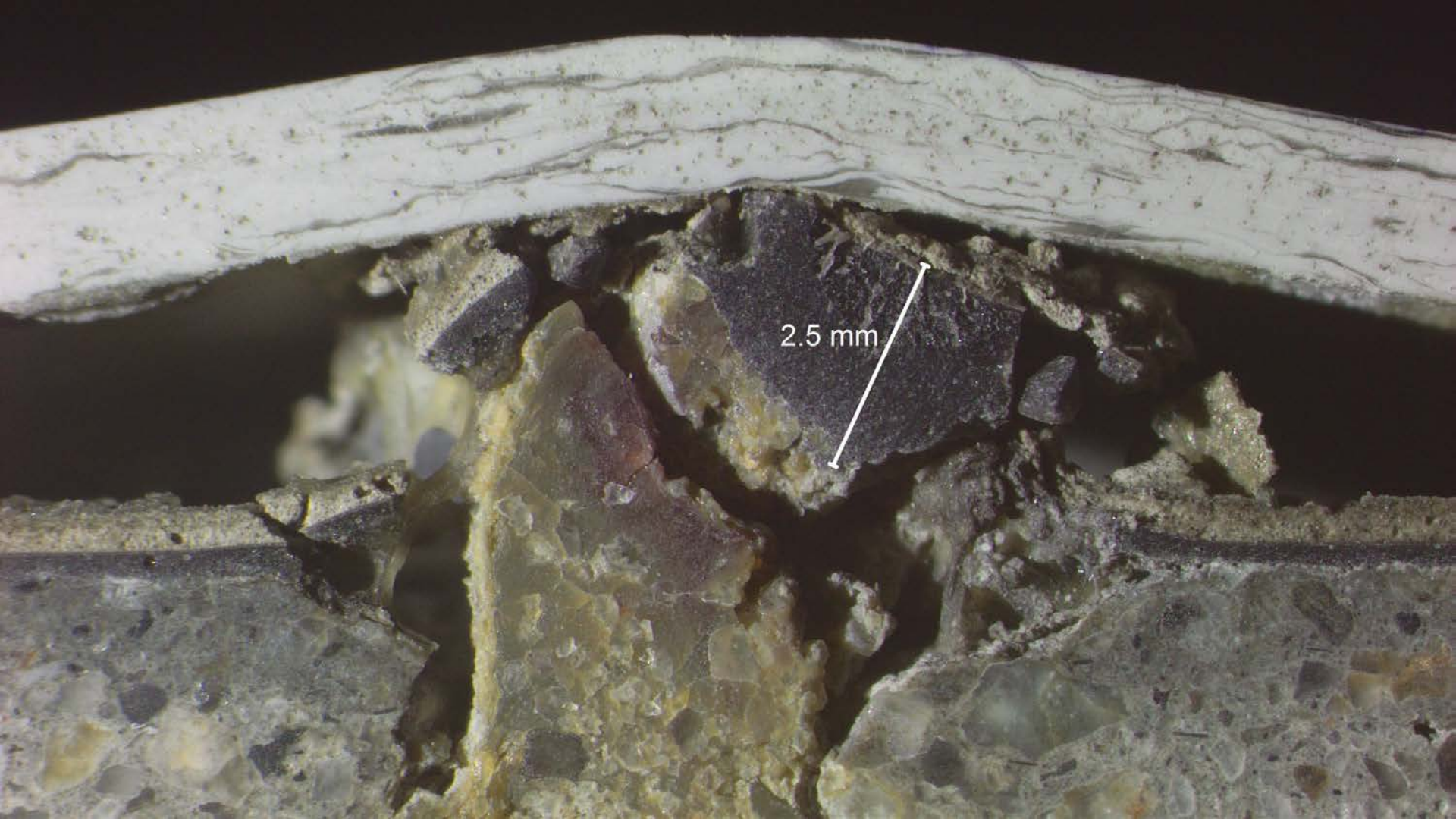
Laboratory Facility
Arizona

- New flooring system Oct. 2017
- Blisters August 2018
- 13k ft^2

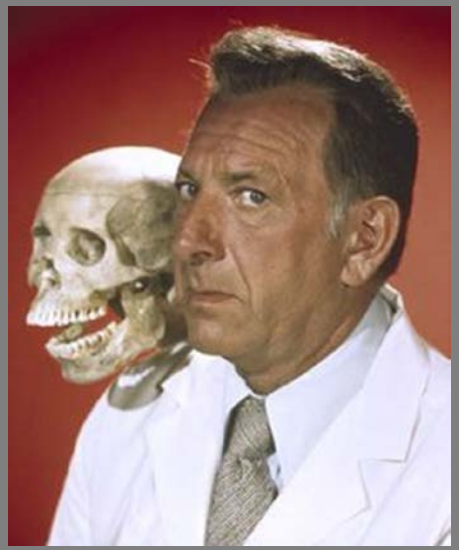

5.0 mm


2.0 mm
2.6 mm


5.0 mm


2.5 mm

Thank You!



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