

# Near Surface Aggregate Reactivity (NSAR): What We Know

Gerard Moulzolf,

PG



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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

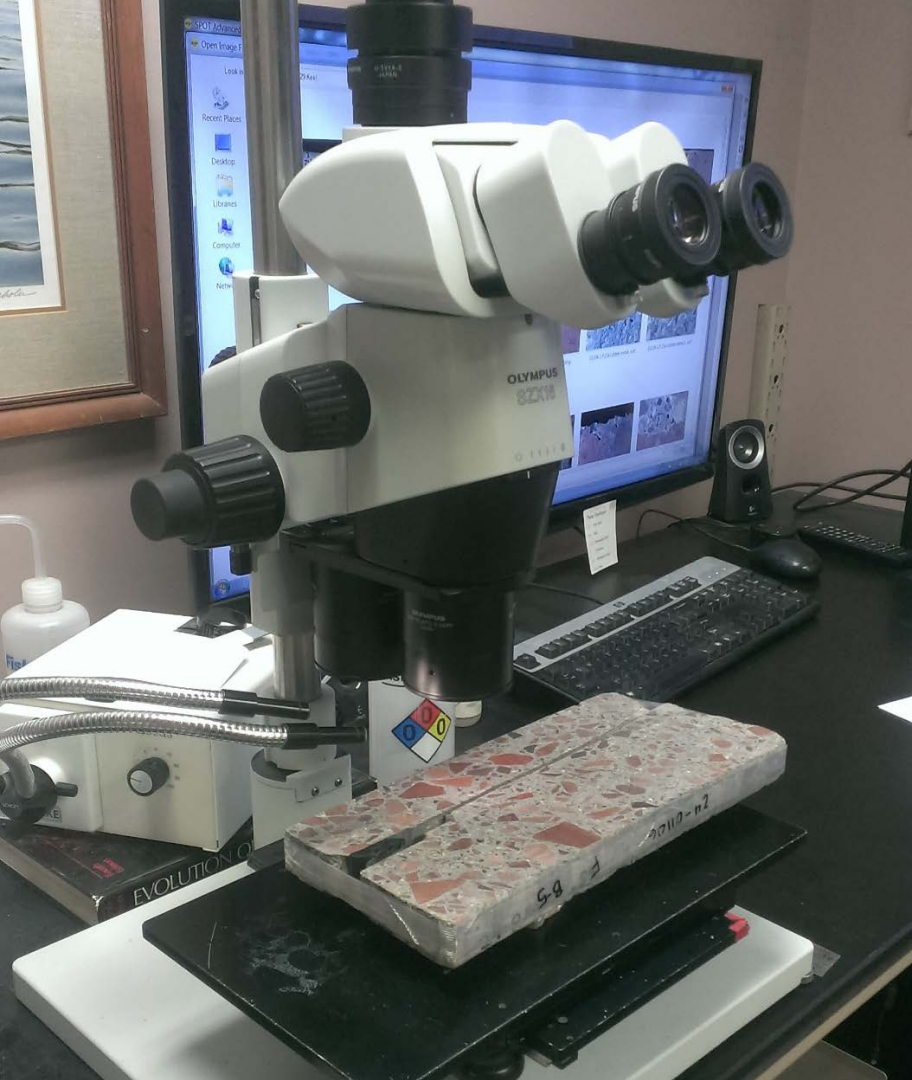






Soft Soap  
TERRA  
Dose 100 ml

TERRA  
Dose 100 ml







# Alkali-Silica Reaction (ASR)

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

ASR produces a hygroscopic gel product.



Ramps and  
Bridges



# Water Control Structures

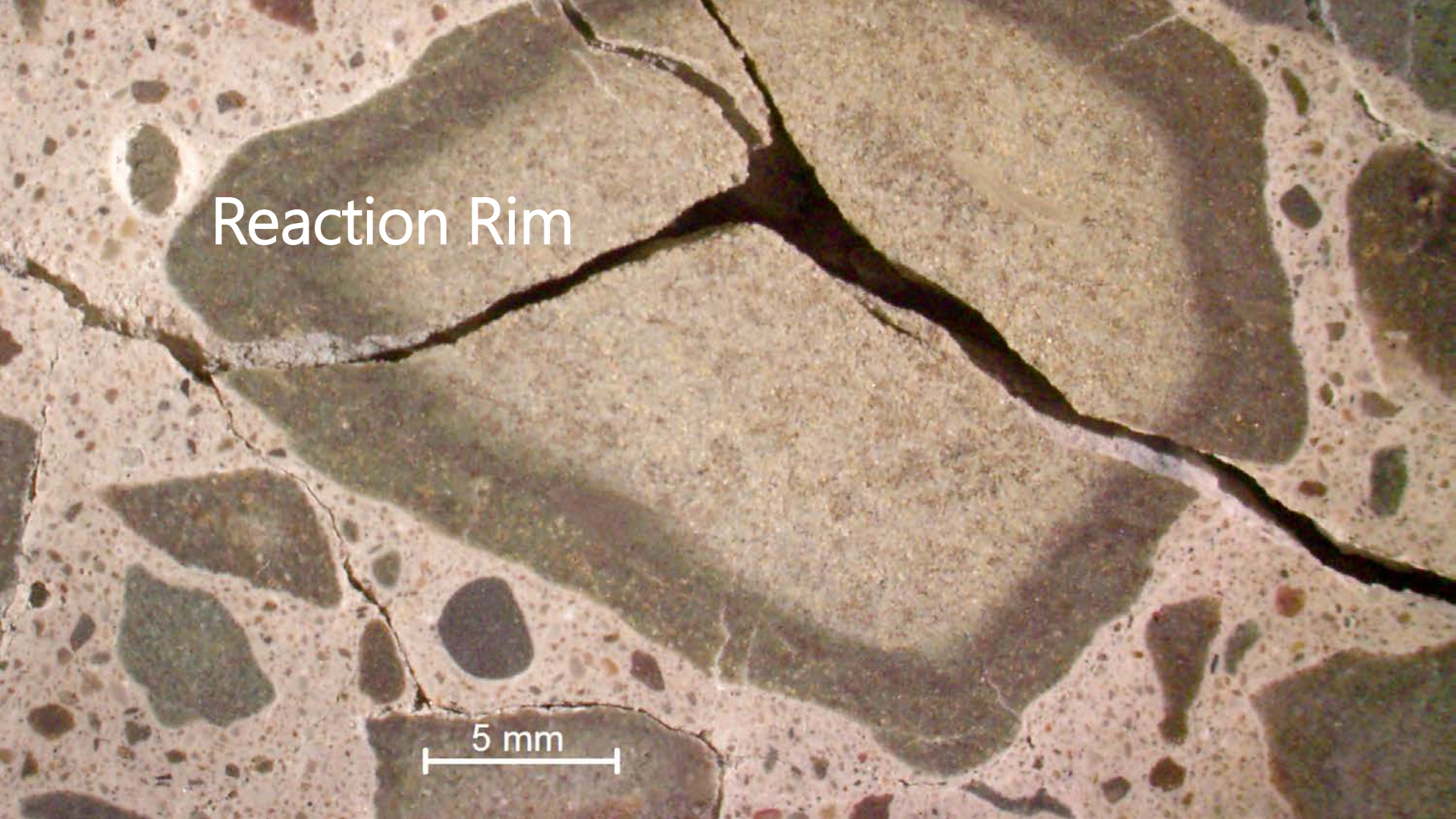




Pavements

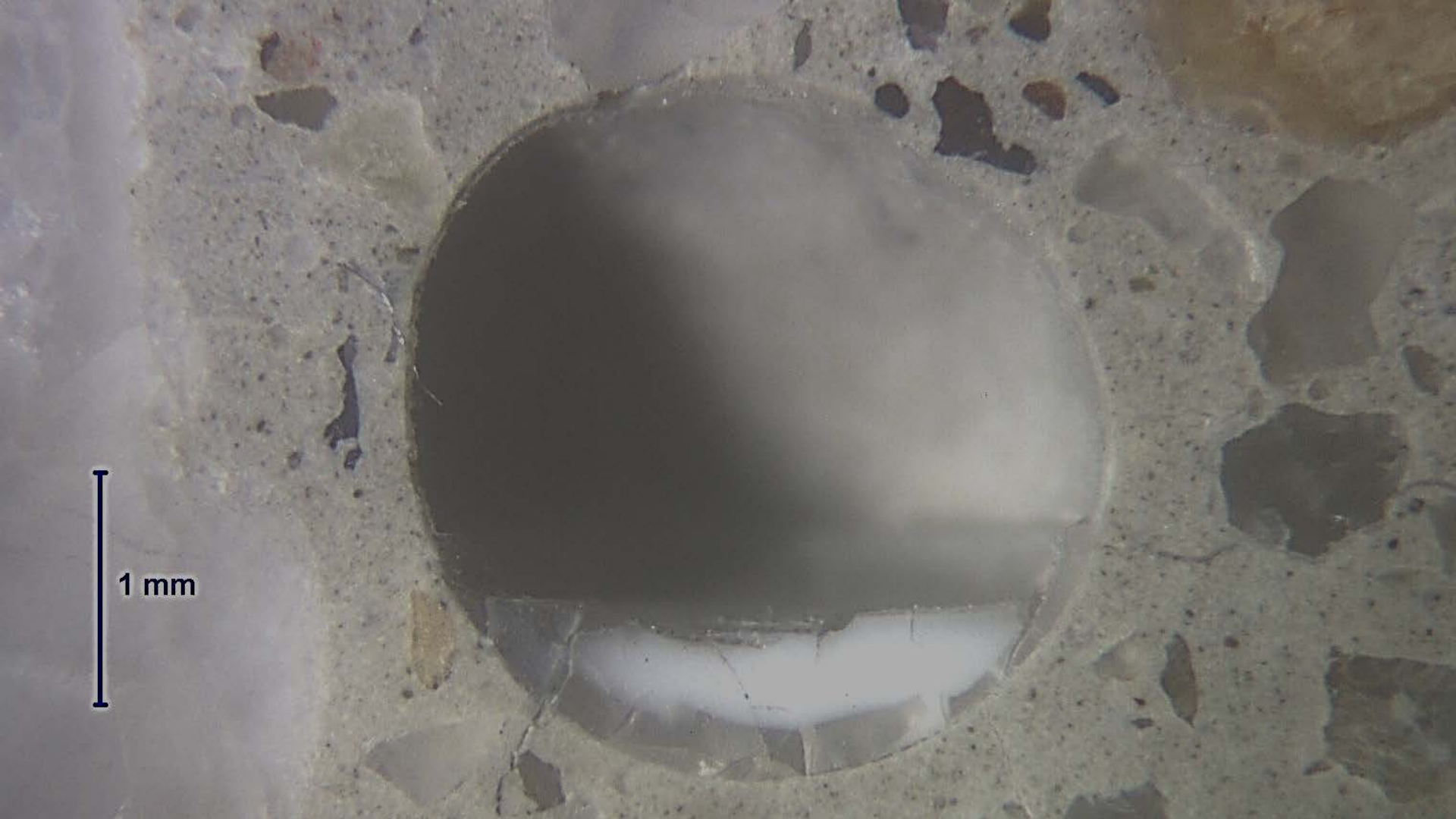
Reaction Rim

5 mm

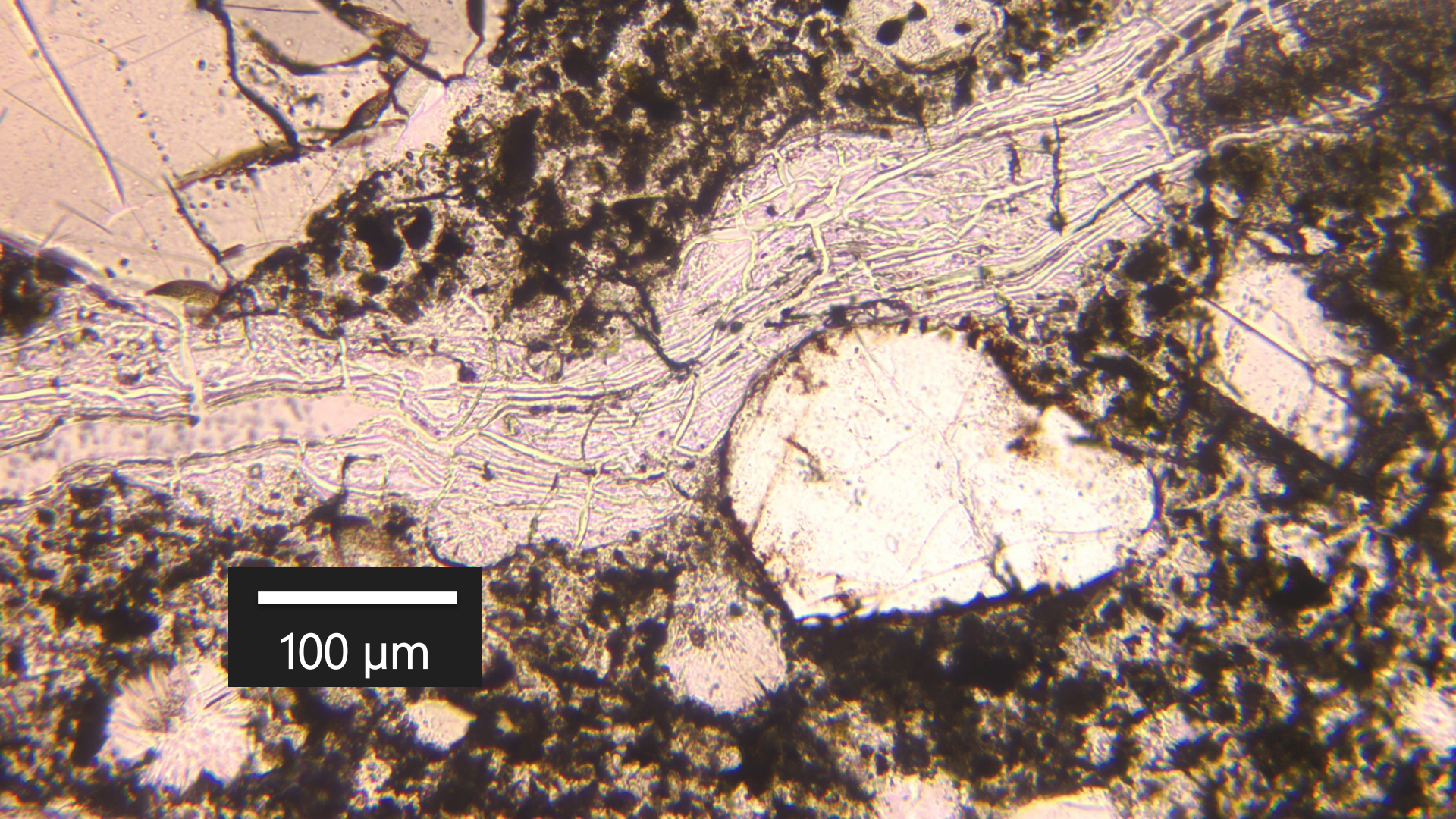


1 mm





1 mm



100 μm



0.25mm



gel

chert

chert



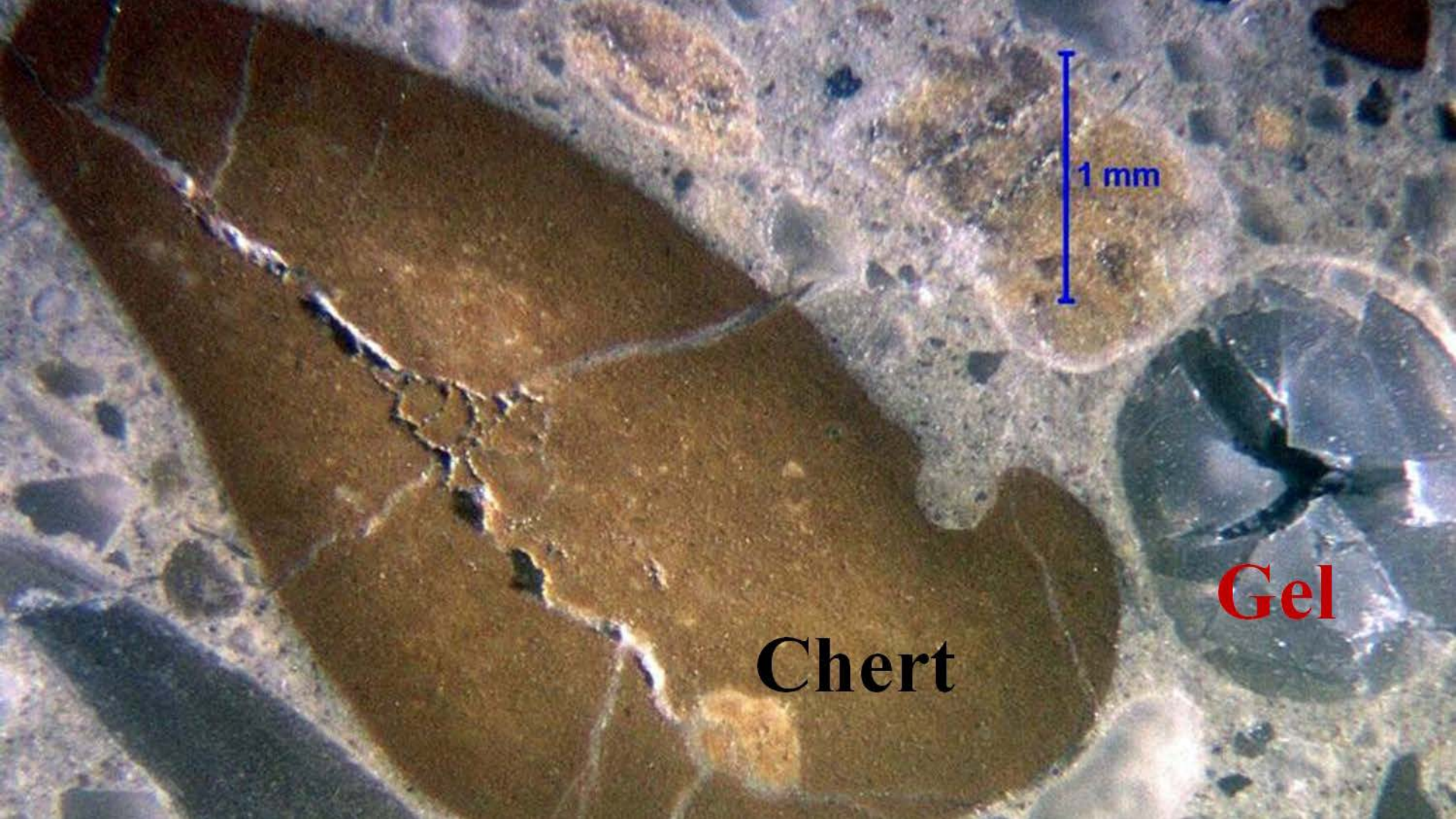
# Alkali-Silica Reaction (ASR)

## “Fast” Reactors

- Shales
- Some cherts
- Glassy volcanics

## “Slow” Reactors

- Metamorphic lithologies
- Argillites
- Silicified carbonates
- Quartzite



1 mm

**Chert**

**Gel**



Volcànic Gravel  
Arizona Airport



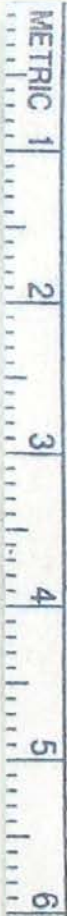
... SERVICES, INC.

METRIC 1 2 3 4 5 6 7





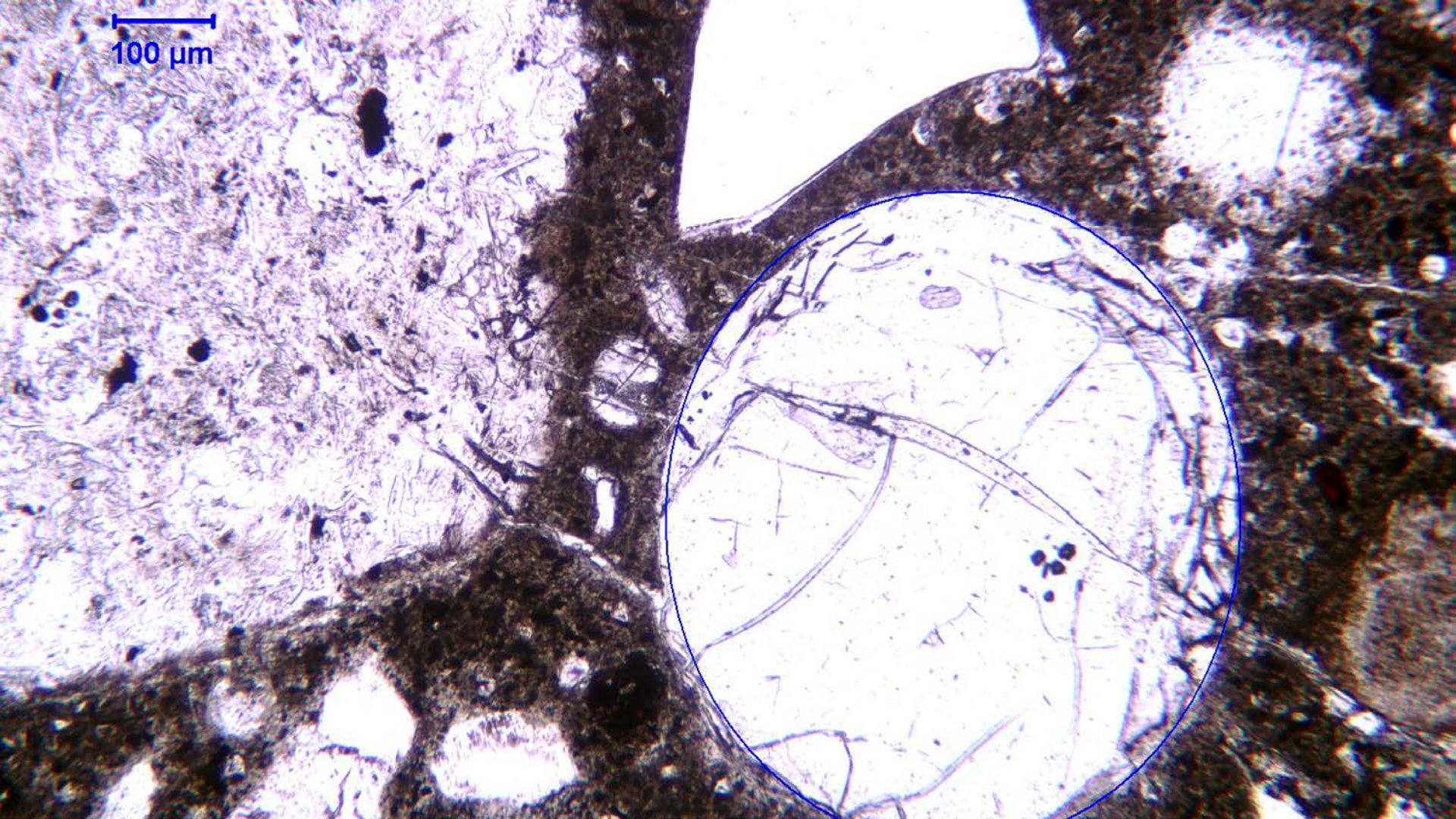
AMERICAN  
PETROGRAPHIC  
SERVICES, INC.







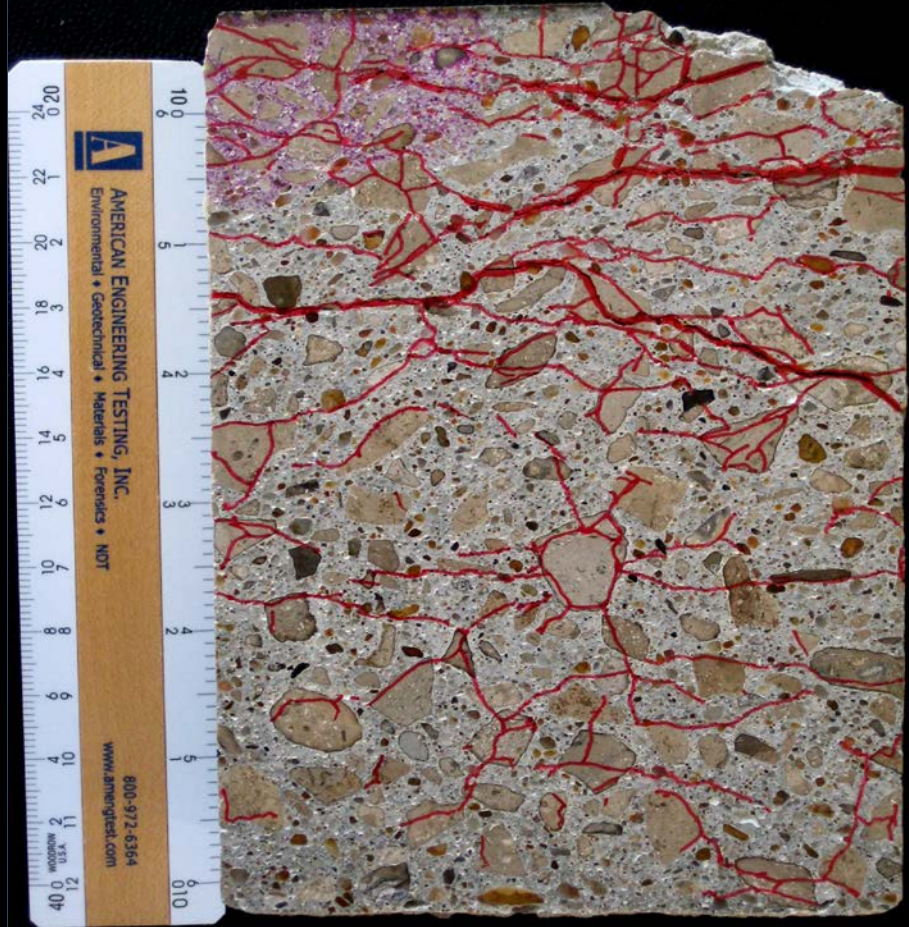
100  $\mu\text{m}$





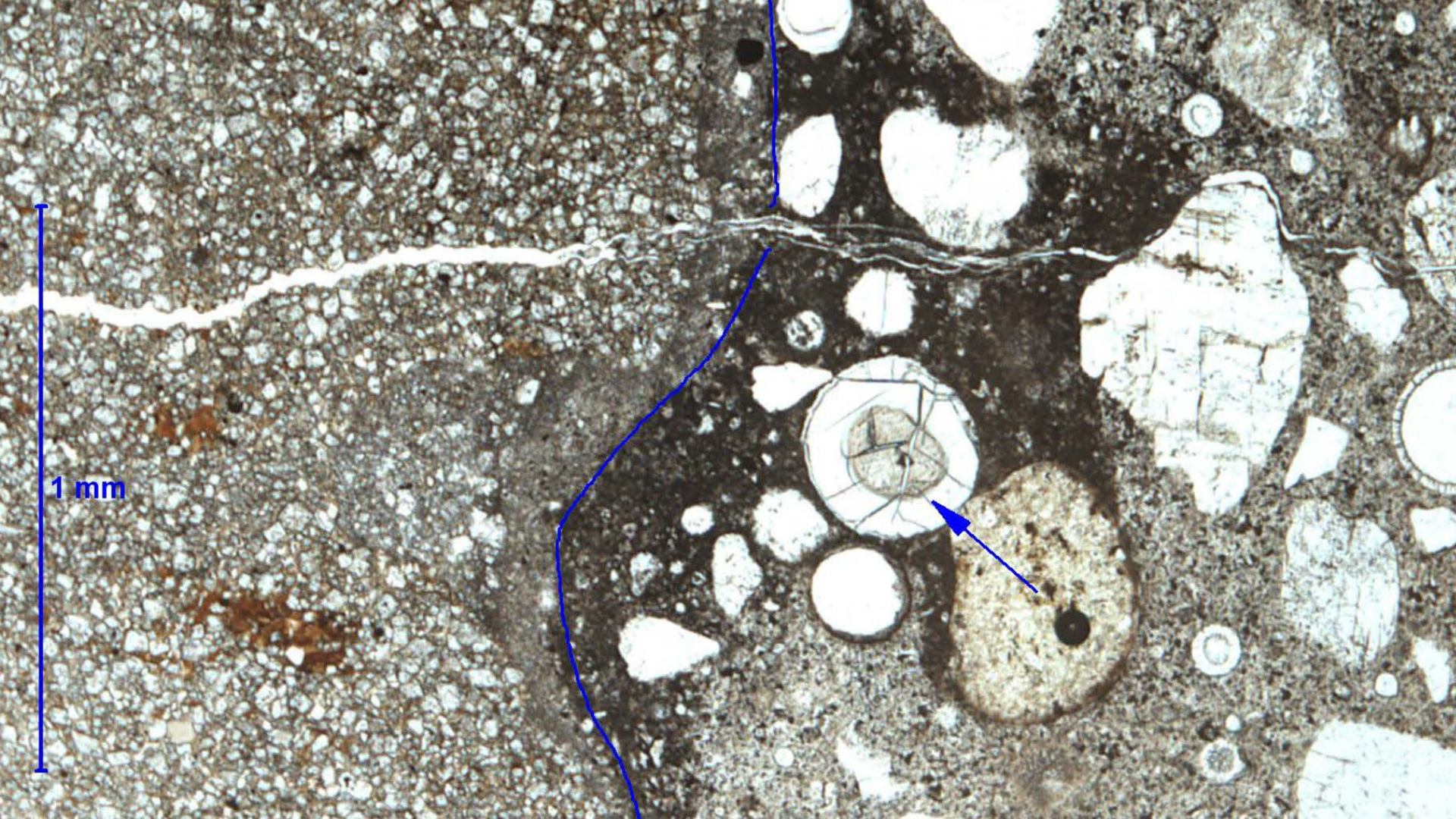
Distribution Center  
Pavement - Kansas

# Silicified Carbonate





1 mm



1 mm

I-29 NB

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578+00

South Dakota

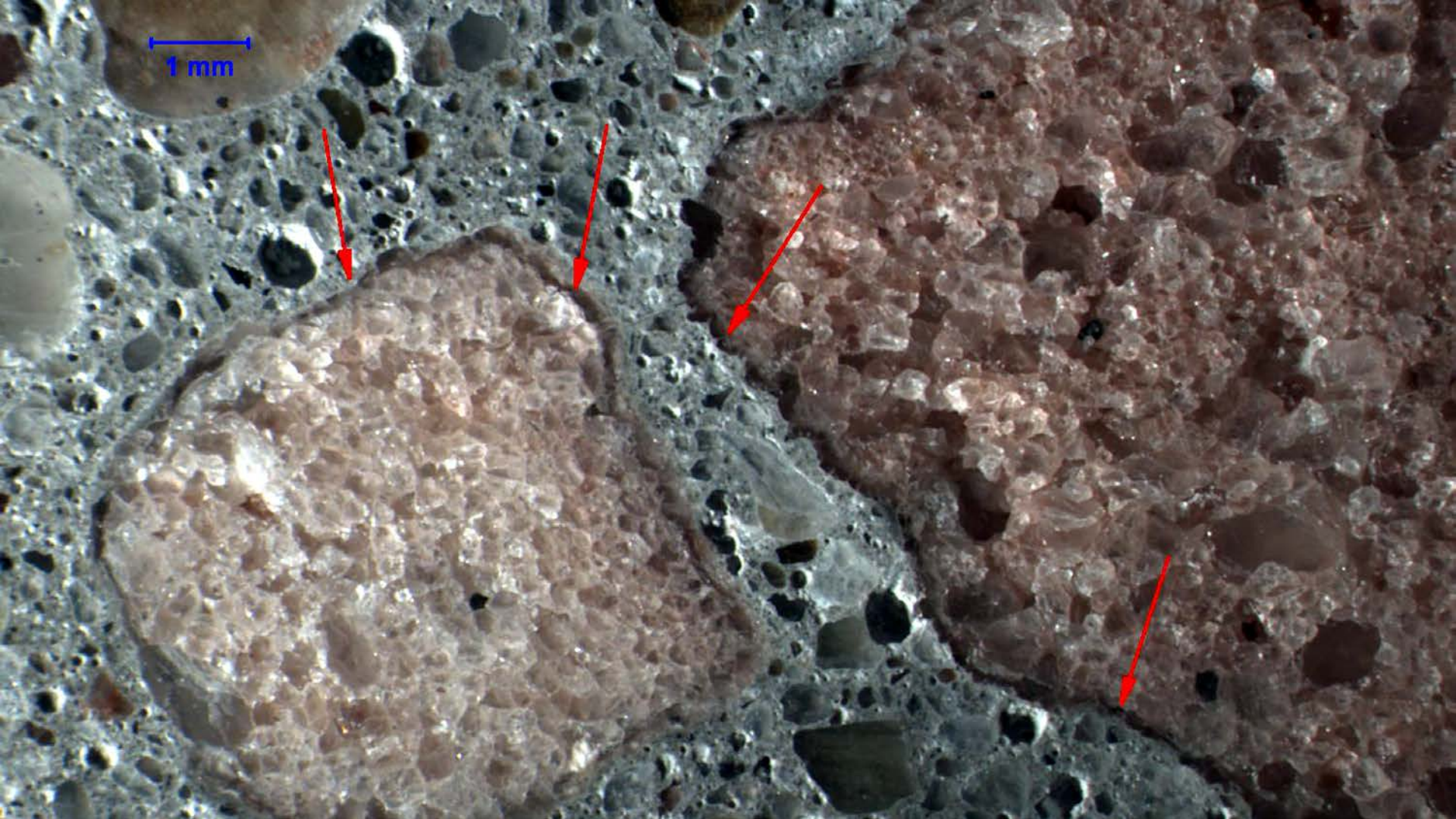


Quartzite



1 mm

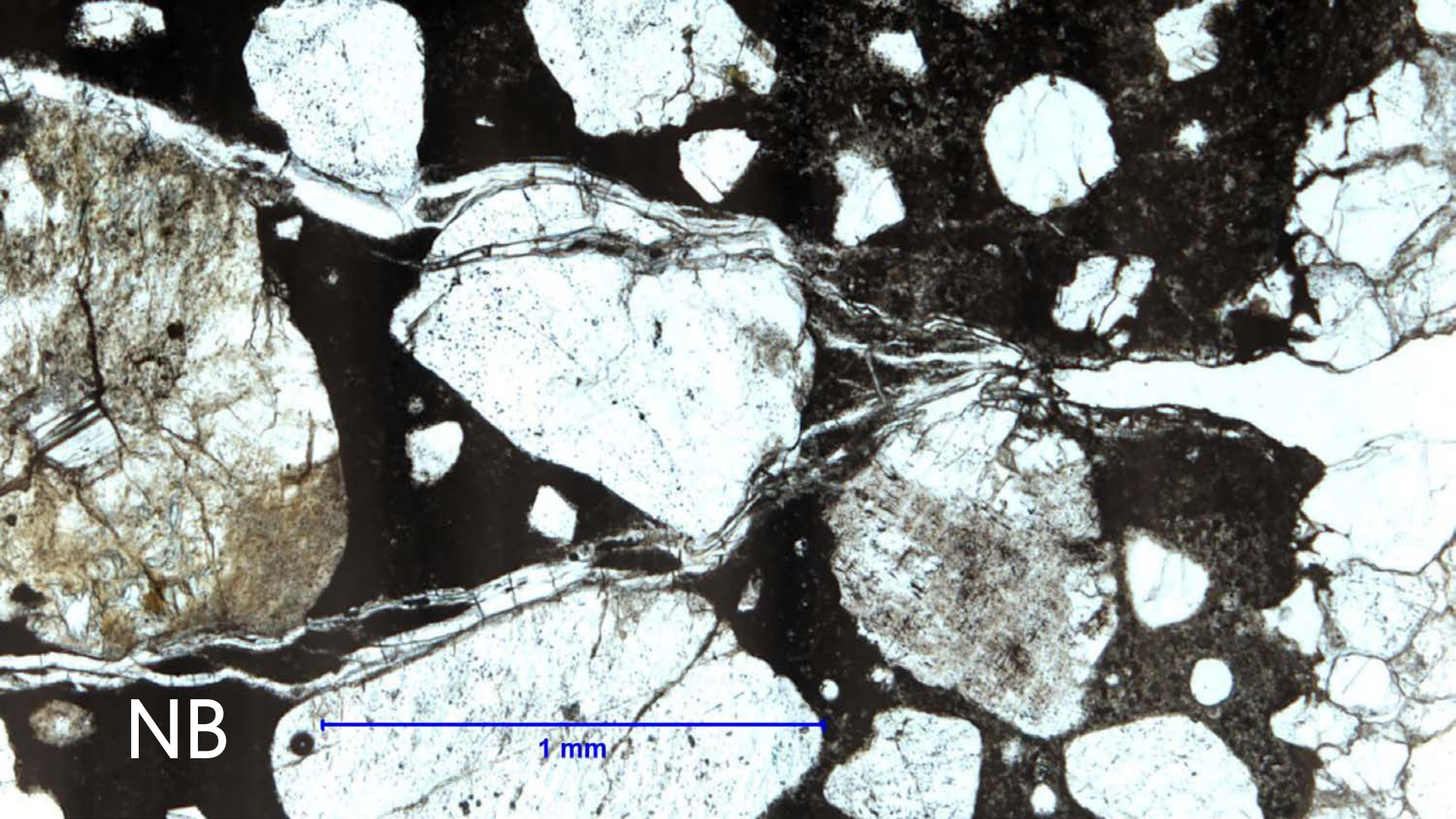






NB

1 mm



NB

1 mm

# Near Surface Aggregate Reactivity

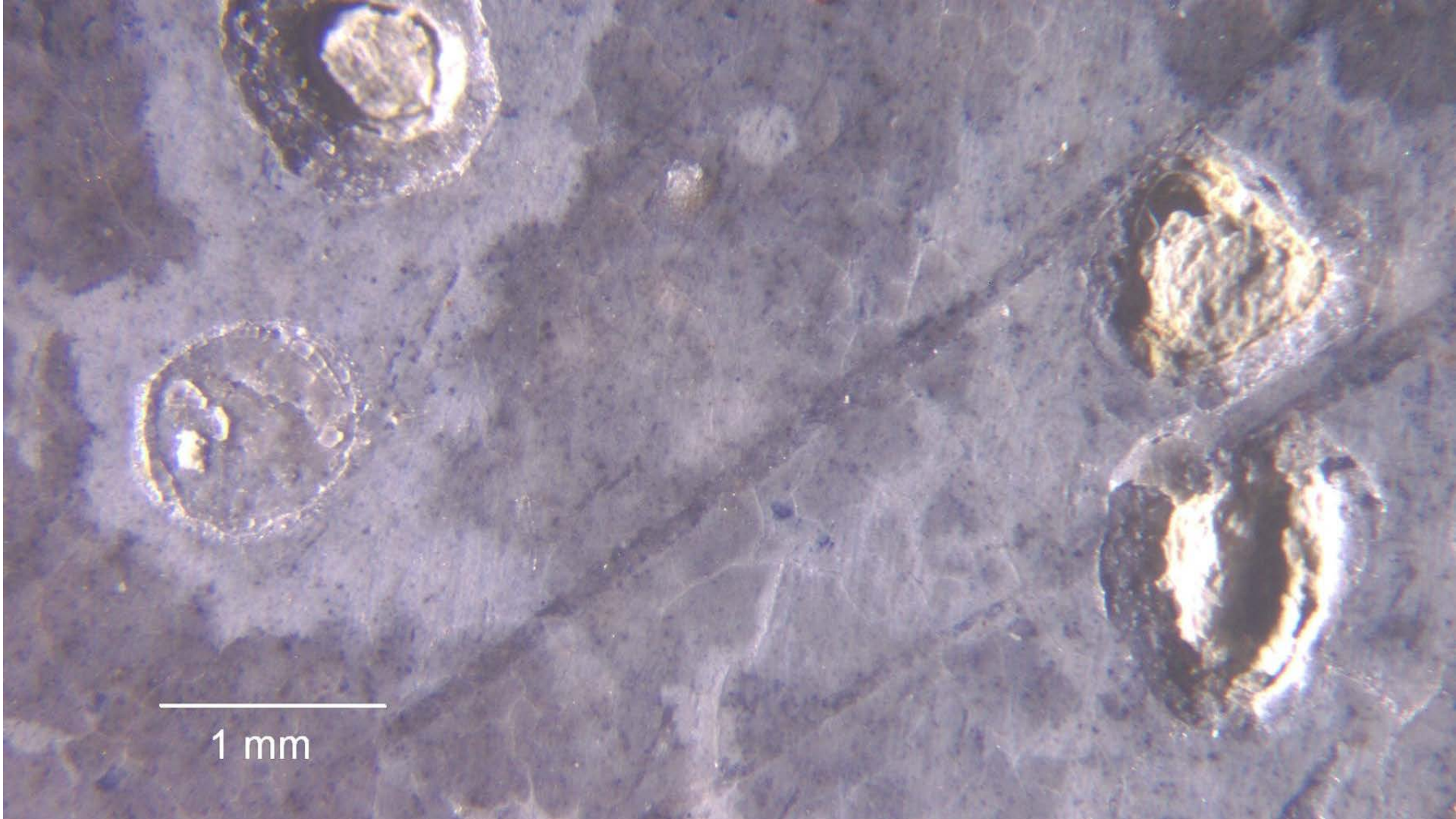
- ASR in the near surface concrete only
- Induced beneath M-S floorings by:
  - high RH
  - conc. of alkalis and OH-
- Produces a defect in flooring bond
- Allows osmotic pressure to produce a liquid-filled blister

NSAR



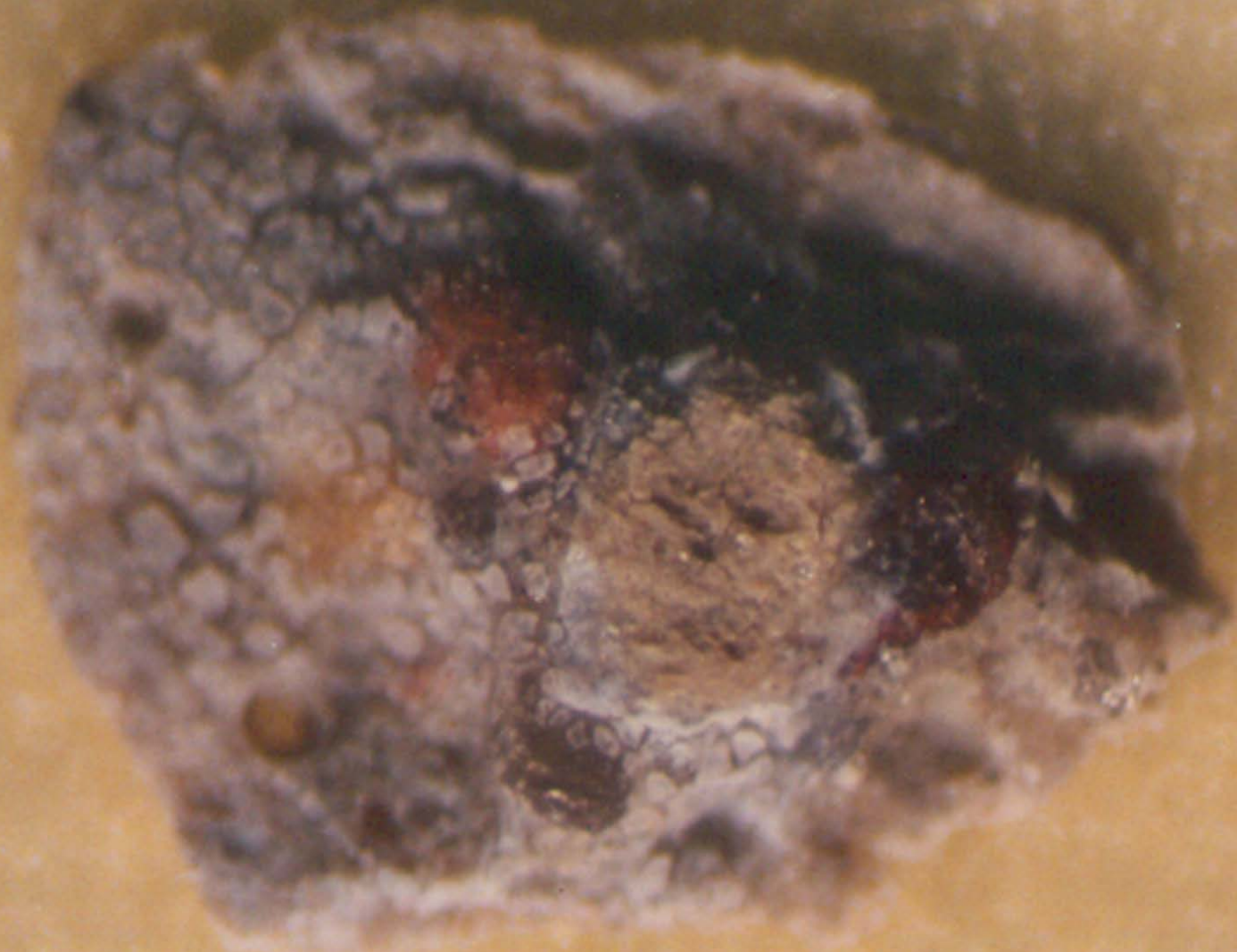






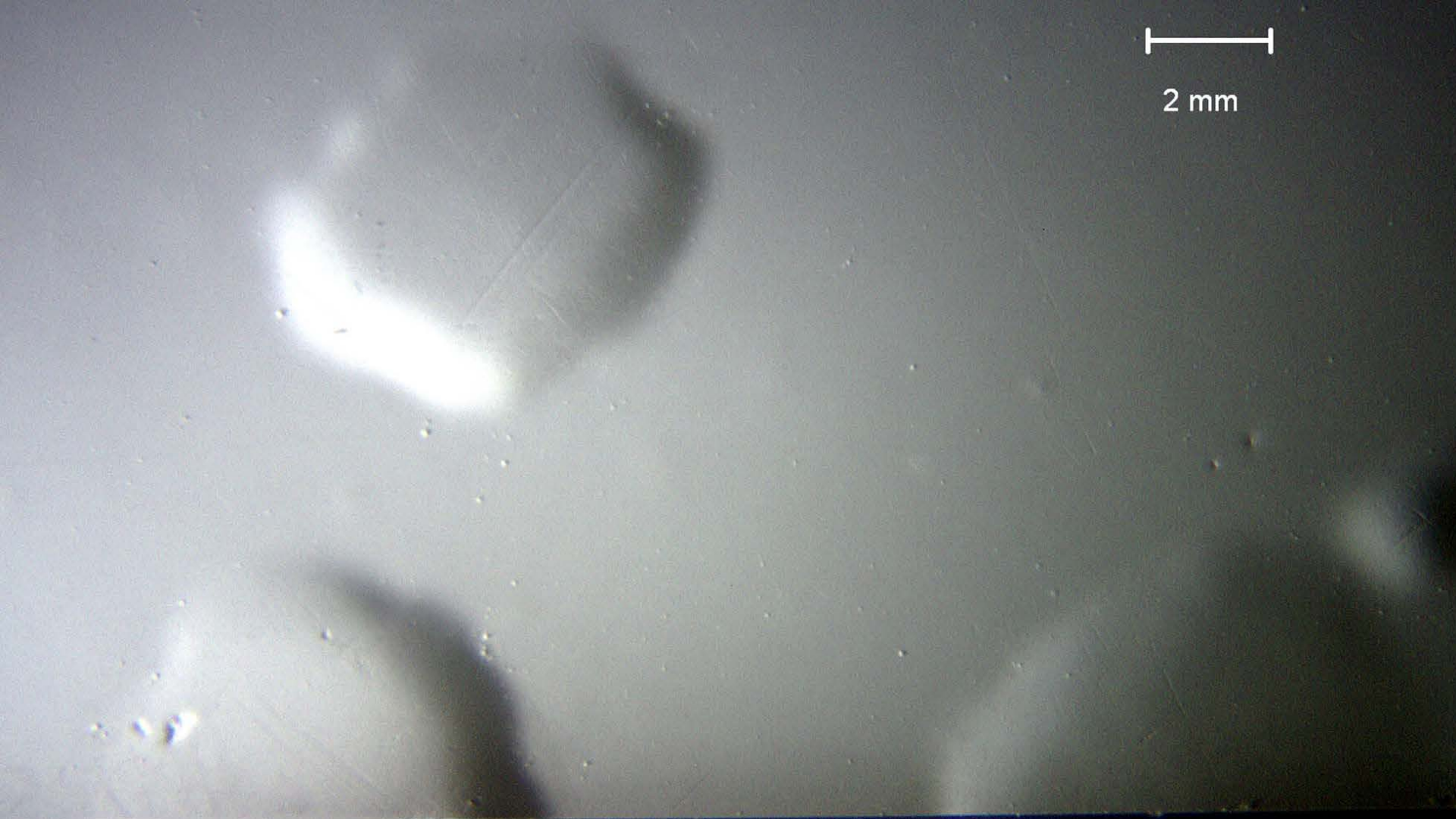
1 mm

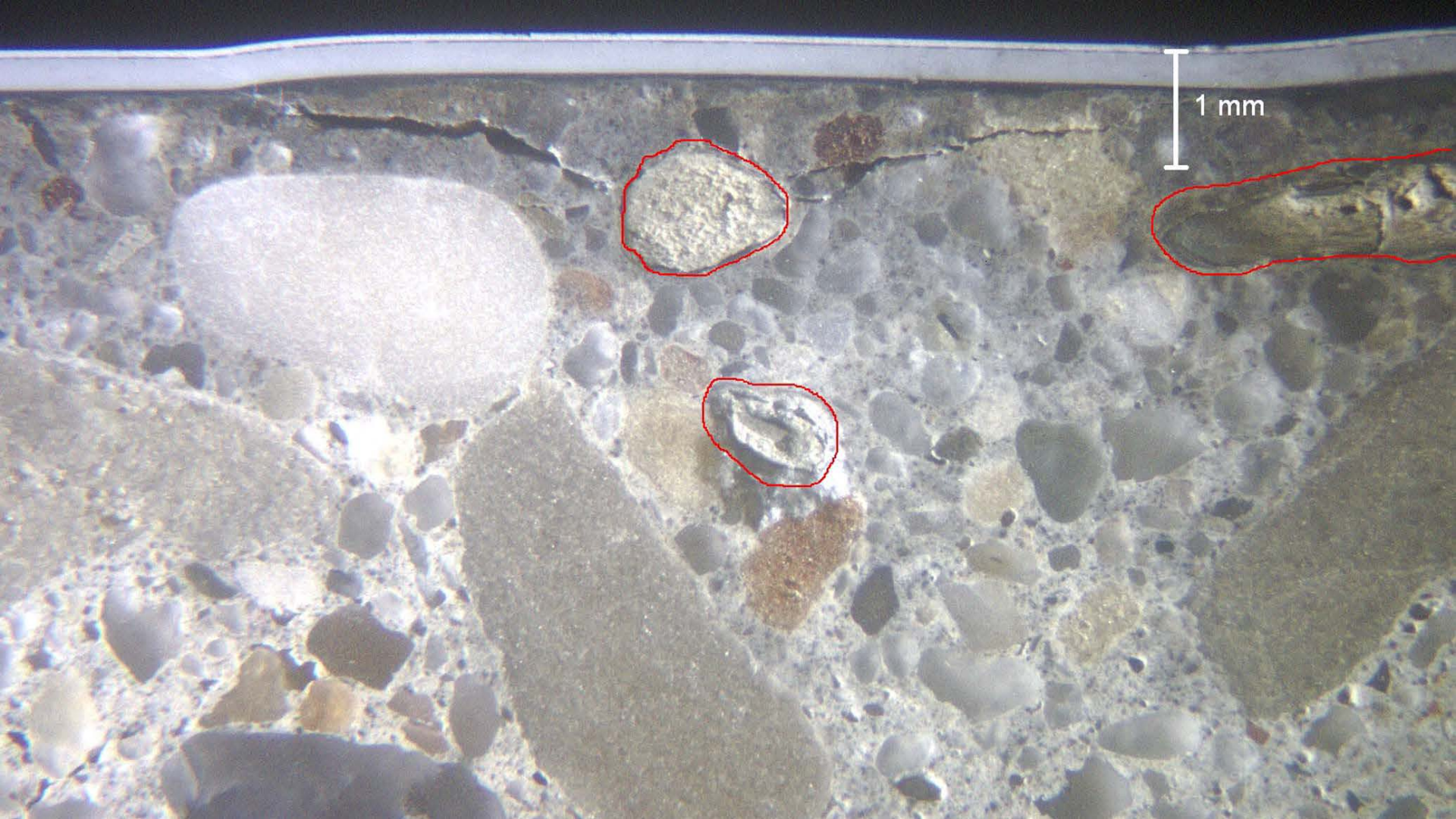






2 mm





1 mm

# Pierre Shale

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



Grey Drift

Red Drift

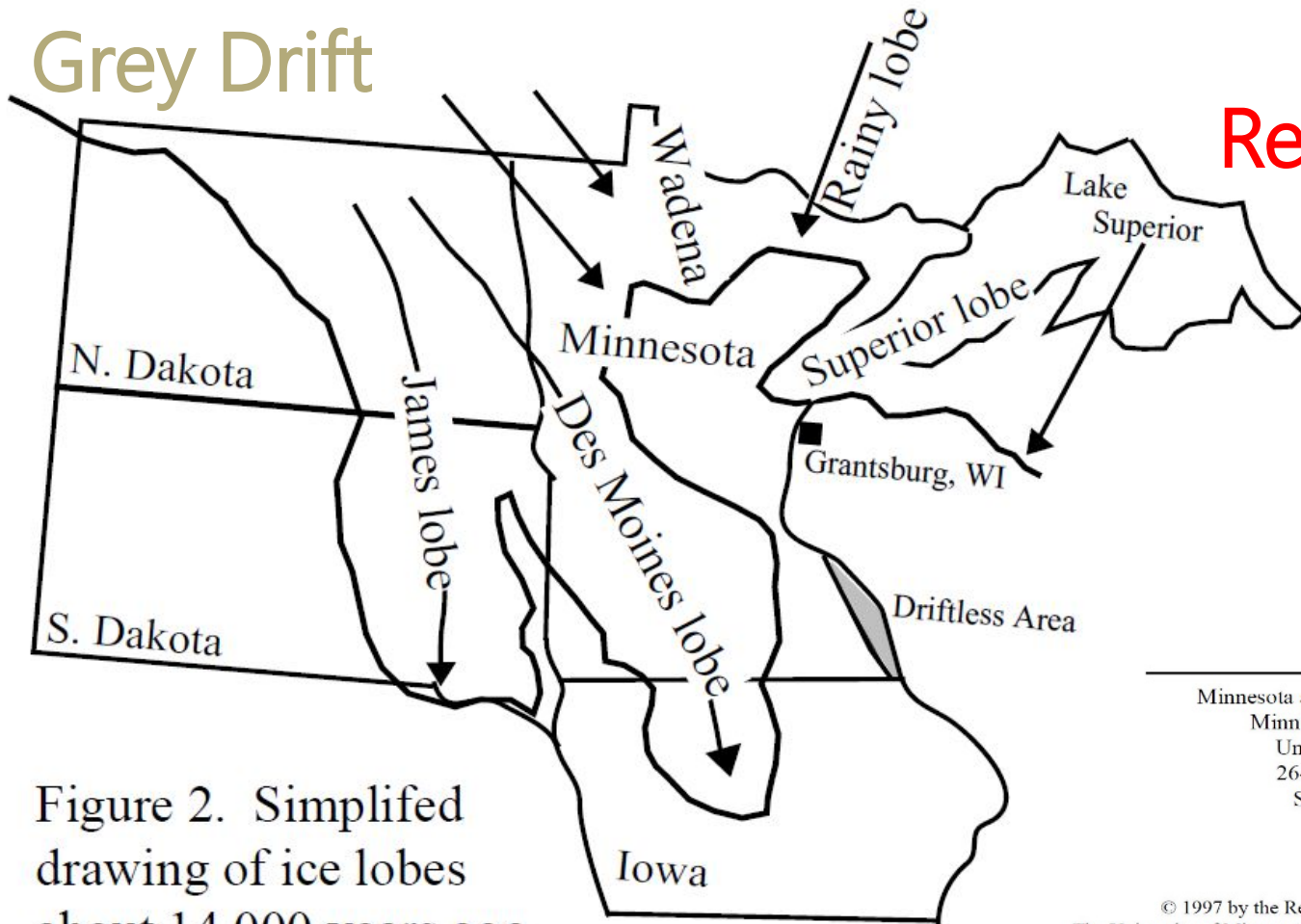
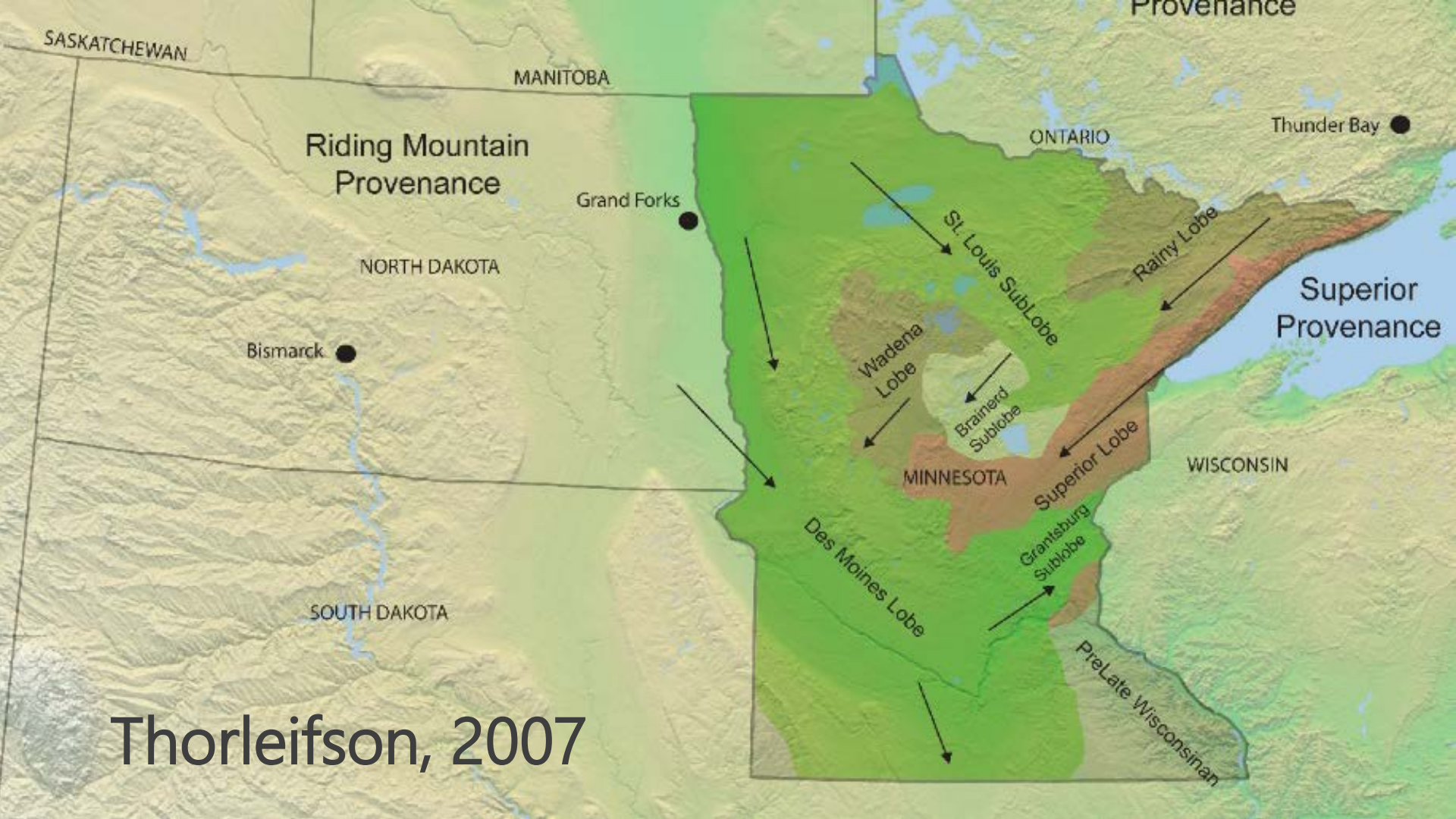


Figure 2. Simplified drawing of ice lobes about 14,000 years ago.

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

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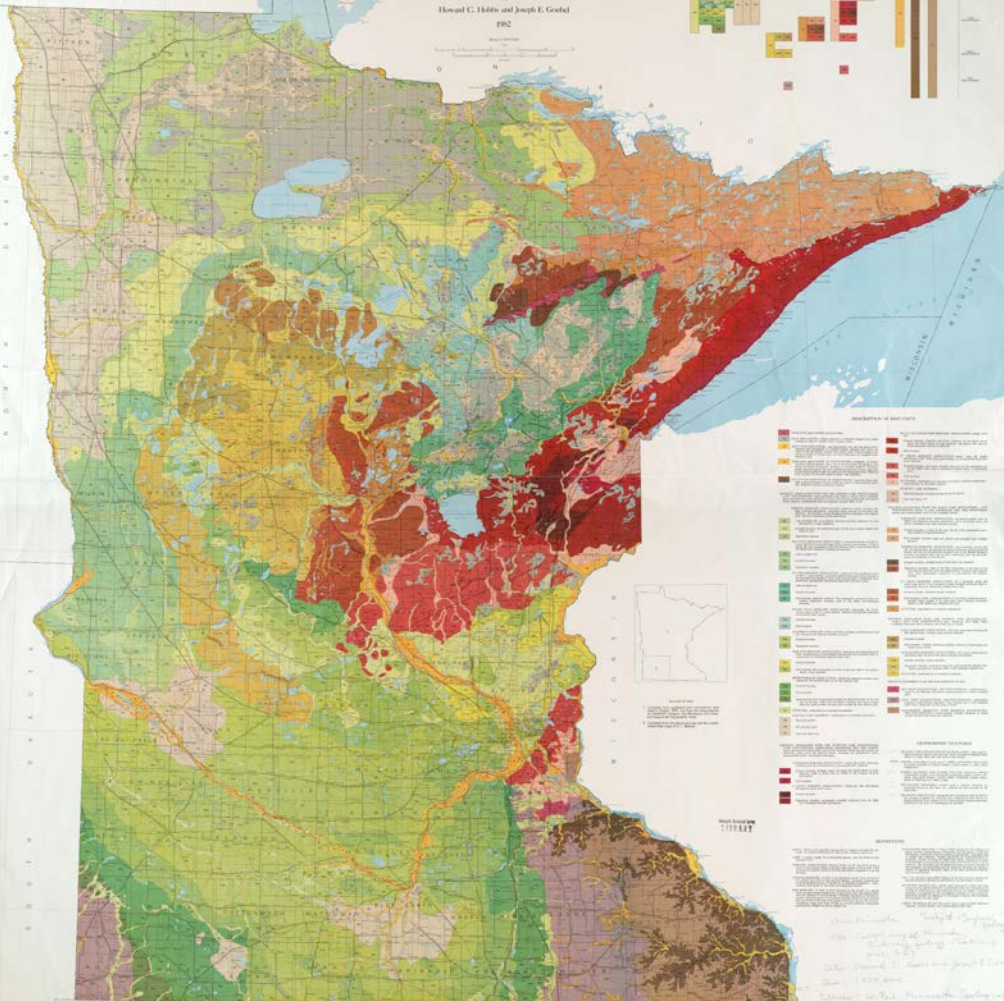
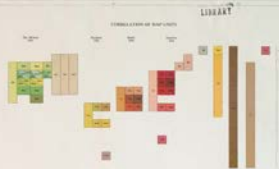


Thorleifson, 2007

MANITOBA

# GEOLOGIC MAP OF MINNESOTA QUATERNARY GEOLOGY

by  
Howard C. Little and Joseph E. Grodal  
1962

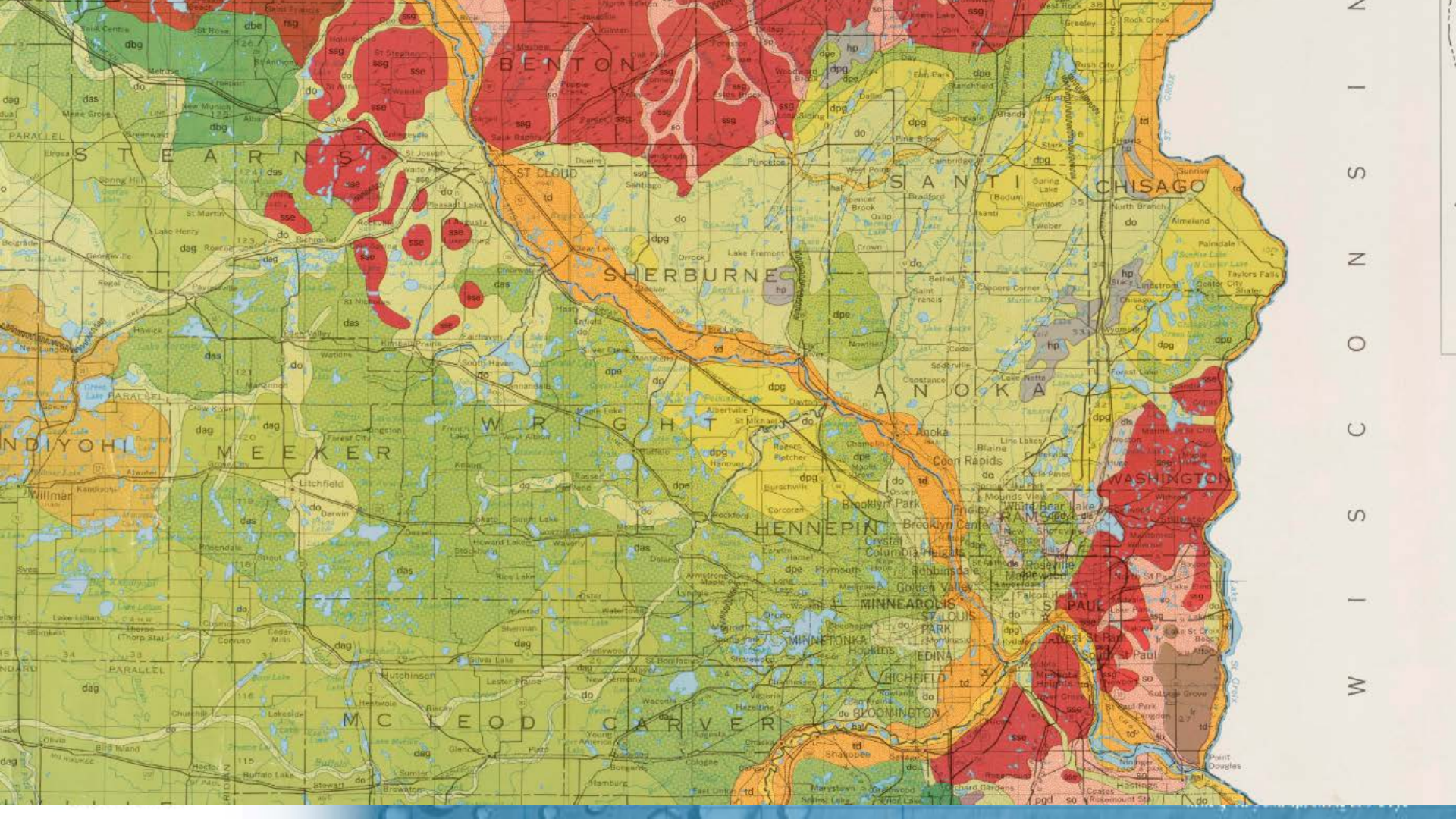


- DESCRIPTION OF QUATERNARY UNITS**
- WISCONSINAN:** Includes the Wisconsinan, Kansan, Illinoian, and Sangre de Cristo stages. Descriptions detail the glacial and interglacial features characteristic of each stage.
  - RECENT:** Describes the most recent geological features, including alluvial deposits and recent glacial activity.
- SYMBOLS:** A list of symbols used on the map to represent different geological features such as faults, folds, and unconformities.
- ABBREVIATIONS:** A list of abbreviations used throughout the map and legend to denote specific geological units and features.



Howard C. Little and Joseph E. Grodal  
Geological Survey of Minnesota  
1962







C123 -2.4spg



1 mm



C123 -2.4spg

2 mm

# ASTM C33 Aggregate Quality

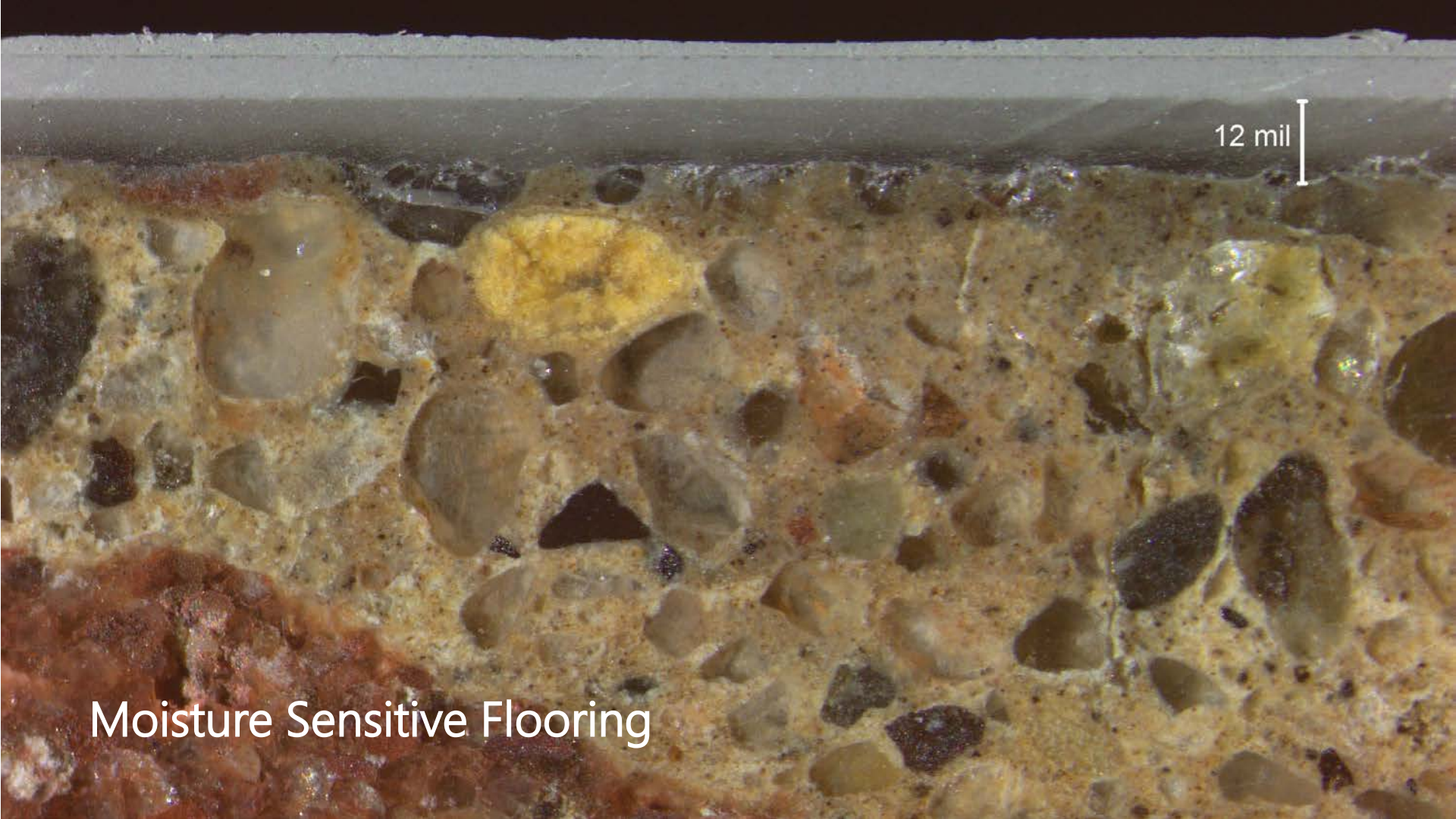
**TABLE 2 Limits for Deleterious Substances in Fine Aggregate for Concrete**

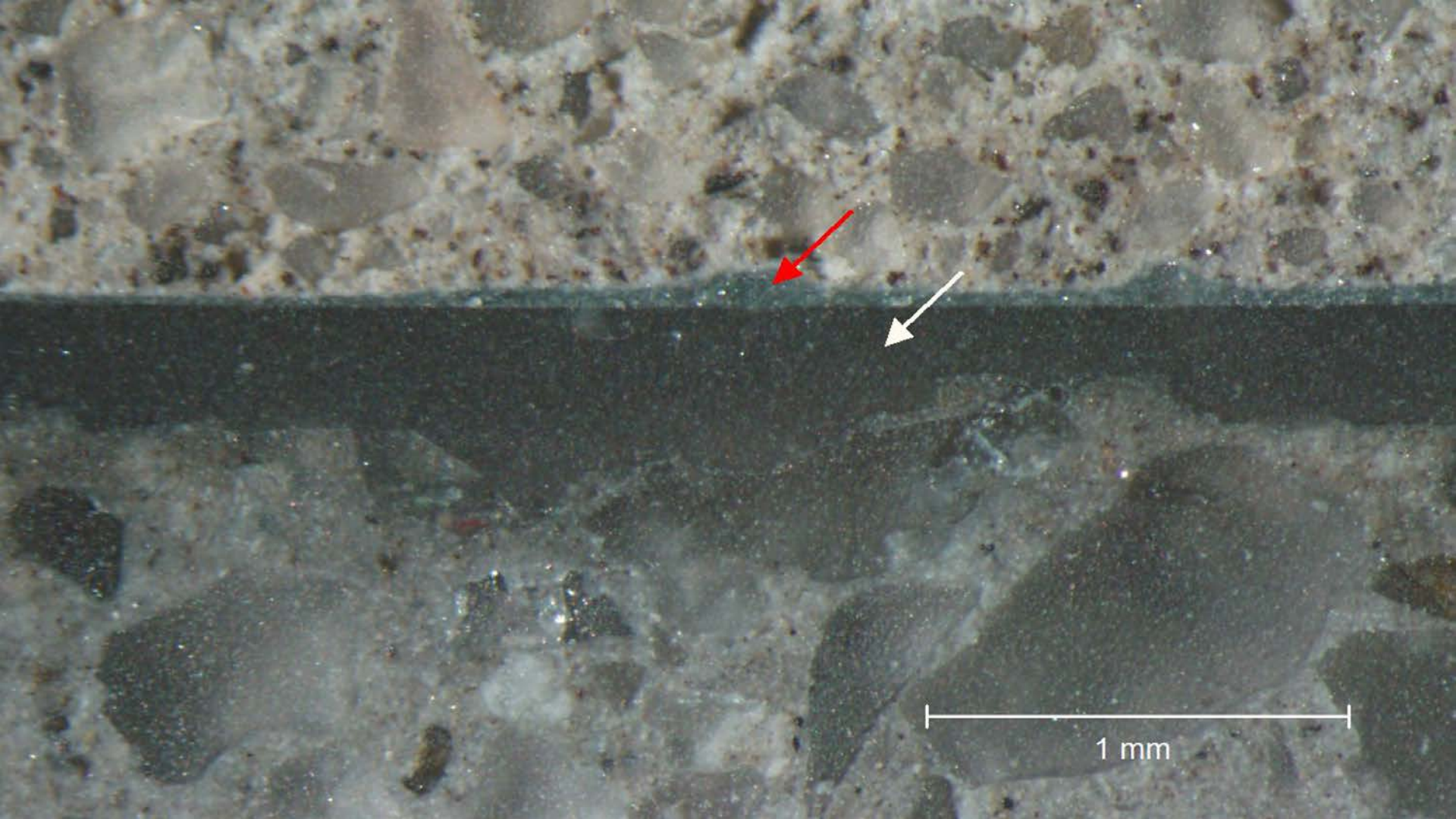
Item	Mass Percent of Total Sample, max
Clay lumps and friable particles	3.0
Coal and lignite:	
Where surface appearance of concrete is of importance	0.5
All other concrete	1.0



12 mil

Moisture Sensitive Flooring






1 mm

# Surface Prep

1 mm







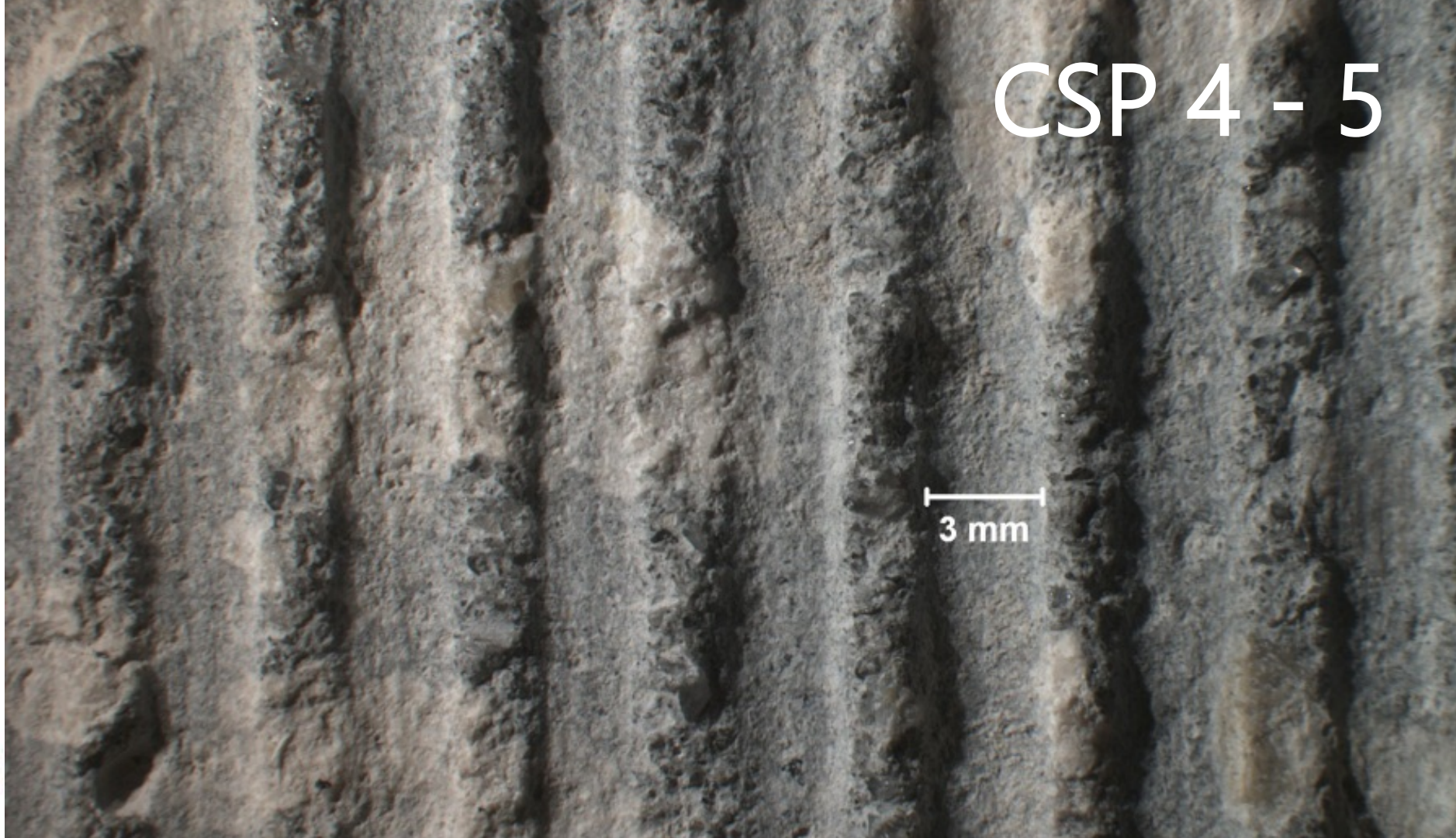
ICRI CSP "chips"

CSP 3

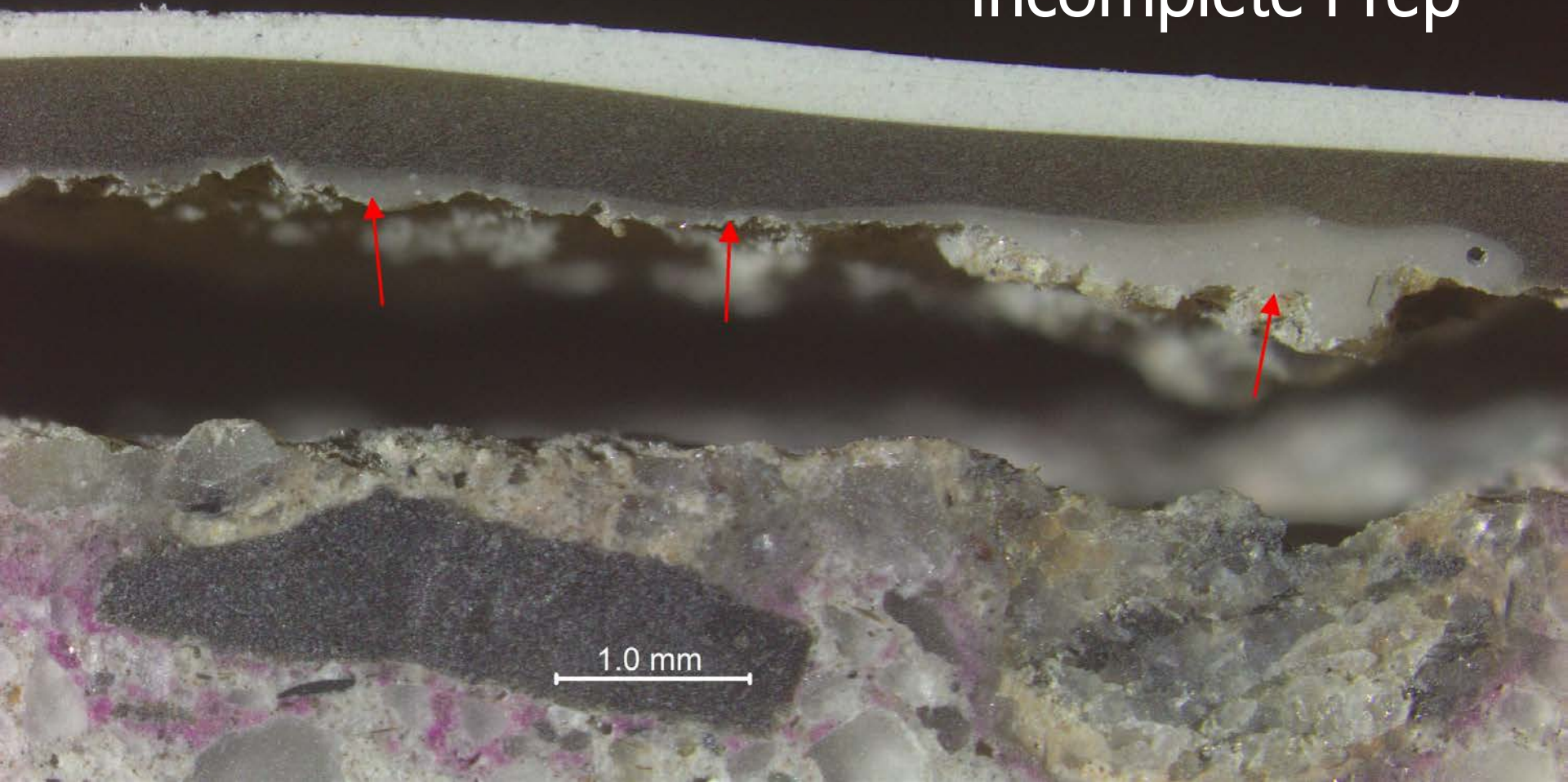
1 mm

CSP 4 - 5

3 mm



# Incomplete Prep



# Incomplete Prep

-Curing Compound

1 mm



# Incomplete Prep

-penetrating sealer

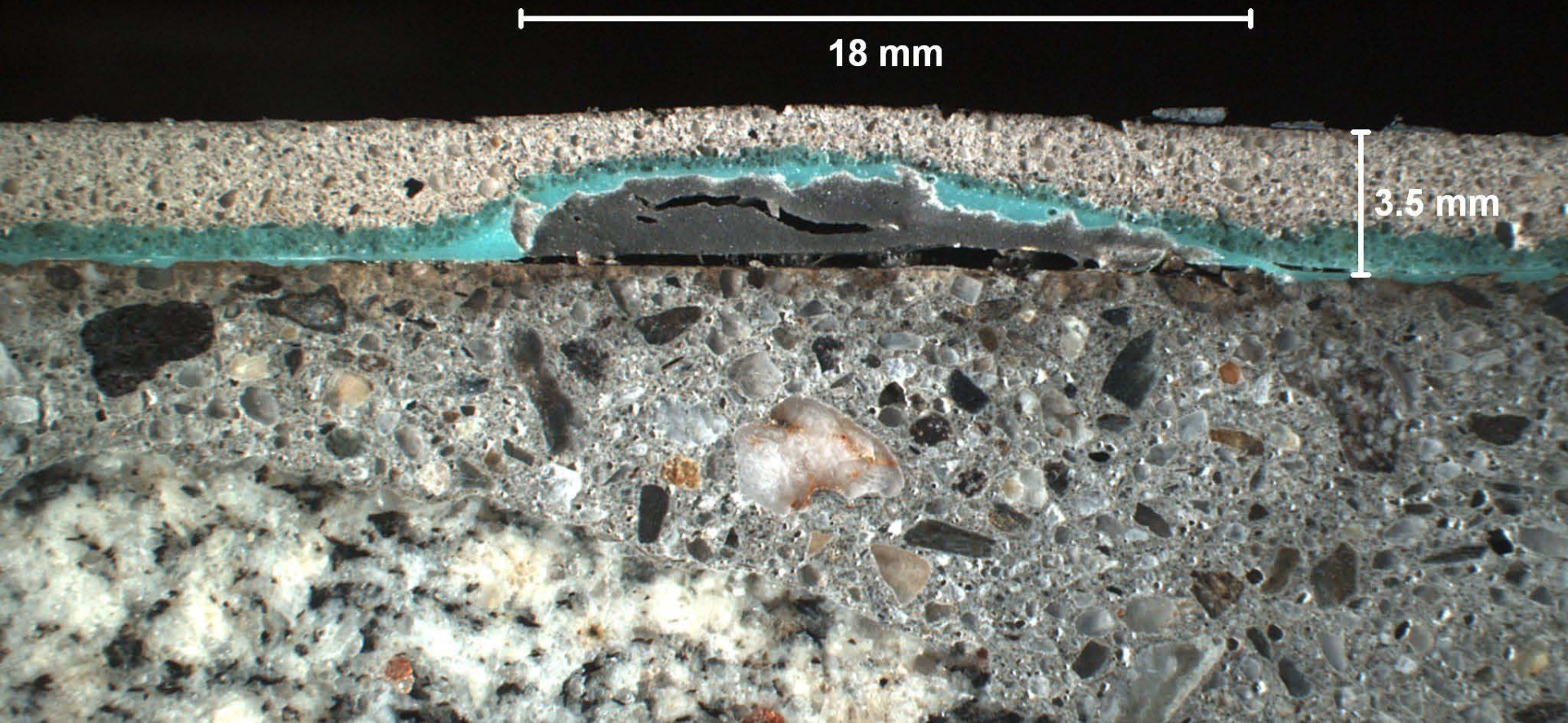


1 mm

Bruising



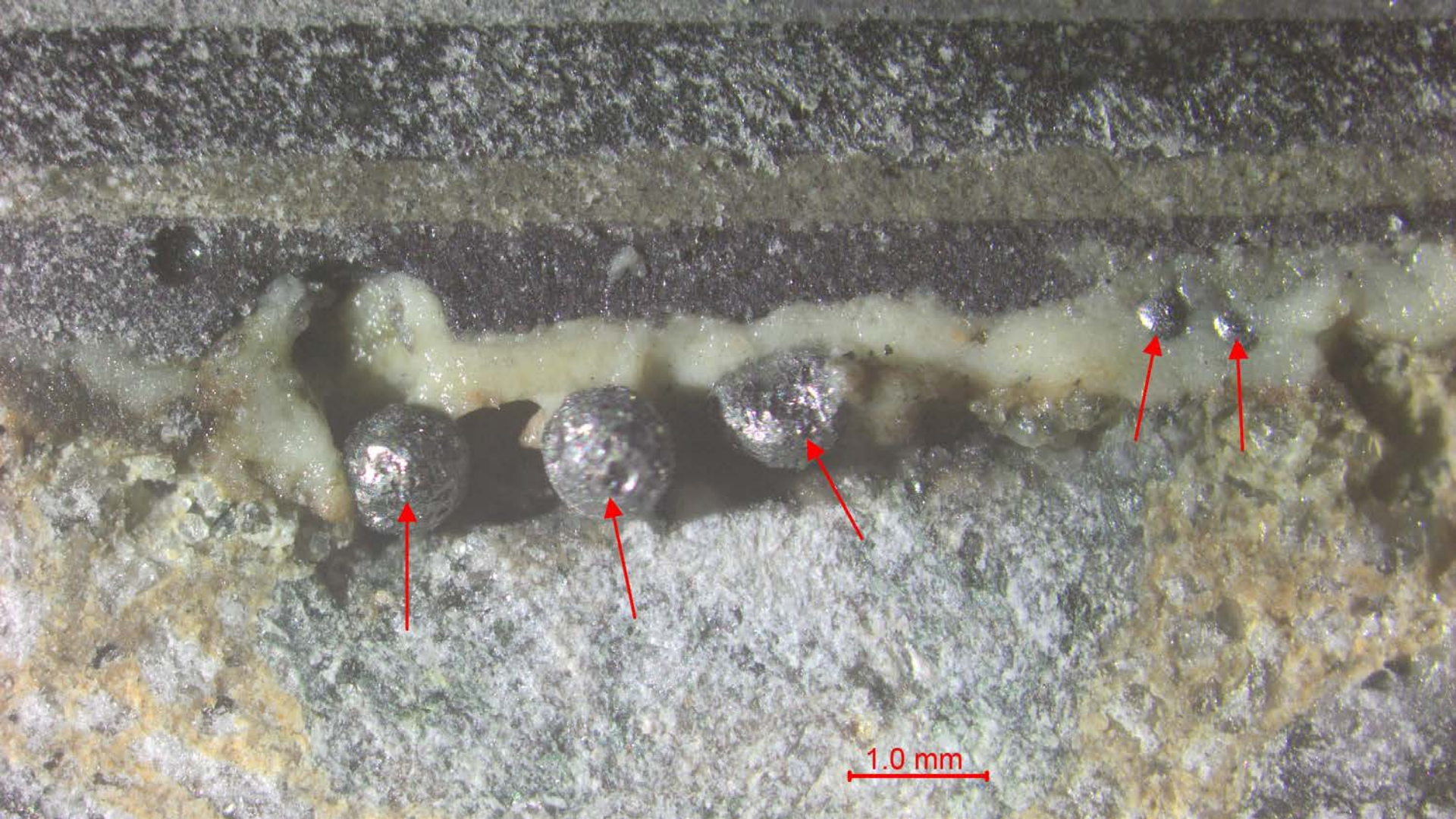
# Construction Debris



18 mm

3.5 mm





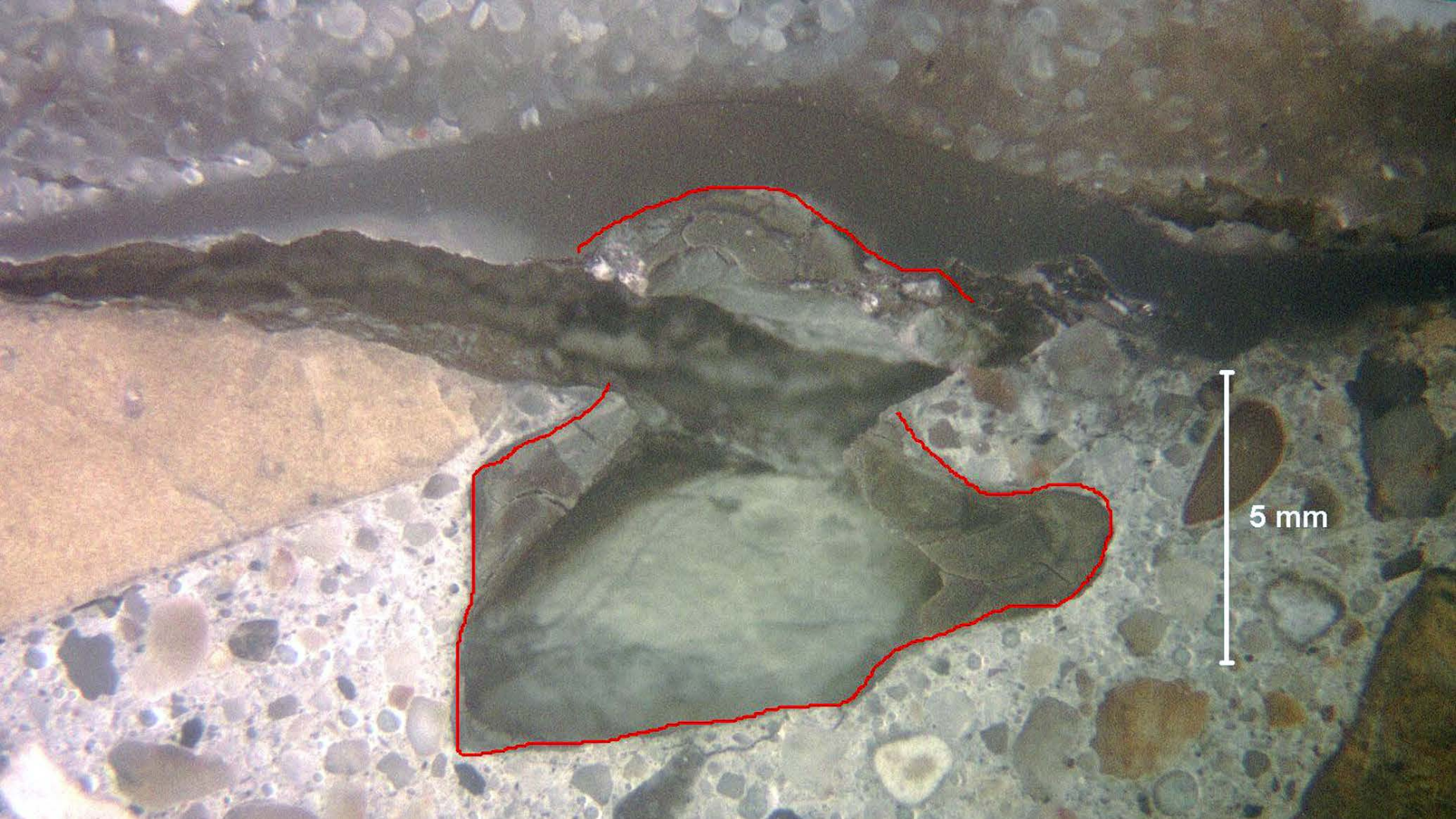
1.0 mm

Hangar Floor

MN

5 mm





Defects in Bond may = Osmotic Blisters



Local Commercial Floor







Local Commercial Floor – preexisting

The image shows a dark, glossy epoxy floor that is wet. Two bright, vertical streaks of light reflect off the surface, one on the left and one on the right. The floor is covered with numerous small, white droplets of water, which are more concentrated around the light reflections. The overall appearance is that of a recently installed, high-gloss epoxy coating.

New Epoxy Flooring – 2 months







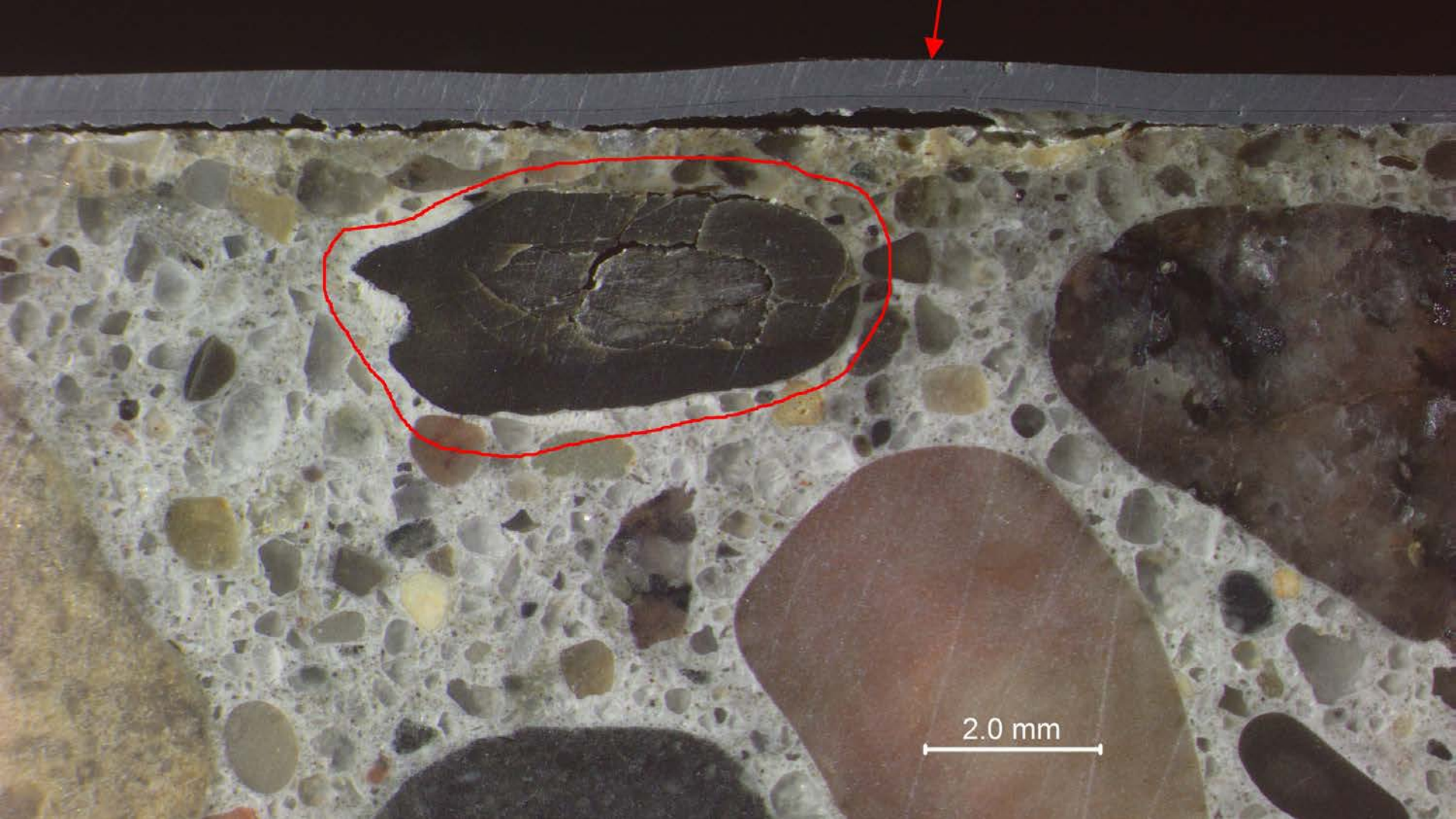
CM



AMERICAN



5.0 mm



2.0 mm

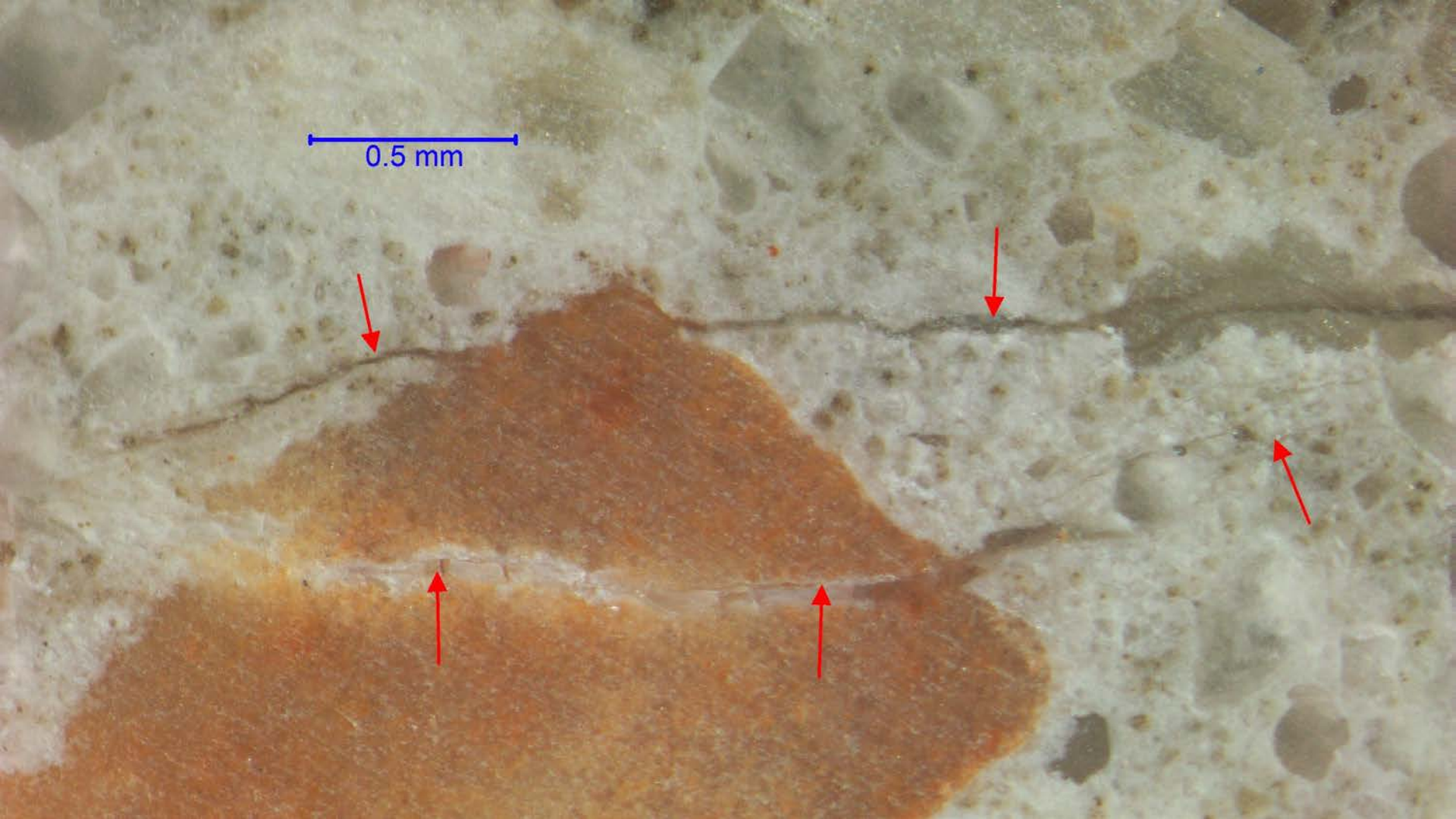
# Hangar Floor, Texas



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

2.0 mm

0.5 mm





## Commercial VCT installation – Colorado

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







CM

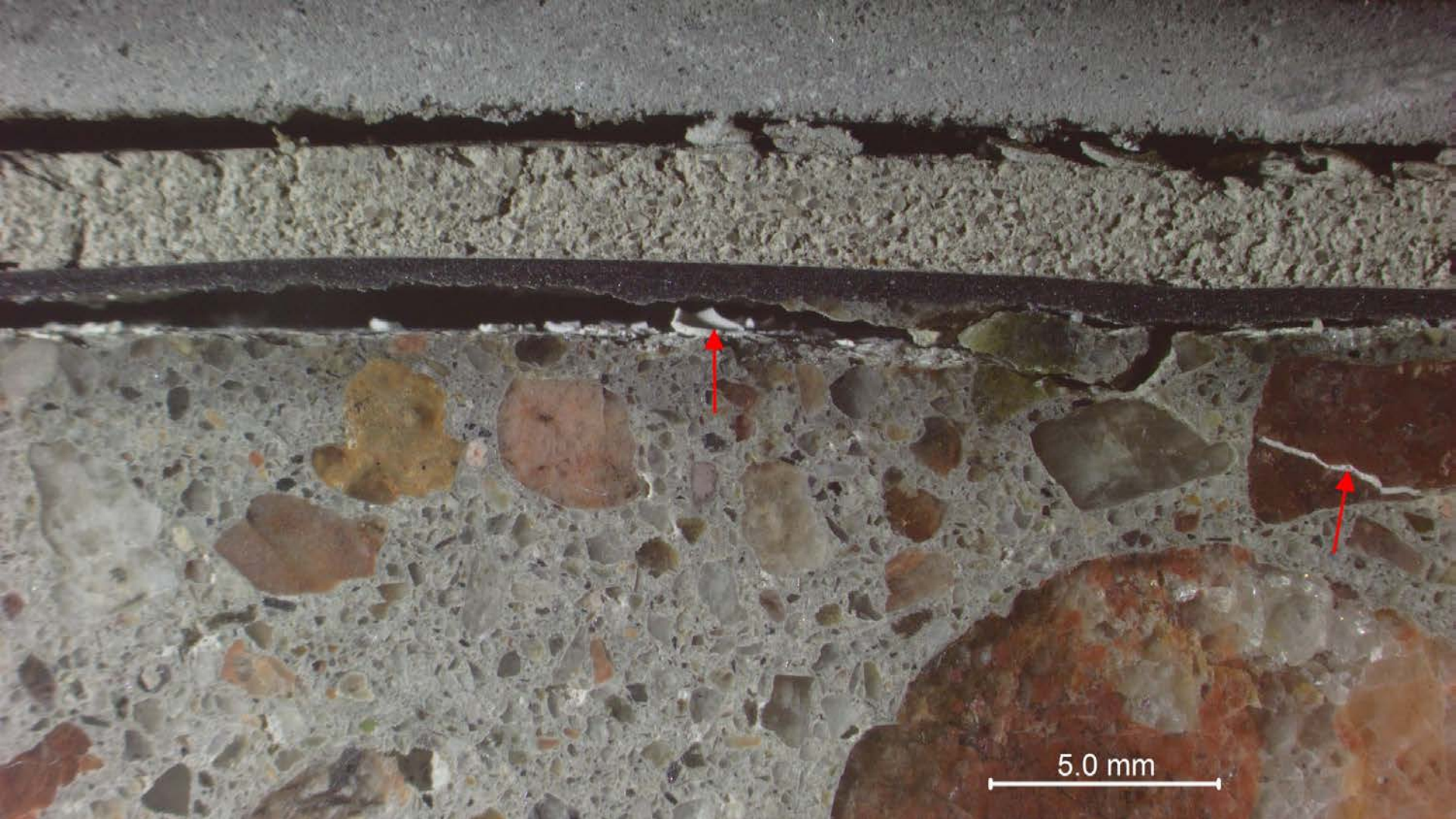
AMERICAN

24.20291

AET 1

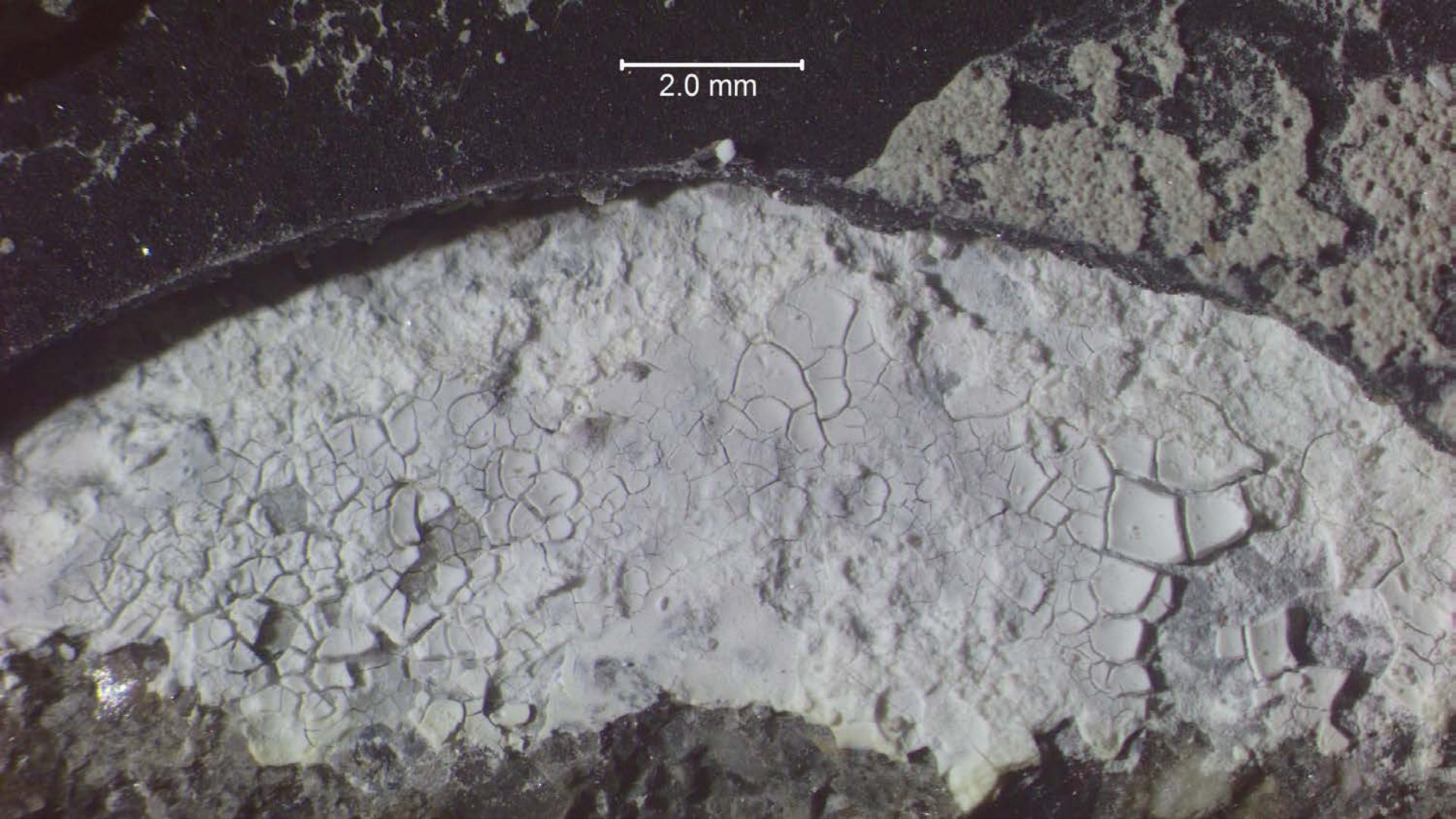
CM

AMERICAN



5.0 mm

2.0 mm



Bank  
Arizona

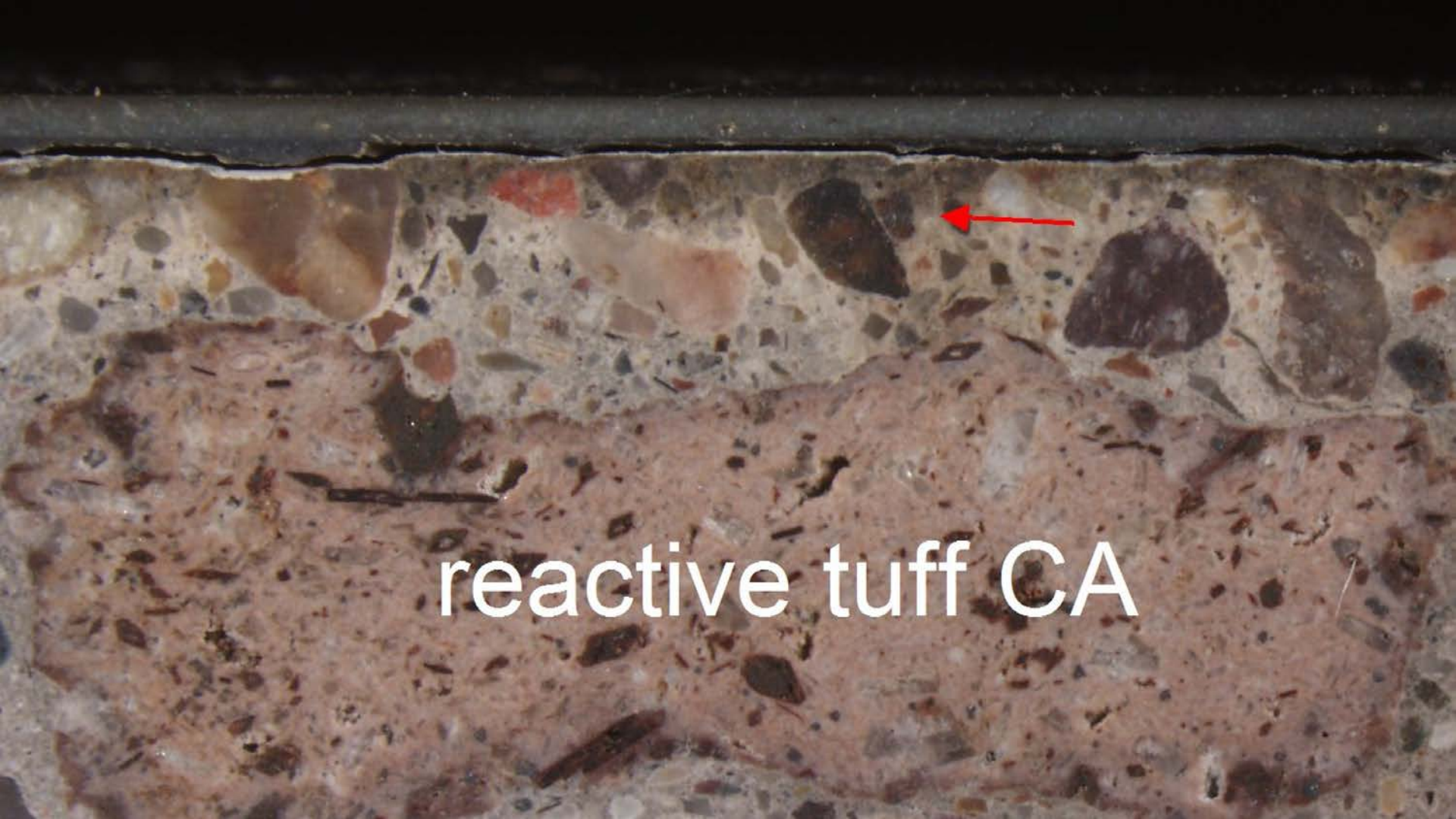






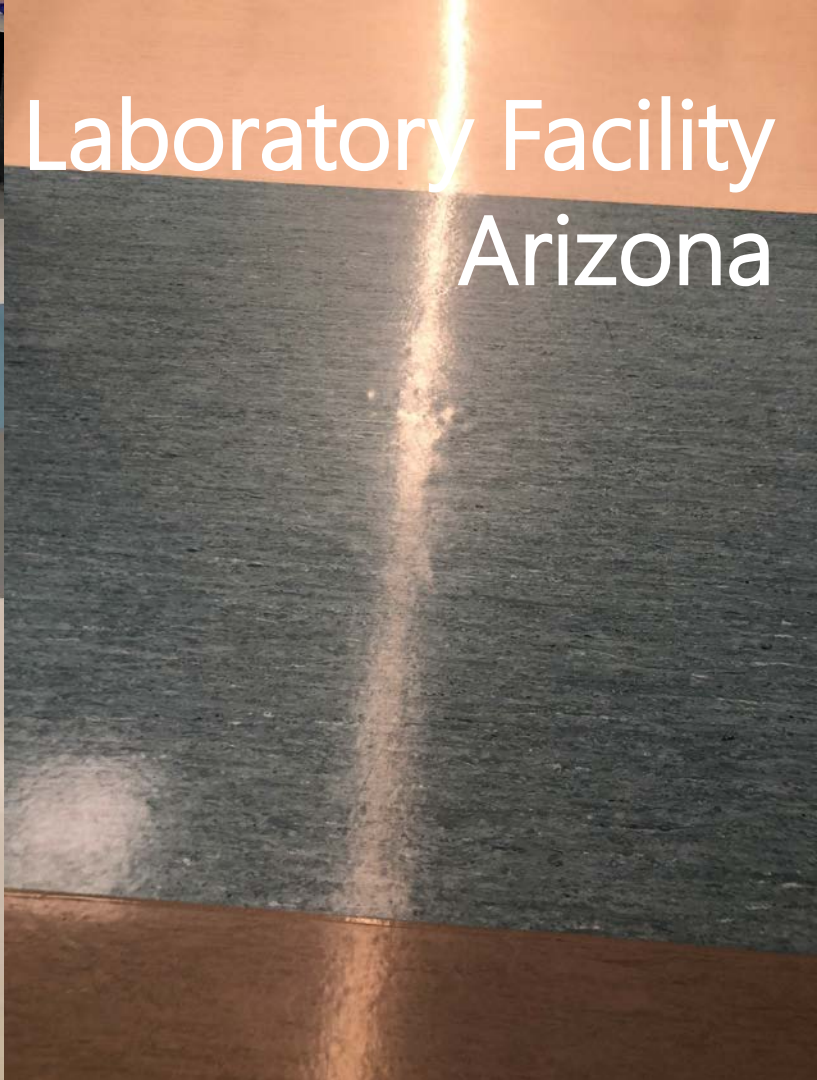
A high-magnification microscopic image showing a textured, light-colored surface with a network of fine, dark, branching lines. The texture appears granular and porous. A red scale bar is located on the left side of the image, consisting of a horizontal line with vertical end caps, positioned above the text '0.25 mm'.

0.25 mm



reactive tuff CA



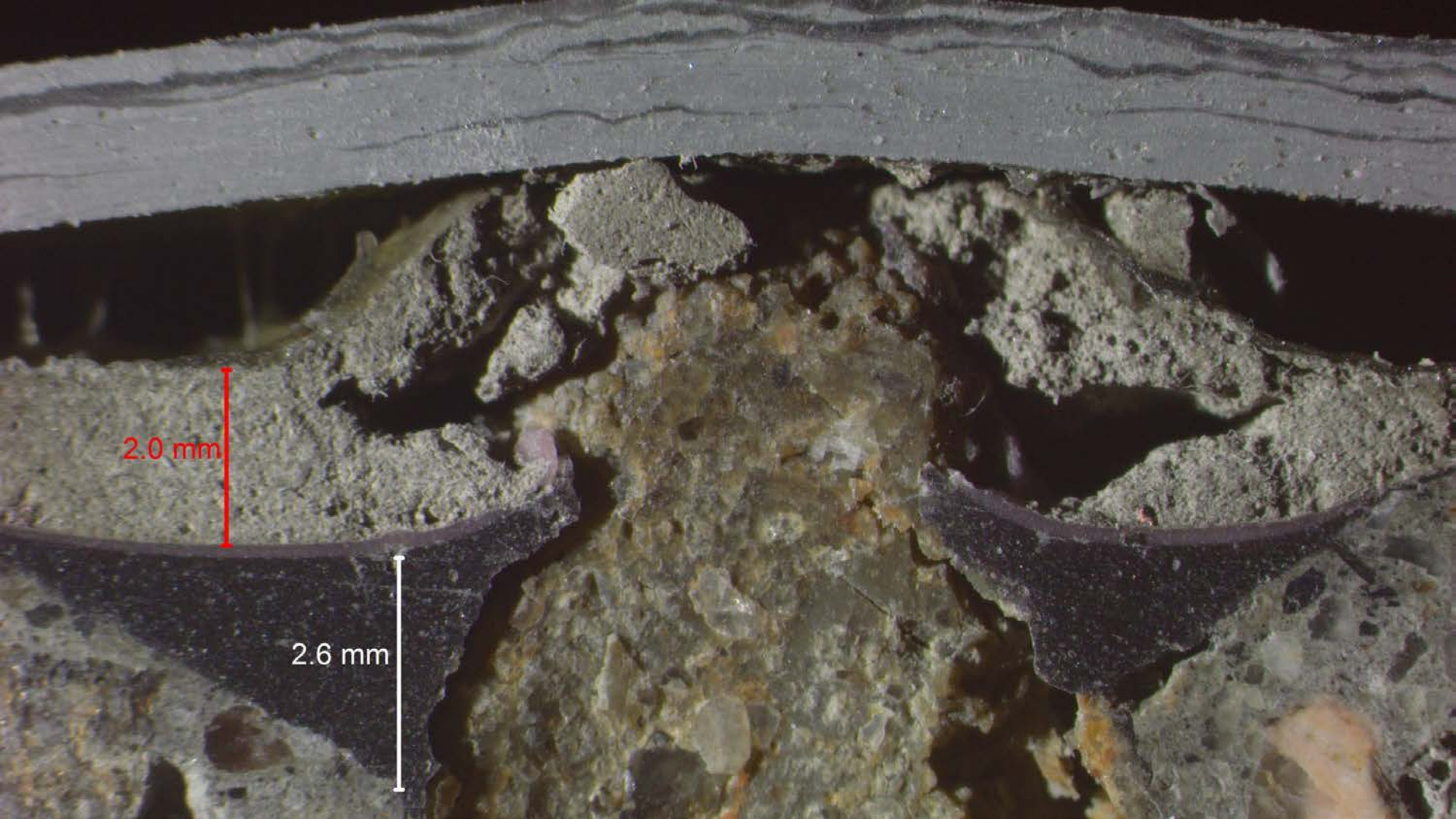


# Laboratory Facility Arizona

- New flooring system Oct. 2017
- Blisters August 2018
- 13k ft<sup>2</sup>



5.0 mm

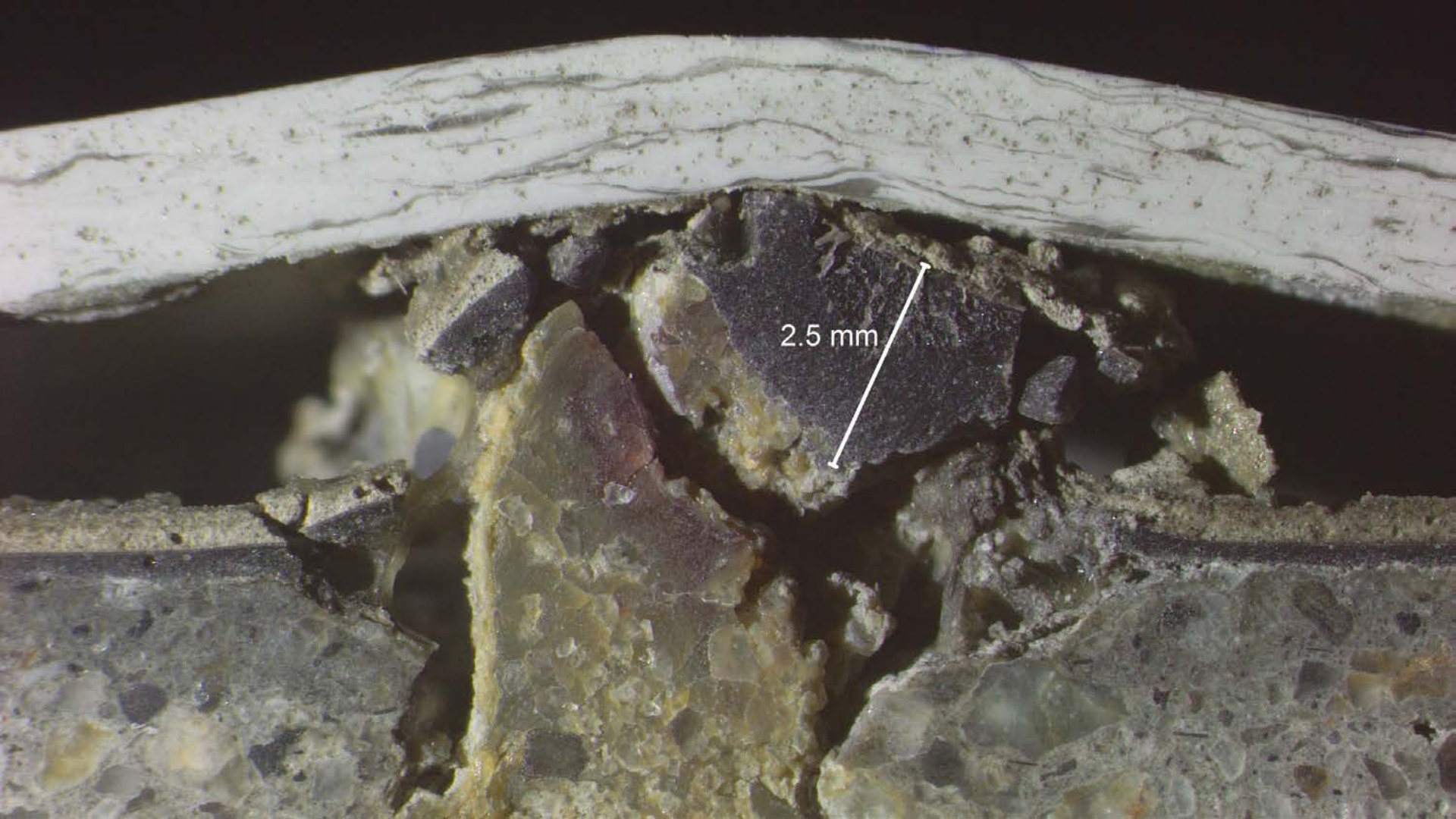


2.0 mm

2.6 mm



5.0 mm



2.5 mm

# Thank You!



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Trust *Delivered.*<sup>™</sup>