U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: MECHANICAL ATTRIBUTES OF WASTE PACKAGE ENVIRONMENT

PRESENTER: STEPHEN C. BLAIR

PRESENTER'S TITLE: GEOPHYSICIST
AND ORGANIZATION: LAWRENCE LIVERMORE NATIONAL LABORATORY
LIVERMORE, CALIFORNIA 94550

PRESENTER'S
TELEPHONE NUMBER: (415) 422-6467

JANUARY 18-19, 1990

Outline

- Thermomechanical Effects of Waste Package Emplacement
- Borehole Stability

  Rock Properties

  Fracture Properties
- Modeling and Validation
- Summary

Thermomechanical Effects

Excavation increases stress

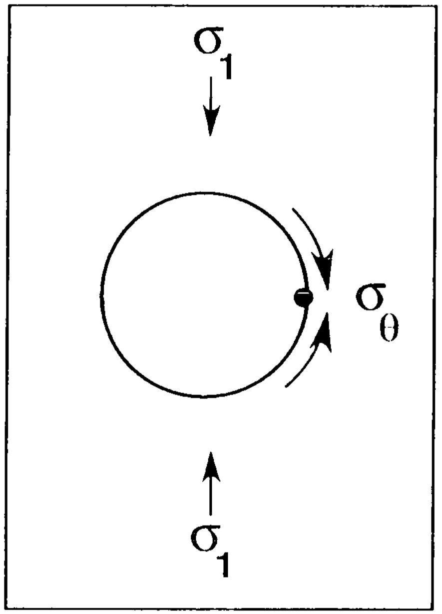
Increasing temperature affects

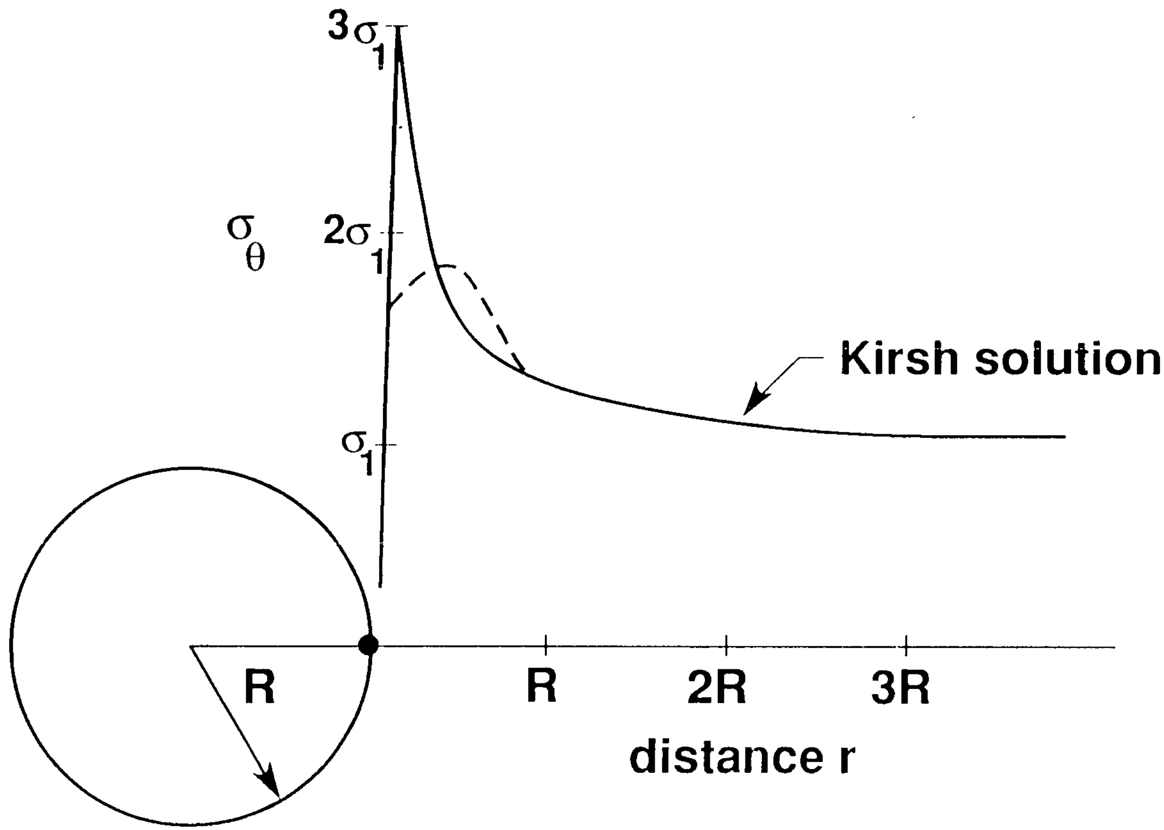
- Stress
- Moisture
- Strength
- Creep Rate
- May cause phase transformations

Decreasing temperature (cool down) affects

- Stress
- Moisture

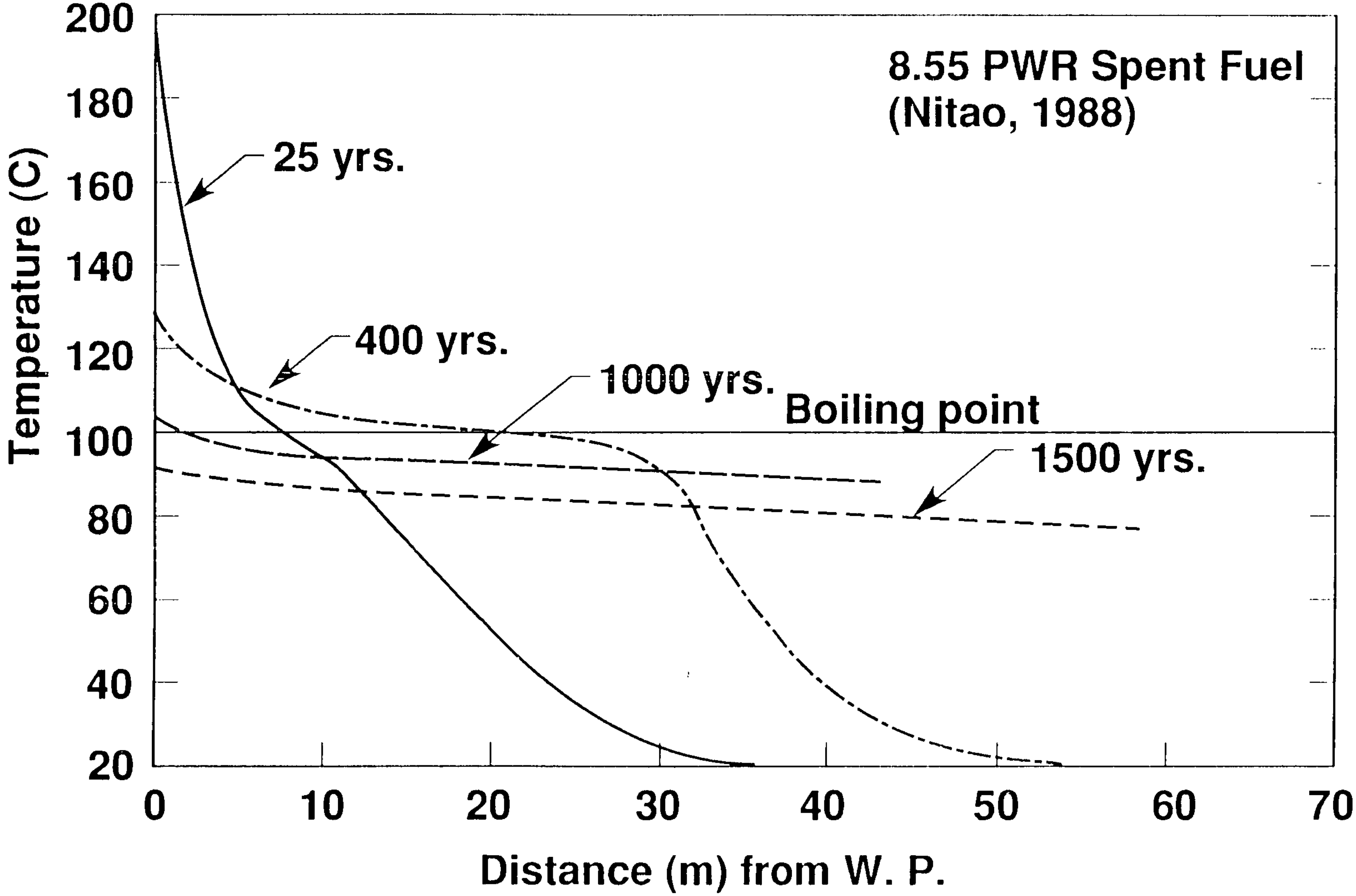
Stress near a borehole—Uniaxial stress field





$$\sigma_\theta \text{ (compressive)} = \frac{1}{2}\sigma_1\left(1 + \frac{R^2}{r^2}\right) - \frac{1}{2}\sigma_1\left(1 + \frac{3R^4}{r^4}\right)\cos 2\theta$$

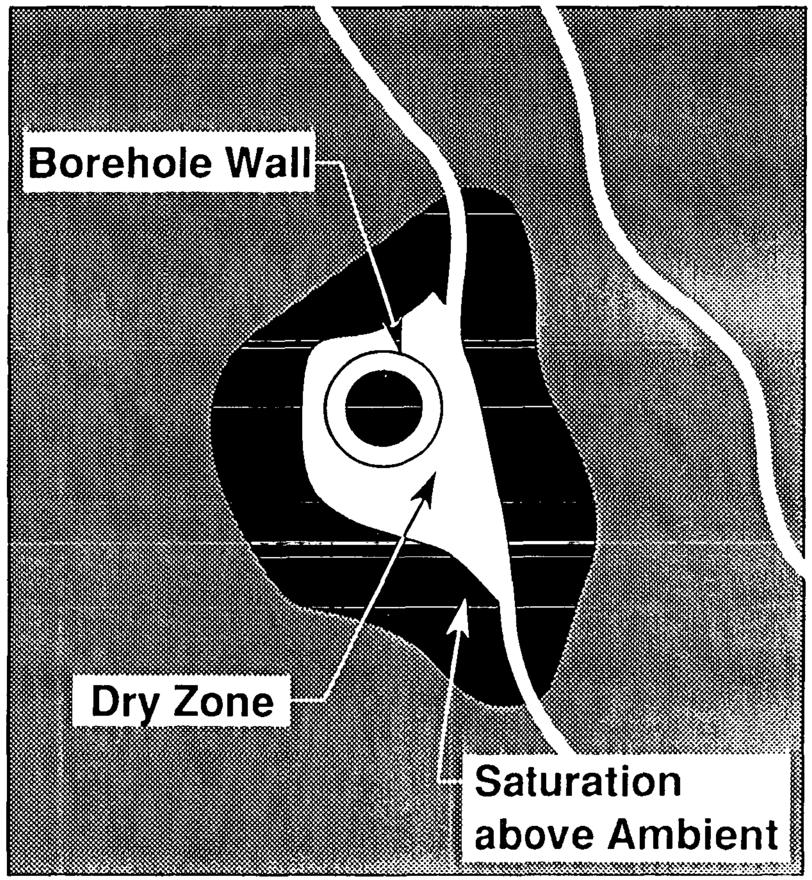
Temperature Profile



ES 01/09/90 SB#6 01

Moisture distribution

Results from G-Tunnel show that moisture is redistributed as the rock is heated.



Borehole Stability

Mechanisms such as subcritical crack growth or creep, acting over long time periods may affect the borehole wall.

Our purpose is to increase confidence in the estimates of the amount and type of mechanical loading on the waste package by investigating these phenomena.

Borehole Stability

Mechanism	Effect
• Spalling	Wicking of water
	Loading of container
• Block Movement	Wicking of water
	Point Loading
Creep	Reduction of air gap
	Loading of container

Borehole Stability - Spalling

The rate of subcritical crack growth increases with increasing temperature and stress.

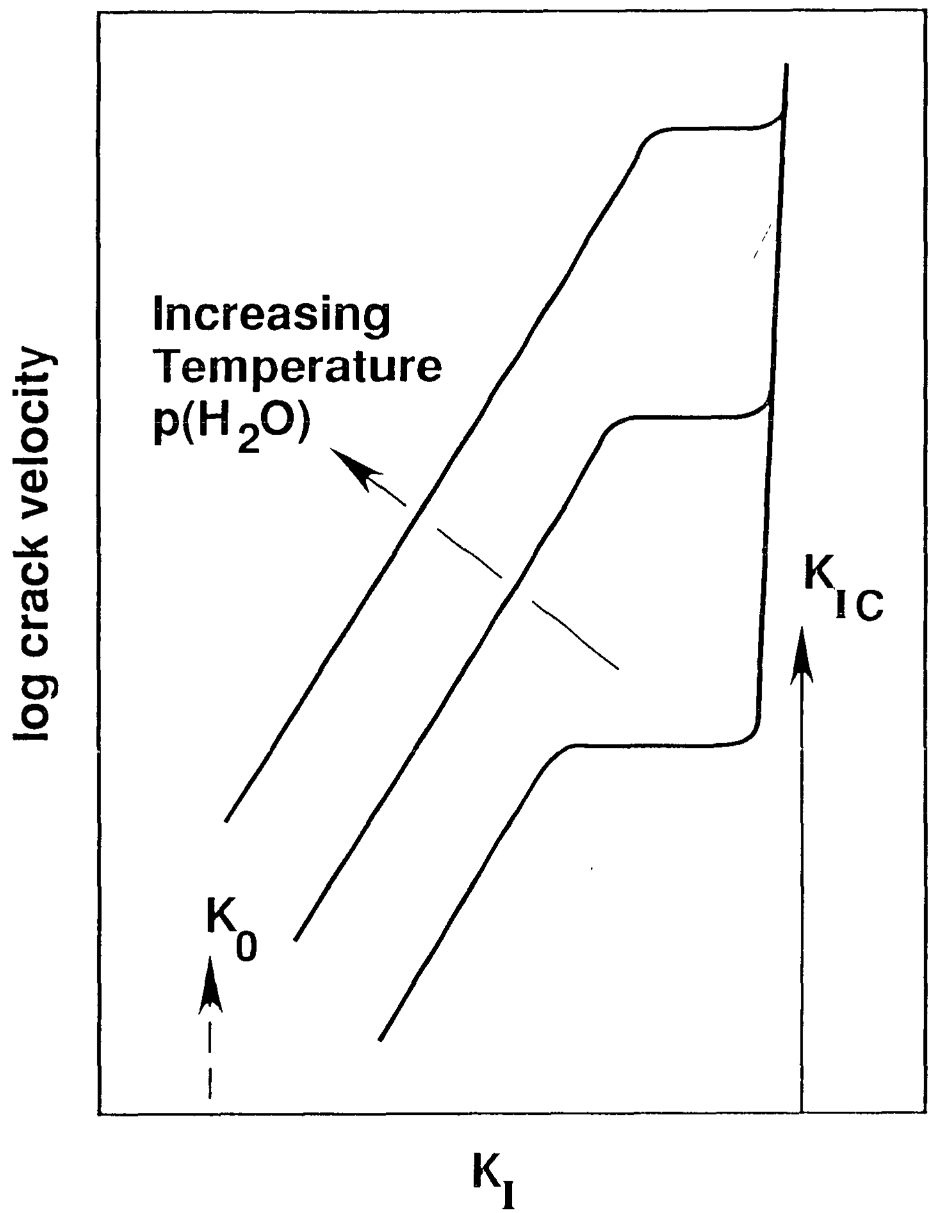
Spalling (post emplacement) may occur due to growth of cracks near the borehole wall.

Over long times subcritical crack growth may be significant.

We will study this mechanism in the laboratory and with numerical models.

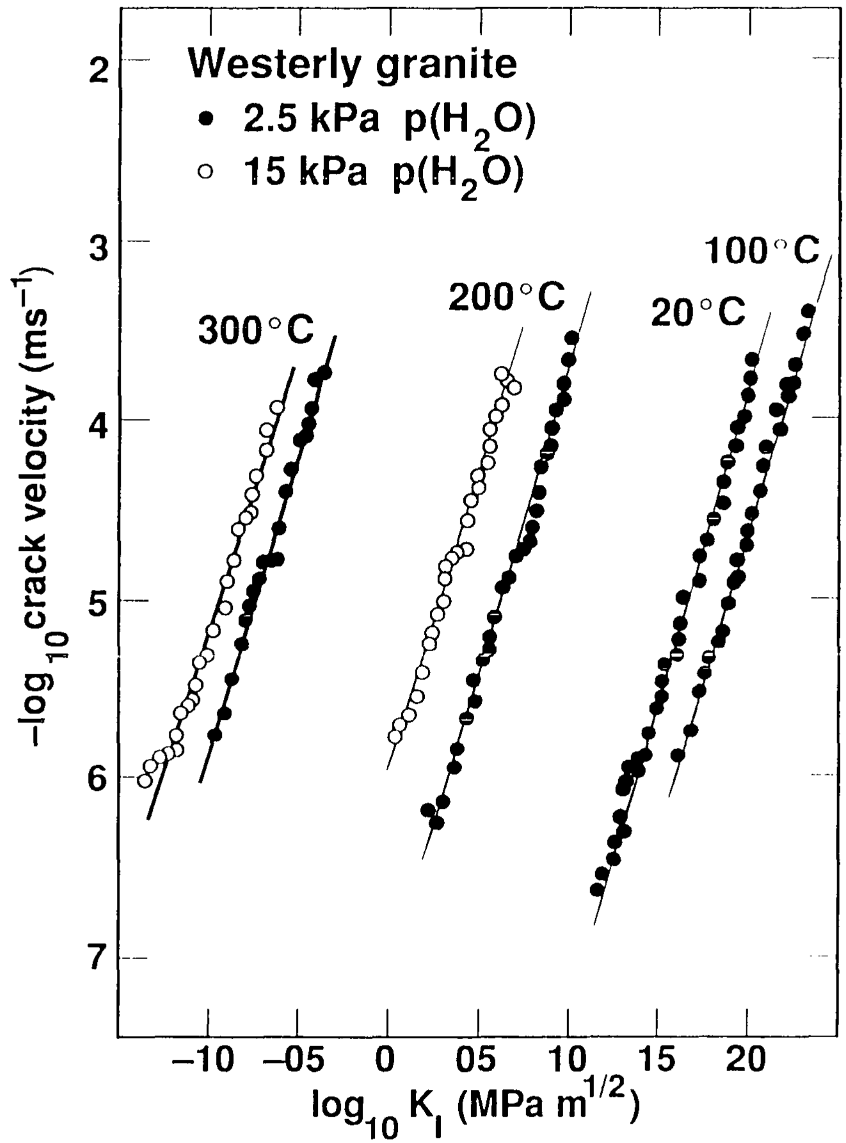
Note - Climax and G-Tunnel show no evidence of this effect in short term tests, but it must be examined.

Schematic stress intensity factor/crack velocity diagram



Influence of temperature and water vapor pressure on crack velocity in Westerly granite

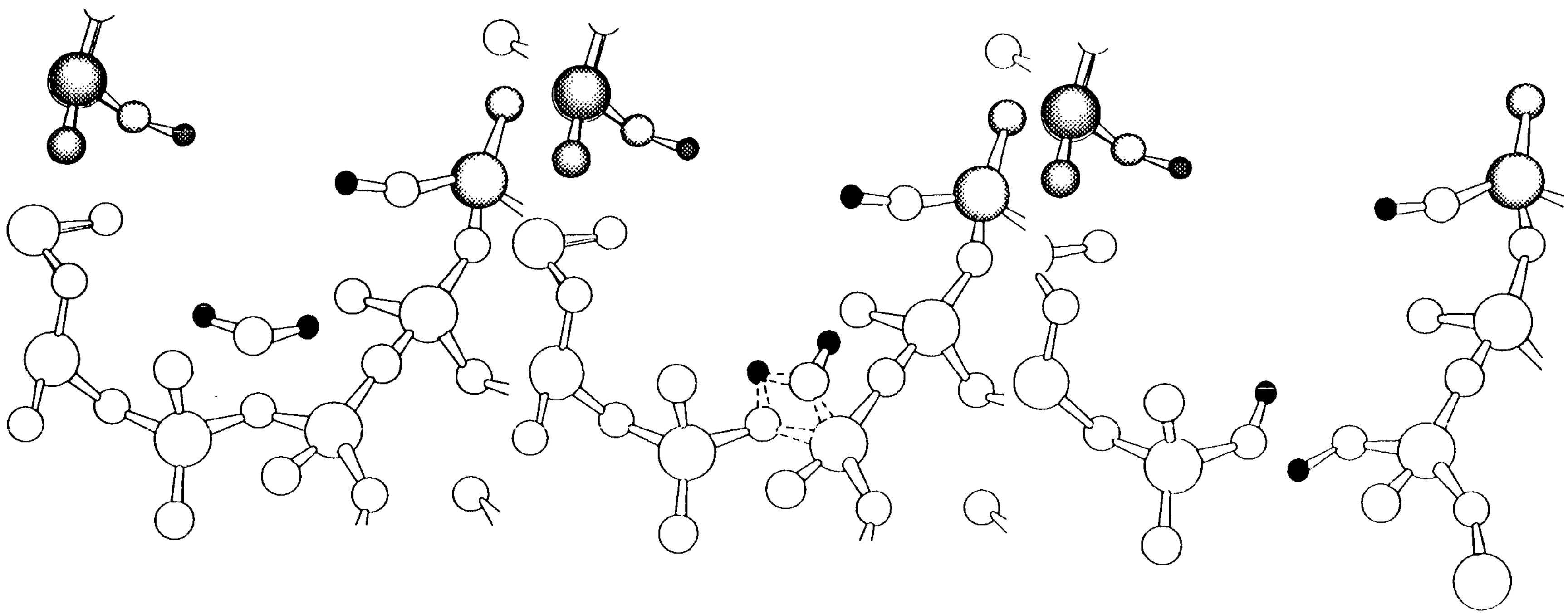
(Atkinson, 1987)



ES-01/08/90 SB#6-02

Water can react with glass and cause it to crack more easily.

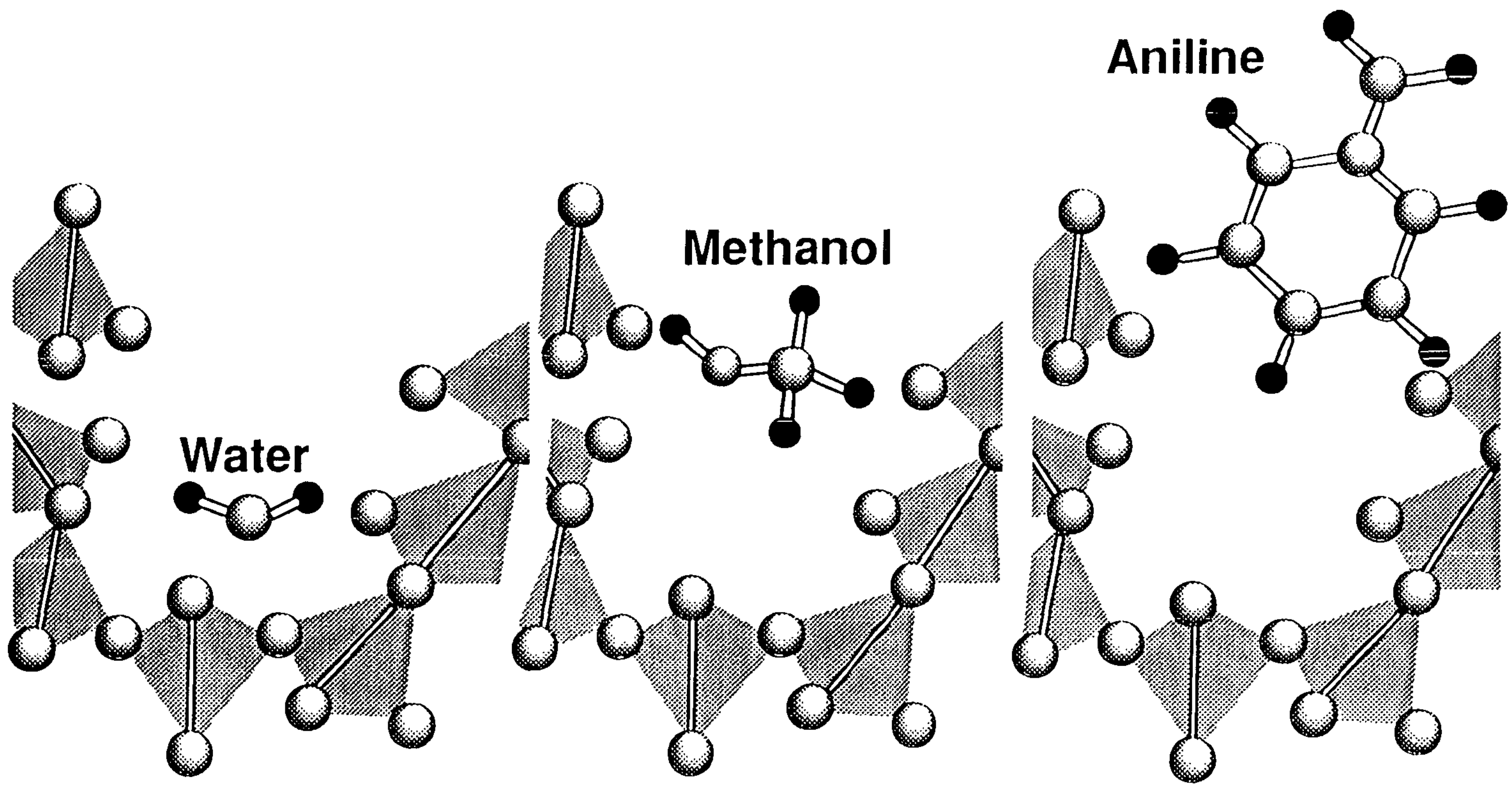
(Michalske & Bunker, 1987)



ES-12/21/89-SB6-03

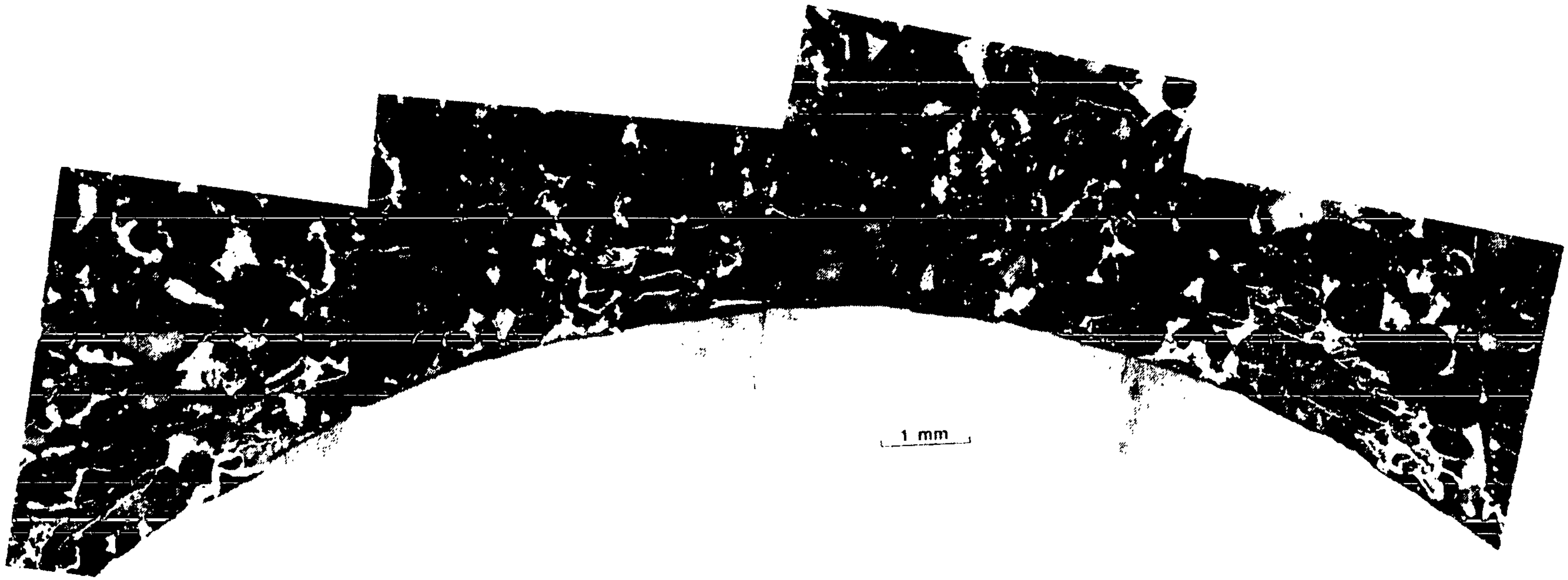
Molecular size of chemical substance affects its ability to speed the growth of cracks in glass.

(Michalske & Bunker, 1987)



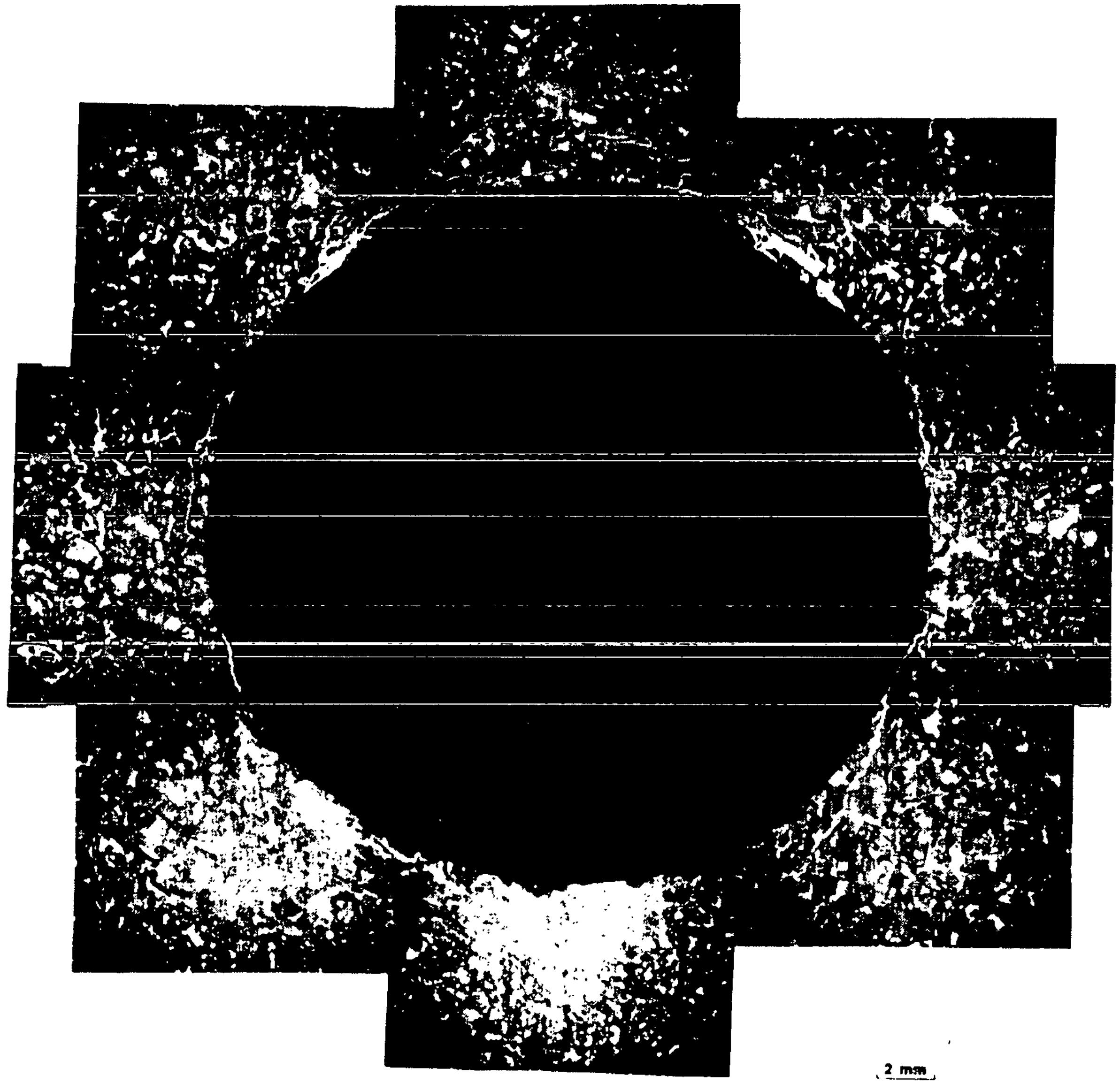
Early stage of fracturing in Indiana limestone

(Ewy, 1989)



Advanced fracturing in Indiana limestone

(Ewy, 1989)



ES-01/08/89-SB#6-01

Borehole Stability - Block Stability Analysis

- Identify blocks and shapes based on distribution of fractures.

- Determine kinematic stability to identify keyblocks and associated failure modes.

- Conduct stability analysis for selected keyblocks.

- To be initiated when ESF becomes available.

Modeling and Validation

- Develop required conceptual models for
  - Time dependence
  - Temperature dependence
  - Effects of radiation
  - Mineral phase transformations
- Evaluate existing codes

Spalling & Creep	Block Stability
FEFFLAP	BSTAB3D
SANCHO	
HEFF	

- Simulate laboratory tests as part of validation

SUMMARY

The purpose of this task is to characterize the mechanical behavior of the WP environment (post-emplacement)

Focus is on time dependent and temperature dependent mechanisms.

Work is in the planning phase.