

CNWRA A center of excellence in earth sciences and engineering

A Division of Southwest Research Institute®
6220 Culebra Road • San Antonio, Texas, U.S.A. 78228-5166
(210) 522-5160 • Fax (210) 522-5155

August 8, 2003

U.S. Nuclear Regulatory Commission
ATT: Deborah DeMarco
Office of Nuclear Materials Safety and Safeguards
Two Whiter Flint North
Mail Stop 8 A23
Washington, D.C. 20555

Subject: Submittal of Presentation Titled "A Comparative Analysis of Fault Zone Architectures in Welded Tuff at Yucca Mountain, NV, with Implications for Paleohydrology"

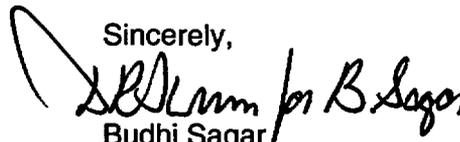
Dear Mrs. De Marco:

The purpose of this letter is to transmit the aforementioned presentation Dr. Mary Beth Gray will give at the California Institute for Geophysics and Planetary Physics (IGPP) Workshop on Fluid Flow and Transport through Faulted Igimbrites and Other Porous Media. The presentation discusses the classification and origin of four types of faults found at Yucca Mountain. Three of the fault types are formed by progressive cataclasis. The fourth type is characterized by puzzle-piece breccia cores consisting of > 65% calcite indicating that these faults had a strong dilatational components and formed under fluid saturated conditions. These faults indicate that at some time in the geologic history of Yucca Mountain, fluid fluxes were sufficient to develop secondary minerals at elevated temperatures.

This work was initiated to refine models of faulting used in repository assessment codes to evaluate uncertainties of the risk associated with potential direct disruption of the emplaced waste by fault movement.

If you have any questions please contact Dr. John Stamatakos at (210) 522-5247 or me at (210) 522-5252.

Sincerely,


Budhi Sagar
Technical Director

BS/slo
Enclosure

cc (w/o Encl.): M. Leach	D. Riffle	K. Stablein	W. Patrick
W. Reamer	B. Meehan	L. Campbell	CNWRA Dirs/EMs
J. Schlueter	J. Greeves	C. Trottier	D. Ferrill
D. DeMarco	S. Wastler	P. Justus	J. Stamatakos



Washington Office • Twinbrook Metro Plaza #210
12300 Twinbrook Parkway • Rockville, Maryland 20852-1606

**A Comparative Analysis of Fault Zone Architectures
in Welded Tuff at Yucca Mountain, NV,
with Implications for Paleohydrology***

Mary Beth Gray, Bucknell University

John A. Stamatakos, CNWRA

David A. Ferrill, CNWRA

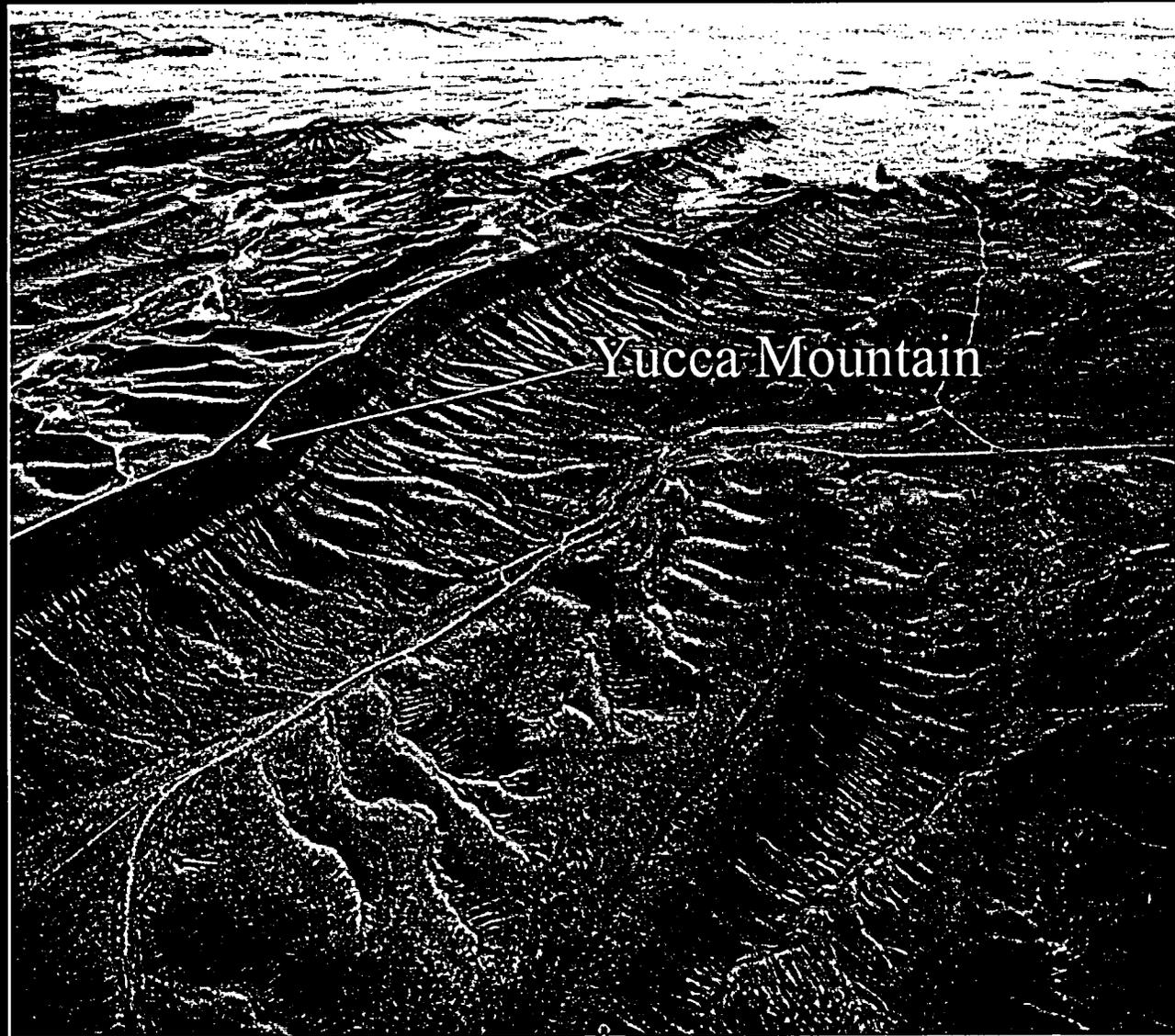
Mark A. Evans, U. Pittsburgh

* Work supported by the U.S. Nuclear Regulatory Commission (contract NRC 02-02-012). This abstract is an independent product of the CNWRA and does not necessarily reflect the views or regulatory positions of the NRC.

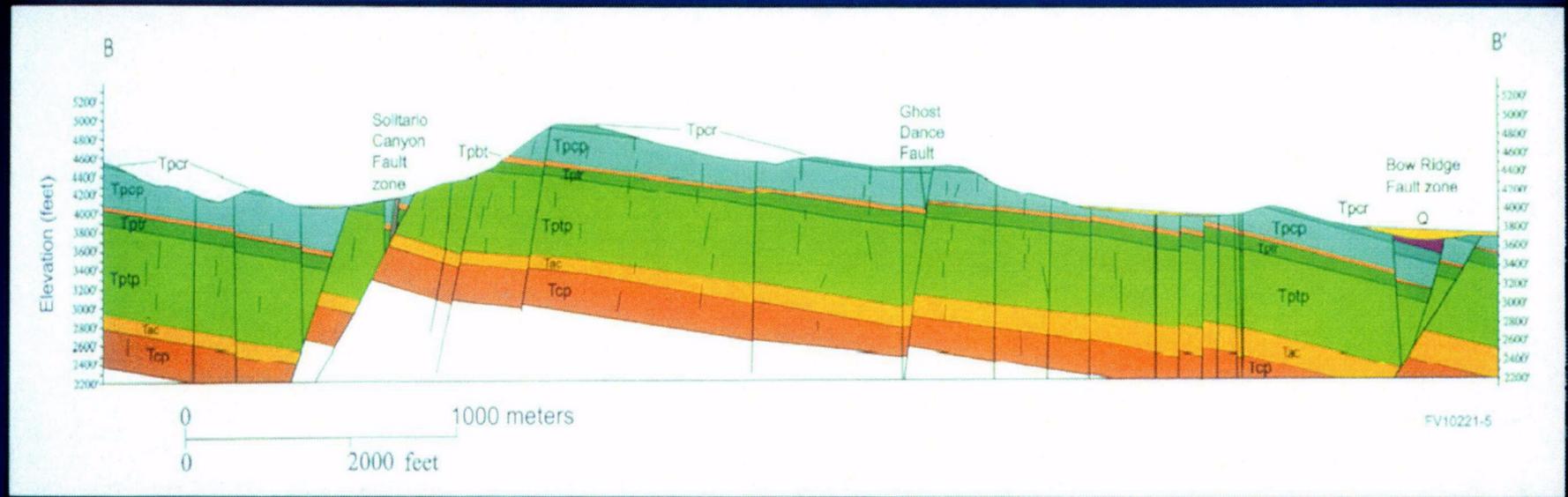
Study Objectives

- Evaluate uncertainties in the direct rupture of waste package by faulting (e.g., SDS IRSR rev. 2).
- Evaluate significance of uncertainties in fault and fracture control of groundwater flow (e.g., Farrell et al., 1999; Ferrill et al., 1999; SDS IRSR rev. 2).

Site Location



Simplified Geologic Cross Section of Yucca Mountain, West to East



after Day et al., 1997

Fault Zone Classes

Class A

Reactivated cooling joints
or fractures

Slickenlines or
slickensides

mm

little or no damage away
from fault surface

Class B

Fault Core

Puzzle-piece breccia

Calcite matrix

Crack-seal margin

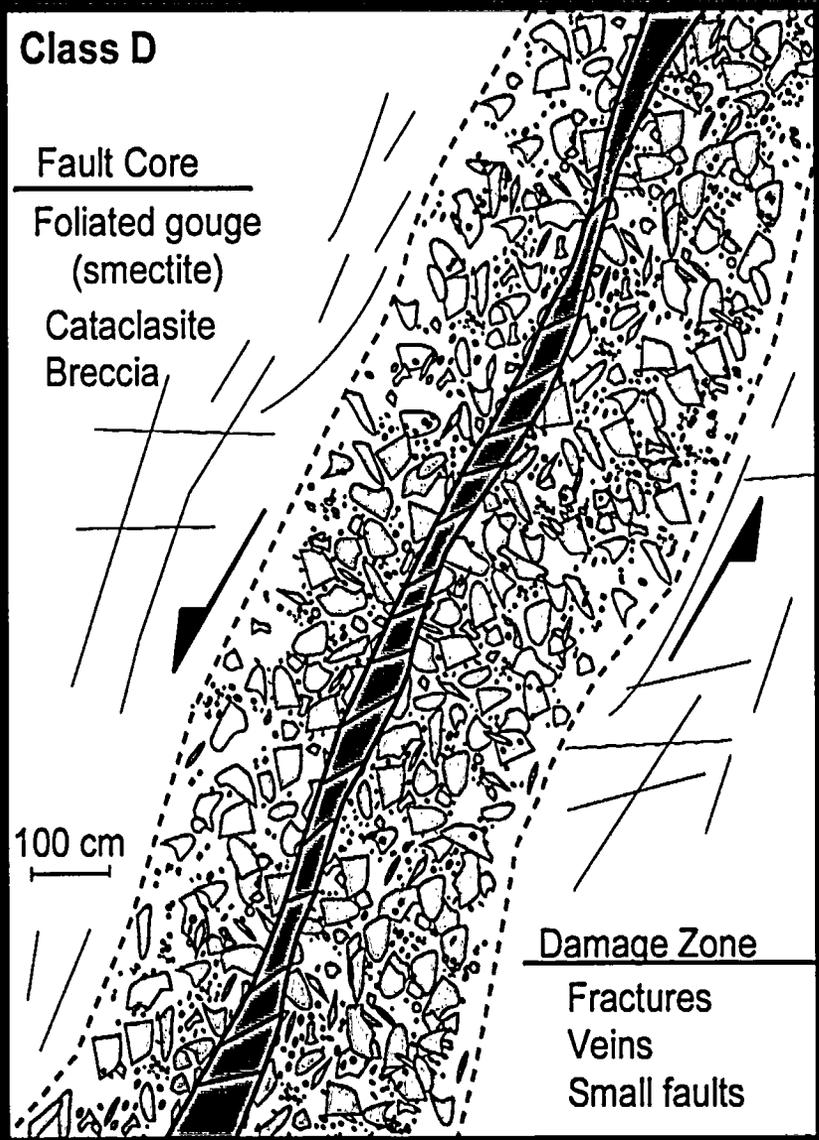
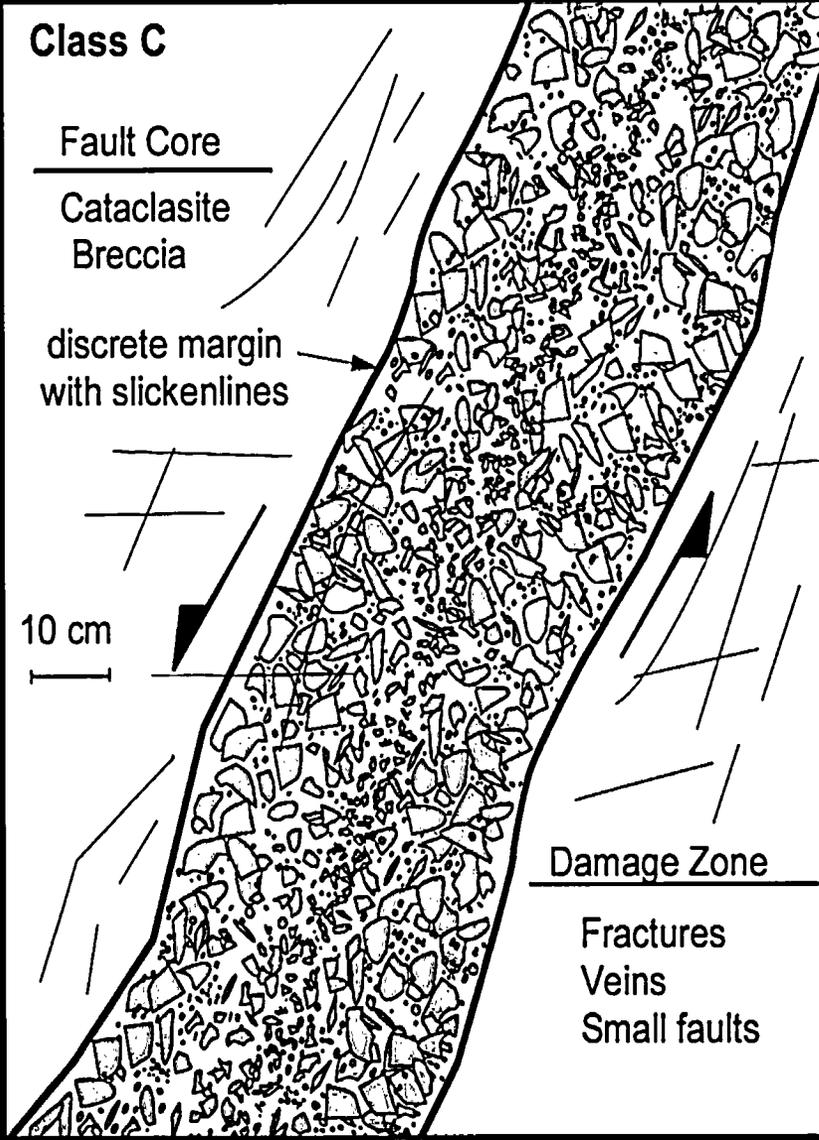
calcite

slickensides

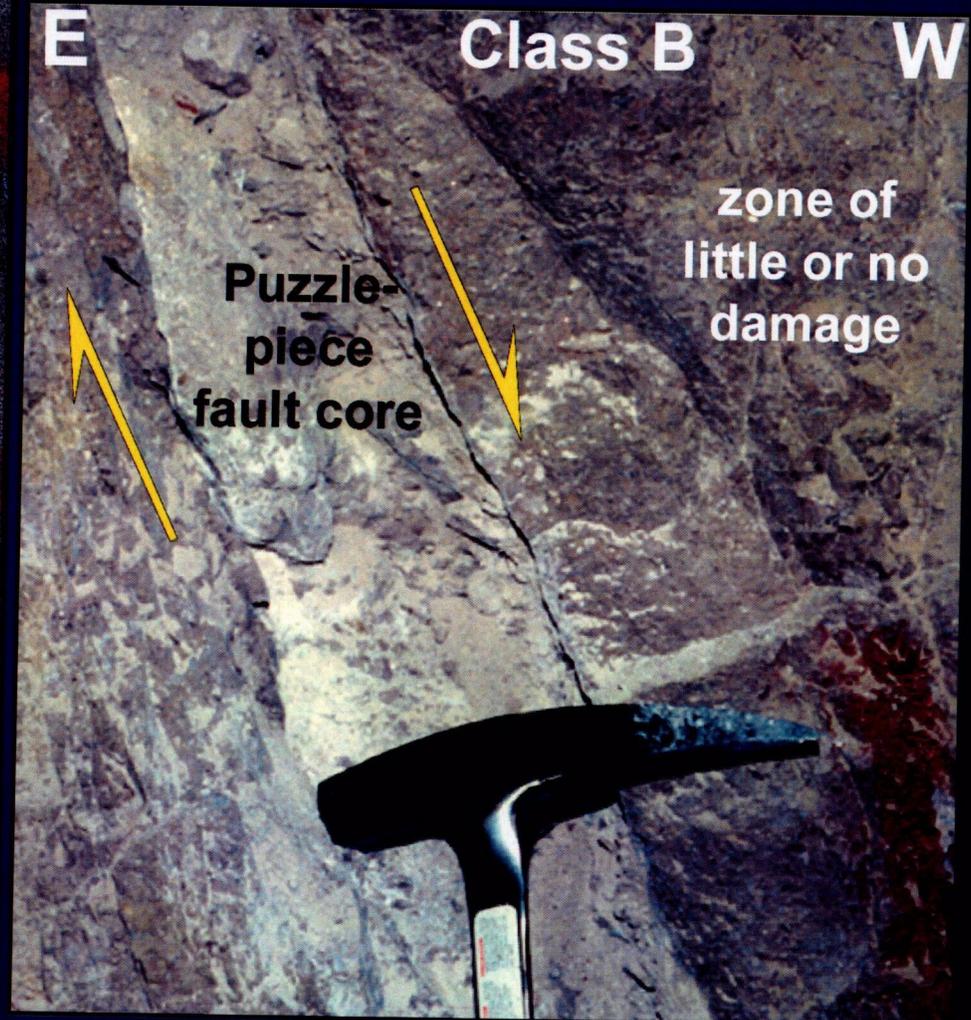
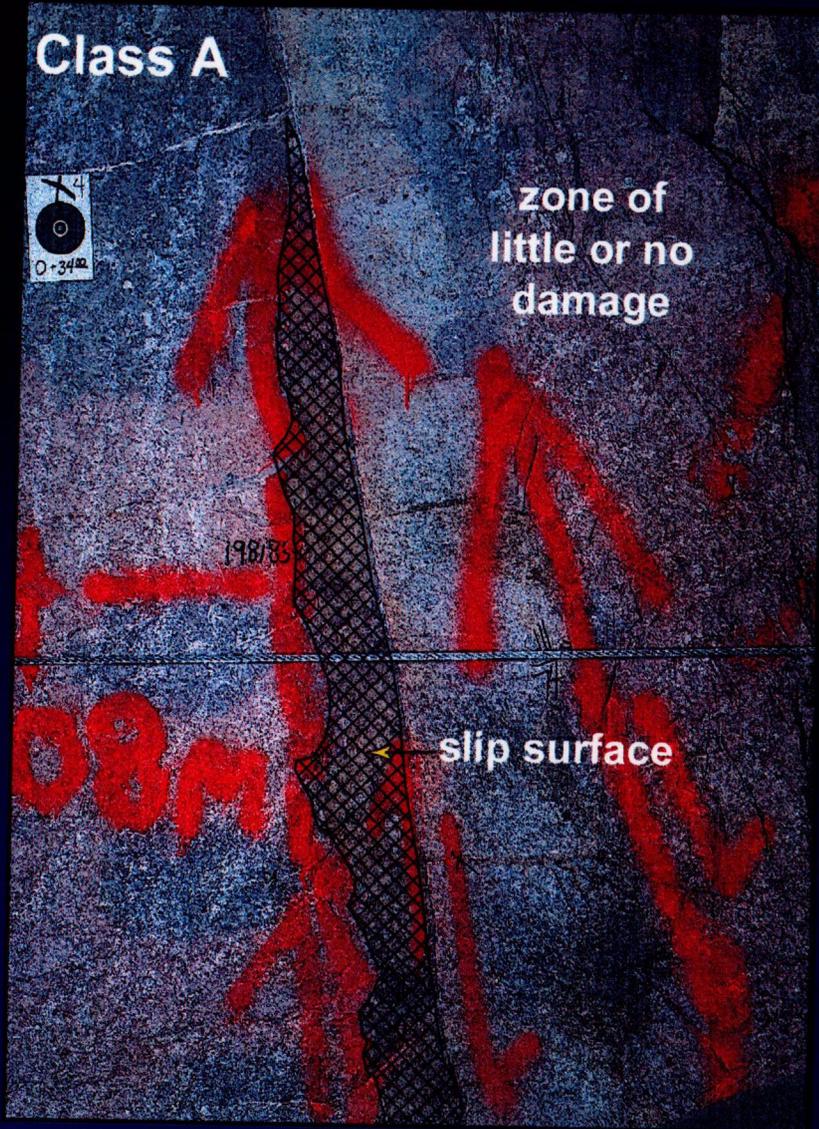
cm

little or no
damage zone

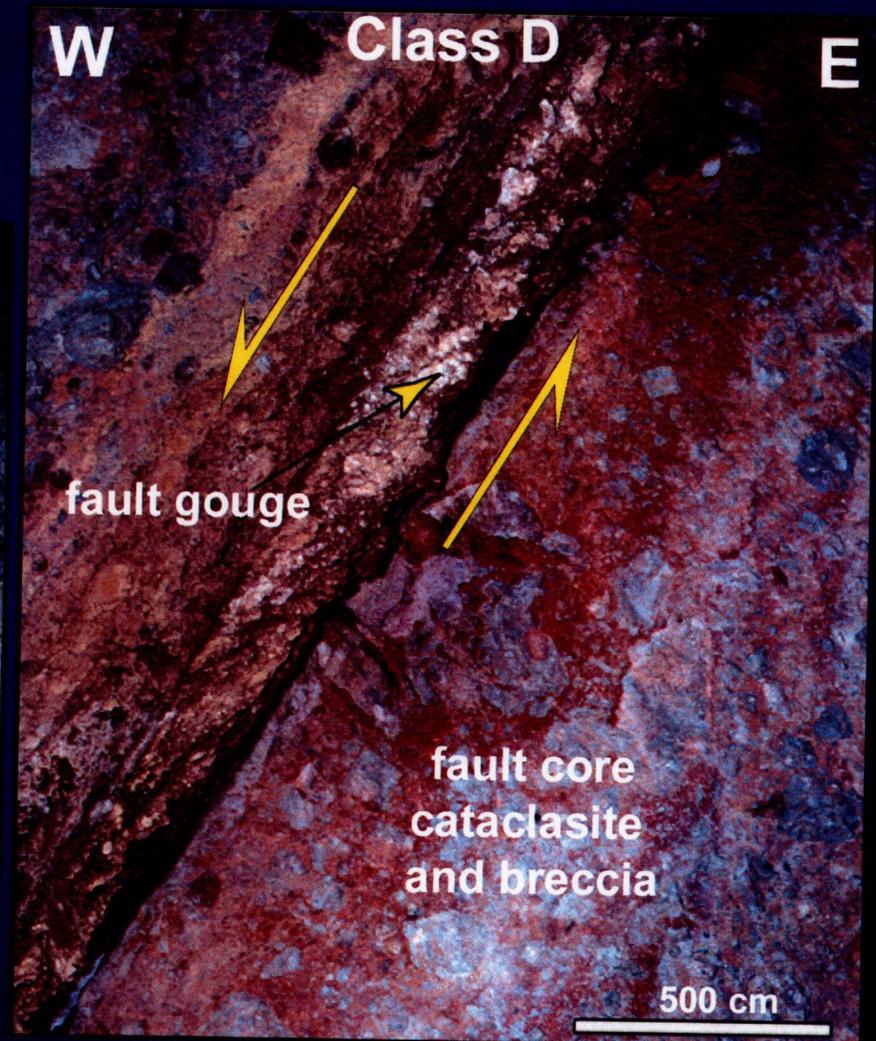
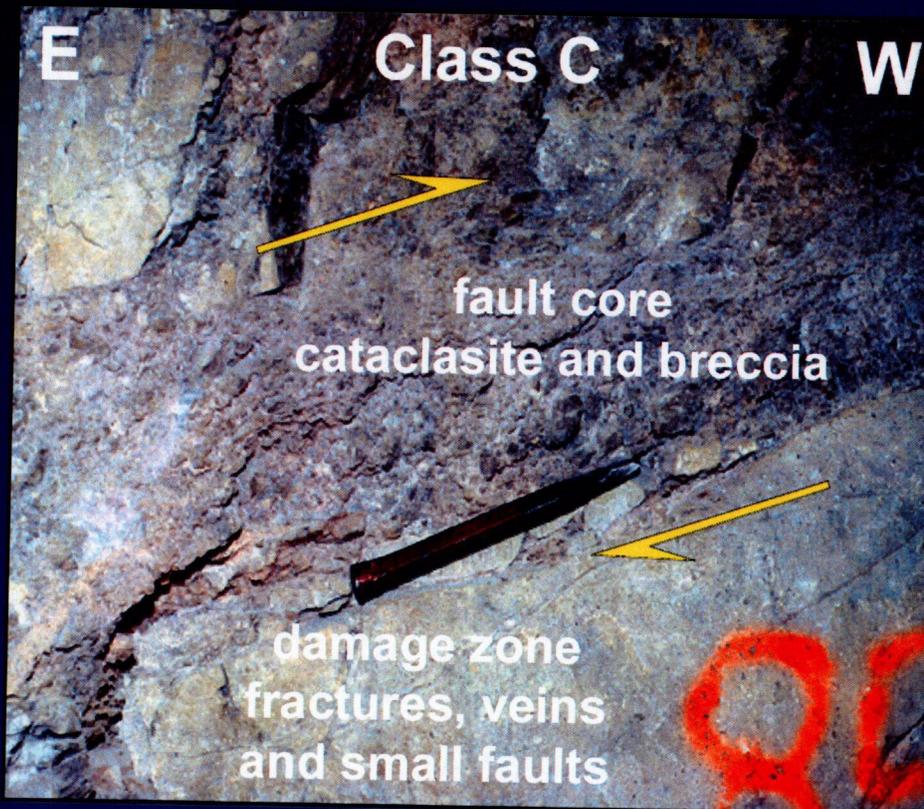
Fault Zone Classes



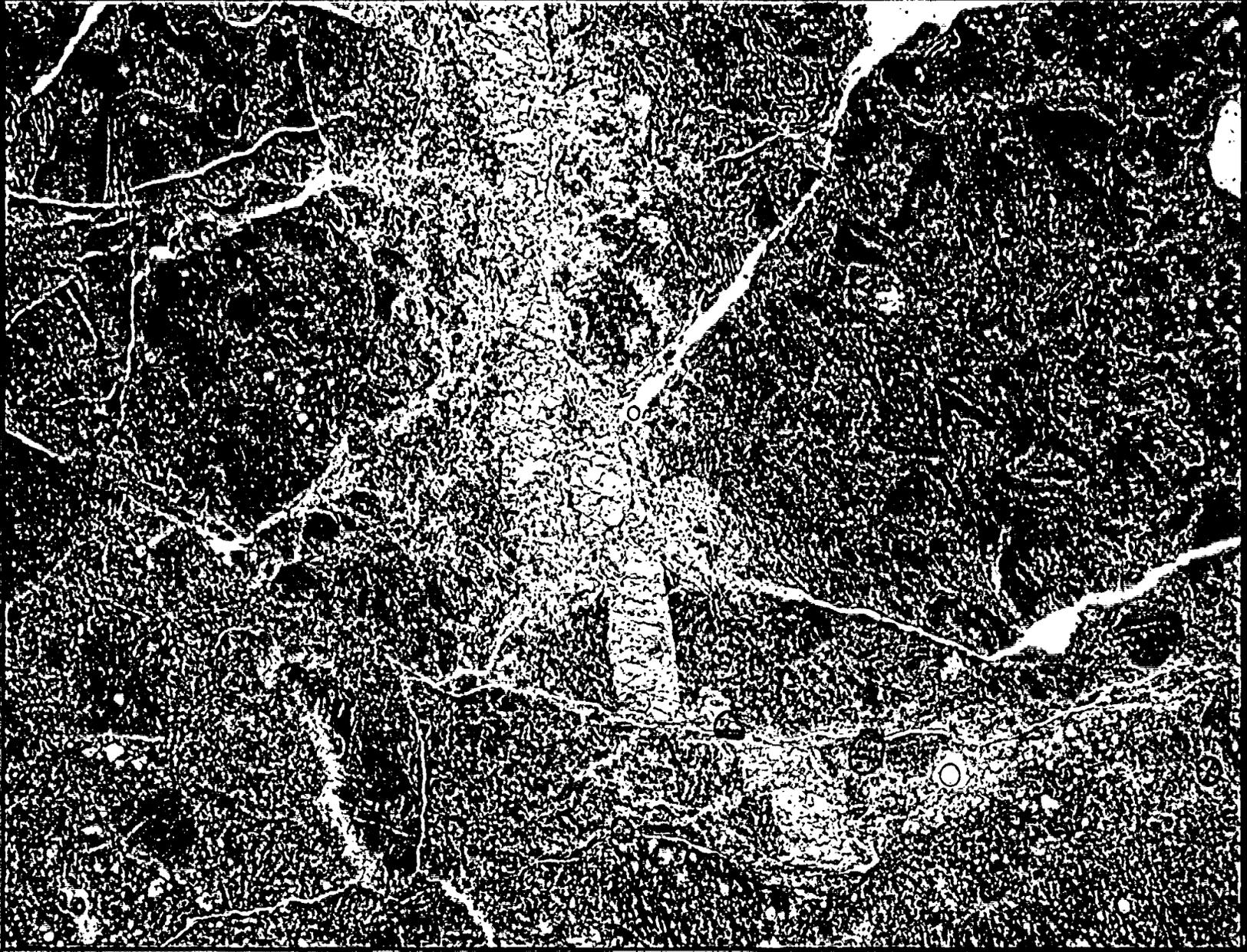
Photographs of Fault Zone Classes



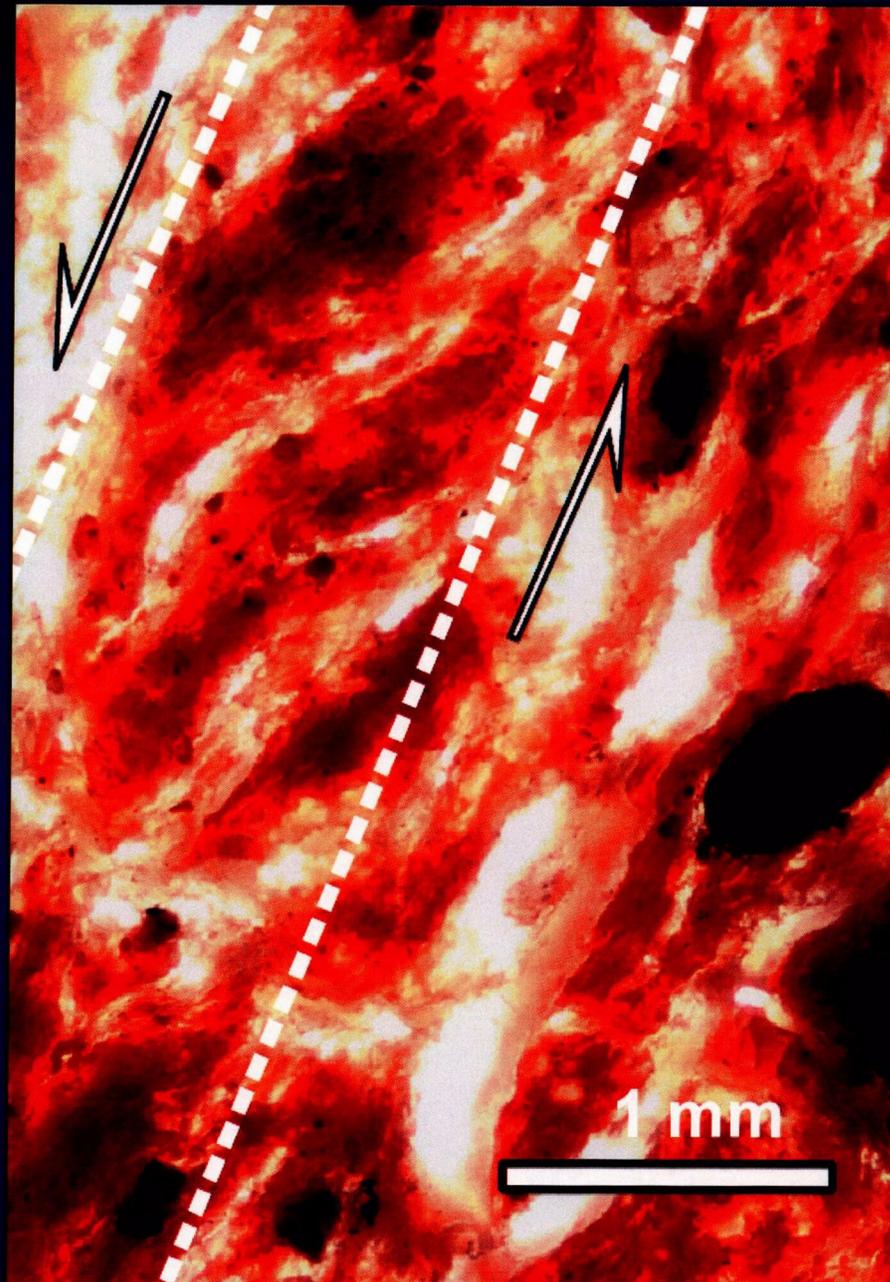
Photographs of Fault Zone Classes



Cataclasite in Sundance Fault Zone



**Foliated Gouge in
Solitario Canyon
Fault Core**



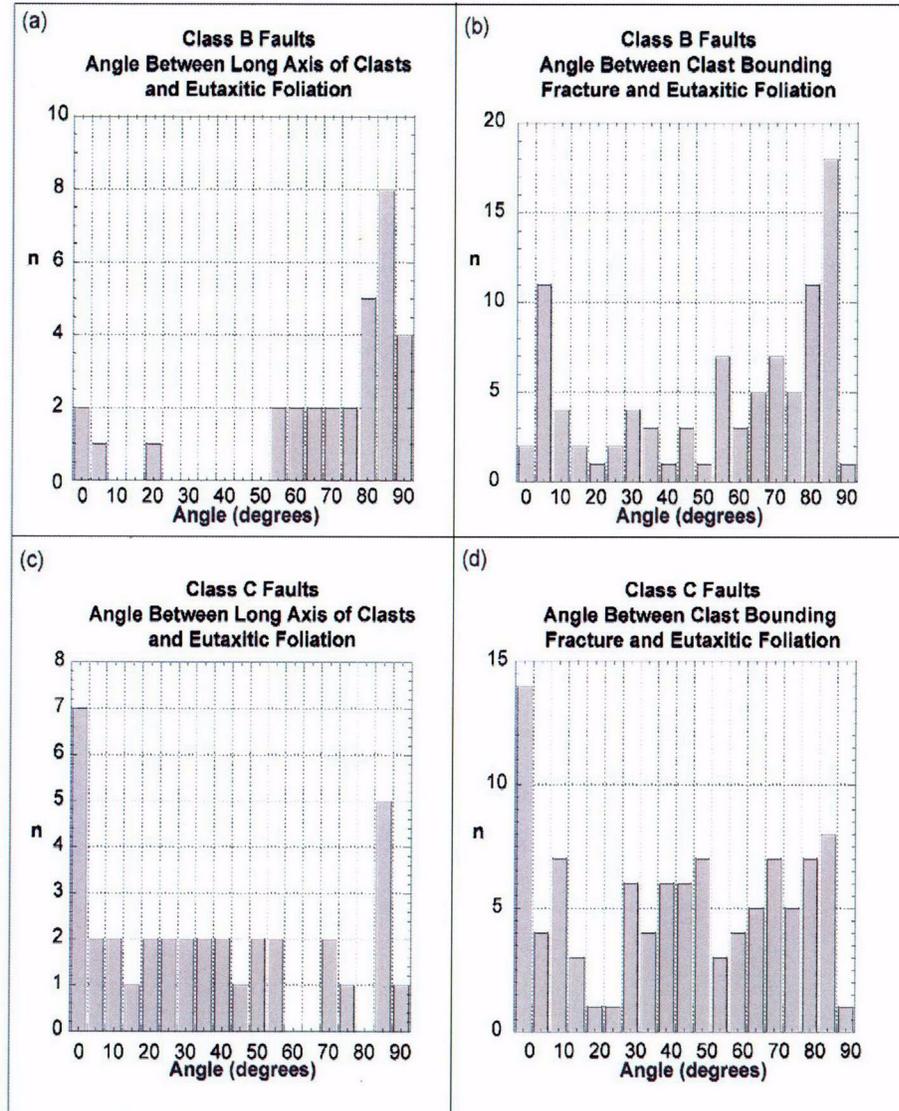
Calcite Matrix from Class B Fault Zone



**Calcite
Deformation
Twins**



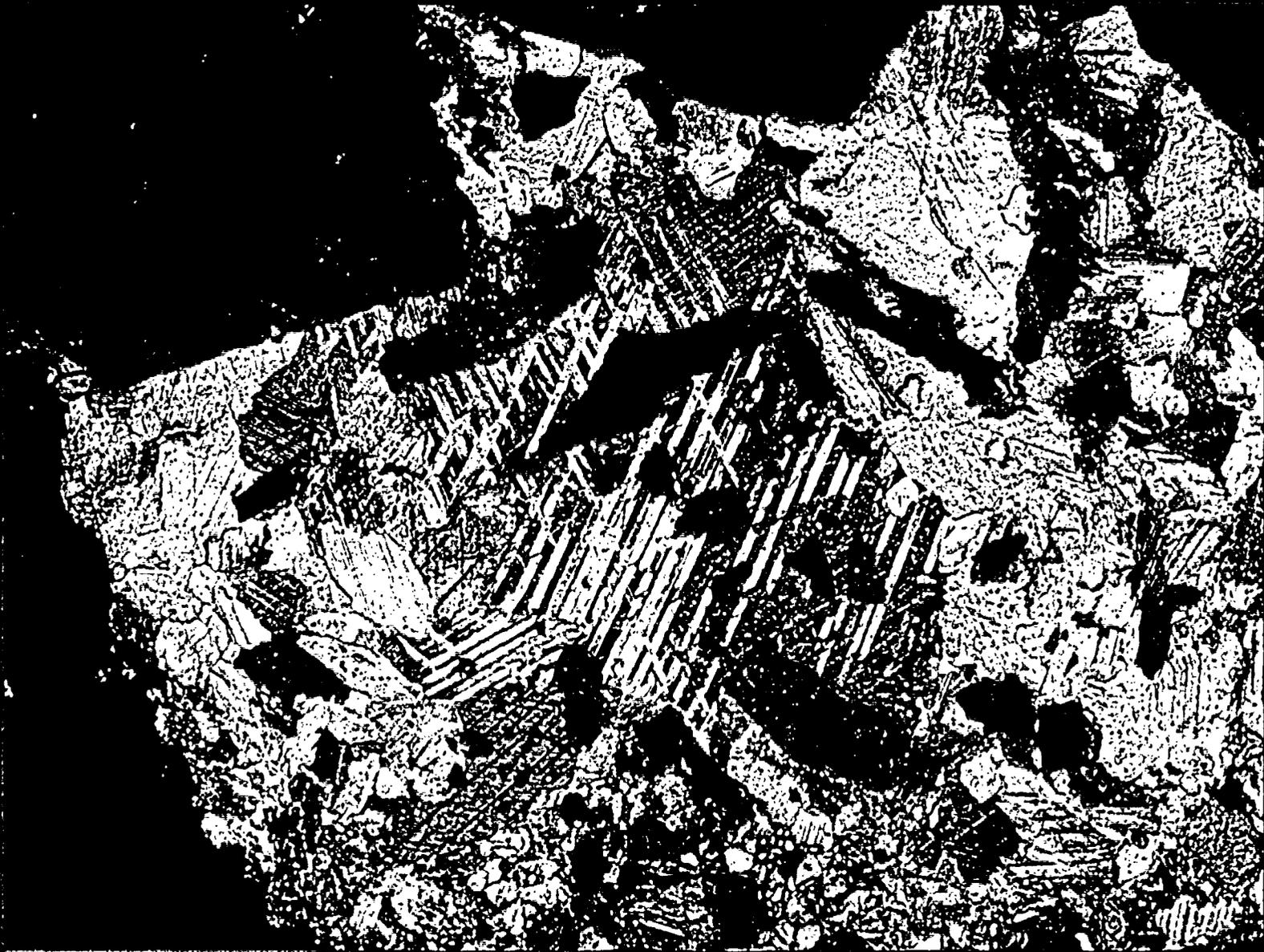
Clast Geometries



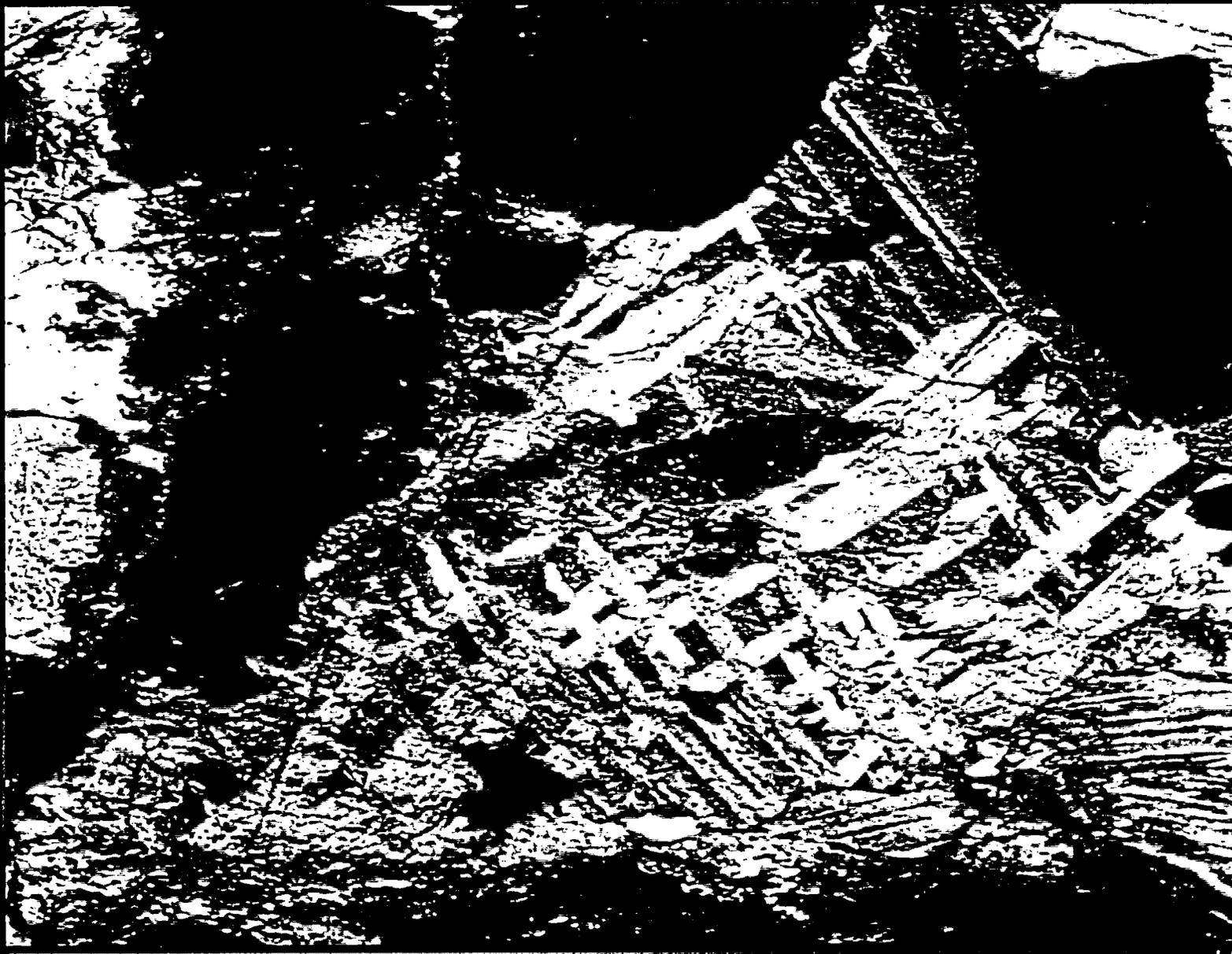
Deformed Calcite Crystal



Thick Twins in Calcite Matrix Crystal



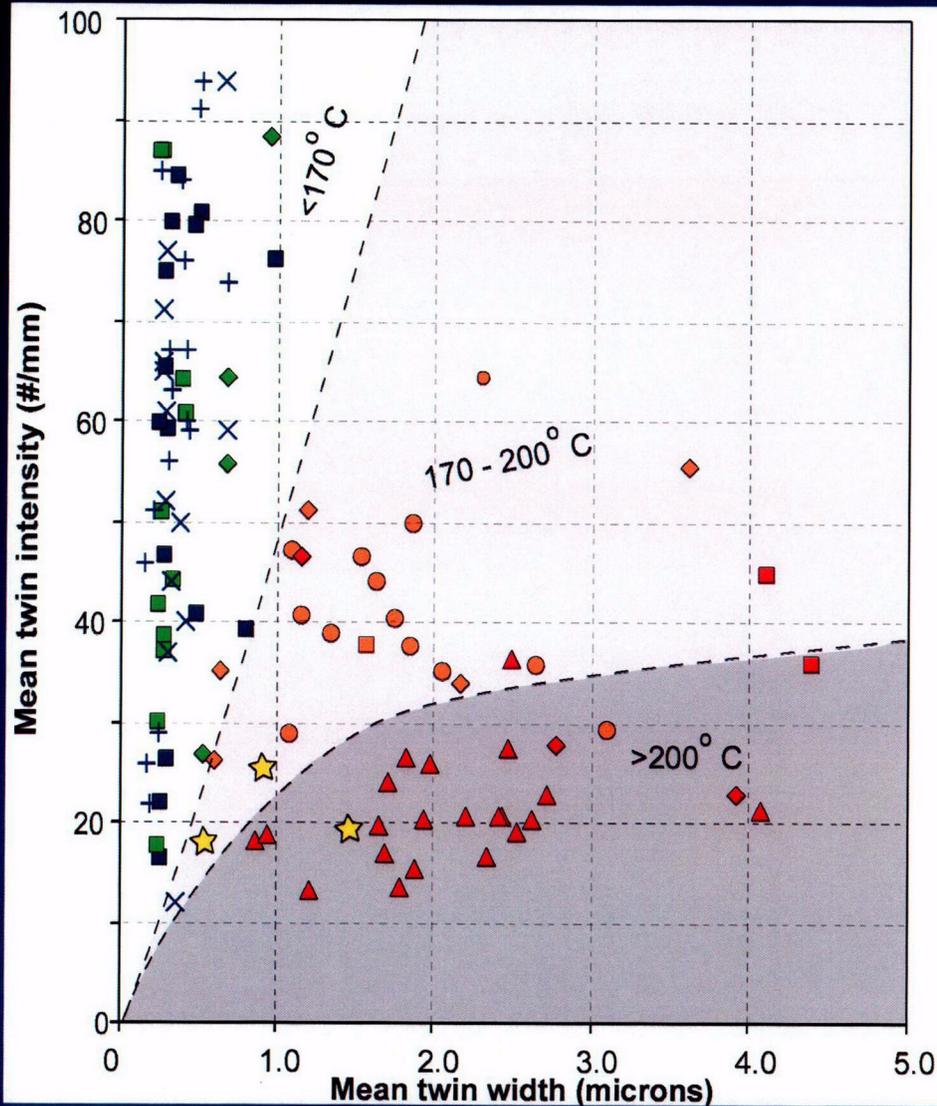
Thick Twins in Calcite Matrix Crystal



Post-Kinematic Vein



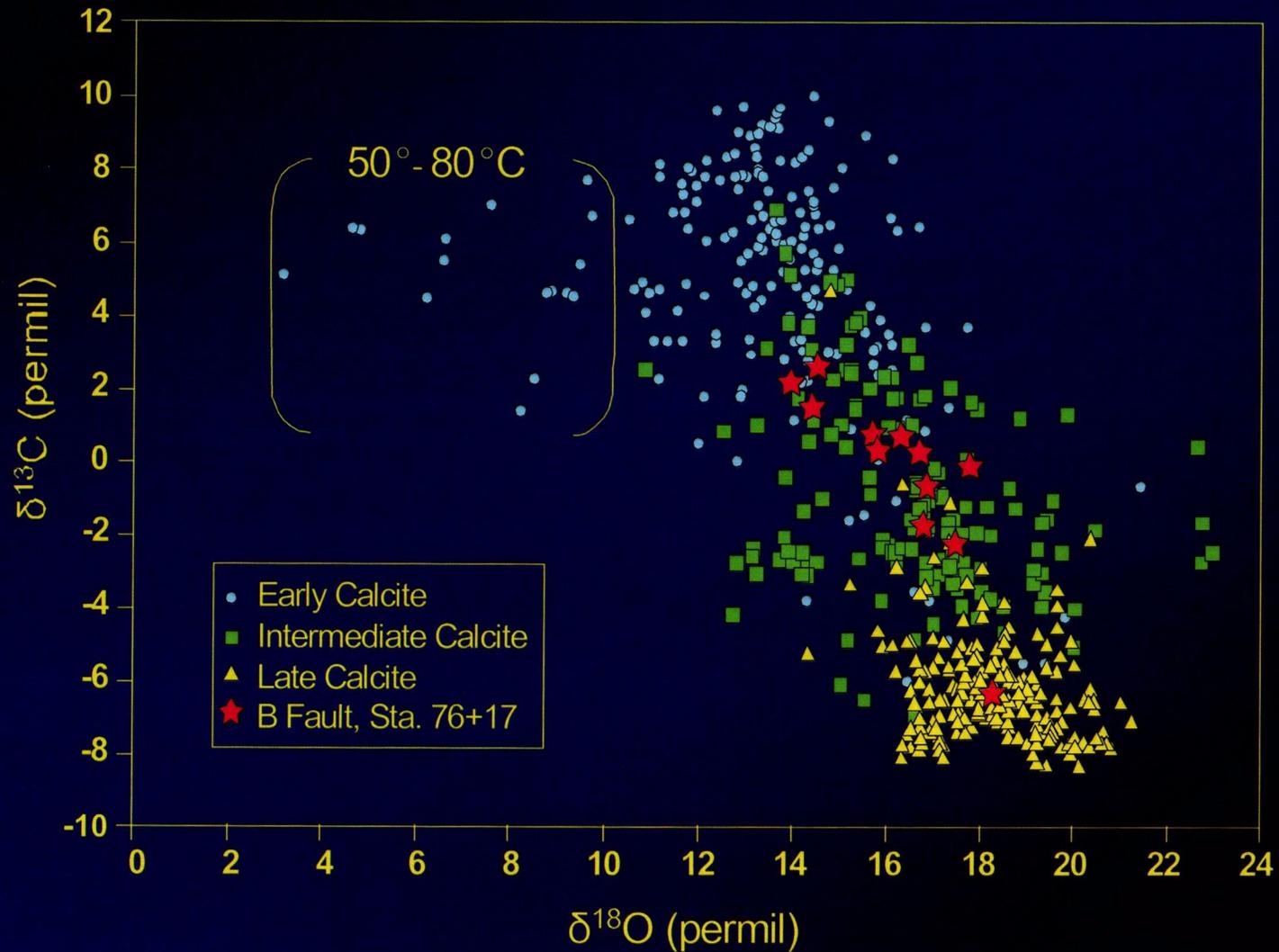
Temperature Conditions of Deformation



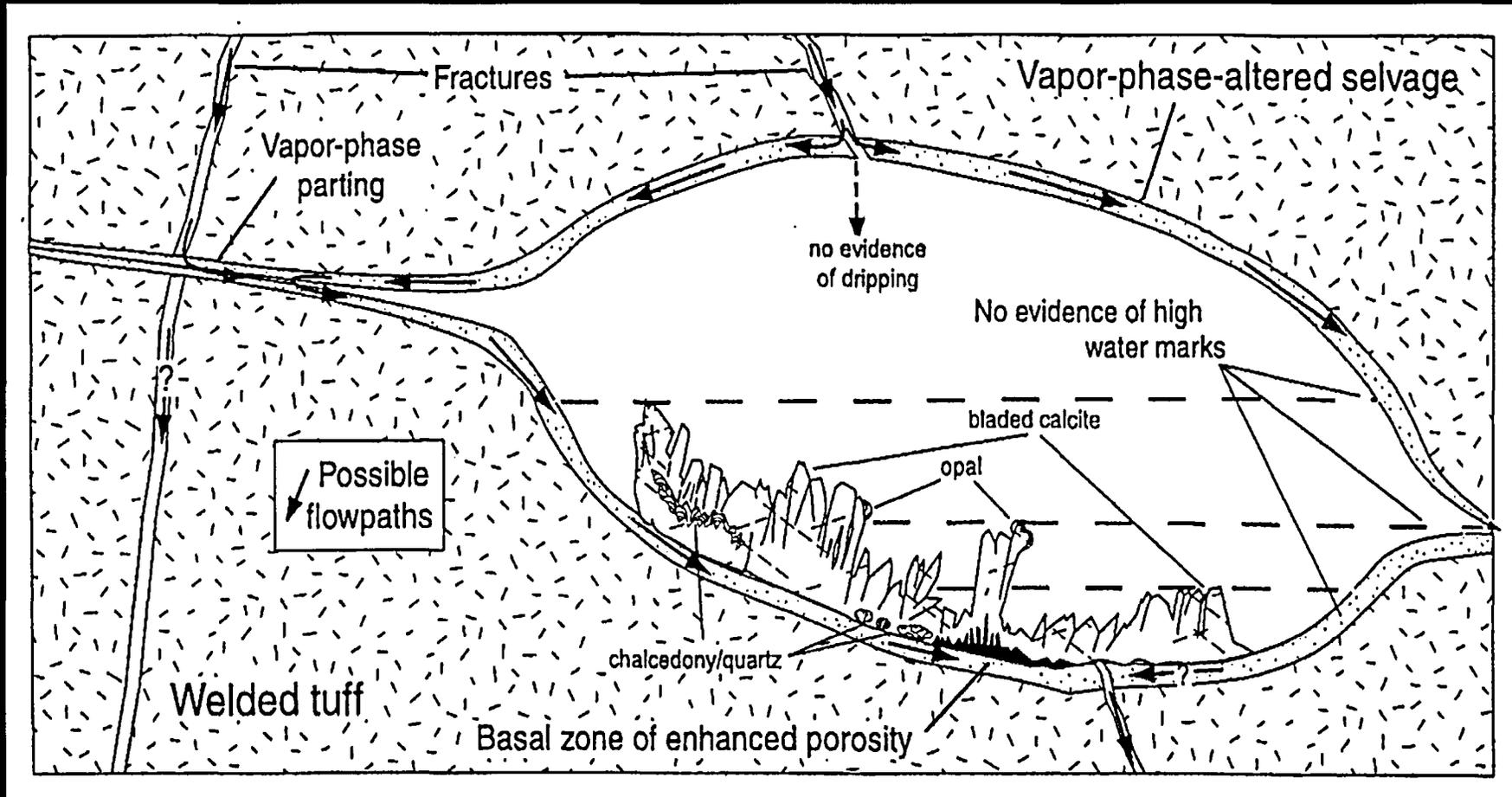
KEY

- ◆ Groshong et al., 1984; $70 - 180^{\circ}\text{C}$
- ◇ Groshong et al., 1984; $160 - 250^{\circ}\text{C}$
- ◆ Groshong et al., 1984; $250 - 300^{\circ}\text{C}$
- Ferrill 1991; Ferrill & Groshong 1993 a,b; $<90 - 125^{\circ}\text{C}$
- Ferrill 1991; Ferrill & Groshong 1993 a,b; $90 - 170^{\circ}\text{C}$
- Ferrill 1991; Ferrill & Groshong 1993 a,b; $150 - 190^{\circ}\text{C}$
- Ferrill 1991; Ferrill & Groshong 1993 ab; $190 - 300^{\circ}\text{C}$
- ▲ Evans & Dunne 1991, unpublished data; $250 - 350^{\circ}\text{C}$
- Onasch unpublished data; $\sim 200^{\circ}\text{C}$
- + Smart et al., 1997; < 3 km burial
- × Spraggins and Dunne 2002; < 3 km burial
- ★ Type B faults at Yucca Mountain

Oxygen and Carbon Isotopes (From the USGS, Yucca Mountain Project)



Saturated or Unsaturated Conditions?



(Whelan et al., 2002)

Conclusions

- Classes A, C, and D can be genetically linked (a breccia-cataclasite-gouge progression with increased fault displacement) and are generally not associated with abundant calcite mineralization.
- Class B fault zones are heavily mineralized with calcite and appear to be unrelated to other faults at Yucca Mountain.

Conclusions

- Class B fault zones have distinctive mineralization histories when compared to other faults, lithophysae, or fractures.
- Class B fault zones are dilational and calcite mineralization accompanied and assisted fault displacement in a fluid saturated environment.
- Mechanical twins suggest faulting occurred at > 170 °C.
- The age of Class B fault zones remains unknown.