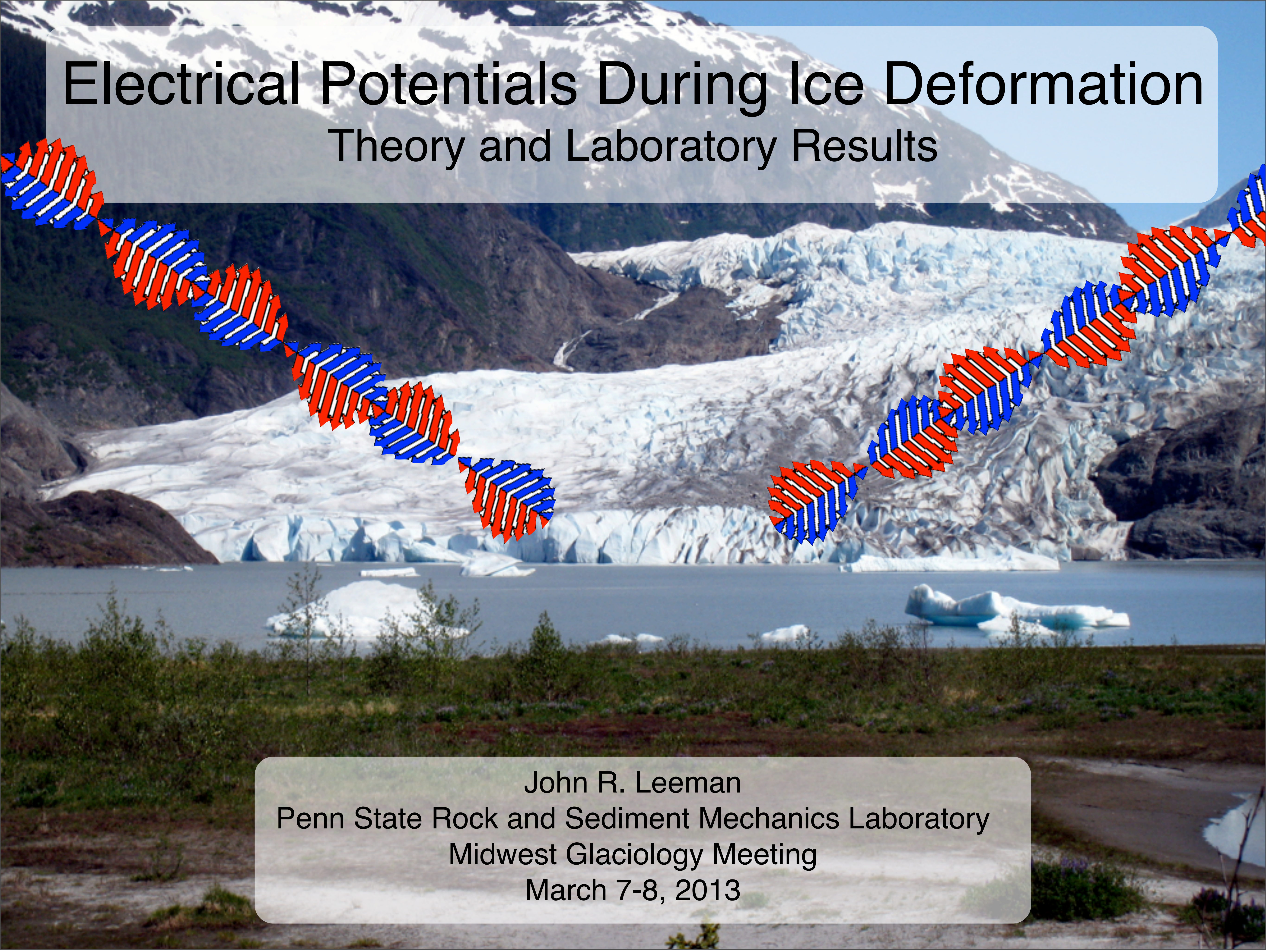
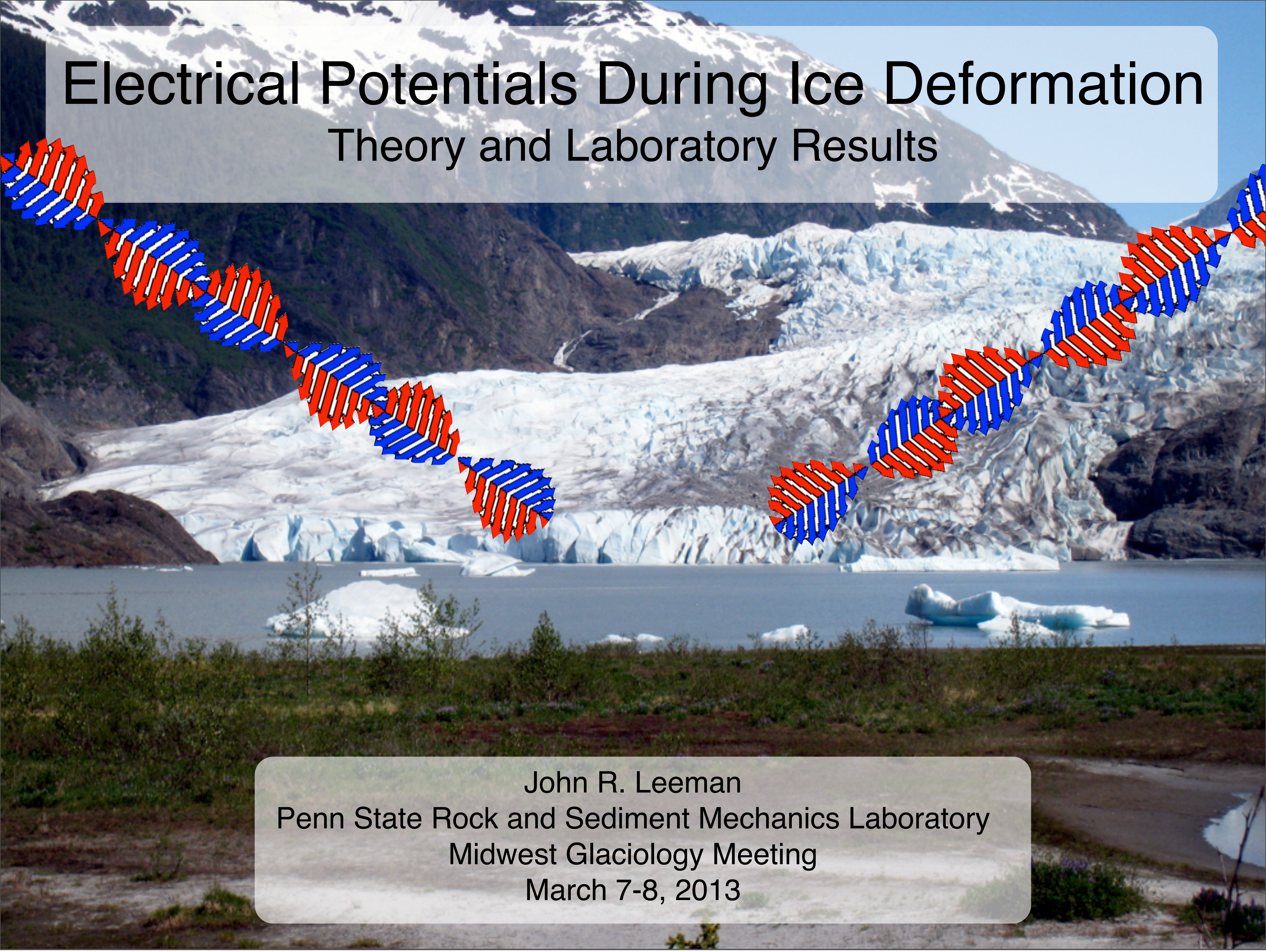
Electrical Potentials During Ice Deformation

Theory and Laboratory Results



John R. Leeman
Penn State Rock and Sediment Mechanics Laboratory
Midwest Glaciology Meeting
March 7-8, 2013



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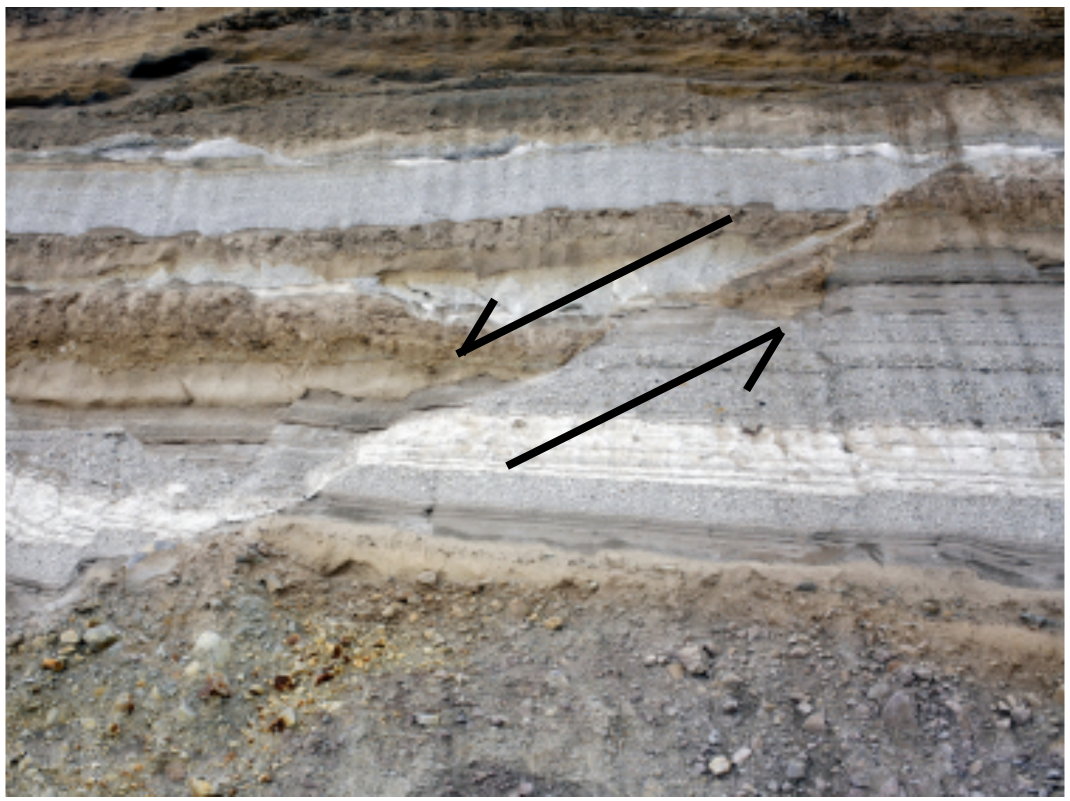
The Day Job:

Could Faults be Natural Transmitters?



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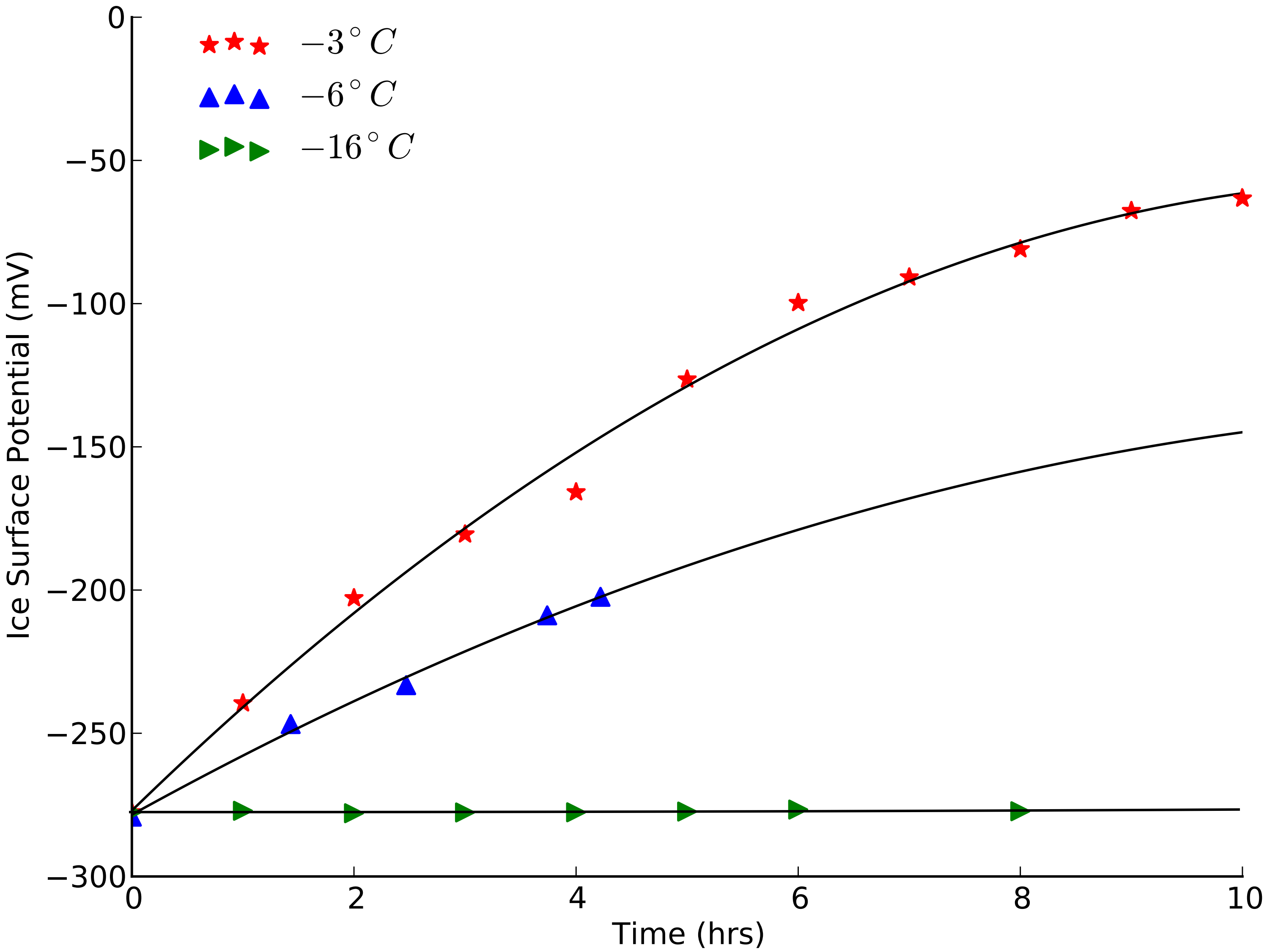
Other materials have electrical anomalies during deformation and failure... could ice?

Could this inform laboratory or field experiments?

Early Experiments



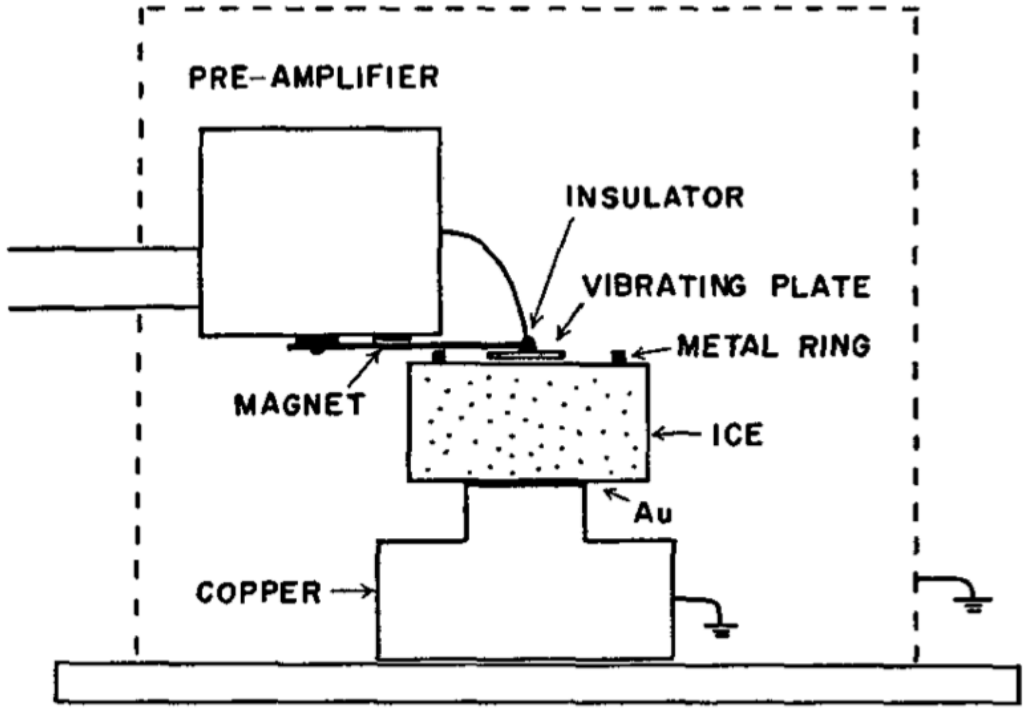
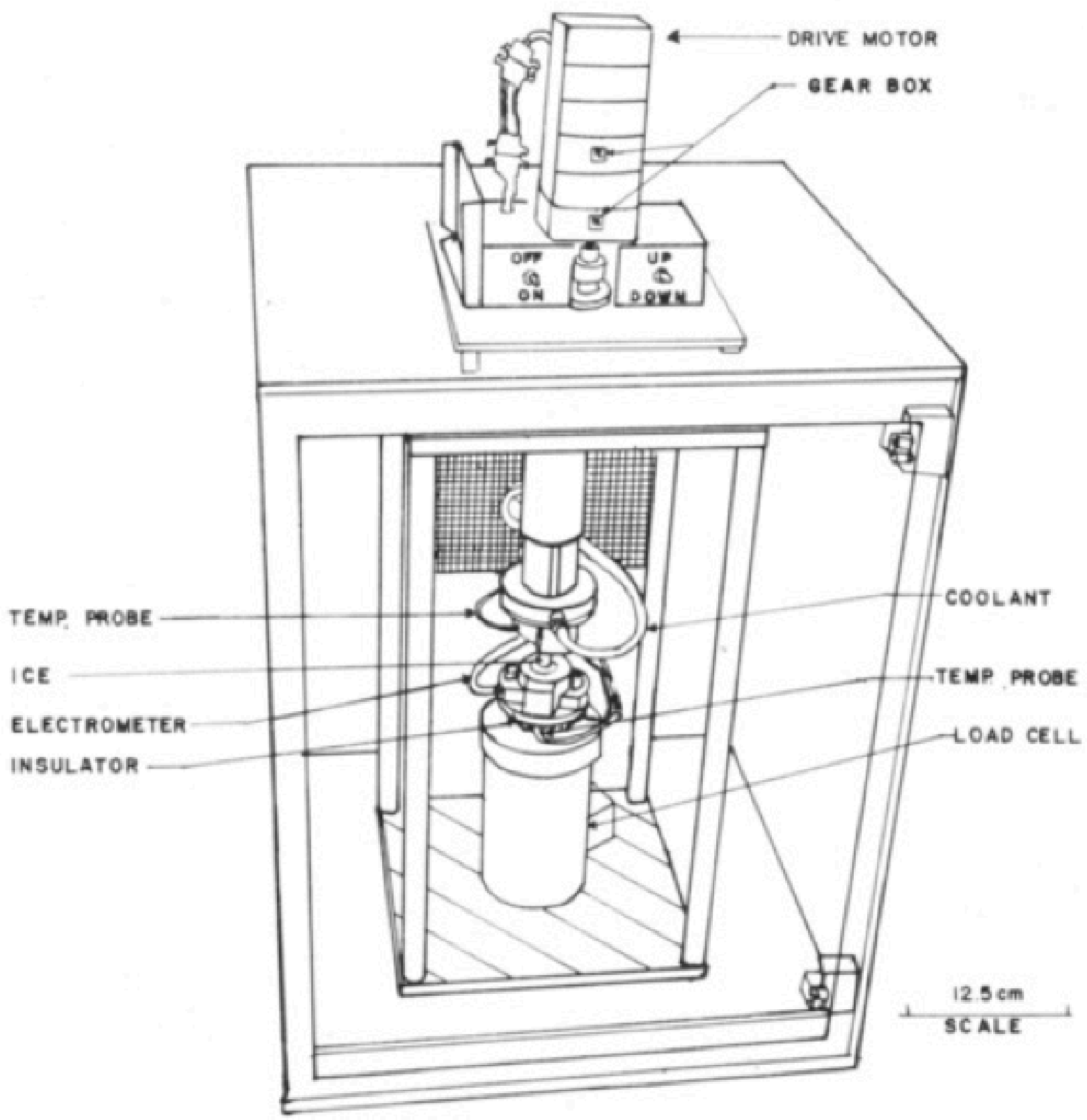
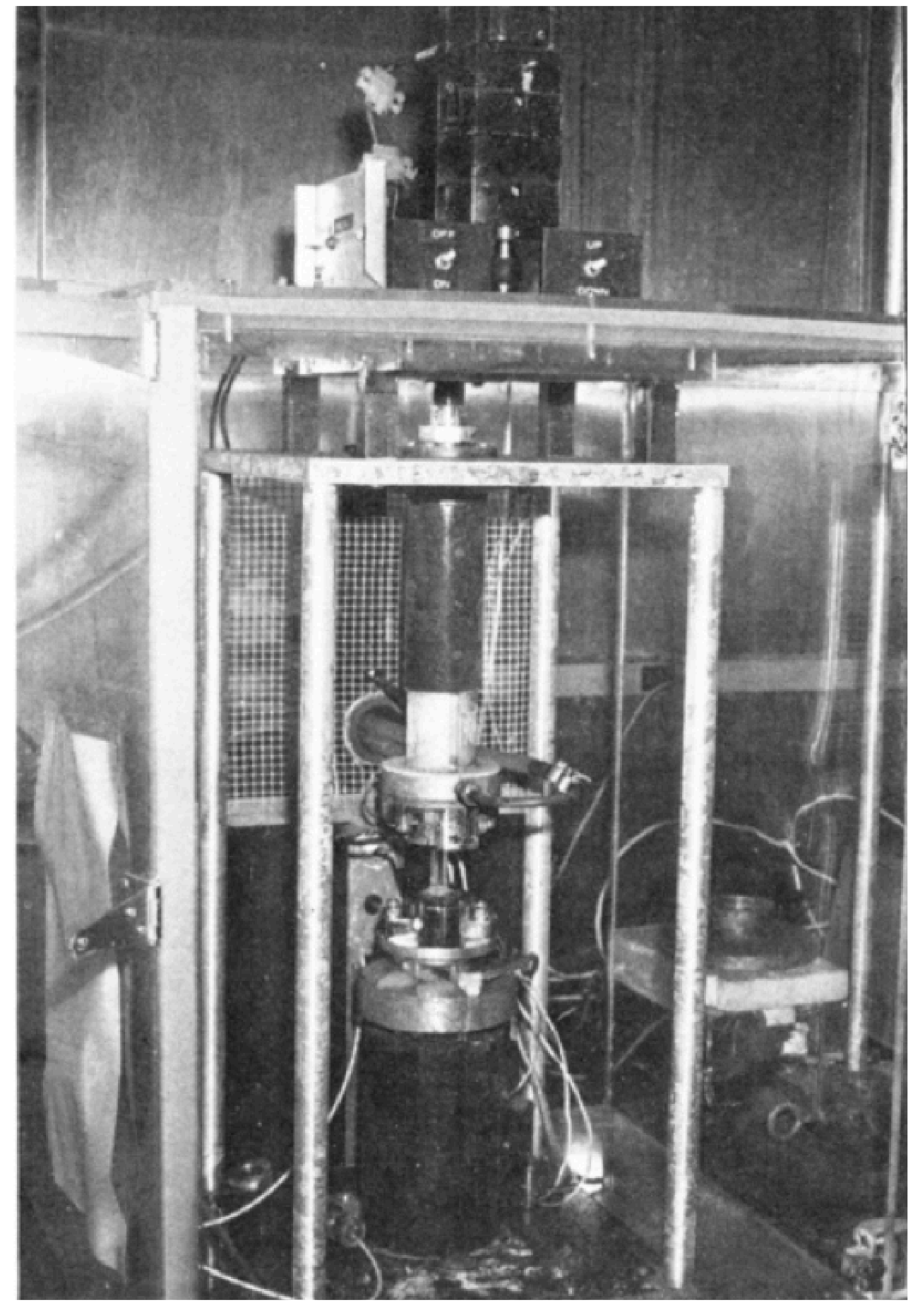


FIG. 1. Experimental apparatus for measuring the electric potential of a crystal ice surface.

Takahashi (1969)

Early Experiments





Takahashi (1983)

Theory of Charge Separation

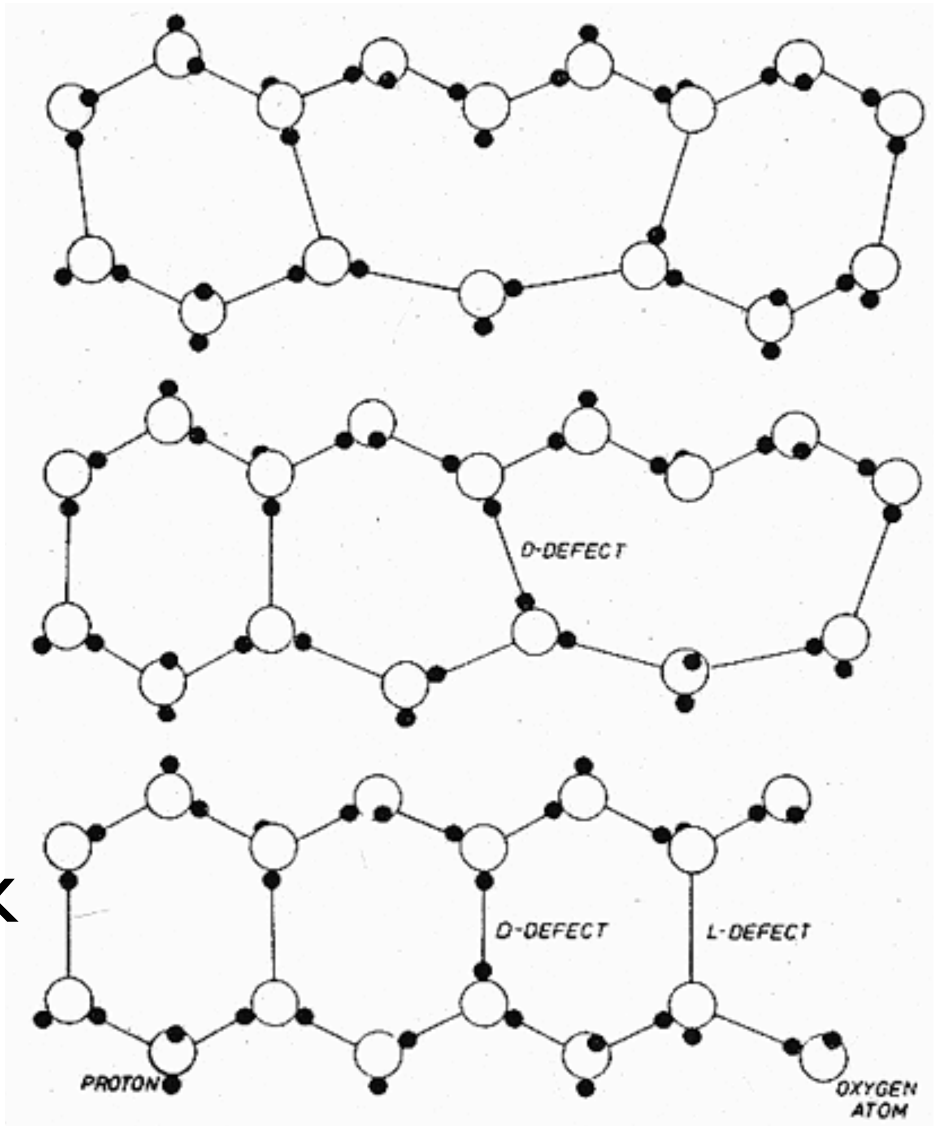
1) Dislocations accommodate strain

2) A pair of defects (L and D) are produced

3) Moving dislocations are negatively charged, dislocations repel each other

4) Dislocations reach surface, protons released, negative charge diffuses into bulk

5) Protons diffuse along thermal gradient faster than OH^{-1}



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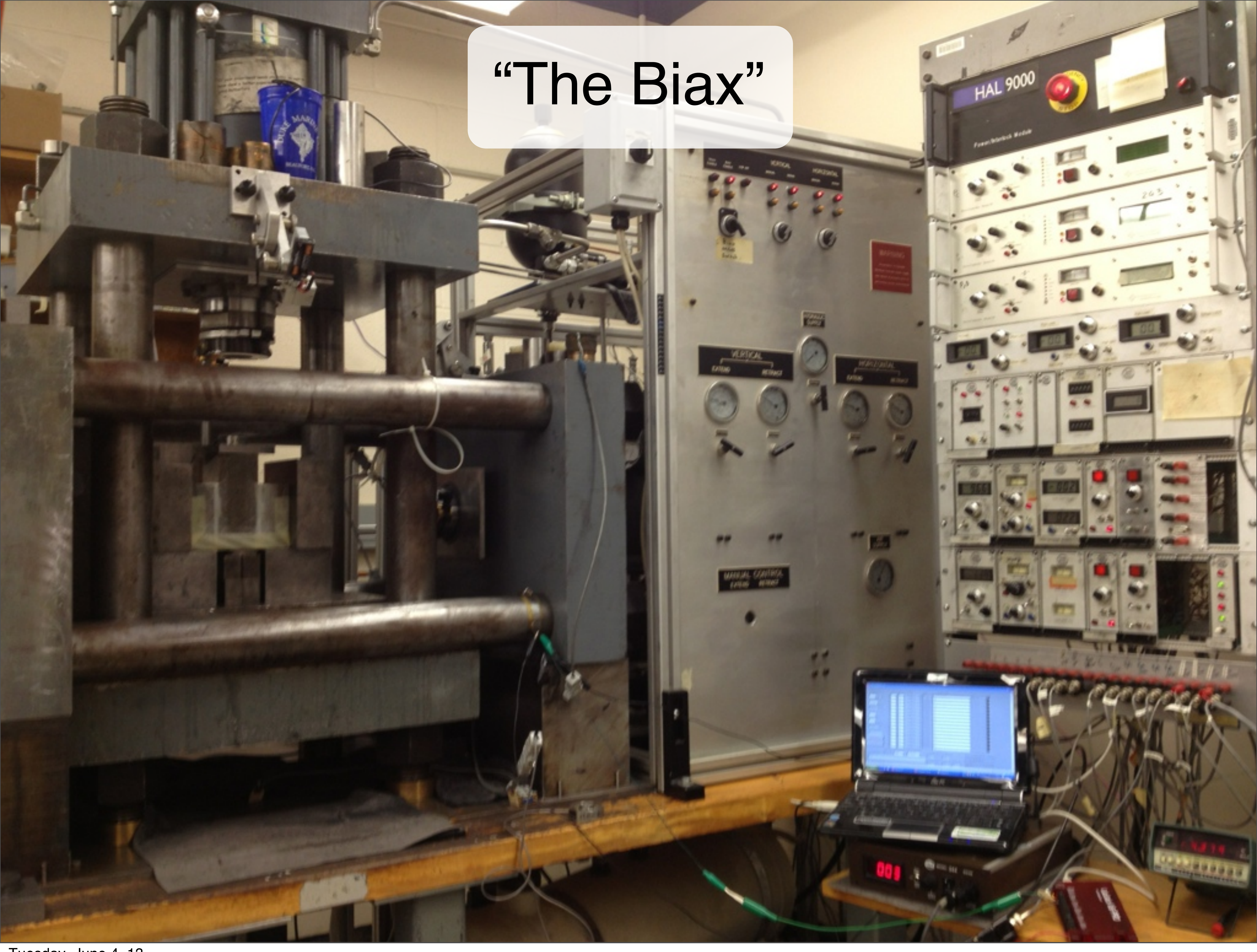
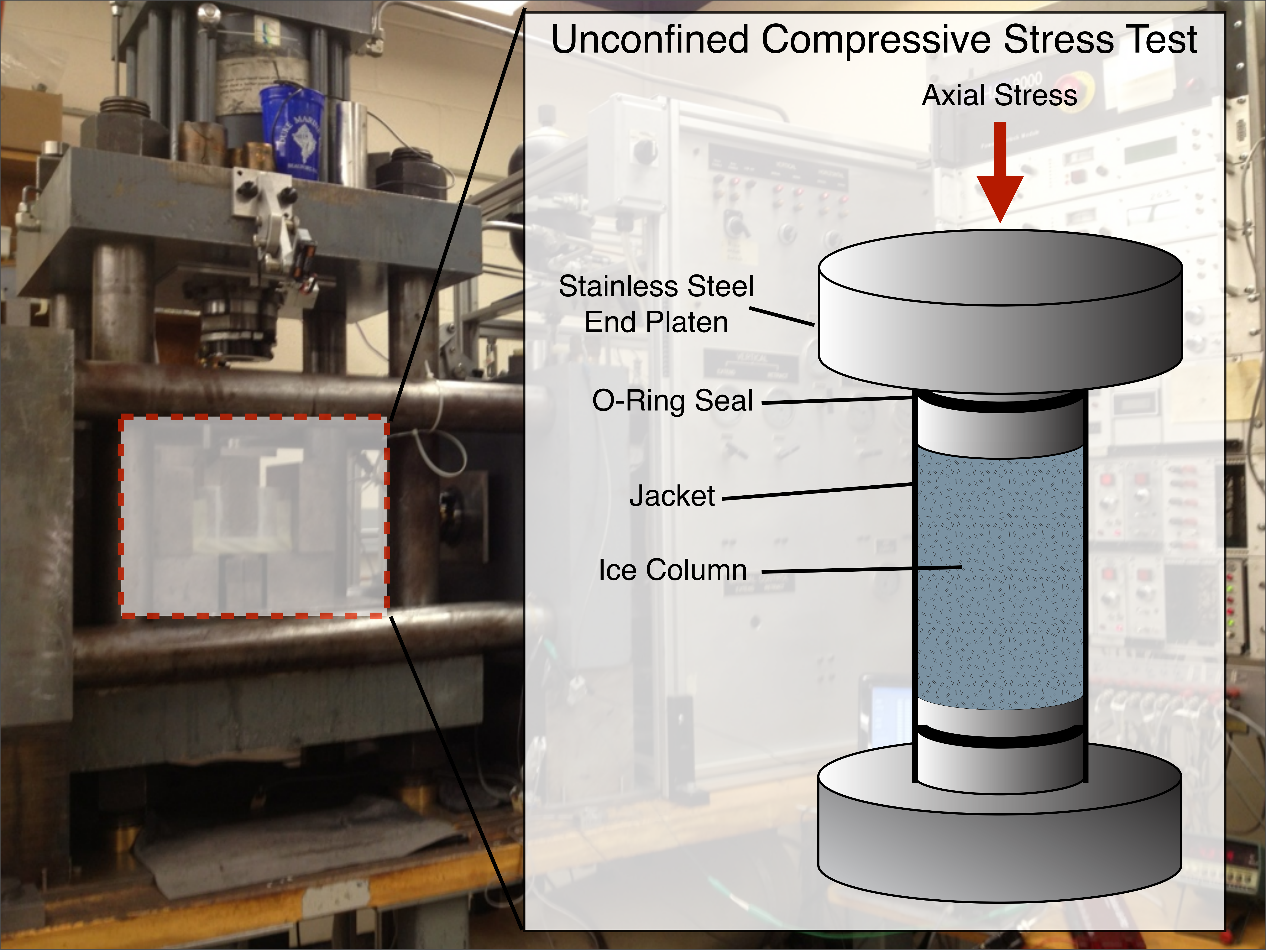
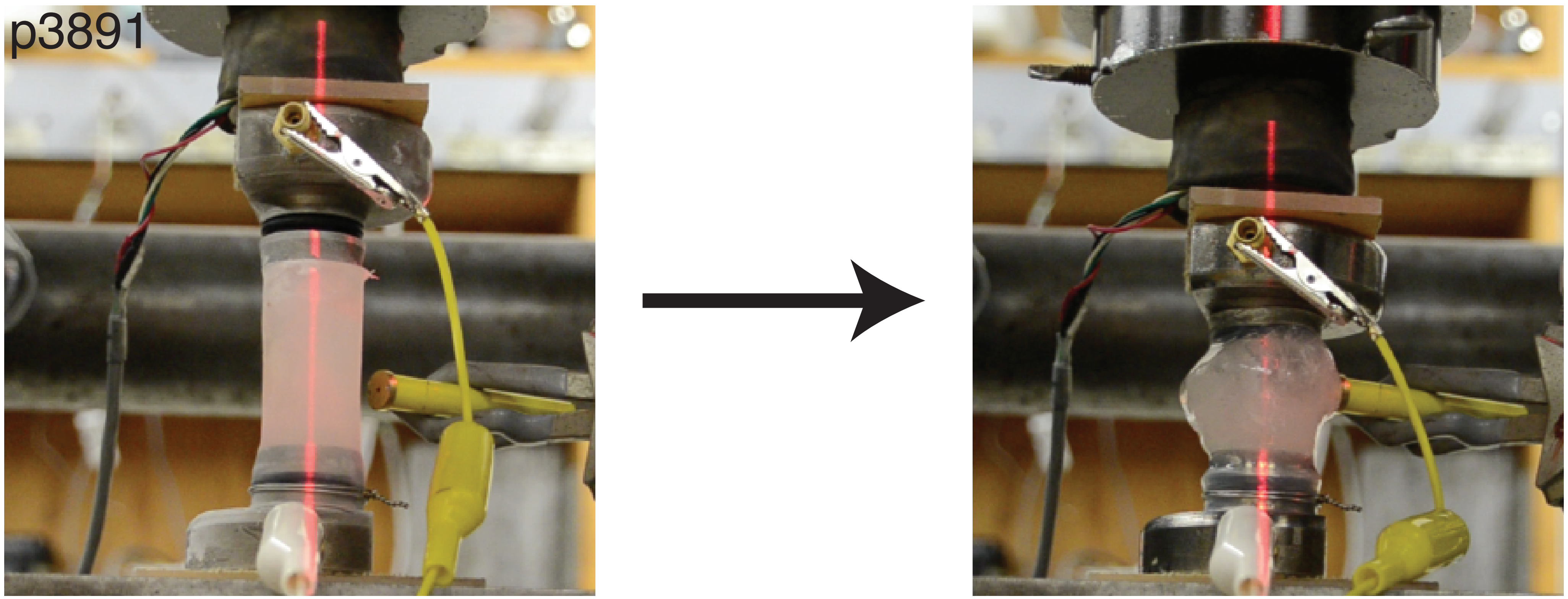
“The Biax”



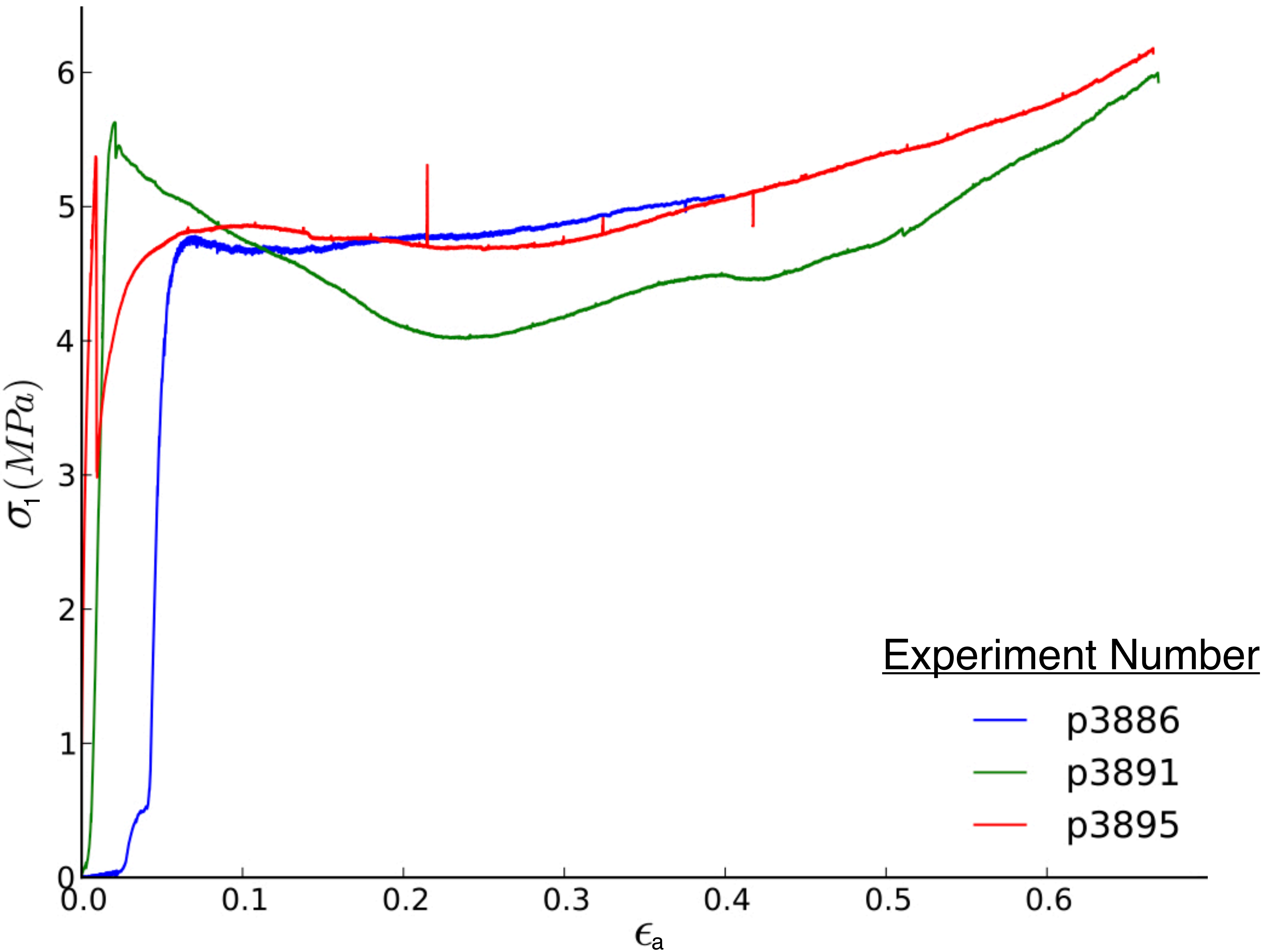

Unconfined Compressive Stress Test
Axial Stress
Stainless Steel
End Platen
O-Ring Seal
Jacket
Ice Column

Deformation Experiments

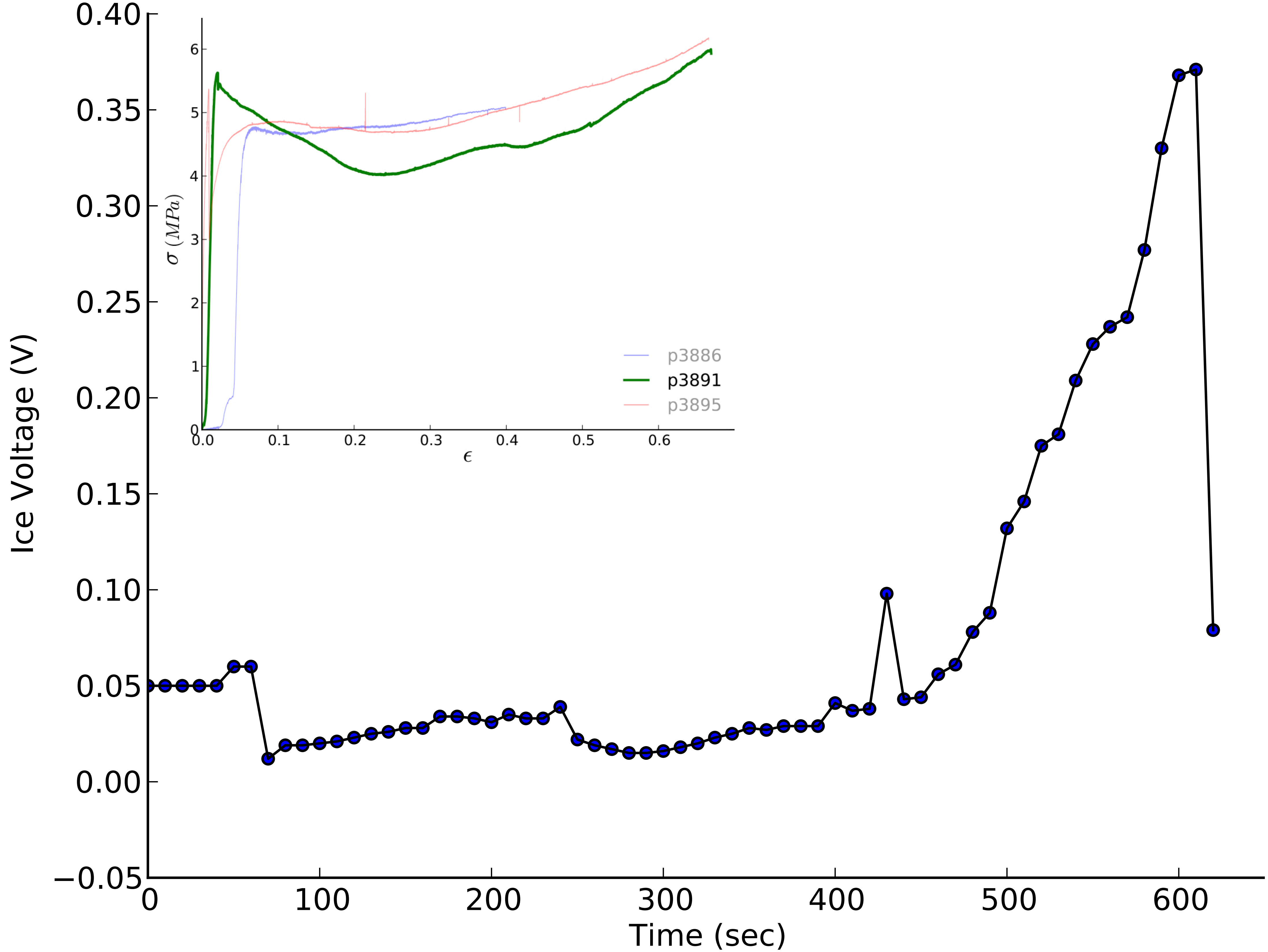


- Strains of 0.4-0.6
- Loading Rate of 100μm/s

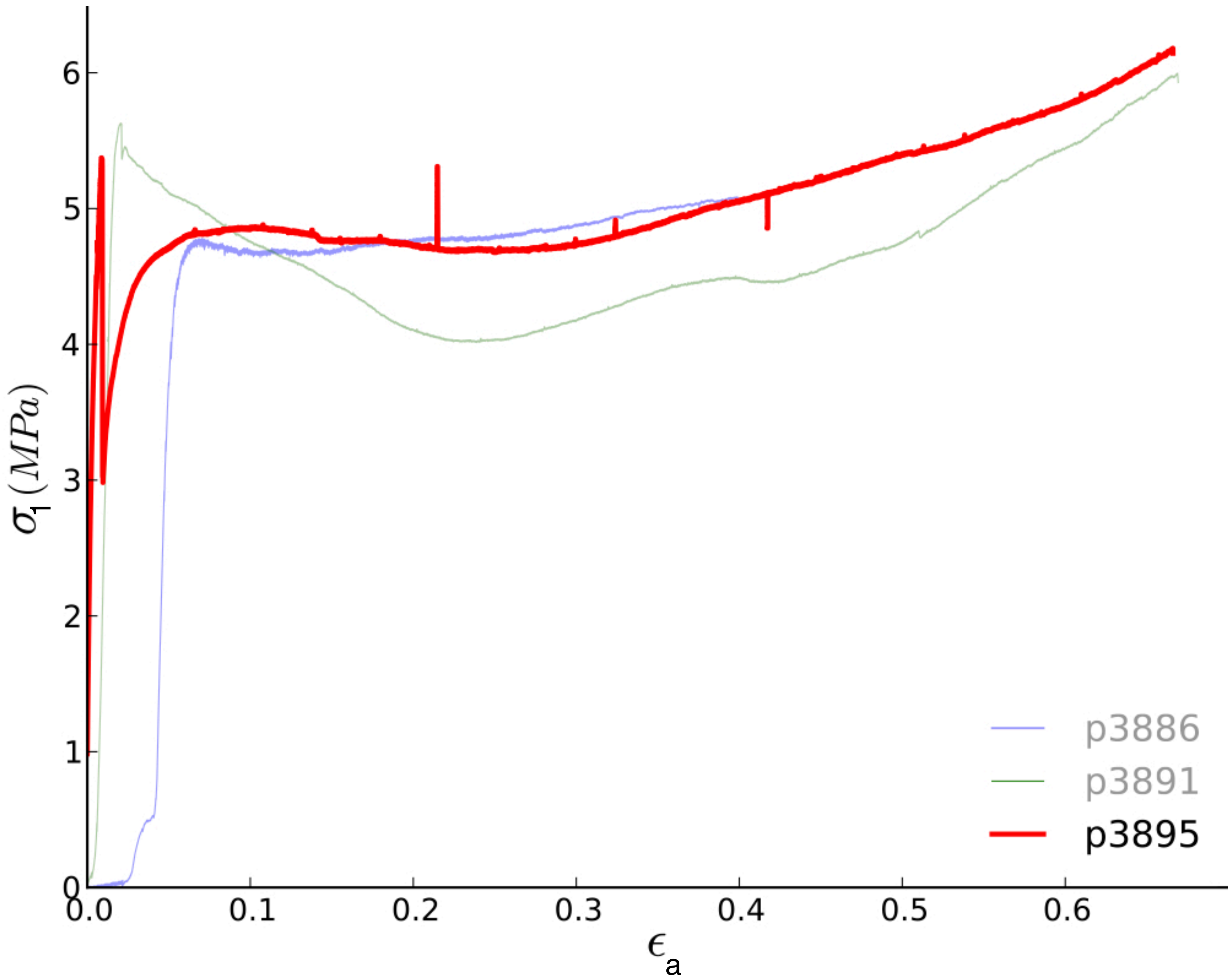
Mechanical Behavior is Consistent



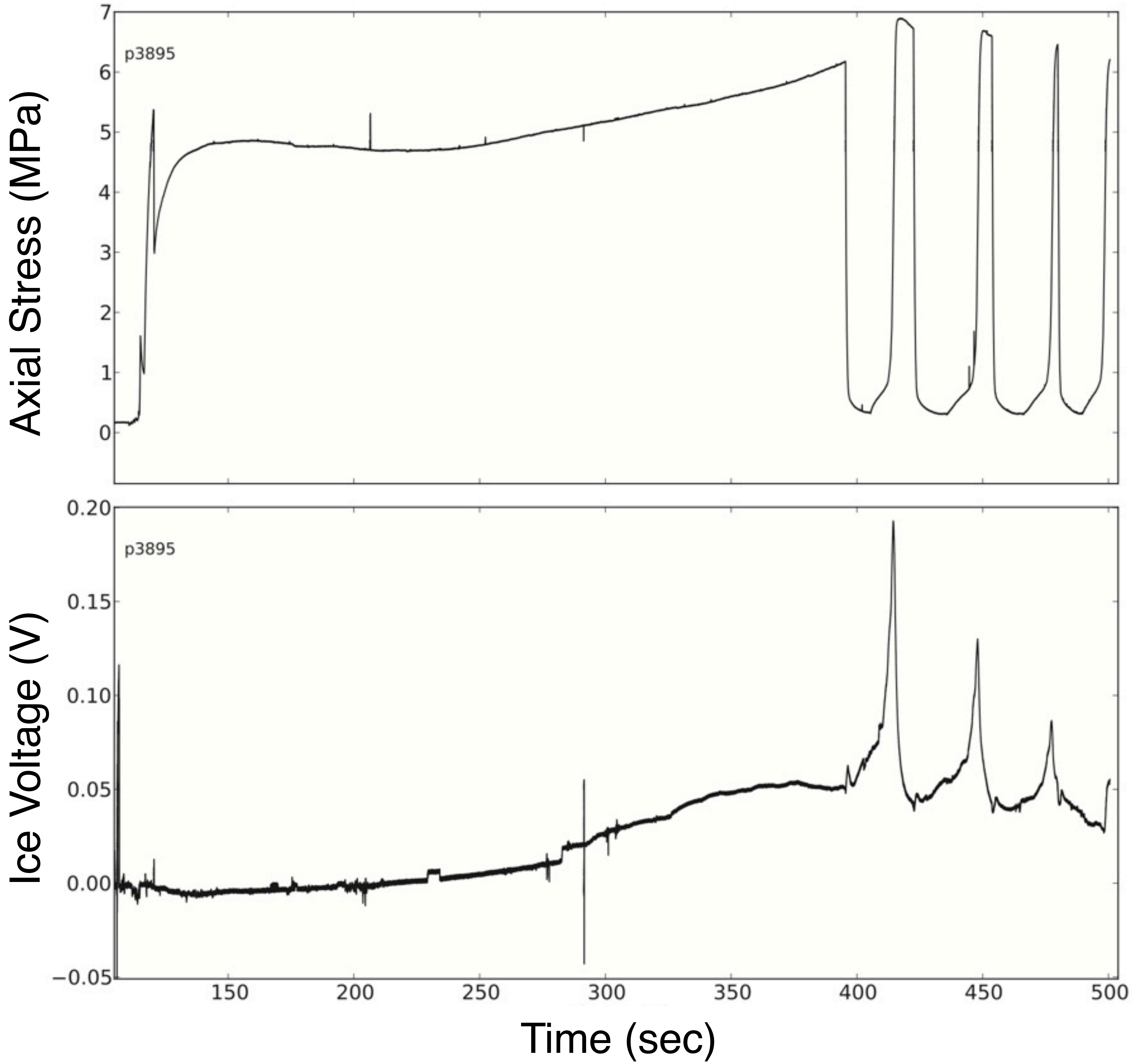
First Try: Voltage Observed During Loading



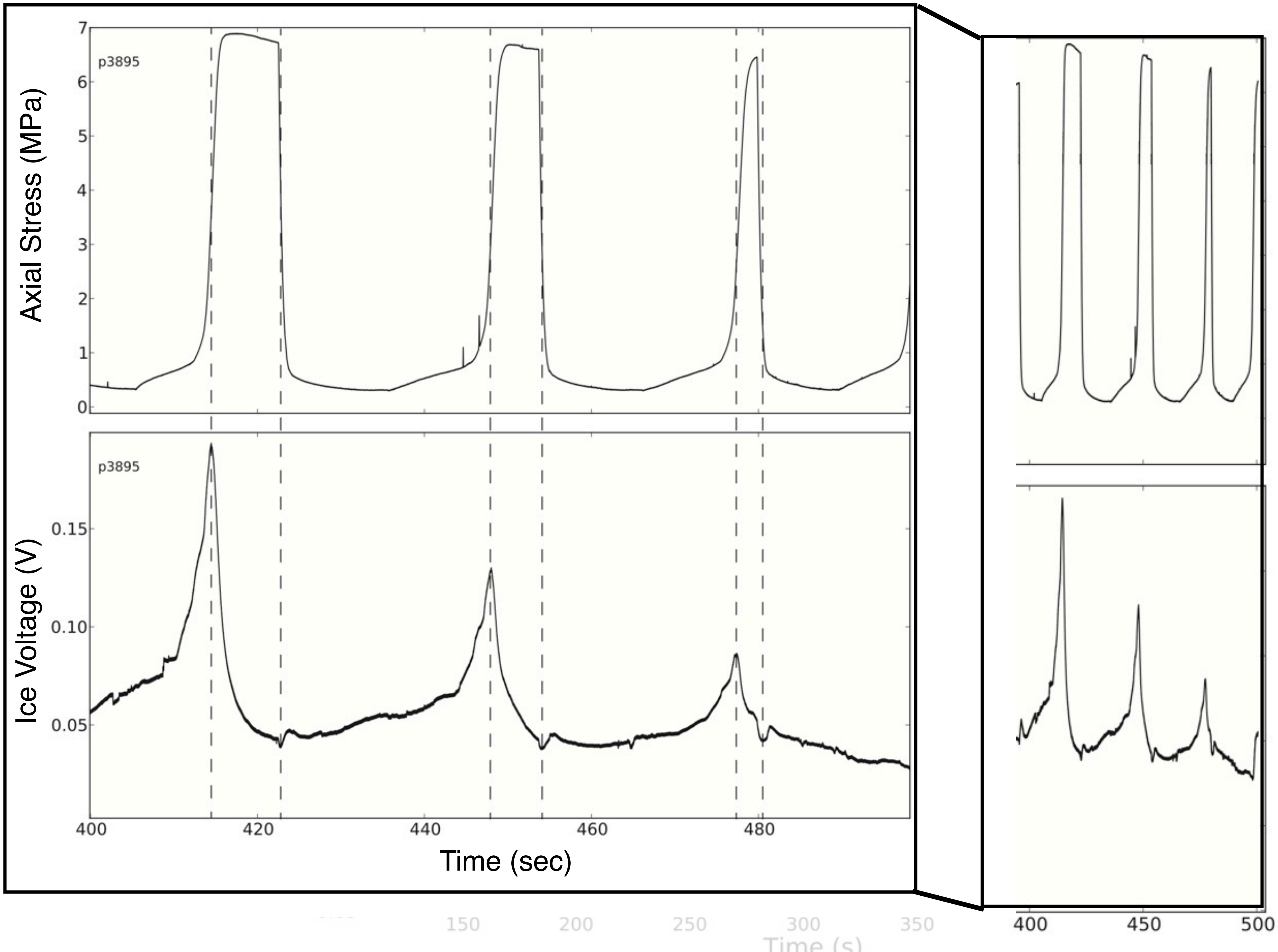
Experiment Two: Using a 24-bit ADC



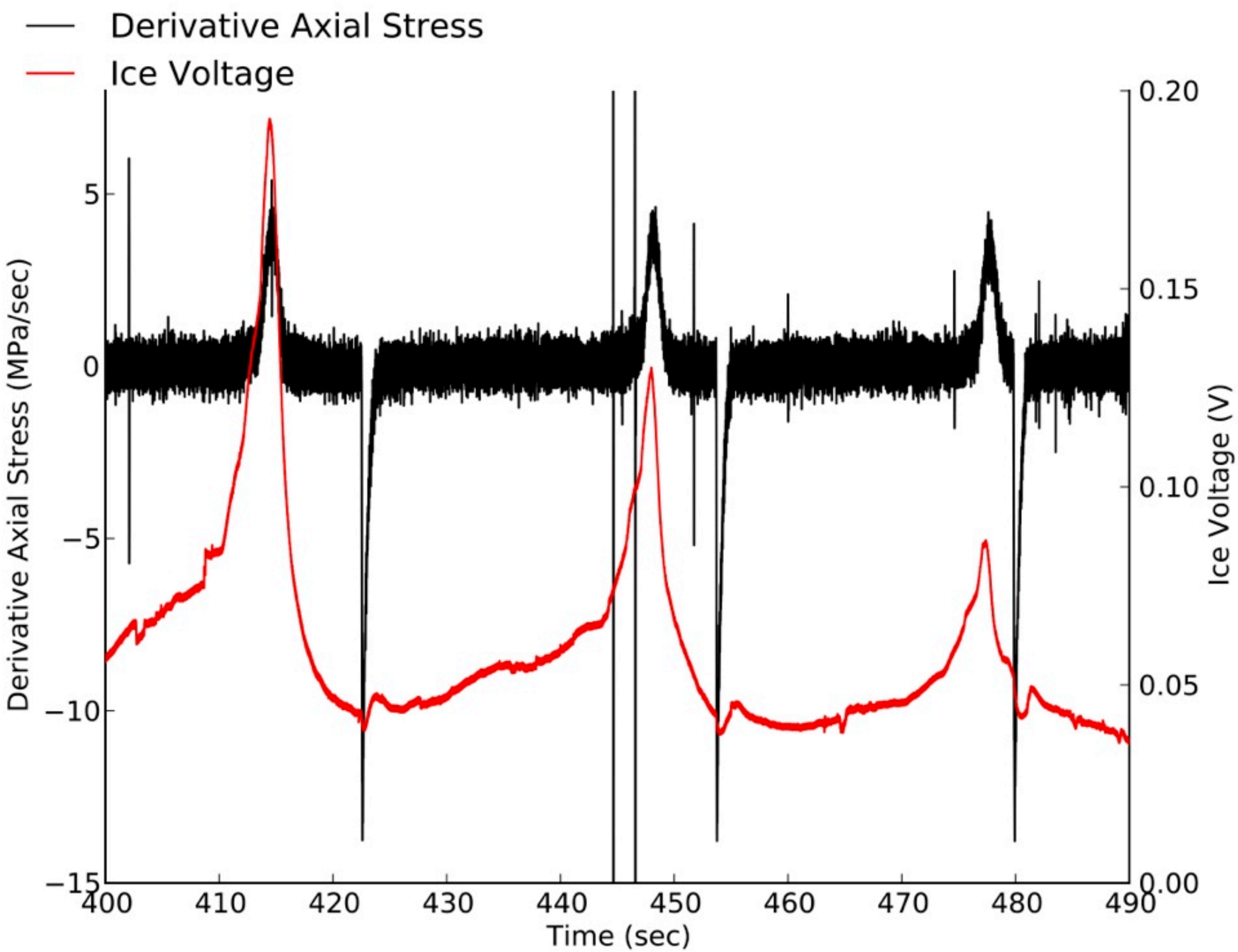
Loading and Load Cycling



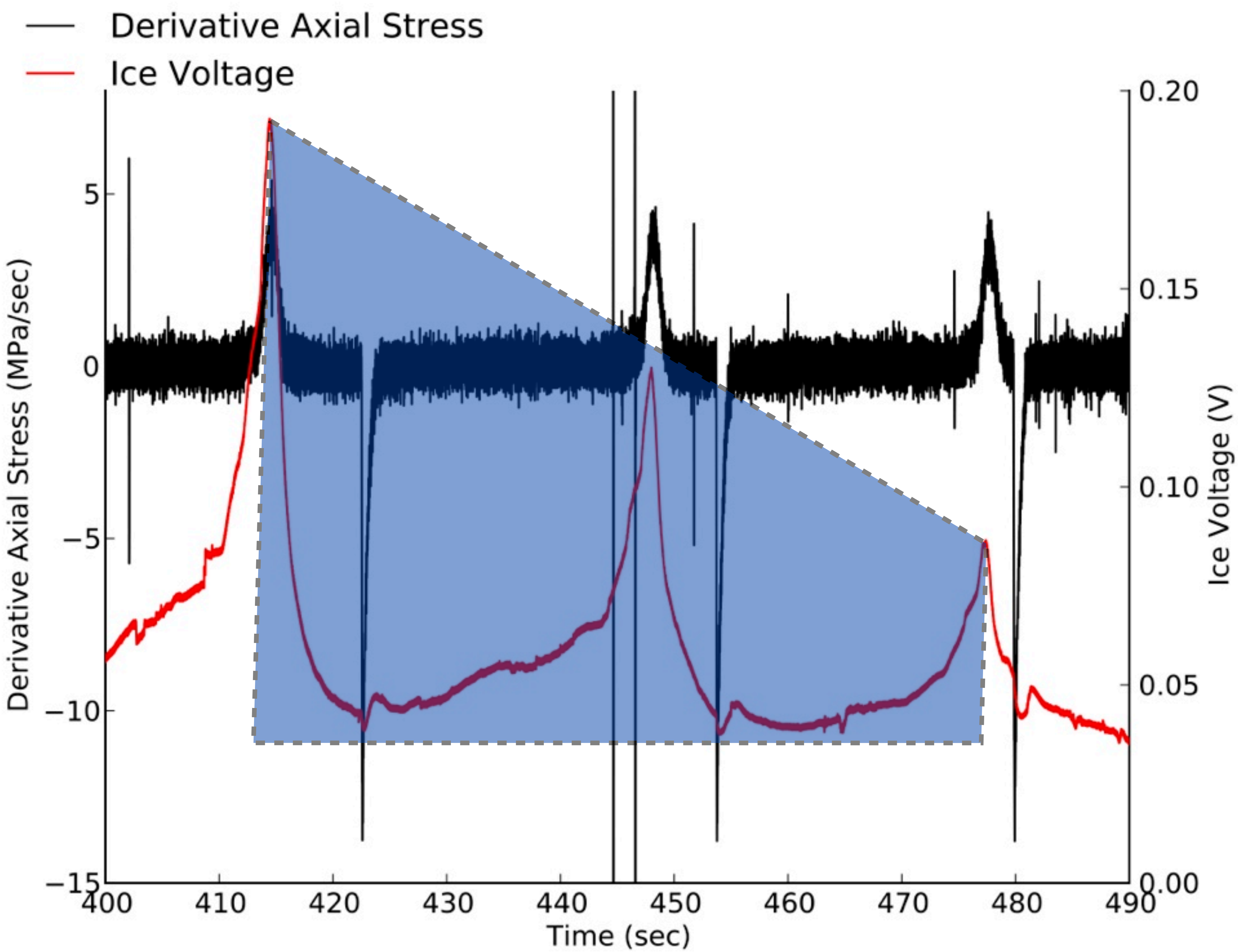
Loading and Load Cycling



Stress Change and Voltage



Stress Change and Voltage



Challenge: Protons vs. Electrons

“Conclusions”

- Electrical charge separation seems to be correlated with dislocation flux

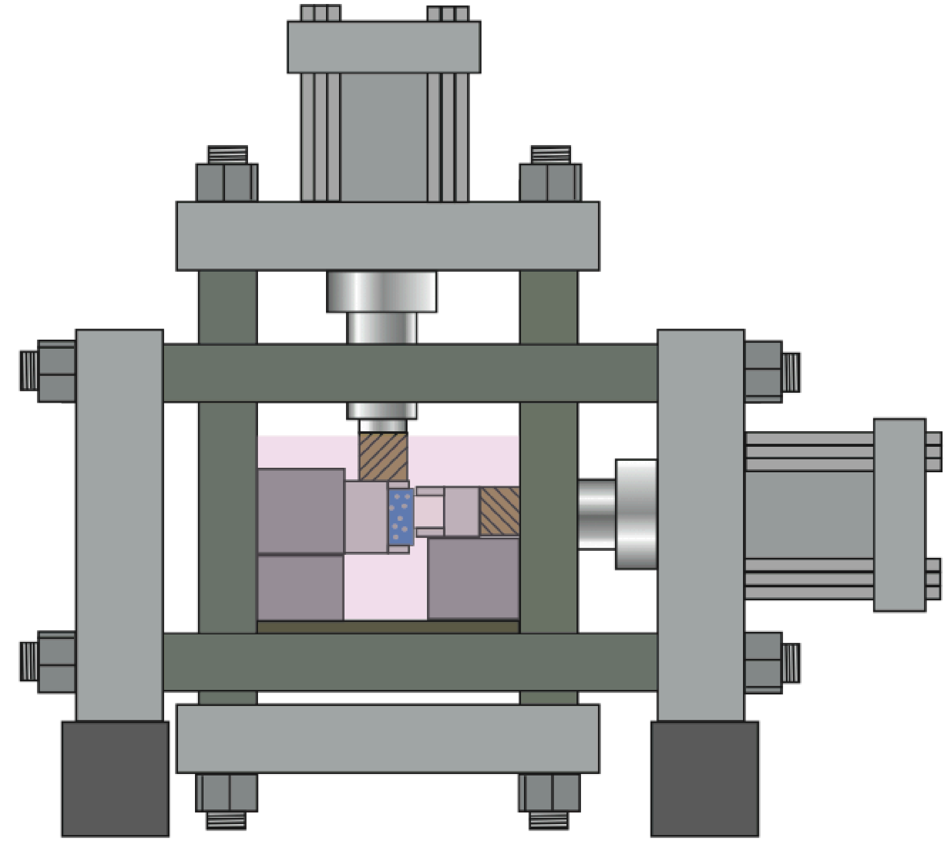
- Sample charge balance is rapidly compensated

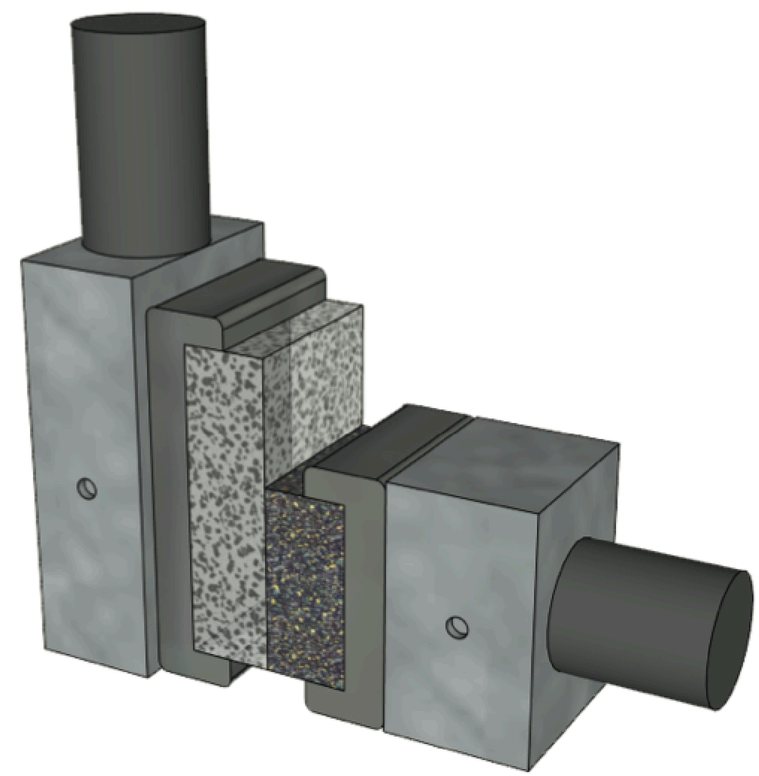
- Diffusion of protons influenced by temperature gradients

- New electrodes are needed to increase coupling

What's Next

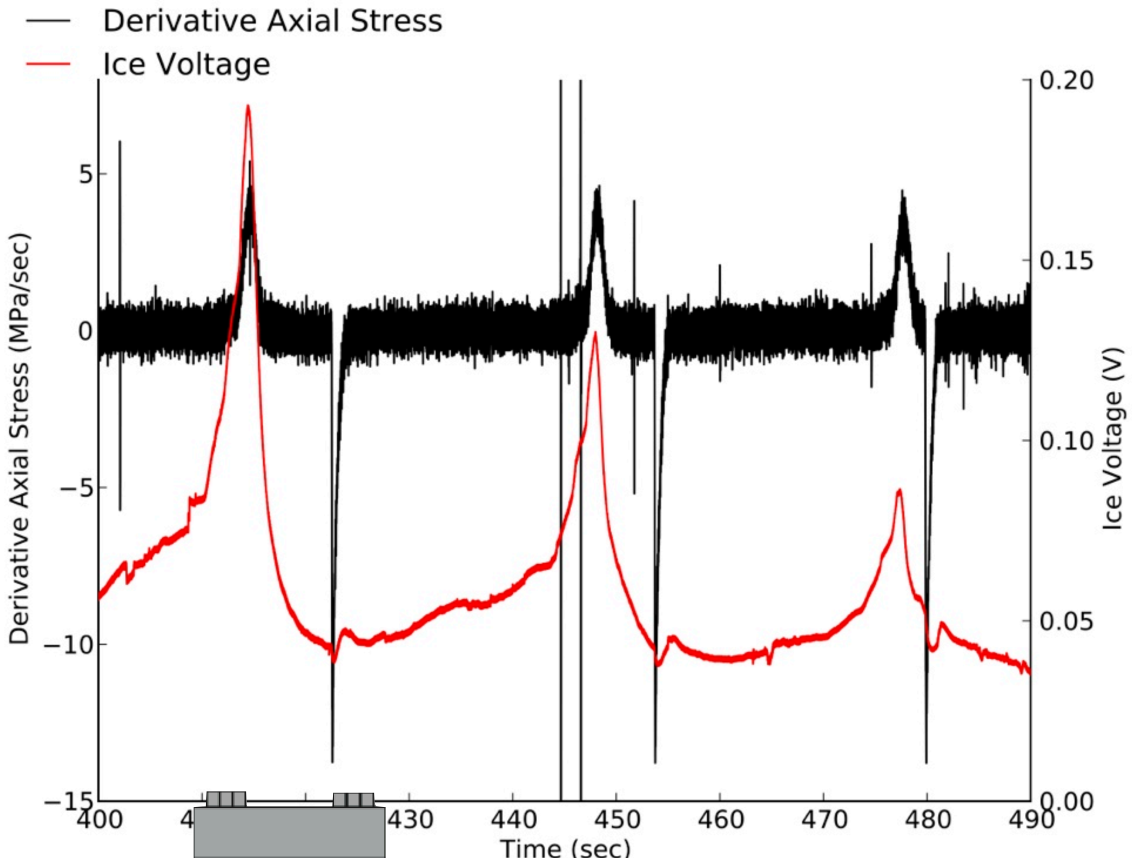
- Keep ice at PMP
- Use single crystal ice
- Test c-axis orientation
- Ice/rock friction
- Are there electrokinetic effects?
- Can this be applied in the field?

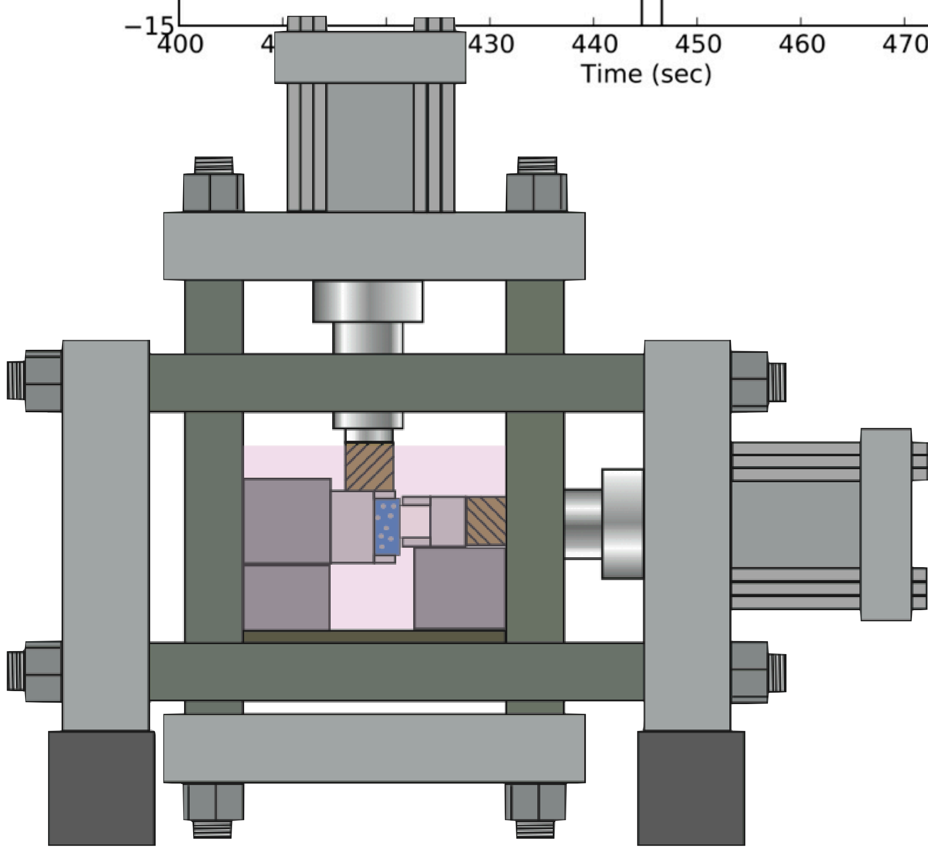


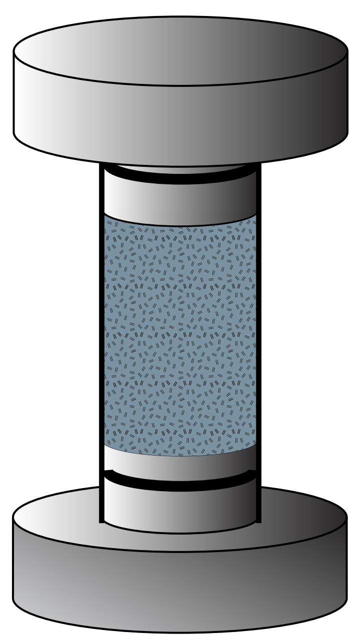


Images: Zoet *et al.*, In Press

Questions?







Acknowledgements:

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