Electrical Potentials During Ice Deformation
Theory and Laboratory Results

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The Day Job:
Could Faults be Natural Transmitters?
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\(^{-1}\)
"The Biax"
Unconfined Compressive Stress Test

Stainless Steel End Platen
O-Ring Seal
Jacket
Ice Column

Axial Stress
Deformation Experiments

- Strains of 0.4-0.6
- Loading Rate of 100µm/s
Mechanical Behavior is Consistent

Experiment Number

- p3886
- p3891
- p3895
First Try: Voltage Observed During Loading

![Graph showing voltage observed during loading](image)
Experiment Two: Using a 24-bit ADC
Loading and Load Cycling

![Graph showing axial stress and ice voltage over time](image)
Loading and Load Cycling

Axial Stress (MPa) vs. Time (sec)

Ice Voltage (V) vs. Time (sec)

Tuesday, June 4, 13
Stress Change and Voltage

- Derivative Axial Stress
- Ice 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?

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