Grain size is a critical parameter in the viscosity of polycrystalline ice under icy satellite conditions. At pressures and temperatures expected within an icy satellite, ice deforms via the grain size-sensitive process of Grain Boundary Sliding (GBS)\[1\].

GBS is one of four mechanisms by which polycrystalline ice deforms:\[2\]
- Dislocation Creep
- Grain Boundary Sliding
  - Limited by grain boundary viscosity:
  - Limited by grain boundary curvature
- Basal Slip
- Diffusion Creep
- Grain size-sensitivity
- Steady-state never observed experimentally

Grain size is a critical parameter in the viscosity of ice. We have conducted creep in the GBS regime and simultaneous, Electron Backscatter Diffraction (EBSD)\[7\] Grain size analysis by grain boundary etching. Initial and final grain sizes for our Deformed (black) and Thermal History (gray) samples. In all cases, Thermal History samples show substantially more grain growth than the Deformed samples.

Models of Grain Size
Grain size is generally considered using piezometers - formulae relating stress to grain size, assuming a balance between dynamic recrystallization, which reduces grain size, and grain growth.\[3,4,5\]

Regulating Grain Growth
Microstructural Effects and Dissipation Dynamics
- Possibilities: Reducing Driving Force
  - Dissipate energy faster via GBS
  - Naturally maximizes energy dissipation rate.
- Possibilities: Grain Growth Dissipation
  - Maintains constant as long as the ice continues to deform via grain size-sensitive GBS.
- Possibilities: Reducing Mobility
  - Grain Boundary Drag
  - Bubbles? Microstructures show no evidence for bubbles on grain boundaries.
- Particles? Microstructures show no evidence for bubbles on grain boundaries.
- Voids? Section of a deformed sample reinserted into the cryostat without load experienced growth. Cavitation does not produce voids in our samples.

Results
Grain growth kinetics are expressed as:

\[ D^2 - D_0^2 = 4kt \]

where:
- \( D \) is the final grain size
- \( D_0 \) is the initial grain size
- \( k \) is the grain growth constant
- \( t \) is the elapsed time

Initial and final grain sizes for our Deformed (black) and Thermal History (gray) samples. In all cases, Thermal History samples show substantially more grain growth than the Deformed samples.

Implications for Icy Worlds
Our results suggest that the field boundary approach\[6\] is best to determine the grain size in a deforming ice shell.

Methodology
We have conducted creep in the GBS regime and simultaneous, stress-free, grain growth experiments, along with careful microstructural analyses to understand how the lack of recrystallization affects grain size during GBS in ice.