Sampling and In-situ Analysis

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Unlocking the Climate Record Stored within Mars' Polar Layered Deposits
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Collection - Curation - Characterization

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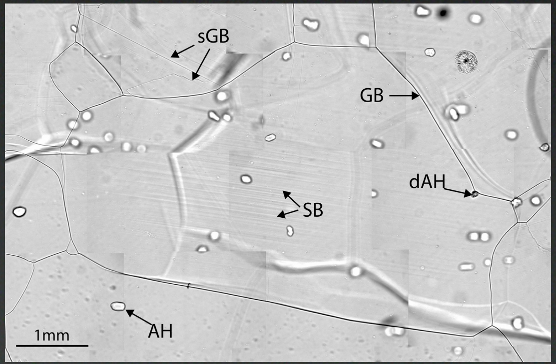
Some lander sample types

- Surface imaging and samples
- Borehole logs – optical, acoustic, sonic
- Cuttings/chips
- Ice cores

Surface imaging and samples

- Surface optical Imaging
  - Dust grain size, shape and areal coverage
  - Snow grain size with SWNIR
- Confocal Raman spectroscopy
  - *In situ* chemistry of particles, layers, and bubbles in top 1 cm (?)



- Sample collection (scooping, scraping or cutting)
  - Density (ice + dust)
  - Composition of ice and dust on surface

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Borehole logging

- Types: optical, acoustic, sonic
- Requires no sample collection, but could be complementary to sample collection techniques
- Vertical resolution depends on logging speed… as fine as ~1 mm

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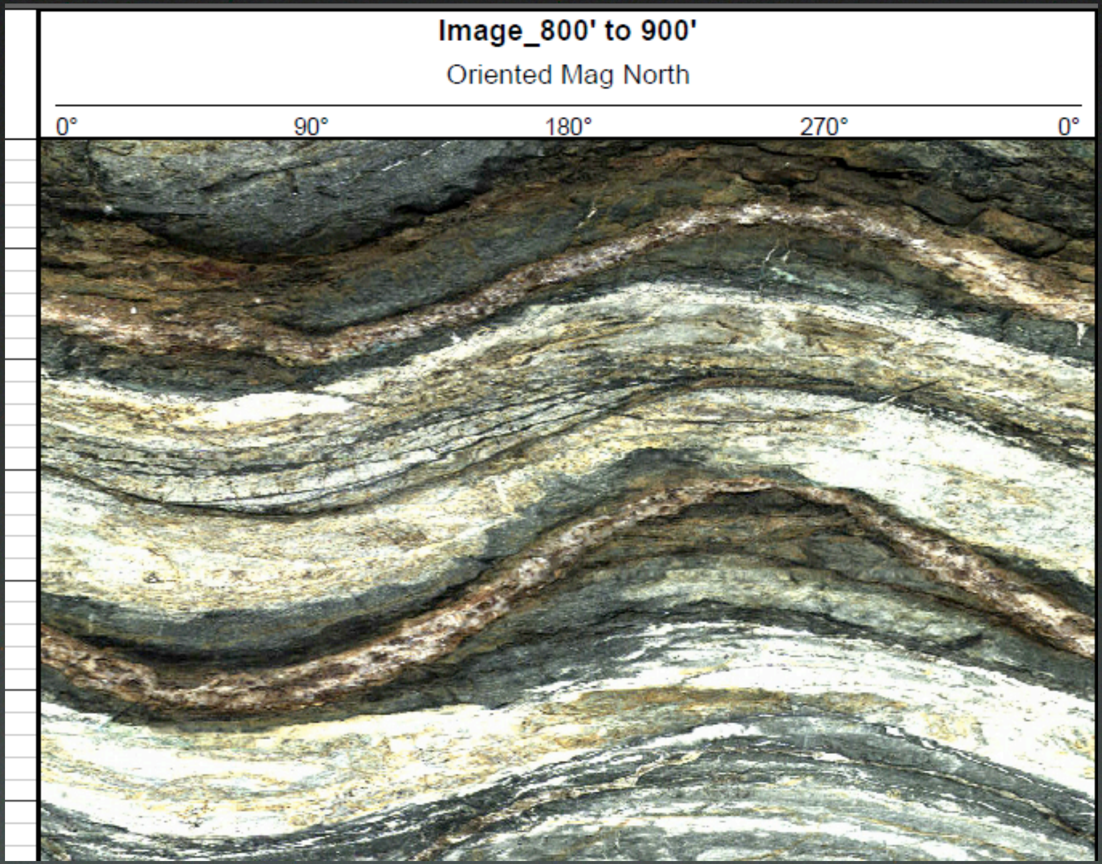
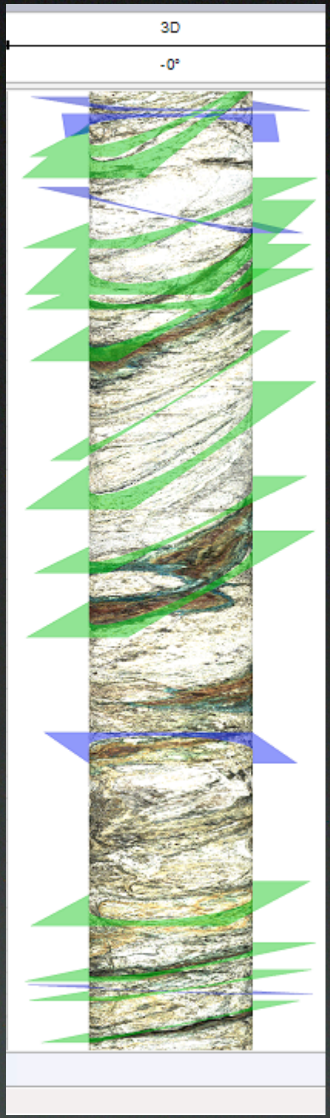
Optical borehole logging

- LEDs illuminate hole and wide angle camera captures images
- Produces a 360°unwrapped and 3D image of the borehole wall and thin layers.
- Detection of thin beds
- Determination of bedding dip
- Lithology and mineralogical characterization
- Can run in dry borehole

Optical borehole logs





Acoustic borehole logging

- Tool emits an 1.2MHz beam towards the formation and records the amplitude and the travel time of the reflected signal
  - Amplitude represents impedance contrast
  - Travel time gives borehole shape
- Produces a 360°unwrapped and 3D image of the borehole wall and thin layers.
- *Requires fluid in the hole*

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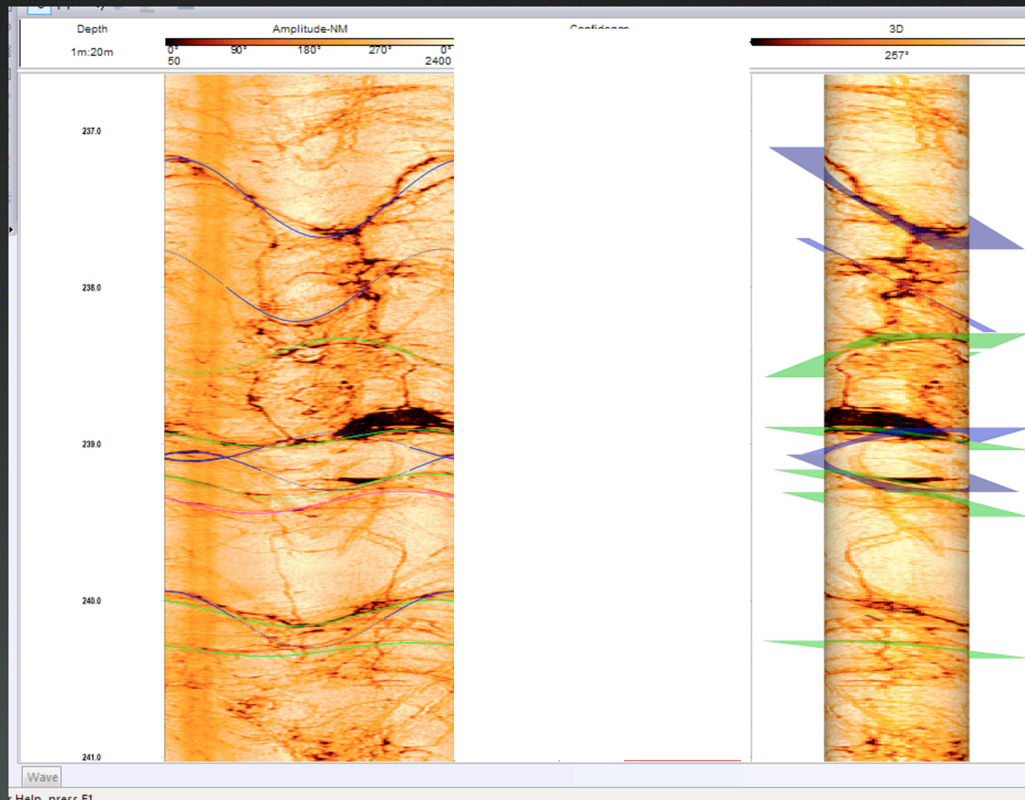
Acoustic borehole log



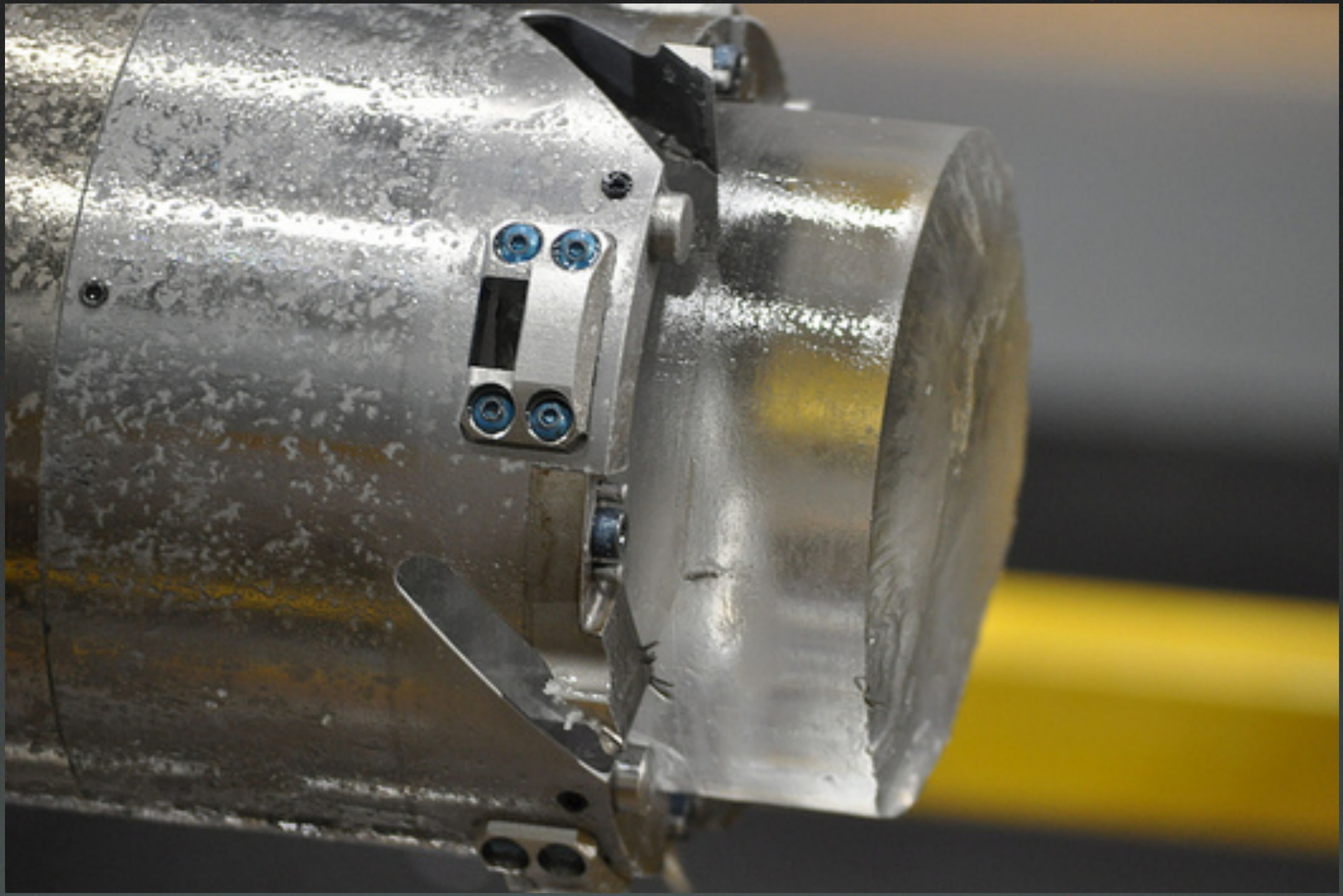
Sonic borehole logging

- A 6 hHz source wave is generated by a ceramic-piezoelectric transducer to excite the adjacent formation.
- Waves of different frequencies are produced, propagated, and measured to
  - Identify individual layers
  - Measure porosity and permeability
  - Measure variations in mechanical properties (strength, Young's modulus, Poisson's ratio…)
- *Requires fluid in the hole*

Cuttings (chips)

- Some drills produce cuttings which can be collected, melted, and analyzed
- Ion chromatography for soluble impurities
- Isotope analysis on meltwater
- Laser light scattering for insoluble impurity (dust/sand) concentration
- *Vertical resolution of data from cuttings?*

Ice cores



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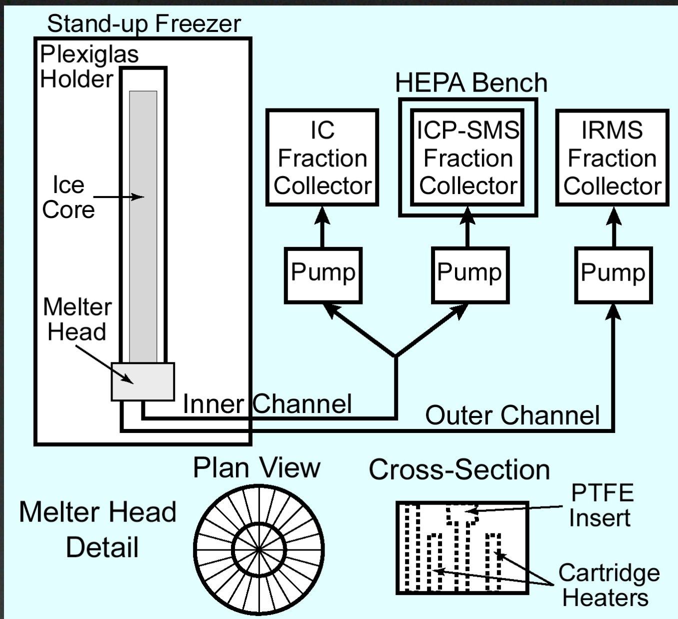
Ice cores

- Optical stratigraphy of core, image discrete layers
- Electrical conductivity measurement (ECM) for identification variations in acidity (multitrace can also resolve tilted layers)
- *Ice microstructure (crystal size and orientation) through thin sections (probably not possible)*
- Continuous flow meltwater analysis for
  – Dust concentration (laser light scattering)
  – Ion chromatography, GC-MS
  – Stable isotopes

Sample system



Osterberg et al., 2006
Cole-Dai et al., 2006
Breton et al., 2012
Koffman et al., 2014

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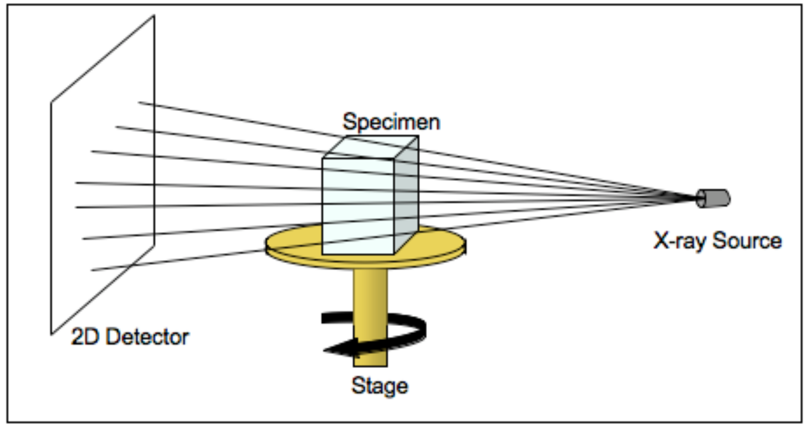
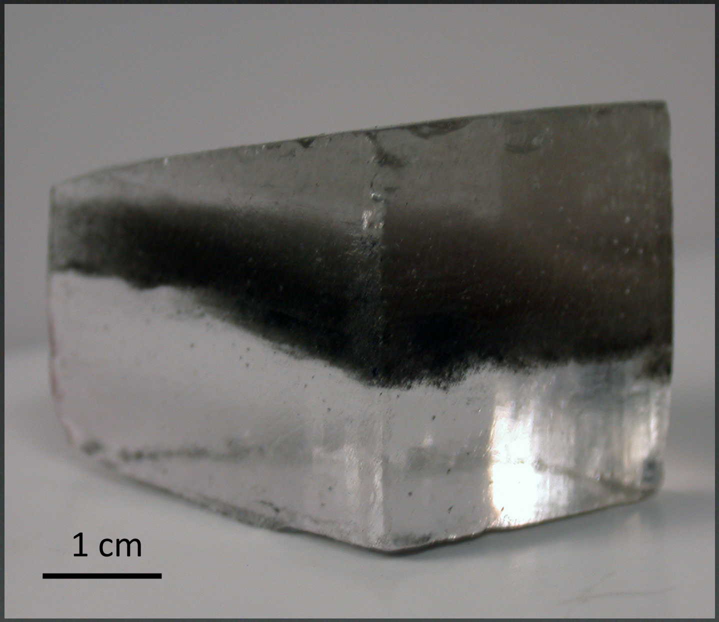
Out of the box idea

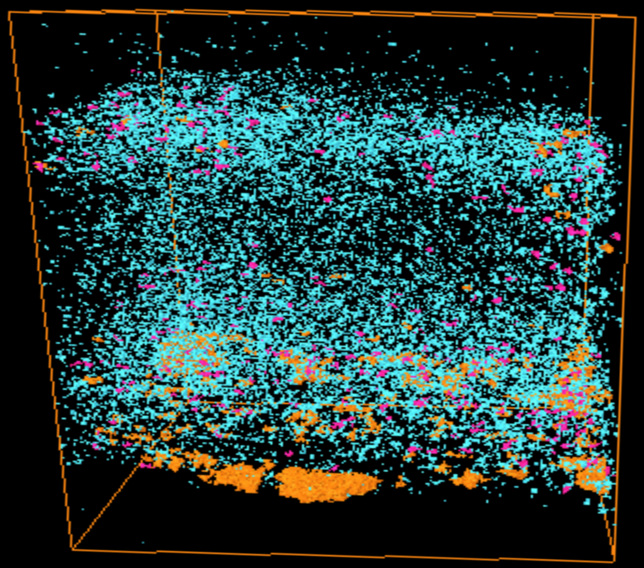
- X-ray Microcomputed tomography either on board, or bring cores home…
- With microCT we could examine distribution of dust, sand, tephra, pores... In 3D at <1 mm resolution
- Fun examples follow...



Identifying ash layers in West Antarctica: Using particle size and shape distribution for depositional history



Core sample from West Antarctic Ice Sheet, 3149 m



MicroCT reconstruction, ash color coded by size

- Small particles (0.844 - 1.688 x 10^{-3} mm^3)
- Medium particles (1.688 - 3.375 x 10^{-3} mm^3)
- Large particles (> 3.375 x 10^{-3} mm^3)

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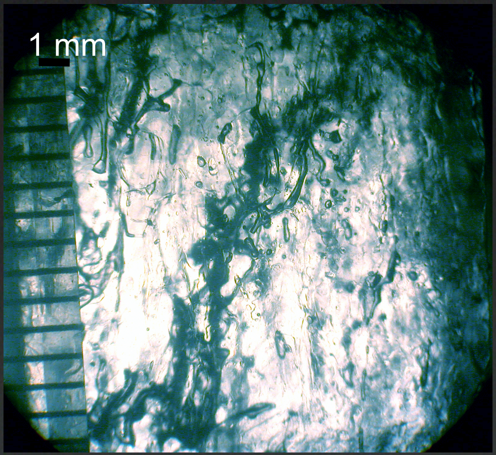
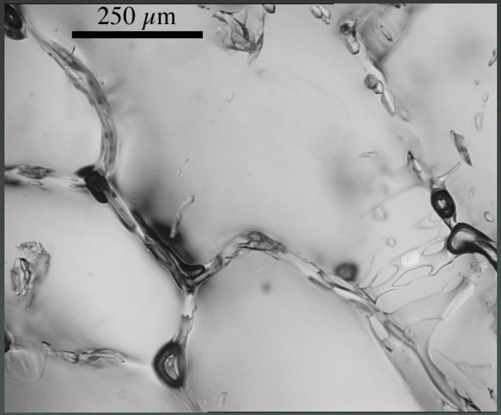
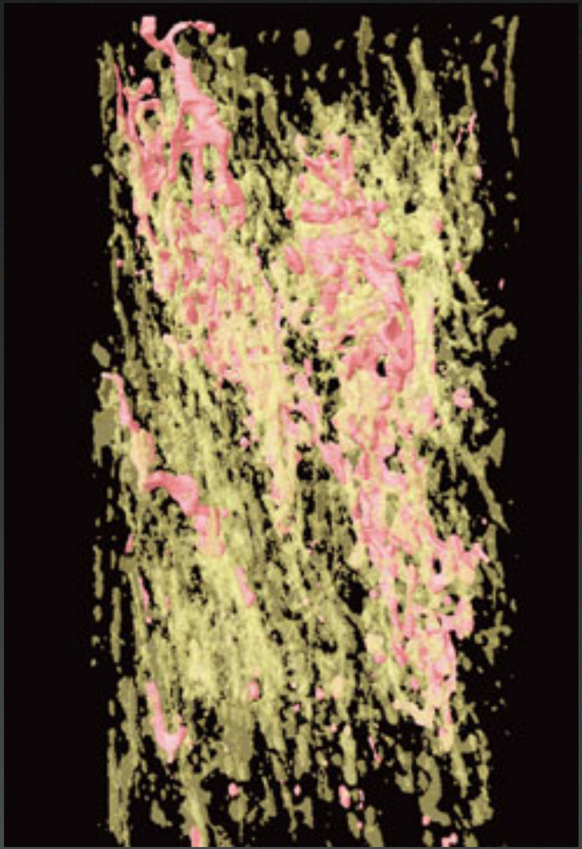
Brine networks in sea ice



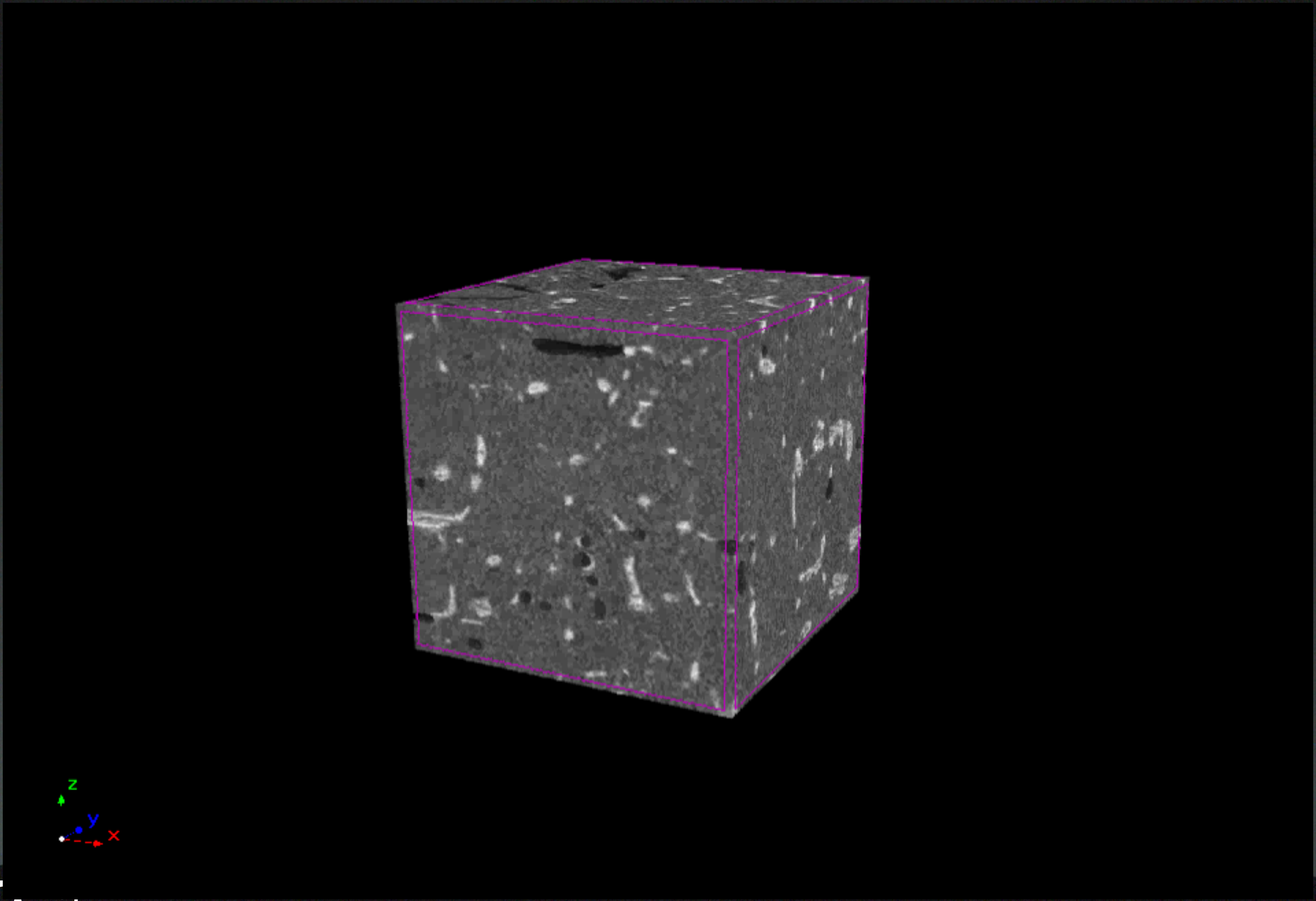




Brine channels at 20 cm depth in an Amundsen Sea ice core, -11°C (Obbard et al., 2009)

130 cm depth in Ross Sea ice core, -20°C

VOI 7.5 mm/side



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