# RAID: RAPID ACCESS ICE DRILLING

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## SCIENCE RATIONALE

Rapid access to deep ice in the ice caps of Antarctica and Greenland will provide the first opportunity to systematically study spatial variability in deep ice, subice geology, and the interface between them. This unique ability will allow us to study, for example, the Milankovitch transition from 40 kyr to 100 kyr climate cycles (by sampling ice as old as ~1.5 Ma ice), and to document the presence of Eemian-age ice to test models of ice sheet collapse in West Antarctica (~125 Ka). Rapid access through deep ice will also allow us to explore the deep interior geology of Antarctica for the first time. As the last continental frontier, the Antarctic lithosphere is virtually unknown except by extrapolation from coastal outcrop and limited geophysical data. Recent attempts to reveal the geological substrate beneath the major ice caps by means of ice-sheet margin glacial deposits and geophysical potential-field data provide a limited framework for understanding the geology of the Antarctic interior. Direct sampling by rock coring, however, will enable us to evaluate the bed conditions at the base of the ice sheets, characterize geological features imaged with geophysical data, and test models of cratonic growth related to supercontinent assembly in the Mesoproterozoic (~1 Ga). In both cases, a single deep ice core and/or rock core would represent merely a single point in a continent-scale geosystem. Such a new technology will define geothermal flux and basal properties, allow study of ice dynamics, and provide constraints for ice-sheet modeling. We advocate development of drilling technology that will enable the ability to quickly access deep ice and the rock below in a large number of sites in order to capture as complete a spatial and temporal record of the coupled ice-rock system as possible.

## SCIENCE REQUIREMENTS

Below are the minimum science requirements for a Rapid Access Ice Drilling (RAID) system.

- Ice penetration up to 4000 m in 1 week

- 2” diameter ice hole for down-hole observations
- Ice drilling through dry, frozen-bed conditions (clean access not required)
- Ability to acquire 1-2” rock core, cable-suspended, 25 m minimum bedrock length
- Ability to acquire short ice core (50 cm)
- Can decouple ice and rock drilling systems, if cost-effective
- Stand-alone, traverse-capable, over-ice system
- Smooth borehole wall for optical measurements
- Rapid drilling timeframe (≤4 weeks top to bottom, including coring)
- Allowance for multiple penetrations for observation and sampling
- Keep borehole open for 5 years
- Drilling fluid for pressure stabilization
- Bipolar capability

## SUGGESTED TECHNICAL CAPABILITIES

Below are suggestions for system capabilities as engineering concepts are developed.

- Skid-mounted drilling platform, deployable with a self-supported heavy-lift tractor train
- Twin Otter resupply and personnel rotation
- Drilling fluid is butyl acetate
- Drilling fluid supplied in bladder
- Install firn casing
- Drilling and support units are containerizable
- Integrated drilling crane/riser/tower
- Build multiple rigs
- RAID can be used in wet-based systems but no plans to penetrate at this time with clean technology; RAID paves the way for future clean access to wet-based systems

## TIMELINE

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|---|---|
| Technology proposal | 2011 |
| Science proposals | 2013 |
| Construction & testing | 2014 |
| Science operations | 2015 (depending on implementation) |

## SCIENCE GOALS

1. Geological goals
    - Map bedrock geology of East and West Antarctica, and determine lithologies, physical properties, ages, ancestries and assembly boundaries
    - Retrieve basement samples for characterization of geophysical anomalies
    - Test SWEAT hypothesis for Rodinia supercontinent assembly
    - Characterize geology and character of Gamburtsev Subglacial Mountains

- Collect rock samples for physical rock properties (density, seismic anisotropy, magnetic susceptibility, heat production, thermal conductivity, etc.) as baseline for geophysical models
- Paleoclimate records from sedimentary basin deposits
- Test whether volcanism is active in West Antarctica Rift System

2. Glaciological and paleoclimate goals
   - Exposure age dating of basement highs to test WAIS collapse hypothesis
   - Transect across Herc Dome to get at WAIS collapse with total air content, isotopes, biogenic species in Marine Isotope Stage 5e ice
   - Synergize with Herc Dome deep core by providing spatial context
   - Determine character of ice bed materials, including characterization of basal till condition and rheology
   - Spatial variability (ice stratigraphy, depth-age, heat flow) around ice coring sites using optical, temperature and sonic logging
   - Map geothermal flux at base of the ice sheets
   - Ice dynamics and spatial dimensions of ice flow related properties
   - Derive ice flow-law parameters, including anisotropic rheology
   - Transects across ice stream boundaries
   - Paleowind from dense grid of optical logging
   - Mapping 3D temperature field (including frozen bed extent)
   - Paleothermometry from borehole temperatures

3. Biological goals
   - Determine extremophile biota within deep ice
   - Biological studies of in frozen basal materials
   - Optical logging for microbes