WAIS Divide Ice Core Project

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West Antarctic Ice Sheet (WAIS)

East Antarctica

WAIS Divide

Ice Cores reaching the last glacial maximum and beyond
Drill Arch
Drill Arch will be completely buried
WAISSCORES: History

1989: Included in ICWG long term plan

1992: Science plan for WAISCORES Deep Ice Coring (ICWG/Alley) “Inland Divide Site” and Siple Dome

2000: WAISCORES: A Science and Implementation plan

2002: Proposal to build and test the drill

2004: Full project proposed

2005: Established WAIS Divide site

2011: Main hole completed, replicate coring test

2012: Replicate coring

Ongoing: Borehole Logging
WAIS Divide Goals

~80,000 year record with high time resolution
Initiation of climate changes during the last glacial
North-South phasing of abrupt climate phasing
Greenhouse gas (particularly CO$_2$)
Holocene Variability
Microbial biology of the ice
Biology of the basal environment
Stability of WAIS
High time resolution, ~80,000 years

Oldest ice is 68,000 years
High time resolution, ~80,000 years

Annual resolution to 31 ka

~26,000 years ago
High time resolution, ~80,000 years

Gas-age ice-age difference < 500 years

Allows precise comparisons between hemispheres
Initiation of climate changes during the last glacial

WAIS Divide begins warming thousands of years before commonly accepted start of deglaciation in East Antarctica

WAIS Divide Project Members, 2013, Nature
Initiation of climate changes during the last glacial

200 year Halogen rich volcanic event

Creates ozone hole as evidence by drop in bromine

McConnell et al., in review, Nature
North-South Phasing of Abrupt Climate Change

Vertical lines show times of abrupt climate change

WAIS Divide Project Members,
In review, Nature
North-South Phasing of Abrupt Climate Change

Antarctic temperature lags abrupt Northern Hemisphere changes by 200 years

Ocean processes dominate heat transport

WAIS Divide Project Members, In review, Nature
North-South Phasing of Abrupt Climate Change

Deuterium excess also shows a synchronous atmospheric response

Centennial-scale oceanic response warms Southern Ocean sea surface temperatures

Synchronous shift in winds changes moisture source which is detected by deuterium excess

Brad Markle, in prep
Greenhouse Gases

Marcott et al.,
In press, Nature
Greenhouse Gases

3 abrupt increases in CO2, exactly synchronous with methane increases, account for about half of glacial-interglacial rise

Marcott et al., in press, Nature
Abrupt CO2 increases also occur in the glacial period

Marcott et al., in prep
Modern isotopic warming rare but not unprecedented

Steig et al., 2013
Nature Geoscience
Microbiology of the Ice

Ibanez and Priscu, in prep.
We didn’t try

Drilling was stopped ~50 m above the bed
Stability of West Antarctica

No information on whether WAIS collapsed in MIS5e because no old ice was recovered
Stability of West Antarctica

Use heat equation to calculate vertical velocity

\[ w = \left[ \frac{k}{\rho c_p} \left( \frac{\partial^2 T}{\partial z^2} \right) - b \frac{k}{\rho c_p} \left( \frac{\partial T}{\partial z} \right)^2 - \frac{\partial T}{\partial t} + \frac{1}{\rho c_p} Q \right] / \frac{\partial T}{\partial z} \]

Basal melt rate of \(~1\) cm per year
Geothermal flux of \(~180\) mW m\(^{-2}\)
Stability of West Antarctica

But then we drilled 70 m more of ice
And the deep layers are strained more than expected

Accumulation from firn thickness

Best fit: 0.17 cm of melt

Geothermal flux of \( \sim 100 \text{ mW m}^{-2} \)
Complex basal topography may be complicating analyses.

Definitely melting, but by how much?
Geothermal flux between 100 and 200 mW m\(^{-2}\)
Future Ice Coring Efforts

Funded
2014/2015 and 2015/2016 – 1500 m South Pole Ice Core

In planning
2018 – Previous Interglacial (Hercules Dome) deep core
2022 – Amundsen Coast change (Coastal Domes)
2024 – 1.5 Million Year Old Ice
WAIS Divide Reliquary

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