



AGU Town Hall TH010



Scientific Drilling in the Polar Regions



AGU Fall Meeting 2021



Scientific Drilling in the Polar Regions



Agenda

NSF Remarks – Paul Cutler

IDP – Mary Albert

ICYS – Kathleen Wendt

IPICS & COLDEX – Ed Brook

Hercules Dome – Heidi Roop

GreenDrill – Joerg Schaefer

RAID – John Goodge

Q&A with the audience



NSF Remarks

Dr. Paul Cutler

NSF-OPP Program Director
Glaciology, Ice Core Science, & Geomorphology



Update from the Ice Drilling Program

Mary Albert
IDP Executive Director



www.icedrill.org



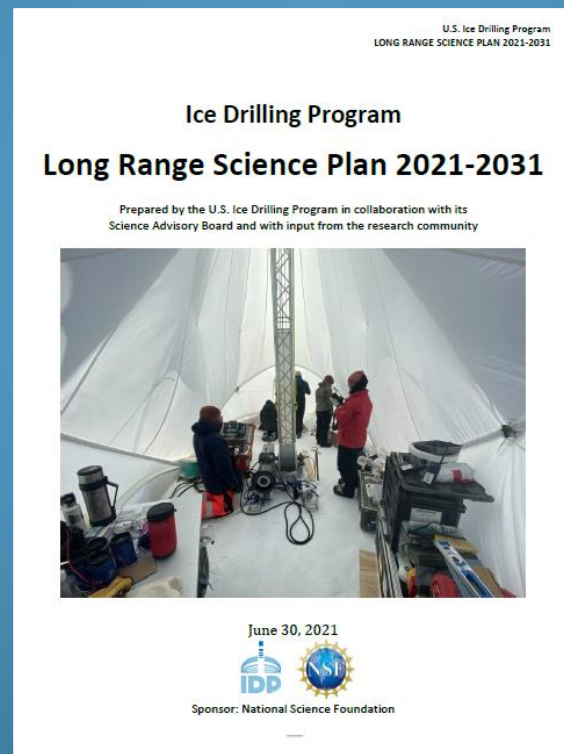
Ice Drilling Program



Long Range Planning & Drilling for Multiple Fields of Science

IDP Working Groups

- Ice core working group
- Subglacial science working group
- Borehole logging working group



Contents

Past Climate Change

Ice Dynamics and Glacial History

Subglacial Geology, Sediments & Ecosystems

Ice as a Scientific Observatory

www.Icedrill.org



Ice Drilling Program Office Planning Workshops



IDP Subglacial Access Science Planning Workshop 2019 Herndon VA. Result: 4 white papers:

<https://icedrill.org/about/science-advisory-board/subglacial-access-working-group>

IDP Ice Core Working Group Community Workshop 2020 (virtual due to covid) Result: 4 white papers:

<https://icedrill.org/about/science-advisory-board/working-groups#icwg>

IDP & SCO Greenland Traverse Planning Workshop 2021
(virtual do to covid) Result: Workshop report with 2 white papers:

<https://icedrill.org/meetings/us-scientific-traverses-gris-planning-workshop>

**IDP-ICWG Ice Core Early Career Researcher Workshop 2022
(ICECReW)** Salt Lake City, Utah January 5-8, 2022

Goal: Professional development + two synthesis papers

<https://icedrill.org/meetings/ice-core-early-career-researchers-workshop-icecrew>

www.Icedrill.org



IDP Drill Highlights: Rock cores beneath glacial ice



Agile Sub-Ice Geologic Drill (ASIG)
10 m bedrock under ≤ 700 m of ice



First use now at Pirrit Hills.
Next up: *GreenDrill*

Ice-enabled Winkie Drill
5-6 m of rock under tens of m firn



Used in Ohio Range, Ong Valley
Next up: *GreenDrill*

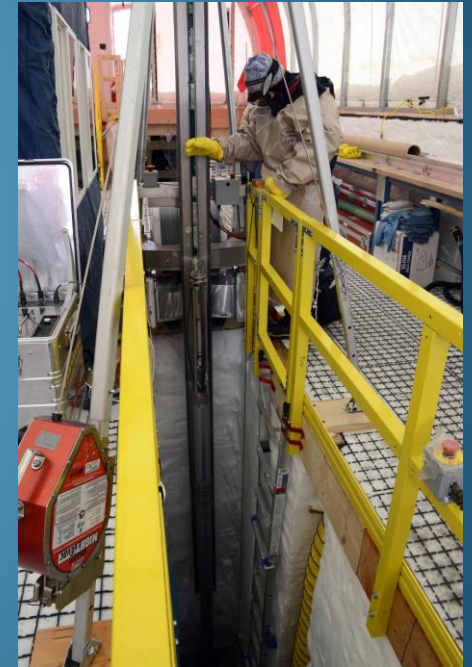
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IDP Drill Highlight:

Foro 3000 Drill

Ice coring to 3,000 m depth



Will be ready for use at Hercules Dome

www.Icedrill.org



Ice Drilling Program

Education & Outreach

featuring *your* science!



- IDP School of Ice
- Golden Apple, SACNAS, NSTA conferences
- Webinars for teacher education
- Educational resources online

Louise Huffman
IDP Education & Outreach

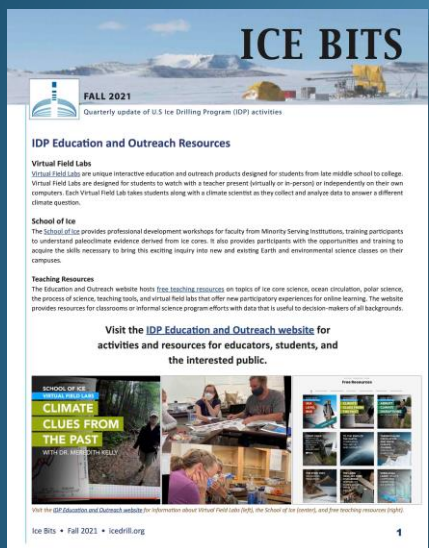


Contact Louise!!
Louise.T.Huffman@Dartmouth.edu

www.icedrill.org and <http://icedrill-education.org/>



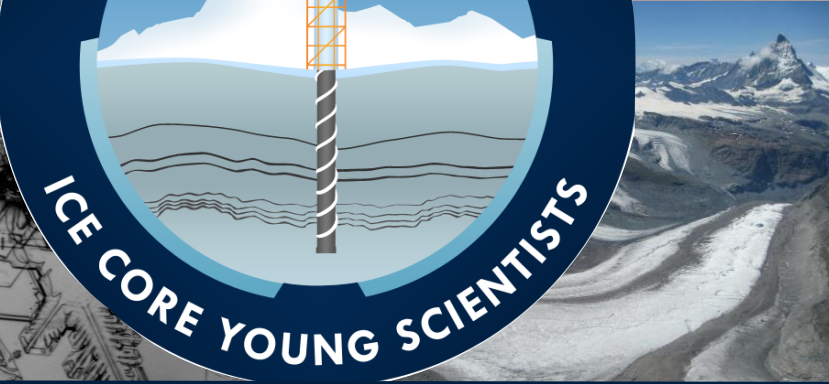
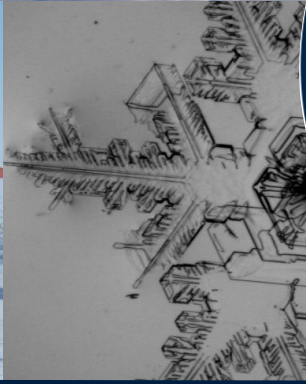
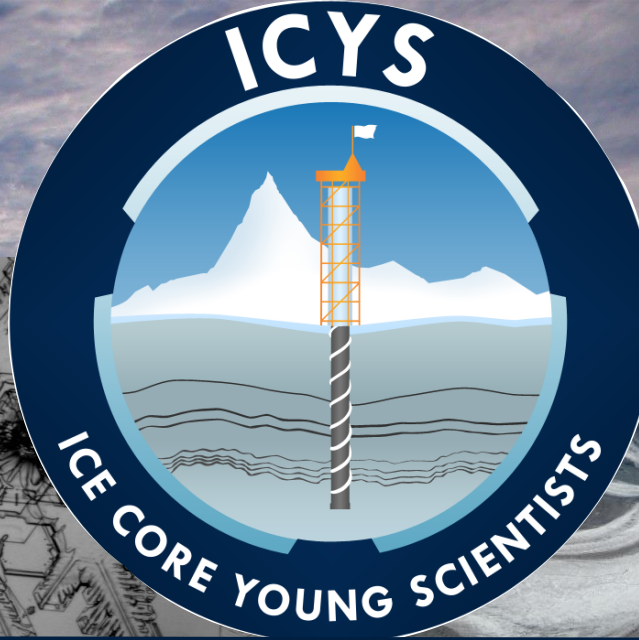
Ice Drilling Program Get involved !



- Sign up for our newsletter!
- Join our working groups!
- Make sure your science is in the IDP Long Range Science Plan!
- Get help with outreach for your science!
- Request drilling & EO support for your NSF proposal!

www.lcedrill.org

Kathleen Wendt
for ICYS



**We are an international group
of early career researchers
studying ice cores!**

Twitter: @ICYSci

Email: icecoreys@gmail.com

Web: <https://pastglobalchanges.org/science/end-aff/icys>



Who we are...

- 26 active members
- 70% female
- 20% non-white or mixed race
- 20% identify with the LGBTQ+ community
- 15% 1st generation
- Over 10 languages spoken



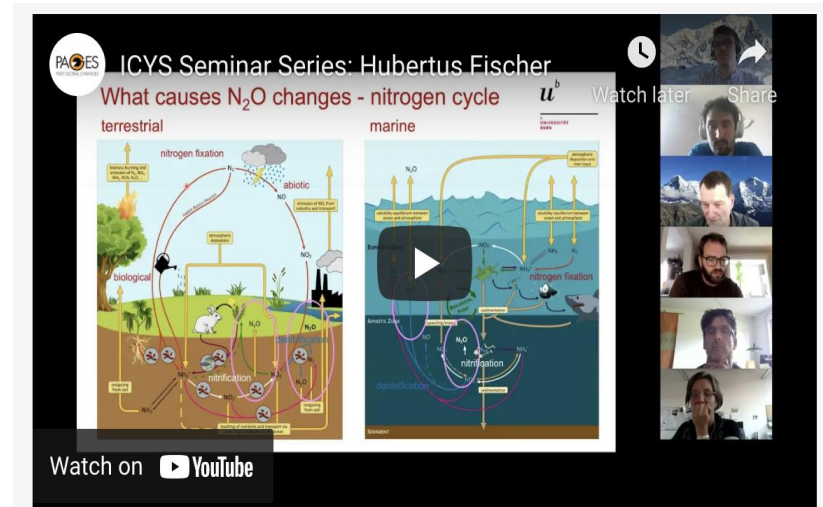
<https://pastglobalchanges.org/science/end-aff/icys>

ICYS Online Seminar Series

Join us monthly for our online seminar!

Schedule, past recordings, and info on how to attend is on our [website](#).

Interested in presenting?
Contact us! icecoreys@gmail.com



<https://pastglobalchanges.org/science/end-aff/icys>

Upcoming events...

October 1st 2022

ICYS will hold a **one-day workshop** as part of the 3rd IPICS Open Science Conference in Crans-Montana, Switzerland.

International Partnerships in Ice Core Sciences 3rd Open Science Conference



Ice Core Science at the three Poles



<https://pastglobalchanges.org/science/end-aff/icys>

Join us!

Benefits of becoming a member:

- Build your network within a supportive community
- Discover upcoming opportunities
- Develop new skills
- Stay connected during COVID!

To become an ICYS member, email: icecoreys@gmail.com

Follow us on Twitter: @ICYSci

<https://pastglobalchanges.org/science/end-aff/icys>





International Partnerships in Ice Core Sciences

IPICS Update: Ed Brook
on behalf of co-chairs Hubertus Fischer and Tas van Ommen



IPICS is an international organization of ice core scientists formed to facilitate international collaboration and planning via workshops

<https://pastglobalchanges.org/science/end-aff/ipics/intro>

The Oldest Ice Challenge



EU Beyond EPICA – Oldest Ice
Core Little Dome C camp
completed, season ongoing!



Australia: Little Dome C, setup season now



US A: Allan Hills Blue Ice / COLDEX



deep drilling starting 2026

Russia: Ridge B deep drilling from 2024



Japan: Dome Fuji area deep drilling from 2024



China: Dome A drilling ongoing



South Korea: Dome C area deep drilling from 2027





International Partnerships in Ice Core Sciences

3rd Open Science Conference



Ice Core Science at the three Poles

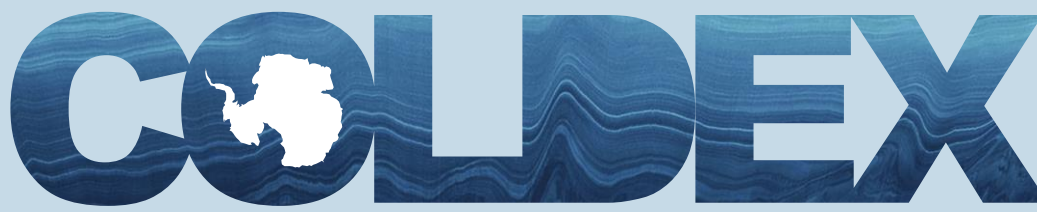
Open Science Conference & Ice Core Young Scientist
Workshop

Crans Montana, Switzerland

New dates (postponed from 2020):

October 2-7, 2022

<https://indico.psi.ch/event/6697/>



Center for Oldest Ice Exploration

Director: Ed Brook, College of Earth, Ocean, and Atmospheric Sciences (CEOAS), Oregon State University

Funded by the NSF Science and Technology Center Program September 2021

www.coldex.org

COLDEX Institutions

Oregon State University

University of Washington

Princeton University

University of California-Berkeley

Dartmouth College-Ice Drilling Program

University of Minnesota Twin Cities

Amherst College

American Meteorological Society

Earth Science Women's Network

University of Kansas

University of Texas

University of California-Irvine

University of Maine

University of California-San Diego

University of Minnesota Duluth

Brown University

Inspiring Girls Expeditions

Alaska Native Science and Engineering Program



BROWN



PRINCETON UNIVERSITY



Oregon State University



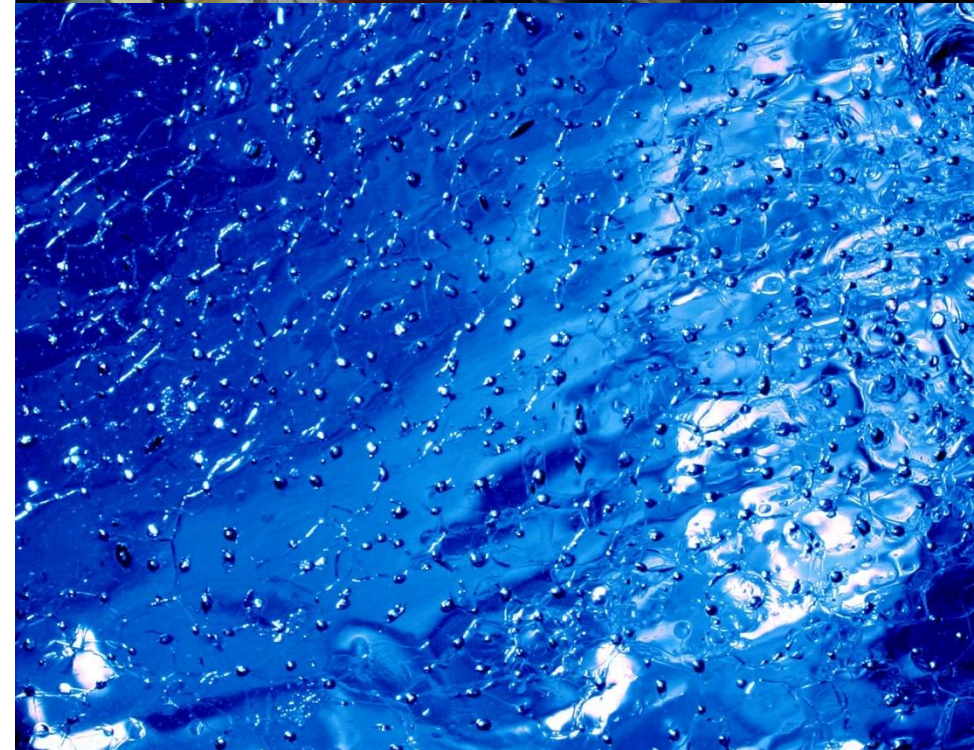
Amherst College





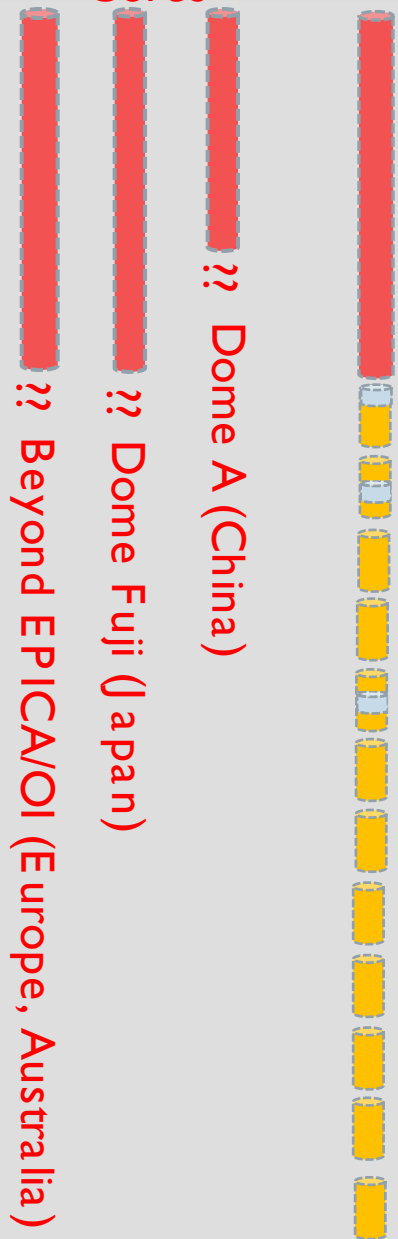
Why COLDEX? The Oldest Ice Challenge

- Data from ice cores have provided remarkable insight about Earth's history.
- This includes the only direct constraints on the past composition of the atmosphere.
- The ice core record is not long enough to answer key questions about how the Earth System works, questions important for understanding both our past and future.
- Extending the record to much older times is a major international challenge.
- There are equally big challenges in broadening participation in earth and polar science and transferring knowledge to stakeholders and the public.
- COLDEX is developing programs to address all of these challenges.

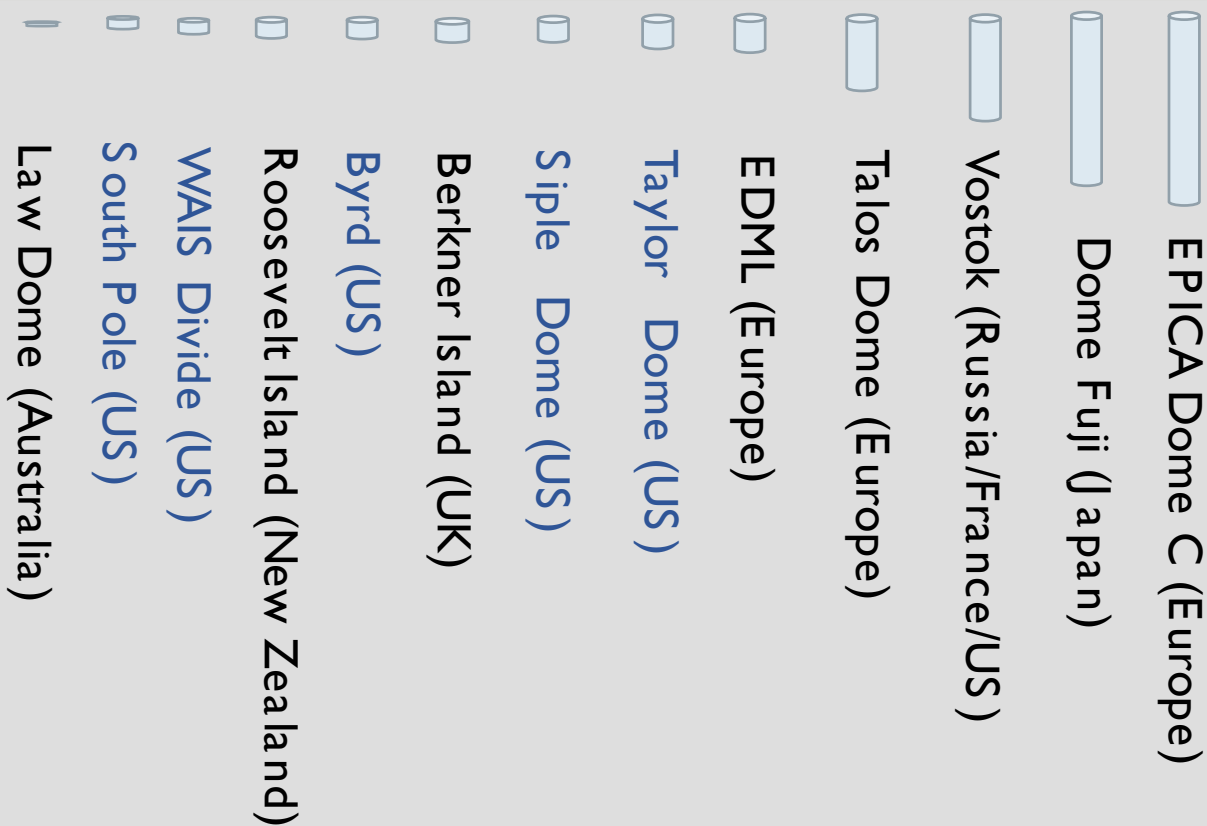


Planned
Cores

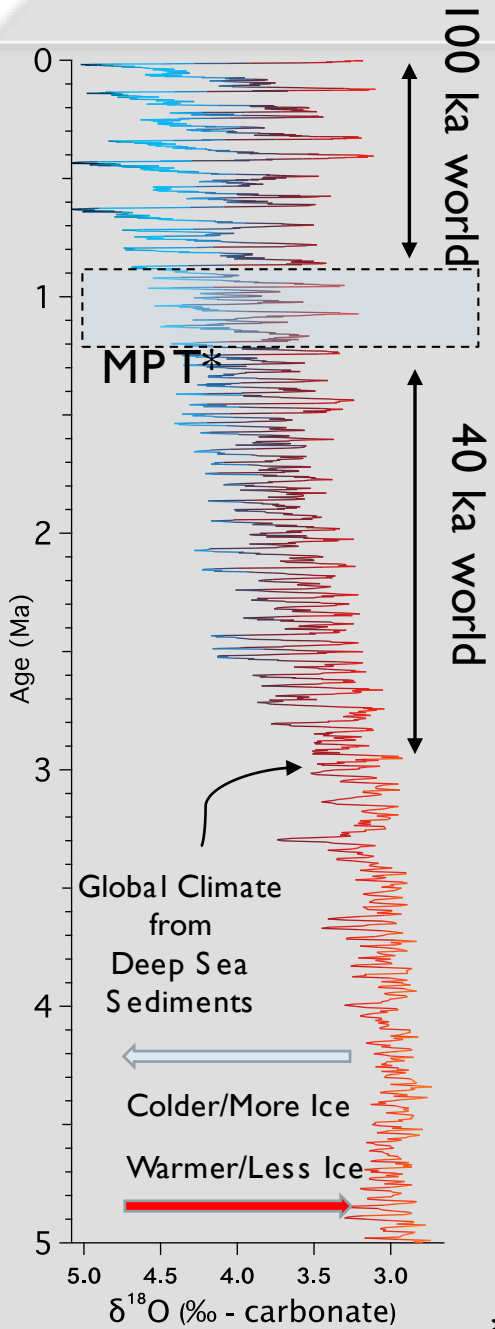
COLDX
Continuous Core Discontinuous Cores



Existing Cores (Blue=U.S.-led Project)

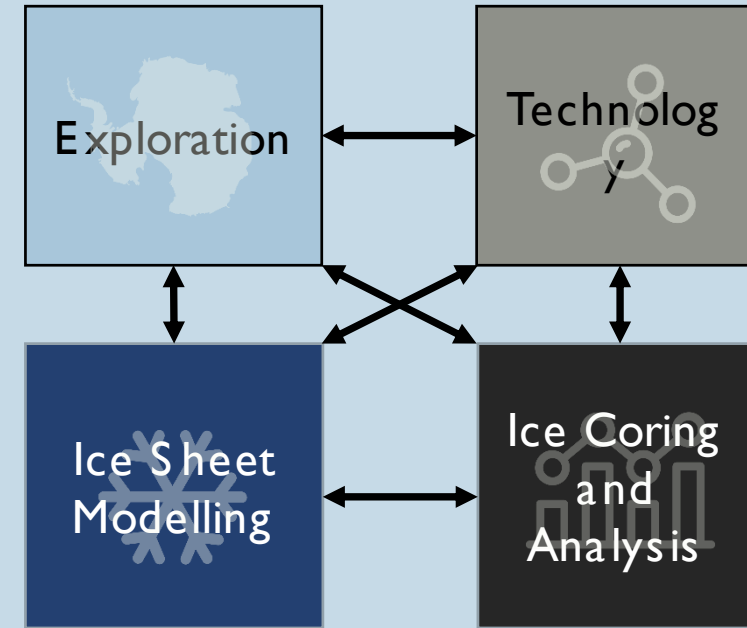
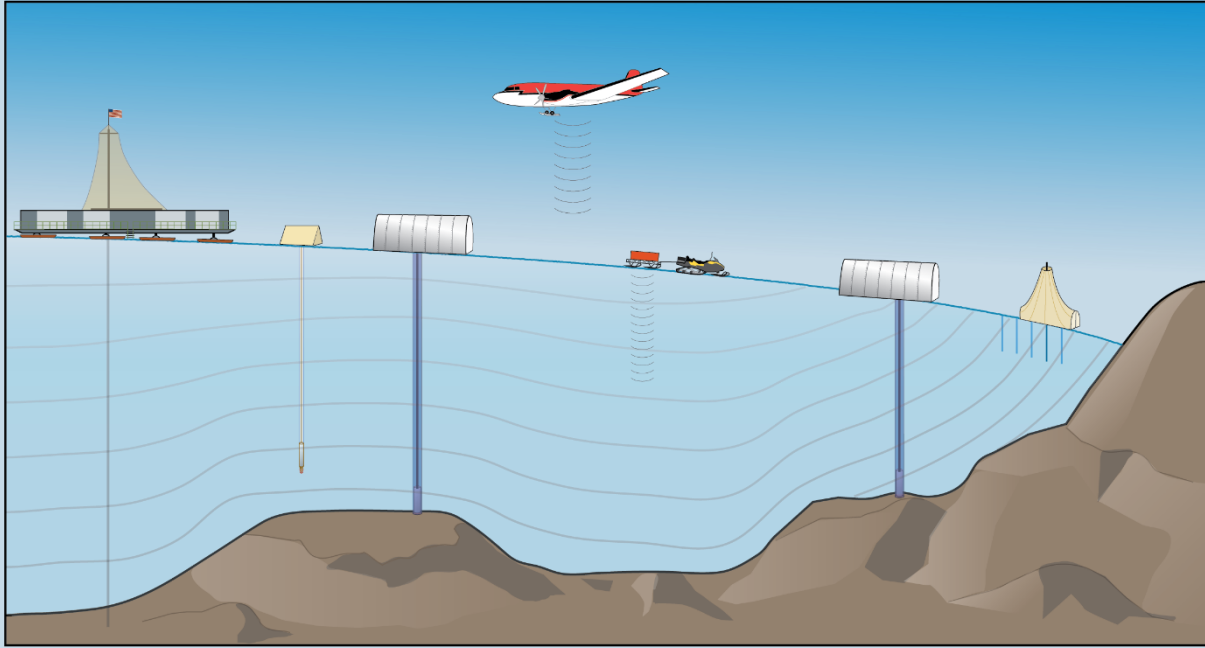


Major Antarctic Ice Coring Over The
Past 50+ Years – Context for COLDEX



*Mid-Pleistocene Transition

COLDEX Disciplinary Makeup – Designed to Find and Analyze the Oldest Possible Ice Cores



- Modelling ice flow and history to understand old ice (UW)
- Advanced radar imaging of ice sheet structure and dynamics (KU, UT, UW, Amherst)
- Novel thermal probes for ice sheet age vs. depth relationship (UW, UC Berkeley)
- Ice core science (group effort led by Princeton in first 5 years. Drilling by IDP)
- Ice core analysis including dating old ice with advanced methods and new centralized facility
- (OSU, Princeton, UW, UC San Diego, UC Irvine, U Maine)

Join Us!



- K-12 Teachers and MSI Faculty
 - Summer professional development programs and further networking possibilities
- Undergraduates
 - REU program (starts summer 2023) and other research opportunities
- Graduate students, post docs, technical staff
 - Research positions
 - Professional development seminars
 - Scholarships
- Scientific community
 - Meetings and seminars
 - New partners welcome!

Ed Brook, brooke@geo.oregonstate.edu

www.coldex.org



Hercules Dome Ice Core Project

Eric J. Steig, Heidi A. Roop, Murat Aydin, TJ
Fudge, Mark Twickler, Joe Souney

herculesdome.org

@HerculesDome

W UNIVERSITY of WASHINGTON



UCIRVINE

M
UNIVERSITY OF MINNESOTA



University of
New Hampshire

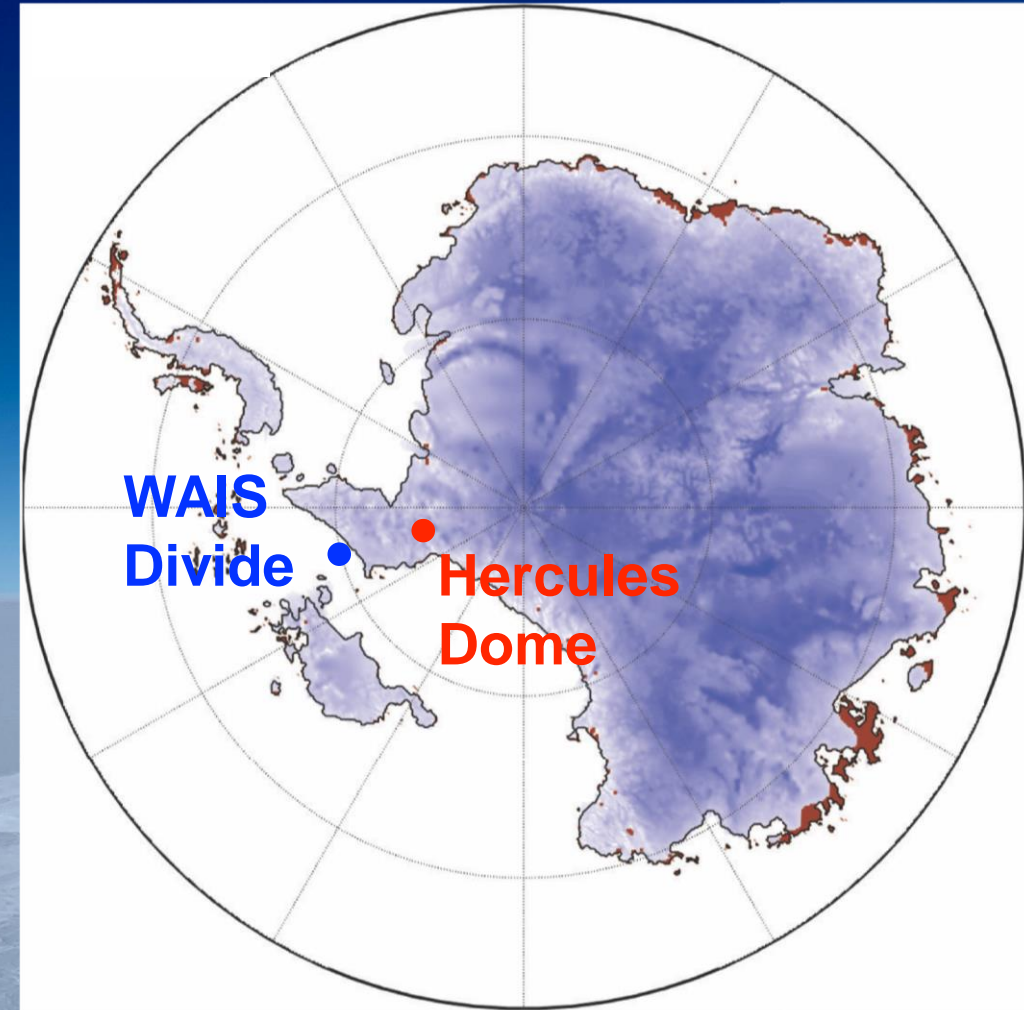


Hercules Dome Ice Core

Collapse of the West Antarctic ice sheet alters atmospheric circulation, increasing moist marine air transport to Hercules Dome.

Evidence of past demise of the WAIS is likely to be discovered in the Herc Dome ice core.

NSF-funded community drilling project.
Drilling hopefully begins in 2024.



<https://herculesdome.org/>

Recent Activities

Held our first Community Workshop & Science Planning Meeting in May 2021

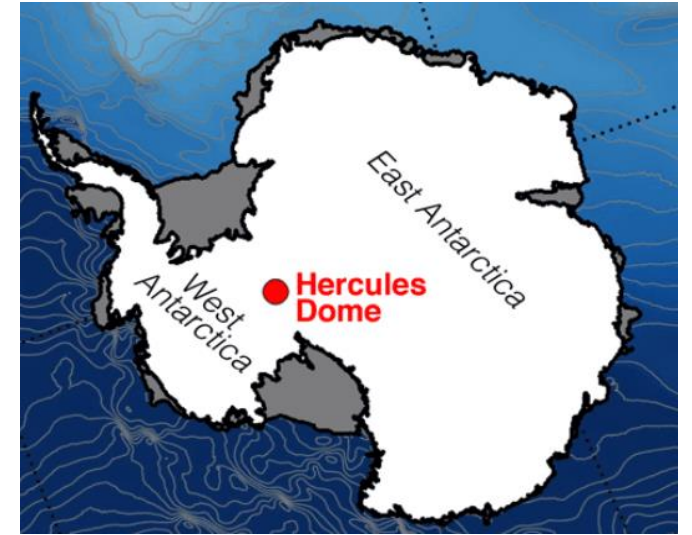
Hosted Informational Webinars & Special Lecture

Conducted initial communications audit and started engagement strategy development

Currently navigating logistics and operations planning.

- First full season of drilling now planned for 2024/25
- June 2025 first possible ice sampling

<https://herculesdome.org>



Upcoming Activities



Ice Core Early Career Researchers Workshop (ICECReW) professional development hybrid workshop.

January 2022; registration deadline passed.

<https://icedrill.org/meetings/ice-core-early-career-researchers-workshop-icecrew>



SAVE THE DATE: Open Science Conference in La Jolla, CA.

Virtual participation option available.

*Tentatively scheduled for **May 23rd-May 27th, 2022.***



Regular webinars & convenings. Updates via website, newsletter and Twitter.

<https://herculesdome.org>

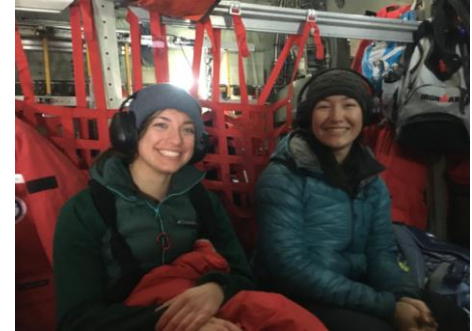
Get involved!



Sign-up for our newsletter for updates direct to your inbox: herculesdome.org/getinvolved



Join us at the Open Science Conference in May 2022
(virtual or in-person)



Proposal Planning *(not official NSF guidance)*



Science proposals to begin working on relevant science or lab development work, **could be submitted any time.**

Proposals to analyze the ice should likely wait until at least 2022/23.



The GreenDrill Project (NSF # 1923927)

Collaborative Research: GreenDrill:
The response of the northern Greenland Ice Sheet to Arctic Warmth
- Direct constraints from sub-ice bedrock

Joerg Schaefer (Lamont/Columbia) & Jason Briner (U. Buffalo)

Sridhar Anandakrishnan (Penn State)

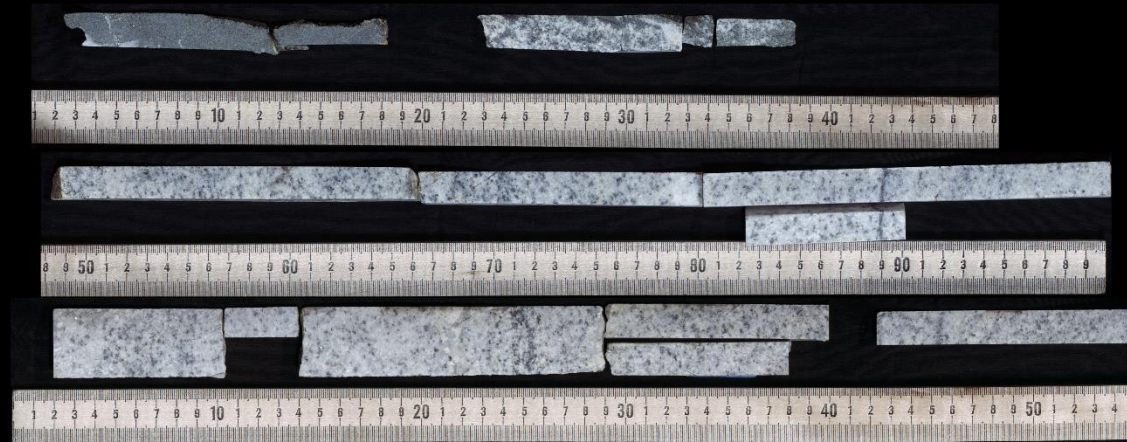
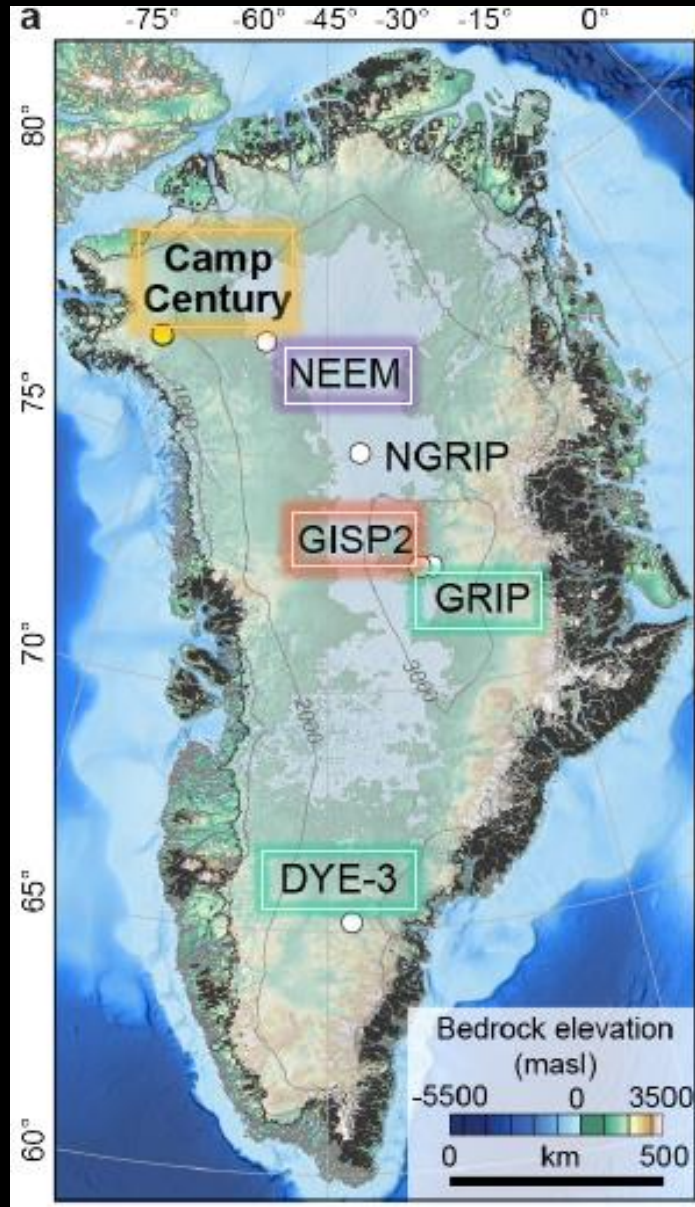
Rob de Conto (U Mass Amherst)

Investigators: Nicolas Young & Gisela Winckler (co PIs, Lamont)
Benjamin Keisling, Allie Balter, Steven Cox, Jacky Austermann,
Margie Turrin (Lamont); Joe MacGregor

Collaborators: Kurt Kjaer (GEUS, Copenhagen), Mary Albert/IDP (Dartmouth),
Joe MacGregor (NASA), Eduard Bard (CEREGE), Marc Caffee (Purdue),
Alan Hidy (LLNL-CAMS), Ryan Vachon (INSTAAR).



The Greenland Ice Sheet was gone in the recent geologic past – 2 basal tests, same result!



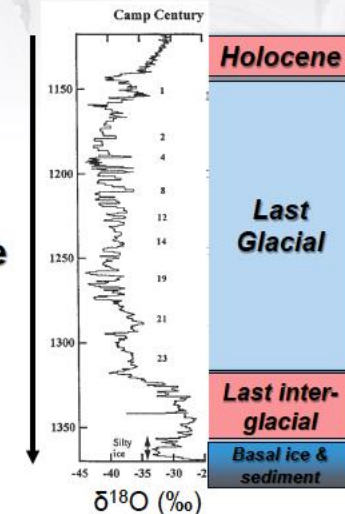
1. The GISP2 Bedrock Core

2. The Camp Century Basal Sediments

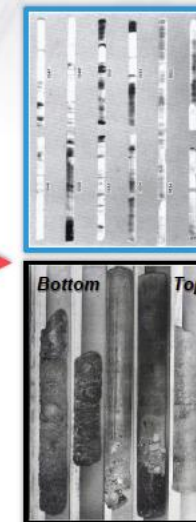


Retrieval of the ice core, c. 1966
CRREL, U.S. Army

1372 m
clean ice



Johnsen et al., 2001; Dansgaard et al., 1969



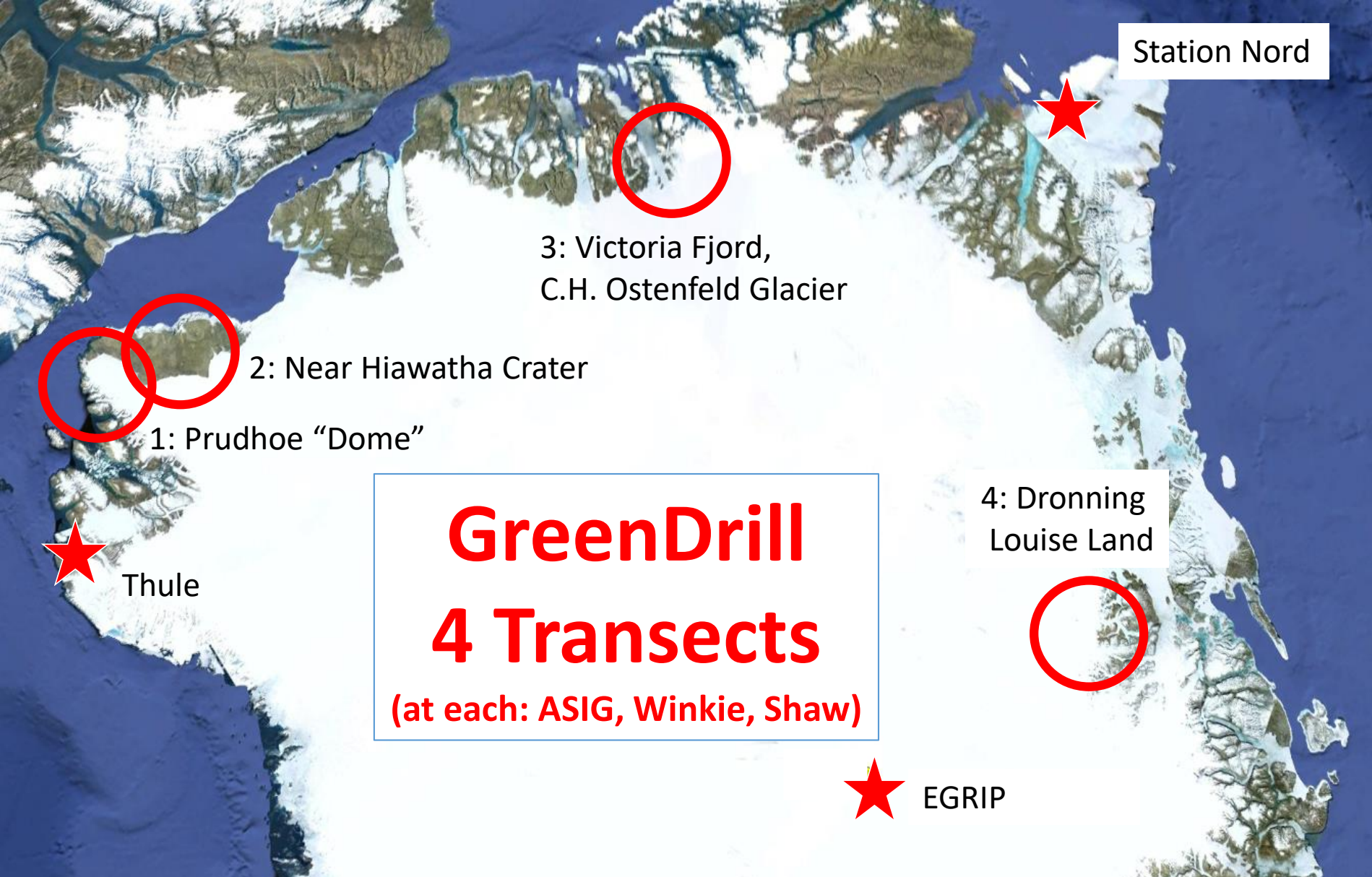
15.7 m of
basal silty ice

Herron & Langway, 1979

3.5 m of
frozen
subglacial
sediment

Fountain et al., 1981

Christ et al., 2021



@ transect
locations:

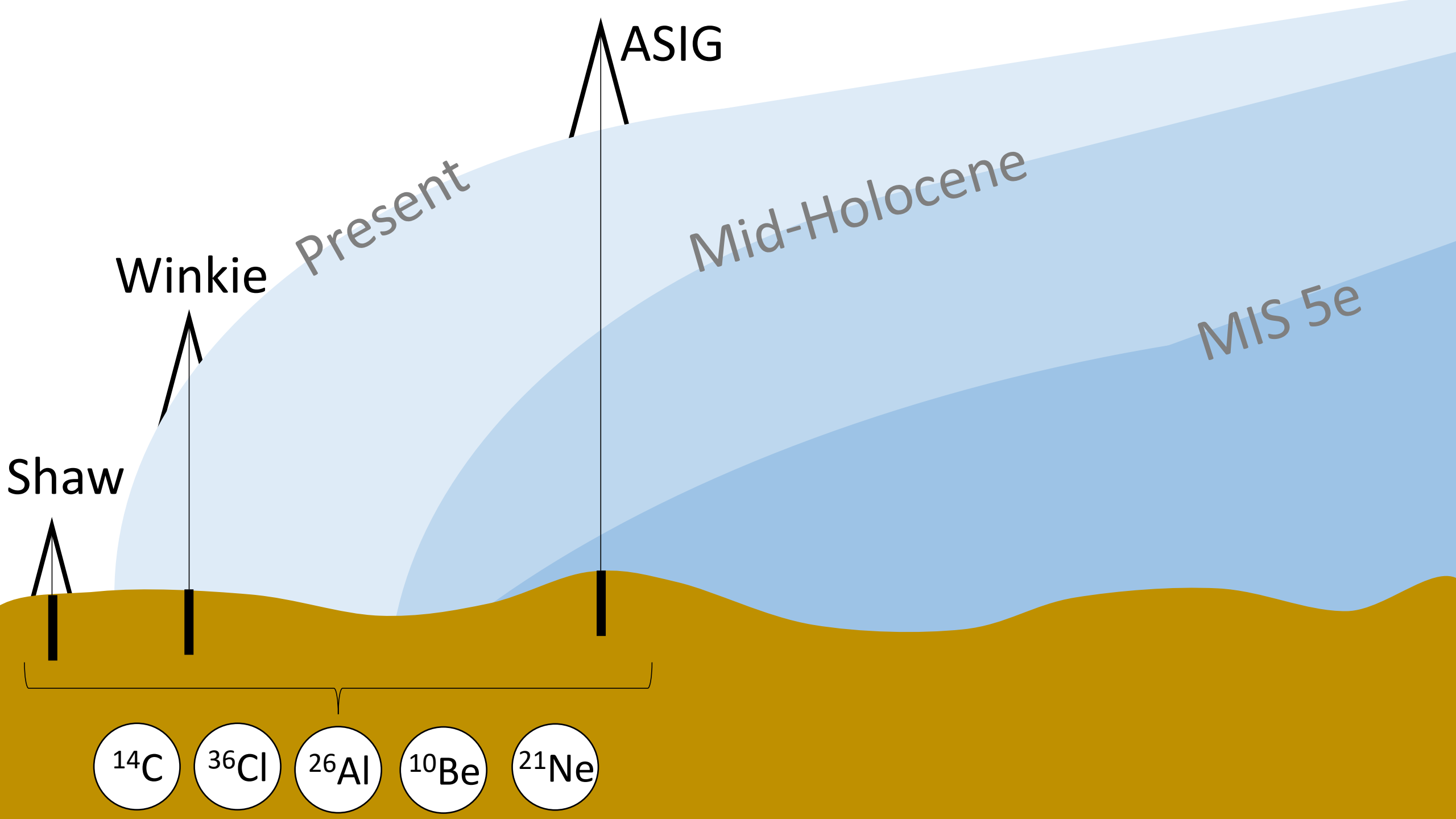
ASIG Drill site: 500-300
m ice thickness.

Winkie Drill site: 100 m
ice thickness

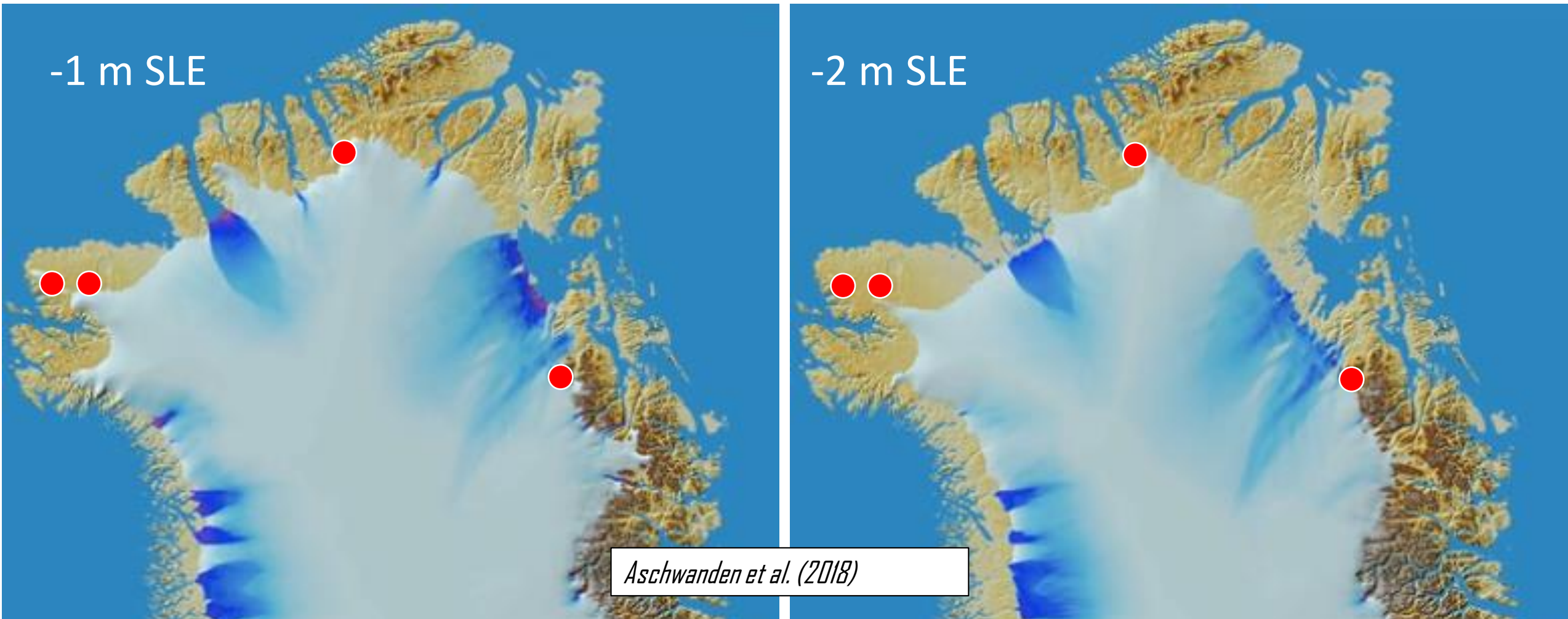
Shaw Drill sites: pro-
glacial landscape

We will target
4+ m-long
rock cores.
Drilling to
start in 2023

The selected sites check out for bedrock lithology; frozen bed; ASIG
>ELA = DC3 landing; ice thickness; Stars = landing strips/stations



The critical first few feet of SLR from Greenland: Where from?



- > Locations chosen to represent a range of sites to constrain ice sheet contributions to sea level during past interglacials.
- > At each of four locations, a range of drills will be used to acquire bedrock cores from a transect of sites.

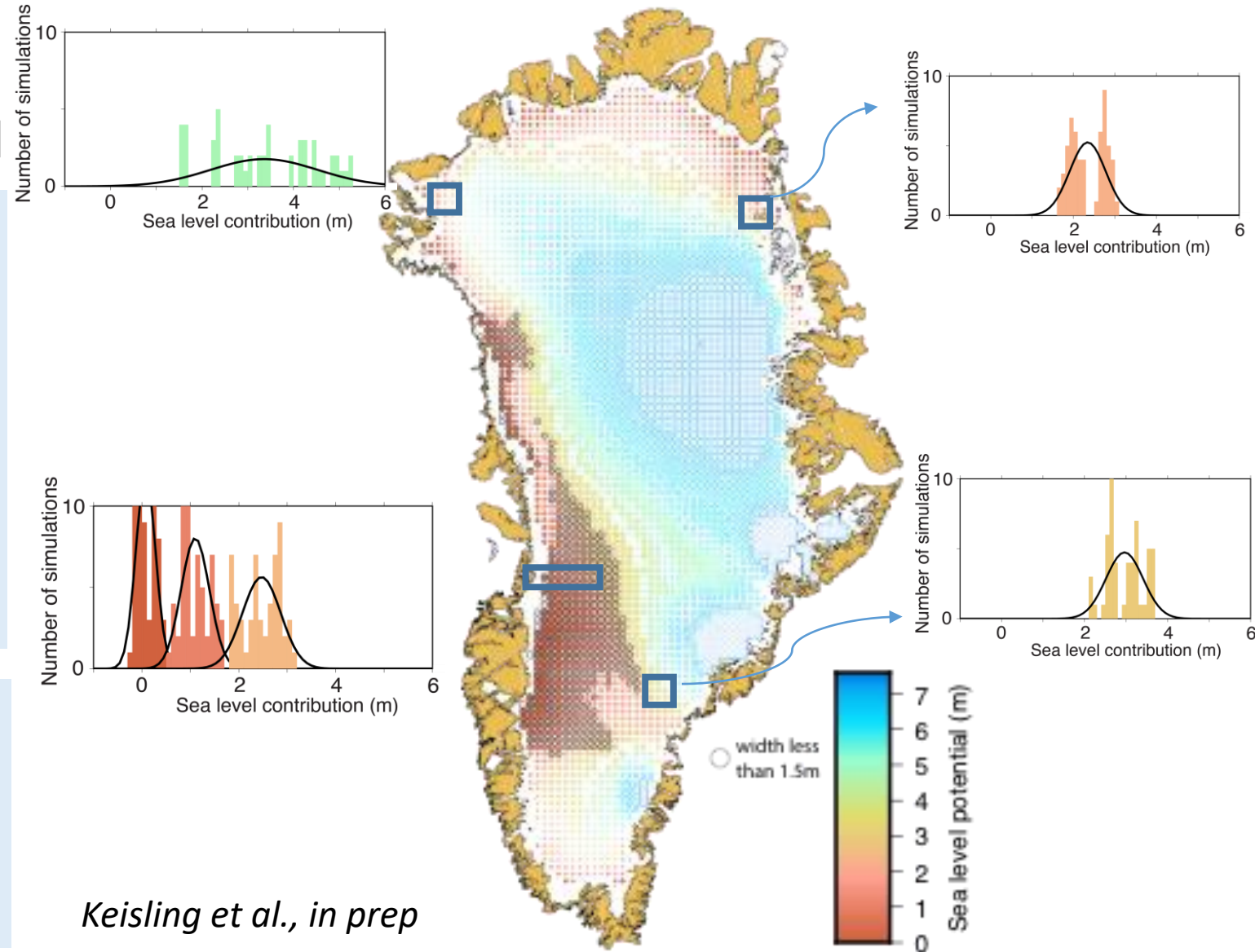
Ice sheet modeling to map Greenland's sea level potential

Ensemble of 96 simulations with varying:

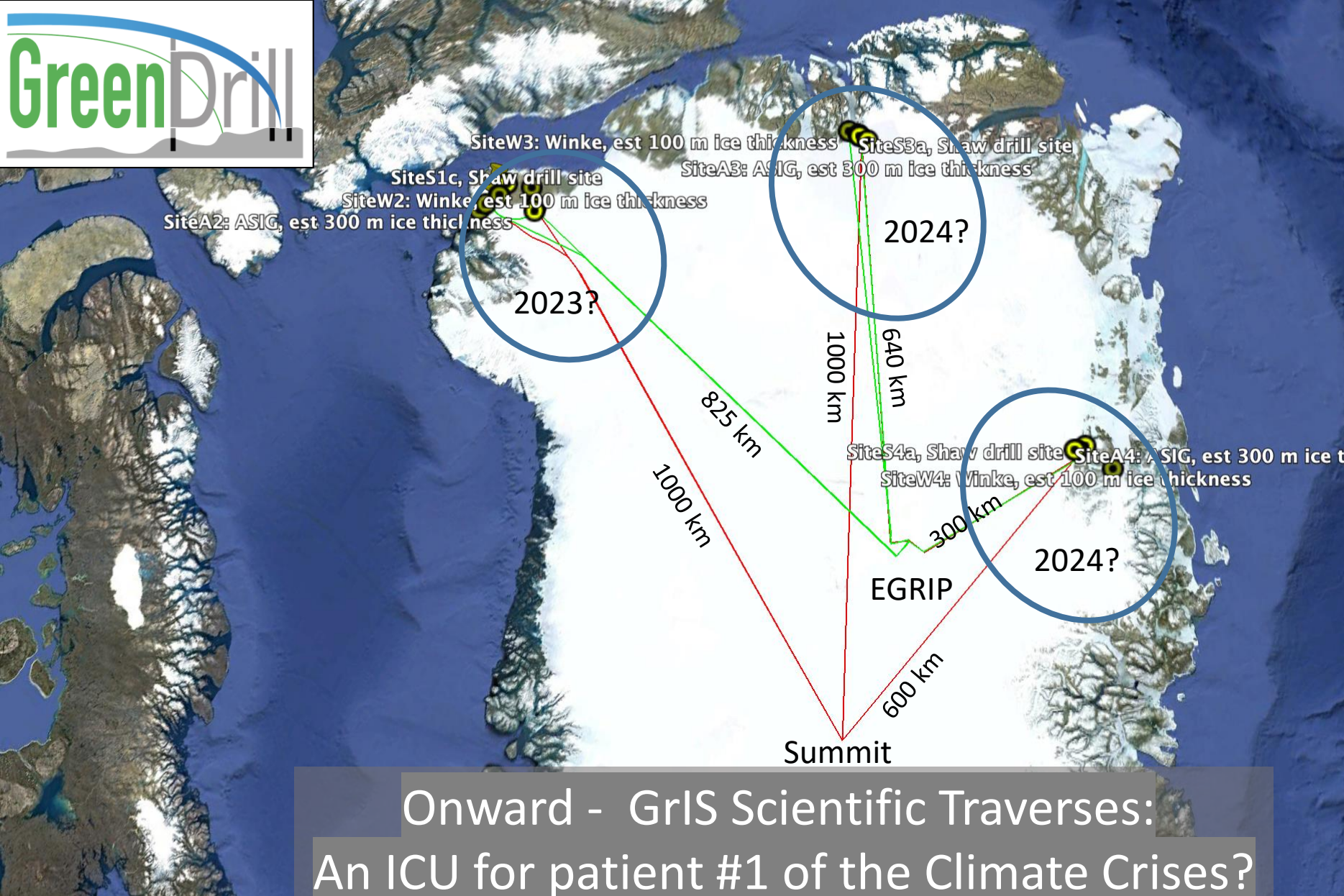
- Initial ice-sheet geometry
- Rate of interglacial warming
- Initial surface mass balance
- Lithospheric relaxation time
- Precipitation lapse rate

We are using this to determine where the first meters of sea level rise from Greenland likely came from in the past.

****stop by poster C35B-0882,
Wednesday 12/15 from 16:00-
18:00 to learn more!***



Total sea level contributed by Greenland when that location is ice-free (colors). Larger dots mean a smaller spread in the ensemble, e.g. a more robust prediction. Black outlines highlight areas where the width of the ensemble prediction is less than 1.5 meters.



Onward - GrIS Scientific Traverses:
An ICU for patient #1 of the Climate Crises?

Download the Workshop Report and get involved!

<https://icedrill.org/meetings/us-scientific-traverses-gris-planning-workshop>



Success!

RAID field trials 2019-20

routine use of 'packer' in firn to seal borehole

fast drilling in thick ice

penetration of glacial bed & retrieval of ice & rock cores

John Goodge
University of Minnesota Duluth

Jeff Severinghaus
Scripps Institution of Oceanography

Completion of 3 boreholes

Hole #1 – *Deep Aggravation*

- good packer set
- ice drilling to 140 m (460 ft)

Hole #2 – *Deep Together*

- slow & steady
- made it to bottom!
- 4 m core at 681 m (2,235 ft)
- borehole dust logging

Hole #3 – *Deep Speed*

- amped up penetration rate
- drilling to 442 m (1,450 ft)
- borehole dust logging

Annals of Glaciology



2021

Article

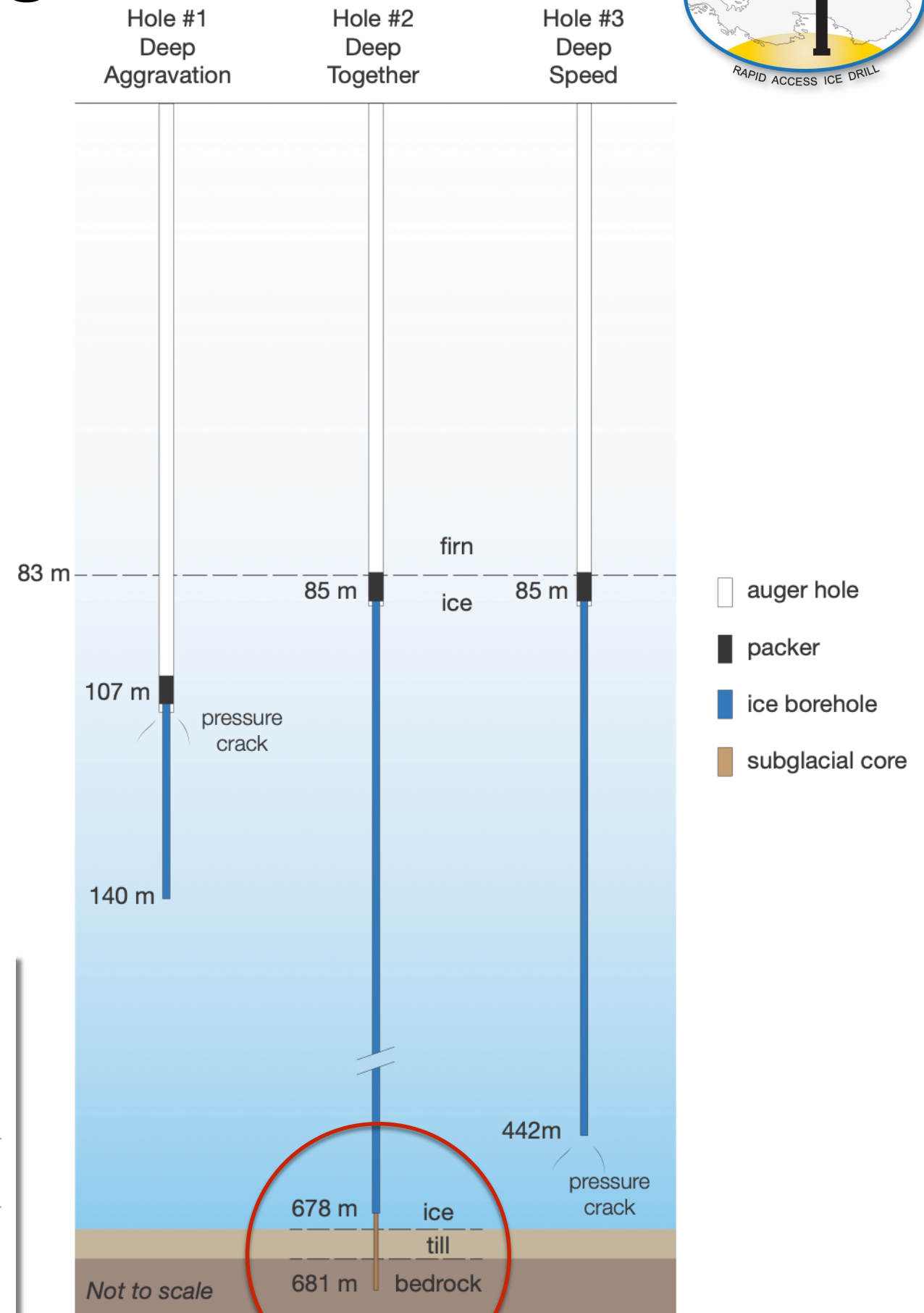
Cite this article: Goodge JW, Severinghaus JP, Johnson J, Tosi D, Bay R (2021). Deep ice drilling, bedrock coring and dust logging with the Rapid Access Ice Drill (RAID) at Minna Bluff, Antarctica. *Annals of Glaciology* 1–16. <https://doi.org/10.1017/aog.2021.13>

Deep ice drilling, bedrock coring and dust logging with the Rapid Access Ice Drill (RAID) at Minna Bluff, Antarctica

John W. Goodge¹, Jeffrey P. Severinghaus², Jay Johnson³, Delia Tosi⁴ and Ryan Bay⁵

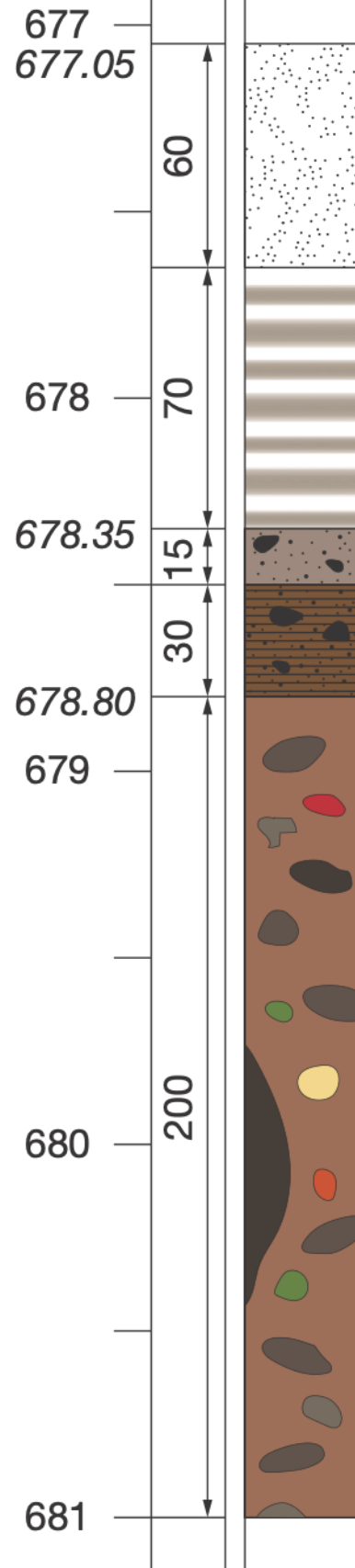
¹Department of Earth and Environmental Sciences, University of Minnesota, Duluth, MN 55812, USA; ²Scripps Institution of Oceanography, UC San Diego, La Jolla, CA 92093, USA; ³U.S. Ice Drilling Program, University of Wisconsin-Madison, Madison, WI 53706, USA; ⁴Wisconsin IceCube Particle Astrophysics Center, University of Wisconsin-Madison, Madison, WI 53703, USA and ⁵Department of Physics and Space Sciences Laboratory, UC Berkeley, Berkeley, CA 94720, USA

AFT3 MINNA BLUFF



Depth (m) Thickness (cm)

Minna Bluff Hole #2



top of core

glacial ice, with flecks of dark, gritty rock debris

dirty, banded ice

soft, muddy till containing pebbles and grit

hard, dry, compacted till

heterolithic tillite containing rock clasts of volcanic, hypabyssal igneous, and hydrothermally altered rock

bottom of core





Partnership – RAID is a partner in COLDEX initiative

- deep boreholes for oldest-ice exploration
- in collaboration with geophysics & Ice Diver

Goals – prepare for Plateau drilling by 2024

- engineering upgrades & enhancements in 2022
- McMurdo deployment in 2023-24
- readiness for science drilling beginning in 2024-25
- initial targets focused on corridor between South Pole and Dome A



[What is RAID? ▾](#)

[Development ▾](#)

[Get Involved ▾](#)

[Learn ▾](#)

[Blog](#)

[Contact](#)



- join the RAID community (contact a PI)
- identify sites, study samples (ice, bed, rock) or borehole access

RAPID ACCESS ICE DRILL

The Rapid Access Ice Drill (RAID) will drill a borehole through deep Antarctic ice into the glacial bed and bedrock below. This new technology will provide access to the interface between major ice caps and their subglacial features.

[Learn More](#)



DRILLING UPS AND DOWNS

Jan 14, 2020

I'd like to say that we are on schedule and that everything has gone according to plan! But that is not the reality of drilling in Antarctica when you're developing an entirely new approach. We've had steady downward progress, that much is good, and we've passed...

[read more](#)



AGU Town Hall TH010
Scientific Drilling in the Polar Regions

**Questions or announcements
from the audience?**

Thanks for participating!