The South Pole ice core (SPICEcore) project

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Abstract

The stable isotope, aerosol, and atmospheric gas records in ice cores provide exceptional archives of past climate. Supported by the U.S. National Science Foundation (Office of Polar Programs – Antarctic Glaciology), a new 1,750-meter long ice core (SPC14) was recovered from South Pole, Antarctica, during the 2014-2015 (0 to 736 m) and 2015-2016 (736 to 1750 m) field seasons. SPC14 is the highest resolution interior East Antarctic ice core that extends into the glacial period. It provides a record of the climate history of a unique area of the East Antarctic plateau that is partially influenced by weather systems that cross the West Antarctic ice sheet. The SPICEcore project also includes novel measurements of ultra-trace level atmospheric gases that are made feasible by the very cold temperatures, low impurity levels, and the relatively high accumulation rate at the South Pole. Preliminary estimates of the timescale suggest that the ice at 1750 meters depth is ˜54,000 years in age and therefore the SPICEcore project contributes towards the International Partnerships in Ice Core Sciences (IPICS) goal to create a bipolar network of ice core climate and climate forcing records for the last 40,000 years. This presentation provides a high-level overview of the SPICEcore project.

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The South Pole Ice Core (SPICEcore) Project

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ABSTRACT

The stable isotope, aerosol, and atmospheric gas records in ice cores provide exceptional archives of past climate. Supported by the U.S. National Science Foundation (Office of Polar Programs – Antarctic Glaciology), a new 1,750-meter long ice core (SPC14) was recovered from South Pole, Antarctica, during the 2014-2015 (0 to 736 m) and 2015-2016 (736 to 1750 m) field seasons. SPC14 is the highest resolution interior East Antarctic ice core that extends into the glacial period. It provides a record of the climate history of a unique area of the East Antarctic plateau that is partially influenced by weather systems that cross the West Antarctic ice sheet. The SPICEcore project also includes novel measurements of ultra-trace level atmospheric gases that are made feasible by the very cold temperatures, low impurity levels, and the relatively high accumulation rate at the South Pole. The preliminary timescale suggests that the ice at 1750 meters depth is ~54,000 years in age. Therefore the SPICEcore project also contributes towards the International Partnerships in Ice Core Sciences (IPICS) goal to create a bipolar network of ice core climate and climate forcing records for the last 40,000 years.

SITE CHARACTERISTICS

Latitude	89°59’ 20.168” S
Longitude	98°09’ 34.528” W
Altitude	2835 m a.s.l.
Ice thickness	2700 m
Accumulation rate	8 cm w.e.a^{-1} (20 cm snow)
Ice velocity	10 ma^{-1} along 40°W
Mean annual temperature	-49°C (-56°F)
15 m depth firn temperature	-51°C (-60°F)

LOCATION

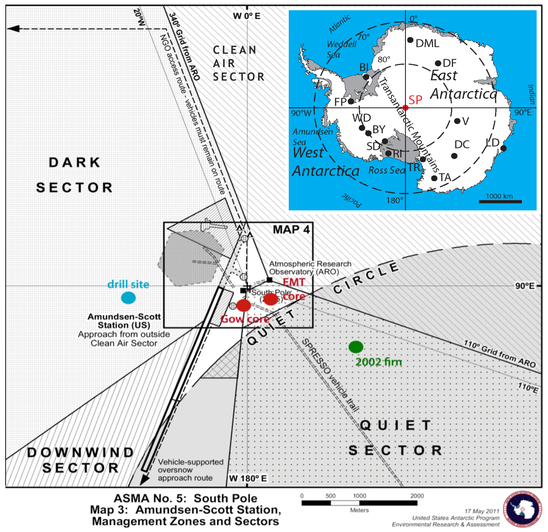

FIGURE 1. South Pole (SP, inset) drill site (blue circle) relative to dark, clean air, quiet and downwind sectors.

Also shown are prior South Pole firn and ice cores (EMT - Mosley-Thompson, 1980; Gow - Kuivinen, 1983; 2002 firn - Aydin et al., 2008).

The drill site is approximately 2.7 km from South Pole Station at 89°59’ 20.168” S, 98°09’ 34.528” W.

DRILLING OPERATION

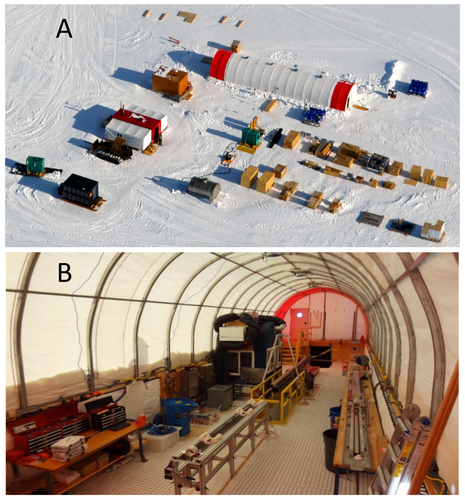

FIGURE 2. Panel A shows an aerial view of the drill site, located about 2 km from South Pole Station. The drilling took place inside the long red and white tent. The drill tent is a 19.5 m L x 4.9 m W x 2.8 m H un-insulated WeatherPORT tent.

Panel B shows the inside of the drilling tent.

The Ice Drilling Design and Operations (IDDO) group at the University of Wisconsin-Madison designed and built the drilling system, called the Intermediate Depth Drill (IDD). Based on the Danish Hans-Tausen drill (Johnson et al., Annals Glac. 2014), the IDD was purpose-built for coring 1,500+ meters of ice.

GENERALIZED CUT PLAN

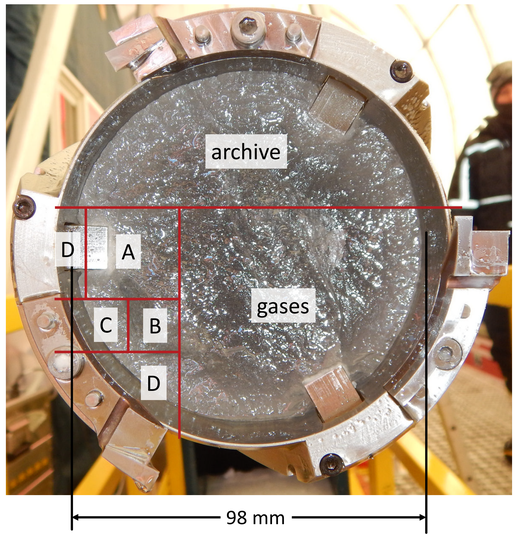

FIGURE 3. Generalized cut plan of the 98 mm diameter SPC14 ice core.

The ice core was cut and sampled at the National Science Foundation Ice Core Facility in Lakewood, CO, during the summer of 2015, 2016, and 2017.

Over 10,200 samples have been cut to date from the ice core and sent to 14 individually funded institutions for analysis.

A: chemistry
B: continuous water isotopes
C: discrete water isotopes
D: Beryllium-10

DEPTH-AGE SCALE AND ANNUAL LAYER THICKNESS

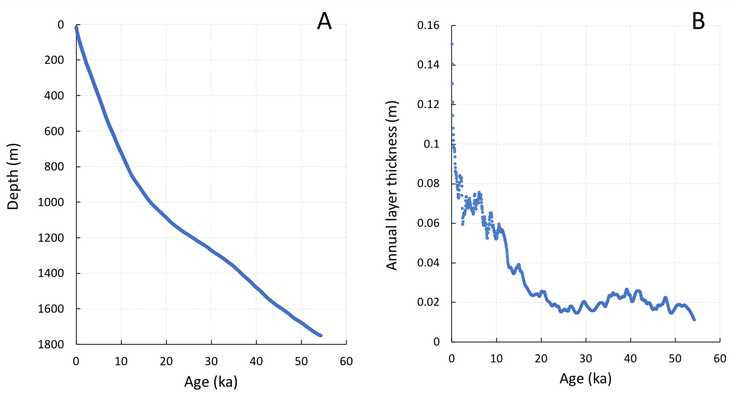

FIGURE 4. Panel A shows the preliminary depth-age (ice) scale (SPC14-03) in the SPC14 ice core. The depth-age scale to 1463 meters is tied to the WAIS Divide ice core depth-age scale (WD2014) primarily using sulfate, but also ECM. Below 1463 meters, the depth-age scale is tied to WAIS Divide using only ECM. Annual layers to 798 meters depth are used to interpolate between the WAIS Divide tie points. Below 798 meters, the ages between ties points are interpolated by finding the smoothest annual layer thickness. Panel B shows annual layer thicknesses calculated from the depth-age scale. The annual layer thicknesses shown are smoothed with a 200-year sliding window and then averaged over 50-years.

FUNDED SCIENCE/MEASUREMENTS

Gases
Carbonyl Sulfide, Methyl Chloride, Methyl Bromide – M. Aydin, E. Saltzman, M. Nicewonger
Ethane and Acetylene – M. Aydin, M. Nicewonger
Methane, Inert Gases ($\delta^{15}N$, $\delta^{40}Ar$), ^{18}O of O_2, O_2/N_2 –J. Severinghaus, E. Brook, T. Sowers, C. Buizert
Carbon Monoxide (and CO Isotopes) – V. Petrenko, J. Mak
Carbon Dioxide and Nitrous Oxide - E. Brook
Total Air Content, Gas Age Scale – E. Brook, J. Epifanio

Stable Isotopes, Aerosols/Chemistry, Chronology
Water Isotopes (δD, $\delta^{18}O$, $\Delta^{17}O$) – E. Steig, J. White, B. Vaughn, E. Kahle
Trace Elements, Major Ions, Particles, Conductivity – E. Osterberg, K. Kreutz, J. Cole-Dai, D. Winski
Beryllium-10 – J. Schaefer, E. Steig
Timescale, Accumulation History – T. Fudge, D. Winski, J. Fegyveresi, J. Epifanio, C. Buizert, et al.
Laser Dust Logging of SPICEcore Borehole – R. Bay

Physical Properties, Volcanics, Ice Dynamics
Electrical Conductivity – E. Waddington, T.J. Fudge
Physical Properties – R. Alley, J. Fegyveresi
Tephrochronology – N. Dunbar, A. Kurbatov, N. Iverson
Upstream Ice and Firn Dynamics – M. Koutnik, E. Waddington, H. Conway, T.J. Fudge, D. Lilien, M. Stevens, R. Hawley, E. Osterberg

Institutions Involved
Columbia Univ.
Dartmouth College
New Mexico Tech
Oregon State Univ.
Penn State Univ. / CRREL
Scripps Inst. Oceanography
South Dakota State Univ.
Stony Brook Univ.
Univ. California, Berkeley
* Univ. California, Irvine
Univ. Colorado Boulder
Univ. Maine
Univ. New Hampshire
Univ. Rochester
Univ. Washington

* Lead Institution, Dr. Murat Aydin

2018 AGU FALL MEETING PRESENTATIONS

TALKS

U13B-17 **Past temperature and snow accumulation at the South Pole from ice-core water-isotope diffusion** Emma Kahle, Mon, 10 Dec, 14:29 - 14:32, Walter E. Washington Convention Ctr, eLightning Theater I

C52A-02 **Ice core measurements of ethane and acetylene over the last 2,000 years and implications for preindustrial biomass burning variability** Melinda Nicewonger, Fri, 14 Dec, 10:35 - 10:50, Walter E. Washington Convention Ctr, Salon H

C52A-06 **Time-scale independent patterns of Antarctic temperature change** Bradley Markle, Fri, 14 Dec, 11:35 - 11:50, Walter E. Washington Convention Ctr, Salon H

POSTERS

Walter E. Washington Convention Ctr
Tues, 11 Dec, 13:40 - 18:00
V23M-0222 **Transcontinental Tephra: Linking the East and West Antarctica volcanic record through SPICEcore** Nels Iverson

Thurs, 13 Dec, 08:00 - 12:20
C41C-1750 **Measurement and interpretation of bubble number-density evolution through the upper 1200 meters of the SPC14 South Pole Ice Core (SPICEcore)** John Fegyveresi

C41C-1757 **New developments in evaluation of record of global volcanism from polar ice cores** Andrei Kurbatov

C41C-1762 **Holocene Fractional Trace Element Concentrations from the South Pole Ice Core (SPICEcore)** Aaron Chesler

C41C-1768 **Carbonyl Sulfide Variability over the Last 40,000 Years from the Intermediate Depth Ice Core Drilled at South Pole, Antarctica** Murat Aydin

C41C-1769 **Gas age scale and total air content record for the South Pole ice core** Jenna Epifanio

C41C-1770 **Firn Smoothing of Abrupt Methane Variations in the South Pole Ice Core** Ekaterina Elena Hood

ACKNOWLEDGEMENTS
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Johnson, JA, Shturmakov, TW Kuhl, N Mortensen, CJ Gibson. Next generation of an intermediate depth drill. *Ann. Glaciol.* 55(68), 27-33, 2014.
Kuivinen, K. A 237-m ice core from South Pole Station. *Ant. J. US*, 18(5), 113-114, 1983.
Mosley-Thompson, E. 911 years of microparticle deposition at the South Pole: a climatic interpretation. *Inst. Polar Stud. Rep. 73*, 1980.
Nicholas JP, DH Bromwich. Climate of West Antarctica and influence of marine air intrusions. *J. Climate*, 2(1), 49-67, 2011.