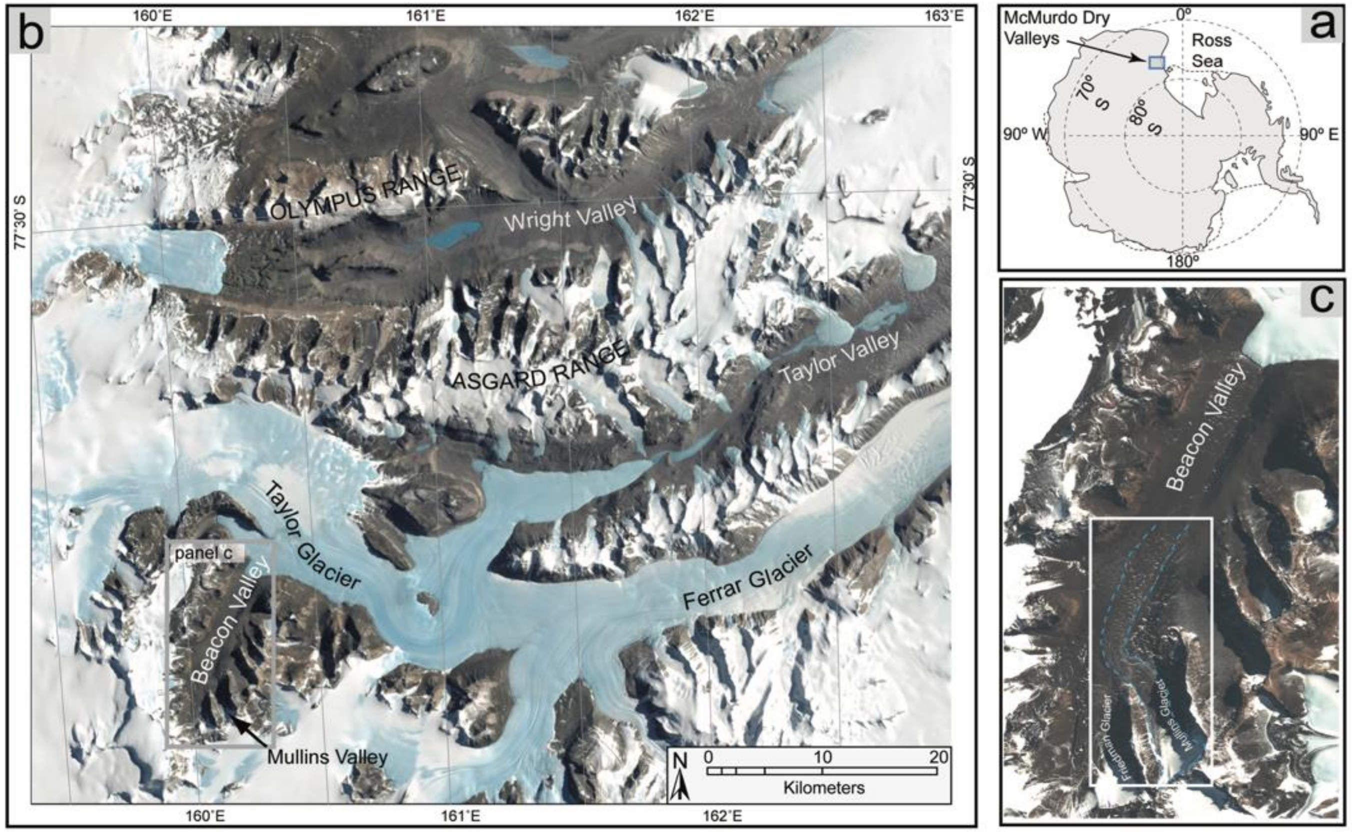
Beacon/Mullins Valley Cores - Background Information

- **VERY OLD buried ice deposits from the MCM Dry Valleys**.
- Not "typical" ice cores because of their high mixed ice/sediment content.
- Mixed ice/sediment cores aren't supposed to be at the NSF Ice Core Facility. Most cores shouldn't be cut in the exam room because of their high sediment content.
- Collected by David Marchant (2004/05; G-054-M), Kate Swanger (2006/07; G-054-M), and Michael Bender (2008/09, 2009/10; G-070-M).
- Metadata for the cores is sparse. Some info in MacKay et al. (2014) https://doi.org/10.1002/2014JF003178, Swanger (2017) https://doi.org/10.1017/S0954102016000687, and Grimm et al. (2015) https://doi.org/10.3189/2015JoG15J113
- Shipped directly from Antarctica to the NSF-ICF and have remained in the main archive freezer since then.
- The cores have remained at the NSF-ICF, with little interest in them from the scientific community. In 2023 and 2024, there were several unsuccessful attempts with community members to try and find a new home (Oregon State Univ marine and geology repository, WHOI) for the cores.
- **Please tell your community members about these cores!!!** Go to https://icecores.org/inventory/beacon-and-mullins-valley and download the "**Beacon/Mullins Valley PDF document**" for more information (including pictures) about these cores.

Beacon/Mullins Valley Cores – Summary of NSF-ICF Archive

Core ID Type	Location	Year Drilled	Event #	Core ⌀	Original PI	# Cores in Inventory	# Meters in Inventory
MCI04-###	Mullins Valley	2004	G-054-M	8.19 cm (3.2 inch)	D. Marchant	18	~44
DC06-### SC06-###	Mullins Valley Kennar Valley	2006	G-054-M	7.6 cm (3 inch)	K. Swanger / D. Marchant	44 2	~118 ~4
MCI-008-###	Beacon Valley Mullins Valley	2008	G-070-M	7.6 cm (3 inch)	M. Bender / D. Marchant	3	~28
MCI-009-###	Beacon Valley	2009	G-070-M	7.6 cm (3 inch)	M. Bender / D. Marchant	3	~58



Site map from Mackay and others, 2016 (Supplemental_2).
https://doi.org/10.1016/j.quascirev.2016.03.013

2004-2005 Field Season

Age, origin, and climatic significance of buried ice in the western Dry Valleys

Program Manager: Dr. Thomas Wagner
Event Number: G-054-M
ASC POC/Implementer: Melissa Rider

Dr. David R. Marchant (Principal Investigator)
Boston University
Department of Earth Sciences

Supporting Stations: McMurdo Station
Research Locations: **Western Olympus Range, Asgard Range, upper Beacon Valley and adjacent valleys in the Quartermain Mountains, Kennar Valley**

Research Objectives:
Buried ice deposits represent an exciting and potentially far-reaching archive of atmosphere and climate on Earth extending back for many millions of years. These deposits are terrestrial analogs to widespread and young buried ice on the Martian surface as identified by recent data from Mars Odyssey.

This project will evaluate the age, origin, and climatic significance of buried ice in the western Dry Valleys region. These and other researchers have published evidence that the ice to be examined is over a million years in age, making it by far the oldest ice yet known on this planet.

An alternative view is that the buried ice is more recent segregation ice produced from the in-situ freezing of groundwater. Distinguishing between these hypotheses is key to understanding Neogene climate change of Antarctica. First steps toward addressing this question have shown that glacier ice, far older than in the Vostok ice core (420,000 yrs), exists in Mullins Valley, southern Victoria Land, and that it contains the typical "saw-tooth" pattern for downcore changes in dD and d18O that so characterize climate records in late Quaternary ice cores.

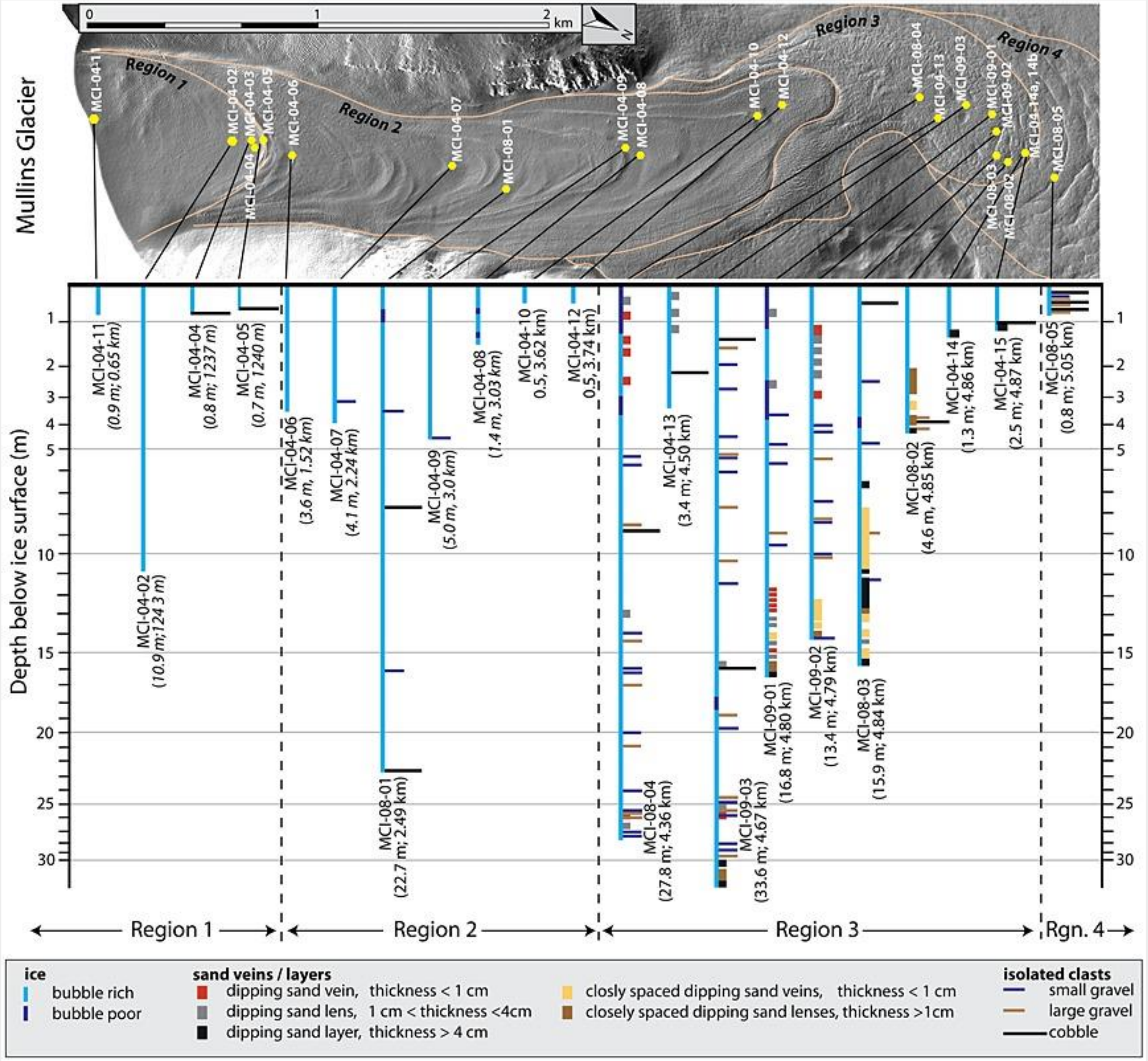
The project team comprises a diverse research group with expertise in Antarctic geomorphology, numerical modeling, cosmogenic dating, 40Ar/39Ar analyses, ice-core analyses, and ice-core drilling technology. The interdisciplinary research program proposes to:

- Understand better the surface processes that permit ice preservation,
- Test the efficacy of cosmogenic and 40Ar/39Ar analyses in dating tills above buried ice,
- Further assess the use of cosmogenic-nuclide analyses and 40Ar/39Ar analyses of ashfall deposits to date buried ice, and
- Use these data to help resolve the debate between "young" and "old" ice scenarios.

Deploying Team Members:
James W. Head, Douglas Kowalewski, Joseph Levy, Adam R. Lewis, David R. Marchant, Rebecca Parsons, Joerg Schaefer, David Shean, Kate Swanger

Cores at NSF-ICF

MCI04-###	Mullins Valley	8.19 cm (3.2 inch) ⌀	18 cores in inventory; ~44 meters total



From MacKay et al., 2014. https://doi.org/10.1002/2014JF003178

Location and description of ice cores collected from Regions 1–4 of Mullins Glacier. Depth and general englacial characteristics for each core are shown in the second panel. In general, the majority of ice cores from Regions 1 and 2 show clean, bubbly glacial ice with isolated gravels and cobbles (existing cores in Region 2 do not penetrate IDL). Ice cores in Region 3 uniformly show increasing amounts of gravel-and-cobble-sized clasts, as well as abundant sand veins filled with sand-and-granule-sized grains of quartz and dolerite grus (e.g., local infill of thermal contraction cracks [Kowalewski et al., 2011]). Ice from Region 4 contains up to 50% gravel-and-cobble-sized clasts, and, with increasing distance down valley, an ever increasing concentration of sand veins. As such, ice-core penetration in Region 4 is minimal, and with existing drill technology (KOCI drill [Green et al., 2007]) is limited to <1 m depth.

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3.3 Ice Core Drilling
We collected 21 shallow ice cores along the central flowline of Mullins glacier (Figure S1). Seven relatively deep cores (15–30 m) were extracted using an electrically driven Koci Drill designed and manufactured by Ice Core Drilling Services for use in both clean and dirty ice glaciers [*Green et al.*, 2007]. Fourteen shallow cores, each ≤ ~5 m, were obtained using Snow, Ice, and Permafrost Research Establishment and Kovacs Mark II hand corers; core recovery at all sites was >95%. Drill sites were cleared of supraglacial debris (if present), photographed, and georeferenced using high-resolution GPS. To protect the pristine environment, no drilling fluids were used. Drill heads on the KOCI drill were changed from ice cutters to rock-drilling heads whenever isolated rocks and/or thick (>10 cm wide) sand wedges were encountered [*Green et al.*, 2007; *Kowalewski et al.*, 2011]. Maximum penetration using the KOCI drill was ~30 m (at MCI-09-03); the primary obstacle in drilling deeper was frictional heat (increasing the probability of drill entrapment downhole via the refreezing of meltwater) generated by cutting through rock and ice-rich sediment.

4.4.1.2. Ice-Core Data
Four shallow ice cores (maximum depth of 11 m for core MCI-11-02) obtained from Region 1 of Mullins Glacier all show clean, bubbly ice that is largely devoid of debris (Figure 7). Cores that penetrate the region of superposed ice in the distal end of Region 1 met refusal (additional penetration became impossible) at a shallow, horizontal rocky layer at ~80–90 cm. This rocky layer, visible at the lateral margins of the superposed ice, is well displayed in GPR profiles using a 200 MHz antenna [see Shean and Marchant, 2010].

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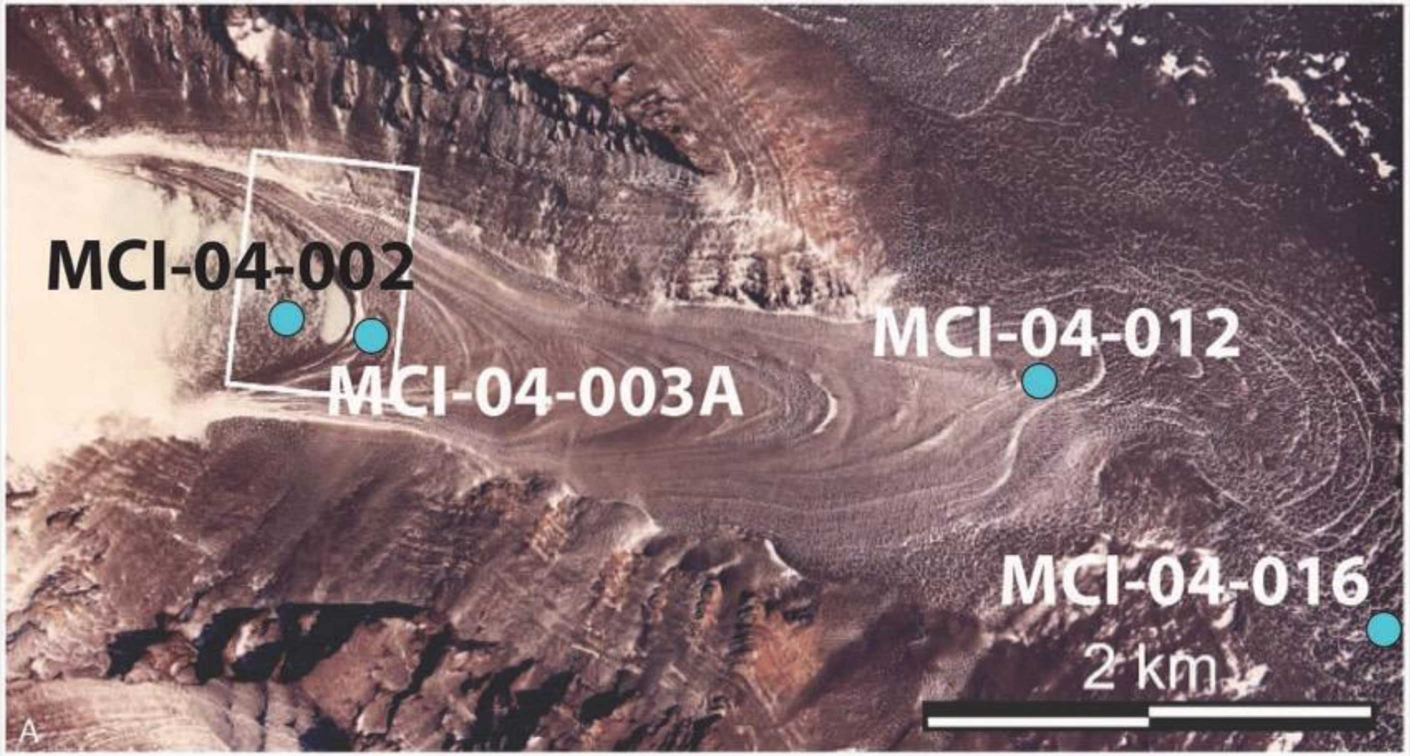

Upper Mullins Valley debris covered glacier. Source: Doug Kowalewski email to Mark Twickler, June 2014.

2006-2007 Field Season

Age, Origin, And Climatic Significance Of Buried Ice In The Western Dry Valleys

Program Manager: Dr. Dr. Thomas Wagner
Event Number: G-054-M
ASC POC/Implementer: Michael McClanahan

Dr. Kate Swanger (Principal Investigator) Kate_Swanger@uml.edu
University of Massachusetts
Lowell, Massachusetts

Supporting Stations: McMurdo Station
Research Locations: McMurdo Dry Valleys

Project Description:
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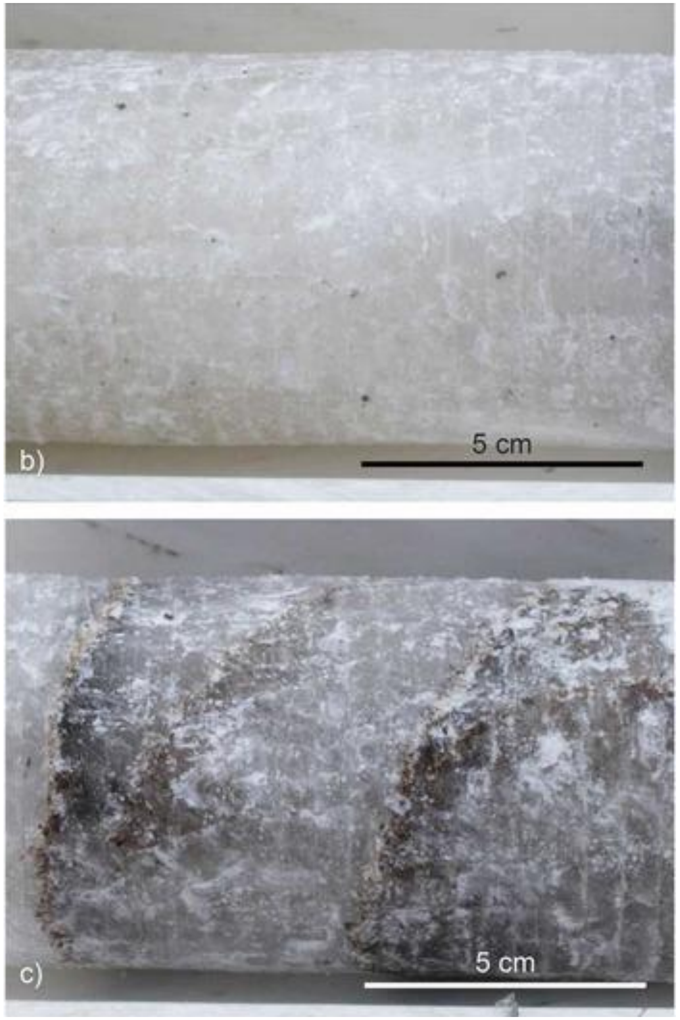
Cores at NSF-ICF

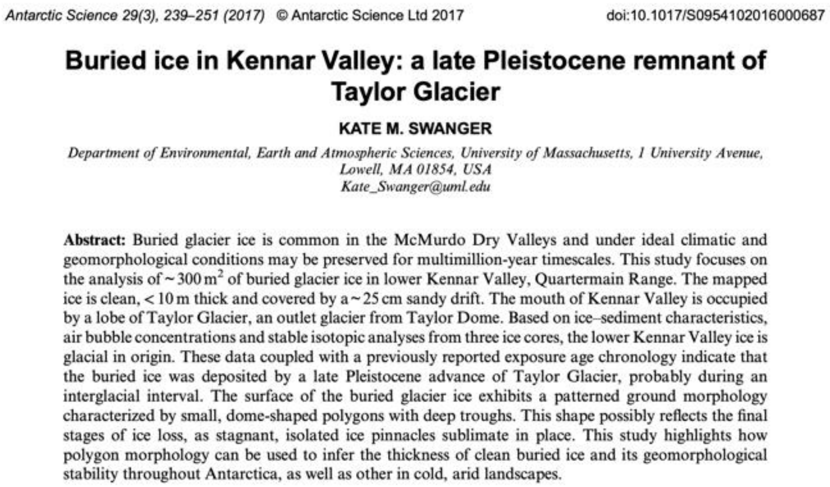
DC06-###	Mullins Valley	unknown ⌀	44 cores in inventory; ~118 meters total
SC06-###	Mullins Valley	unknown ⌀	2 cores in inventory; ~4 meters total

NSF-ICF Database Notes: These cores were collected by Dave Marchant and delivered to the NICL with the 2007 Antarctic Retro. They are from Mullins Valley in the Dry Valleys.



From Swanger, 2017, Figure 4.
https://doi.org/10.1017/S0954102016000687

b) Ice core DC-06-52, 40–50 cm depth, top of ice core is on the right.
c) Ice core DC-06-52, 30–40 cm depth, top of ice core is on the right.
b) & c) show the range in sediment concentrations common across cores.



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Buried ice in Kennar Valley: a late Pleistocene remnant of Taylor Glacier

KATE M. SWANGER
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Kate_Swanger@uml.edu

Abstract: Buried glacier ice is common in the McMurdo Dry Valleys and under ideal climatic and geomorphological conditions may be preserved for multimillion-year timescales. This study focuses on the analysis of ~ 300 m^2 of buried glacier ice in lower Kennar Valley, Quartermain Range. The mapped ice is clean, < 10 m thick and covered by a ~ 25 cm sandy drift. The mouth of Kennar Valley is occupied by a lobe of Taylor Glacier, an outlet glacier from Taylor Dome. Based on ice–sediment characteristics, air bubble concentrations and stable isotopic analyses from three ice cores, the lower Kennar Valley ice is glacial in origin. These data coupled with a previously reported exposure age chronology indicate that the buried ice was deposited by a late Pleistocene advance of Taylor Glacier, probably during an interglacial interval. The surface of the buried glacier ice exhibits a patterned ground morphology characterized by small, dome-shaped polygons with deep troughs. This shape possibly reflects the final stages of ice loss, as stagnant, isolated ice pinnacles sublimate in place. This study highlights how polygon morphology can be used to infer the thickness of clean buried ice and its geomorphological stability throughout Antarctica, as well as other in cold, arid landscapes.

2006-2007 Field Season

Age, Origin, And Climatic Significance Of Buried Ice In The Western Dry Valleys

Program Manager: Dr. Dr. Thomas Wagner
Event Number: G-054-M
ASC POC/Implementer: Michael McClanahan

Dr. Kate Swanger (Principal Investigator) Kate_Swanger@uml.edu
University of Massachusetts
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Supporting Stations: McMurdo Station
Research Locations: McMurdo Dry Valleys

Project Description:
This project will investigate two aspects the Dry Valley environment as analogues for conditions on Mars: Buried ice deposits and microclimates. Buried ice deposits represent an exciting and potentially far-reaching archive of atmosphere and climate on Earth extending back for many millions of years. These deposits are terrestrial analogs to widespread and young buried ice on the Martian surface as identified by recent data from Mars Odyssey. This project will evaluate the age, origin, and climatic significance of buried ice in the western Dry Valleys region. Microclimates of the Dry Valleys hold implications for landscape evolution and climate change on Mars. The Antarctic Dry Valleys are commonly viewed as a relatively fixed cold polar desert with little internal variation. Recent analyses have shown that there are three fundamentally different microclimate zones within this general 'stereotypical' cold polar desert, and that these may hold the keys to climate change on Mars.

Field Season Overview:
The field team plans to pursue a two-pronged study plan. One group of researchers will attempt to determine the age, origin, and climate significance of buried ice in the western Dry Valleys region. The other will study Dry Valley microclimates to better understand ancient and current climate processes on Mars. The first group will travel by helicopter to set up a field camp in Beacon Valley. This team will drill and collect no less than 15 cores from buried ice. The cores will be packaged in the field and returned to McMurdo for safe storage until they are shipped to the home institution for analysis. The second group will travel by helicopter to establish a field camp at Don Juan Pond. This team plans to document the range of surface geomorphic processes in at least three discrete microclimate zones in the Dry Valleys (a coastal-thaw zone, and inland-mixed zone, and a stable-upland zone).

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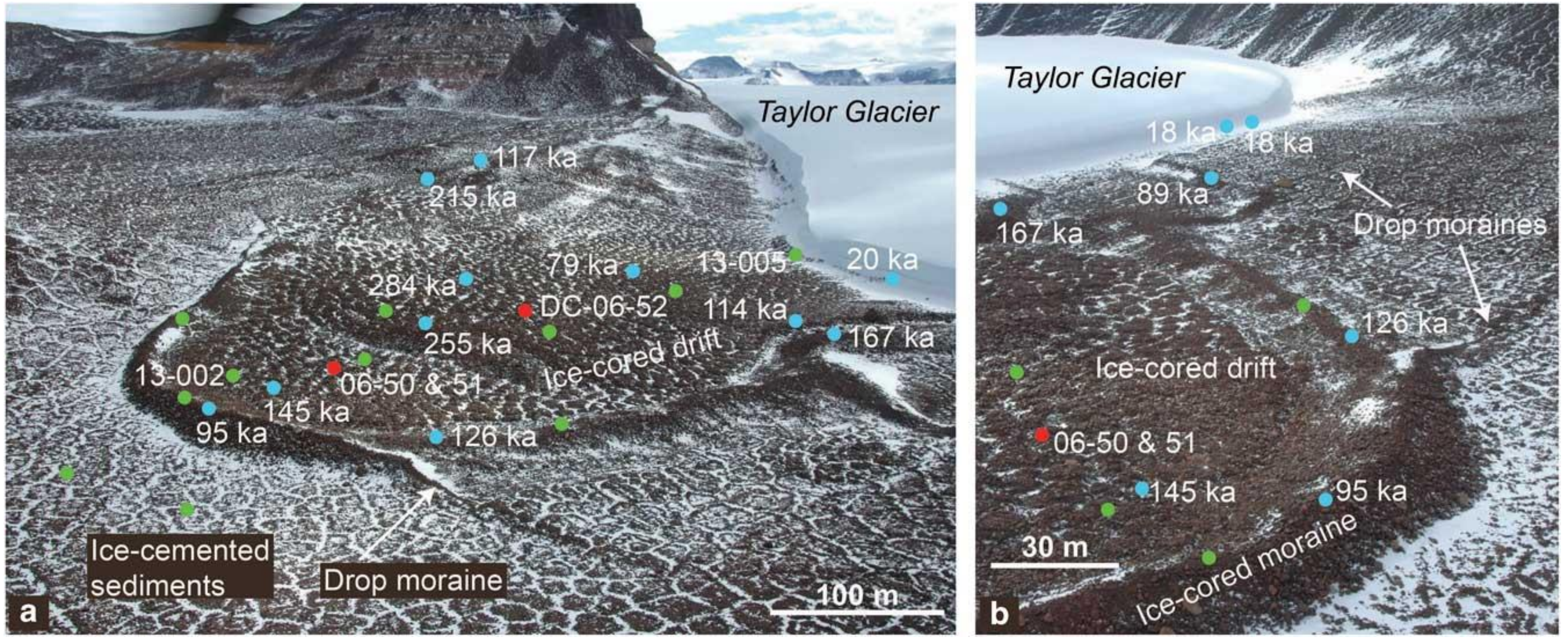

From Swanger, 2017, Figure 2. https://doi.org/10.1017/S0954102016000687

Oblique aerial photographs of the ice-cored drift, ice-cored moraines and drop moraines in lower Kennar Valley, adjacent to the modern lobe of Taylor Glacier. Blue circles=uncorrected 3He exposure ages of surface clasts (Swanger et al. Reference Swanger, Marchant, Schaefer, Winckler and Head III2011). The three youngest dates (18–20 ka) are from clasts imbedded in Taylor Glacier terminus. Red circles=ice cores. Green circles=sediment excavations. Labels refer to excavations specifically referenced in text, with additional (unlabelled) excavations that were used in analyses. Note complex moraine–drift relationships, indicating multiple advances and retreats of Taylor Glacier. a. Image is looking north and b. image is looking east.

06-50, 06-51, and DC-06-52 are archived at the NSF-ICF.

2006-2007 Field Season

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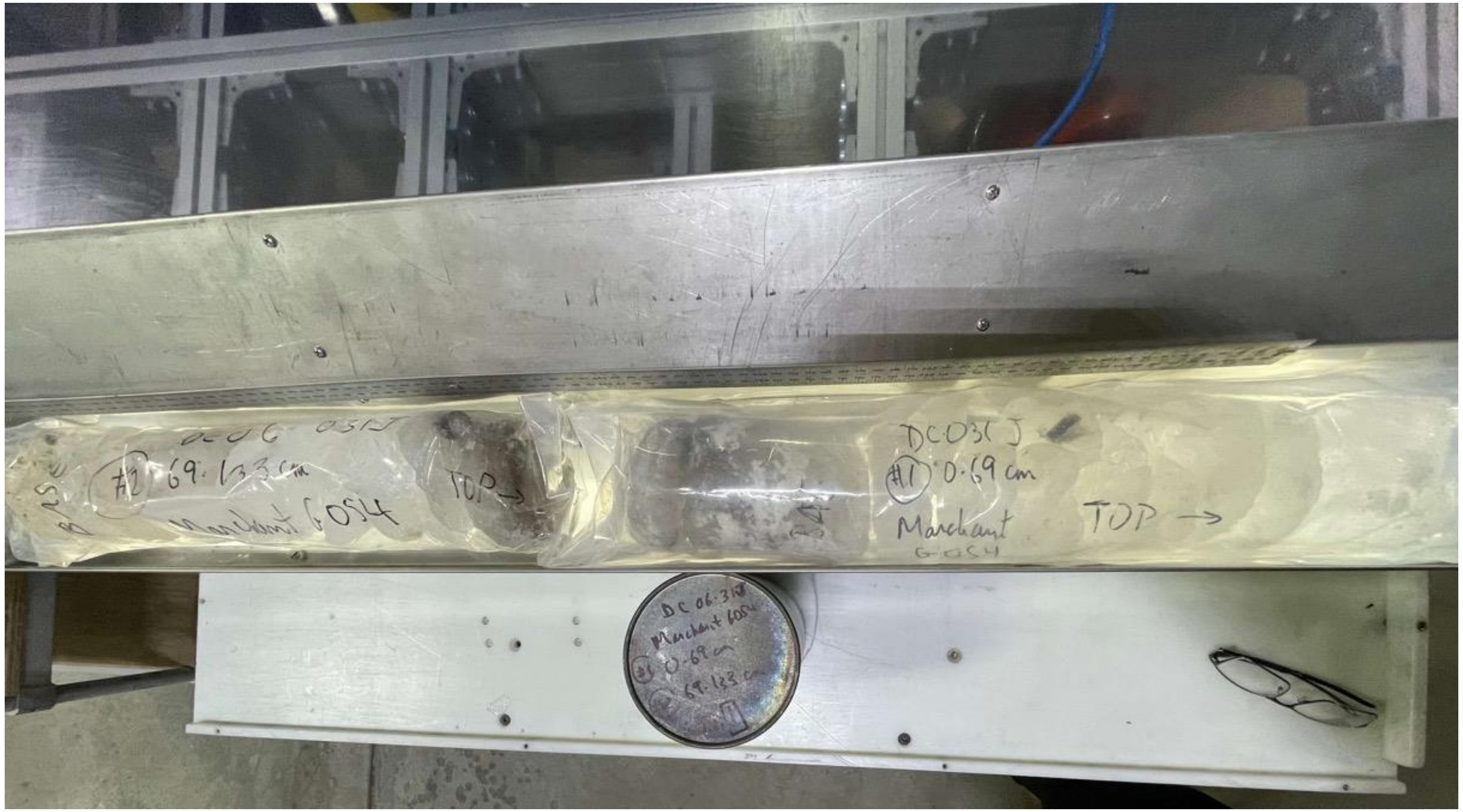

Credit: Curt La Bombard

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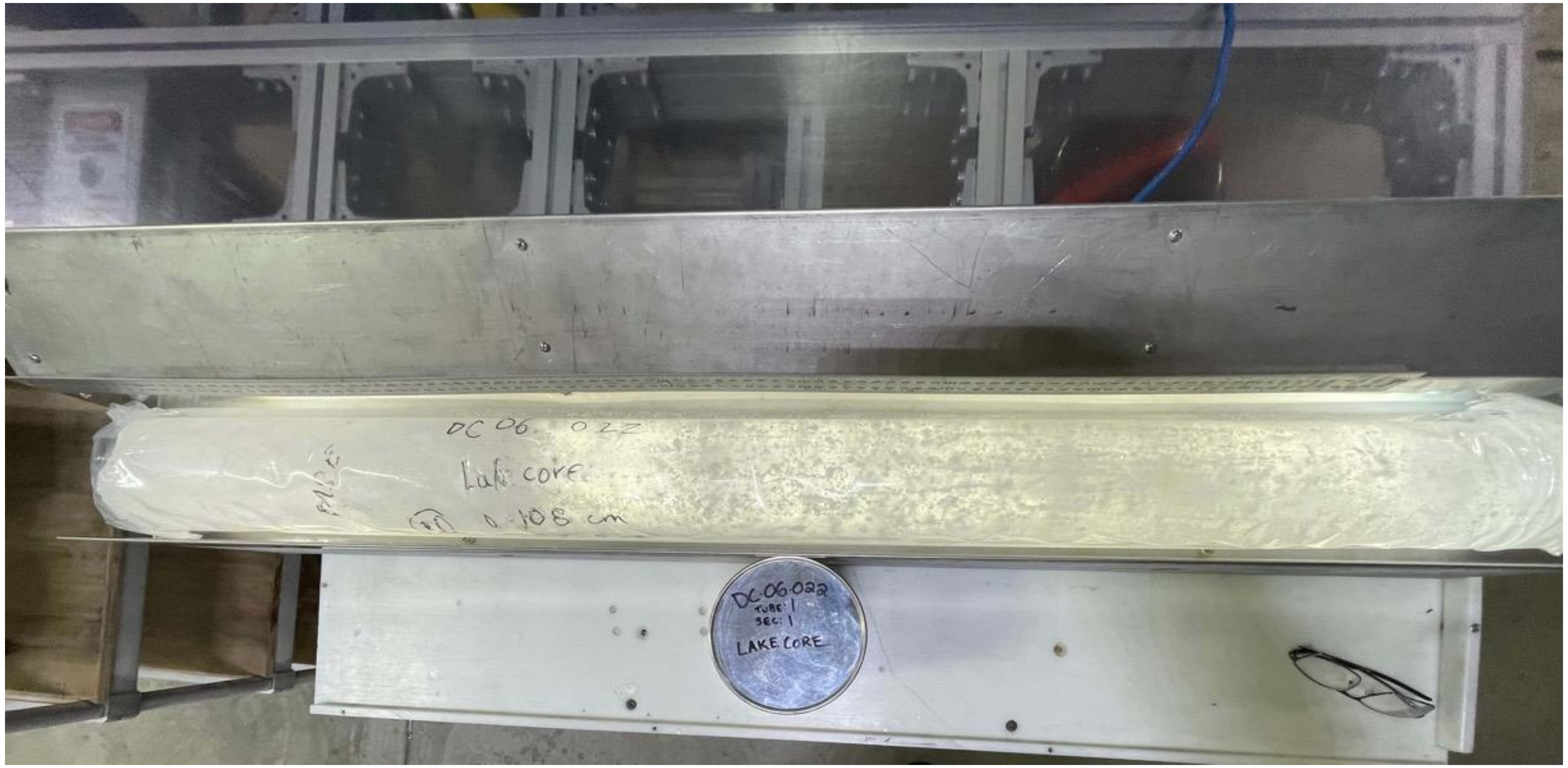

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The field team plans to pursue a two-pronged study plan. One group of researchers will attempt to determine the age, origin, and climate significance of buried ice in the western Dry Valleys region. The other will study Dry Valley microclimates to better understand ancient and current climate processes on Mars. The first group will travel by helicopter to set up a field camp in Beacon Valley. This team will drill and collect no less than 15 cores from buried ice. The cores will be packaged in the field and returned to McMurdo for safe storage until they are shipped to the home institution for analysis. The second group will travel by helicopter to establish a field camp at Don Juan Pond. This team plans to document the range of surface geomorphic processes in at least three discrete microclimate zones in the Dry Valleys (a coastal-thaw zone, and inland-mixed zone, and a stable-upland zone).

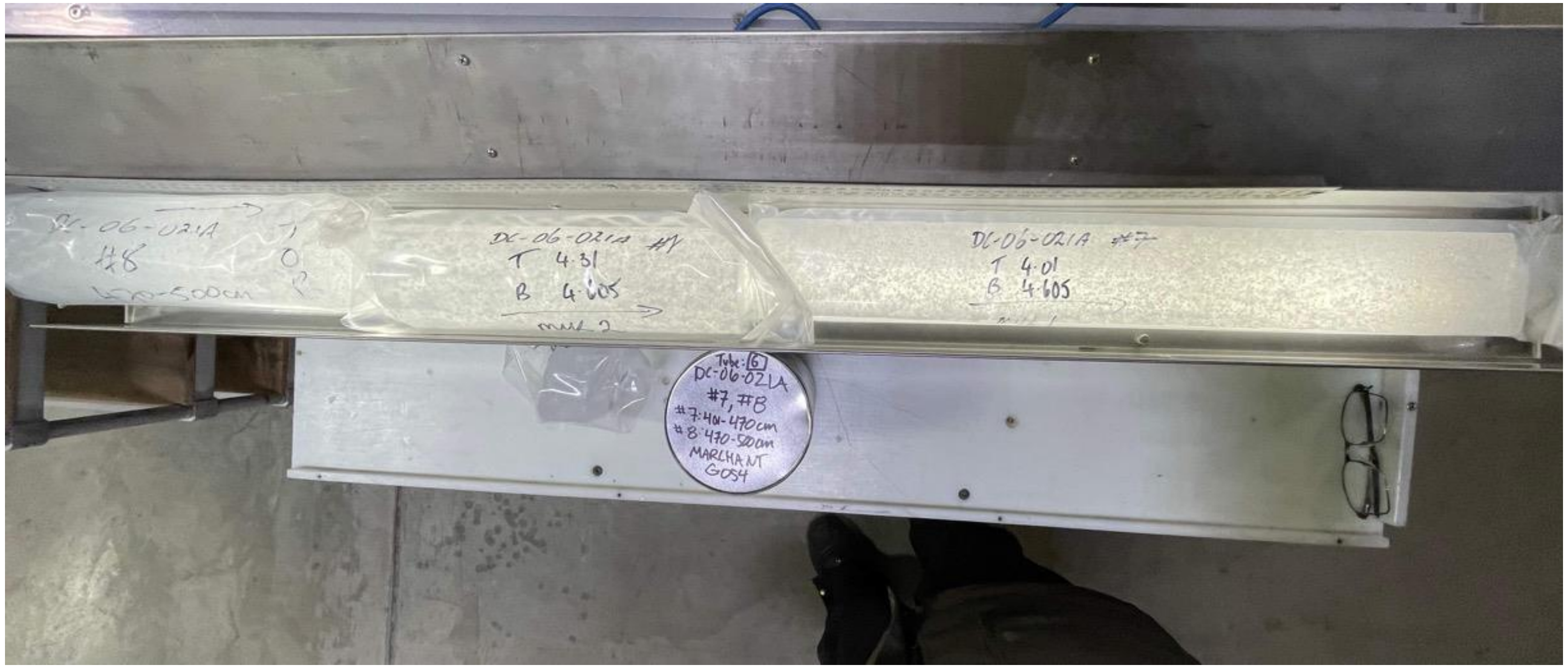
Members of both field camps will make day trips by helicopter to install data loggers and measure micro-, meso-, and macro-scale landforms at other sites in the Dry Valleys. A number of smaller, temporary field camps may also be established for this purpose. All team members will return to McMurdo by helicopter by the end of January.

Deploying Team Members:
Michael Bender, Jay Dickson, James Green (Team Leader), James Head (Co-PI), Doug Kowalewski (Team Leader), Joseph Levy, Gareth Morgan, Laura Robinson, David Shean (Team Leader)

Cores at NSF-ICF

DC06-###	Mullins Valley	unknown ⌀	44 cores in inventory; ~118 meters total
SC06-###	Mullins Valley	unknown ⌀	2 cores in inventory; ~4 meters total

NSF-ICF Database Notes: These cores were collected by Dave Marchant and delivered to the NICL with the 2007 Antarctic Retro. They are from Mullins Valley in the Dry Valleys.



Credit: Curt La Bombard

2006-2007 Field Season

Age, Origin, And Climatic Significance Of Buried Ice In The Western Dry Valleys

Program Manager: Dr. Dr. Thomas Wagner
Event Number: G-054-M
ASC POC/Implementer: Michael McClanahan

Dr. Kate Swanger (Principal Investigator) Kate_Swanger@uml.edu
University of Massachusetts
Lowell, Massachusetts

Supporting Stations: McMurdo Station
Research Locations: McMurdo Dry Valleys

Project Description:
This project will investigate two aspects the Dry Valley environment as analogues for conditions on Mars: Buried ice deposits and microclimates. Buried ice deposits represent an exciting and potentially far-reaching archive of atmosphere and climate on Earth extending back for many millions of years. These deposits are terrestrial analogs to widespread and young buried ice on the Martian surface as identified by recent data from Mars Odyssey. This project will evaluate the age, origin, and climatic significance of buried ice in the western Dry Valleys region. Microclimates of the Dry Valleys hold implications for landscape evolution and climate change on Mars. The Antarctic Dry Valleys are commonly viewed as a relatively fixed cold polar desert with little internal variation. Recent analyses have shown that there are three fundamentally different microclimate zones within this general 'stereotypical' cold polar desert, and that these may hold the keys to climate change on Mars.

Field Season Overview:
The field team plans to pursue a two-pronged study plan. One group of researchers will attempt to determine the age, origin, and climate significance of buried ice in the western Dry Valleys region. The other will study Dry Valley microclimates to better understand ancient and current climate processes on Mars. The first group will travel by helicopter to set up a field camp in Beacon Valley. This team will drill and collect no less than 15 cores from buried ice. The cores will be packaged in the field and returned to McMurdo for safe storage until they are shipped to the home institution for analysis. The second group will travel by helicopter to establish a field camp at Don Juan Pond. This team plans to document the range of surface geomorphic processes in at least three discrete microclimate zones in the Dry Valleys (a coastal-thaw zone, and inland-mixed zone, and a stable-upland zone).

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Michael Bender, Jay Dickson, James Green (Team Leader), James Head (Co-PI), Doug Kowalewski (Team Leader), Joseph Levy, Gareth Morgan, Laura Robinson, David Shean (Team Leader)

Cores at NSF-ICF

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NSF-ICF Database Notes: These cores were collected by Dave Marchant and delivered to the NICL with the 2007 Antarctic Retro. They are from Mullins Valley in the Dry Valleys.

Credit: Curt La Bombard

2008-2009 Field Season

Collaborative Research: Dating And Paleoenvironmental Studies On Ancient Ice In The Dry Valleys, Antarctica

Program Manager: Dr. Vladimir Papitashvili
Event Number: G-070-M
ASC POC/Implementer: Chad Naughton

Dr. Michael Bender (Principal Investigator) bender@princeton.edu
Princeton University
Department of Geosciences Princeton, New Jersey

Supporting Stations: McMurdo Station
Research Locations: Taylor Valley, Beacon Valley, Mullins Valley

Project Description:
The Mullins Valley debris-covered glacier forms at the headwall of Mullins Valley, Dry Valleys region of Antarctica. As it flows down this small valley, it enters a region of net ablation, and mass loss leads to the surface exposure of dirt and rocks that fell in at the headwall. The dirt/rock layer, which eventually reaches a thickness of about 1 m, insulates the ice and causes evaporation to be very slow. In addition, glacial flow alleviates thinning due to ablation, so that glacial ice is foreshortened laterally, rather than vertically. The consequence of these two features is that very old ice is preserved: 40Ar/39Ar ages of volcanic ashes found in the rock layer progressively increase down the length of the glacier, and reach nearly 10 Ma at the outer limit.

Field Season Overview:
1. Establish Camp with driller and 3 scientists, Drill at Site 1 for days 1-11. Retrograde ice during drill move on day 12.
2. Move drill (helo flight), drill at Site 2 for days 12-21. Scientist 1 departs on Day 14. Retrograde ice during drill move on day 22.
3. Move drill (helo flight), drill at Site 3 for days 21-40. Scientists 2-3 depart on Day 30. Retrograde ice on day 30. 2 GA's come to camp on Day 30.
4. Break camp on day 40; retrograde ice; driller and GA's return to McMurdo.

Deploying Team Members:
David Marchant, Sean MacKay, Joe Levy, Gareth Morgan, Andrew Knott, Tanner Kuhl

Cores at NSF-ICF

MCI-08-001	Mullins Valley	7.6 cm (3 inch) ⌀	0 - 22.78 m	77.89438 S, 160.58324°E
MCI-08-003	Beacon Valley	7.6 cm (3 inch) ⌀	13.51 – 14.06 m	
MCI-08-004	Beacon Valley	7.6 cm (3 inch) ⌀	0 – 27.32 m	

Coordinates from Mackay SL and others (2014) Cold-based debris-covered glaciers: Evaluating their potential as climate archives through studies of ground-penetrating radar and surface morphology, *J. Geophys. Res. Earth Surf.* 10.1002/2014JF003178.

Driller Notes (source: Tanner Kuhl)

Mullins Valley
MCI-08-001
One hole was drilled at this location to a **depth of approximately 23 meters**. The surface ice was mostly clean with occasional, small sand cracks. Three lines (1 strap hoist with webbing sling front, 2 chain hoists rear) were used to stabilize the drill tower (Figure 1). Most coring was done with the stainless steel core barrels with HDPE flights. One barrel without core dogs was used to drill and clean chips from the hole by means of a barrel puck. A second barrel with core dogs was used for core retrieval. Predominantly clean, bubbly ice was found at this site. Occasional, small rocks (<3cm) and sand veins were encountered. The rack feed was used for the majority of drilling; the micro-feed was engaged when rocks were encountered. Rock drilling heads were not needed at this site. At a depth of approximately 5 meters, and beyond, the capstan winch and snatch block were used to pull the drill string from the hole. The drill string was belayed at depth with the winch rope run through a figure-8 device. The drill was stuck once in the borehole and was freed using approximately 1 pint of ethanol (~1 hour wait). Drilling was stopped at this site to allow more time at Beacon Valley locations. Hole 1 required 4 days, with approximately 74 separate runs down-hole to complete (37 runs retrieved core).

Beacon Valley
MCI-08-003
The third hole was drilled in the same general area as MCI-08-002. Surface ice characteristics and drill configuration were similar to the previous hole. The first 8 meters of core were drilled and recovered using the aluminum core barrel with no core dogs. Core dogs were used after the aluminum core barrels had been modified at McMurdo Station to accept them. Clean ice was found initially, with progressively dirtier ice being encountered with depth (Figure 3). Tightly spaced sand veins and thick layers of consolidated sand were drilled using the carbide cutters (Figure 4). Rocks as deep as 8 cm and up to 120° of kerf were drilled with the carbide inserts and micro-feed (Figure 5). The drill was stuck twice due to heat from drilling rock with the carbide cutters. One to two pints of ethanol and about one hour unstuck the drill on both occasions. Coring continued in dirty ice down to **approximately 16 meters**, when increasing rocks and the first signs of ice cement made further penetration impractical. Six days were spent on the third hole with nearly 100 runs down-hole with the drill or vacuum.

MCI-08-004
Hole four was drilled at a site known as the J, about one kilometer up-valley from holes two and three. A **final depth of 28 meters** was reached in four days, requiring approximately 100 separate runs down-hole with the drill or vacuum. Drill configuration was typical. The stainless steel and HDPE barrels were used initially (HDPE flight diameter had been reduced and repairs made in MCM) but were found to still bind in the hole and transport chips poorly. The aluminum core barrels were used for the remainder of the hole. Surface ice conditions were similar to the first site with mostly clean ice and occasional sand cracks, some fairly large. Near surface ice contained small rocks (<3 cm) and sand veins (Figure 6). Larger rocks, up to 5 cm deep and nearly 160° of kerf were drilled with the carbide cutters and micro-feed. Rocks of various sizes were encountered on the majority of runs. The hole was abandoned at 28 meters due to the limits of the capstan winch.

2008-2009 Field Season

Collaborative Research: Dating And Paleoenvironmental Studies On Ancient Ice In The Dry Valleys, Antarctica

Program Manager: Dr. Vladimir Papitashvili
Event Number: G-070-M
ASC POC/Implementer: Chad Naughton

Dr. Michael Bender (Principal Investigator) bender@princeton.edu
Princeton University
Department of Geosciences Princeton, New Jersey

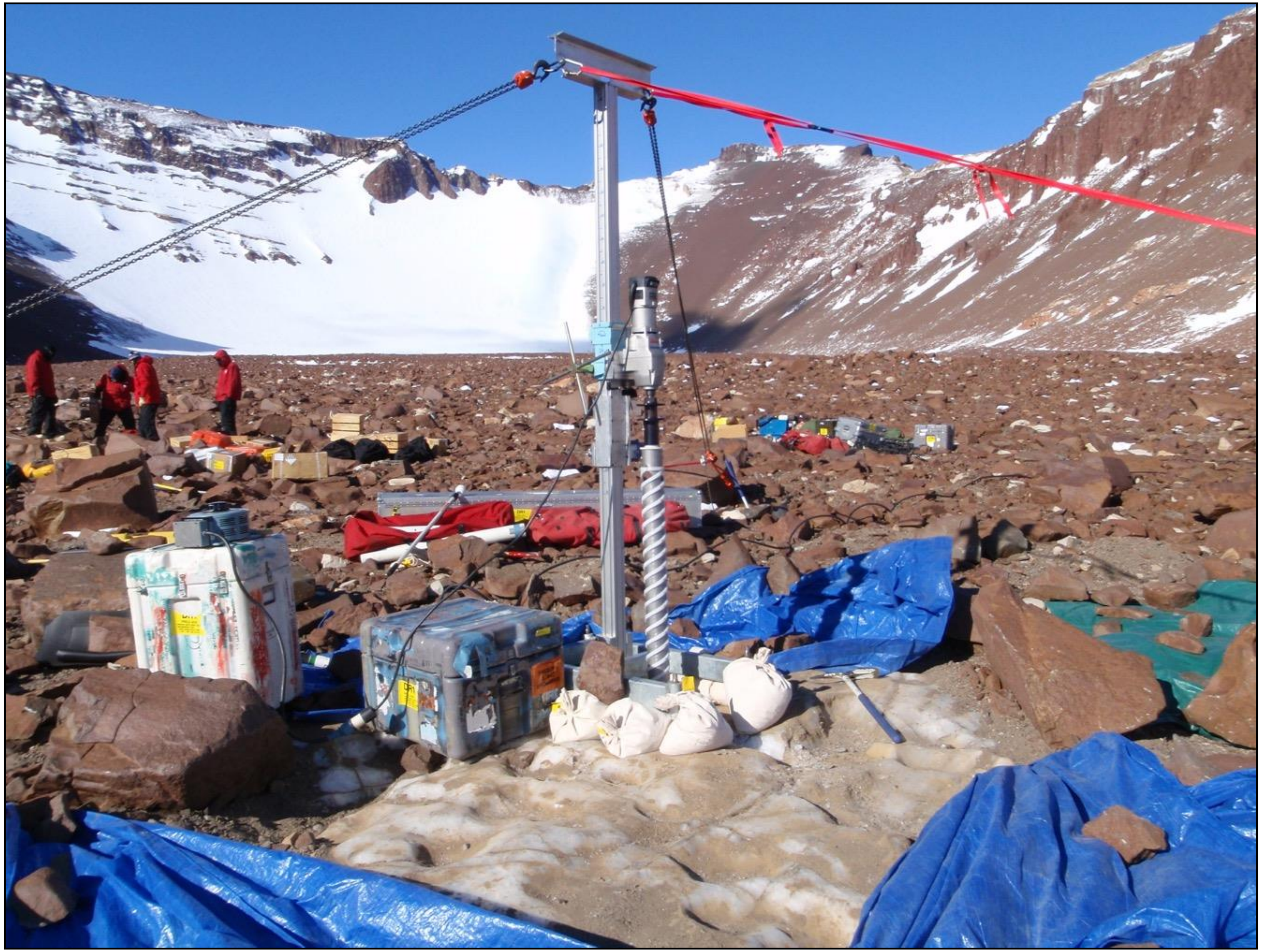
Supporting Stations: McMurdo Station
Research Locations: Taylor Valley, Beacon Valley, Mullins Valley

Project Description:
The Mullins Valley debris-covered glacier forms at the headwall of Mullins Valley, Dry Valleys region of Antarctica. As it flows down this small valley, it enters a region of net ablation, and mass loss leads to the surface exposure of dirt and rocks that fell in at the headwall. The dirt/rock layer, which eventually reaches a thickness of about 1 m, insulates the ice and causes evaporation to be very slow. In addition, glacial flow alleviates thinning due to ablation, so that glacial ice is foreshortened laterally, rather than vertically. The consequence of these two features is that very old ice is preserved: 40Ar/39Ar ages of volcanic ashes found in the rock layer progressively increase down the length of the glacier, and reach nearly 10 Ma at the outer limit.

Field Season Overview:

1. Establish Camp with driller and 3 scientists, Drill at Site 1 for days 1-11. Retrograde ice during drill move on day 12.
2. Move drill (helo flight), drill at Site 2 for days 12-21. Scientist 1 departs on Day 14. Retrograde ice during drill move on day 22.
3. Move drill (helo flight), drill at Site 3 for days 21-40. Scientists 2-3 depart on Day 30. Retrograde ice on day 30. 2 GA's come to camp on Day 30.
4. Break camp on day 40; retrograde ice; driller and GA's return to McMurdo.

Deploying Team Members:
David Marchant, Sean MacKay, Joe Levy, Gareth Morgan, Andrew Knott, Tanner Kuhl



Drill site in Mullins Valley for hole **MCI-08-001**. Credit: Tanner Kuhl

2008-2009 Field Season

Collaborative Research: Dating And Paleoenvironmental Studies On Ancient Ice In The Dry Valleys, Antarctica

Program Manager: Dr. Vladimir Papitashvili
Event Number: G-070-M
ASC POC/Implementer: Chad Naughton

Dr. Michael Bender (Principal Investigator) bender@princeton.edu
Princeton University
Department of Geosciences Princeton, New Jersey

Supporting Stations: McMurdo Station
Research Locations: Taylor Valley, Beacon Valley, Mullins Valley

Project Description:
The Mullins Valley debris-covered glacier forms at the headwall of Mullins Valley, Dry Valleys region of Antarctica. As it flows down this small valley, it enters a region of net ablation, and mass loss leads to the surface exposure of dirt and rocks that fell in at the headwall. The dirt/rock layer, which eventually reaches a thickness of about 1 m, insulates the ice and causes evaporation to be very slow. In addition, glacial flow alleviates thinning due to ablation, so that glacial ice is foreshortened laterally, rather than vertically. The consequence of these two features is that very old ice is preserved: 40Ar/39Ar ages of volcanic ashes found in the rock layer progressively increase down the length of the glacier, and reach nearly 10 Ma at the outer limit.

Field Season Overview:
1. Establish Camp with driller and 3 scientists, Drill at Site 1 for days 1-11. Retrograde ice during drill move on day 12.
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3. Move drill (helo flight), drill at Site 3 for days 21-40. Scientists 2-3 depart on Day 30. Retrograde ice on day 30. 2 GA's come to camp on Day 30.
4. Break camp on day 40; retrograde ice; driller and GA's return to McMurdo.

Deploying Team Members:
David Marchant, Sean MacKay, Joe Levy, Gareth Morgan, Andrew Knott, Tanner Kuhl

Typical core from site **MCI-08-003** in the Beacon Valley, Antarctica, showing alternating sand and ice bands. Credit: Tanner Kuhl

This section of **MCI-08-003** is NOT at the NSF-ICF.

An ice core drilled with the Koci Drill from site **MCI-08-004** in Beacon Valley, Antarctica, during the 2008-2009 field season. Credit: Tanner Kuhl.

2009-2010 Field Season

Collaborative Research: Dating And Paleoenvironmental Studies On Ancient Ice In The Dry Valleys, Antarctica

Program Manager: Dr. Vladimir Papitashvili
Event Number: G-070-M
ASC POC/Implementer: Chad Naughton

Dr. Michael Bender (Principal Investigator) bender@princeton.edu
Princeton University
Department of Geosciences Princeton, New Jersey

Supporting Stations: McMurdo Station
Research Locations: Beacon and Mullins Valleys

Project Description:
The Mullins Valley debris-covered glacier forms at the headwall of Mullins Valley, Dry Valleys region of Antarctica. As it flows down this small valley, it enters a region of net ablation, and mass loss leads to the surface exposure of dirt and rocks that fell in at the headwall. The dirt/rock layer, which eventually reaches a thickness of about 1 m, insulates the ice and causes evaporation to be very slow. In addition, glacial flow alleviates thinning due to ablation, so that glacial ice is foreshortened laterally, rather than vertically. The consequence of these two features is that very old ice is preserved: 40Ar/39Ar ages of volcanic ashes found in the rock layer progressively increase down the length of the glacier and reach nearly 10 Ma at the outer limit.

Field Season Overview:
Field team members will establish three separate field camps in Beacon and Mullins Valleys. They will use pre-existing campsite locations and pre- existing helicopter pads wherever possible. Throughout the field season, they will assist G-440 with sample collection and geomorphological interpretation and may initiate one or two personnel exchanges between groups. Researchers plan to drill and collect ice cores (each as much as 20- 30 m deep) at five localities along the debris-covered glacier to determine the age of the ice by dating trapped gases held within. This will help reconstruct aspects of atmospheric greenhouse gas concentrations and regional climate in the past. Ice cores will be periodically retrograded to McMurdo Station and will be returned to CONUS at the end of the season.

Deploying Team Members:
Brandon Boldt, Doug Kowalewski, Jennifer Lamp, Gareth Morgan, Kate Swanger, Tanner Kuhl

Cores at NSF-ICF

MCI-09-001	Beacon Valley	7.6 cm (3 inch) ⌀	0 – 13.68 m	
MCI-09-002	Beacon Valley	7.6 cm (3 inch) ⌀	0 – 12.86 m	
MCI-09-003	Beacon Valley	7.6 cm (3 inch) ⌀	0 – 31.30 m	77.8787°S, 160.53614°E

Coordinates from Mackay SL and others (2014) Cold-based debris-covered glaciers: Evaluating their potential as climate archives through studies of ground-penetrating radar and surface morphology, *J. Geophys. Res. Earth Surf*. 10.1002/2014JF003178.

Driller Notes (source: Tanner Kuhl)

Prior to field deployment all cargo was checked at McMurdo Station and staged for helicopter transport to **Beacon Valley**. The drill system was shipped from Madison ready for the field. Camp and additional drill equipment was procured from the Berg Field Center (BFC) and several non-critical modifications were made to the drill during this time.

<u>November 3 – 16, 2009</u>
Camp put-in took place on Nov. 3; the drill system followed on Nov. 6 after a site had been selected and prepared. Drilling commenced on the same day and continued until Nov. 16. The hole was abandoned after drilling through approximately 2.5 meters of sand/gravel with no sign of clean ice. Both coring heads and the non-coring rock auger and bit were used depending on ice condition. An aluminum coring barrel was stuck once at approximately 17.5 meters while drilling a thick layer of sand and small rock. Three liters of ethanol (half liter per hour for first 6 hours) and a wait of 24 hours were necessary to free the drill.

Hole MCI-09-001
Final Depth: ~18 meters
Drilling Days: 8
Weather Days: 2
Production: Most = 8.5 m/day, Least = 5 cm/day, Avg = 2.3 m/day
Surface Condition: Mostly clean with sparse, small rocks frozen in ice
Ice Conditions Encountered: Clean; small (<5 cm), sparse rocks; consolidated sand/ice layers, large (>5 cm) rock, mobile rocks

<u>November 18 – 21, 2009</u>
Upon returning from McMurdo the drill was moved approximately 10 meters to a new site and drilling resumed on the afternoon of Nov. 18. Drilling proceeded quickly, despite encountering 3 rocks around 15 cm deep each and nearly 100% of the hole area, until a similar rock and sand layer as was found in the first hole was encountered. The rock auger and rock bit were used for all rock drilling in this hole, as most coring heads were being repaired in McMurdo at the time. The drill was moved by hand up valley 150 meters on the afternoon of Nov. 21 to a new drill site.

Hole MCI-09-002
Final Depth: ~14 meters
Drilling Days: 3
Weather Days: 0
Production: Most = 8 m/day, Least = 2 m/day, Avg = 4.7 m/day
Surface Condition: Mostly clean with sparse, small rocks frozen in ice
Ice Conditions Encountered: Clean; small (<5 cm), sparse rocks; consolidated sand/ice layers, large (up to 15 cm) rock, mobile rocks

<u>November 22 – 30, 2009</u>
The third hole was begun on the afternoon of Nov. 22 and continued until Nov. 28. Coring and non-coring heads were used to drill rock in this hole. The drill was stuck at around 30 meters depth and was freed with 1.5 liters of ethanol after about 5 hours time. The downhole vacuum was also stuck for a time in this hole at 32 meters but was removed without the used of ethanol. The hole was stopped to allow time to drill in a separate glacial system within Beacon Valley. On Nov. 30 the drill was disassembled and sling loads were prepared to move the drill down valley.

Hole MCI-09-003
Final Depth: ~34 meters
Drilling Days: 6.5
Weather Days: 0
Production: Most = 10 m/day, Least = 1 m/day, Avg = 5.2 m/day
Surface Condition: Mostly clean with sparse, small rocks frozen in ice
Ice Conditions Encountered: Clean; small (<5 cm), sparse rocks; consolidated sand/ice layers