ANDRILL Coulman High Project and Beyond

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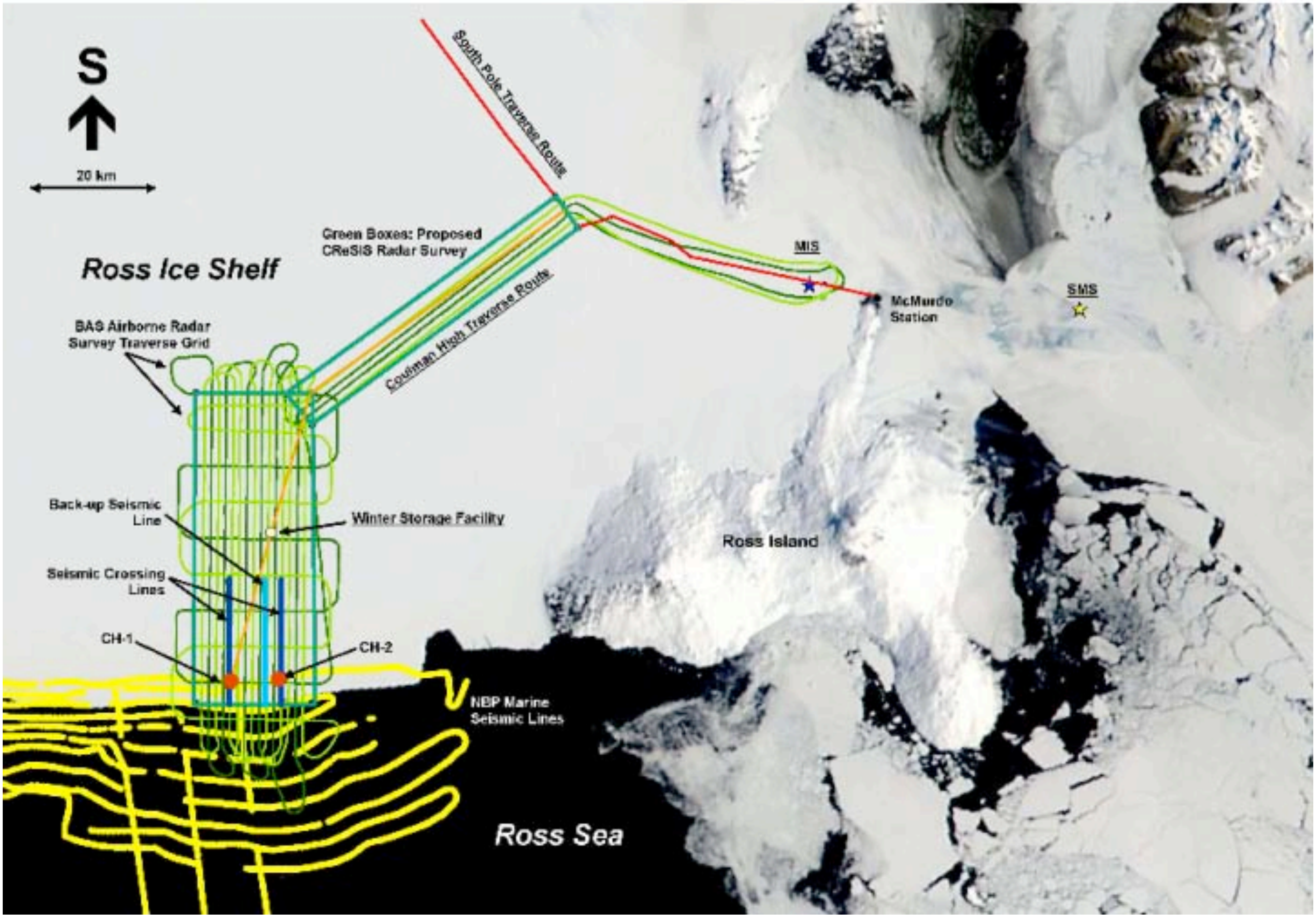
IDPO 2011 Science Planning Workshop, Washington, DC, April 15-16, 2011

South Pole and Coulman High Traverse Routes

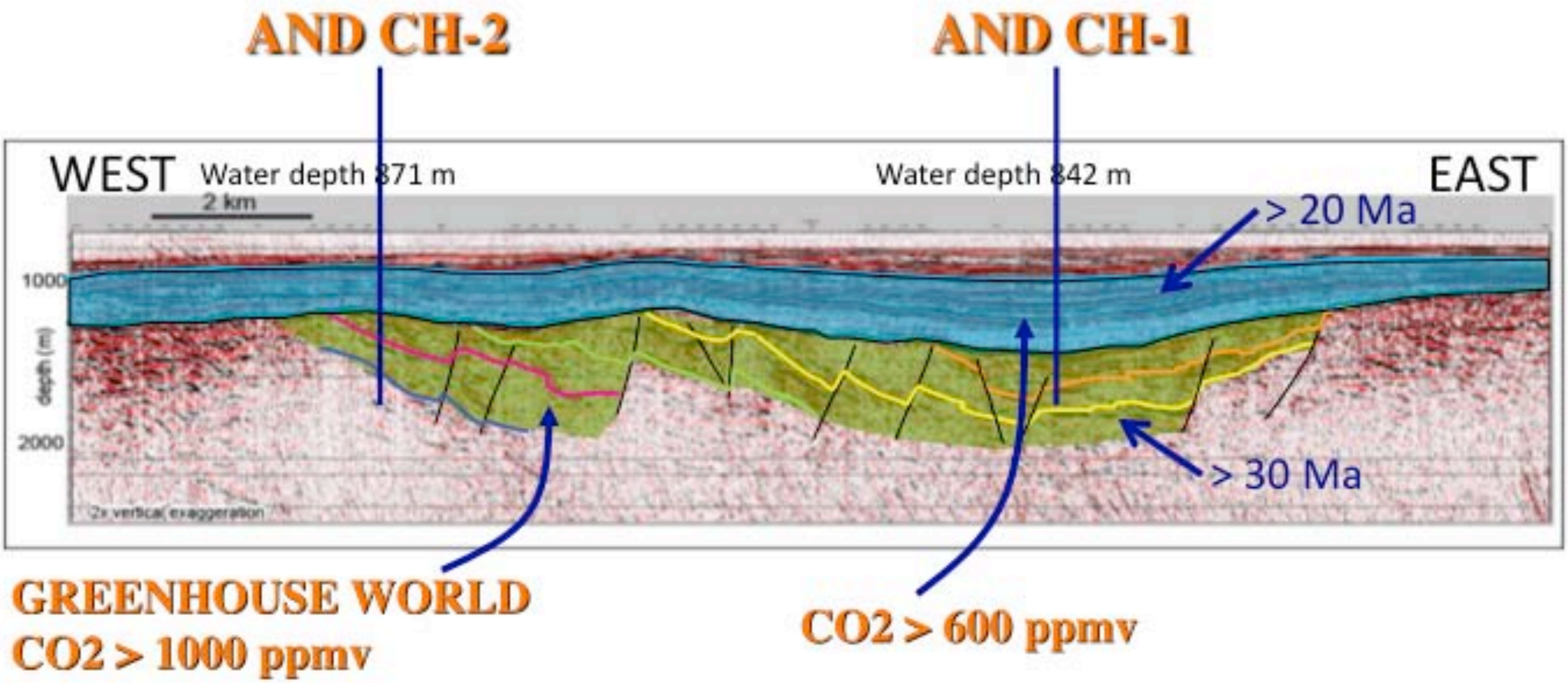


Drilling Targets 2012-2014

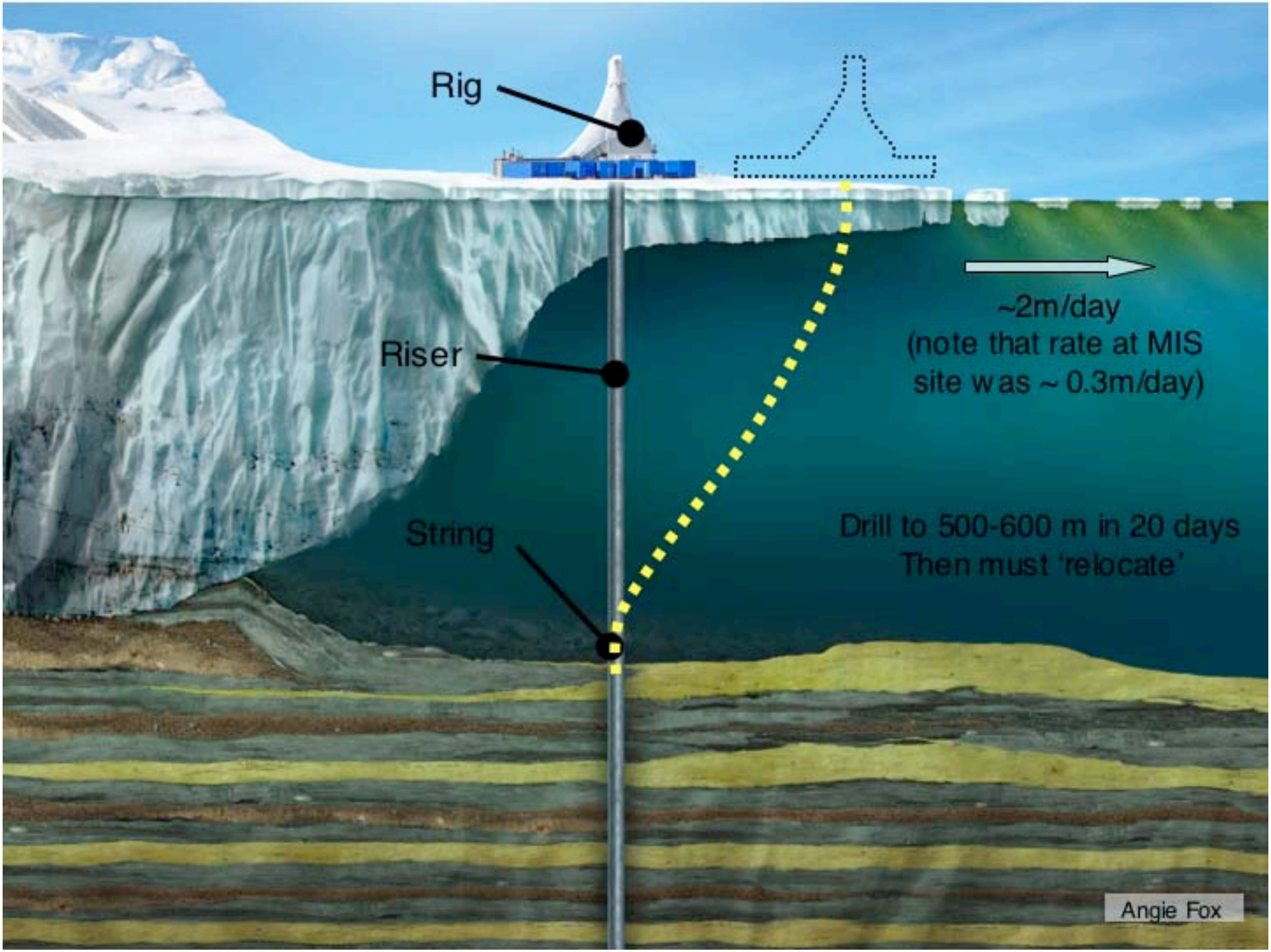
Key Science Drivers:

1. Uncover the evolution and behavior of the West Antarctic Ice Sheet in a high CO_2 world (> 600 ppmv)

2. Constrain West Antarctic geography through time to improve ice sheet models

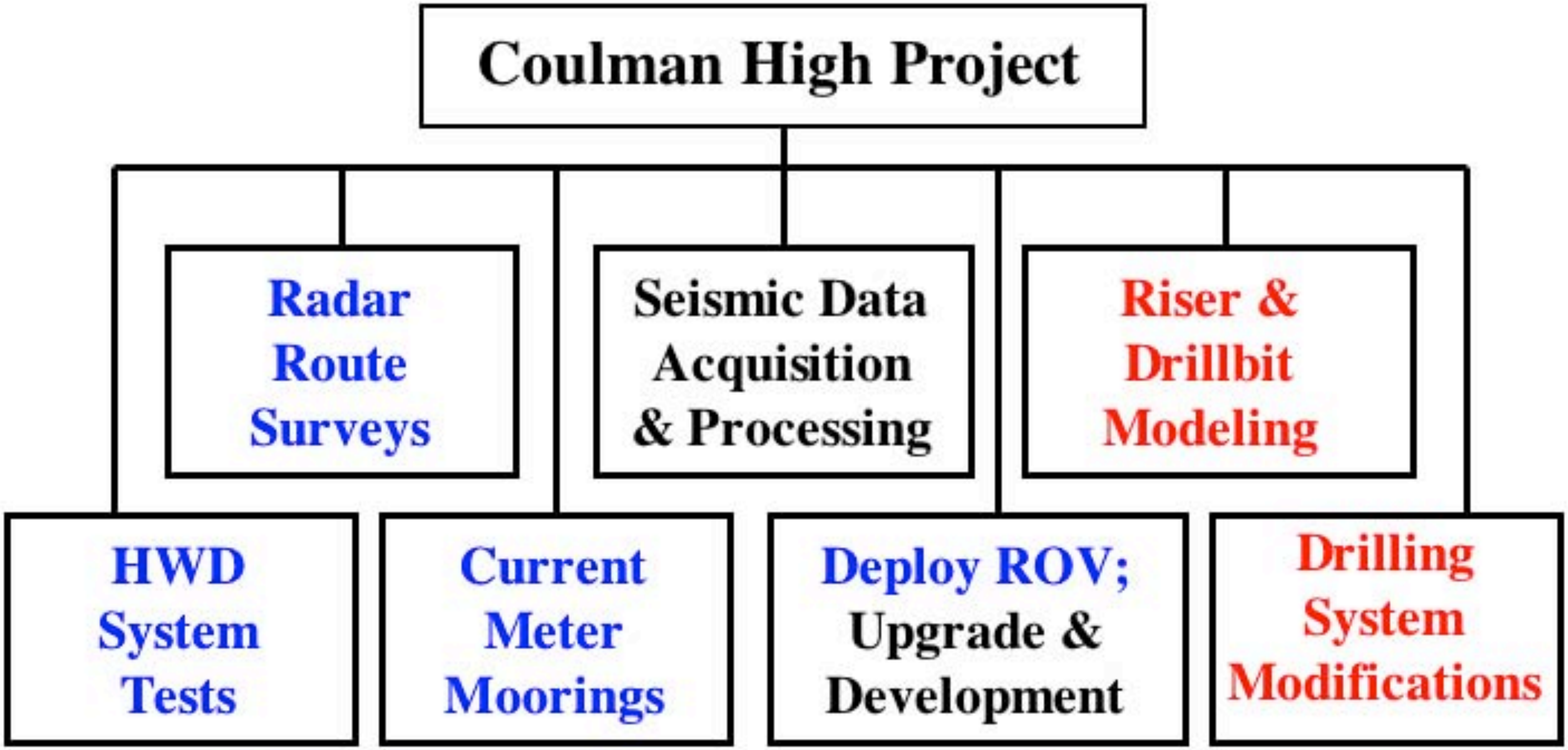


Palmer line 0301 1A0; Interpretation by Sorlien, Luyendyk, D. Wilson; UCSB



Rig
Riser
String
~2m/day
(note that rate at MIS
site was ~ 0.3m/day)
Drill to 500-600 m in 20 days
Then must 'relocate'
Angie Fox

Coulman High Project Planning Requirements



Note: Blue = Planned survey tasks; Black = Pending discussion or further funding; Red = Non-survey-related activities.

Generalized Oceanography of Ross Sea and Ice Shelf Cavity

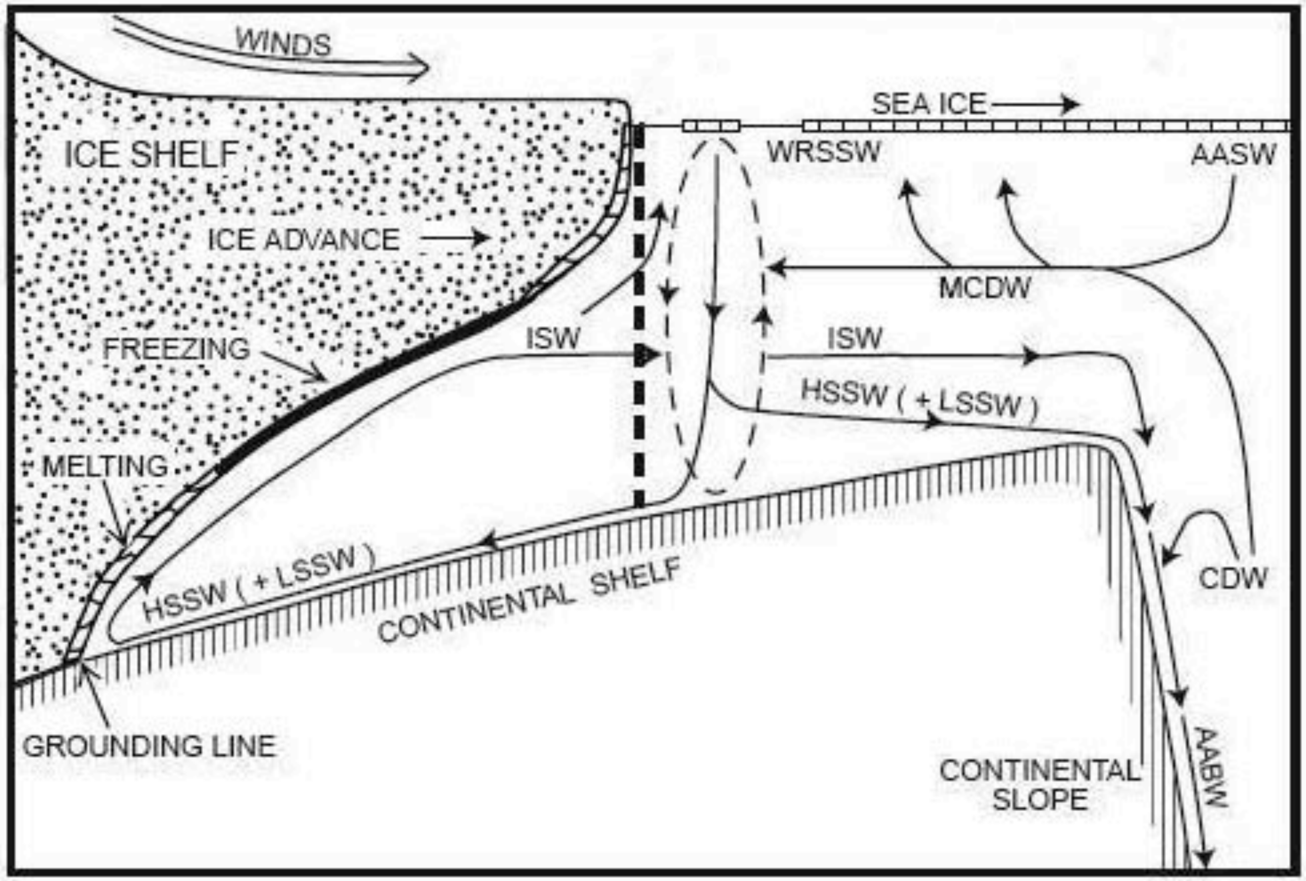


Figure 1.2: CDW intruding on shelf. Taken from Smethie and Jacobs (2005). Cartoon displaying circumpolar Deep Water intruding onto the shelf and mixing with Ice Shelf Water to form Bottom Water on the Ross Ice Front. AASW = Antarctic Surface Water, CDW = Circumpolar Deep Water, WRSSW = Western Ross Sea Surface Water, ISW = Ice Shelf Water, HSSW = High Salinity Shelf Water, LSSW = Low Salinity Shelf Water, AABW = Antarctic Bottom Water. Robinson (2009) MS Thesis, LSU.

Spatial Pattern of Sub-ice Melting from Ross Ice Shelf Model

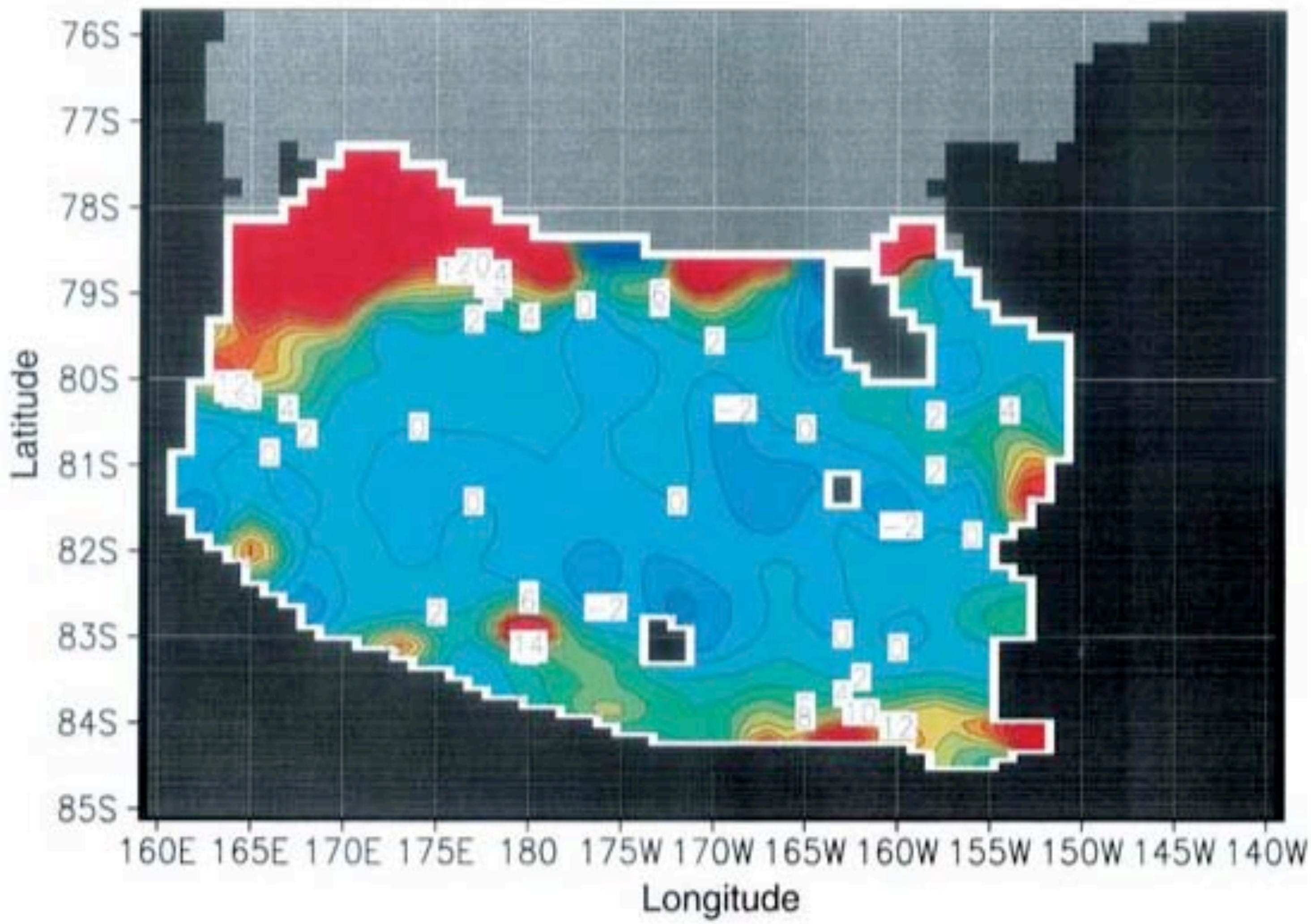
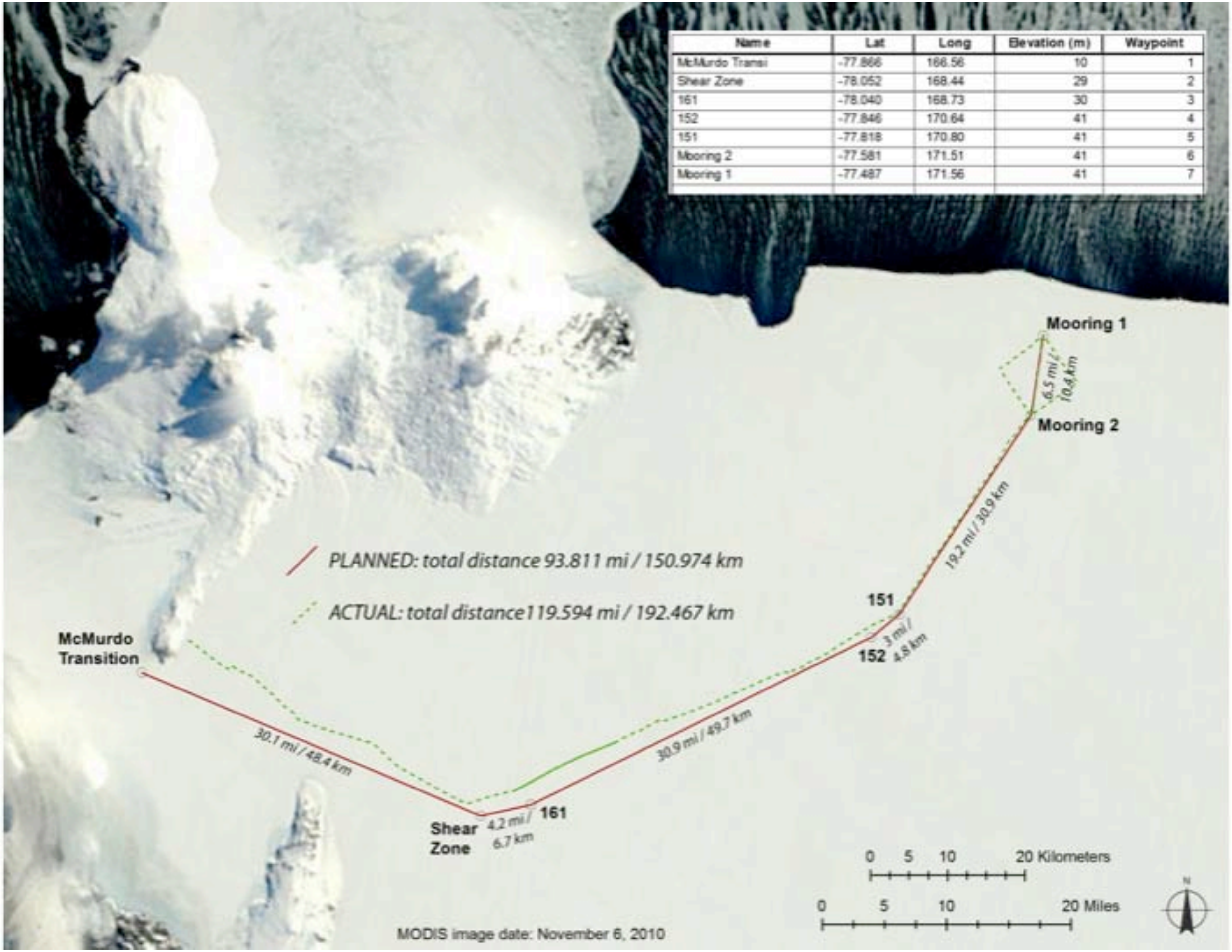
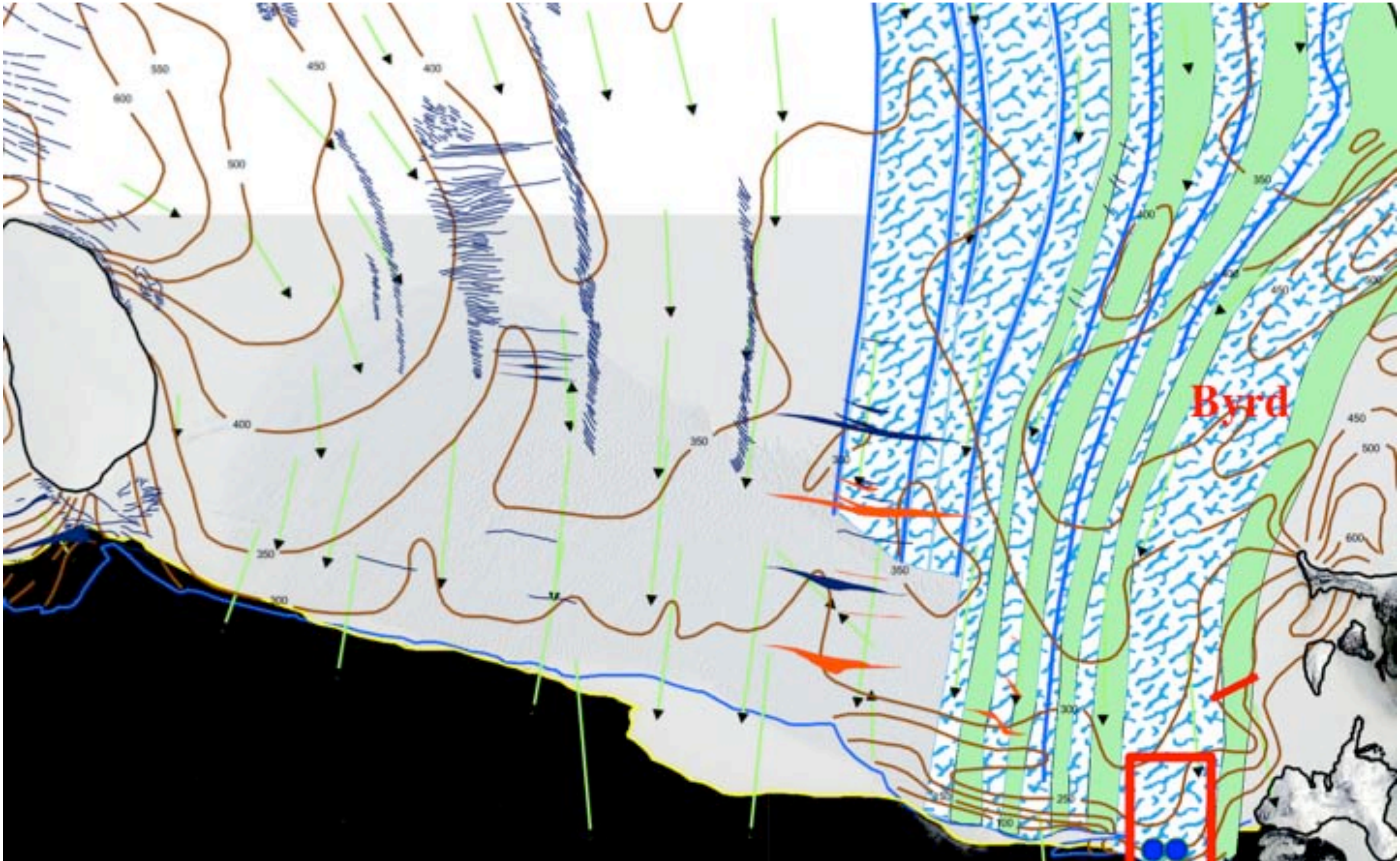


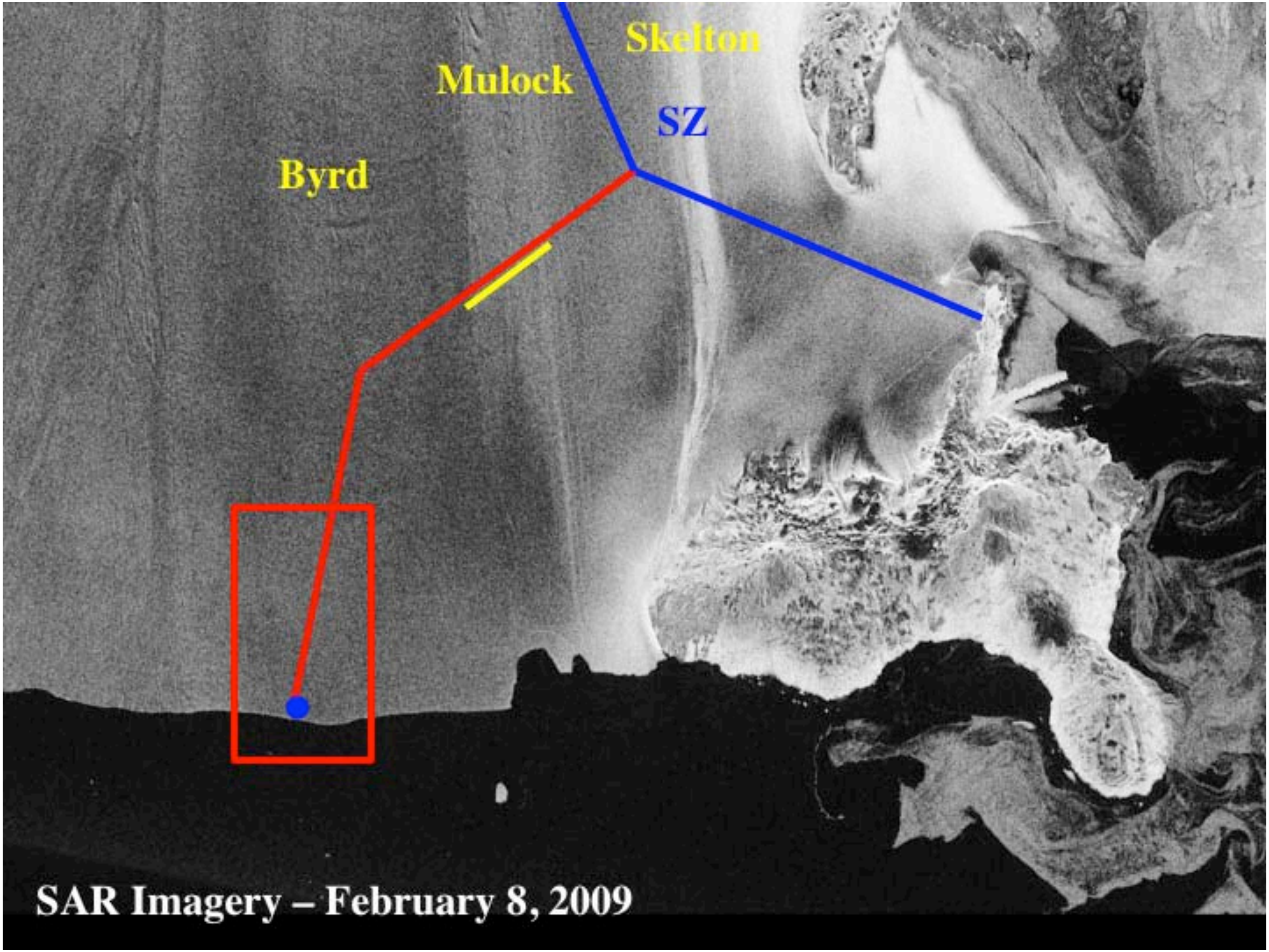
Fig. 10. Spatial pattern of melting (cm a-1) over the base of the Ross Ice Shelf, averaged over the last year of the model run. Holland et al., 2003.



Name	Lat	Long	Elevation (m)	Waypoint
McMurdo Transi	-77.866	166.56	10	1
Shear Zone	-78.052	168.44	29	2
161	-78.040	168.73	30	3
152	-77.846	170.64	41	4
151	-77.818	170.80	41	5
Mooring 2	-77.581	171.51	41	6
Mooring 1	-77.487	171.56	41	7

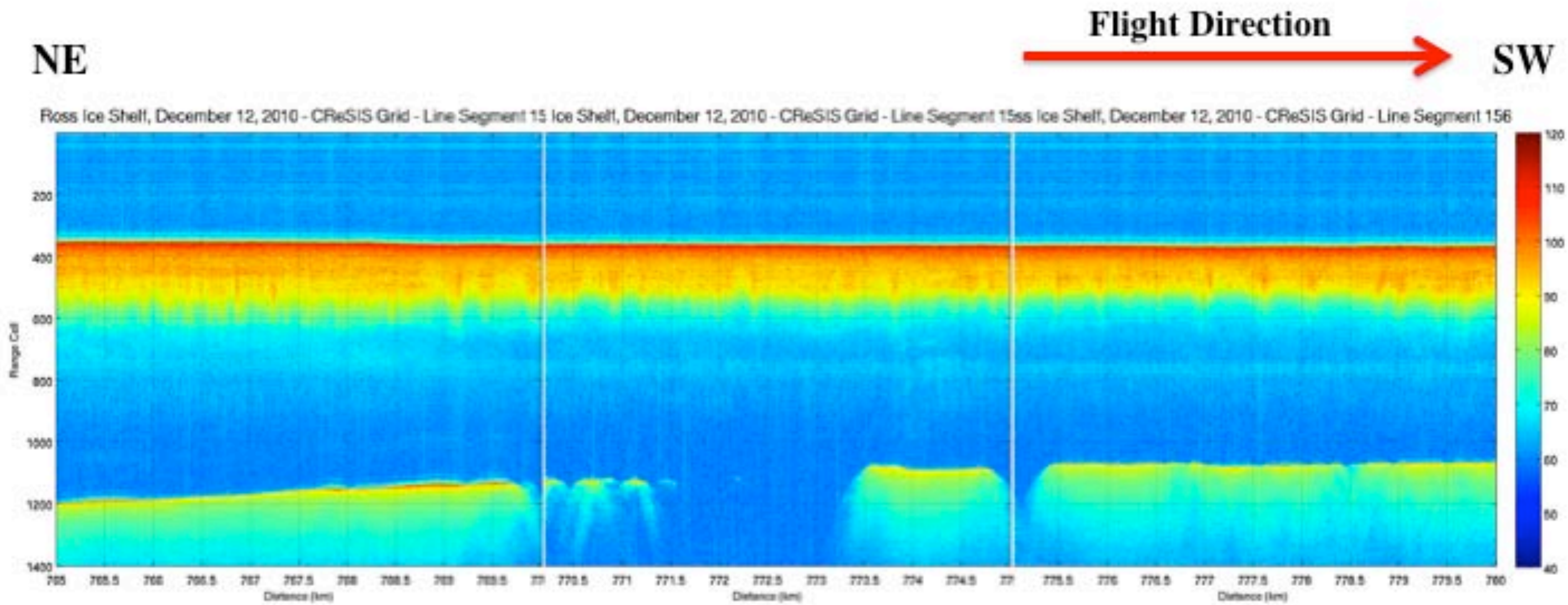


Digitized USGS Map of Ross Ice Shelf Features
Migrated from 1973, with 2008 MODIS Image.
Courtesy of Steve Fischbein (ANDRILL SMO)

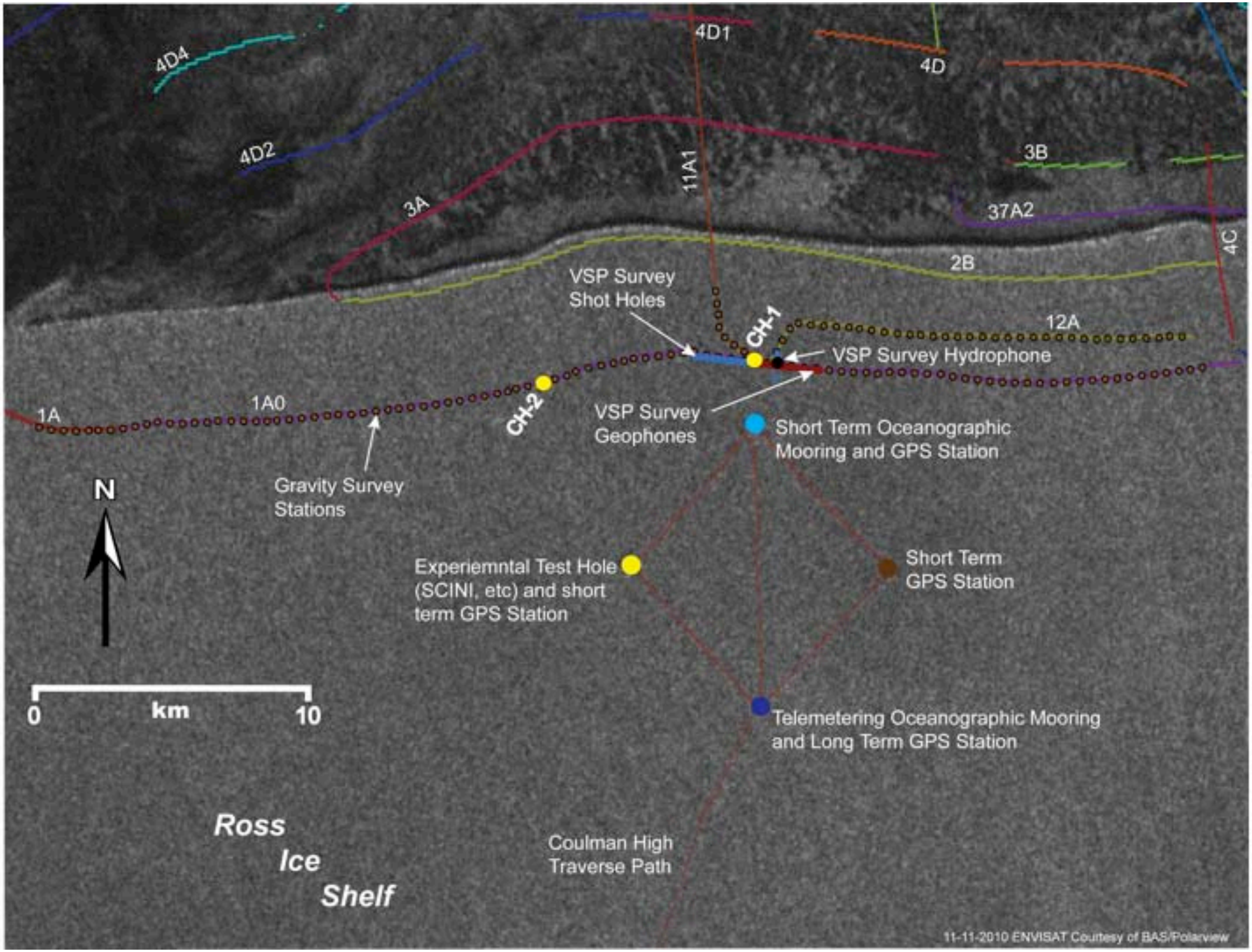


Skelton
Mulock
SZ
Byrd
SAR Imagery – February 8, 2009

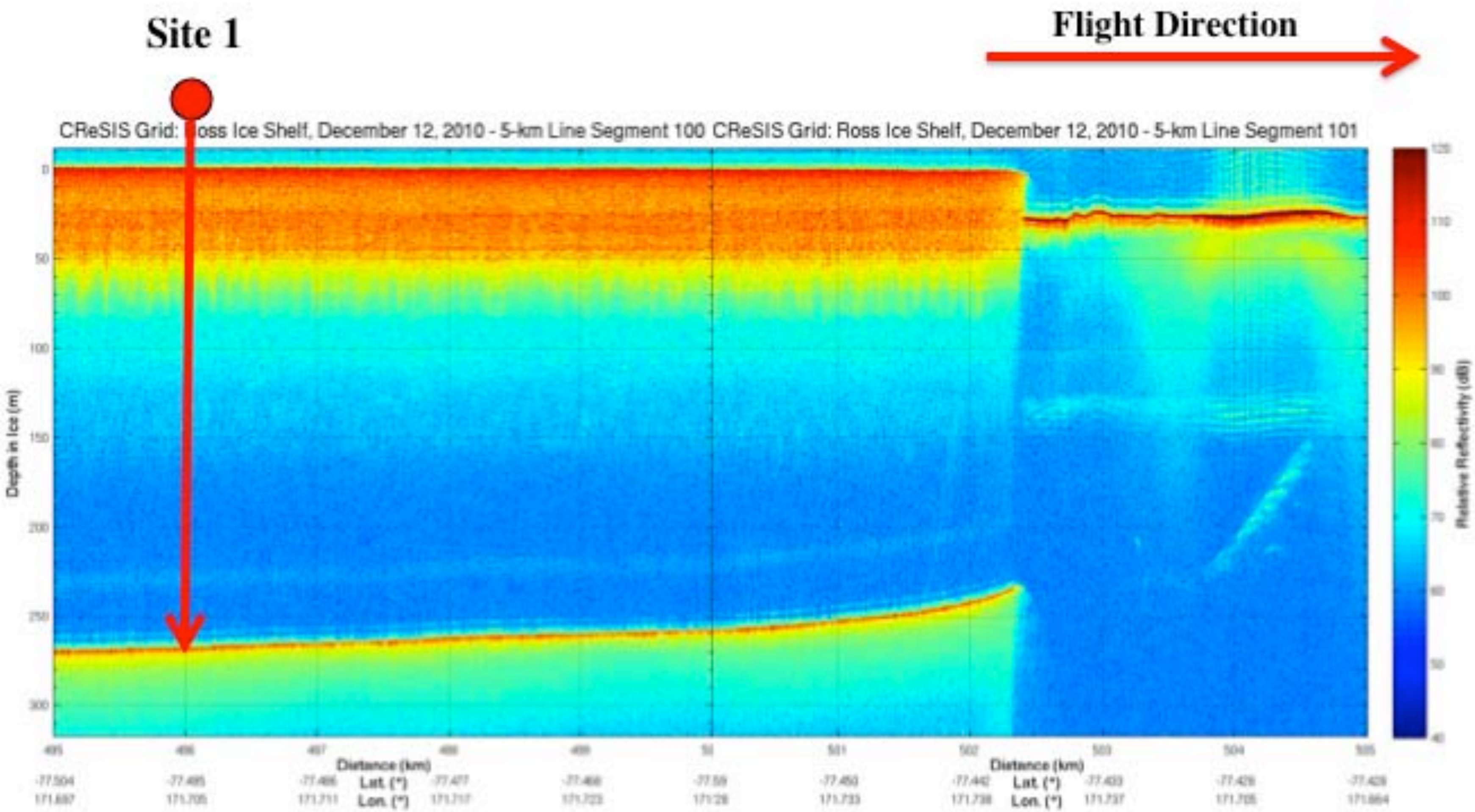
CReSIS Airborne Radar Profile Perpendicular to the Ross Ice Shelf Edge



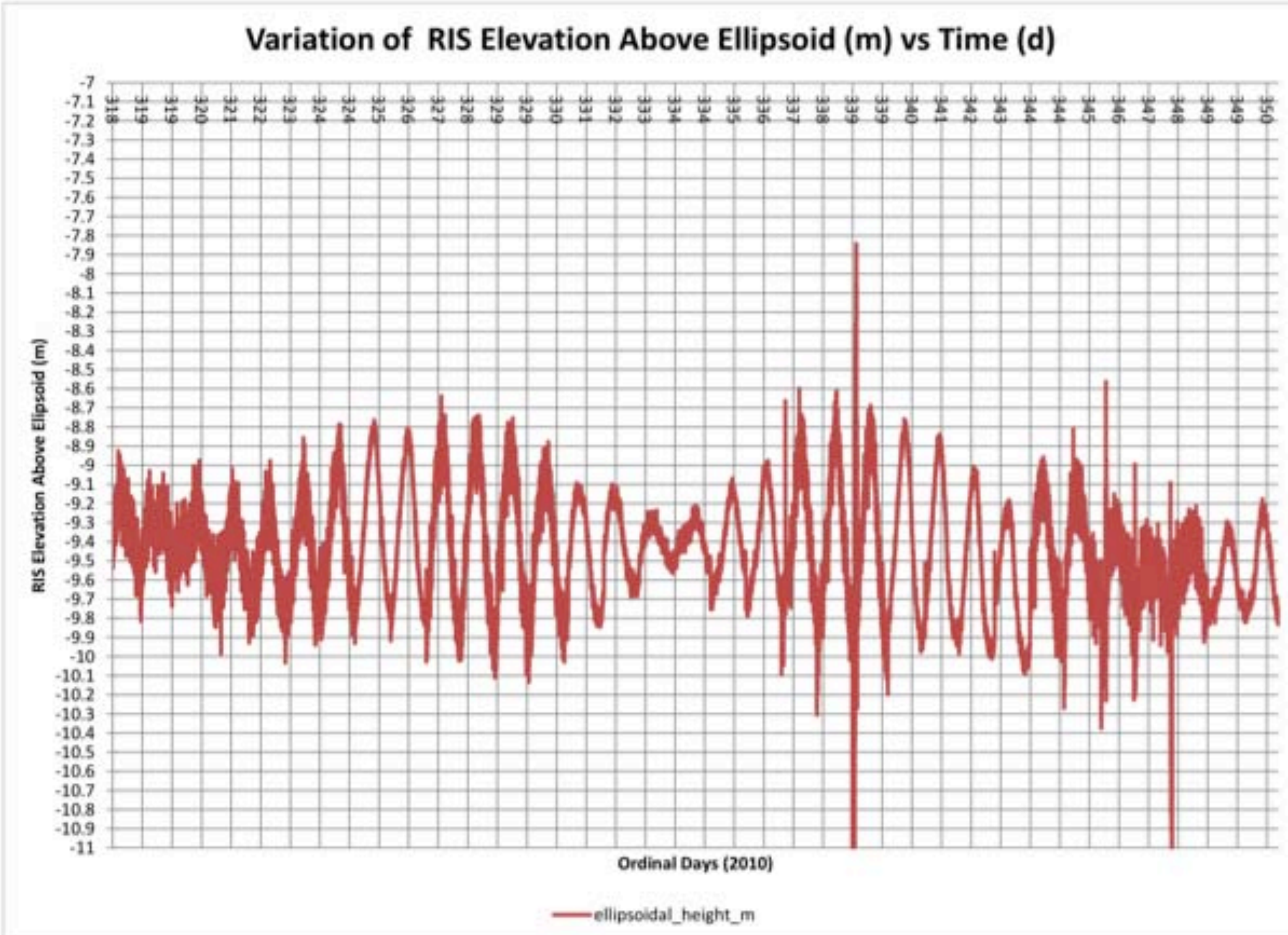
I did not collect this data, so it would be dangerous for me to offer an interpretation; however, it appears that the ice shelf lower surface is "mushy" or discontinuous at the resolution of the airborne radar (~750 MHz; 600-900 MHz) data over this 15 km line. This basal feature of the ice shelf seems to correspond to a possible transition between ice coming from the Byrd Glacier entrained in the Ross Ice Shelf and the ice flowing northward to the east of the Shear Zone, which didn't intersect with Minna Bluff.


4D4
4D2
4D1
4D
3A
3B
11A1
37A2
4C
2B
12A
VSP Survey
Shot Holes
CH-1
VSP Survey Hydrophone
1A
1A0
CH-2
VSP Survey
Geophones
Short Term Oceanographic
Mooring and GPS Station
Gravity Survey
Stations
N
Experiemntal Test Hole
(SCINI, etc) and short
term GPS Station
Short Term
GPS Station
0
km
10
Telemetering Oceanographic Mooring
and Long Term GPS Station
Ross
Ice
Shelf
Coulman High
Traverse Path
11-11-2010 ENVISAT Courtesy of BAS/Polarview

CReSIS Airborne Radar Profile Perpendicular to the Ross Ice Shelf Edge



The ice shelf's upper and lower surfaces are fairly flat, continuous and featureless at the resolution of the airborne radar (~750 MHz; 600-900 MHz), with a slight slope.



Raw data collected through December 16, 2010 by GPS Station at CH Site #2; Initial (unpublished) data processing courtesy of Steve Fischbein (UNL SMO).

ANDRILL HOT WATER DRILL

Heating system
- Boilers
- Heat exchanger
- Snow melting
- Winch container

Drilling through the ice shelf
- Capstan setup in MECC
- Tools for hole creation

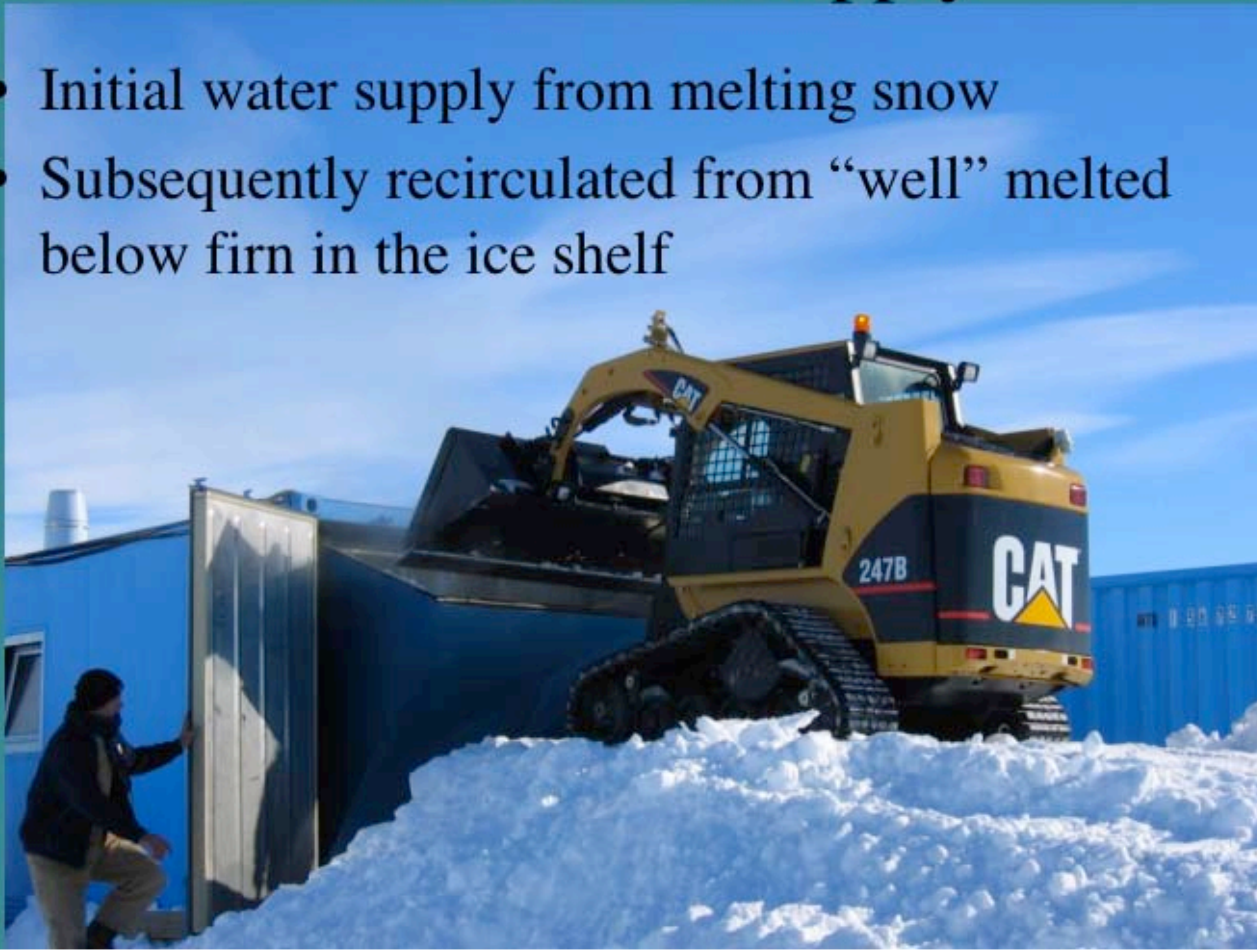
ANDRILL HWD System and Camp Modules at Coulman High

See Rack Blogs: http://andrill.org/science/ch/news
(ANDRILL HWD system and camp move on November 15 & 26, 2010)

HWD Winch systems for hoses & ropes

HWD Water supply

- Initial water supply from melting snow
- Subsequently recirculated from “well” melted below firn in the ice shelf



ANDRILL Hot Water Drill Tools

Pilot lance
•Jets water downwards through a leading nozzle
•Makes a small hole (~100 mm diameter)

Reaming lance
•Follows hole made by pilot lance
•Directs hot water up hole to ream the hole to a wider diameter (up to 600 mm)

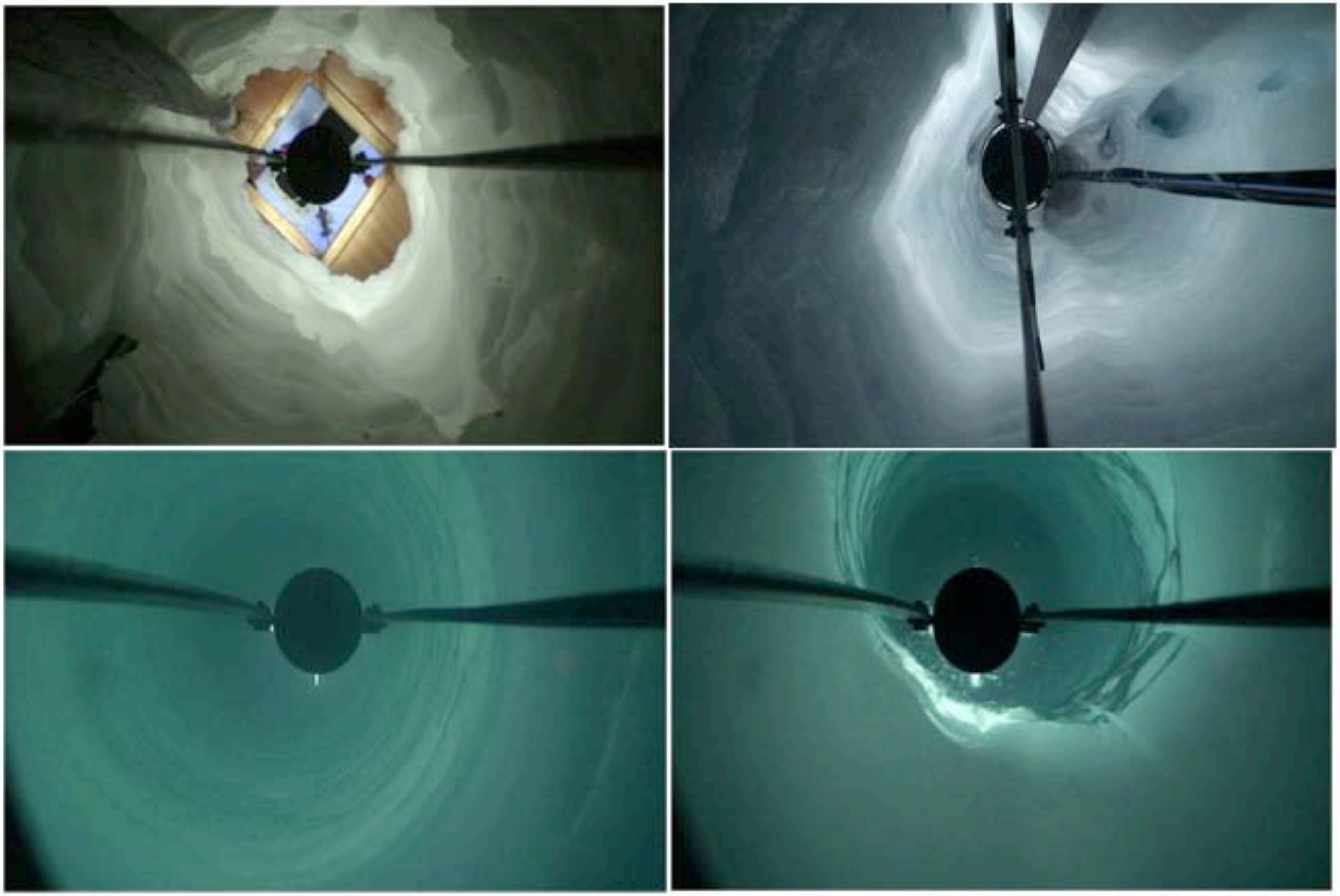
Ring reamer
•300 mm diameter for entire depth of hole
•Directs water out top or bottom ring, or can recirculate a non-freezing fluid
•Designed to run up and down hole while drilling with sea riser in place

Cable following melter (new)
•Designed to melt out around frozen in cables

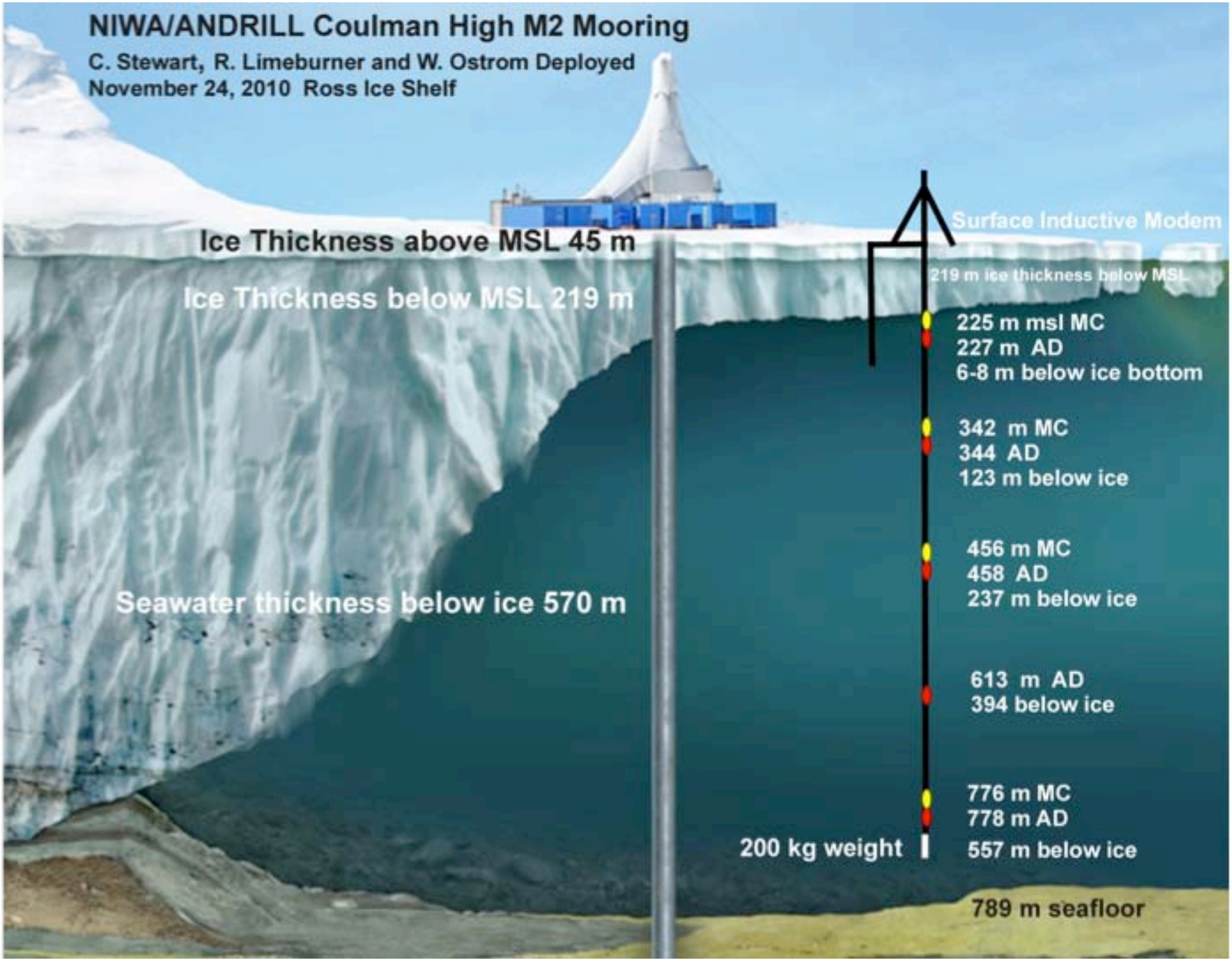
Seafloor camera

- Old Benthos housing
- New for Coulman High – HD Video camera
- Careful winch operator

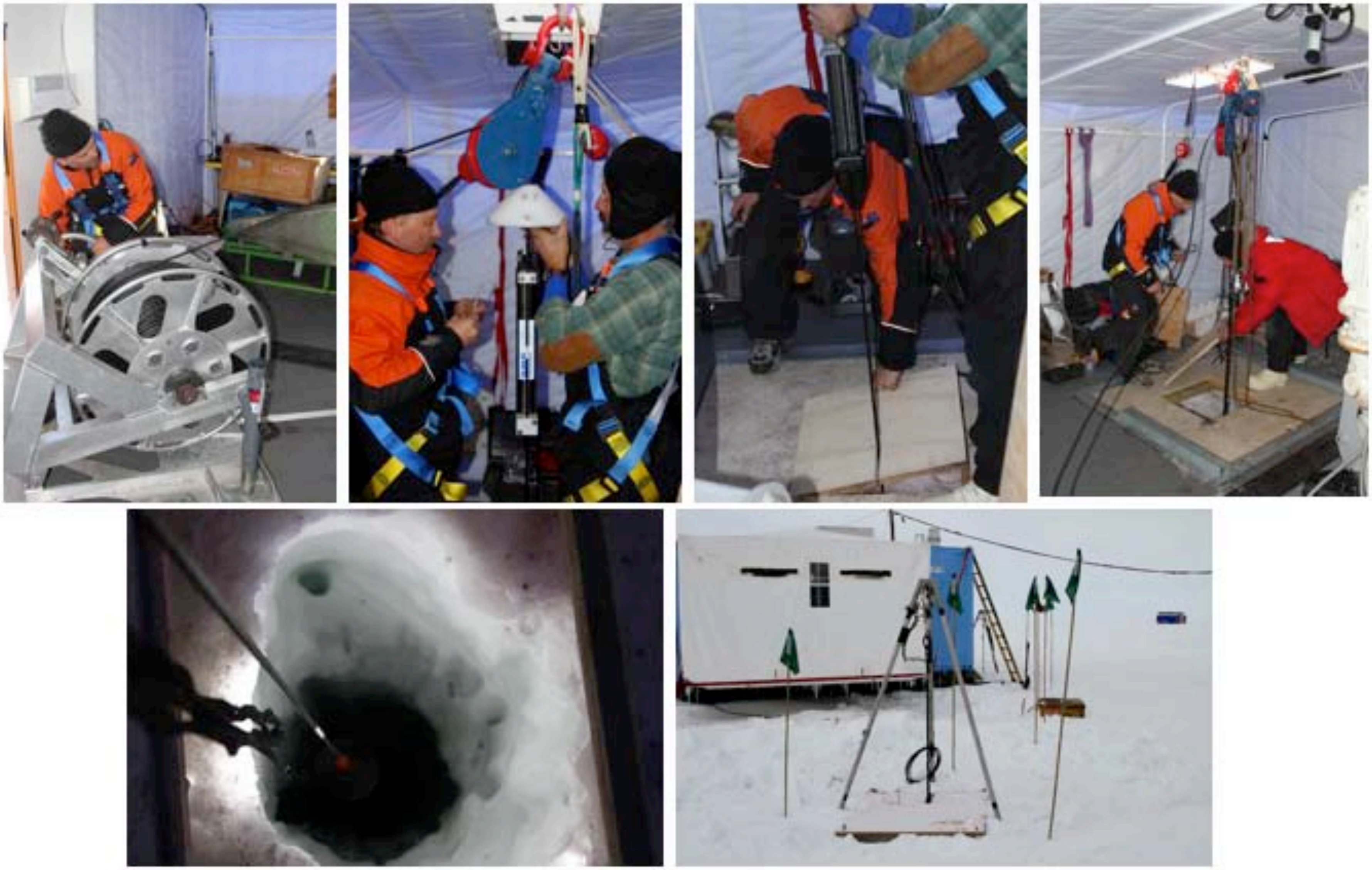
Video Images from ANDRILL Coulman High Borehole



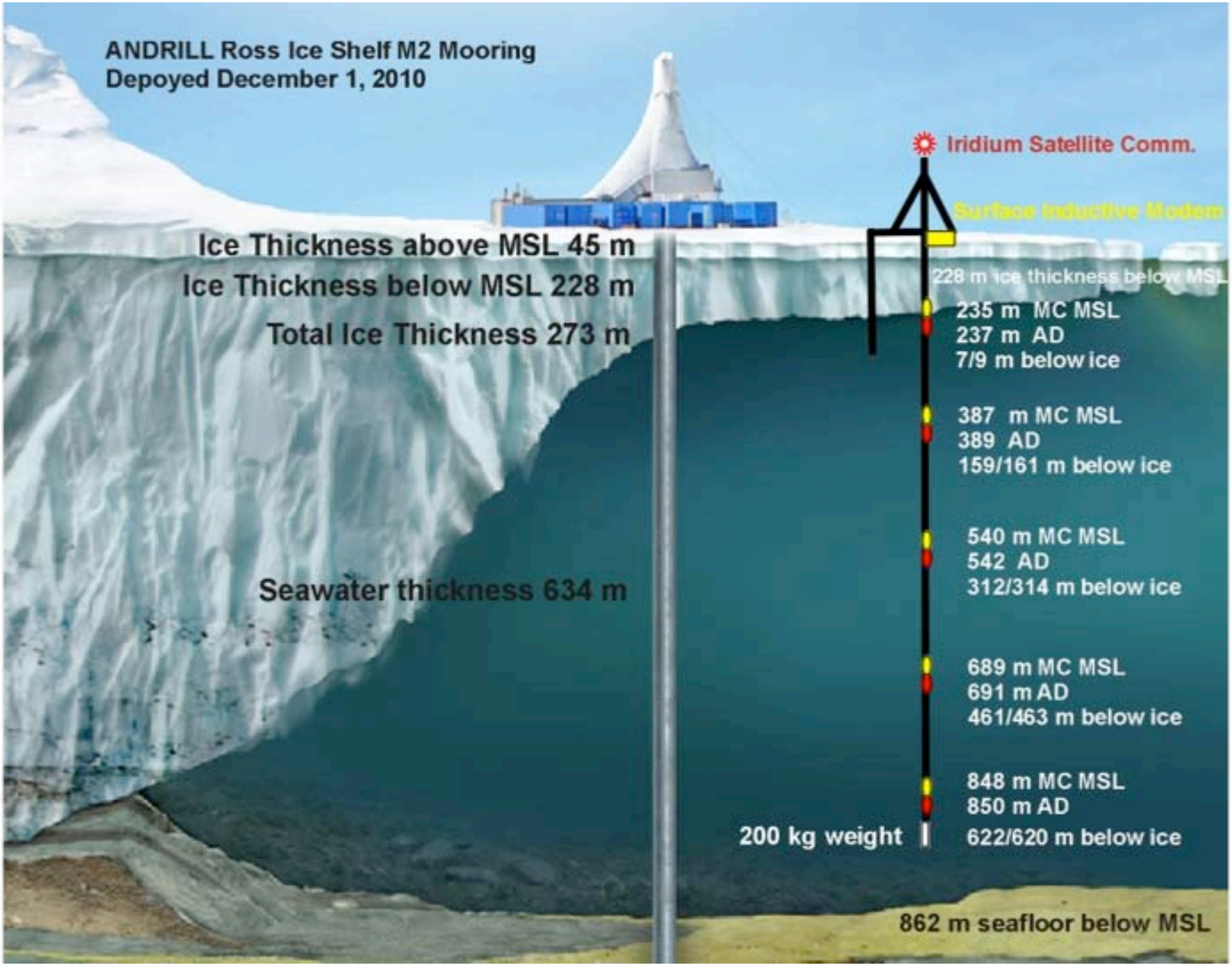
See Rack Blogs: http://andrill.org/science/ch/news
(Borehole camera imagery on November 21, 2010)


NIWA/ANDRILL Coulman High M2 Mooring
C. Stewart, R. Limeburner and W. Ostrom Deployed
November 24, 2010 Ross Ice Shelf
Ice Thickness above MSL 45 m
Ice Thickness below MSL 219 m
Seawater thickness below ice 570 m
Surface Inductive Modem
219 m ice thickness below MSL
225 m msl MC
227 m AD
6-8 m below ice bottom
342 m MC
344 AD
123 m below ice
456 m MC
458 AD
237 m below ice
613 m AD
394 below ice
776 m MC
778 m AD
200 kg weight
557 m below ice
789 m seafloor

Deployment of Inductive Oceanographic Mooring at Coulman High



See Rack Blogs: http://andrill.org/science/ch/news
(Inductive Mooring Deployment on November 25-26, 2010)

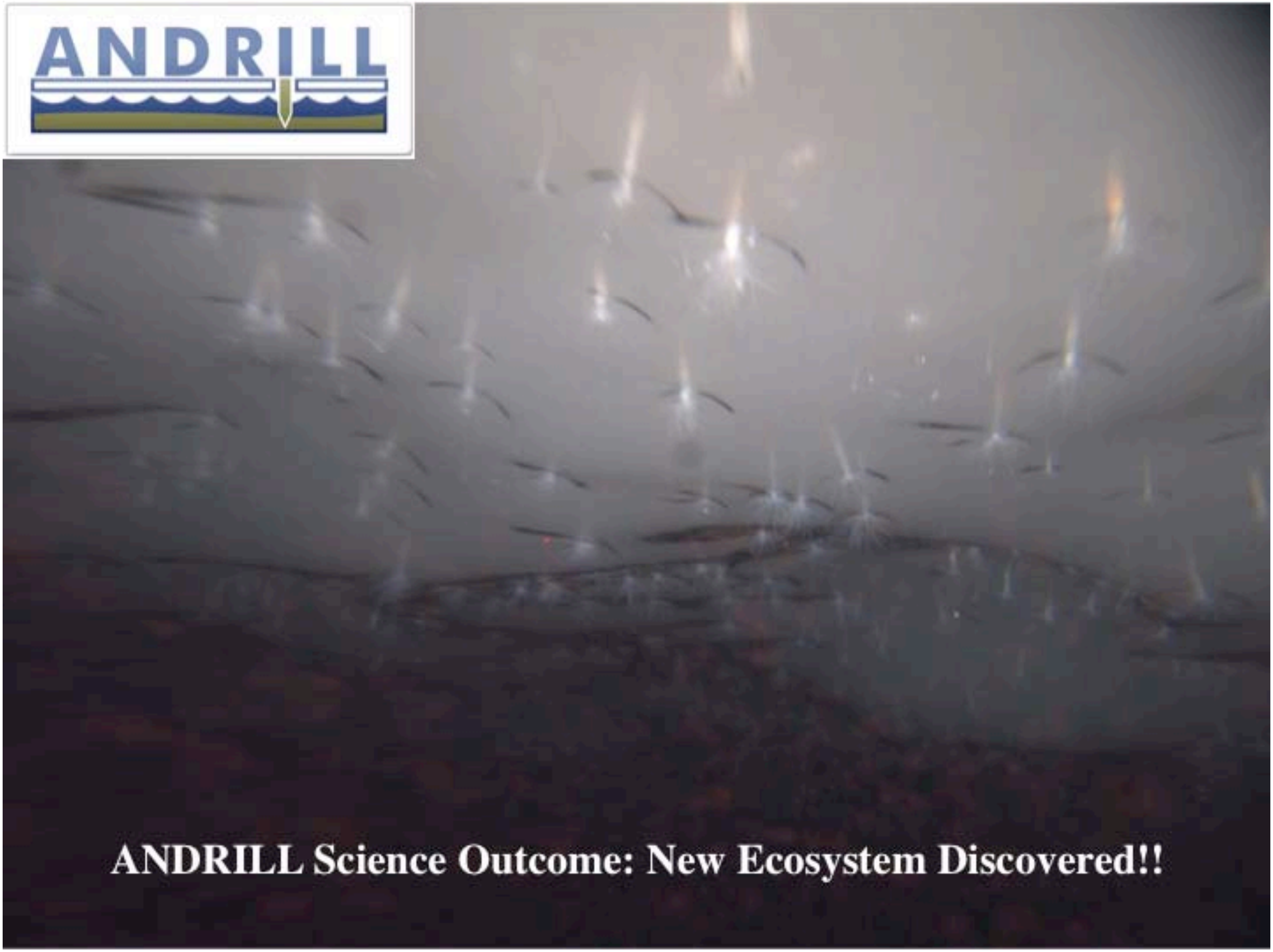

ANDRILL Ross Ice Shelf M2 Mooring
Depoyed December 1, 2010
Iridium Satellite Comm.
Surface Inductive Modem
Ice Thickness above MSL 45 m
Ice Thickness below MSL 228 m
Total Ice Thickness 273 m
228 m ice thickness below MSL
235 m MC MSL
237 m AD
7/9 m below ice
387 m MC MSL
389 AD
159/161 m below ice
540 m MC MSL
542 AD
312/314 m below ice
Seawater thickness 634 m
689 m MC MSL
691 m AD
461/463 m below ice
848 m MC MSL
850 m AD
200 kg weight
622/620 m below ice
862 m seafloor below MSL

SCINI Remotely Operated Vehicle (ROV) Team

Technical Outcomes of SCINI Dives through the Ross Ice Shelf

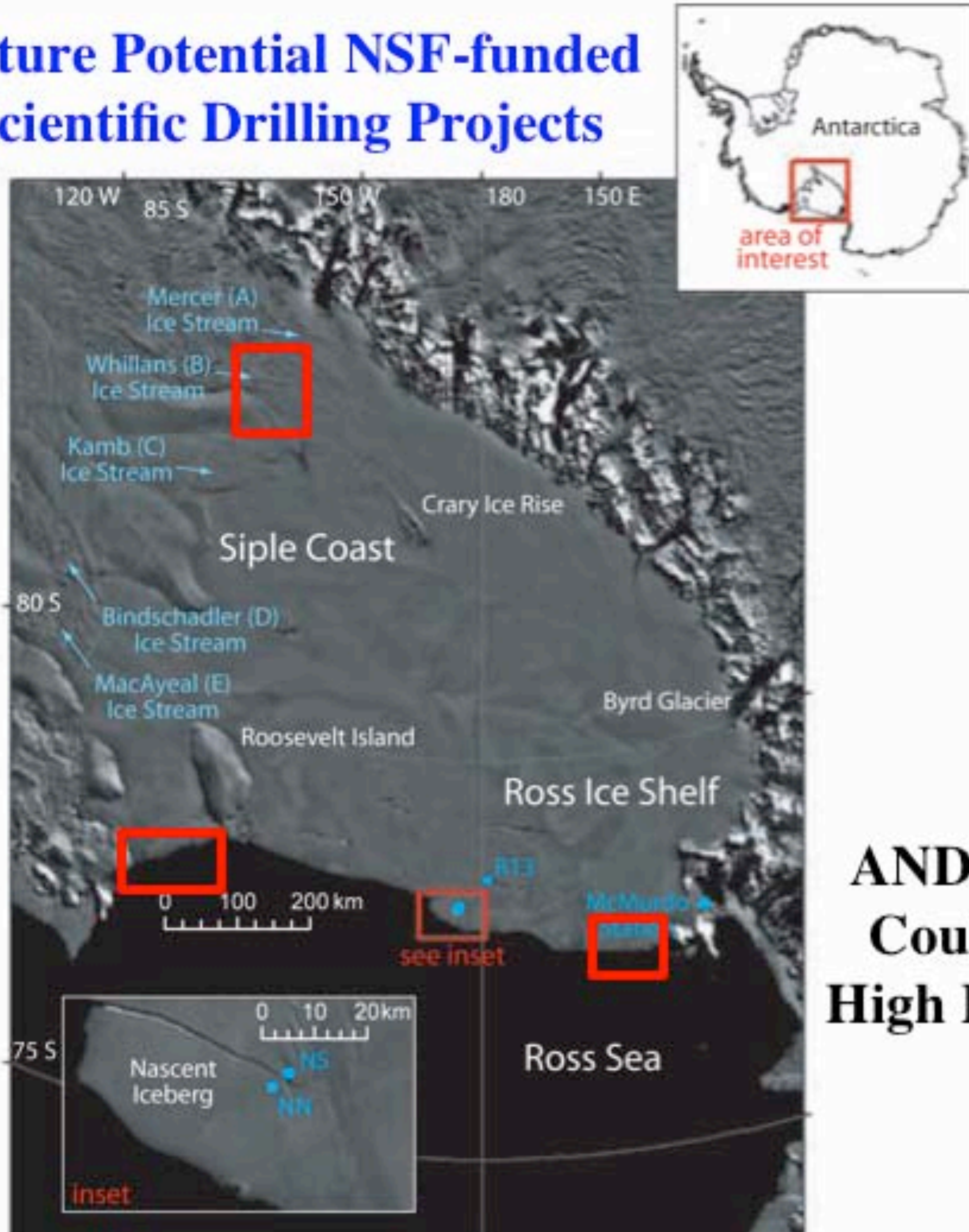
Total Dives = 14
Total Dive Time = 39.12 hours
Deepest Dive = 920 feet (~300 meters)
Longest Dive = 9 hours 15 minutes
Number of Dive Sites = 2
Images Recorded = >1.5 Million images
Deployed suction sampler = 10 dives
Flew Inverted = all dives
Number of Elphel cameras = 2
Image Size (forward-looking camera) = 1260 x 960 pixels (fisheye lens)
Image Size (upward-looking camera) = 2592 x 1936 pixels (flat lens)

ANDRILL


ANDRILL Science Outcome: New Ecosystem Discovered!!


Coulman High Drilling Project:
Proposed for 2013-2014 to 2014-2015,
assuming high scientific ranking and
sufficient international funding.
ANDRILL

Future Potential NSF-funded Scientific Drilling Projects



WISSARD

SHALDRIL
Bay of Whales

ANDRILL
Coulman High Project

Eos, Vol. 91, No. 46, 16 November 2010
Eisen, O., Hofstede, C., Miller, H., Kristoffersen, Y., Blenkner, R., Lambrecht, A., Mayer, C.

EOS
EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOLUME 91 NUMBER 46
16 NOVEMBER 2010
PAGES 429–440

A New Approach for Exploring Ice Sheets and Sub-Ice Geology

PAGES 429–430

Active seismic measurements were an important part of geophysical traverses on the Antarctic ice sheet as far back as the 1920s. These methods lost their leading role for ice thickness measurements to much faster ground-based and airborne radar sur-

as an acoustic waveguide, or trap, making the excitation of seismic waves from a surface source difficult. Soft firn causes large inelastic energy losses for impulsive sources. During most seismic surveys in Antarctica, researchers have used explosives in 10- to 20-meter-deep boreholes to overcome signal attenuation caused by the steep velocity gradient in the surface layer between soft firn and harder ice. The boreholes are drilled by different techniques, requiring considerable time and energy for each hole. With the seismic source below the surface, surface ghost reflections are commonly present in the data. Despite these difficulties, explosives sources in shallow boreholes are still the simplest way to obtain acceptable data quality. Even with this approach, involving minimal efforts, the necessary logistical requirements have discouraged the acquisition of longer seismic profiles, for example, as part of overland traverses.

Future Vision: Use tracked vehicles for rapid vibroseis (vibrator source in active seismics) surveys as part of over-ice traverses.

[NOTE: 10 to 20 km/day or higher rates are possible with current system; with multiple vehicles working together multi-fold coverage could be expanded.]

INOVA XVib tracked vibrator trucks traveling in tandem.

INOVA XVib tracked vibrator truck towing containers.

Recommendations and Conclusions

- The community needs a mobile, flexible, integrated environmental and geophysical survey capability that can provide consistent access through the ice shelf/ice sheet, allow the deployment of oceanographic moorings, remotely operated vehicles, and instrument packages, operate safely and efficiently, and allow a wide range of exploration to take place at a rapid rate over a wide area.

- The survey capability should be designed, re-configured and optimized to work in an integrated fashion with camp and support infrastructures while minimizing the set-up and tear-down time between site moves to support a wide range of potential users.

- We have come a long way since the Ross Ice Shelf Project surveys (1974-1979), but there remains a lot to be discovered under the RIS and other ice shelves using integrated geophysical, glaciological, oceanographic and environmental techniques coupled with advanced traversing and ice drilling technologies.

Acknowledgements

Thanks to all of the RPSC and ANZ staff and the communities at McMurdo Station and Scott Base who have helped us to plan and implement the Coulman High Project site surveys in 2010-2011. We are very grateful for their continuing support. This work was funded in the U.S. by the NSF-OPP (Grant ANT-0838914) and in NZ by the NZ Foundation for Research, Science and Technology.

QUESTIONS?

ANDRILL Coulman High Project Team – November 19, 2010

Download Booklet from: http://andrill.org/publications