Meeting Minutes
Ice Drilling Design and Operations – Technical Advisory Board
April 24 & 25, 2012
Union South
1308 W. Dayton St
University of Wisconsin - Madison
Madison, WI 53706

Meeting Attendees (dates attended)

Peter Doran	University of Illinois at Chicago	(April 24-25)
Bill Eustes	Colorado School of Mines	(April 24-25)
Steffen Bo Hansen	University of Copenhagen	(April 24-25)
Dale Pomraning	University of Alaska - Fairbanks	(April 24-25)
Marshall Pardey	QD Tech, Inc.	(April 24-25)
Alex Pyne	Victoria University of Wellington	(April 24-25)
Pavel Talalay	Polar Research Center, Jilin University	(April 24-25)
Frank Wilhelms	Alfred Wegener Institute	(April 24-25)
George Cooper	University of California - Berkeley	(April 24-25)
Keith Makinson	British Antarctic Survey	(April 24-25)
Zheng Zhichuan	Polar Research Center, Jilin University	(April 24-25)
Cao Pinlu	Polar Research Center, Jilin University	(April 24-25)
Joe Souney	University of New Hampshire	(April 24-25)
Ryan Bay	University of California - Berkeley	(April 24-25)
David Bresnahan	Bresnahan Consulting	(April 24-25)
Lou Albershardt	LCA	(April 24-25)
Tanner Kuhl	IDDO Contractor	(April 24-25)
Mike Jayred	Jayred Enterprises	(April 24-25)
Charles Bentley	University of Wisconsin - Madison	(April 24-25)
Don Lebar	University of Wisconsin - Madison	(April 24-25)
Alex Shturmakov	University of Wisconsin - Madison	(April 24-25)
Jay Johnson	University of Wisconsin - Madison	(April 24-25)
Nicolai Mortensen	University of Wisconsin - Madison	(April 24-25)
Krissy Dahnert	University of Wisconsin - Madison	(April 24-25)
Josh Goetz	University of Wisconsin - Madison	(April 24-25)
Chris Gibson	University of Wisconsin - Madison	(April 24-25)
Jamie Coyne	University of Wisconsin - Madison	(April 24-25)
Tony Wendricks	Bjorksten - Bit7	(April 24-25)
Jeff Cherwinka	University of Wisconsin - Madison	(April 24)

Chairperson: Alex Pyne
Vice Chairperson: Peter Doran
Secretary: Jamie Coyne

Tuesday, April 24, Industry Room

– *Welcome (Bentley)*

Charles Bentley opened the 4th annual meeting of TAB by thanking all attendees for their attendance and valuable participation.
General introductions were called for and offered by all.
Ryan Bay had joined the meeting as the SAB representative.
Experts from industry and university programs were in attendance and the countries represented included: China, US, Russia, New Zealand, England, Denmark, and Germany.

– *Logistic matters (Wendricks)*

Concerning logistic matters, Tony Wendricks handed out papers and wiscards and took head count for dinner at Brocach. There is a hard stop for leaving the Industry Room at 5p. In trying to figure out how to dial in to Dartmouth success was had by dialing 8 instead of 9.

– *Additions and corrections to the Agenda*
– *TAB Terms of Reference: any changes needed?*

Bentley discussed the TAB Terms of Reference and asked for any changes needed. Thereafter he thanked the previous chair, Dr. William Harrison, and thanked Alex Pyne for assuming the current chairpersonship. Bentley handed over the group to Pyne.
Pyne asked individuals to talk to him for any points of interest. He then turned to Terms of Reference and restated that the TAB is independent from IDDO. One of the issues to come up is that of the chairpersonship and not sure how to handle that in the future. He stated the chairperson should be independent. A volunteer for the position is requested.
Bentley assured that the work is not onerous, besides chairing the meeting, mostly involves agreeing on an agenda before the annual meeting and working with the Secretary before sending out minutes.
Pyne asked if the group should proceed or table the discussion.
Bill Eustus had a comment as to whether the group needs a vice chair, who would be the next chair, with respect to annual rotation. A vice chair may have momentum when going into the position of chairperson.
Pyne thought the position should be annual and asked again for input.

Julie Palais called in and Pyne greeted her and brought her up to speed about agenda and vice chair/chairpersonship. Palais thanked the group for going to Madison for the TAB meeting.
Pyne restated the call for a future chair/vice chair and tabled it. He then suggested alphabetical volunteerism if no takers presented themselves.

– Summary of IDPO/IDDO structure and purpose (Souney)

Joe Souney gave a history of IDDO/IDPO and went through slides (all available later for each presenter), describing the organizations. He discussed the change of interaction between the two groups. The cooperative agreement allows a mechanism for scientists to access or conduct their science more easily and reach their science goals. He talked about IDPO which convenes the SAB and updates the long range science plan annually. IDDO is meant to function as the principal supplier for NSF funded drilling technologies. Where equipment does not exist IDPO/IDDO will work to deliver the equipment. He discussed the organizational chart and pointed out the online repository of technical documents available at icedrill.org/library/… Past articles and technical documents are widely available.

– Update from the IDPO-Science Advisory Board (Bay)

Ryan Bay described last SAB meeting on March 21 and 22, 2012. He described working group changes whereby the Ice Core working group (ICWG), Subglacial WG, and Borehole Logging WG will be separate groups. Bay talked about the idea of an international clearinghouse for equipment. Also the possible future formation of a non-profit corporation (similar to UCAR), called COINCIDE (Consortium for Inter-University Cooperation on Ice Core Drilling and Experimentation) that would provide benefits including an enduring structure and liability protection. Bay talked about geology and microbiology with work and goals therein. He talked about the IceMole project and Wilhelms described that partial funding came from German government for development of the navigation system. Bay talked about IceCube drill possibly being used by various groups in the future. Bay talked about upcoming low energy projects. Each project will have to reconstruct the IceCube drill. Some points of interest included how to make hot water cleaner, and how close can one hole be drilled to another hole.

George Cooper asked about diagram describing "straw man" map of DM-Ice boreholes on the Bay presentation and the holes represented are to be drilled to 2500m deep.

On high energy end, Bay talked about hundreds of 200m deep holes for ARA experiment. Previous drill seasons have not gone as hoped. Perhaps more cooperation could help between scientists and IDPO. Borehole logging is important to the community and Gary Clow was thanked for his winch and expertise and cooperation. Perhaps an IceCube logging winch may work for certain depths. Bay thinks the community should have a set of winches for target depths. He talked about the necessity of permanent winch operators and support equipment packages as well as communal tools – loggers, winches, etc. There is a need for protocols for borehole use and maintenance. NSF wants some way of vetting instruments and protocols for what to do in the field. Other discussion included the 100m Blue Ice Drill, 1500m hot water drill, million year ice, and what to do with DISC. John Goodge submitted the RAID proposal last Friday April 20, 2012. Bentley says there will be discussion on fluids later.

Dale Pomraning talked about compatibility of drilling fluids.

Pyne asked about how to pursue a clearinghouse for borehole logging tools and personnel.

Bay says the IDDO is the near term supplier for equipment. The idea of personnel is less fleshed out as to who would handle that. Also asks about how to mate logging tools to community winches. Intermediate depth logging winch funded and technical review comes after funding. More borehole talk scheduled for 16:00 April 24.

Doran asked about WISSARD extension or still expected to end after this season.

Joe Souney says a maximum of four years' time is required to get old IceCube logging winch into IDDO inventory.. WISSARD project is still assessing whether they want to continue using the winch as usefulness of the winch is under inspection.

Discussion of existing systems

– Overview of systems and projects (Lebar)

Don Lebar started with mention of the SIPRE and PICO hand augers leading to the current Josh Goetz design. Of the shallow depth powered systems, the 2-Inch system has not been requested since its one use many years ago. There are no deployments or modifications currently planned for the 2-Inch system. Lebar said the Eclipse and 4-Inch systems are being updated. Of the deep tethered systems, the DISC drill completed the primary WAIS hole this year. Replicate drilling is discussed later by IDDO engineers. The Koci drill has reached its limit of usefulness and requires consideration of new technologies. Tanner Kuhl will talk about the BID later. The RAM drill was tested at South Pole for possible use on ARA. Firn is difficult for drilling with air, thus hot water drills are used frequently. Caltech drill is still in the box with some equipment being lent out. He talked about upcoming technologies from IDDO engineers including: Replicate coring system, Intermediate Depth Drill, Intermediate Depth logging winch, 100m Blue Ice Drill, Hand augers, etc. He similarly discussed Antarctic operations at WAIS and Taylor glacier. Arctic programs mentioned included Greenland 4-Inch and Greenland hand augers. Lebar also talked about the development of a deep logging winch.

Pyne said last year every presentation was cataloged and Wendricks has an USB drive on which to save the presentations from this TAB.

– DISC drill (Dahnert, Johnson,)

Review of 2011-12 season

Krissy Dahnert delivered the DISC drill overview which has completed the 5th season at WAIS. Drill arch is covered with snow and one can walk across the top at snow surface level. Floor buckling is a major problem. Also have some problems with availability of snow moving equipment. At last season opening the floor heave was 19" at center. Dahnert talked about borehole operation –first was borehole logging, and then replacing the 2600m cable (3400m before kinking), with a 4200m cable that was spare onsite. Season drilling completed the WAIS hole to stewardship depth. Cable manufacturer Rochester removed more of the black cable filler on this cable, thus penetration was not impeded by frozen filler at the top of the hole. Dahnert talked about logging with four tools. A fifth logging tool was tried but did not successfully determine the depth of the ice above the bed as intended. WAIS borehole starting depth was 3331.538m and ending was 3405.077m. All original borehole drilling and logging was completed on schedule.

Jay Johnson talked about drill fluid. The total fluid loss for drilling was around 35% and fluid loss for replicate drilling around 94%. No leaks in instrument sections this season. Johnson talked about challenges encountered this season. Final depth reached on Dec 31. Some logging tools onsite were not useful in defining depth. Said again the weather was bad, so a lot of digging. Johnson discussed WAIS visit by Steffen Bo Hansen where Hansen aided in Eclipse operations, DISC observations, etc.

Dahnert talked about upcoming plans for next season. Current plan is to ship back to Madison 2013-2014. 2012-2013 will be deviation drilling. Thanks to the drill crew.

Bay asked about the real-time video camera function and Johnson said there will be borehole pictures taken from camera video later in his presentation.
Pavel Talalay is interested in the temperature at depth, which was around -6C to -8C.
Wilhelms interested in temperature profile.
Pomraning asked about ice packing with depth, temp and feed rate.
Pyne asked if drill actually reached warm ice.
Souney says Gary Clow gave them temperature profile so can look at that during replicate discussion.
Discussion about the drilling arch floor being suitable –support staff will cut slot accordingly.
Wilhelms asked about pressure balance and returning drillers will see where the level is going in this next season. He also asked about fiber optics and asked about efficacy of using it.
Dahnert and Johnson say terminating takes 3-5 days for two ends. Optical slip rings are expensive, costing $20K for a rebuild. Furcation tubing hardens in 141b so working with it is difficult.
Cooper asked how can easily fix the heaving floor; the Antarctic Support Contractor does plan to lift the floor and dig out as he suggested.
Plans for next season consist of production replicate coring of up to 400m.

– Agile drills

- Review of past field seasons and plans for next (Dahnert)

Krissy Dahnert talked about Agile Drills including the 4-Inch system for Rick Forster's ACT 11 that produced high quality core. ACT 11 did encounter water in two holes and had to abandon those holes. Kent Anderson's GLISN project also made use of a 4-Inch system to drill a 300 meter hole for seismometer deployment.
Hand augers are out in the field in Arctic and Antarctic. Eclipse was used for training at WAIS. BID in Taylor was very successful –see BID talk by Kuhl for information. Portable hot water drills used in Antarctica drilled over 500 boreholes for seismic research. Goetz tested new design of hand auger – see Goetz talk for information. The hand auger is 3" diameter.
Upcoming Arctic seasons will use thermal drill, and hand augers. Some systems have shipped and others are being prepared for field deployment. There is some interest in using our equipment from outside sources –NASA, US Park Service.
Future equipment plans include work on hand augers, a water resistant 4-Inch drill, deeper BID, etc.
Pyne asked about BFC having sufficient supplies of hand augers to which Dahnert said that thus far there have not been any conflicts.
Dale Pomraning asked about the NASA cutter head scheduled for use in the Dry Valleys. NASA has developed cutter head and is just using an IDDO auger.

– Status of drills

- Blue Ice Drill (Kuhl)

Tanner Kuhl presented the BID status update and configuration of the drill. The BID was designed to be lightweight and fast and made to be helicoptered to site on one flight. Some updates include a sled and painted barrels. One feature of the drill is the separate core retrieval tool. Coring rate is at one meter per minute. The drill can deploy with a lighter configuration of 500 kg. Other updates include downsizing drill motor, shoe design, and carbide cutters for the ice surface that have a sharper edge. Since motor was changed the power cord can be changed for weight savings. Barrel coating successful as no melt encountered. Drillers are still having problem with not cutting with carbide at 10 m and deeper.

Pyne suggested ice unit structure may be different due to winter and summer wave.
Hansen suggested step cutters.
Cooper asked about choking or clogging.
Doran asked if cutters are detached and changed in each hole. Kuhl said the order of operations has been optimized for starting several holes before changing cutter.
For future BID to drill to 100m or 200m it requires a 4-Inch–like tower and slide hammer. There is also a possible project of slant coring at 20degree below horizontal.
Pyne asked if this is still agile at 200m.
Cooper asked about antitorque (AT), orientation at 200m and whether some weight could be shaved, but since ATs are aluminum rod it is lightweight.
Pomraning asked about slide hammer destroying motor.
Cooper asked about coating carbide cutters with TiNi, etc.

- Shallow-depth electromechanical and electrothermal drills (Coyne)

Jamie Coyne delivered a very succinct description of actions on 4-Inch and Eclipse systems. The 4-Inch system motor and gear sections are being overhauled. All winch sleds are being fitted with handbrakes and hand wheels. The traversing sled is being repaired due to hard use from the last traverse.

- Hand augers (Goetz)
- Modified hand augers (Sidewinder, Prairie Dog) (Goetz)

Josh Goetz described overview of PICO and SIPRE augers. There is one Kovacs at IDDO and several at BFC.
Pomraning asked if it is two or three cutters. Kovacs is two cutters.
Goetz has four sidewinders in inventory. He has one incomplete Prairie Dog and spare parts. Missing parts lost in shipping. Goetz says equipment in inventory is regularly failing thus requiring regular repair. New hand auger features v-belt flights. V-belts are polyurethane and attached with VHB tape. Goetz talked about new cutter head design from last season testing.
Pyne asked if there is a manner of supplying the three systems to scientists. Goetz said some scientists ask for what they like and IDDO suggests equipment to scientists based on what they do and where they will go.
Lebar said there is a history of BFC giving out systems that may or may not be appropriate, and IDDO does not get feedback from BFC.

<u>Discussion of systems under development (Shturmakov)</u>

– *Replicate Coring Drill (Shturmakov, Johnson, Gibson, Mortensen,)*

Summary of current status
Consultations:
Bjorksten | bit 7 workshop;
IDPO experts review (Eustes, Cooper)
Plans for upgrades and modifications (Mortensen, Johnson, Gibson)

Alex Shturmakov stated the outline of the Replicate Coring drill presentation, including status update of unmet goals/ unexpected challenges from previous season. Shturmakov handed it over to the engineering team of Jay Johnson, Nicolai Mortensen, and Chris Gibson.

Johnson talked about navigation test and location on upside of borehole. Johnson discussed season results of pulling 25-30 screens of chips. Johnson talked about helpfulness of imaging system. There is deviation drilling but unsure about localization vs. cutter head orbiting around borehole.

Gibson talked about actuator orientation.

Mortensen talked about electromechanical overview of actuator assemblies. There are six actuators and EM systems. There is telemetry for operation feedback. The Replicate uses what are essentially DISC geometries. Mortensen recapped the major issues encountered viz., in order of encountering, 1) stick-slip, 2) sonde flexure and 3) cutter geometry.

Stick slip is discontinuous and non-linear thus difficult to characterize.

Flexure reduces cutting force and introduces orbiting, etc. Engineers in Madison have sought to characterize sonde flexure via direct measurement and models. They now seem to have a model that reflects what was seen in field. They will test further in Madison and seek to characterize the sonde in toto.

Cutter geometry describes the cutter and bumper stacking on broaching head. Drillers were not able to assess cutter geometry due to flexure.

Drillers were able to remove 25-30 screenfuls total of chips which was less than expected for regular cutting. Flexure and stick slip seem to answer the partially-filled screens recovered. Drillers were unable to start cutting the ledge which is essential to deviation drilling. The possible solutions to stick slip could include axial rollers and using broaching cuts as that is insensitive to stick slip. Another option may be a screw to control radial motion.

For minimizing flexure, system design can go to shorter modular borehole assembly (BHA).

New cutter design can perhaps be based on Danish success with deviation cutting. There is preferred orientation for up or down cutting. Most cutting is axially and not radially so can focus on axial orientation.

Testing and verification includes characterizing the drill via testing in Madison. To which end, there is a test fixture at the warehouse for navigation tests in vertical orientation. Following the deflection characterization engineers will look at cutter head tests using resources on hand. Cutter head testing would use a drive mechanism coupled to the cutter head seated in an ice borehole.

In summary there is strong motivation for testing prior to 2012/2013 as next season is a production season.

Bay asked if uphill cutting is causing undue hardship. Mortensen said it seems it adds more difficulty but is required for further science goals to drill uphill.

Eustes has never seen uphill in industry and wonders if there is a physical reason why. And what is the backup plan.

Mortensen does not see physical reason why it cannot work and backup plan that is not available is to drill downhill. Science requirements state that the project must drill up hill.

Richard Alley called in to conversation. Previous attempt did not work.

Cooper continued to state that what is in order is continued experimentation.

Pardey asked about sonde length and flexure and Gibson said flex functions as cube of the length, so flex drops off quickly with decreasing length.

Pyne asked whether a work around could be to extend cutter length. Perhaps a slower feed rate would work.

Mortensen said stick slip last season limited sonde lowering rates to greater than 200 mm/s.

Hansen asked if adding a substantial weight to sonde would prevent stick slip. Answer is it will still stick slip but may reduce frequency of stick slip occurrence.

Cooper asked about hydrodynamics as pump pulls sonde downhole.

Talalay asked what the cutter test in ice is seeking. Mortensen says torque.

Wilhelms asked about collaring the sonde to prevent flexure and Gibson answered the collars will seek to do that and are not yet sure where to put them.
Pomraning suggested having arms near cutter head, within a foot, to direct the cutter. He also asked about the screw to control radial motion.
Cooper says to pursue Pomraning's point and to cut without screen sections for an orientation of a cutter and actuators directly behind. The cutting length is so short can just go back later for chips.
Kuhl asks about driving drill to ledge from below. But stick slip is present in both directions.
Stick slip from cable but major component from actuators sticking and slipping.
Pyne said perhaps vibration in the sonde would alleviate stick slip in actuators. Johnson says vibration in cable would be difficult to get along the length and is concerned about optical fibers in cable.
Eustes asked about the roughness of the new cable introducing the stick slip.
Pomraning suggested driven wheels at actuator arms.

– *Intermediate-depth drill (Johnson, Shturmakov)*

Summary of current status
Extending depth capability; comparison with DISC Drill
What and how much drilling fluid should be used
Logistic burden vs. hole depth
Underbalanced hole: pros and cons (discussion)

Note: With respect to the discussions on Underbalanced holes and Drilling Fluid, see Appendix A for correspondence from several drilling experts (some TAB member, some not).

Johnson introduced current design and specifications of IDD. See IDD – Jay Johnson slides.
Wilhelms asked what components of the level wind system are commercial-off-the-shelf (COTS), and Johnson said the slide is COTS and the rest will be made in-house.
Core barrel tube investigation options include fiberglass and aluminum options. Cooper asked about economy of scale via letting excess tubes go to other groups or NSF. Wilhelms suggested a German company working in stainless $15k tooling plus $6K per tube using flow forming. Supplier is evaluating sharp geometries (chip transport), on inside surface. Talk to Frank Wilhelms for more information.
Power requirement considered only for drilling and core handling and not camp operations.

Underbalanced holes:
Core quality is of interest in uncompensated holes.
Richard Alley has an analogy of drilling 200m or 300m underbalanced is like drilling that deep dry. It can be done but is not optimal. A 1500m deep hole at Pole without a densifier is about 150m uncompensated; taking the low-density firn into account that goes to ~130m uncompensated, so there is a reasonable chance that core quality will be acceptable.
Hansen said core quality at 400 meters depth at NEEM was directly dependent upon compensating to 260m depth. The ice depends on site. NEEM was running Estisol around 0.9kg/m^3 which is more dense than Isopar-K for IDD.
Talalay volunteered doing borehole closure calculations at underbalanced drilling if given temp profile.

- Pyne said that casing may need to rest a season before being usable with respect to holding fluid.

Bentley asks Alley quantitatively about underbalanced holes with brittle ice.

Alley's gut feeling is that core will be of fine quality. The question is if strain in the ice during drilling is reasonable or if the drill is banging violently. Smooth drilling should produce fine core.

Johnson said that 141b is not available so will have to look at something else if using 141b. There are sources from non-signing countries (China).

The Hansen description of the new Estisol follows in these minutes.

Discussion of systems under development (Shturmakov; continued)

– Rapid Access Ice Drill (RAID)

Lebar discussed the RAID project as a rapid access drill has been discussed for more than a decade. The original idea has split into a couple ideas –one focusing on geological investigation and the other with the idea of coring ice. Mike Gerasimoff investigated the geologically focused drill with the interests of cores-of-opportunity, accessing the basal geology and creating a borehole to later log. Details can be found in the presentation.

Doran asked about the depth of 3300m and Lebar replied that it is dependent upon the tubing that suppliers can offer. Concept based on "diamond drilling" industry practices and technology including wireline technology for coring "on the fly." Cutter heads will be ice cutting heads. Drill tubulars are straight without flared ends. Tube sizes would be B (BRQ), or N (NRQ), size tubulars. There will be a stepped configuration. Diamond drilling rigs are suitable for the project. Several truck-mounted rigs are available COTS. Concentrating on 20m rod sections as 30m sections are available but the mast becomes too large. Temperature is a big consideration so engineering and collaboration will be important between supplier and drill community engineers. Drilling fluid is, again, a big issue for usability and hole pressurization. N-butyl acetate has its own problems but availability of densifiers for a two-part system has become problematic. Chip production and fluid flow and surface pressure were discussed, as well as fluid handling. Bore hole must be cased as fluid pressure at surface will be ~500-600psi. Fire suppression discussed as drill fluid could be flammable or combustible.

Jeff Cherwinka asked about how to get pieces around. It will be traversed.

Cooper asked about drill brittleness correlating to strength.

Marshall Pardey suggested the drill string is 4130 steel.

Pyne suggested that this RAID rig be much like ANDRILL, which was modular, and other companies should be able to offer that.

The drill rig discussed is one of six identified.

Pyne also suggested the system should be Herc-able.

Lebar said another issue is having experienced drillers.

Pardey suggests that the engine is oversized and the scientists will be paying for fuel. Pipe size discussed is not used in industry anymore. Also, the size is small for wireline drills.

Pyne asked if there were calculations for fluid flow through the borehole annulus. Lebar did not know what was included in the calculations. He also suggested that one may be able to drill with NRQ all the way down.

Cooper discussed "slim hole" drilling in the oil industry and its abandonment. There is difficulty in balancing fluid flow (that would prevent chip transport stalling), against bottom of hole pressures that fracture the borehole wall.

Pyne suggested air drilling (recirculation), in the firn. From ANDRILL experience he suggests communicating with the hydraulic engineers from the start which will cost more. Usability requires that hydraulics be addressed first.

The prospectus is not available to the community as there is a proposal submitted and it can be thought of as proprietary.

Discussion of non-IDDO drilling and systems

– *Impromptu discussion: Wireline drilling history (Talalay)*

Talalay stated that wireline drilling first published by Hansen in first international symposium. First core recovered by RISP group. Pavel Talalay gave history of wireline drilling -see slides. Last wireline drill was 1998 and has access holes started with hot water drills. Talalay says wireline drilling has many problems. Hydraulic systems should be purpose-designed, the drill should be enclosed from blowing snow, the chip extraction and fluid input needs to be balanced, sealing of the borehole casing, etc.,

Pomraning discussed his experience with Black Rapids glacier and logistics and characteristics of drill. Pomraning also recalled a mining company wireline drilling in AK.

– *Russian drilling at Vostok (Talalay)*

Talalay stated Vostok Hole 5G started 22 years ago on Feb 20, 1990. See slides for information and diagrams. Pavel Talalay showed a video of Vostok from two years ago. Drill encountered accretion ice on January 2, 2012 and samples were taken directly to Moscow. Depth of sample around 3769.3m.

No silicone fluid was put into the borehole as was promised to the international community.

One planned operation for next season is the recoring lowest 10-15m.

Doran noted that Lipenkov said something interesting about the last core smelling like a swamp.

Talalay says recoring is not warranted as there will be contamination from drill fluid. Recoring the refrozen ice is also difficult, as experienced with NGRIP in 2004, where the drill deviated from the original borehole.

Talalay suggested the pressure at Vostok is higher than rho*g*h and that fluid rose higher in the borehole than would calculate from pressure with depth.

– *Chinese drilling projects: Dome A and Gamburtsev Mts (Talalay, Cao, Zheng)*

Dome A is highest point in Antarctica at 4091m. The thinking is that the oldest ice could be found there; one million year old ice is the goal. See slides for history of Kunlun Base and drilling therein. First cores returned to China two weeks ago. They were drilled with a shallow drill and hole was enlarged. Next drill season will use the deep drill for the first year. Fluid is n-butyl acetate.

Drilling at the Gamburtsev Mountains. See slides for history and details of the mountain science. No rock samples are currently available from the Gamburtsevs. The goal of drilling in the mountains is to reach and sample bedrock at a depth of 1000m. A traverse will go to site.

Wilhelms asked if the BHA will be handled vertically or laid horizontally for core removal.

Talalay says it will be disconnected vertically then manipulated horizontally. The plan is to field test at Zhongshan Station during the 2013-2014 season, taking core samples. In the 2014-2015 season drillers will traverse to the drill site and drill ice to ~1000m. The current timeline is very tight.

Pyne asks if the modified rock bits have the same penetration.

Talalay said that rock bits with windows drill slower and have a shorter lifetime but that is not such a serious consideration as they need only 2m of bedrock core.

– *Update on ANDRILL (Pyne)*

Next proposal is to drill on Ross Ice Shelf at Coulman High which is similar to previous experience. The wrinkle is that the ice shelf moves 2m per day. Water depth is 770m and ice shelf thickness 250m. The goal is to drill ~1000m below sea floor. See presentation for graphs of water current speed. About 90% of the water current can be attributed to seasonal tides. One main issue is the pipe bend at sea floor.

Proposal submitted to NSF in March 2012 and would like to discuss at SCAR in July. Pyne says this site is special due to the geology.

*The meeting secretary was temporarily called away with dial-in phone problems where radio was playing over intercom. Severed connection and used a separate phone conference service.

– *Update on Roosevelt Island drilling (Albershardt, Pyne)*

Roosevelt is an ice island. Twin Otter flights were used in design but are not usable in practice. Baslers and Herc fights are ideal but there is not good access to Hercs. The camp was water-rich due to waste heat recovery from the generators. See slides for drill specifics. This drill features a hydraulic cylinder to raise and lower the mast and drilling penetration is dependent upon mast movement. Onsite processing consists of cutting core to 1m length. There is a buffer room off the drill floor for brittle ice. Another room off the drill floor is used for core storage. 2012-2013 planning is to drill wet to 760m, logging the borehole, then decommissioning drill and camp.

Gibson asked if the core cave was getting solar gain from tent or drill floor, and Pyne said that the cave is 6m away from drill floor.

– *Update on Lake Ellsworth access drilling (Makinson)*

Keith Makinson stated that most equipment is on continent and the goal is to start drilling next season. See presentation for slides of drill specifics. This is a clean drill to 0.2 micron filtration and UV treatment. Thinking is that the drill is a one-shot operation so redundancies were built into the system as the budget allowed. The drill is comprised of a single boiler system with water as the working fluid being put through the heat exchanger. Submersible borehole pump drills own way down. Water level will be 300m below surface necessitating large lifting pumps. Water level kept to under-pressurize the hole.

Talalay asked about the length of piston core that was decided to be 4m.

Cherwinka asked about hot pumping and it has been tested for 8 hours and is rated by CAT pumps. The pumps are all stainless.

– *ARA hot water drilling at South Pole (Cherwinka)*

ARA is a physics project over a large scale compared to IceCube. There is renewed interest in the drill after non-optimal drilling previous season. Goal for next year is two stations plus calibration holes. Drillers will drill with lost water for the first 40m then pump out while drilling. Hole will be pumped dry when final depth reached. Currently have money to complete upgrades to reach production drilling rates. See presentation for specifics on the drill system.

Wilhelms asked about the efficiency of the generator highlighted and Cherwinka said it was about 29% but ~33% is the standard. Plus you can get waste heat.

Pardey checked and said that noise rating is 65dB at 10m.

– *Update on European drilling activities (Hansen, Wilhelms)*

Steffan Bo Hansen presented on replicate drilling and rock drilling at NEEM. See presentation for specifics on deviation drilling. Deviation completed in eight hours with minimal modification to the cutters. Drilling completed with the HT intermediate-depth drill on the downhill side of hole.

Rock drilling utilized carbide inserts then standard rock drilling bits. Each bit drilled about 1m. Water was encountered and drilling suspended.

Potential upcoming drill sites include undisturbed Eemian, 1 MA, ice stream at Northeast Greenland Ice Stream (NEGIS), which moves ~100m per year. See presentation for specifics of drilling.

Frank Wilhelms talked about direct drive motors that move fluid through the inside. They have a 6m tower that operates a 5m drill. The idea is to get away from cutting slots. It is a 250m depth drill but was designed to scale to intermediate depths. Drilling this summer will be in Greenland.

– *Adjourn*

Pyne asked TAB members to think about vice chairperson and to place all presentations on memory stick.

Time is 17:20pm. Festivities called quits for the day. Group dinner at Brocach Irish Pub.

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<u>Wednesday, April 25, Agriculture Room</u>

Begin second day session at 8:10am. Wendricks asks for travel reimbursement forms and for taxi rides needed.

Pyne announces that Peter Doran volunteered to act as vice chairperson.

– *Borehole logging: what should be IDDO's role? (Bay; Shturmakov, Dahnert)*

Krissy Dahnert asked Jamie Coyne to talk briefly about the winch that has been selected. The logging winch will be a lightly modified DS2000 from Downhole Surveys.

Bay said that drilling and logging are perhaps inseparable.

Bentley asked what IDDO should be charged to do as current status limits IDDO participation to engineering.
Bay states there should be some borehole stewardship and logging equipment conservator and supplier. Perhaps that could be IDDO.
Pyne asked if this winch would be universally connectable. There has been some experience with common winches in which tools did not operate properly.
Wilhelms suggested that the only standard now is the Danish winch.
Cooper asked who maintains the boreholes now and the answer is nobody.
Mark Twickler of IDPO joined the conversation and Pyne appraised that it is not trivial to get your tools to work on somebody else's winch.
Lebar said the SAB working group could help direct the IDDO effort. Also with respect to the equipment, IDDO is reluctant to leave equipment in Antarctica but would rather bring it back to Madison.
Bay said that NSF has an effort to reduce logistics and so may have to push back. Bay said that the winch design has been constructed with the idea of being able to mate and be usable with community tools.
Pyne asked if the SAB would want the winch in US for testing. Yes, they would.
Wilhelms said there is the idea that the Danish system is geared toward telemetry and onboard memory.
Cooper asked again if there should be a borehole stewardship body.
Souney said specifically to WAIS hole the present group "owns" the hole.
Fishing is a different operation than logging.
Eustes suggested that the RAID drill could be used for fishing.
Pardey suggested a piston driven crosshead attachment to the logging winch for fishing.
Pyne says then that we should think about a logging winch being able to perform fishing operations.
Bay said that the idea is to be able to gently retrieve a lost tool not a heavy pull machine.
Wilhelms asked how tools are lost as his concern is getting it stuck.
Bay said tools are lost via poorly maintained cable head or loose sets crews, etc. In event of stuck tools some operational expertise would be preference, not brute force.
Pyne said to Cooper's comment about reaming holes that once they are finished nothing happens with the hole except logging.
Hansen can imagine a reamer device like at DYE 3 reaming localized spots.
Bay said something as simple as an ice plug could be worked out by those logging the hole, but something like Siple with collapsing fiberglass is larger than a logging group can handle.
Wilhelms said steel casing is more resilient than fiberglass. So should think about how to maintain holes.

Wilhelms suggested talking at the next TAB about how to preserve boreholes for long duration?

Pyne asked to summarize the conversation to what the tasking for IDDO should be with respect to logging boreholes, supplying equipment, operator, etc.
Kuhl said that for IDDO to log boreholes after drilling requires drillers work with loggers.
Pyne said he was thinking about having a logging winch on site independent of drill equip.
Bay said that ties up the logging winch.
Wilhelms suggests that the existing system can be coupled to any drill.
Pyne said a need has been identified to log while drilling and some work need be done assessing how to do that.
Kuhl said there may be a couple of logging regimes where one is detailed and the other is a simple caliper or the like.
Pyne suggested IDDO and SAB work it out together.

– Drilling fluids for the future (Shturmakov; Talalay, Souney, Hansen, Eustes, Wilhelms)

Shturmakov suggested talking about: availability, detrimental effect on environs, detrimental impact to equipment, operational safety, influence on ice properties, science challenges, and impact on drill system performances.
Wilhelms also suggested thinking about entry to subglacial biological systems.

Talalay started with general requirements. See presentation for specifics. Fluids are single or two component. He presented his work on testing two-component systems.
Mortensen asked about the respective dielectric strengths and Talalay has not done that work on the new samples.
Pyne asked if Talalay can set up an experimental measure of lubricity. Talalay thinks lubricity is important only for warm ice.
The Chinese Polar Research Center is now printing technical reports with three issues currently out. They are available to the drilling community on the US Ice Drilling Program web-site: http://www.icedrill.org/library/index.shtml.

Hansen presented on fluids that they have been using at NEEM. See presentation for material specifics of ESTISOL. The bore was increased from130mm to 132mm to account for increased viscosity. Hansen said production was as great as 1,700m in the 2009 season. New ESTISOL 140 may be a good single fluid useable also in Antarctica, and will be field tested next season at NEEM. There are very little manufacturer-provided property specifications so testing in lab and in field are the only ways to find specifications.
Kuhl asked about the RAID project if the group has any input for fluids to be used in the drill. Eustes and Pardey said that in the oil industry the equipment is designed to be explosion proof where that may not be the case for mineral drills like the RAID drill.
Bay noted that Gary Clow does not favor ESTISOL as convection cells wreak havoc on his temperature data. <Please see Appendix A for further correspondence.>
Pyne said that is especially important in the RAID drill as temperature is one of the major data components. That is something to consider.

– Hot-water drilling (Lebar; Makinson, Wilhelms, Pomraning)

- British Antarctic Survey (BAS), Ice Sheet Drilling in the 2011/2012 Field Season (Makinson)

Makinson states that there is interest in having an intermediate (1000m -1500m) system portable by Twin Otter. It is difficult to get equipment into Twin Otters. A solution to ice necking at the ice shelf and sea water interface is a brush that is used as a plug for updrilling from the ice-water interface. Next season will see a 1000m hose with the addition of one heater and another generator to power new pumps.

- Pine Island Glacier (PIG), Drilling in the 2011/2012 Season (Pomraning)

Dale Pomraning discussed the difficulties of transportation and weather for the last season on Pine Island Glacier. The group packaged helicopters for transport in Hercs with the idea of transporting helos to PIG air strip (from McMurdo), for helo shuttles to PIG. There was one Herc boomerang to PIG strip but sastrugi was perpendicular to what was expected with nearly buried flags. Bad weather

at McMurdo, PIG strip, or Byrd prevented flights. Plan is to return in December 2012 for another attempt.

Doran said that a Kovacs hot water drill is at BFC that is IDDOs for the taking. Some repair and upgrades required.

– Presentations by IDDO staff on problems they face and discussion thereof

No discussion followed.

– Carry-overs from yesterday

Kuhl asked about RAID and drill string dynamics of using a NQ size.
Pomraning asked what would happen to the holes after drilling.
Lebar said they will be kept as observatories.
Pardey says strings should be supported by an outer pipe the length of a core barrel. Benefit is that this system will have low bit weight so should drill quite straight.
Pyne said rule of thumb is a straight hole is within two degrees.
Pardey says whipping increases with larger annulus. A good rule is not to exceed 0.5" total diametral clearance. This system is not the same as with oil rigs as this string will be in compression where in oil drilling it is in tension. Pardey says that this project is at the terminus of Borat Longyear pipe capabilities. General question about why 10ft length is required.
Pyne asked what a Hercules aircraft can handle to which Bresnahan said a six meter length in combat offload should not be a problem.
Pyne asked how long a section a thin-walled pipe handling system can handle without bending the pipe. Kuhl said the Versa-Drill company said 20 foot sections are the longest.
Pardey says a hybrid system of oil and diamond systems may be useful to investigate. Matrix builds his (ANDRILL) pipe and does custom diamond pipe. Tubing based on ANDRILL could be used for RAID with the example of N-size core with 3.5" borehole. He suggested looking at TenarusHydril wedge thread for RAID. Problem is only get it threaded in three places in the world and one is in Texas. Pardey also has the concern that a single rig cannot be bought off the shelf and may actually have to piece together a system. A case drain kidney loop for hydraulic system is important. Pardey said the science interest of RAID capturing soft wet sediment samples is not a problem but may have to fabricate capture tools to fit pipe size.
Pomraning had difficult experience collecting subglacial fines although large sediment was not such a problem. Difficulty may have owed to tube string bending geometry.
Pardey asked if there has been any thought on a whipstock orientation tools setup for replicate drilling – a casing wedge. Such a system is used to start a pilot and later ream to desired diameter. This is one piece where the whipstock captures the wedge assembly and returns both to the surface.
A similar design was considered where the whipstock and wedge were separate pieces. The group decided to pursue the actuator avenue.

– Review of Long Range Drilling Technology Plan (Bentley)
– Updating the Long Range Drilling Technology Plan (Bentley)

Bentley asked for any comments to the Plan, and upon not receiving any said that he will circulate updates.

– Next TAB meeting – combine with 7th International Workshop on Ice Drilling Technology? (Wilhelms, Bentley, Souney)

Wilhelms earlier proposed that the next meeting be coupled with the next IPICS meeting in October this year. There were difficulties in including the Madison drill community calendar so it was suggested to hold the meeting in Madison in 2013 and connect it to the TAB. TAB has also coincided with EGU which is not optimal for the community. Wilhelms contacted the editor of a new journal to have a proceedings issue published. The editor is interested.

Bentley said that Madison group is ready to go ahead with hosting. Field seasons are a consideration and scheduling must accommodate deployments and returns. The meeting discussed possible dates and late August or early September was thought to be possible for all groups. Wilhelms will check with the community for ability to attend. Funding required for university services are very different than for off-campus services and the UW-Madison availability will be investigated.

An organizing committee will be started by Wilhelms. There will be discussions later how to organize meeting specifics of poster sessions and lecture sessions.

Wendricks will be Madison area organizer.

– Wrap-up and action items
– Adjourn

Peter Doran takes control for meeting with the exit of Alex Pyne.
Doran asked for further discussion and upon receiving none asks for closing remarks.
Bentley thanked the meeting attendees.
Doran adjourns the meeting.

Appendix A

The following correspondences should be considered in the TAB discussion of underbalanced holes, what drilling fluid, and how much drilling fluid should be used.

The following is an email sent to TAB members from Charles R. Bentley on April 27, 2012.

Dear TAB members,

We never came to closure about the under-compensated drilling question while we were meeting so I'm asking for your opinions now. For reference, here's how I put the question to someone yesterday and would now like to put it to you (with the same time schedule):

"Dear _____,

As you know, we at IDDO are developing an intermediate depth drill that is planned for its inauguration to core to 1500 m at South Pole. Because of current difficulty in availability of densifiers, we're considering drilling without one, using just Isopar K, with a specific gravity of about 0.81 at Pole temperatures.

The question has arisen as to whether under-compensation in the hole would have an adverse effect on the quality of core from the brittle ice zone, i.e. as compared to full compensation, which would require a densifier.

Any thoughts you have on that question would be very useful to us, particularly if we could receive them by Tuesday, May 1, in time for a discussion of the topic on a Wednesday telecon with other players in the game.

Many thanks for any help you can provide."

The following fax, dated April 23, 2012, was sent to Dr. Charles Bentley from Dr. Tony Gow.

Dear Charlie,

Sorry for the delayed response to your email of the 18th. Currently experiencing computer problems so faxing the information you requested instead.

1. *Use of IsoparK (SG 0.81) at the South Pole should take care of hole closure, given the cold temperatures of the ice, even at 1500 meters depth. Temperature profiles have been measured within 500 meters of the bed by Amanda and IceCube projects and you should have access to this information.*

2. *All deep core holes drilled with densifiers or dense liquids in Antarctica and Greenland also exhibit brittle ice characteristics. As to the quality of the ice in the brittle zone I would not expect any significant change in brittle ice characteristic in a hole filled with IsoparK. Optical logging of boreholes at the South Pole indicated that scattering from bubbles shows that they become undetectable between 1300 and 1350 meters, signaling the onset of ductile ice at around 1500 meters. Furthermore the differences in density between IsoparK and other densifiers are not likely to exceed 15%. This should lead to a minimal decrease in the quality of brittle zone ice at the South Pole.*

Best Wishes,
Tony

Herb Ueda sent the following email on April 22, 2012.

Hi Charlie,

In regard to the effects of a slightly lower density hole-fluid, I don't think the change in effect on the quality of the cores or the effect on the drilling would be significant. The effects of brittleness ˆthe ice breaking up- begins on the trip out of the hole and of course at the surface as the pressure decreases. Incidentally we tried capturing whole cores in the brittle zone before they started breaking up and putting them under pressure immediately upon retrieval. We then released the pressure at various rates but the end results were about the same. I believe some day we should be able to capture whole cores in the brittle zone and keep them whole for analysis.

Of course lower density fluids could create hole closure problems in the long run, depending on how long the accessibility of the hole is required.

Herb Ueda

The following email is from Bill Eustus on April 20, 2012.

Dear Charlie,

Here is another fluid densifier to consider. Citrofol BI or BII.

Bill

Alfred William Eustes III, Ph.D., P.E.
Colorado School of Mines
Petroleum Engineering Department
Golden, Colorado 80401
303 273 3745 Office
303 273 3189 Fax

Steffen Bo Hansen sent the following emails.

Dear Charlie,

It seems clear to me that under-compensation in the hole could have an effect on the quality of core from the brittle ice zone. The question is how much under-compensation would still be acceptable.

At Neem it turned out, that when drilling a 400 m deep hole using Estisol 240, we could not allow the liquid level to drop below 260 m without affecting the core quality. It was significant, and we repeated the test several times by letting the liquid level drop and bringing it back up again. Until that depth the core quality seemed unaffected by not being pressure compensated.

At CIC we have identified a new version of Estisol which we believe could be an interesting candidate for drilling fluid for use in Antarctica. That version called Estisol 140 have been taken through lab test in Copenhagen and shows promising values regarding viscosity and density in low temperatures. We have scheduled a field test of the Estisol 140 at Neem in May 2012.

Best regards
Steff

Dear Charlie,

You can also find some information about bore hole closure rates in our old paper "Instruments and Methods" pages 172 - 173.
<Johnsen, S. J., et al. 1980. Instruments and Methods: A fast light-weight core drill. Journal of Glaciology. Volume 25, Number 91, Pages 169-174.>

Best regards
Steff

Pavel Talalay sent the following email.

Dear Charlie,

I suppose that you should also consider the hole closure while drilling at under-compensated conditions. You know that at Vostok station drilling without densifier brought a lot of accidents with drill sticking.

I (or your guys) can estimate the hole closure at South Pole at under-compensated conditions using temperature profile (see attachment) from:
Price P. B., Nagornov O.V., Bay R., Chirkin D., He Y., Miocinovic P., Richards A., Woschnagg K., Koci B., and Zagorodnov V. (2002): Temperature profile for glacial ice at the South Pole: Implications for life in a nearby subglacial lake. PNAS. Vol. 99, N 12. 7844-7847.

For calculation of the bore-hole closure rate you can use equations and coefficients from: Talalay, P.G. and R.L. Hooke. 2007. Closure of deep boreholes in ice sheets: a discussion, Annals of Glaciology, Volume 47, Number 1, Pages 125-133

It was nice to see you at the TAB meeting.
Best regards,
Pavel

_____
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Joan Fitzpatrick sent the following email.

Dear Charlie –

As you know, I'm not an engineer, so all I can really offer are my thoughts based on my own experiences and I don't know how helpful these will be. But for what they're worth, here are they are.

For me the question has two aspects. First, how brittle is the brittle-ice zone at South Pole likely to be, and second, what will the subsequent interaction of the drill with this ice be as a result.

Regarding the first point, my reaction is to look for analogs to help estimate what the brittle behavior is likely to be. In comparing conditions at South Pole with sites we have already drilled, I believe there may be several unusual or unaccustomed factors at work there for us. First, it will be significantly colder than most other places we've drilled ('we' being the U.S.) It looks like your warmest temperatures will be about -41°C at 1500 meters. Going by the Japanese experience at Dome Fuji, this should work in our favor with the brittle ice both during drilling and during handling. If an effort is made to keep the ice at this temperature or colder once it's at the surface, this should minimize post-recovery core decomposition as well. Grain sizes at pore close-off will be small due to the low temperature and the rate of grain growth will be low for the same reason. This should suppress crack propagation in the ice. So the takeaway message from the likely temperature profile is a favorable one in the brittle ice.

Next, South Pole is not on an ice divide. Strain conditions there are likely to be different from what we are accustomed to but I do not think things will be as bad as they were at Siple Dome where we had two fast moving ice streams on either side of the drill site (and a badly de-tuned drill, warm temperatures, and amazingly coarse ice... the perfect storm of unfavorable conditions). If I am to believe Buford Price's calculations of the horizontal velocity profile based on AMANDA, the ice sheet at this location does not begin to experience significant horizontal shear until well below 1500 meters. I do not have any vertical strain information, but I expect that you do via the Amanda or Ice Cube folks. You

might have a look at it and form an opinion regarding how this looks as well, but at first blush, I'd say that the takeaway message from the flow regime is also favorable.

So the next topic is, what will be the likely interaction of the drill with this ice? Here my main concern is not the fact that the hole will be underpressured, it's the fact that the temperature profile does not appear to be isothermal through this depth interval, the way it is at, for example, WAIS Divide. It looks like it's about 10°C colder at the surface than it is at 1500 m and you will be cooling all the way up the hole. This raises the specter of thermal shock, however, no matter what drill you're using, you won't be able to get around this. So although it is something to bear in mind, there are no implications for the drill. To my way of thinking, temperature is much more important than pressure in this process. Repeated relaxation measurements on samples I've taken in the field indicate that the drilling and recovery time is quite short relative to the relaxation time.

If the brittle ice comes out of the barrel in pieces, in my experience, we have always had difficulty isolating where this is actually happening during the drilling process, and therefore we don't know what to do to fix it. Does the ice break immediately upon drilling because of the tensile stresses set up at the cutter/ice interface? Does it actually drill intact but fracture on the way out of the hole due to either thermal stress or the pressure drop on the way up the hole? Does it break in the barrel after it arrives at the surface before unloading due to mechanical shock during handling? In the past we've not been able to localize the cause of the breakage, if it occurs, and we simply keep trying different things to see if the situation improves while we're in the field. It's a hit-or-miss proposition and we have no systematic information on it. One thing I will offer is that I have looked carefully at the edges of the brittle ice and cracks do not seem to propagate from the cutter/ice interface into the body of the core more than a few mm in sections I've examined (which are, admittedly, few).

So, I have not provided much assistance here except to offer that I do think temperature is much more important than pressure in thinking about brittle ice recovery. We also need to consider the goal of this project which is to provide performance data on a new drill and not to produce a perfect ice core. (At least I certainly hope that's the purpose of this project!)

Thanks for providing the opportunity to think about this and I look forward to hearing about how the new drill performs at South Pole.

All the best -

Joan [Fitzpatrick]

Geoffrey Hargreaves sent the following email.

Dear Charlie,

I am certainly not the expert on this, and you should also ask the physical properties group.

But since you asked, I don't think the difference between just Isopar and Isopar with densifier will have a very great effect. Logically, you are bringing the core up the borehole, It will depressurize a little faster in just Isopar, than it will with Isopar with densifier, it is still depressurizing and you will have the

same pressure drop problems (if you have any) when you pull up through the fluid air interface no matter what the fluid. I don't think that will make much difference.

I think thermal stress has a greater affect on the core, if you can keep the core as cold as it is in situ, then I think there is good possibility the core won't fracture as much.

I think the stress between the inner core and the outer skin as the outer skin warms contributes to much of the fracturing.

Like I said, I'm not really the expert, this is just from information I've gotten from Joan Fitzpatrick and a little bit of reading.

Sincerely,
Geoff

==========
Geoffrey Hargreaves
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USGS/National Ice Core Laboratory
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Denver, CO 80225
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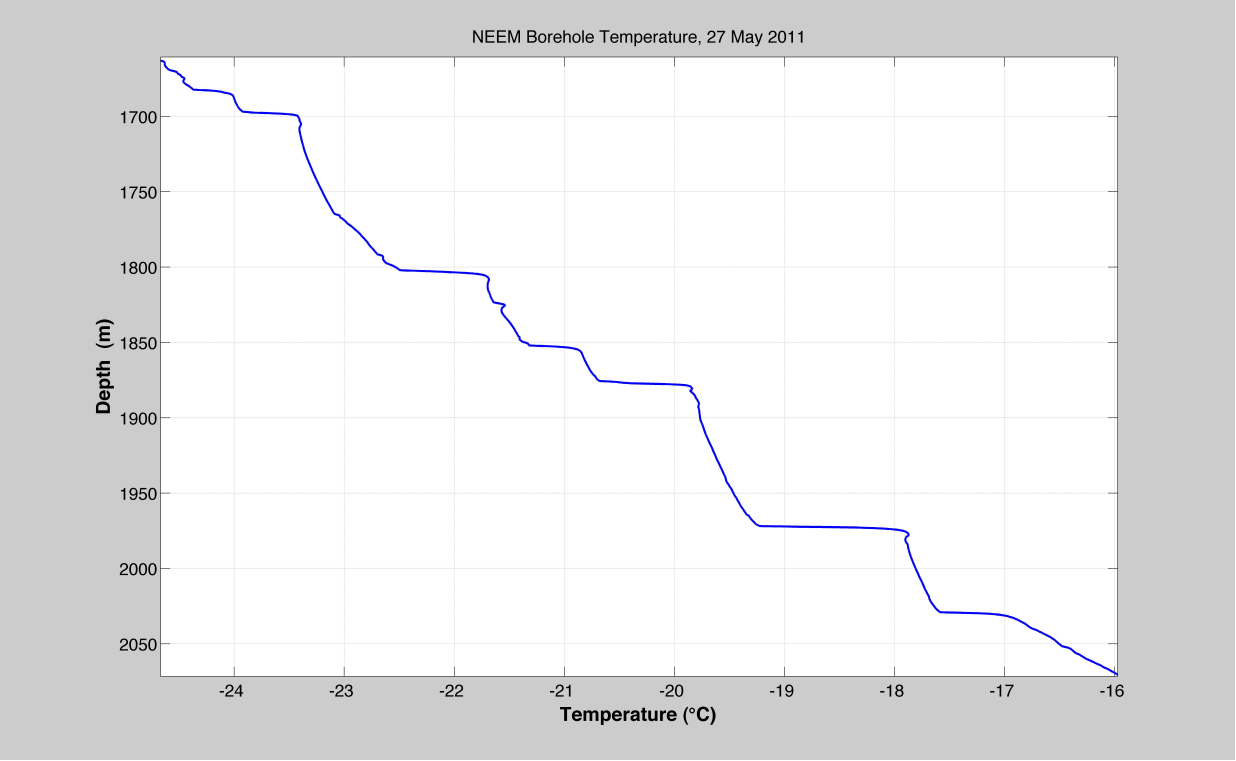
(303) 202-4830

Gary Clow sent the following email on May 22, 2012.

Hi Jamie,

Based on my experience at NEEM, it doesn't appear we can acquire good temperature profiles in Estisol-filled boreholes. At NEEM the borehole fluid convects in the laminar mode for a large section of the borehole. Although this in itself is not unusual (large sections of the GRIP and NGRIP boreholes also convect in the laminar mode), what is unusual in the Estisol-filled NEEM hole is the extraordinary length (up to 100 meters) of the convection cells. This length leads to temperature jumps of up to 1 C across the cell boundaries (see attached figure) making it difficult to know what the actual temperature is in the surrounding ice (which is our goal). The magnitude of these temperature jumps is an order of magnitude greater than I've ever seen before. I'm guessing this is due to the viscosity of Estisol. When trying to invert borehole temperatures for past climate changes (i.e. using borehole paleothermometry), the uncertainties in the temperature measurements needs to be somewhere in the 1-10 mK range to be useful. The 1000 mK uncertainties associated with huge convection cells is just too much.

Cheers,
Gary



This concludes the minutes for the IDDO TAB meeting held April 24 and 25, 2012.