TAB MEETING APRIL 20-21, 2011--MINUTES

WEDNESDAY MORNING APRIL 20, 2011

Charles Bentley opens the meeting, announces that Will Harrison has agreed to accept the Chairmanship of the TAB, and introduces Fred Best, SSEC Executive Director, Technology.

Best welcomes the attendees, stating that IDDO has the best team ever and "the best drilling systems in the world." He thanks Bentley for organizing the group. Tony Wendricks tells attendees that they have wireless internet access. Lunch with the WiscCard ($20.00 debit). Dinner will be at the Brickhouse BBQ. All presentations will be made available online.

The Terms of Reference are presented and it is agreed that they will be reviewed and discussed tomorrow.

MARY ALBERT--IDPO AND IDDO ORGANIZATIONAL STRUCTURE ETC

Albert gave a PowerPoint presentation outlining the IDPO/ IDDO structure and some history, as well as some information on scientific agenda

Albert noted that there is rapid change in the cryosphere, as well as in the funding environment from NSF

NSF is requiring the formation of 'consortia' as an effort to reduce management overhead

The aim is to develop a non-profit consortium to manage the organization, after the current IDPO mandate runs out

Review or Summary of NSF site review (late March, 2011):

Scientific objectives are extremely important internationally

Drilling products and the resulting core quality have been excellent. The DISC drill is superb.

Science Advisory Board (SAB) provides guidance to the IDPO and the IDDO, in terms of identifying short-term and long-term expectations

Summary of the SAB Meeting, April, 2011:

IDPO has a website which is a useful reference (www.icedrill.org)

There are a number of different scientific foci for the Long Range Science Plan including

- Climate
- Ice Dynamics and Glacial History
- The Subglacial Environment
- The Ice as an Observatory

SAB recommended that logistical principles be applied to drill development projects:

- Logistical overhead considerations to be important for engineering design and fabrication
- Science requirements need to be balanced by logistical demands
- Drill equipment for one project should be adaptable for future work

For ice dynamics and glacial history studies, a great demand to develop new drills and technologies is looming

For sub-glacial access, the WISSARD project is currently the only one on the horizon, but it is an important first step

The following technology investments have been identified (but *not prioritized*) by the SAB:

- Agile drills
- Logging winches
- Replicate coring
- Intermediate depth drilling systems
- 'Cold DISC' drill modifications
- Rapid basal access
- Clean access protocols (& technology)
- Rapid Access Ice Drilling will be important for mapping of bedrock in East Antarctica
- It is anticipated that most of the Rapid Access bores would be filled with fluid, perhaps n-butyl acetate, and that they would remain open / accessible for logging etc for at least 5 years
- Hot water drills

An Ice Science Drilling Community Workshop held just last week yielded short white papers on four aspects:

Science requirements for a hot water drill
Rapid access ice drilling
Subglacial aquatic environments access drilling
10-year plan for shallow coring capabilities

Summaries of these white papers can be found on the presentations DVD under agenda item "Other discussions"

DON LEBAR--REVIEW OF IDDO INVENTORY AND CAPABILITIES

Lebar gave a PowerPoint presentation on the equipment inventory and capabilities of IDDO, roughly divided into Boring and Coring equipment

Coring drills – hand auger; shallow depth tethered systems; deep tethered systems (DISC and replicate systems); specialty drills

Boring drills – RAM drill; hot water drills

Future systems – replicate (2011-12); hand auger; intermediate depth drill; access drills.

Lebar also indicated that he had been asked by the TAB chairman to give some discussion about the WISSARD project; the following were his comments on WISSARD:

- WISSARD came to UW-Madison as a ARRA stimulus-funding project
- WISSARD was managed under a separate umbrella of ICDS instead of IDDO, because of the funding route
- ICDS started work on this project in July 2009
- Stop work order was issued in August of 2010

- The PIs are in the process of terminating the subcontract with UW (as distinct from the stop-work order, which is part of the contract process)
- The project had a number of twists and turns. For example, it was initially envisaged as a light traverse, but the logistics group, Raytheon, lobbed it into the heavy traverse category. This went from heavy traverse on conventional sledges to a (probable) traverse on sledges of flexible polyethylene [NB: as of the Stop Work order, the design for these wasn't finalized]
- The initial budget estimate, supposedly a placeholder for future re-estimation, at 3.5 million dollars subsequently became a fixed limit.
- Shortly before the "stop work order" was placed, ICDS was asked to formally guarantee that ICDS would "guarantee" [absorb] any cost overruns, i.e., in excess of $3.5 million
- Absorbing cost overruns was not an option from the UW point of view
- Lessons learned include that projects need to have well defined requirements and time constraints before reasonable budgets can be estimated [you cannot get "backed in" by both time and money, and expect a good outcome]

JAY JOHNSON: REVIEW OF DISC DRILL SEASON 2010-2011

Johnson gave a PowerPoint presentation on the recently completed DISC drill season
Noted that there were issues with the set-up / re-opening of the Arch, the re-alignment of the core-transport trusses (from drilling side, to core-processing side of the Arch)
There were several electronics issues confined to the "instrument section" of the drill: the motor controller boards, as well as a problem with vessel sealing and resultant leakage of drill fluid into the vessel
In the motor section, there was some leakage and loss of the immersion oil
Over-greasing of the pump thrust bearing resulted in heavy thrust loads, high starting torque etc; Learned to not apply grease to this area unless it was required
Leakage of drilling fluid into the Weight On Bit (WOB) housing caused erratic operation of the piezoelectric load cell there
Faulty WOB readings resulted in "floating" the drill during a downward trip, loose cable, and a kink in the cable---the result of the WOB failure was a loss of time to cut and re-terminate the cable and fiber optic lines
WOB has been redesigned and will now feature a Belleville spring + LVDT arrangement [as is used in the DISC Drill level wind assembly]
The springs and other components are in the process of being characterized, prior to committing to final design and fabrication

COMMENTS

- Frank Wilhelms-- suggested that IDDO should consider reaming the bore to remove any constrictions that might result in local resistance and "floating" of the drill; noted that increasing the EPICA - DML bore by even a small amount made a very large difference in tripping speed / resistance

- Steffen Bo Hansen -- noted that the WOB unit in the Neem Drill is no longer used for controlling weight on bits during drilling. Our experience in Greenland shows that using only the load cell in the tower sheave gives the most reliable control. The WOB unit in the drill is now only used to determine if the velocity during descent gets too high, and therefore could cause a kink in the cable.

- Johnson-- the DISC drill has a load cell in both the tower sheave and at the winch drum (level wind) mechanism; however, the DISC drill also makes use of the on-board pump to pull the drill into the bore. This complicates any calculation of what the tension in the cable might be immediately above the drill.

- Hansen-- in any case, there is no harm in implementing a 'program' that would monitor the tower sheave load and calculate the theoretical weight on bit [tension immediately above the drill]. This would also be a back-up system for the WOB in the drill.
- Incidents with a kink in the cable can be avoided by taking advantage of the data from a load cell in the top sheave, and combining them with the length of the cable deployed into the hole. It is quite obvious that for a given depth, the weight of the drill and deployed amount cable must have a certain minimum value, and a simple software program can simultaneously check if this is obtained. No sophisticated calculation is needed in this safety check for the descent speed of the drill.

- Wilhelms-- What is the Baud rate for the fiber optic communications?

- Nicolai Mortensen-- The Baud rate is relatively low, compatible with the RS-232 communication modules that were available at the time of development of the circuit boards; it is likely that faster modules are available now.

[At this point, John Robinson made a presentation of a plaque to Charlie Bentley, commemorating his years on the Ice and the recent drilling record of the DISC drill at WAIS divide. The Plaque features a length of the DISC drill cable mounted on a short section of a *Jamesway* arch, dating back to 1955]

Reviews of past field seasons and plans for the next:

Bentley--Review of 2010 Arctic Season

[see PowerPoint presentation]

Bentley--Review of 2010-2011 Antarctic Season

[see PowerPoint presentation]

Krissy Dahnert--Arctic 2011 Review

[see PowerPoint presentation]

Dahnert -Planned Work for Antarctica 2011-2012 Season

[see PowerPoint presentation]

Dahnert-- Planned Work for Arctic 2012 Season

[see PowerPoint presentation]

TANNER KUHL--BLUE ICE DRILL SYSTEM

Overview of Structure and operations via PowerPoint Presentation

Overview of first (2010-2011 Antarctic) Blue Ice Drill deployment

- Blue Ice Drill is very efficient:

  56 days in field; 24 drill days
  34 holes
  35m/day
  35m (7 holes) in 6 – 8 hours
  21m (1 hole) in 3.5 hours
  Approximately 4-6 m/hr.
- Meets all science requirements
- Developed a Core Recovery Tool (CRT) which was used almost exclusively, in lieu of traditional core dogs
- Breaking core with a Slide Hammer is also possible, but this eventually destroyed one of the motors
- Developed a "dumping chip separator" while in the field, which greatly increased speed of operation of the drill---did not require separating the inner and outer barrels of the drill
- Found that the drill hammered (vertical vibration) when the Weight on Bit was positive; it was necessary to hold-back the drill ("negative" Weight on Bit)
- Warm conditions were problematic and caused melting due to translucent barrels, which acted as a greenhouse (temperature between barrels reached at least =15 C!)
- The 6 HP motor was probably overkill, probably 2 times larger than absolutely necessary for the current application. Motor size was predicated on the use of the "New Zealand" 12-inch Auger with continuous flights to a depth of 4 meters
- The system will return to Antarctica (Taylor Valley) in the 2011-2012 season with minor modifications

- There is some discussion but no mandate presently to modify the drill for use to about 100-200 meters depth. This would require significant changes

TANNER KUHL-- THERMAL, ECLIPSE AND 4-INCH DRILL SYSTEMS

Kuhl compared and contrasted the Eclipse and 4-inch drill systems
Listed planned improvements for 4-inch system:

- New collets
- New barrel design
- Slip ring redesign
- Fluid-tight motor section

Thermal Drill Work and Re-design

- Stainless Steel core barrel (~3.3")
- Develop an insulator above the heating element to make it more efficient

Eclipse Drill Work

- New Cables
- Complete new barrels which are in progress

Possible Future work and Development Projects for the 4-inch drill

- Merge design of 4-inch with design of the new Intermediate drill system including the antitorque system
- Change to a steel cable, rather than a fiber-based cable
- Improve the winch design

Possible Future Developments for the Thermal Drill system:

- Move to a 4" diameter core
- Procure a Coaxial cable
- Provisions for ethanol "injection" [dosing]

Eclipse system Future Developments

- Develop a compatible 4-inch sonde
- Refurbish the Mark I (DC-driven) system

Questions, Comments and Answers:

Eric Salzman: Can you comment on core quality for these systems?
Kuhl: As I understand it, the quality is generally good to very good

Salzman: Not his experience/impression that this is the case; he's heard a lot of complaints about the core quality for these 'agile' drills
Lebar: This is not the impression he has from the community of scientists and drillers working with the agile drilling systems--that the quality is in fact pretty high
Peter Doran: Well, it has been his experience on lake ice that the proportion of good core and "pucks" is about 50-50.
Wilhelms: What about these collets?
Kuhl: We use collets in virtually all of our smaller drills
Johnson: Collets work particularly well in firn.
Doran: How do these collets work?
Kuhl: They are a taper-locking device. There is a taper in the head and the collet slides and wedges against that taper
Marshall Pardey: Collets are used exclusively in the rock coring industry
Wilhelms: Coaxial cable? Why coaxial?
Kuhl: Not known why a coaxial cable was chosen
Mike Gerasimoff: The coaxial cable probably avoids the problem of twisting under tension load
Talalay: Why would you choose to use a thermal drill rather than electromechanical drill?
Kuhl: Most of our projects that employ the thermal drills do so to prevent chemical contamination of the core

TANNER KUHL---KOCI DRILL SYSTEM

Overview of drill system
Carbide tip (30 degree rake angle)
Two feed mechanisms: a coarse feed (drill press crank) and a geared, sub-millimeter-pitch, feed system
Review of the performance history of various incarnations of the Koci Drill system
The Koci drill is capable of coring both rock and ice and rock/ice mixtures
Consistently drill and recover 45 cm long cores
Rocks or sand in great quantities generate heat with drilling. The heat melts ice, which soon refreezes. You have to get through the hard stuff quickly.
Use non-coring bit to get through the hard sections.
Actually works quite well in straight ice

Questions, Comments and Answers:

Kris Zacny: How long do these cutters last?
Kuhl: Of course that depends on what material is being drilled. There is frequent breakage of carbide tips. The loose carbide can damage the cutter head if not retrieved.

There are limitations on the Koci system imposed by

- cutter damage and loose chips of cutters in the annular space
- loose gravel in the bore
- the torsional rigidity of the drill string

Questions, Comments and Answers:

- Wilhelms: Can you / do you retrieve the broken bits of tungsten carbide from the bore, before drilling further?
- Kuhl: Yes in fact we do have down-hole vacuum cleaner systems to retrieve chunks; drilling against the tungsten carbide chips will do a lot of damage to the head and so forth.

- JOSH GOETZ--HAND AUGER SYSTEMS

An overview was provided for the PICO, SIPRE, and KOVACS systems we have at IDDO
The Sidewinder accessory was described
The Prairie Dog modification was described [NB: the only Prairie Dog drill was lost at Lake Vida during the 2010-2011 Antarctic Season; no immediate plans to replace it with another]
Problems with Hand Auger Systems:

- These are all old systems. There is significant wear in all the systems and their components

Progress with Hand Augers:
New design is in process for a new 3-inch auger system; it will feature a 3-cutter head and will come in 1-meter and 2-meter long core versions. It will have solid flights to avoid problems with flights coming loose or screw heads messing up core sample.

Questions, Comments and Answers:

- Alex Pyne: Many scientists have chosen the wrong drill for their hand-auger application and had poor performance as a result. Need to have a system to appropriately guide and narrow the choices for users.

- Lebar: We are trying to discourage / limit the availability of hand augers from the Berg Field Center at McMurdo---rather, we'd have scientists go directly through us for hand augers.

- Doran: There is a perception that the number of drills available at the BFC has declined.

- Lebar: Yes, Raytheon has had issues with turnover of staff and, as a result, they'd prefer that we handle the equipment [rather than have poor / inexperienced help in choosing and preparing equipment]

CHRIS GIBSON--REPLICATE CORING SYSTEM OVERVIEW AND UPPER SONDE COMPONENTS

Gibson provided an overview of the current state of the Replicate Coring system development
An overview was provided of the prototype testing [See PowerPoint presentation]

- Fail-safe discs
- Fluid delivery module
- Prototype actuators are being tested.
- 4 production actuator modules are assembled.
- Testing ongoing through August.

There are multiple choices for the actuator lever contact points
The lever force has been characterized
There has been an evaluation of the potential problem of the stick-slip at the lever-to-ice contact point
The ability of the lever system(s) to act as anti-torque devices has been evaluated
Gerasimoff – Lower sonde:

- From the pump down
- Uses off-the-shelf materials
- Coring head – familiar 3-head design
- Concern is that you can twist the drill into the offshoot and get stuck. Head is designed to break off if need be.

Deviation cutting tools:

- Shell type:
- Milling head – regular spinning drill head
- Broaching head – raise and lower drill; blades cut; no spin. That eventually creates the second shaft and then you send down the regular core drill with levers to turn the corner.
- Mechanical design is complete and in production.

Questions, Comments and Answers:

- Wilhelms: Glycol bladder of 2 liters seems to be too small compared to the 4-5 kg of pellets deployed to loosen a stuck EPICA drill system. The amount and type of 'glycol' to be used, and its dilution, depends on the temperature conditions in the bore and particularly at the sticking point. Pure 'glycol' [ethylene glycol] solidifies at -13C. One needs to avoid automotive antifreeze, as this has undesirable additives. We have found with EPICA that the application of 'glycol' can release gas clathrates, forming bubbles, which then result in the glycol floating away from the desired location.

- Hansen: Glycol can refreeze after deployment, often at higher (= colder) locations in the bore. This can result in a stuck drill.

NICOLAI MORTENSON--REPLICATE DRILL ELECTRONICS DEVELOPMENT

Mortensen gave a PowerPoint presentation on the work underway at IDDO [see slides]
Replicate Coring Overview:
2 actuator sections; barrels
Using DC motors – torque proportional to current; speed proportional to voltage.
Navigation – gyro-stabilized and magnetic – 3D orientation in world space.

Question: How much vertical travel to produce a deflection of one drill diameter? 30m.

Questions, Comments and Answers:

- Kris Zacny: Can you explain [elaborate on] the use of the wobbling actuation mode?
- Nicolai Mortensen: Due to the friction in the lever arm drive system, it is not possible to measure the force directly via motor torque.
- Salzman: Can you use current rise [spiking] at the limit of motion [of the lever arm] to detect the touch point with the wall?
- Mortensen: No, because the electronic controllers are set to limit current to protect the motors and so forth.
- Zacny: So, only the motor(s) pressing against the bore are making noise [in the demonstration video sound track]?
- Mortensen: Yes.
- Wang Rushen: I have concern about the arms pointing upward in the bore [possibility for sticking]
- Mortensen: the arms are angled downward in the bore so that they can collapse inward by pulling on the cable with sufficient force [which is lower than the breaking point of the cable and 'mechanical fuse']
- Hansen: We [drillers at NEEM] will be attempting to use a 'passive deviation from the NEEM bore using a system like that used at VOSTOK Station [this involves taking advantage of a natural inclination in the bore, and deviating into the 'footwall' of the bore]. But of course that system isn't sophisticated [like the DISC replicate system] and cannot allow you to re-enter the main bore [on future runs].

JAY JOHNSON-- INTERMEDIATE DEPTH DRILLING EQUIPMENT DEVELOPMENT

Johnson gave a PowerPoint presentation on the preliminary design of an Intermediate depth system and the agreements in place to share responsibilities with the European community
Surface to 1500m; 2m core; core diameter 98mm plus/minus 3mm
Simple, lightweight and adaptable to conditions
Turnkey to reduce logistic requirements.
Winch design – 23 layers deep (dependent on width/ diameter)
Timeline:

2011 – Plan, determine costs, start design
2012 – Design/build drill
2013 – Finish building
2014 – Test in Greenland; send to Antarctic in the fall.

Questions, Comments and Answers:

- Wilhelms: What is the reduction ratio of the winch drive? He uses 50%
- Johnson: With the [Mavilor] pancake style motor option it is about 38:1, but with a conventional 3-phase AC induction motor the gear reduction need only be 25:1
- Wilhelms: Consider using a higher reduction ratio and make use of a self-locking worm-gear drive [as a safety feature against back-driving under load]
- Pyne: Will there be a backup drive system to retrieve the drill [winch drive backup system]?
- Johnson: No, but there'd be spares and we could use cable grips to hold the cable while the system is repaired using the spares.
- Salzman: Are they [winch drive motors] both 3-phase motors?
- Johnson: No, the pancake motor is DC
- Wilhelms: Would the tower be sectional for transport?
- Johnson: Yes, it is not shown that way on the sketches, though.
- [Johnson explains more here about the layout of the drilling rig and the shelter, and the provision for a 'core buffer' {storage} in the layout]...
- Wilhelms: Yes, you would probably want to have a core buffer, because it'll be necessary to store the core as you go through the brittle zone.
- Salzman: The places where this system would first be used are at Hercules Dome and at South Pole dome.
- Wilhelms: The tent brings with it a lot of heat. We found this out at Dome C, and this is not good from the standpoint of preserving the physical properties of the ice. So it is good to see that here, in this design, we see that you will be using at least a partially trenched system.
- Lebar: What do you envisage as the time to set up the system?
- Johnson: [making inquiries from the audience...] One to two weeks seems reasonable.
- Salzman: What is the state of inquiry about a drill [fluid] depth [for an intermediate bore system]?
- Wilhelms: I will be making a short presentation about this [later].

STEFFEN BO HANSEN---THE HANS TAUSEN DRILL FOR INTERMEDIATE DEPTH

Hansen gave a PowerPoint presentation about the current Hans Tausen system, some comparisons with other systems and the anticipated design changes to be incorporated in a new US Polar Program drill system

Indicated that the European community would like to be involved in the US program to design and build a new Intermediate drill, because it would be an opportunity to redesign and improve the current Hans Tausen drill.

We'd like to keep the hammer function, and prefer to use a booster screw (helix) rather than a piston pump [as used on the EPICA drills]. We found that the piston pump became necessary when the core length was more than 2 meters.

The Hans Tausen system includes reamers to allow the change from dry drilling [small kerf] to wet drilling [larger kerf]

We tried step [partial kerf-width] cutters at NEEM this past year. This was a long-term suggestion of Victor Zagorodnov. Those step cutters consumed less power, and produced coarser chips, which were easier to transport. We found that the use of only one, partial-width shoe, behind one of the step cutters produced the best results.

The principal modifications we'd like to make to the Hans Tausen drill are:

2-meter core length

A separate barrel for the outer barrel and the chips chamber

The option to employ step cutters

Removal of the hammer from the antitorque system, and use of only the SuperBanger device, which has the same function, but is closer to the cutter head and more effective

A simplification of the SuperBanger design

Questions, Comments and Answers:

- Zacny: Why do you employ the step cutters and how do they work?
- Hansen: Each step cutters cuts full pitch depth but only 1/3rd of the width of the kerf [conventional cutters cut 1/3rd of the nominal pitch, and full width of the kerf]. The chips are coarser this way, and we have found that this makes it easier to penetrate in warm ice.
- Salzman: Can you go to 1500 meters depth without a pump [just a Booster screw]?
- Hansen: Yes, I think we can do that.
- Wilhelms: The pump was changed at NGRIP when there were changes of fluid, which in turn resulted in chip agglomeration and other problems.
- Pavel Talalay: British Antarctic Survey [BAS] has used the Hans Tausen drill system at Berkner Island with good results
- Pyne: At Berkner, and at Talos Dome, the hole was filled with drilling fluid.
- Wilhelms: Yes, at 1500 meters, of course you would need to have a fluid-filled hole [for compensation].
- Pyne: You also have to consider that a hole must be approximately balanced for it to overwinter for a subsequent season [otherwise the walls will collapse inward].

- Wilhelms: Our group is currently building a Hans Tausen type drill which, eventually, will feature an oil-flooded hollow-shaft DC motor [without gear reducer] and an off-the-shelf electronic controller module.

FRANK WILHELMS--DEPTH AND AGE CALCULATIONS FOR SITE SELECTION

Wilhelms presented calculations he has undertaken for the age of the ice that might be present at the bottom of a 1500-meter bore at Hercules Dome and South Pole Dome [2 initial targets for intermediate-depth drilling in the US Polar Program]

Questions are, what is the age at the depth limit of the system? The scientific program is nominally trying to go beyond the beginning of the last Ice Age [i.e., more than 40 ka old ice]

You need to know the accumulation rate in order to calculate the needed depth to reach the ice of intended age.

Wilhelms indicated that calculating the age at depth must take into account the probable rate of thinning of layers due to pure shear [there are published formulas for this, which Wilhelms references in his slides]

According to his calculations, at 1500 meters at Hercules Dome, the ice would be only ~ 20 ka and 40ka ice would exist at depth in excess of 2000 meters; at South Pole Dome, the ice at 1500 meters would be about 35 ka.

Questions, Comments and Answers:

- Salzman: How far can the design [of an intermediate drill based on the Hans Tausen] be pushed, depth-wise, without significant design changes?

- Wilhelms: Notes that the EPICA drill system and the Hans Tausen drill share a lot of design features, except the use of the piston pump [so it is a continuum, allowing extending the system to > 3000 meters depth]

- Kuhl: We could [as another approach] consider down-sizing the DISC drill system

- Lebar: The European program has done quite well by up-scaling the Hans Tausen drill design; that is probably a more reasonable approach than trying to down-size the DISC system

- Pyne: Just because you design the components of a system to fit inside a Twin Otter, it doesn't mean that a Twin Otter is the best choice for actually deploying the system in a given situation

- [Discussion at this point generally concurs that this is true, but that having the largest component fit into an envelope like the Twin Otter is probably a reasonable design objective to allow the flexibility to use a Twin Otter, for some situations]

MIKE JAYRED--RAM DRILL TEST AT SOUTH POLE

Mike Jayred gave a PowerPoint presentation on the past season's deployment of the RAM Drill, at South Pole. Had trouble getting down past 30m. Firn absorbed air pressure and defeated the blowout of the chips. Tried different configurations/air pressure/temperatures, etc. Maximum depth attained was 63 m on a packed surface.

The conclusion from the tests is that the RAM drill is not suitable for emplacing the ARA radio antenna array at South Pole.

Future work with the RAM drill will likely be preceded by modifications including a new multi-layer hose reel [smaller diameter; wide]; the development of technology or systems to case the firn portion of the bore is essential to allow the drill to go deeper, consistently, at different locations.

PAVEL TALALAY-- VOSTOK ICE CORE DRILLING PROJECT: LAST EVENTS

Talalay gave a PowerPoint presentation on the successful deviation of the VOSTOK 5G bore, during the season 2009-2010.

The deviation of the bore was accomplished by using modified cutters with a more aggressive side-cutting edge. Deviation use of an existing higher-inclination section of the bore at depth 3580 meters, and the KEMS-135 drill was allowed to swing plumb at this point, cutting into the sidewall.

The deviation proceeded over the interval 3560 to 3580 meters.

Coring from 3592 to 3599 meters gradually enlarged the sector of core taken to nearly full core-drill diameter.

Subsequent discussions [by Talalay with colleagues] have shown that this method of deviation was successfully used several times at the super-deep crustal drilling site, Kola SG-3. Engineers there found that it was possible to deviate this way anytime the bore was inclined from the vertical by 3 or more degrees.

I the summer season 2010-2011 the drilling was continued up to the depth of 3720.4 m.

For final penetration into Lake Vostok, at depth 3760 ± 5 m, the bore will be filled at the bottom with silicone oil, using a special tanker.

The silicone oil is environmentally friendly and essentially inert, and has been approved by the Antarctic Treaty Committee on Environmental Protection for this use.

The silicone oil is denser than the normal drilling fluid, but less dense than the water in the lake. Therefore, there will be essentially no danger of the fluid entering the lake.

In fact, water will rise in the bore with the silicone oil floating above it when the lake is penetrated.

Final penetration of the lake is to be accomplished using a special drill, of smaller diameter than the coring drill system, with a thermal melt head [essentially, a 'hypodermic' piercing of the ice overlying the lake].

Some water will be retrieved in this special thermal drill system and returned to the surface.

Over the next winter, the ice will freeze in the bore and can be retrieved by coring with the KEMS-135 drill. This is the way that the water of the lake will be sampled again

Questions, Comments and Answers:

- Doran: How can you be sure that you will truly sample the re-frozen water in the bore, when you return with the KEMS drill in the following year?

- Talalay [with concurrence from Wilhelms]: the crystal structure of this recently refrozen water will be significantly different than the ice surrounding it. The crystals will be on the order of 5 mm, not ~ 1 meter, as they are in the surroundings.

PAVEL TALALAY--CHINESE DEEP DRILLING IN ANTARCTICA

Talalay made a PowerPoint presentation about Chinese drilling in Antarctica.
Two projects are planned: deep drilling at Dome A and also at the Gamburtsev Mountains.
Dome A, elevation 4100 m, is near the center of Antarctica, 1228 km from Zhongshan Station; the average temperature there is -58.4 C. The coldest temperature recorded from the AWS installed at Dome A is -82.5 C. The ice depth at Dome A is more than 3139 meters
The Gamburtsev Mountains are an ice-buried range in central Antarctica. The base of the mountains is about 1000 meters above sea level, and the peaks are about 2700 meters above sea level. The highest peaks are covered with about 600 meters of ice.
For the Gamburtsev Mountains and Dome A projects we anticipate using an electromechanical drill with a penetration rate of 25 meters per day. The projects will be staffed during the summer only, and 1-2 seasons of drilling are anticipated.
We will redesign the KEMS-135 drill to use only one motor. The pump will be connected directly to the drilling rotation motor.
We will be employing a Grundfos submersible-well type motor, which is filled with silicone oil.
A sub-glacial rock coring system will be developed, but this presents problems with torque and power requirements

Questions, Comments and Answers:

- Wilhelms: So, the silicone oil to be used is the same as at VOSTOK? And, is it [the oil] now approved by the Antarctic Treaty committee?

- Talalay: Yes.

- Wilhelms: What we have heard in the past is that this oil was found to creep upward over plywood panels in the drilling area over a long time [indicating that it was slow to evaporate, if it evaporates at all]. Does your experience with this new fluid indicate that it is lighter and evaporates cleanly? Because, if the price is now ~6 $US per kilo as you say then this is about the same as the cost of our conventional [two-phase, HCFC-141b based] fluid.

- Talalay: Yes, these new silicone oils we intend to use evaporate cleanly.

HIDEAKI MOTOYAMA--NEW JARE DEEP DRILL SYSTEM

Motoyama made a PowerPoint presentation about the new JARE deep-drilling equipment used at Dome Fuji ("Dome F")
This second-generation drill was developed after the first drill was stuck irretrievably at Dome Fuji (1996, at a depth of 2507 meters)
New design features DC motor (not AC as in previous design), which is slower.
New design uses Harmonic drive reducer, rather than the multi-stage planetary design found in old design
The design was extensively tested including the use of a high scaffolding tower and artificial ice columns to drill through
At new Dome Fuji bore, extraneous ice chips were found (i.e., more ice than could be expected from coring the annulus)
Probable source for these chips, which are very fine grained, is inter-crystalline pore water flowing into the bore and re-freezing.

Heat flux at bottom of bore is 10 mW/m^2; this can account for the melting of about 1.1 mm of ice from the bottom of the ice per year.
The annual layers of ice at that bottom are about 1.3mm.thick...therefore, the glacier is losing one year of accumulation at this location per year, due to basal melting.

ALEX PYNE- SEA FLOOR DRILLING FROM THE ROSS ICE SHELF

Pyne brought us up to date on the current ANDRILL project to drill through the Ross Ice Shelf about 100 km east of Ross Island
Site investigation included the placement of oceanographic moorings to measure currents, so that forces on the tubular [diamond-drilling] string could be calculated and accounted for in the design.
An ROV was deployed through the ice at the site. An interesting discovery was of organisms attached to the bottom of the ice at this location.
Modeling of the water-column and riser design has begun. They have concluded that, due to the speed of the ice movement at this location, that they will begin drilling "up stream", drift over the penetration point on the sea floor, and then drift "down stream" from it. Starting the drill into the ocean floor on an angle will require the use of an ROV to tether the drill string, and the tether will be used to pull the string sideways for starting.

ALEX PYNE- DRILLING PROGRAMME AT ROOSEVELT ISLAND

Pyne brought us up to date on the work in progress for the Roosevelt Island project.
They are building a new version of the Hans Tausen drill for this work
A delay of the program was caused by a hiccup in the shipments to Antarctica. A similar delay might have happened anyway due to parallel problems in the logistical support delivered in Antarctica.

KEITH MAKINSON - PROJECT TO DRILL INTO SUBGLACIAL LAKE ELLSWORTH

Makinson brought us up to date on the progress of the SLE project to drill into a subglacial lake to the west of the Ellsworth Mountains.
Funding awarded October 2009.
Majority of logistics from private operator, Punta Arenas, Chile to Union Glacier using IL-76 aircraft and over snow traverse to drill site.
Geophysical surveys shows subglacial fjorded region around drill site.
Lake depth 143m; ice thickness 3155m; drilling in 2012-13.
Hot water drill will be used to gain clean access to lake with single length hose to avoid previous couplings failures.
Water to be filtered to 0.2 micron and UV treated.
Power up to 1.5 MW, flow of 180-210 liters/minute at 2000 psi and 90 deg C.
Hole will be about 36 cm in diameter and will take about 3 days to complete.
All large drill components ordered, with delivery and testing during summer 2011.
Most items housed in shipping containers.
Filtration system accounts for expected dust size distribution and concentration found in the ice.
Multi-parameter probe to be used in lake with 24 100 ml titanium sample bottles that can open and close with high differential pressure and withstand freezing pressure of 2700 bar.
Sediment corer designs being finalized with UWITEC in Austria. 3-4 m core barrel.
Second full time engineer now working on the hot water drill.
Drill testing in UK during summer, shipping in September, and to be depoted near drill site December 2011.
Drilling and lake sampling to be completed January 2013.

Future plans for drill include work on Rutford Ice Stream in 2014/15 season.

TAB MEETING APRIL 21, 2011 (THURSDAY)

Harrison – Have you read the "Terms of Reference?" No response. Time given to read them.
Discussion of Terms of Reference.
Bill Eustes wants some continuity between meetings. Can we have ongoing communication through the year? Someplace to post current events? Forum? Bulletin board? Not for the general public/restricted access.
It already exists. Email questions to the TAB. Make a mailing list? Anyone can send questions.
Doesn't need to be a bullet in the Terms of Reference
The Terms of Reference were approved as they stand.

KRIS ZACNY--HONEYBEE ROBOTICS

Zacny delivered a PowerPoint presentation on the robotic systems developed by Honeybee Robotics for both terrestrial and extra-terrestrial projects.
A graphical view of the "requirements and constraints" approach used at Honeybee was shown; connections were drawn with the comments Lebar made the previous day about the difficulties IDDO (ICDS) has with establishing project requirements.
The Mars sampling system for >=1-meter cores, ICE BREAKER, was shown in some detail. Field tests for the ICE BREAKER undertaken at Cape Armitage and at University Valley were shown
Drilling mission approach:

- Different from IDDO – low mass; low power; transmission delays.
- Similar to IDDO – need good scientific samples.
- Mars drill takes the sensor down hole; brings vapors to the surface
- Can only upload/download data to Mars twice a day due to restrictions of Deep Space Network and Mars Orbiter.

Ice breaker mission –

- Return to a site on Mars that revealed ice before.
- Rotary percussion drill – big chips – don't need a sharp drill.
- Less energy, so less heat in drill hole.
- The ice is vapor-deposited.
- Test drill in Antarctica.
- They ran their tests in University Valley because the vapor-deposited, dust covered ice there is similar to that on Mars.
- A group of 5th graders in California controlled the drill from California.

Drill also tested in a vacuum chamber. In a vacuum, ice turns directly to vapor, which can then blow out of the drill hole. Hole stays cold because all the heat goes into the sublimation.
Laser induced breakdown spectroscopy – Laser abrades the surface.
The ultrasonic AutoGopher was also detailed. It will be tested in Death Valley.

Questions, Comments and Answers:

- Mortensen: How do you know the frequency required to drive the ultrasonic system?
- Zacny: We don't; the ultrasonic horn vibrates an intermediate anvil at "random" frequency and, when the frequency of the system reaches its natural harmonic, the drill vibrates, drilling work is done and the frequency drops. The system then rebuilds its energy until it can harmonically vibrate again and do work.

- Albert: What are the core-quality requirements for this system?
- Zacny: These are not as stringent as those for terrestrial programs. It is a demonstration of technology.
- Albert: So the scientists would be happy to get any reasonable samples including dust, chips and so forth
- Zacny: In our tests in the Mojave Desert, layering [stratigraphy] was still visible in the samples so it is better than just chips and dust.
- Pardey: I am concerned about the lack of a core spring in this system [to hold and retrieve the core]
- Zacny: There are a number of problems [related to core retrieval and core chip retrieval]; we are going to have a vacuum cleaner
- Pardey: You could use a basket type core catcher
- Best: Are these part of a specific sample-return [to Earth] mission?
- Zacny: No; the 2018 Mars mission in discussion now will require multiple missions and multiple space vehicles to return the samples [using cache on the surface, picking up the cache, blasting it into orbit on one vehicle, transferring it to another vehicle for return to Earth....etc]

At this point there is a departure from the set TAB Agenda. Questions for IDDO (& IDPO) are solicited from TAB members:

- Lebar (addressing TAB members): To those who are rock drilling experts: We have a member of the scientific community who wants a >25 meter rock core from the bottom of an "access" bore.
- Harrison (and Bentley): I think this is a discussion we'd best have under the topic "Access Drilling"
- [at this point, no coherent questions are raised from the TAB members for IDDO / IDPO]

PETER DORAN- PRESENTATION ON *'SALE'* AND *'ATHENA'*

Doran made a brief PowerPoint presentation on the SALE (Subglacial Antarctic Lake Exploration) and ATHENA (Advancing Technological and Environmental Stewardship for Subglacial Exploration in Antarctica) working groups.

SALE has recently been disbanded. It has been replaced, in many aspects, by ATHENA. Both are (were) tasked with advising SCAR regarding subglacial access protocols and research generally

Questions, Comments and Answers:

- Albert: The biggest issue lately seems to be "how clean is clean?"
- Doran: This has been difficult to define of course but now the Treaty organization has abandoned a "set" numerical standard in favor of the system being maintained as clean, or cleaner, than the ice immediately overlying the sub-glacial access point.

OPEN DISCUSSION--DRILLING FLUIDS

- Bentley opened the floor for the Agenda item, "Drilling Fluids"
- Talalay noted that he did not bring a formal presentation but would open with a few comments on the current situation in the community. Talalay noted that there are a number of "old friends" including n-butyl acetate (being used by the JARE), petroleum solvents, and so forth
- Bentley asked Wilhelms to comment.
- Wilhelms noted that there has been an objection to silicone oil that it will not evaporate cleanly. However, Dr. Sapp Kipfstuhl uses such fluids in his [ice crystallography] work and he indicates that the new silicone fluids do evaporate cleanly. Gerasimoff raised the objection that silicone oils are potential poisons for mass spectrometry systems but similar objections were raised with HCFC fluids and those problems were eventually identified and overcome. Presently nobody seems to be coming forward to volunteer to test these fluids in their mass spectrometers. If these silicone oils can be had for about $6 US per kg as Talalay says, then this brings their price in alignment with the price we currently pay to buy fluid for deep drilling projects. And one has to consider the overall cost of the fluid landed at the drilling site [which makes the price FOB the manufacturer pale in comparison].
- Pyne: With any 1000 meter bore, even filling the bore with a petroleum fluid will result in closure of the bore, because it is unbalanced.
- Talalay: Yes, this is true, but you can start the season in an undisturbed hole with logging and follow that by reaming [back to the desire diameter]
- Wilhelms: It is a matter of balancing [accounting for] logistical cost [cost of fluid delivered to the site] and the follow-on cost to the project. Also, you must consider that the requirements of [temperature] logging afterward may require higher viscosity to prevent fluid convection in the bore.
- Hansen: The Estisol and Coasol combination has slightly higher viscosity, requiring a larger kerf to lower the drag on the drill, but the fact is that this is an environmentally safe and approved combination. Also, the fluid is somewhat greasy and this prevents packing of the chips; it also seems to handle the presence of water in the bore.

- Alex Shturmakov: Well, but this combination is not applicable to cold Antarctic conditions
- Pyne: At Roosevelt Island, we are looking at high closure rates if we use straight Estisol, because the ice is relatively warm. Now, we are considering the use of Coasol to increase the density. Or we could increase the fluid column height by raising it above the firn-ice transition level. Any comments?
- Hansen: We have had 50-50 success with sealing the casing in the first year, which you are intending to do here [i.e., you run the risk of leaking fluid into the firn, through the bottom of the casing]
- Johnson: We have not had similar problems with the casing leaking at DISC-WAIS Divide. We are using silicone O-rings at the end and around the outside of the casing tube. These swell in contact with petroleum solvent and tighten the seal against the ice.
- Wilhelms: JP [Steffensen] was using paint at home and discovered that it was so heavy because of the content of titanium dioxide. He procured some TiO2, but found that the paste it is supplied in is difficult to suspend in drilling fluid.
- [At this point there was a free-for-all discussion on the possibility of using suspended solids as densifiers, as is the case in the petroleum drilling industry. Eustes mentioned microfine barite, Gerasimoff mentioned nano-particle sized ceramics now being used as pigments in the paint industry etc.— the general consensus is that any suspended particles would have to be small enough to remain suspended indefinitely, or at least a very long time {a colloidal suspension of particles stirred by Brownian motion--MG} and that the particles would have to be innocuous from the standpoint of scientific analytical work]
- Bentley: I wonder if we should be reconsidering n-butyl acetate as a drilling fluid, considering the success, which JARE has been having with it; I remember the gas masks being used at GISP, but the Japanese seem to be able to work without masks.
- Motoyama: We have not had problem with using n-butyl acetate without gas masks
- Mark Twickler: I think that one of the problems with GISP was that the drill didn't use a slot [trench], so that the fluid drained all over the drilling platform area [NB: the JARE drill system employs a tilting tower and trench arrangement)

Bentley: I think it is time now to move on to ***Access Drilling*** *[Bentley asks Dahnert to display the white paper resulting from the April 2011 SAB meeting].*

Bentley then presents the White Paper contents to the TAB meeting members.

Questions, Comments and Answers:

- Wilhelms: I think that Twin Otter transport [proposed for the hot water drills] is unrealistic except for the very smallest hot water systems
- Gerasimoff: I believe the intent is that the largest component could fit a Twin Otter, not that the entire system would fit in one trip.
- Makinson: I think that, for up to about 1000 meters depth, that components of such a drill can be expected to fit in a Twin Otter, but the hose for a 2000-meter system is another story.
- Pyne: Do I understand correctly, that these systems are not destined to allow rock coring at the bottom of the bore?
- Albert [and Bentley]: that is correct - no rock coring
- Pyne: Ok then is it sensible to consider that a Twin Otter is the best way to go? I think there is a significant technological step being required here, for a system that is Twin Otter- able.
- Wilhelms: For our (AWI) hot-water systems that were transported by Twin Otter [or equivalent], we had to have use of an on-site helicopter as a crane to make loading and unloading possible.
- Twickler: Martin Truffer's hot-water system is small apparently capable of both significant depth, and Twin Otter deployment.
- Makinson: Truffer's system makes use of figure-8 loops of hose and capstan hauling of the hose, so there are no hose reels to deal with. I can see this being practical for some applications up to 1 kilometer.
- Bentley: In terms of the science and environmental requirements, is it practical to add a suitable filtration system to an existing, conventional hot-water drilling system?
- Makinson: I do not believe it is possible.
- Wilhelms: I worked with one of our biologists who believe that our system with all that rust and so forth could never come clean. And yet, when we tested the system we found that eventually it did come very clean [no viable micro organisms]
- Gerasimoff: Yes but our requirements for WISSARD were for no iron contamination of the water, for fear that this would fertilize the sub-glacial lakes. So it is not just killing microorganisms that is important.

- Lebar: Yes, this is a good example of the sorts of problems we were faced with [with WISSARD]

RAPID ACCESS DRILLING SYSTEMS--SAB RECOMMENDATIONS FROM 2011 WHITE PAPER

Questions, Comments and Answers:

- Wilhelms: Rather than Rapid Access, why not drill an ice core to the base and then drill into the bed afterwards [explaining that the cost of drilling to the bed this way might not be any more expensive, and we could get a core from the site as well]

- Pyne: New, conventional mineral drilling rigs can use straight pipe (rods) from the surface with automated joint make-and-break; we could use fuel for the drilling fluid, and recover that fluid by back filling with water. The system would have to be modified for cold weather use, but you'd be starting with a "known" entity.

- Eustes and Marshall Pardey: [concurring] The depth range of that technology is almost certainly adaptable to the depth and speed required for these Rapid Access projects.

- Bentley: [reviewing for the audience, the time-line suggested by the SAB white paper for investigating and procuring Rapid Access technology]---General concurrence that it wasn't entirely unreasonable.

SUBGLACIAL AQUATIC ENVIRONMENT ACCESS DRILLING--SAB RECOMMENDATIONS FROM 2011 WHITE PAPER

Bentley: opens TAB discussion about sub-glacial access drilling, with the first target (after completion of WISSARD) being South Pole Lake.
General Consensus of Discussion: the proposal to adapt the Enhanced Hot Water Drill currently at South Pole for such use is not reasonable. Besides technological problems, there is the likelihood that the EHWD might be slated for drilling the neutrino antenna array, as well as for extending the Ice Cube photomultiplier-detector array.

SHALLOW ICE DRILLING--SAB RECOMMENDATIONS FROM 2011 WHITE PAPER

Bentley reviewed the suggestions from the SAB white paper, and opened them for discussion The suggestions included the procuring of a 2-inch diameter Stampfli drill. There were no coherent comments from the TAB about this move.
When discussing the electromechanical drilling systems for use 30-400 meters, there was some debate and discussion from the TAB about the quality of core that could be obtained from a "dry" hole. The consensus was that dry-bore core quality is always somewhat unpredictable; good quality core may always require the provision of a wet or semi-wet bore.

SUBGLACIAL BEDROCK DRILLING--SAB RECOMMENDATIONS FROM 2011 WHITE PAPER

PAVEL TALALAY-HISTORY OF GLACIAL BED DRILLING FROM GLACIAL BORES

Talalay made a short PowerPoint presentation on the history and state-of-the-art for subglacial bedrock drilling. Examples were given from the early 1950's at Camp Century (CRREL), Mirny Station and Franz Josef Land (Soviet program), as well as failed attempts at Byrd Station (CRREL).

- Harrison: Did you attempt to categorize these results according to the temperature of the ice-bed interface?

- Talalay: At the base of Severnaya Zemlya, the ice is about -6 C. Elsewhere I do not know the temperatures.

- Harrison: [responding here to Talalay's note that the CRREL drill failed to retrieve basal samples at Byrd station, but was previously successful at Camp Century]: At Ice Stream B, the [basal till] core was retrieved with a piston corer.

STEFFEN BO HANSEN--SUBGLACIAL CORING OF BEDROCK
Hansen outlined the intentions to retrieve basal samples at NEEM
Present drilling is at or very near to the bed of the glacier
The actual status of the bed material is unknown; could be rock, a rock + ice conglomerate, till, or some other material
The intent is to use conventional machine-tool tungsten carbide inserts in modified cutters that will fit the standard ice-drilling head. In parallel to this, a head, bits, and a pump that would allow the use of polycrystalline diamond bits obtained from IDDO [surplus from GISP drill system] is underway.

[end of notes]