U.S. ICE DRILLING PROGRAM (IDP)
TECHNICAL ASSISTANCE BOARD (TAB) MEETING
Wednesday, March 22 - Thursday, March 23, 2023
Fluno Center - 601 University Ave, Madison, WI 53715
Room 219
University of Wisconsin - Madison

Technical Advisory Board Members present:

Jeff Cherwinka	Physical Sciences Lab University of Wisconsin – Madison
Chris Delahunty	Matrix Drilling Products
Steff Bo Hansen	University of Copenhagen
Tim Lyons	Australian Antarctic Division
Keith Makinson	British Antarctic Survey
Jakob Schwander	University of Bern
Frank Wilhelms (virtual)	Alfred Wegener Institute
Kris Zacny (virtual)	Honeybee Robotics

Ice Drilling Program – WI

Jess Ackerman	Space Science & Engineering Center University of Wisconsin – Madison
Barb Birrittella	Space Science & Engineering Center University of Wisconsin – Madison
Dusty Brunner	Space Science & Engineering Center University of Wisconsin – Madison
Chelsea Dahmen	Space Science & Engineering Center University of Wisconsin – Madison
Mike Jayred (virtual)	Space Science & Engineering Center University of Wisconsin – Madison
Jay Johnson	Space Science & Engineering Center University of Wisconsin – Madison
Jim Koehler	Space Science & Engineering Center University of Wisconsin – Madison
Tanner Kuhl	Space Science & Engineering Center University of Wisconsin – Madison
Elliot Moravec	Space Science & Engineering Center University of Wisconsin – Madison
Elizabeth Morton (virtual)	Space Science & Engineering Center University of Wisconsin – Madison
Mark Mulligan	Space Science & Engineering Center University of Wisconsin – Madison
Chris Niendorf	Space Science & Engineering Center University of Wisconsin – Madison
Chris Rush	Space Science & Engineering Center University of Wisconsin – Madison
Krissy Slawny	Space Science & Engineering Center University of Wisconsin – Madison
Umberto Stefanini	Space Science & Engineering Center University of Wisconsin – Madison
Todd Turner	Space Science & Engineering Center University of Wisconsin – Madison
Dom Winski (virtual)	University of Wisconsin – Madison / University of Maine

Ice Drilling Program – Dartmouth

Mary Albert (virtual)	Dartmouth College
Blaise Stephanus (virtual)	Dartmouth College

Ice Drilling Program – UNH

Joe Souney	University of New Hampshire

Other Guests

Terry Benson	Physical Sciences Lab University of Wisconsin – Madison
Grant Boeckmann	University of Copenhagen
Paul Cutler (virtual)	National Science Foundation
Tony Wendricks	University of Wisconsin – Madison (retired)

WEDNESDAY, MARCH 22, 2023

Arrival & Coffee

Opening Remarks & Chair Comments

Peru Field Project Update – Moravec

- Cherwinka: Where do the chips go in the vacuum head?
    - Moravec: One way check valve to seal in the collected sample.
- Makinson: What size material can you collect with the vacuum? What volume of fluid does it collect?
    - Moravec/Johnson: 1-3 mm; coarse sand; 2-3 L of fluid.
    - Makinson: Would work well to collect basal water and sediment for Geochemists.
- Moravec: Can collect sediment at the bedrock interface or sediment that was drilled through and has settled to the bottom.
- Delahunty: Are there small viscosifiers you can use to suspend the sediment and make it easier to collect?
    - Moravec: Interesting thought to investigate.
    - Delahunty: Could be a small packet with a water membrane that dissolves in water.
    - Johnson: Sucked up 1/4”-3/8” of sediment during testing.
- Cherwinka: What happens to the ethanol added to the borehole?
    - Moravec: It likely floats and seeps out into the firn at a certain depth. In this case, it didn’t contaminate the sample. Most freezing happens at the air/water interface.
- Cherwinka: How high was your water column?
    - Moravec: About a 50 m column or 80 m below surface at the bottom.
- Cherwinka: Could use a microturbine for high altitude power. Only 5% efficient but has extremely high power density.

Tunu Field Project Update – Kuhl

- Hansen: Do you know why chip transport is hampered with the aluminum barrel? What type of cutters were you using?
    - TK: Tried step, scoop, etc. cutters and different pitches.
- Delahunty: Beautiful tent design.
    - Kuhl: It is a 300 lb. game changer as it allows you to keep drilling during bad weather and is much better than windscreens. Goes up in a matter of hours and has good ventilation so it does not warm up too much in there.

GHOST Field Project Update – Rush

- Boeckmann: Ideally, you'd like to use smaller compressors? Were you able to test air flow?
    - Johnson: We're experiencing air loss, even when using both large compressors from the original RAM Drill system. Chris Gibson had tested smaller compressors, but determined they need larger engines.
- Schwander: Consider implementing vacuum chip circulation. Successful to 100 m with RADIX drill. Slower penetration rate but helps mitigate air losses to firn.
- Moravec: What did you try in the field and what did you learn? How is the ethanol deployed?
    - Rush: The ethanol is deployed via the air treatment system coming from the compressors.
    - Johnson: Were able to prove that the parameters tested during the 2019-2020 season work well.
    - Moravec: Is there an air dryer?
        - Rush: Yes, one on the air treatment system and one on each compressor.
    - Moravec: Any issues with the downhole power cable (3/16")? Could that be slowing down the air? Trying to determine what is the difference between this and the original RAM Drill system.
        - Cherwinka: Is this an electric motor?
            - Rush/Johnson: Yes, whereas the old system was an air motor. This makes more air available for chip transport.
    - Moravec: Does the ethanol close up the firn porosity?
        - Johnson: Ethanol was originally introduced to reduce frost on the air hose that would plug up at the head; operations started without the ethanol drip, but were then able to drill 10-15 m deeper after introducing the ethanol drip.

Allan Hills Field Project Update – Slawny

- Hansen: Have you tried carbide cutters?
    - Kuhl/Johnson: The Blue Ice Drill (BID) has carbide cutters as an option, but we generally see degraded core quality with carbide cutters. Our cutters are also cryogenically treated. This was implemented after cutters were fracturing in cold ice at South Pole during SPICEcore.

GHC Field Project Update – Moravec

- Delahunty: Were the bits glazed or smeared with clay? Clay would turn to porcelain if very hot.
    - Moravec: Smeared; the borehole temperatures do not get hot enough to 'glaze.' Bit and barrel were both affected.

Break/Morning Refreshments

Upcoming Arctic 2023 and Antarctic 2023-2024 Field Work – Ackerman

700 Drill Development – Johnson / Birrittella

- What is the anti-torque configuration of the Foro Drill?

    - The Foro Drill has centered blades. The Eclipse Drill has both center and offset blades. Center blades have the most axial drag.
- Hansen: Very well-designed system. Why would you restrict yourself to 1 m core per run?. This will cost you time and fluid loss at depth. If your core barrel is 1 m, you may only collect 0.8 m cores.
    - Johnson/Slawny: Chose one meter to minimize transport of long pieces, tent modifications, extra equipment needed to cut core in the field, etc.
- Hansen: What is your anticipated travel speed downhole?
    - Johnson: 0.7-1.0 m/s.
- Delahunty: Keeping cutters sharp seems to be key.
    - Johnson: Depends on the ice; at WAIS Divide, we were only changing cutters about every 150 m.
- Delahunty: Can you add a 1 m segment to the core barrel?
    - Johnson: The 2 mm wall thickness doesn't really allow for a connection, but we could change out the barrels to add longer barrels in the future.
- Boeckman: Can you change your kerf to collect more core vs. chips?
- Boeckmann: Is it possible to add an older style dry barrel where the chips drop in on top of the core?
    - Johnson: Yes.
- Hansen: Consider broaching the borehole for repeatable cutter head alignment during replicate coring.
- Hansen: Consider implementing an 'auger' during chip bailing to better pack the filter. Use perforated welded tube for filtration. Not convinced fine chips are causing difficulties with drilling. Only an issue if you are trying to optically log the borehole.

BASE Drill Development – Slawny / Kuhl

- Is the rig made from steel or aluminum?
    - Kuhl: Aluminum where possible; the last rig purchased was too heavy upon delivery but was then modified by the vendor.
- Delahunty: Are rotational cages mandated by your safety department?
    - Kuhl: Not mandated, but we prefer to use them.
        - Delahunty: There are other options to consider that are very light weight (e.g. banner safety interlocks).
- Boeckmann: What is the order of magnitude of weights between IDP rock drills?
    - Kuhl: ASIG is about 30,000 lbs., Winkie is between 3,000-5,000 lbs., and the BASE Drill should be in between those two.

Working Lunch – Fluno Executive Dining Room

Drill System Electronics – Stefanini

- Brunner: Regarding vibration monitoring, you mentioned a single axis sensor? Is there a particular part of the drill you're trying to tie into and measure?
    - Stefanini: There is a nav module that detects and transmits angular speed, direction that the sonde is pointing, inclination of the sonde and direction of inclination.

- Delahunty: Are you using Earth or generator ground?
    - Stefanini: It is generator ground because earth ground is not possible in most polar locations.

Improving Core Quality in Dry Boreholes/Stressed Ice Conditions – Kuhl

- Kuhl: Heat is your enemy in ice drilling; cold chips are happy chips.
- Schwander: Did you ever consider using a pre-cutter and then standard cutters?
- Wilhelms (via Zoom chat): How about staggered cutters, as they at least make bigger chips?
    - Kuhl: We've had mixed success with these. We send regular, step and scoop cutters with almost all of our drills.
- Delahunty: Are the tubes broached or extruded?
    - Kuhl: Extruded.
    - Investigate what produces a smoother outer barrel groove surface finish, broaching or extrusion.
    - Moravec: Consider altering the fiber wrap profile for carbon/fiberglass core barrels to increase torsional rigidity.
- Wilhelms: I've also considered putting an o-ring or step seal at the lower end of the core barrel to prevent chips from moving in.
    - Kuhl: Sure, or maybe even a brush seal.
- Stefanini: Would an ethanol drip help with sticking of ice on drill parts? Would it allow things to melt without heating up?
    - Kuhl: It's difficult to implement well. Generally, introducing water/melting into a dry drilling operation is ill-advised.
    - Stefanini: Consider using ice-phobic coatings like durable surface coatings used on icebreakers to repel ice instead of just decreasing surface friction.
- Stefanini: Would increasing down force or sonde weight reduce stick-slip?
    - Kuhl: Those have been considered, but there's only so much weight you can put downhole, though you do want the sonde as heavy as possible.
- Delahunty: Are you seeing axial vibration or the drill walking around the hole?
    - Kuhl: We do see axial vibration due to the cutting/weight of the drill, but stick-slip is a big issue.
- Delahunty: Have you looked at nano-ceramic coatings? These reduce heat by a few degrees C. Investigate stamping die existing technology to see if applicable for cutters.
    - Kuhl: Not yet.
- Delahunty: Have you tried holes higher up the barrel?
    - Kuhl: This has been tried.
- Hansen: We've only seen too fine of chips and plugged grooves; larger chips transport very well in stainless steel barrels in both Antarctica and Greenland. Maybe alter your flights in the center of the tube (hourglass shape), like Henry Rufli suggested?
    - Kuhl: We tried decreasing the flight diameter across the length of the barrel, but haven't tried the hourglass shape.
- Kuhl: Primarily focused on low pitch drilling.
    - Hansen: That's the road to hell.

- Brunner: Could investigate engineered surfaces between your flights and the interior of your core barrel; it changes the composition of the materials to reduce friction.
- Hansen: Could you replace core barrel flights with brushes for finer chips?
- Wilhelms: How about drilling with liquid to lubricate?
    - Albert: While the gas scientists really want dry drilling, could Tanner go to his slide on "Causes of Poor Core Quality" and identify which of those would be alleviated by use of a drilling fluid? It might be good to find a drilling fluid that doesn't hurt the gas analysis.
        - Kuhl: Would mitigate stick-slip, traction, chip transport issues, instantaneous ice expansion. Wet drilling is better in a lot of ways.
        - Slawny: We are looking to move toward a wet drilling option for the Foro 400 Drill in the coming years, or possibly a wet version of the Eclipse Drill.
        - Kuhl: Tried a shallow fluid column. It didn't help, and it made a huge mess.
- Boeckman: Is barrel rigidity an issue?
    - Kuhl: Tried a carbon fiber barrel, but the paint introduced too much friction; it has been stripped off, but the barrel hasn't been field tested since.
    - Moravec: Were the fiberglass barrels wrapped by Amalga Composites Inc.? Could we do this differently?
        - Johnson: The carbon fiber barrel was wrapped for torsional strength.
- Hansen: Have you tried a cutter configuration where only 1 cutter touches the core?
    - Kuhl: Yes.

IDP Science Advisory Board & Working Groups Update – Albert

- Zacny expressed very positive comments about IDP having done this work for a couple of decades now as a consistent group.

IDP Website and Newsletter – Souney

- 25% of all Icedrill.org website visits are viewing the Library page.
- The Equipment page is the second most visited page, making up 22% of the visits.

Break/Afternoon Refreshments

Challenges with Drilling in Clay – Moravec

- Need to explore drill fluid chemical additives that are compatible with Isopar, that don't freeze and that prevent clay from sticking to the core bit/barrels.
- Delahunty: Is the clay coming from the rock you're drilling or from an actual clay layer.
    - Moravec: An actual clay layer, likely caused by the glacier moving over the bedrock.
- Delahunty: You need to put an 'inhibitor' down the hole that counteracts the hydration and swelling of the clay. This has traditionally amounted to salt mixtures. But, you would need to ensure these polymers would play nicely with Isopar, as they can become like gummy worms and ball up.
    - Kuhl: Do you want it to be denser than Isopar and not mix with it?
    - Schwander: Could use a molecular sieve for filtering out water from drill fluid. Could prevent clay swelling.

- Delahunty: Introducing metal down the hole can work to sharpen and clear the bit, but it is difficult to remove those materials from the hole. What you add to the hole must be heavier than clay. Throw grade 5 nuts down the hole to clean the bit (i.e. 'tumbler media'). Use a tumbler media that is grated and will not produce more clay downhole.
    - Moravec: The scientists recommended using a granular coarse crystal.
- Delahunty: Drag bits are great, but create very large chips and the Winkie Drill has a very small annular space. They do make drag bits that collect a core.
    - Kuhl: What's the difference between a coring drag bit and a PDC bit?
- Moravec: We aren't able to reverse fluid flow with the current Winkie Drill setup.
- Brunner: How thick is the clay layer you're trying to get through?
    - Moravec: Unknown.
- Delahunty: How many cm sections did you collect per run?
    - Moravec: ~4 cm.
- Delahunty: Do you have shut off valves in your drill string? Were you seeing water pressure spikes?
- Delahunty: This looks like core blocking because you're cutting too narrow; it starts to wash the hole away. This also creates more chips than you're anticipating. Need more clearance between your core barrel and your core cutter.
- Delahunty: Procure tooling that drills an undersized core. This could prevent core blockage and help with penetration if the core is swelling after it has been cut.
- Kuhl: Did you ever get a pressure spike/plug or lose fluid return?
    - Moravec: This was common. Three failure modes witnessed in the field: 1) clay packs in the top of the barrel in the bearing section, 2) clay packs at the bit or 3) clay packs in the waterways.
- Delahunty: If you see clay/mud rings on the inside of the pipe, you're circulating dirty fluid.
- Kuhl: How fast does the clay settle out? Would a big, baffled settling tank help clean the fluid?
    - Delahunty/Moravec: Would not work fast enough.
    - Delahunty: Centrifuges are available, but are finnicky and energy intensive.
    - Turner: What about a bubble screen?
- Delahunty: We don't conventional drill anymore because it takes so long to trip rods.
- Kuhl: Do they make wireline for AW34 rod?
    - Delahunty: Would have to change your rod and add a winch?
- Johnson: The Winkie system has really tight clearances.
- Delahunty: Flow rate is only 3 gpm. Can you increase this?
    - Moravec: We commonly drilled on the edge at 150 psi.
    - Boeckmann: Were you only using one pump?
        - Moravec: Yes, as we had issues with the second pump.
- Kuhl: In the rock drilling industry, do you switch to full face bits in trouble zones?
    - Delahunty: All the time.
- Delahunty: Are you getting liquid water return?
    - Moravec: The fluid is at -7°C.
- Hansen: Is occlusion/percussion drilling an option?
- Moravec: Consider implementing a debris vacuum for cleaning the Winkie borehole if there is a lot of clay accumulation at the hole bottom.

- Stefanini: Consider using DC voltage as a flocculant to precipitate clay out of a solution.

Open Discussion

- Makinson: Any ideas about coatings/finishes?
    - Kuhl: We've been hard coat anodizing our aluminum barrels but aren't sure if it's helping.
    - Brunner: There are bake-on PEK (polyetherketone) coatings that are chemical impervious except to sulfuric acid.
        - Delahunty: PEK has a high temp and pressure range.
        - Brunner: Could powder coat a stainless steel barrel with PEK.
    - Delahunty: There are hard chromed ID tubes, but it smears off easily when you encounter an imperfection. Use harder materials (stainless steel 17-4, nitriding) to prevent chips from sticking to surfaces.
    - Brunner: Some nitrides are meant for high wear situations.
- Moravec: Has anyone considered ceramic cutters or other materials that may stay sharper longer?
    - Turner: May chip or break when they hit something hard.
    - Hansen: Can drill several hundred meters in very cold ice with standard cutters in Greenland; can show carbide cutters tomorrow that produced decent core quality.
    - Kuhl: The cryogenic treatment has helped maintain cutters in cold ice, but in shallow, gritty ice, someone has to be sharpening the cutters frequently.
    - Brunner: Have you tried coated cutters (Teflon, nitride)? Though these cannot be resharpened.
    - Delahunty: Lots of coatings available for carbide.
        - Kuhl: Most of those are for heat resistance and galling.
- Delahunty: I know you've played with cutter geometries. If you're getting chips on the inner edge of cutters, have you tried a rounded edge on the cutters?
    - Kuhl: Yes.
- Hansen: Still waiting to try our 3D printed cutters. This would allow some freedom in the field. Check out Viking Steel, a Swedish company.
    - Johnson: Grant 3D printed full face ice bits for the Winkie Drill.
- Seems to be a feeling in the science community that the PICO 4-Inch Drill creates better core quality than the Foro 400. Could you test these drills side-by-side?
    - Kuhl: Had them both at Allan Hills in 2019-2020, but ran out of time.
    - Slawny: Will ideally do a side-by-side test at Summit in the coming years.
- RAM Drill
    - Slawny: Thoughts on why the RAM 2 Drill (3-Inch) cannot drill as deep as the original RAM Drill (4-Inch) in west Antarctica?
    - Johnson: Drilling progress is very susceptible to firn conditions.
        - Kuhl: Is your ROP the same as the RAM Drill?
        - Kuhl: Does smaller hose reduce the annular space?
            - Benson: You increase your annular space with smaller hose.
        - Delahunty: Is it all or nothing when you're adding air? You might be super turbulent in your 3-Inch hole. If you need every ounce of pressure in your 4-Inch

hole, you might be eroding the hole more in your 3-inch hole. Once the firn gets more dense, you could be lifting your bit off the bottom of the hole.
    - Kuhl: You encounter melt layers that affect your plume/penetration.
- Delahunty: Suggest a valve to dial back your air flow.
    - Johnson: One compressor shut down and the plume was lost. Occasionally encounter an unexpected blowout.
- Delahunty: Is it possible you're fracking the firn/ice?
    - Johnson: We wondered that, but we haven't gotten into hard/competent ice.
- Cherwinka: Is the drill rate constant? As you get deeper, the column gets heavier.
    - Johnson: We continuously slow down as we go deeper.
- Delahunty: Is the air hot or cold?
    - Johnson: Cold; we start seeing issues when the air gets to -3° or -4°C.
- Koehler: Has anyone logged the holes to see what's going on?
    - Johnson: Yes.
- Brunner: Have you considered casing the firn?
    - YES!
- Kuhl: Jakob, how deep were you able to use a vacuum?
    - Jakob: 107 m.
    - Boeckmann: How long does it take to get that deep?
        - Schwander: 10 hours.
            - Johnson: With RAM, the scientists need a hole every ~30 minutes.
- Stefanini: Could you melt/case the upper part of the hole?
    - Johnson: Tried a hot water spray, but this created slush at the bottom of the hole. When the hot water spray did freeze on the wall, the air then ejected shards of ice out of the hole.
- Delahunty: Original RAID pilot hole concept was tube-in-tube, but this is heavy with rod.
    - Johnson: We looked at this with hose in hose.
- Johnson: Could consider a Rolatube tower for tube in tube.
- Johnson: Also tried a nylon parachute sleeve for casing the hole, but it wasn't rigid enough.

End of Day Wrap-Up / Travel Expense Reimbursement instructions / Adjourn

Group Dinner and Continued Discussion - The Great Dane, 123 E. Doty Street, Madison, WI 53703

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Arrival & Coffee

TAB Membership & Next TAB Meeting – Slawny

Australian Antarctic Division Update – Lyons

- 26-person drill camp; camp infrastructure can accommodate 16 people; the traverse can accommodate an additional 10 people.
- Cherwinka: What is the allowable tow load of each Challenger?
    - Lyons: 80 tons pulling; the tractor itself is 20 tons.
    - Cherwinka: What did you use for your coefficient of friction?
        - Lyons: Unsure; can send some numbers to compare with numbers from the U.S. program.
- Lyons: Going to try white poly vs. black poly skis.
- Trying to move from ISO (10 ft, 10,000 L) containers, Qty. 54 of them, to bladders.
- Using JetA1 fuel.
- Kuhl: Sleds with bladders don't allow for retro cargo; USAP program considering moving away from bladders to allow for cargo/trash to depart South Pole.
- Kuhl: U.S. traverse uses traverse sled skis that are wider than the Challenger tracks; this allows for a higher pull load per tractor.
- Johnson: What kind of casing are you using?
    - Lyons: Fiberglass reinforced casing identical to that used with the Beyond EPICA-Oldest Ice (BE-OI) project; Estisol makes the O-ring at each joint swell, but don't plan to seal it to the top of the glacier.

BigRAID Development & Other BAS Drilling Activities – Makinson

- Fuel injected engines worked well and used around half the fuel of the carbureted engines.
- Xylan 8870 auger coating on BigRAID to prevent chips from sticking to auger.
- IDP to request pop up tent information from Makinson; easy to set up and performs well in strong winds.
- Cherwinka: What's the function of the drill built for KOPRI (Korea Polar Research Institute)?
    - Makinson: For oceanography on the floating ice shelves to study ocean currents, glacial outflows, etc.
- Cherwinka: What temp are you pumping with the CAT pump?
    - Makinson: 90°C.

- Hansen: Surprised there's no AT slip mitigation so as not to wreck the cable; there should be a bearing on the cable, not a fixed cable; should also implement auto shut-off during a slip.
- Turner: What do you use to sense position?
    - Makinson: An encoder.

IceCube Update – Cherwinka

- IceCube Upgrade is funded to add 7 strings to the IceCube array.
- Gen2 not yet funded; NSF has a backlog of projects to support due to COVID.
- Converted the check valve to PEK for high temps.
- Integrating microturbine and solar (up to 1 MW) to reduce fuel use.

Beyond EPICA – Oldest Ice Update – Wilhelms

- Ultimaker 3D printer onsite allowed for real-time design tweaks.
- The last core was 4.54 m long.
- Stefanini: For the 800V connection between the cable and the sonde, what connector are you using?
    - Wilhelms: Triaxial plugs with isolation monitor; don't understand why isolation is required, as it's a pain; similar power to the EGRIP electronics, but BE-OI uses only the inner conductors.

Break/Morning Refreshments

Are 20-mm boreholes a real option for deep ice surveys? Lessons learned from RADIX – Schwander

- 7 m x 7 m inflatable shelter; weighs only 70 kg.
    - Moravec: Could be a good way to enclose Winkie Drill operations.
- Stick a 1.5 m aluminum tube into the surface to start a straight pilot hole and prevent wall collapse.
- Electromechanical firn drill attached to a vacuum.
- Changed extension tubes from brass to tungsten for rigidity.
- Cherwinka: What was your hose material?
    - Hytrel (polyester); a little heavier than the fluid.
    - Makinson: Jakob mentioned greasy flakes in the hose after long-term storage; could this be the same issue the IceCube hose had?
        - Cherwinka: IceCube had no issues with Hytrel storage at -55°C at South Pole.
        - Kuhl: Is it a chemical compatibility with the silicone oil?
            - Schwander: No.
            - Kuhl: Can you switch to stainless steel tubing?
                - Schwander: Would need an injector and the system would get much larger.

JMH Methane Hydrate - Kinley Bore Hole Mining – Delahunty

- Working with the Japanese government to drill in the Canadian Shield to find new sources of energy.

- Have found this methane hydrate phenomena in various locations around the world; “there is 5,000 years of energy at today’s burn rate around the Japanese islands”; now how do you collect it?
- Matrix makes Dual Channel Drill Pipe (DCDP).
- Requirement of 5000 psi for a 3-day period; normal operations may be closer to 2500 psi.
- Kinley Exploration
    - Mining remotely from the surface without having to go underground; diamonds coming up on the shaker.
- Boring 60 ft. diameter caverns in a depleted oil field near Bakersfield, CA.
    - 800 barrels/day will make this the largest producing oil field in the U.S.
- Moravec: How do you make the high-pressure connections between the inner and outer tubes?
    - Delahunty: Urethane crown sleeves with an O-ring behind it; slip fit; doesn’t even need to be clean to make a good connection.
- Boeckmann: All pumping is on the surface? What is the pressure of the water jet?
    - Delahunty: 7000 psi in the first cavity; the second cavity is 5000 psi; can cut soft formations or solid rock.
- Cherwinka: What are the bits made of?
    - Delahunty: Tungsten carbide replaceable inserts.
- Brunner: What kind of life are you getting on the little orifices?
    - Delahunty: About 8 hours.
- Stefanini: Have seen photos of jets at an angle, does that have a better reach? Would you get more reach with a parabola?
    - Delahunty: Possibly, but the design parameter for this was just straight.

Working Lunch - Fluno Executive Dining Room

Europa Probe – Zacny

- NASA trying to determine whether we’re alone or whether there is alien life on other planets.
- Europa is a moon of Jupiter that has more water than Earth.
- Kuhl: Does percussion significantly increase your penetration with your auger system?
    - Zacny: Yes it does; our teeth are not sharp and this is cryogenic ice; if you don’t have percussion, your WOB (weight on bit) must be very high.

EGRIP Drilling Status – Hansen

- Extensive excavation required for the trench ceiling after three years of no activity.
- Same winch used at GRIP, NGRIP, NEEM with no issue, but core breaks were higher at EGRIP.

Open Discussion

- Kuhl/Johnson: Encouraged by the BAS success with EFI (electronic fuel injection) generators.
- Kuhl: Interested in Jakob’s bit with the screw thread on the end. Does this have applications within IDP?
- Wilhelms: Would like to propose the next Symposium on Ice Drilling Technology be held in Bremen, Germany in 2025 or 2026.

- Wilhelms: Pavel Talalay had circulated some journals championed by his group, but these were recently found to be predatory. Annals is recommended.
- If the meetings are held too often, there is not sufficient material to publish.
    - Makinson: Agree that Annals is preferred and 2025 or 2026 feels right.
    - Wilhelms: China is not desirable.
        - Hansen: The Chinese group are very nice hosts and have more capacity for logistics/planning than some of us.
    - Wilhelms: Frank will call a video conference with Pavel and others from this group to discuss and avoid any hard feelings.
    - Hansen: Could meet in Germany to wrap up/celebrate the conclusion of BE-OI.
- Slawny: Recommendations for the next TAB Meeting?
    - Two full days?
    - Include a visit to the IDP facility?
    - Makinson: The amount of presentations is good. Maybe longer breaks and a second evening. Maybe a third half day for a morning warehouse tour.
- Hansen: Will the presentations be shared?
    - Yes, Krissy will send a link.

Meeting Wrap-Up / Adjourn