



**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 6746**

**Summary of a workshop on light-weight coring
techniques and equipment used by Northern Canada
Division, Geological Survey of Canada**

G.R. Brooks (Editor)

2011



Natural Resources
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ABSTRACT

This Open File is the record of a workshop on light-weight coring techniques and equipment used by staff of Geological Survey of Canada-Northern Canada (GSC-NC) Division on November 15, 2010. It contains an overview of the rationale behind the workshop, abstracts and pdf files of the nine presentations, and a list of current, in-house, light-weight coring equipment (as of December 1, 2010).

INTRODUCTION

Scientists within Geological Survey of Canada-Northern Canada (GSC-NC) Division contribute to numerous Earth Sciences Sector Programs, addressing diverse topics in the fields of environmental geoscience, natural hazards, climate change and northern development. Many of the research activities have a need to collect sediment samples using shallow coring techniques in a range of environmental settings, including lake basins, wetlands, permafrost terrain, river channels and floodplains, landslide scars, sand dunes and peatlands. A variety of light-weight coring systems are available to collect shallow core. Such systems need to be robust, readily transportable, cost-effective, and suitable for use by small field teams, possibly in remote areas. GSC scientists have many decades of experience using a variety of light-weight coring equipment and techniques.

A workshop on light-weight coring techniques currently used by GSC-NC Division staff to collect shallow cores was held on November 15, 2010. The need for this workshop arose because experience with (and even awareness of) specific in-house coring equipment in many cases resides only with small groups of scientists within the Division. This situation reflects, in part, the loss of corporate knowledge through a number of recent retirements, as well as the creation of the Division from the amalgamation of Terrain Sciences Division with part of Mineral Resources Division. The net result is that no single person in GSC-NC Division is familiar with all of the in-house coring equipment and techniques. The goal of this workshop thus was to increase awareness of the in-house coring techniques, expertise and equipment, as well as to foster discussion, cooperation, and potential partnerships amongst the various groups of scientists of widely varying backgrounds and whom in many cases have not previously work together.

This Open File represents a record of the light-weight coring workshop. It contains a summary of the rationale behind the workshop, abstracts and pdf files of the nine presentations, a participant list, points of discussion, and a list of current, in-house, light-weight coring equipment (as of December 1, 2010).

WORKSHOP

Presenters for the workshop were solicited among current and retired Divisional staff to encompass as many coring techniques as possible. Each presenter was asked to focus on 'their' coring technique(s) rather than on the research results obtained from a coring campaign(s). They provided, as appropriate, an overview of the technique(s) and equipment(s), including: suitable applications or environments for use, required platform(s) for operation, limitations (e.g., water depths), advantages/disadvantages, required manpower, depth of core penetration, transportability, and equipment location and availability for use.

Nine presentations were made during the workshop, as listed in Table 1. Abstracts of the presentations are reproduced in the *Abstracts* section (below). Pdf files of the presentations are contained on the Open File CD ROM or within the package of downloaded files. Table 2 summarizes the names of the presentation pdf files with the

respective author(s), presentation title, and relevant coring equipment/techniques. Each of the presentations is a stand-alone, referable document with a reference or further reading list, as appropriate. The workshop was attended by twenty-one participants (see Table 3).

Table 1 Workshop itinerary

9:00-9:10	Introduction	Greg Brooks
9:10-9:40	Soil auger and slide-hammer core sampling	Stephen Wolfe
9:10-10:10	Vibracoring in lakes and on landslides	Greg Brooks
<i>Break</i>		
10:30-11:00	Livingstone Corer	Alain Grenier
11:00-11:30	Development of light-weight permafrost coring equipment at GSC; a review	Jean Veillette
11:30-12:00	Light-weight coring in permafrost at GSC - current activities	Wendy Sladen
<i>Lunch</i>		
13:00-13:30	Peat coring and sampling techniques used at Geological Survey of Canada (1993-2003)	Inez kettles
13:30-14:00	A universal percussion corer for sampling lake sediments	Jocelyne Bourgeois <i>et al.</i>
14:00-14:30	Variations on a theme of gravity coring	Sam Alpay <i>et al.</i>
14:30-15:00	Aquatic soft sediment sampling methods: freeze coring and grab/hand coring	Paul Gammon and Sam Alpay
<i>Break</i>		
15:15	Discussion – future needs?	All

Table 2 Summary of presentation pdf files and attributes in the Appendices

Pfd file name	Author(s)	Presentation title	Equipment/technique(s) summarized
Appendix_A_Alpay.pdf	Sam Alpay, Steve Day, Rick McNeil, Martin McCurdy and Paul Gammon	Variations on a theme of gravity coring: K-B, Glew and TechOps corers with core extrusion and high-resolution sectioning of shallow aquatic sediments	Glew gravity coring, Kajak-Brinkhurst corer and TechOps corer
Appendix_B_Bourgeois.pdf	Jocelyne C. Bourgeois, Konrad Gajewski and Michael N. Demuth	A universal percussion corer for sampling lake sediments	Universal percussion corer
Appendix_C_Brooks.pdf	Greg Brooks	Vibracoring in lakes and on landslides	Vibracoring
Appendix_D_Gammon.pdf	Paul Gammon and Sam Alpay	Aquatic soft sediment sampling methods: freeze coring and grab/hand coring	Freeze corer, Grab/hand coring
Appendix_E_Grenier.pdf	Alain Grenier	Livingstone Corer	Livingstone corer
Appendix_F_Kettles.pdf	Inez Kettles	Peat coring and sampling techniques used at Geological Survey of Canada (1993-2003)	CRREL corer, Macaulay/Russian corer, Wardenaar-style corer, Coûteaux Corer, Handcut Surface Blocks, Coring peat hummocks
Appendix_G_Sladen.pdf	Wendy Sladen	Light-weight coring in permafrost at GSC - current activities	Modified CRREL coring, diamond coring
Appendix_H_Veillete.pdf	Jean Veillete	Development of light-weight permafrost coring equipment at GSC; a review	Acker drive sampler, CRREL auger, Winkie drill, JKS 300, Haynes drill, Hand-held power augers, ATV drill
Appendix_I_Wolfe.pdf	Stephen Wolfe	Soil auger and slide-hammer core sampling	Soil auger and slide-hammer core sampling

Table 3 **Workshop participants**

Participants
Sam Alpay
Andrée Blais-Stevens
Wes Blake
Jocelyne Bourgeois
Greg Brooks
Nicole Couture
Réjean Couture
Steve Day
Caroline Duchesne
Paul Gammon
Alain Grenier
Inez Kettles
Anne-Marie LeBlanc
Martin McCurdy
Isabelle McMartin
Barbara Medioli
Mark Nixon
Alain Plouffe
Wendy Sladen
Jean Veillete
Steve Wolfe

ABSTRACTS

Variations on a theme of gravity coring: K-B, Glew and TechOps corers with core extrusion and high-resolution vertical sectioning of shallow aquatic sediments

Sam Alpay, Steve Day, Rick McNeil, Martin McCurdy and Paul Gammon

The goals of gravity coring for environmental limnological studies are to obtain an undisturbed sample of bottom sediments, preserve the sediment-water interface, maintain the original water content, and maintain the original vertical distributions of chemical, mineralogical, and biological constituents. Gravity coring devices are designed to drive core tubes or cylinders vertically into the sediments and withdraw them back to surface intact. Examples of open-barrel or gravity corers that are used within the Northern Canada Division of the Geological Survey of Canada are a modified Kajak-Brinkhurst (K-B) corer, Glew (and modified Glew) corers, and TechOps corer. Although the principles of operation are similar, each device has advantages and disadvantages that should be taken into consideration for the requirements of each specific lake sediment study.

Shallow lake cores ($\leq 1\text{m}$) taken by gravity coring methods typically require extrusion and sectioning on-site because of the high water content and likelihood of core disturbance during handling and transport. Zorbitrol (a water binding agent) can fix most gravity cores sufficiently to enable gentle transport back to the laboratory; however, it is a source of contamination that would preclude any subsequent geochemical analyses. For high water content cores, vertical extruders are the most effective. There are three components to vertical core extrusion and sectioning: maintenance of the core in a vertical position, advancement of the core material through the core tube so that sections can be expelled, and removal of the extruded section that can be transferred to sample containers. Three examples of vertical core extruding and sectioning devices portable for field use are available: one designed for use with the K-B corer with fixed interval sections and two for which the operator can define the sectioning intervals.

A universal percussion corer for sampling lake sediments

Jocelyne C. Bourgeois, Konrad Gajewski⁽¹⁾ and Michael N. Demuth

Percussion coring systems rely on a moveable weight to push a core barrel into the sediment. The corer, attached to a cable, is lowered through the water column until it reaches the sediment. A second line is then used to raise then drop the weight on top of the core barrel. Over the years, several types of lightweight, percussion coring systems have been developed for use in remote locations where the weight of the equipment is a major concern.

We used a Universal percussion corer to obtain sediment from lakes near the Jorge Montt Glacier in the Chilean Patagonia. Choosing a core sampling system was complicated by

logistics: the remoteness of the field site and by the cumbersome nature of the equipment (including two small, inflatable boats) which had to be carried, on foot, over difficult terrain. We chose this particular corer as it is relatively inexpensive, lightweight, and easily assembled. It consists of a Universal core head (69 mm diam.), gravity weights, clear polycarbonate core barrels (120 cm and 240 cm long) and a slide hammer. We worked on shallow lakes (less than 5 m depth) from an unstable platform. However, this corer can be deployed in much deeper lakes. We could only recover short sediment cores because the lakes around Jorge Montt Glacier are very young. Nonetheless, we found this percussion core sampling system to perform well in the field but its full potential could not be assessed due to various particulars of the expedition.

⁽¹⁾ *Department of Geography, University of Ottawa*

Vibracoring in lakes and on landslides

Gregory R. Brooks

Light-weight vibracoring is a well-established technique used to collect a continuous core of saturated, loose sand and silt deposits. It uses a resonating core barrel that liquefies contacting sediment and sinks into and around the underlying sediment column. GSC-NC equipment consists of a 2.5 hp Honda™ motor that powers a 5.1 cm (2 in) diameter vibrator head via a 10.7 m long flexible steel shaft. Core sediments are collected in 7.6 cm (3 in) O.D. aluminum irrigation pipe cut into 2.3-2.4 m (7.5-8 ft) lengths. The pipes are joined with couplers, as necessary, to create a continuous length of core barrel of up to 12.1 m (40 ft) long. A core catcher at the mouth of the core barrel helps retain penetrated sediment. After vibrating a core barrel into the ground, it is extracted using a one ton hoist mounted on a JAWS™ ‘A’ frame ladder. Shallow cores (less than 2m deep), however, have been recovered manually. The retrieved core barrel is cut up into 1 to 1.5 m lengths, capped, sealed with tape, and transported to the laboratory for analysis. In the laboratory, the core barrel sidewalls are cut longitudinally with a circular saw and the enclosed deposits split, logged and sub-sampled. Core recovery is variable, depending on deposit grain size and sorting, but can exceed 90%. The vibracoring equipment requires a crew of two and can be transported by a pickup truck, ATV and/or snowmobiles. Vibracoring has been used to collect cores up to 5.5 m long from lacustrine deposits in the French River and North Bay areas and, most recently, from small wetlands on Leda clay earthflows in the Ottawa area.

Aquatic soft sediment sampling methods: freeze coring and grab/hand coring

Paul Gammon and Sam Alpay

To obtain reliable cores of shallow aquatic sediments requires a pragmatic marriage of the substrate type that you will be coring to the research goals that you wish to achieve. Aquatic sediment substrates vary from extremely “soupy” to well compacted. The goals can vary from climate histories to geotechnical to geochemical, each of which may

require specific sampling techniques. The resolution required in the study commonly dictates the type of substrate and the type of coring method required.

The highest resolution lake coring, with also the best preservation of geotechnical properties, is freeze coring. When properly deployed this technique preserves sediment stratigraphy in hard to very soft substrates with sediment disturbance reduced to virtually nil either during or post sampling. Freeze cores can be transported back to the lab for detailed stratigraphic study, with resolution at millimetre scales possible through microtoming and X-Ray examination. Freeze coring is logistically difficult, requiring transport of dry ice into the field, and the maintenance of frozen conditions subsequent to sampling. The amount of sediment can also be relatively small in freeze cores, especially for the sediment-water interface. Freeze coring of marine substrates is the same as for fresh water. Other soupy sediment techniques include gravity coring (Sam Alpay) and hand coring. Hand cores can be used delicately and precisely, and hence can be effective coring devices in the softest of substrates.

Hard substrates can cause as many problems as soft substrates, but are advantageous in that they are resistant to disturbance and thus can be relatively easily transported back to the lab. Many gravity corers are unsuited to these kinds of substrates due to a lack of penetration, no matter how good the operator or how heavy the weight used. Hand coring is a good option in these substrates, and can yield long and well preserved cores, although depth penetration can be limited by the amount of weight one can use to push the corer into the substrate (a sharp-ended coring nose is preferable). Short (<30cm) cores of hard substrates can also be obtained by coring the sediment retrieved in a box corer or large grab sampler. This technique provides large sediment volumes with easily correlated core depths.

Lake or marine cores >1-2 metres generally require vibracoring or piston coring techniques, which are logistically difficult unless significant lifting capabilities are available. Small piston and vibracorers can be deployed off small vessels but the depth penetration of these systems is often limited by substrate layers or lift capacity. These techniques can disturb the uppermost 0.5-1 m and so need to be used in conjunction with gravity or other coring techniques that better capture the sediment-water interface (if that is of importance). Stratigraphy from different coring techniques can generally be spliced using radiometric dating and/or proxy data measurements.

Livingstone Corer

Alain Grenier

The Livingstone Corer, developed in the mid 1950's, is a light-weight, piston corer used to collect freshwater sediments from shallow lakes and ponds, up to a depth of 25m. Also referred as a stationary-piston corer, the Livingstone corer can be used year-round; other advantages include portability and ease of use. Cores are extracted either in the field or upon return to the lab. Special care is necessary to ensure minimal disturbance of the sample in transit to the laboratory. Disadvantages include limits on the depth of

water, the length of core and potential for disturbance of the core stratigraphy. The equipment owned by the GSC provides different options for core diameter (2 or 3 inch OD), core barrel length (3 or 6.5 ft long), and different types of core barrel materials (aluminum or clear plastic).

Peat coring and sampling techniques used at Geological Survey of Canada (1993-2003)

Inez M. Kettles (Retired, Geological Survey of Canada)

Most peatlands in Canada take the form of bog or fen but some swamps and marshes have sufficient accumulations of organic materials (40 cm or more) to be classed as peatlands. Most environmental, ecological, or biogeochemical studies of peatlands require stratigraphic sampling and sub-sampling. Peatlands are water-saturated and, over large areas of Canada, they are permafrost-bearing and isolated. Hence, core collection presents many challenges. When choosing the sampling site, it is wise to first use a soil probe with sufficient extensions to test the depth and character of the peat accumulation. For past peatland projects at GSC, cores were collected at depth from permafrost-bearing peat using the CRREL coring kit. A continuous undisturbed core was produced in segments of up to 20 cm from one drilled hole. The segments were retrieved from the hole using a core catcher. Use of the CRREL device took at least 2 people and was difficult. As soon as the motor on the CRREL device stopped, water from the melting of the ice around the cutting head quickly began to refreeze and, if not pulled up immediately, the head was stuck (on one occasion permanently) in the hole. To collect at depth in unfrozen peatlands, the Macaulay corer, referred to also as the modified Russian borer, was effective and not too difficult to use. It is a chambered-type side filling sampler with a T-handle and 1 m long extension rods. Continuous cores were collected in 50 cm segments to the contact with mineral sediment. After the first 1 or 2 extension rods were added, 2 or more people were needed to pull the corer up from the hole. Neither the CRREL work nor the Macaulay were useful for sampling peat at or near the surface. Above the water table in an unfrozen peatland or above permafrost in frozen ones, it worked best to cut out blocks of peat using a large butcher knife and small clippers. If a continuous core of surface peat materials was needed, a Wardenaar-style corer was used for the uppermost 90 cm.

Light-weight coring in permafrost at GSC - current activities

Wendy Sladen

Light-weight coring techniques used by the GSC in recent years include coring with a modified Cold Regions Research and Engineering Laboratory (CRREL) barrel and a diamond impregnated bit barrel. The modified CRREL barrel is a hollow mild steel barrel with welded double helix flight configuration. The removable shoe has replaceable tungsten carbide teeth which do the cutting. Attached to a power head, the

CRREL barrel can retrieve a high-quality, continuous core in snow, ice, and fine-grained organic and mineral soils. The disadvantage of the CRREL barrel is that it does not work well in stony ground, unfrozen soils or soils with a significant unfrozen water content. In addition, the drilling process can be slow due to insufficient storage for the cuttings on the outside of the barrel limiting the length of core recoverable in a single run. A second method used by the GSC is diamond drilling, which uses a core barrel with a diamond impregnated carbide bit. Also attached to a power head, this method can cut through fine-grained soil with ice, sand, gravel, and boulders up to 20 cm in diameter. This off the shelf equipment produces a high quality continuous core. The disadvantages are that in pure ice the core tends to break into smaller segments, slowing drilling, and in warmer permafrost conditions (-2 to 0°C) the core tends to disintegrate due to the uncemented material and frictional heat. Both methods are applicable in a wide range of terrain types, they are light-weight and easily transportable by snow machine, ATV trailer and helicopter.

Development of light-weight permafrost coring equipment at GSC; a review

Jean Veillette

Intensive development of light-weight, permafrost coring equipment was carried out by Terrain Sciences Division during the 1972-1977 period. This work was done in support of the large surficial geology mapping programs conducted along the Mackenzie Valley and the west coast of Hudson Bay in support of proposed pipeline routes. The evaluation of ground ice content and that of basic geotechnical properties of frozen soils to depths of 3-4 m below the surface were the main concerns. Three pieces of equipment resulted from this development work: the permafrost coring kit, the JKS 300 drill and the ATV drill. Apart from the equipment developed, the identification of design parameters regarding torque and rpm requirements for successful coring of frozen soils using light-weight equipment was the most relevant finding. The description of specific coring projects is used to illustrate the results. Recommendations for future work are presented.

Soil auger and slide-hammer core sampling

Stephen Wolfe

After the shovel, hand auger probably represents the simplest of light-weight shallow coring methods available. GSC Northern has a T-handle soil auger, with 4-inch diameter auger heads applicable for loam soils, sand and clay, and extension rods for coring in excess of 5 metres. Experience in a range of soils has shown that the open-faced clay auger head is the ideal all-purpose auger, which permits easy sampling and removal of soil from the auger. A soil auger is ideal in most moist soils (particularly sandy soils), where exposures are absent. The auger can penetrate wet and even saturated silts and clays, permitting sampling several metres below the watertable in some circumstances. It is a good alternative where vibra-coring is not possible. The auger can be operated by one

person, with quick-connect (used by GSC) or threaded options. It is very portable, and typical coring depths reach 3 to 5 metres with excellent core recovery. Disadvantages include recovery of only disturbed samples, and difficulty in recovering very dry or very wet, non-cohesive samples. Most of these disadvantages may be overcome by utilizing a slide-hammer soil core sampler. GSC Northern has experience with a 2-inch diameter, 12-inch long sampler. The short undisturbed samples are ideal for optical dating. The sampler can use an existing auger-hole to obtain a core sample, and uses a slide-hammer for coring, and T-handle for extraction. The ideal method is to combine auger sampling and slide-hammer coring. A disadvantage is that it can be difficult to extract the sample from the corer. For this reason a split-tube sampler is available, but has not been tried by GSC personnel.

DISCUSSION

There was brief discussion at the end of workshop that is encapsulated as follows:

- It was suggested that the GSC-NC division coring equipment, its location, and the names of contact persons be summarized in a table within the workshop Open File. This information is contained in Table 4.
- Research into permafrost drilling techniques should experiment with chilled drilling fluids that are environmentally friendly.
- An operational need was expressed to recover core up to 5 m in length in water depths greater than 5 m. A different version of the Universal Percussion Corer is needed for this.
- A key paper identified that summarizes the development of GSC coring techniques and equipment in permafrost is Veillette and Nixon (1980).
- As regards equipment/techniques not covered in the workshop, none was identified. However, there seems to be a mini-Glew coring in storage somewhere in 601 Booth that is unaccounted for. This equipment was used by a now-defunct paleoenvironmental group within what was Terrain Sciences Division.
- Potential capsizing issues from using a winching frame on a floating platform to recover corer were mentioned.
- The advantages of coring from an ice cover were mentioned.
- The challenges of handling large marine vibracoring equipment from a small floating platform or ice cover were mentioned.

Table 4 Summary of GSC-NC coring equipment and contact persons (as of December 1, 2010)

Coring equipment	Application(s)¹	Equipment location	Contact person
Modified CRREL auger	<ul style="list-style-type: none"> - Coring in snow, ice, fine-grained organic and mineral soil - Used with a STIHL power auger that has a high (150:1) engine to boring spindle reduction ratio. - Can be used with a handheld unit or frame mounted (the Stinkie system) 	<ul style="list-style-type: none"> - TFSS has 5 modified CRREL kits called “Coring auger kits” - TFSS has 6 STIHL O38 auger power heads (2-person handheld) - The Stinkie is stored at TFSS 	Wendy Sladen
Diamond coring (Winkie)	Coring in frozen peat and fine-grained soils with ice, sand, gravel and boulders (may need to circulate chilled fluid)	Presently stored in Churchill, MB	Wendy Sladen
Diamond coring (Portable earth drill)	Coring in frozen fine-grained soils with ice, sand, gravel and boulders up to 20 cm in thickness	Planned to be purchased in near future, storage location not yet determined	Stephen Wolfe
Freeze corer	Obtaining well-preserved deposits up to 1-2 m long from lake or pond basins, including the sediment-water interface.	Most of the equipment is owned by Prof. Tim Patterson, Carleton University	Paul Gammon
Glew corers (two)	Shallow aquatic sediments; 2-1/2” ID, messenger type gravity corer	Can be in various locations depending on usage, see contact person	Steve Day

Modified Glew corer	Shallow aquatic sediments – limit oxidation; 2-½” ID; messenger type gravity corer	Can be in various locations depending on usage, see contact person	Sam Alpay
High-resolution Glew extruder	Mechanical vertical extruder; 2-½” ID, sectioning interval defined by operator	Can be in various locations depending on usage, see contact person	Sam Alpay
Grab/hand coring	For use where aquatic sediments that are stiffer than can be sampled easily using a gravity sampler. Will capture a well-preserved sediment-water interface.	GSC owned, but stored by Prof. Tim Patterson at Carleton University	Paul Gammon
Kajak-Brinkhurst (K-B) corer	Shallow aquatic sediments; 9 cm ID; messenger type gravity corer	Can be in various locations depending on usage, see contact person	Sam Alpay
K-B core extruder	Fixed 1-cm interval mechanical vertical core extruder; 9 cm ID	Can be in various locations depending on usage, see contact person	Sam Alpay
Livingston corers²	Coring soft, fine-grained lacustrine sediments in lake basins, ponds and wetlands. Can be used with 1.5, 2 and 3” OD core barrels. Two complete sets of equipment are available that use 1.5” or 2/3” OD core pistons.	Stored in G70-601 Booth	Alain Grenier or Greg Brooks
Macaulay/Russian peat sampler³	Used to collect a relatively undisturbed peat sample	B52-601 Booth	Rick McNeil
AMS Soil Auger	Coring moist-to-damp unconsolidated and unfrozen sands, silts, clays to depths of 5 m or more	Presently on loan, but can be returned to G70-601 Booth	Stephen Wolfe

TechOps corer	Shallow aquatic sediments; 10 cm ID; close-on-contact type gravity corer	Can be in various locations depending on usage, see contact person	Sam Alpay
TechOps High-resolution hydraulic extruder	Vertical extruder using water pressure; 10 cm ID, sectioning interval defined by operator.	Can be in various locations depending on usage, see contact person	Sam Alpay
Universal percussion corer	Collecting cores in lake basins using core barrels of 1.2 and 2.4 m length. Suitable for use in ‘deep’ and shallow depths of water.	562 Booth, but will be moved to G70, 601 Booth	Jocelyne Bourgeois or Mike Demuth
Vibracorer	Collecting 3” OD cores of saturated, loose sand, silt and/or soft clay sediment from floodplains, deltas and lake basins. Limited penetration may be made into wet, cohesive clay deposits.	Stored in G70-601 Booth	Greg Brooks

¹ See presentations in the Appendix for more details.

² In addition to the equipment summarized by Alain Grenier’s presentation, a second Livingston corer was identified after the workshop. This equipment uses a smaller core barrel of 1.5” diameter. Both Livingston corers are now stored together in G70-601 Booth.

³ A Wardenaar-style peat corer was owned by Terrain Sciences Division. Its whereabouts, however, is not known.

REFERENCES

Veillette, J.J., and Nixon, F.M., 1980. Portable drilling equipment for shallow permafrost sampling. Geological Survey of Canada Paper 79-21. 35 p.



Variations on a theme of gravity coring: K-B, Glew and TechOps corers with core extrusion and high-resolution sectioning of shallow aquatic sediments



Northern Canada Division Coring Workshop

15 November 2010

Sam Alpay, Steve Day, Rick McNeil, Martin McCurdy, Paul Gammon



Natural Resources
Canada

Ressources naturelles
Canada

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Outline

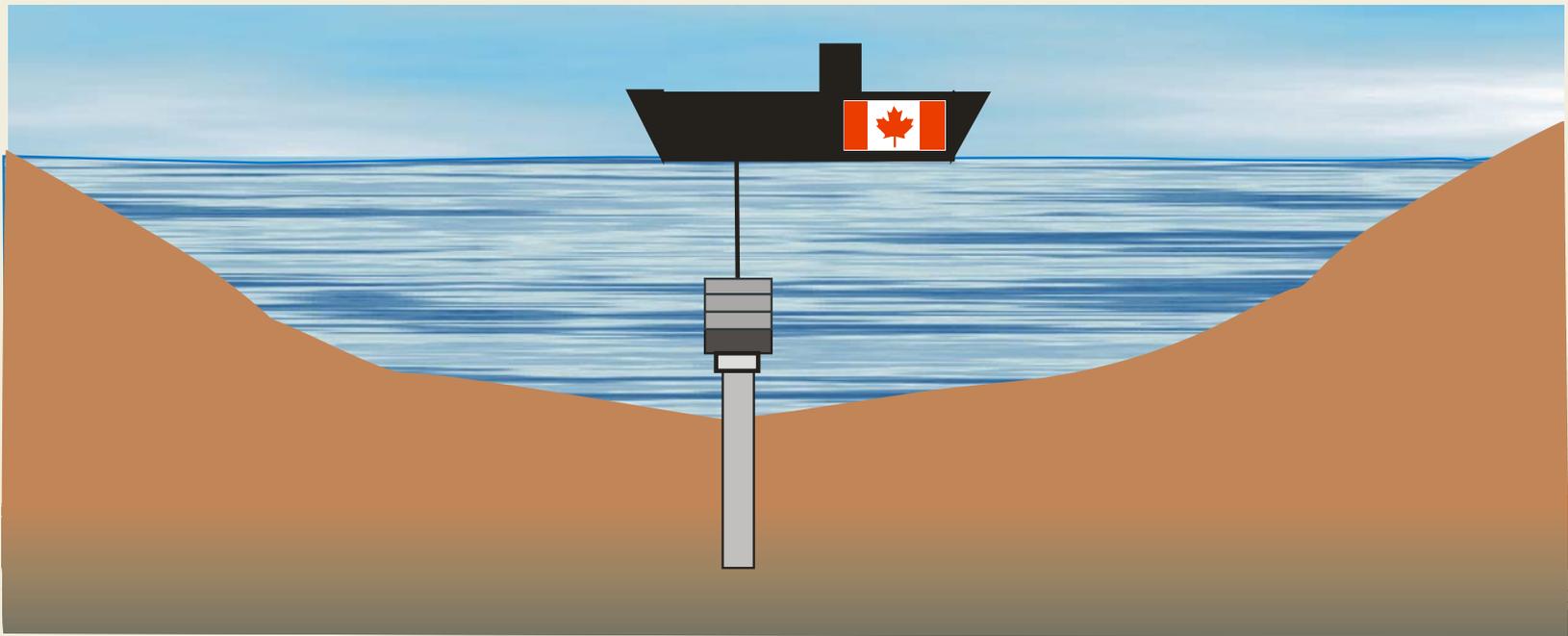
- What is gravity coring?
- Information before doing it ...
- Why gravity coring?
- Principles of gravity coring
- Types of gravity corers
- Operation of gravity corers
 - K-B corer
 - Glew & modified Glew corers
 - TechOps corer
- Core extrusion and sectioning
 - Types of high-resolution vertical extruders
 - Fixed interval, high-res Glew extruder, high-res hydraulic extruder
- Practical considerations for gravity coring and extrusion methods
- References





What is gravity coring?

- Gravity coring devices drive core tubes or cylinders into the bottom sediments and withdraw them back to surface intact.
- They are operated on a single line from surface and allowed to penetrate the sediments using gravity either under the weight of the device or by free fall.





Information before doing it ...

For environmental studies of contamination, identify:

- bathymetry (e.g., marine charts)
- sub-bottom profiling
- spatial contamination gradient
- sediment/contaminant transport pathways

Typically the profundal zone of a lake or basin is chosen for coring where sediment deposition is thick and continuous.

Surface sediments are of greatest interest for environmental investigations to compare recent activity with pre-industrial “background”.





Principles of gravity coring

- A core tube open at both top and bottom is driven into the sediments.
- Once the tube has penetrated the sediments, the top is sealed and pulled back to surface.
- The sediment core remains in the core barrel by:
 - closing the top of the tube (partial vacuum),
 - cohesion of sediments inside the tube, and
 - closing the bottom of the tube *before* breaking the water surface upon retrieval.
- Gravity corers (a.k.a. open barrel corers and open drive samplers) have two types of mechanisms to close the upper seal.



Types of gravity corers

Messenger operated

- The operator drops a weight attached to the line as the trigger to close the top seal.

Close-on-contact

- The top seal is automatically closed either once the corer penetrates the sediment or when the operator applies a force on the line to lift the core.

GSC has examples of these two types of gravity corers.

See Glew et al., 2001;
Mudroch and MacKnight, 1991.





Operation of gravity corers

- Principles of operation are similar for all types of gravity corers available.
- Example of a Maxi-Glew gravity corer
- Full instructions at: <http://post.queensu.ca/~pearl/Maxi.pdf>
- Uses clear polycarbonate core tubes

Brian Cumming, Paleoecological Environmental Assessment and Research Laboratory (PEARL), Department of Biology, Queens University





Operation as defined for paleolimnological studies

Step 1: Corer Preparation

Ensure the top of the core tube (flat end, not tapered end) and the area where the plunger and corer housing meet have been sealed with Vaseline (this typically only needs to be done once per coring day, unless corer is not sealing correctly).





Attach core tube to corer. Make sure flat end of corer is square against ring seal. Tighten hose clamp on tube housing using nut driver, do not over tighten. Core tube should not move within the housing.

Make sure plug fits securely in bottom of core tube.

Note: additional weights may be added to core tube if needed (e.g., if sediments are fairly dense). However, this tends to make corer more top-heavy and likely to fall over on its side.



Step 2: Testing Corer and Lowering

Raise plunger of corer to "loaded" position. Test to see if corer is properly sealed by lowering into water, triggering the corer, and lifting it to see if the tube is filled and holds water. (If water leaks out, re-check seals and Vaseline, and ensure hose clamp is tightened sufficiently around the core tube). Release water and re-set corer to "loaded" position.





Slowly lower corer into water. Lower slowly until corer penetrates into sediment (max. speed $\sim 0.5\text{m/sec}$). It is important not to let the corer freefall, as this can "blow away" surface sediments.

When core tube has entered sediments to required depth, send messenger down the line to trigger corer.

After plunger is triggered, raise slowly to surface.

DO NOT ALLOW BOTTOM OF CORE TUBE TO BREAK SURFACE OF WATER!



Step 3: Retrieval of Corer

While core tube is submerged, insert core plug (black rubber or orange bung) to form a seal in bottom of corer.



Holding bottom of core tube and plug to prevent plug from falling out (which would lead to lost sediment), lift corer slowly out of water.



Be careful not to disturb sediment-water interface.

Check for clarity of water directly above sediment surface and presence of chironomid tubes or algal mats (signs of a good sediment core).



Ensuring the core is secured, loosen hose clamp securing core tube to corer, and remove corer form core.

Be careful not to disturb core.





Add cap to top of core. Secure plug at bottom of core tube with electrical tape to prevent plug from accidentally slipping. Label core tube with masking tape and permanent ink. (lake name, core, top/bottom, date).

Place core in secure position in boat, ensuring core remains vertically upright.

Take new cores back to shore.

NOTE- if multiple cores are being taken, a bucket with a lid with holes to hold cores vertically can be useful.

Adapt technique to study requirements. 15





Gravity corers for shallow aquatic sediments (≤ 1 m)

What do we have in the Northern Canada Division?





K-B corer

Kajak-Brinkhurst corer

- Easy use with a winch; aircraft cable
- Optimal for stiff aquatic sediments
- Yield deeper cores
- Can be used in deeper lakes
- Can be used with up to a 10-m free fall
- Can be used in combination with box core to capture both deeper sediment strata and the sediment-water interface
- Messenger-operated
- 9 cm (3½") ID



Wildco K-B corer; www.wildco.com

See also Mudroch & MacKnight, 1991





Glew and modified Glew corers

Photo of John Glew from <http://post.queensu.ca/~pearl/people.htm> →



↑ John Glew, inventor, preparing for test operation of the modified Glew corer → QUBS 2001



- Lightweight
- Operable from any platform
- Good preservation of sediment-water interface
- Easy penetration to pre-industrial strata
- Modified version limits oxidation of uppermost sediments
- Messenger-operated
- 6.4 cm (2½") ID

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TechOps corer

- Versatile; weights can be added
- Any platform
- Preservation of sediment-water interface
- Penetration to pre-industrial strata
- Yield deeper cores
- Core stiff aquatic sediments
- Close-on-contact operation; floating piston
- 10 cm (3.9") ID; wide diam. = more sediment material





Core extrusion and sectioning

- Most shallow cores taken by gravity coring methods will require extrusion and sectioning on site because of the high water content and likelihood of physical disturbance during handling and transport
- Vertical core extrusion and sectioning requires:
 - the core be maintained in a vertical position,
 - advancing the core material through the core tube so that sections can be expelled, and
 - removal of the extruded sections that can be transferred to sample containers.



Types of extruders: Fixed interval extruder



- Mechanical operation
- Levelling adjustment
- For use with the K-B corer (9 cm ID)
- Fixed 1-cm sectioning intervals



High-resolution Glew extruder

- Mechanical operation with high reproducibility
- Section intervals are set by the operator
- For use with the Glew (or modified Glew) corers (2½" ID)



See Glew, 1988.





High-resolution hydraulic extruder

- Smooth operation with pressurized water to advance core
- Section intervals are defined by the operator
- For use with the TechOps corer (10 cm ID)



23





High-resolution hydraulic extruder





Practical considerations for gravity coring and extrusion methods

- Goals of the aquatic sediment study
- Analytical techniques required; analytes of interest
- Amount of sediment required per interval
- Moisture content of the sediment
- Depth of core required; sedimentation rate
- Sediment type
- Field logistics
- Adaptability of the equipment
- Preservation of the sediment-water interface
- Skill and experience of the operator

25





References

- Glew, J.R. 1988. A portable extruding device for close interval sectioning of unconsolidated core samples. *J. Paleolimnology* 1: 235-239.
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- Mudroch, A. and MacKnight, S.D. 1991. Bottom sediment sampling. pp. 29-95. In: A. Mudroch and S.D. MacKnight [Editors] *CRC Handbook of Techniques for Aquatic Sediments Sampling*. CRC Press, Boca Raton, Florida.





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A Universal Percussion Corer for Sampling Lake Sediments

Jocelyne C. Bourgeois, Konrad Gajewski
and Michael N. Demuth

1



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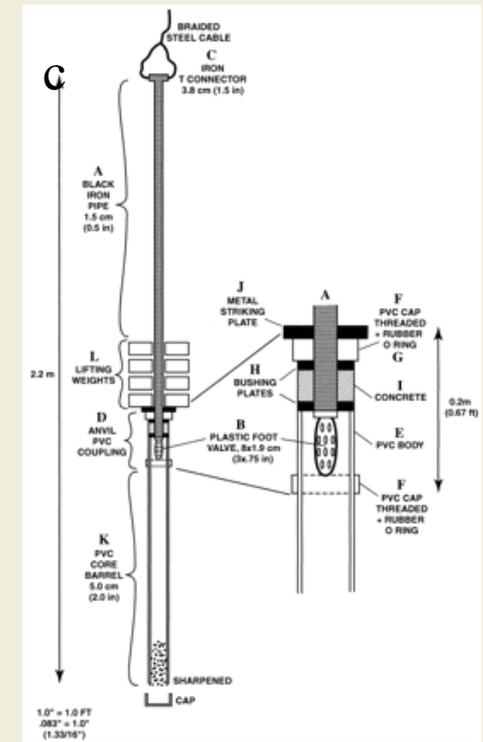
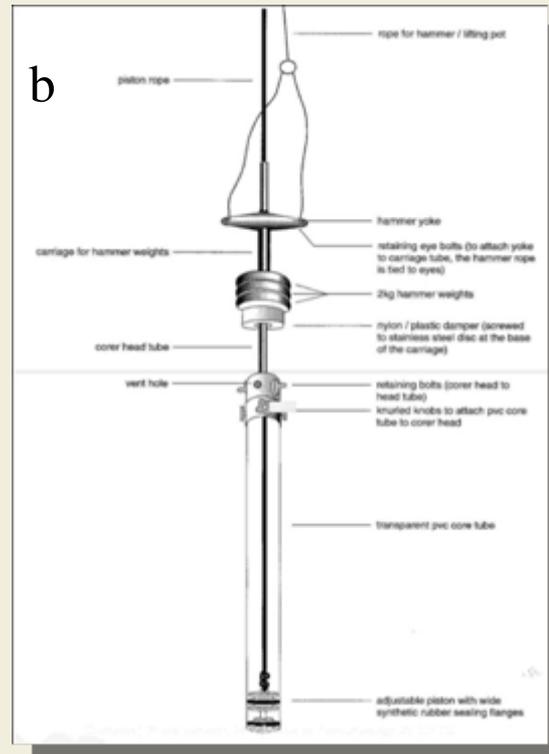
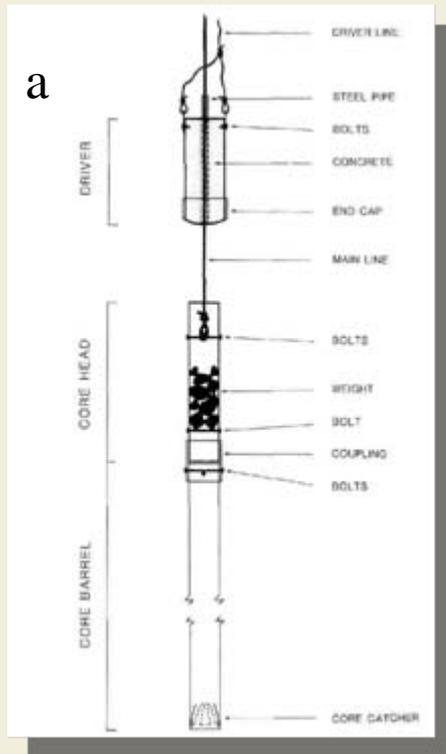
Percussion coring in lake sediments

- Percussion coring systems rely on a moveable weight to push a core barrel into a sediment.
- The corer can be attached to a cable and lowered through the water column until it reaches the sediment. A secondary line is then used to raise and drop the driver on top of the core barrel.
- These systems are, in principle, unrestrained by water depth (they do not require metal rods). However, depth is a constraint for those systems that require a scuba diver.
- Percussion coring systems variably use pistons, core catchers or a one-way check valve to retain the core.
- They are single drive corers and are therefore, limited by the length of the core barrel.





Schematics of rope-operated percussion corers



a. Reasoner (1986); b. Chambers and Cameron (2001); c. Cawley and Parker (2001).



Universal percussion coring system

- The Universal percussion corer is a relatively simple system used to recover sediment cores from the water-sediment interface. It is lightweight and relatively inexpensive (less than \$1,000).
- It consists of three major components: the Universal core head, the core barrel, and the slide hammer (used with or without bronze gravity weights).
- Like other percussion coring system, it can be deployed using ropes. Two lines are used: one to raise and lower the corer and the other to operate the slide hammer.
- The corer can be lowered from a stable platform (ice) or an anchored platform (boats).

4





Major components

- **Universal core head:** can be used with a “T” handle (for shallow marsh or wetlands), aluminum extension rods (up to 15 m), or with ropes in deeper water.
- The core head has a one-way check valve that permits the core barrel to free flush during deployment and also allows it to retain the core sample without using core catchers.



Universal core head
(Aquatic Research Instruments)



Major components (cont.)

- Thin-walled, clear, **polycarbonate core barrels:** usually come in two lengths: 120 cm or 240 cm (x 68 mm x 71 mm). These are readily available from plastic distributors. They can be easily drilled, cut or split.
- **Slide hammer assembly:** can be used with bronze gravity weights.



Universal core head kit (Watermark)



Slide hammer (Aquatic Research Instruments)



Major components (cont.)

- Optional **incremental core extruding apparatus**: allows one to gradually extrude sediments in 0.5 or 1.0 cm increments. When the bottom plug is in place, the barrel can be attached directly to the extruding apparatus.





Core retrieval and sample extraction



Cumming et al. (2009)

www.env.gov.bc.ca/epd/regions/okanagan/waterqual/pdf/osoyoos-paleo-2009.pdf





Some advantages, disadvantages, and other considerations

- Ideal for working in remote areas where weight is a constraint.
- Is easily assembled, lightweight, and inexpensive.
- The corer / slide hammer can be lifted to the surface by hand, from small inflatable boats, by two persons.
- In deep water and for the retrieval of longer cores, a pulley system and a more stable platform, such as ice, is recommended.
- The use of high quality ropes is important to prevent stretching or excessive twist and kinks.
- In deeper lakes, the tangling of the two operating ropes can be problematic.





Some advantages, disadvantages, and other considerations (cont.)

- If care is taken at the initial stage, it is possible to recover, intact, a sample at the sediment water interface.
- The clear core barrels allow visual examination of the core before extrusion.
- The length of the sediment record is limited by the length of core barrel.
- The bottom of the core tube must be plugged before breaking the air-water interface (with core extruding plug or poly end cap) to prevent loss of sample.
- Caution must be exercised with the slide hammer / bronze gravity weight when bringing the coring system to the surface if injury is to be avoided.

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Experience with the Universal Percussion Corer at the GSC/NCD

- Two Universal percussion coring systems were bought in 2010.
- One corer was tested in southern Chile in February 2010 during a collaborative research project to study recent glacier fluctuations in the region.
- The field trip included Canadian, Chilean, and American scientists but only two participants were involved in the paleolimnology study.





Experience with the Universal Percussion Corer at the GSC/NCD (cont.)

- Due to the complicated logistics, it was essential that the coring equipment be lightweight, easy to assemble and easy to operate from two small inflatable boats.
- The lakes we were able to access, near the Jorge Montt Glacier, proved to be quite young and we were only able to extract short sediment cores from 5 m deep lakes. We also used the Universal core head with the “T” handle to recover a short core from a shallow marsh.
- We found the coring system to perform well in the field but its full potential could not be properly assessed due to various particulars of the expedition.





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Cumming, B.F., Gregory-Eaves, I., Jensen, V., Laird, K., Simpson, K., Sokal, M., Walker, I.R. (2009). Osoyoos Lake Sediment Core Project – Final Report. Final Report to the Okanagan Basin Water Board, 44p.

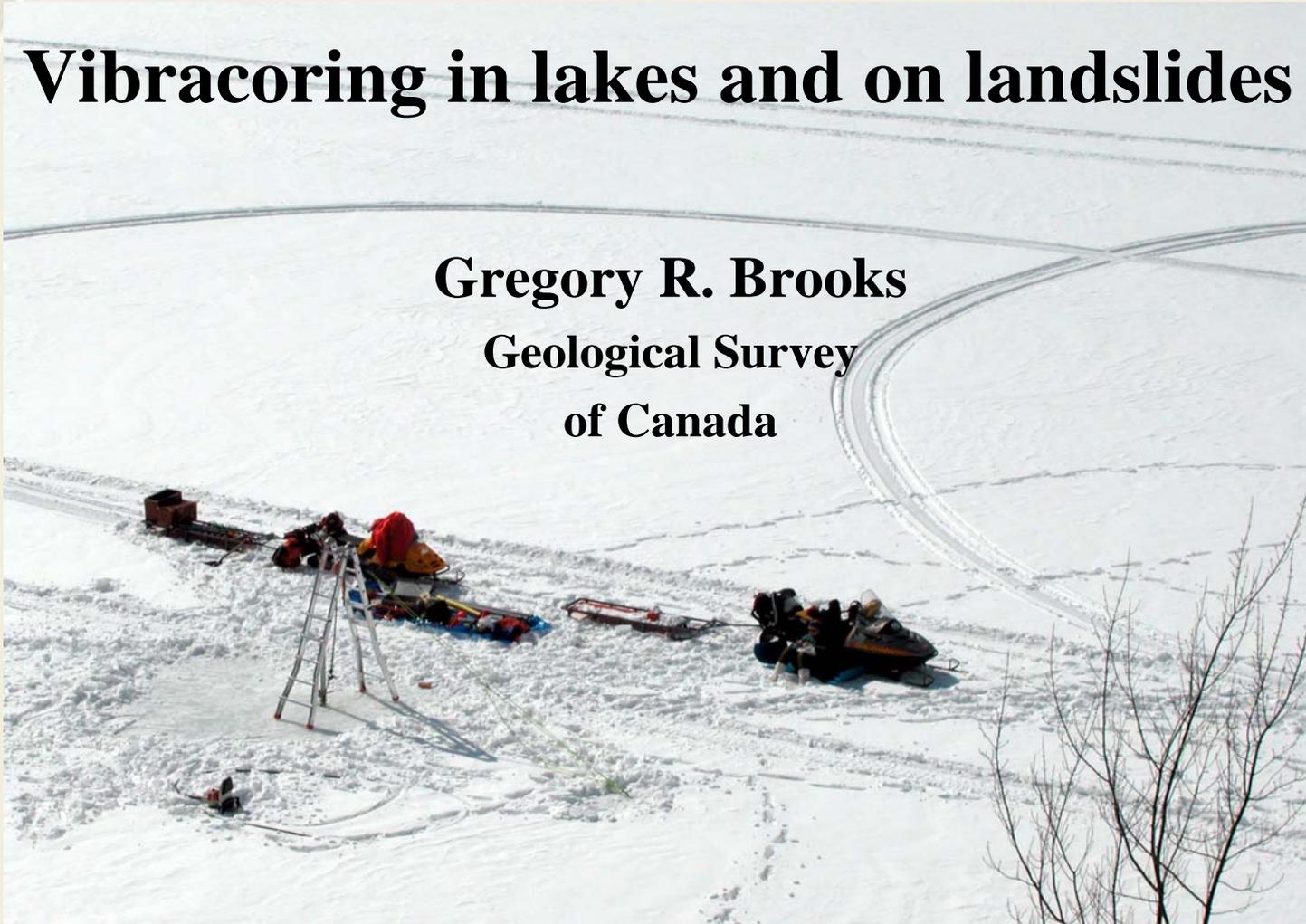
Resoner, M.A. (1986). An inexpensive, lightweight percussion core sampling system. *Géographie physique et Quaternaire*, 40, 217-219.





Vibracoring in lakes and on landslides

Gregory R. Brooks
Geological Survey
of Canada





Basic principles

- Vibrating core barrel liquefies immediately surrounding sediment
- Core barrel sinks into the sediment column





Basic principle

- Vibrating core barrel liquefies immediately surrounding sediment
- Core barrel sinks into and around the underlying sediment column





My applications

- Investigation of Holocene lake basin deposits along the North Bay outlet of the upper Great Lakes (Climate Change Program)
- Dating prehistoric Leda clay landslide deposits in National Capital Area (Public Safety Geoscience Program)





Applications by others

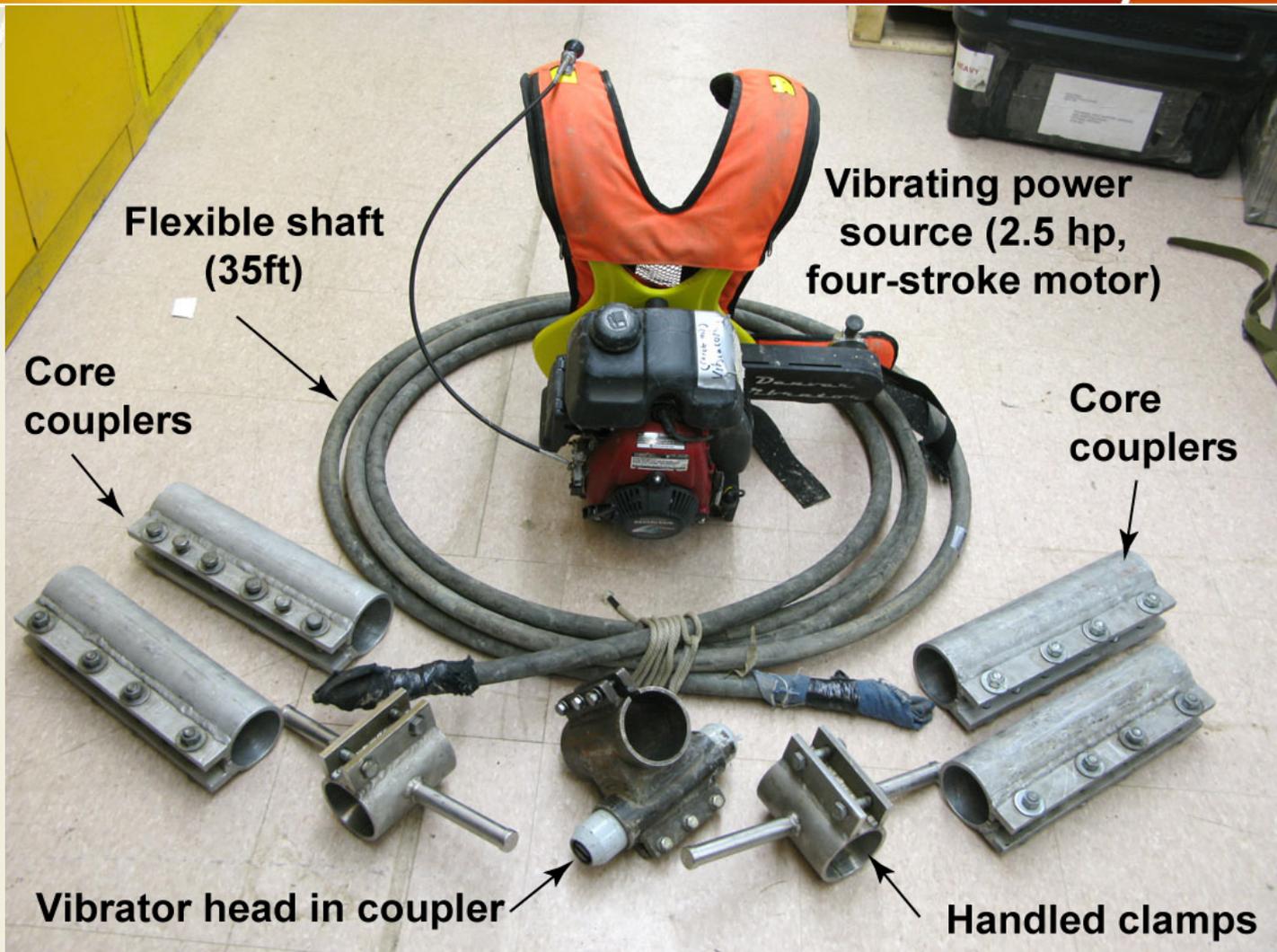
Includes:

- Floodplain deposits
- Deltaic deposits
- Beaches
- etc.





Basic equipment





Core barrels

- 8 ft long aluminum irrigation pipe
- 3 inch OD
- 0.0625 inch (1/16 inch) side wall
- Length limited by shipping and transporting constraints





Lengthening the core barrel

- Core couplers





Core catcher





All set up
and ready to
GO!



10



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OK - Now what?





Hoist core barrel

- Shallow core (less than ~ 2 m)
- Muscle power!





Hoist core barrel

- 'Jaws' collapsible ladder as a winching frame





Core preparation

- Disassemble couplers
- Cut core barrel into manageable lengths (1-1.3 m long)
- Cap and tape ends



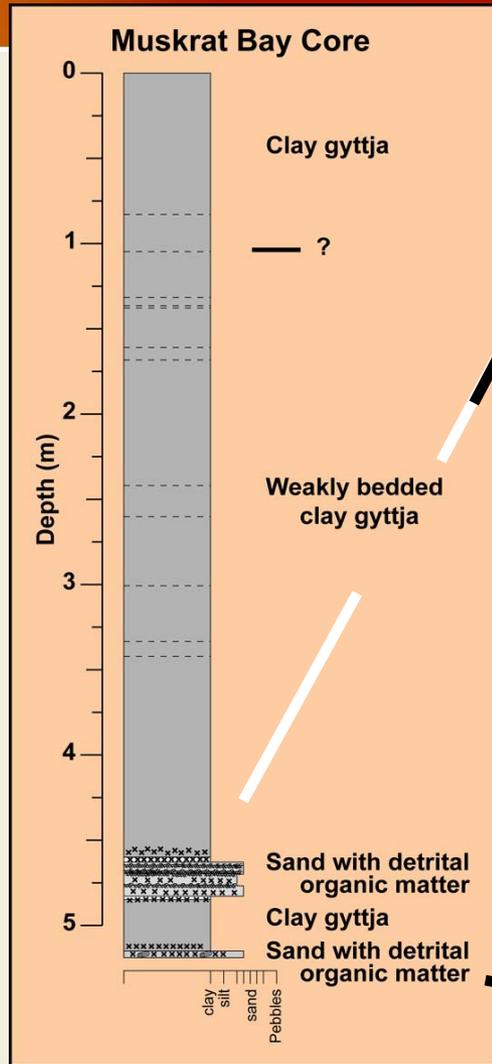


Laboratory work





Muskrat Bay, French River





Portability

Snowmobiles



ATV





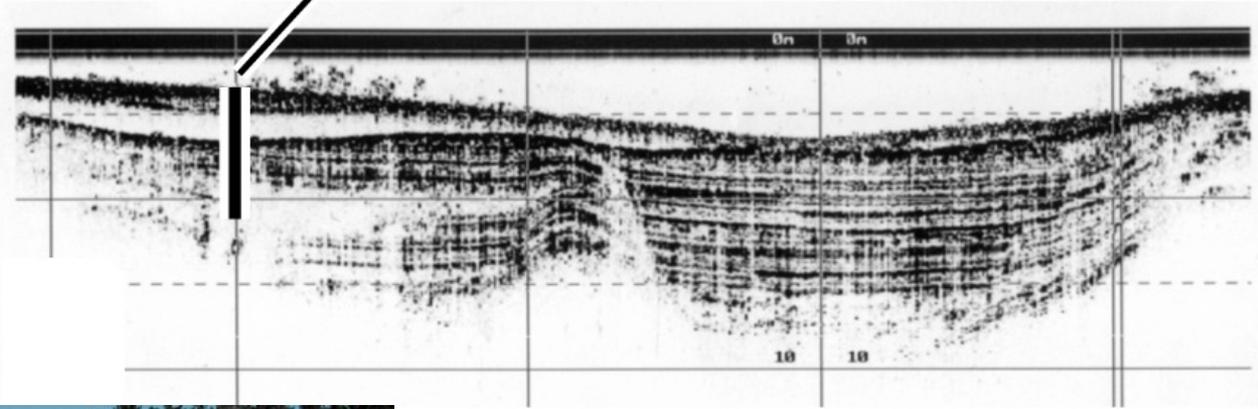
Sub-bottom profiling data

Allen Lake Profile 3

W

Core ALX1

E





Coring on ice

- 6 inch hand
- ice auger





Disadvantages

- Can't inspect collected sediments until core barrel is split
- Lakes - limited to shallow water (<5 m depth) by length of core barrel
- Well-sorted, coarse sand can fall out of the bottom of the core barrel
 - Core recovery as low as 20% (by far the worst)
- Penetration inhibited by coarse gravel, boulders, 'sound' wood and stiff sediment (clay, diamicton)
- Sediment-water interface will be disturbed





Advantages

- Yields a continuous core up to 5.5 m long
- High recovery rates in poorly-sorted or cohesive sediments
 - 88 to 94% typical in French River work
- Light-weight, relatively compact
- Two-person operation
- Ideal for saturated sand, silt and soft clay deposits
- Some penetration of stiffer clays possible (with muscle power)



For additional information see:

Lanesky, D.E., Logan, B.W., Brown, R.G., and Hine, A.C., 1979, A new approach to portable vibracoring underwater and on land: *Journal of Sedimentary Petrology*, v. 49, p. 654-657.

Smith, D.G., 1984, Vibracoring fluvial and deltaic sediments: tips on improving penetration and recovery: *Journal of Sedimentary Petrology*, v. 54, p. 660-663.

Smith, D.G., 1987, A mini-vibracoring system: *Journal of Sedimentary Petrology*, v. 57, p. 757-794.

Smith, D.G., 1992, Vibracoring: recent innovations: *Journal of Paleolimnology*, v. 7, p. 137-143.

Thompson, T.A., Miller, C.S., Doss, P.K., Thompson, L.D.P., and Baedke, S.J., 1991, Land-based vibracoring and vibracoring analysis: tips, tricks, and traps., Indiana Department of Natural Resources, Geological Survey, Occasional Paper 58, p. 13.





Acknowledgements

- Barbara Medioli
- Rick McNeil





Aquatic soft sediment sampling methods: Freeze Coring and Grab/hand coring

Paul Gammon, Sam Alpay





Introduction

Freeze Coring

- Methodology
- Deployment
- Retrieval
- Analysis

Grab/Hand coring

Other

- vibracoring/piston coring





Freeze Coring

Methodology

Dry ice/alcohol slurry freezes sediment onto metal plate





Freeze Coring

Deployment

Uses a tripod-winch assembly with rods for fixed time





Freeze Coring

Retrieval

Release the core and cut into sections

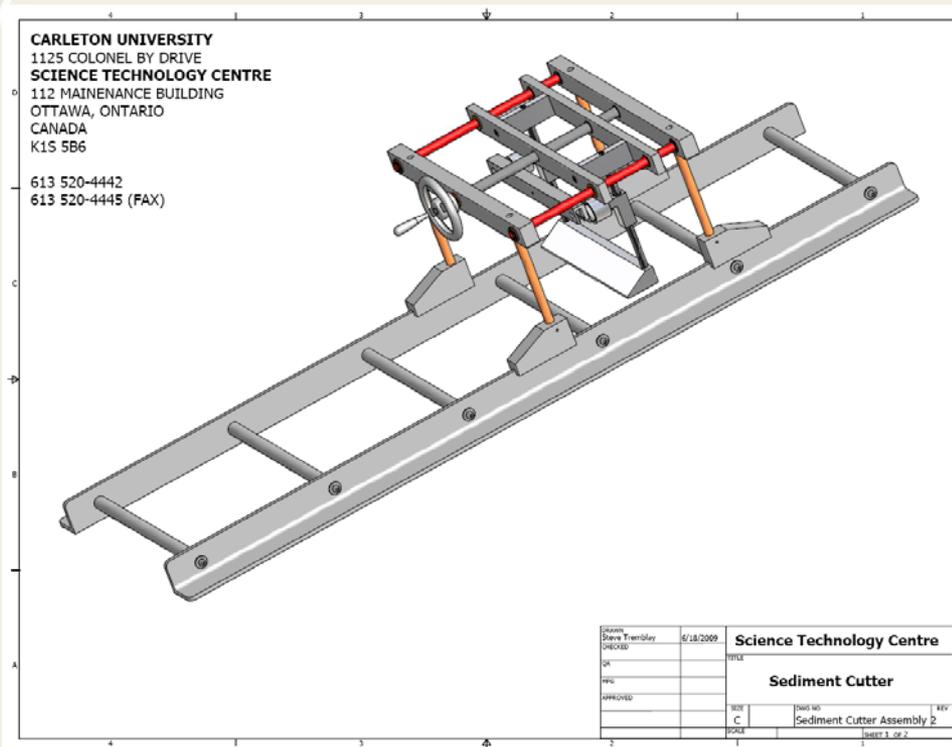
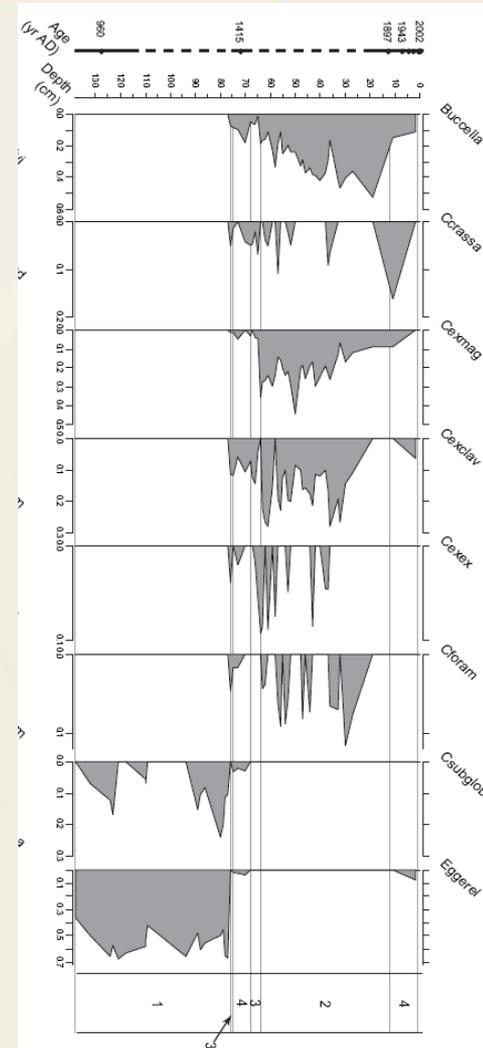




Freeze Coring

Analysis

Depends on needs
Microtome at millimetre scale





Freeze Coring

Strengths

- High resolution
- Low disturbance
- Complete core
- Shape immaterial
- Sed/H₂O interface
- Multiple platforms

Weaknesses

- Logistically difficult
- Needs freezers
- <2-3 m
- Hard sediment
- Safety
- Requires winch





Grab/Hand Coring

Deployment

Uses either line, tripod or rods

Works in either hard or soft substrates





Grab/Hand Coring

Deployment/retrieval/analysis

Uses either line, tripod or rods





Remote Platform

Catarrafts

1600 lbs lift from 96 lbs weight

Easily modified to suit many different coring uses

Collapsible frame and air inflated tubes - small





Livingstone Coring

A. Grenier



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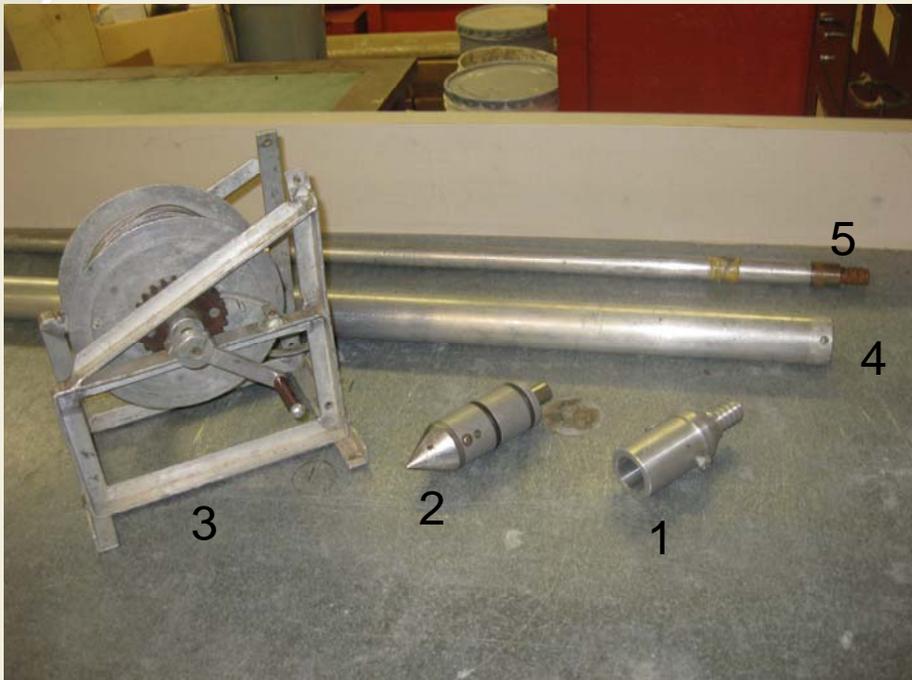
Canada 



- Developed in the mid 1950's
- Used mainly for sampling in shallow water basins such as lakes and ponds
- Light weight sampler
- Allows recovery of a long stratigraphic sequence



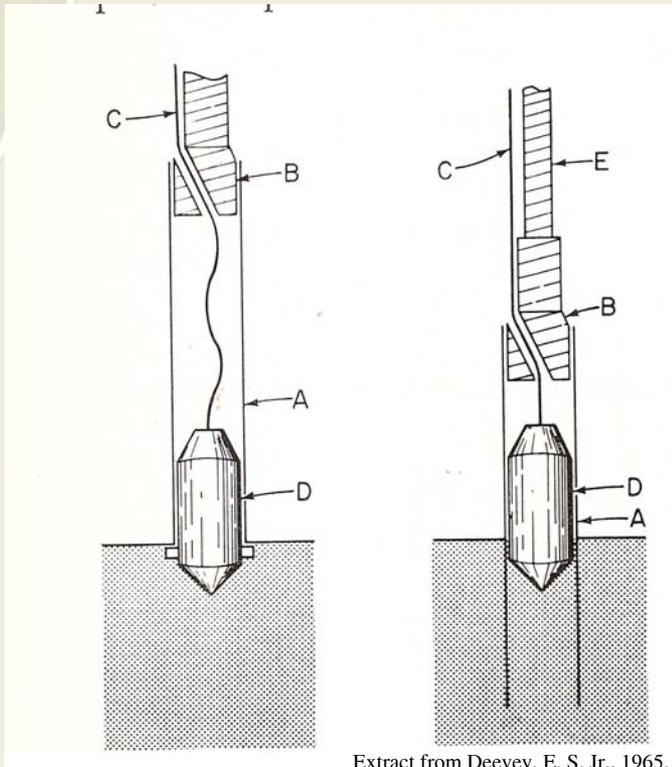
This is the Livingston Corer...



1. Sample tube adapter
2. Piston
3. Piston wire
4. Sample tube
5. Rod



How does it work?



- Piston is locked at bottom of core barrel.
- Sampler is pushed to the desired start depth.
- Piston cable is held firmly.
- Sampler is pushed down while the piston remains at the start depth.



Advantages

- Locked piston prevents any contaminants from entering the tube.
- No airlock is created when penetrating sediments
- Piston creates suction that helps retain sediment when extracting the core
- Can recover long sediment sequences
- Portability and easy to use
- Two operators are sufficient.





Disadvantages

- Can be limited by water depth.
- Non-continuous core.
- Potential for contamination between two drives.
- Cannot penetrate sand, other coarse sediments, and large organic matter.



Sampling in the winter

Advantages

- Very stable platform
- Lots of space for the equipment
- Ease of access with a snowmobile
- Possibility for larger crew





Sampling in the winter

Disadvantages



- Equipment and sample prone to freezing
- Lake bottom profile needs to be done ahead of time
- Possibility of cold / wet conditions for the operators



Sampling in the summer



Photograph by R.J. Mott

Advantages

- Can use a depth finder for site selection.
- Easy to wash out the mud from the equipment.
- Warm conditions.





Sampling in the summer

Disadvantages

- Limited workspace
- Stable anchoring may be a problem
- Winds can cause platform to shift
- Can lose equipment overboard



Photograph by R.J. Mott



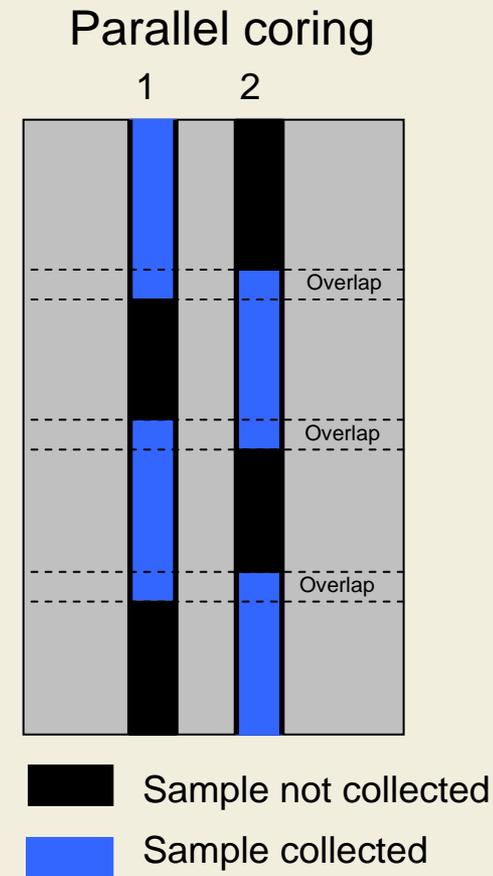
Core handling

- Cap the bottom of the core barrel before pulling it out of water.
- Excess water from the top must be drained
- Spacers are added to the top and the caps sealed.
- Cores should be stored upright if possible.



Coring strategy

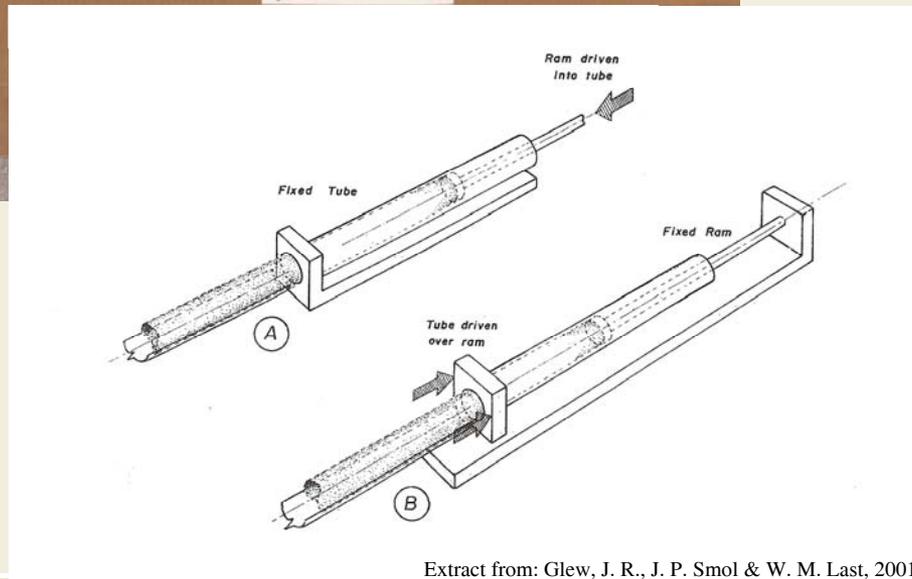
- Parallel coring in two holes with overlapping of core intervals.
- Record start coring depth and the end point of coring depth.





Core extraction

Photograph by R.J. Mott



Extract from: Glew, J. R., J. P. Smol & W. M. Last, 2001

- A. Sample tube is fixed and a rod pushes the sample out.
- B. The rod is fixed and the sample tube slides towards the rod.



Specifics to GSC Livingstone Corer

- 2 sizes of core barrel (2 and 3 inch).
- Sediment core recovery of 3 ft to 6.5 ft long.
- Can be adapted to a clear plastic core barrel.





Summary

- Light weight piston corer used in shallow water
- Portable and easy to use.
- Allows recovery of long sediment sequence.
- Can be used all year round.
- Cores are easily extracted and the core barrel can be re-used.





Acknowledgements

- Martin McCurdy
- Greg Brooks





Additional information

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Questions?





PEAT CORING AND SAMPLING TECHNIQUES USED AT GEOLOGICAL SURVEY OF CANADA (1993-2003)

Inez M. Kettles

Retired, Geological Survey of Canada



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Peatland Distribution

- Peatlands are wetlands with organic matter accumulations of at least 40 cm in thickness (National Wetlands Working Group, 1988).
- Peatlands cover nearly 12% of the Canada landmass (Tarnocai, et al., 2000).
- $1056 \times 10^3 \text{ km}^2$ is the total peatland area in Canada
- $544 \times 10^3 \text{ km}^2$ is the total area of France!!!
- Most peatlands are bogs or fens. However, in places, swamps and marshes have sufficient organic matter accumulation to be classed as peatlands.
- The common average maximum thickness of peat in Canada ranges between 2 and 7 m (Martini and Gooschenko, 1985).





Bog





Fen





Swamp and Marsh



Swamp

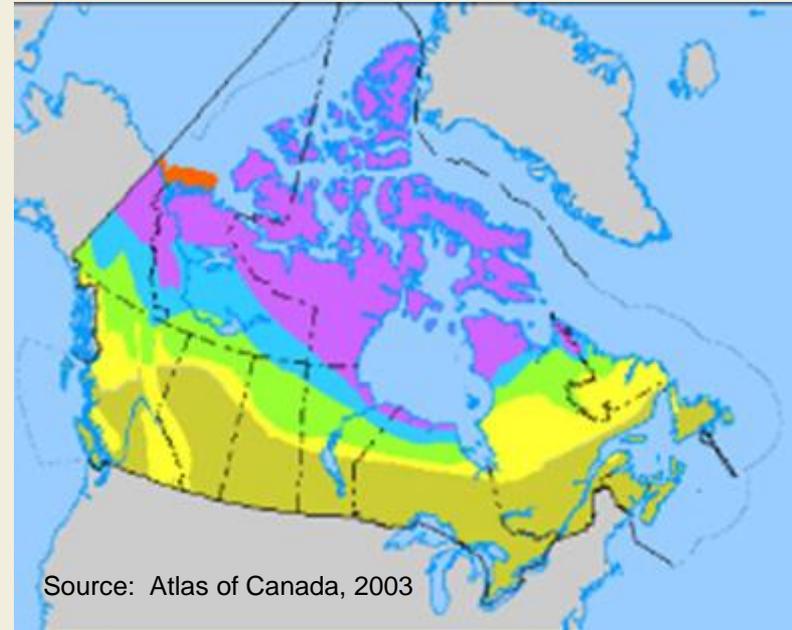
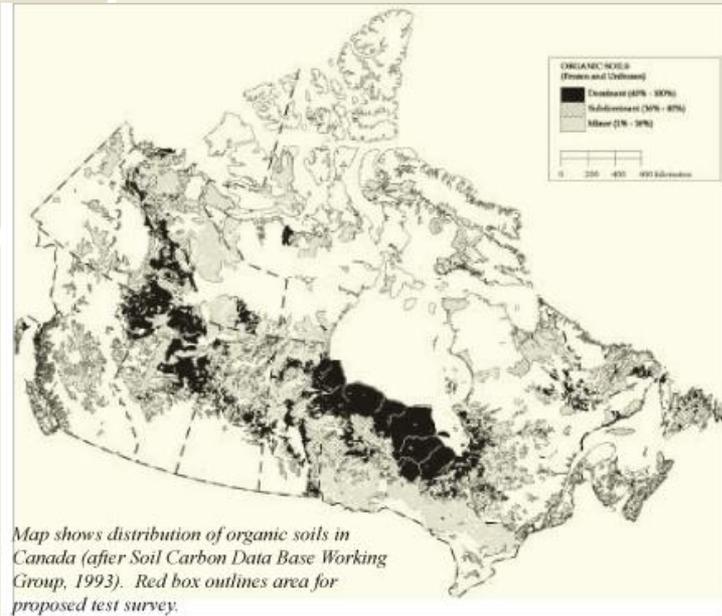


Marsh





Peatlands and Permafrost



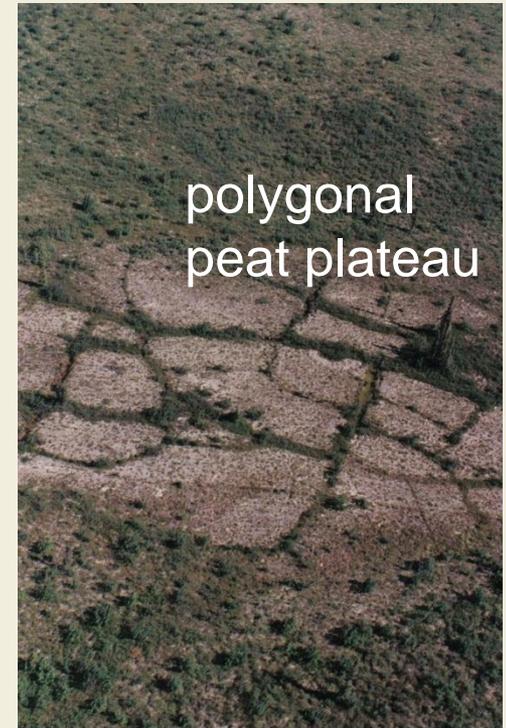
There are strong interrelationships between the distributions of peatlands and permafrost because of the insulating properties of peat and the poor drainage conditions in peatlands (Zoltai, 1988).

- No Permafrost
- Subsea Permafrost
- Isolated Patches (0-10%)
- Sporadic Discontinuous (10-50%)
- Extensive Discontinuous (50-90%)
- Continuous (90-100%)





Peatlands and Permafrost



Permafrost-bearing peatland forms

For more information on peatland landforms, see Zoltai et al. (1988) and Tarnocai and Zoltai (1988).



Testing a Potential Coring Site

A soil probe with sufficient extensions was used to test the depth and character of peat deposits prior to coring.

In peat plateau (frozen bog), it was possible to estimate the depth of peat accumulation by probing the adjacent unfrozen fen, where present.



Probing a fen near Noranda, Quebec.



CRREL Coring in Frozen Peat

Produces frozen undisturbed cores in segments of around 10 to 20 cm in length.



- Device is based on a CRREL design (Cold Regions Research and Engineering Laboratory).
- It was used and modified at GSC by W. Blake, J. Veillette, and M. Nixon in the 1960s and 1970s.

Coring polygonal peat plateau on the Horn Plateau, Northwest Territories.



CRREL Coring in Frozen Peat

- CRREL system is relatively portable
- Produces high quality frozen cores
- Heavy work for 2 or more people
- Potential for problems with the cutting head freezing into the hole.



CRREL coring near Antoine Lake, Northwest Territories.



CRREL Core Segment



Segment from CRREL coring collected from polygonal peat plateau on the Horne Plateau, Northwest Territories. Core is measured in cm.



CRREL Coring Kit



- 1 T-bar handle
- 2 Tool box
- 3 Barrel head for 3 in (7.62 cm) core barrel
- 4 Extension rod, 18 in (45.72 cm) long
- 5 Tool kit:
 - Screwdriver, flat tip
 - Pliers, long nose
 - Pliers, side cutter
 - Hammer
 - Allen keys
 - Magnet
- 6 Core barrel, 3 in (7.62 cm)
- 7 Core barrel, 2 in (5.08 cm)
- 8 Core catcher for 3 in (7.62 cm) core barrel
- 9 Core catcher for 2 in (5.08 cm) core barrel
- 10 Barrel head for 2 in (5.08 cm) core barrel
- 11 Adapter for Stihl power head
- 12 Auger, spiral, 2 in (5.08 cm) diameter x 18 in (45.72 cm) long
- 13 Extension rods, 36 in (91.44 cm) long

Also needed:

- Toggle pins, 3 in (7.62 cm) long
- Extension pins (Clevis)
- Metal clips (hitch pin style)
- Drive pins, 3 3/8 in (8.6 cm) long for 2 in (5.08 cm) core barrel
- Cutters for 2 in (5.08 cm) core barrel
- Cutters for 3 in (7.62 cm) core barrel
- Roll pins (spring tension) 1/8 in (0.32 cm) x 1/2 in (1.27 cm)
- Socket cap screw, 1/4 in (0.64 cm) x 1/2 in (1.27 cm)
- Drive pins 4 1/4 in (10.8 cm) long for 3 in (7.62 cm) core barrel

Source of photo and information: Natural Resources Canada - Technical Field Support Services Catalogue



Further Information on the CRREL System

- System used at Geological Survey of Canada
Veillette, J.J., and Nixon, F.M., 1980. Portable drilling equipment for shallow permafrost sampling. Geological Survey of Canada Paper 79-21. 35 p.
- Description of an updated device modified from GSC design
Nornberg, T., Goodsite, M.E., and Shotyk, W., 2004. An improved motorized corer and sample processing system for frozen peat; Arctic, v. 57, p. 242-248.





Coring in Unfrozen Peatlands

Methodologies used for coring and collecting samples from unfrozen peatlands varied depending on the purpose of the research and the depth of sampling required.



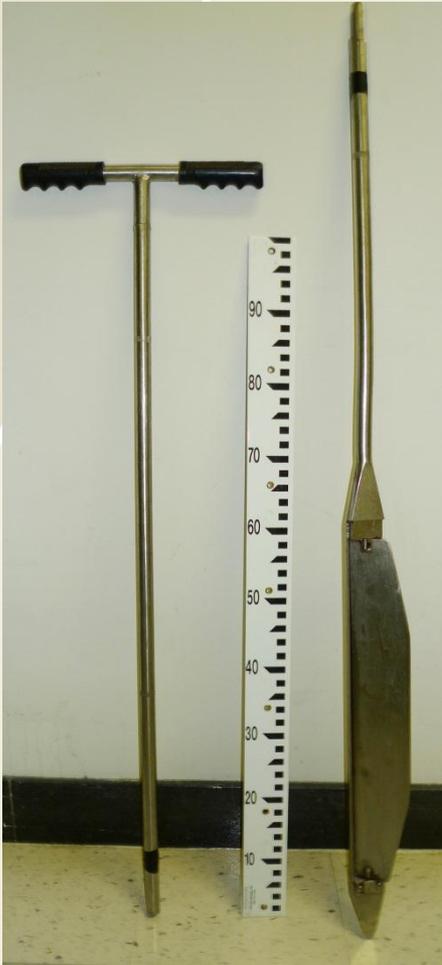
*Coring permafrost-free bog
in the Noranda region, Quebec.*

14





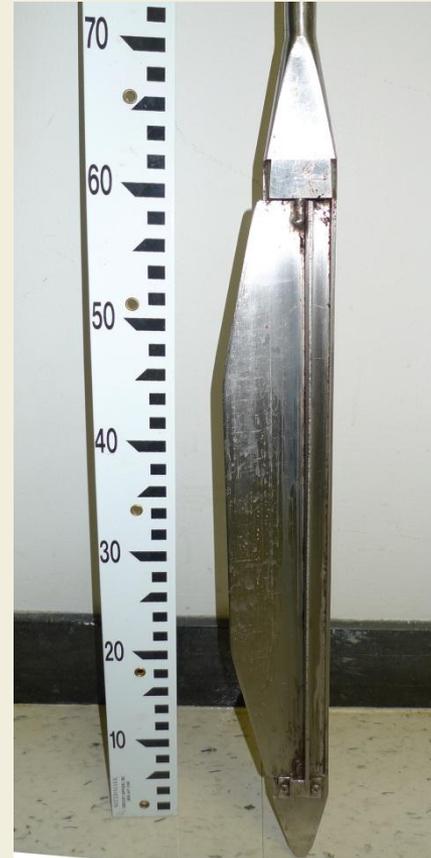
Macaulay Corer



The Macaulay corer, also referred to as the modified Russian borer, is used to core unfrozen peat below depths of around 0.5 m from the surface.

Continuous cores are collected in 50 cm long segments. Segments are semi-circular in shape with diameters of 4.5 cm. Extension rods (1 m long) are flush mounted.

This type of corer is available commercially but the device shown was custom-made for GSC.



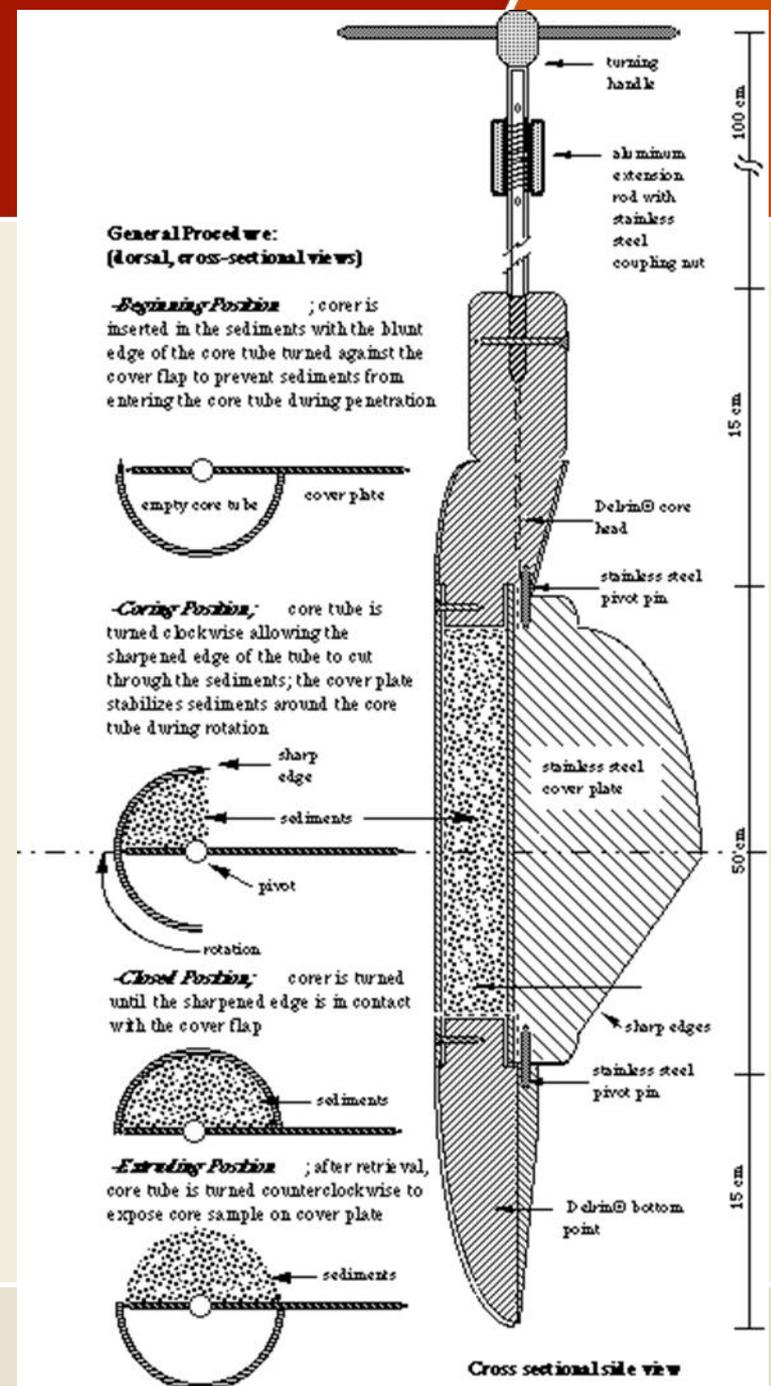
Blade in sampler is shown in starting and mid-point positions.



Macaulay Corer

Diagram shows the construction and operation of a Macaulay-style corer.

Source of diagram:
http://www.aquaticresearch.com/russian_peat_borer.htm





Macaulay Corer

- A continuous core is collected in 50 cm segments to the target depth or the contact with mineral sediment.
- The point at the end of the device is pushed to the desired depth, with the chamber being closed and empty. The T-bar handle is turned clockwise to start cutting the sample. The pivotal cover plate supports the cutting action of the sampler. As the device is turned 180 degrees, the edge of the bore longitudinally cuts a semi-cylindrical shaped sample until the opposite side of the cover plate is contacted.
- The contained sample is recovered without risk of contamination by overlying materials. The sample is extruded from the bore by a counterclockwise rotation where, at the end, the sample rests on cover plate ready for sectioning. Core segments are wrapped in plastic wrap and then rolled in aluminum foil, with segment tops and bottoms clearly labelled on the inside of the foil.
- To collect enough material to meet the analytical needs of the project, it is often necessary to collect cores from multiple holes in the vicinity of the first one.

Peatland in James Bay Lowlands





Macaulay Corer



Macaulay core collected to mineral sediment near Detour Lake in northern Ontario.

The core segments were wrapped first in plastic and then in aluminum foil. The sample number, top and bottom of core segment and the depth measurement of the segment were carefully marked on the inside of the aluminum foil prior to wrapping.

18





Macaulay Corer

- Very portable
- Fairly easy to use and effective below depths of 0.5 to 1.0 m from the surface
- Collects a relatively undisturbed sample
- After 1 or 2 extension rods are added, two or more people were needed to pull the sampler up to the surface.

Further Information

Jowsey, P.C., 1966. An improved peat sampler; *New Phytologist*, v. 65, p. 245-248.





Sampling at the Surface of the Peatland

- Neither the CRREL nor the Macaulay systems work for collecting peat at or near the surface of the peatland.
- Methodology used for collecting surface cores and samples varied depending on the goals of the research project.





Wardenaar-style Corer



- Wardenaar-style corer is portable.
- Used for the uppermost 90 cm of peat
- The two-piece corer is pushed down into the peat deposit using a see-sawing motion.
- Corer has sharp edge at its base for cutting.
- Produces a square-shaped core.

*Sampling at Kinosheo Lake
in Northern Ontario.*

21





Wardenaar-style Corer



Corer is available commercially but one shown above was custom-made for GSC.

Reference: Wardenaar, E.P.C. (1987)





Coûteaux Corer

- Collaborative project was undertaken in James Bay Lowlands with Dr. Michelle Garneau at UQAM; corer is not owned by GSC.
- Used for the uppermost 2 m of peat materials
- Core has a diameter of 10 cm.
- Produces a mostly undisturbed core
- Relatively portable (pulled on a child's sleigh)
- Heavy work





Coûteaux Corer

Further Information

Couteaux, M., 1962. Notes sur le prélèvement et la préparation de certains sédiments; Pollen et Spores, v. 4, p 317-322.



24

Reference unknown at present



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Handcut Surface Blocks

- It is often practical to carefully cut out blocks of surface peat by hand; this method is effective above the water table in unfrozen peatlands and above the permafrost in frozen peatlands.





Coring Peat Hummocks

- High vertical accumulation rates and low decomposition rates occur in peat hummocks compared to hollows (flat part of peatland).
- The analysis of profile samples collected from hummocks resulted in a more highly resolved near-surface geochemical record .





Coring Peat Hummocks

- Prior to carrying out profile sampling on a hummock, a core of material, as intact as possible, was carefully collected for reference purposes, as follows.
- A square-shaped PVC tube was prepared prior to sampling by cutting off, but retaining, one side of the tubing.
- The selected peat hummock was cut open using a large knife, small garden clippers and scissors, as needed, and a face prepared for sampling.
- The PVC tube was trimmed to an appropriate length and placed at the hummock face. A column of peat, the size and shape of the PVC tube, was cut out, face by face, and the tube placed around it.
- Once the cored material was inside the tube, the retained side was taped back on and the ends taped to enclose the cored materials. The tube was wrapped in heavy plastic and taped again.





Sampling Peat Hummocks

- Profile samples were also hand cut from peat hummocks.
- After the hummock was opened and a face prepared for sampling, bread-size slices were cut as thinly as possible (1-3 cm) in sequence down the hummock face.
- The length, width, and height of each slice were measured and recorded, to be used later for bulk density determinations.
- Samples were then stored in well-sealed zip-lock plastic bags.

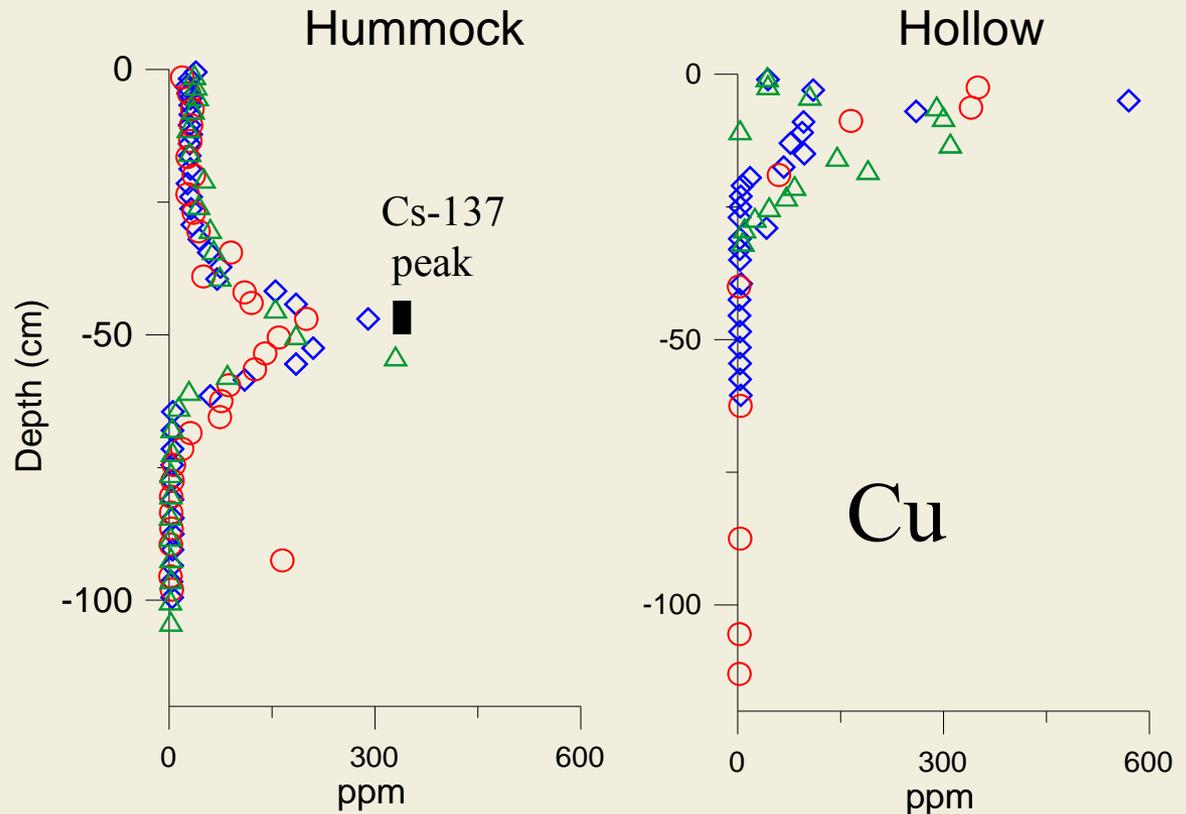


Sampling Peat Hummocks and Hollows



Geochemical profiles show the distribution of Cu in peat samples from a hummock and nearby hollow (flat part of the bog).

Samples were hand cut as slices, as described in the previous slide. Three sets were collected from the same large hummock and two sets from the adjacent hollow. A third set in the hollow was obtained by cutting out blocks at the surface and using the Macaulay corer at depth. Each set is represented by a different symbol.



•Site was located 10 km northwest of the Horne Cu-Zn smelter, Noranda, Quebec (Kettles, 2005; Kettles and Bonham-Carter, 2005).





Selected GSC Contributions Based on Peat Coring (1993-2003)

- Kettles, I.M., 2005. Metal distribution in peat hummocks and hollows within 100 km of the copper smelter, Rouyn-Noranda, Quebec; in, Metals in the environment around smelters at Rouyn-Noranda, Quebec, and Belledune, New Brunswick: Results and conclusions of the GSC MITE Point Sources Project; (ed.) Bonham-Carter, G F.; Geological Survey of Canada, Bulletin 584, 25 pages.
- Kettles, I.M., Robinson, S.D., Bastien, D.-F., Garneau, M., and Hall, G.E.M., 2003. Physical, geochemical, macrofossil and ground penetrating radar information on fourteen permafrost-affected peatlands in the Mackenzie Valley, Northwest Territories; Geological Survey of Canada, Open File 4007, 1 CD-ROM.
- Bell, K. and Kettles, I.M. , 2003. Pb isotope ratio measurements of hummock and hollow peat from Detour Lake area, Ontario Canada; Geological Survey of Canada, Current Research, Winter Release, digital format.
- Kettles, I.M. and Bonham-Carter, G.F., 2002. Modelling dispersal of metals from a Cu-Zn smelter at Rouyn-Noranda (Quebec, Canada) using peatland data; Geochemistry: Exploration, Environment, Analysis, v. 2, p. 99-110.
- Garneau, M., Bernier, M., Warner, B.G., Menard, E., Gauthier, Y., Kettles, I., Boruque, A., Lam, K.-H., and Paradis, S., 2001. Project A279 – Evaluation de l’impact du changement climatique sur les ecosystems tourbeux du Quebec septentrional; INRS-Eau, Rapport Final, no. R-594 (ISBN: 2-89416-451-6)
- Kettles, I.M., Garneau, M., and Jetté, H., 2000. Macrofossil, pollen and geochemical records of peatlands in the Kinosheo Lake and Detour Lake areas, northern Ontario; Geological Survey of Canada, Bulletin 564, 24 p.
- Turner, L.J. and Kettles, I.M., 2000. Data for ^{210}Pb dating of four peat cores from the vicinity of Detour Lake and Kinosheo Lake, Ontario, and Fort Simpson, Northwest Territories; Geological Survey of Canada, Open File 3858, 78 p.





Other References Cited

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- Martini, I.P. and Glosschenko, W.A., 1987. Cold climate peat formation in Canada, and its relevance to Lower Permian coal measures of Australia; *Earth Science Review*, v. 22, p. 107-140.
- National Wetlands Working Group, 1988. Wetlands of Canada. Canada Committee on Ecological Land Classification, Environment Canada, Ecological Land Classification Series, No. 24, 254 p.
- Soil Carbon Database Working Group, 1993. Centre for Land and Biological Resources Research Branch, Agriculture Canada, Ottawa. CLBRR Contribution Number 92-179, 33 p.
- Tarnocai, C. and Zoltai, S.C., 1988. Wetlands of Arctic Canada; in *Wetlands of Canada*, (ed.) National Wetlands Working Group; Environment Canada, Ecological Land Classification Series, No. 24, p. 27-53.
- Tarnocai, C., Kettles, I.M., and Lacelle, B. , 2000: Peatlands of Canada. Geological Survey of Canada Open File 3484, Scale 1:6 500 000.
- Wardenaar, E.P.C., 1987. A new hand tool for cutting peat profiles. *Canadian Journal of Botany*, 65, p. 1772–1773.
- Zoltai, S., 1988. Wetland environments and classification; in *Wetlands of Canada*, (ed.) National Wetlands Working Group; Environment Canada, Ecological Land Classification Series, No. 24, p. 1-26.
- Zoltai, S.C., Wetlands of Subarctic Canada; in *Wetlands of Canada*, (ed.) National Wetlands Working Group; Environment Canada, Ecological Land Classification Series, No. 24, p. 55-96.





Acknowledgments

Thank you to the following:

- Dr. Michelle Garneau, University of Quebec at Montreal, for providing information and photos of the Couteaux corer.
- Jean Bisson, Dr. Stephen Robinson, and Steven Bauke for the hard work necessary to collect CRREL peat cores in the Mackenzie Valley and Mark Nixon for helpful advice when we were preparing for the field operation.
- Dr. Stephen Robinson, Steven Bauke, Jean Bisson, Ken Dion, Manfred Hebel, Leanne Fooks, Eric Menard (late), H. Ghedira, and Rick McNeil for Macaulay and hand coring and sampling for the projects in the Mackenzie Valley, Noranda region, Kinosheo and Detour lakes in northern Ontario, and the Mer Bleue.
- Dr. Greg Brooks for organizing the Coring Workshop at GSC (November 15, 2010).







Light-weight coring in permafrost at GSC – current activities

Wendy Sladen



W. Sladen



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Techniques

- Modified CRREL* coring
- Diamond coring

*Cold Regions Research and Engineering Laboratory

2



Coring Auger Kit –available at TFSS:



Modified
CRREL
coring



One-person power head



STIHL power heads available at TFSS

The Stinkie – frame mounted



Two-person power head





Our experience

- 1-person operation:
 - easily drilled 2m in unconsolidated sediments along Yukon coast
- 2-person operation:
 - easily reached 5m depth in relatively ice-rich silt and clay (time: 3hrs-1day)
 - 4m in palsas (ice-rich peat and mineral soil)
 - fast drilling in frozen sand
- Stinkie:
 - 7.5m in ice-rich silt and clay (time: 3-4 days)





Summary

Advantages

- Snow, ice, fine-grained organic and mineral soil
- High quality, continuous core
- Easily transportable (ski-doo, ATV, helicopter)
- Can be used in a variety of terrain types
- Minimal impact at the site
- Carbide teeth can easily be replaced when dull or broken
- Slow spindle speed allows reaction time when signs of jamming are apparent
- Safer, no kick back (Stinkie)
- Can be operated by 1-person (Stinkie)

Disadvantages

- Gravelly or stony material, unfrozen soils or soils with significant unfrozen water content
- Drilling can be slow: short length of core recoverable each trip down hole – usually 20-50% of barrel length – due to binding between outside of barrel and hole wall
- The 2-person operation can be dangerous, ie. kick backs due to jamming



Diamond coring – portable earth drill



Core barrel



Core catcher



Diamond impregnated teeth

S. Wolfe



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Winkie – frame mounted diamond drill



Ice-rich peat



Ice-rich mineral soil



Easily transportable





Our experience

- Portable earth drill (experience with U. Laval crew):
 - easily drilled 3.3m in ice-rich silts, clays, sands and gravels
- Winkie:
 - easily reached 1.5m depth in ice-rich peat and mineral soil without drilling fluid





Summary

Advantages

- Fine-grained soils with ice, sand, gravel and boulders to 20cm
- High-quality, continuous core
- Easily transportable (ATV, snow machine, helicopter)
- Wide range of terrain types
- Off the shelf equipment
- 2-3 people
- Fast

Disadvantages

- In pure ice, cores tend to break into smaller sections, slowing drilling
- In warmer permafrost (-2 to 0°C) cores tend to disintegrate due to uncemented sediment and frictional heat
- Ice content below saturation can lead to clogging and caving of hole



Helpful references

- Calmels, F., O. Gagnon, and M. Allard. 2005. A portable earth-drill system for permafrost studies. *Permafrost and Periglacial Processes*, vol. 16, p. 311-315.
- Nørnberg, T., M.E. Goodsite, and W. Shotyk. 2004. An improved motorized corer and sample processing system for frozen peat. *Arctic*, vol. 57, p. 242-246.
- Veillette, J. and F.M. Nixon. 1980. Portable drilling equipment for shallow permafrost sampling. GSC paper 79-2, 35p.





Development of light-weight permafrost coring equipment at GSC; a review

J. Veillette



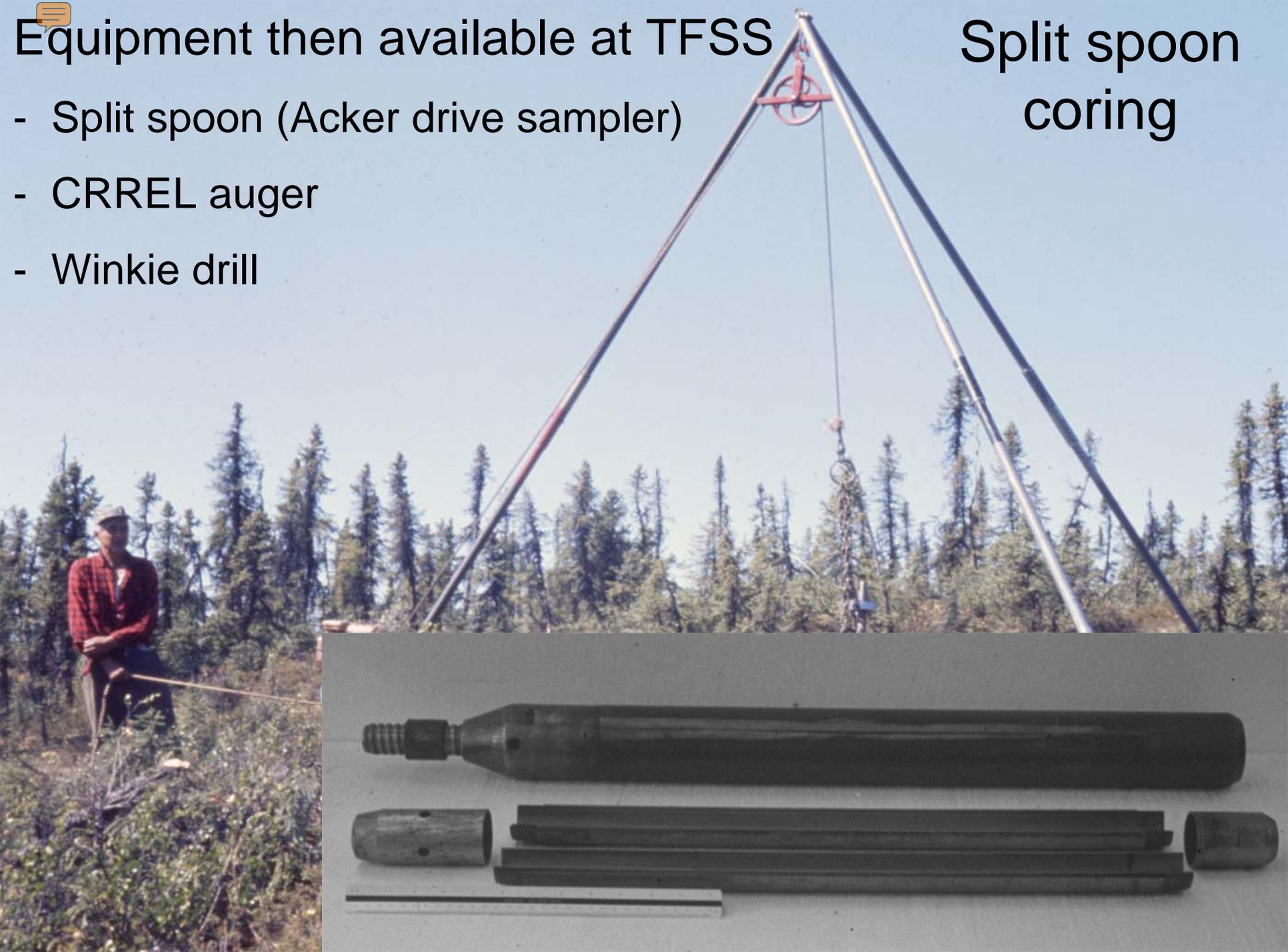
Photo M. Nixon



Equipment then available at TFSS

- Split spoon (Acker drive sampler)
- CRREL auger
- Winkie drill

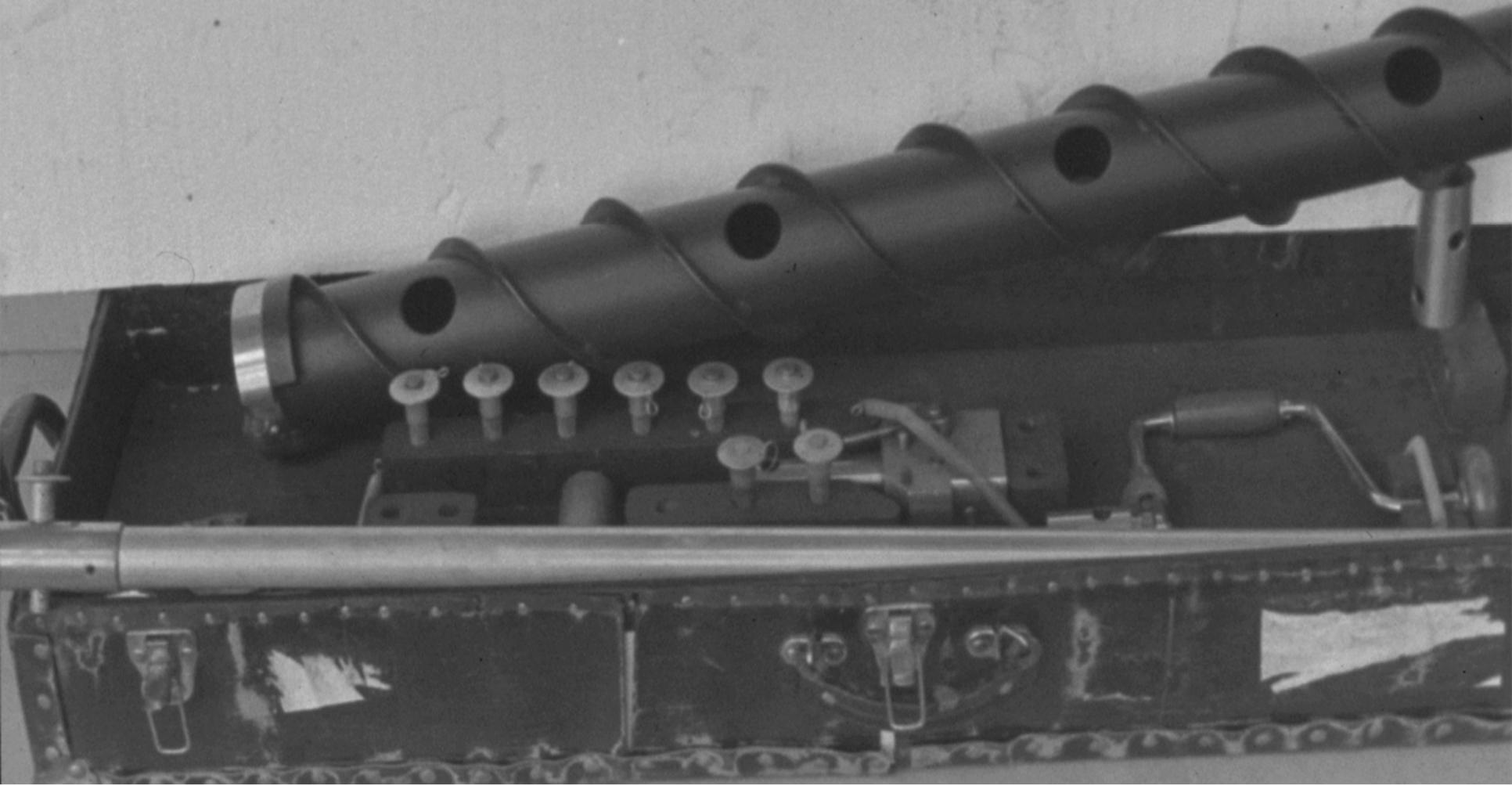
Split spoon coring



CRREL AUGER

Corrections needed:

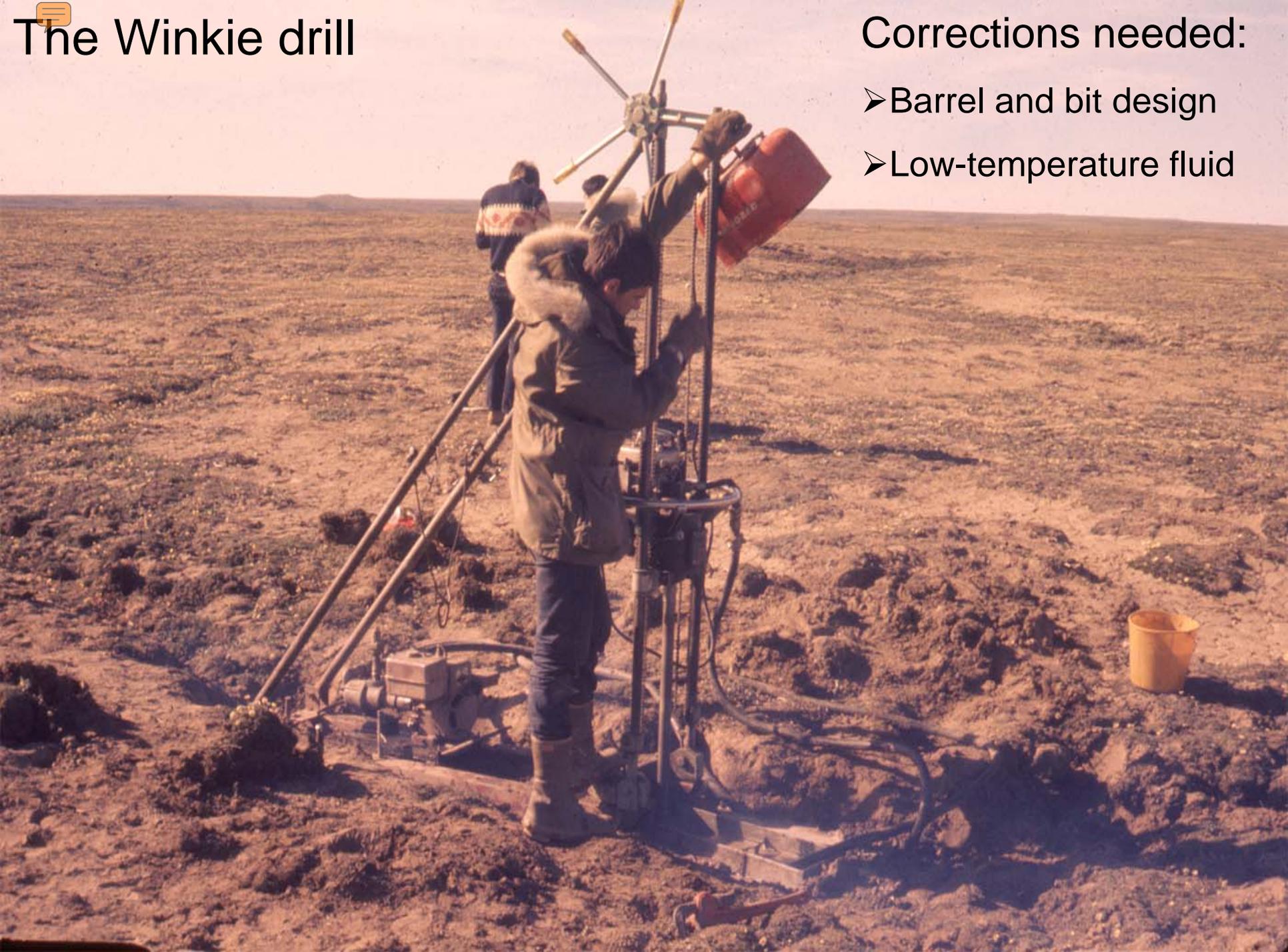
- Adequate power source
- Core barrel design
- Core catcher



The Winkie drill

Corrections needed:

- Barrel and bit design
- Low-temperature fluid



Calgary, winter 73

Experimentation in
"permafrost"





Four sections 8 ft deep

- Clean ice
- Frozen sand
- Gravelly sand
- Stony till-like material

Old Crow, Yukon, winter 73





Hughes 500 (main rotor 26 ft)
was used to minimize the
clearing of landing sites

The whole operation
was by helicopter only





Old Crow cores



O C W W

8

1 0

9

Quartzitic rock of low ice content, slightly weathered





ARD 4 26-29

Ice-rich clay till



ARE 1 32-11

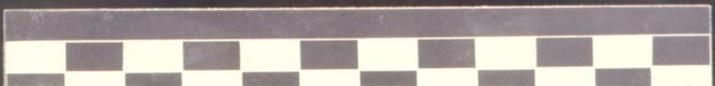
Washing



Bathing lake cores, stony till

AR WW 1 21-17

Clay till, large clasts



ARE 6 29-20

Gravelly sand, low ice content



ARD 4

26-29





Excellent core quality in stony permafrost obtained with a light-weight diamond drill. Why?

Drilling carried out at ambient temperatures -10°C or lower for most of project using a drilling fluid (fuel oil) with a low freezing point chilled naturally

Drilling done from mid-March to late April, when ground temperature in the zone of seasonal fluctuations is lowest

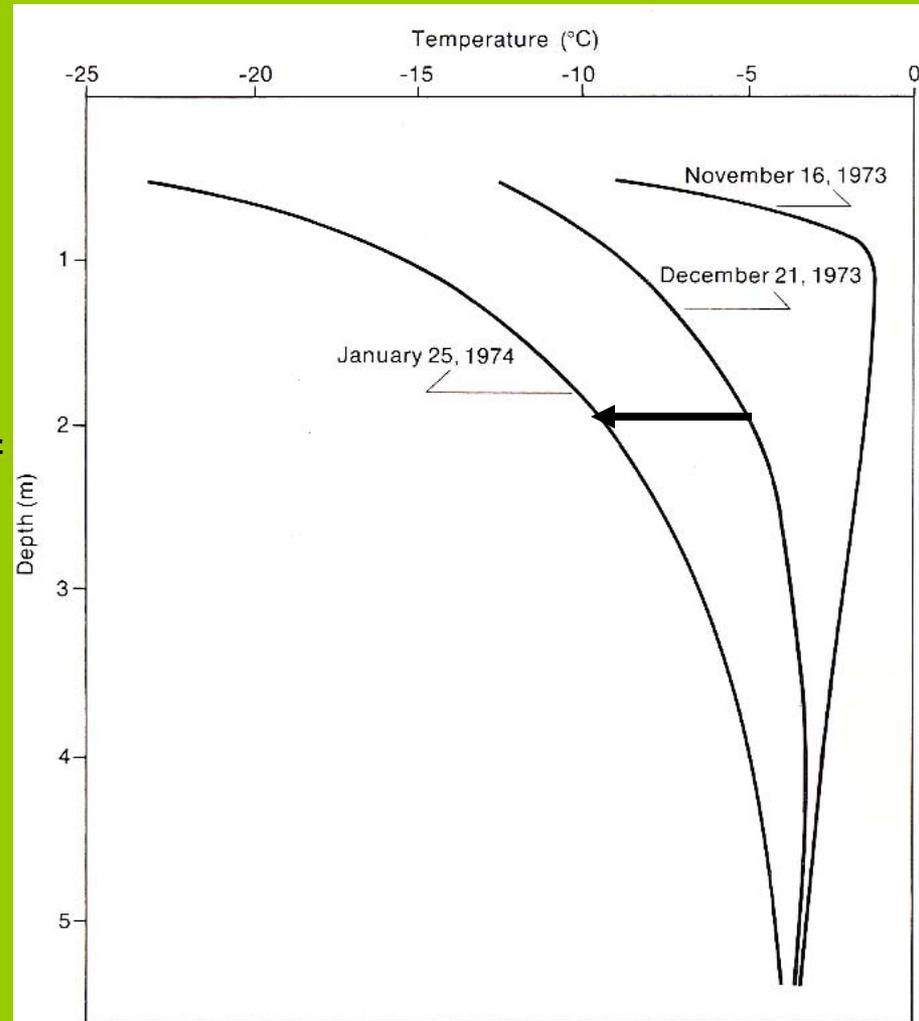


Figure 21. Ground temperature profile, Old Crow, Yukon.



But we kept using the Winkie in summerEllesmere I. summer 73

Doug

Mark





JKS 300 1974

- summer work
- drilling to 10 m





180 kg



300 kg

Assembled





Table 5

Torque at the boring spindle obtained from coring and augering in various types of permafrost, using a 8.9 cm O.D. modified CRREL core barrel or continuous flight augers with a 7.6 cm bit. Data obtained at boring-spindle speed in the 30 to 60 rpm range, with a bit load of 200 kg

Permafrost	Torque, using CRREL core barrel (ft•lb)	Torque, using continuous flight augers (ft•lb)
Friable sand	22	—
Ice	22	—
Silty ice	22-56	—
Clay and ice	22-75	—
Soft shale and ice	22-75	—
Sand and tiny ice lenses	22-66	—
Sand and ice inclusions	94-132	94
Soft shale	38-57	—
Soft sandstone	94	283
Gravel	—	56-132

Table 1

Observed depth of penetration of a modified CRREL
core barrel (5.1 cm core) for one run
in a variety of frozen materials

Material	Penetration (% of core barrel length)	Natural water (ice) content (% by dry weight)	Ground temperature (°C)
Clean ice	60	—	<-10°
	40	—	>-10°
Sand, well bonded pore ice only	40-50	20-25	Any
Soils with 75% or more ice by volume	50	—	<-10°
	30	—	>-10°
Silt	40	25-30	<-10°
	30	25-30	>-10°
Clay	25	30-40	<-10°
	20 or less	30-40	>-10°
<p>Note: Penetration values apply only to a core barrel held in vertical position; horizontal and inclined core barrel positions usually permit longer runs.</p>			

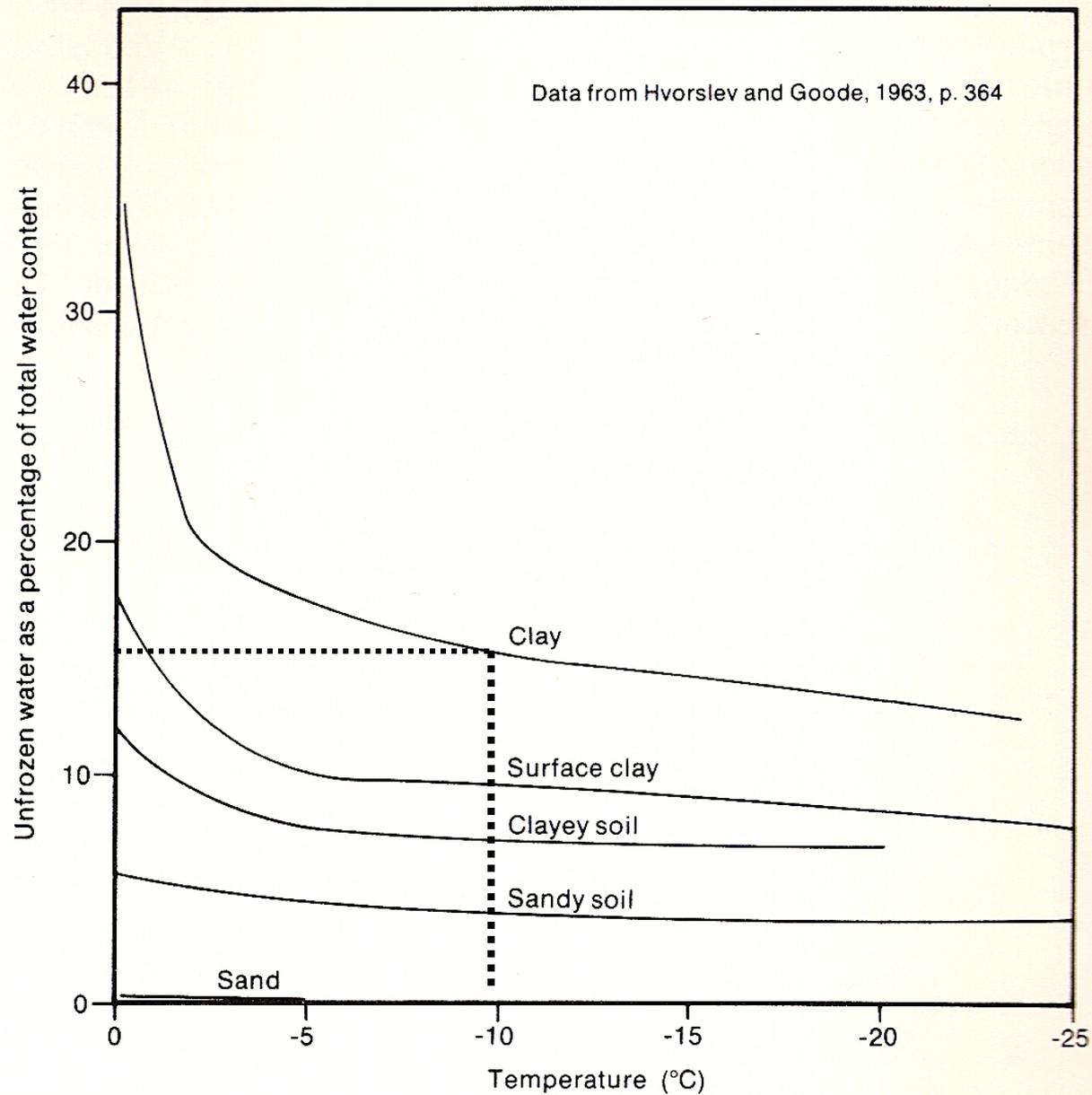


Figure 4. Plot of unfrozen water content of frozen soils vs. temperature.

Why is frozen clay touchy to core with CRREL augers ?

Using the CRREL auger
with light-weight
hand-held power augers



The infamous Haynes drill

Hughes and Terasmae (1963)

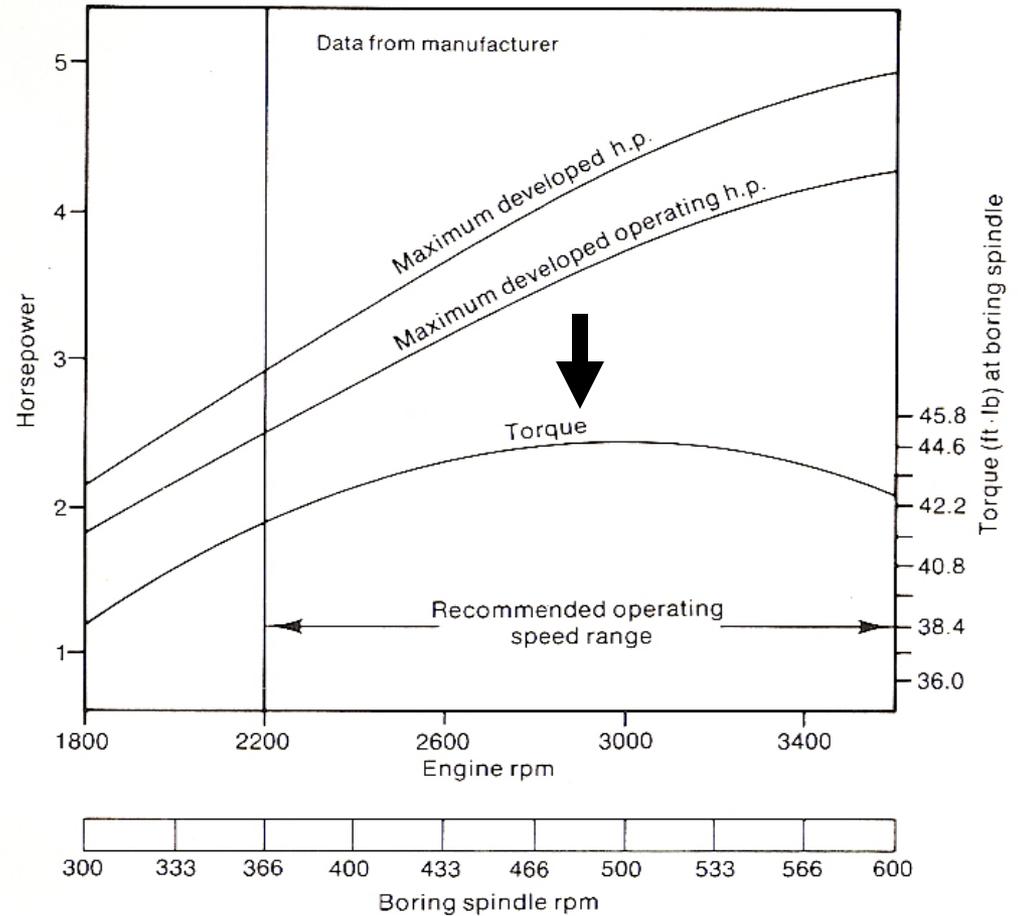
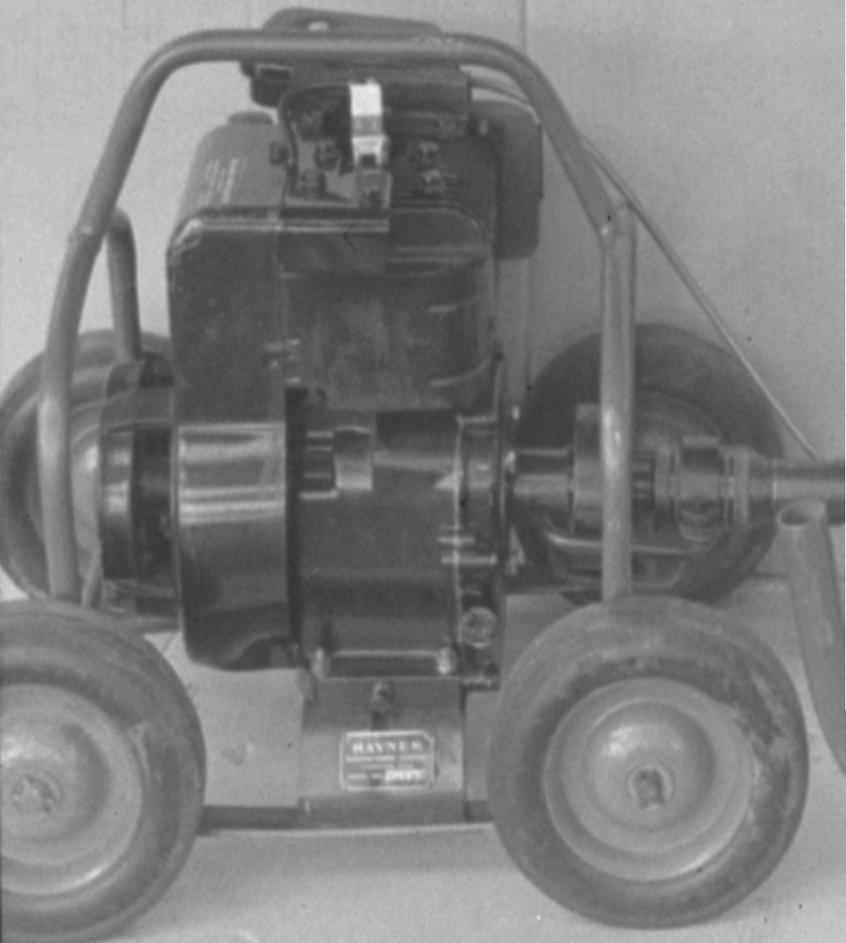
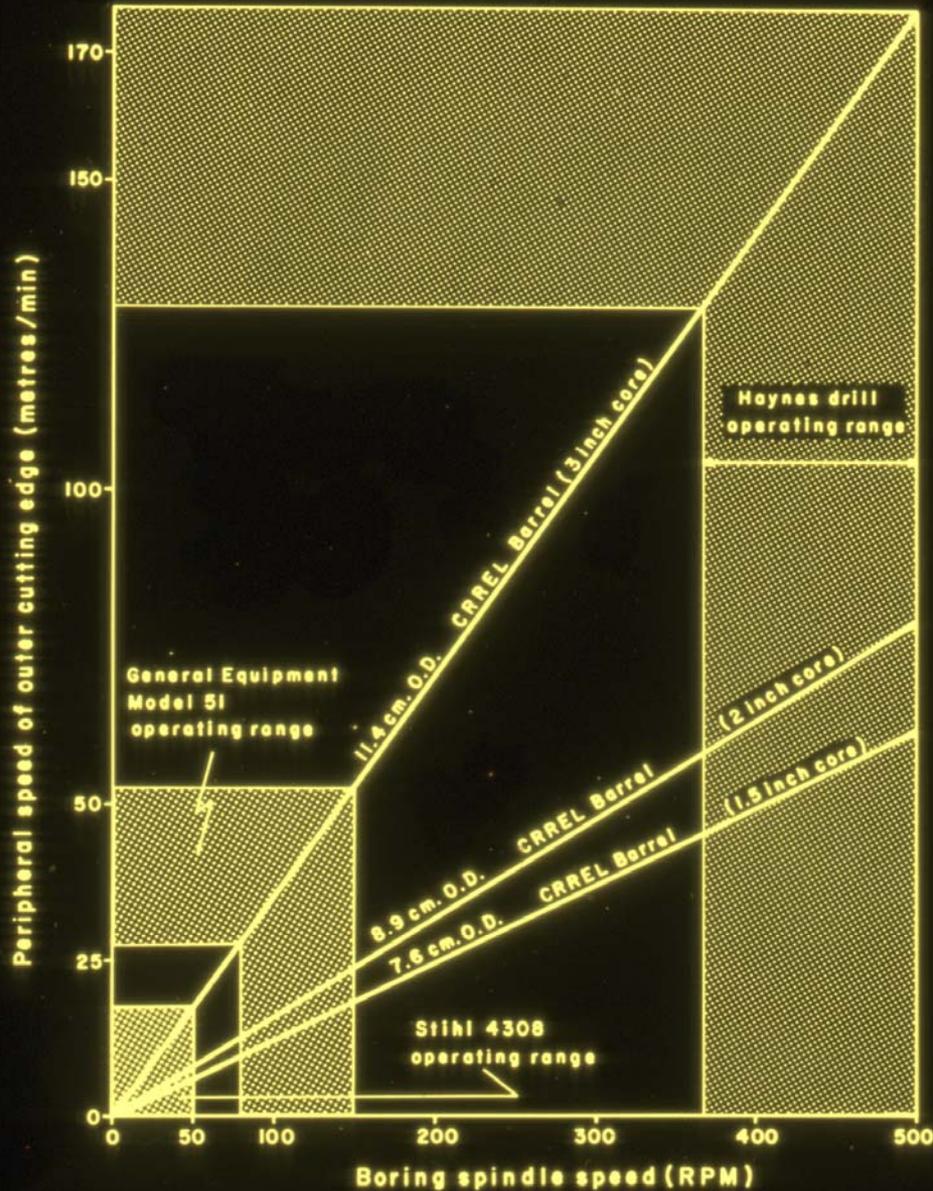


Figure 11. Performance chart, Haynes drill, model 500.

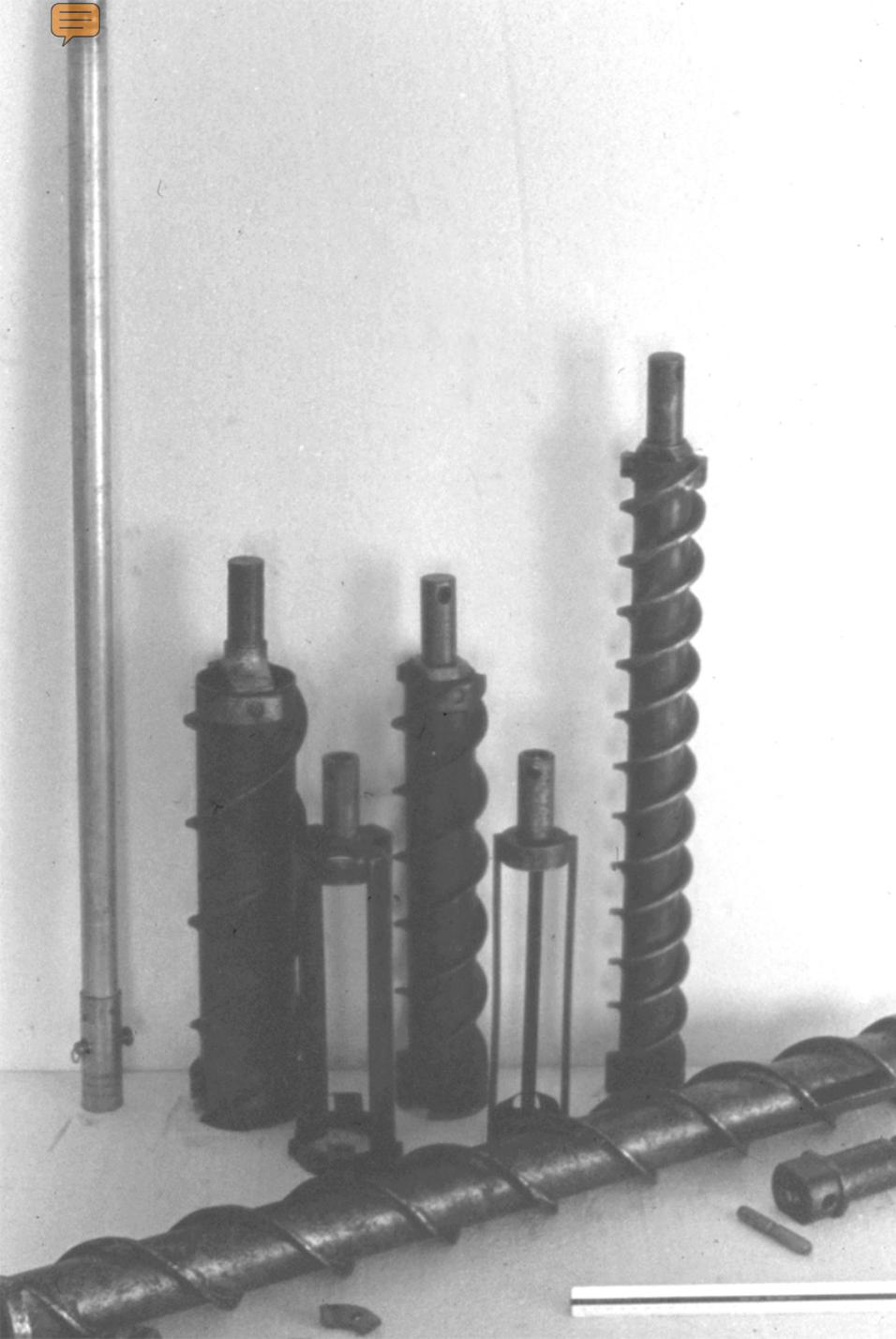


Boring spindle speed vs. peripheral speed of outer cutting edge for modified CRREL barrels of 11.4, 8.9 and 7.6 cm O.D. used on three different power augers.

Testing of 3 different hand-held power augers led to the choice of the Stihl 4308 for use with the CRREL auger

- reduced speed at cutting edge
- high (350 ft-lb) torque at low (50) rpm
- available across the country
- superior quality





Frozen sand core

Hand-held power augers using CRREL barrels require

- Low rotational speed
- High torque
- Perform best in low-temperature permafrost

Main limitations

- Labor intensive
- Poor feed (bit load)
- Prone to seizure in clay soils
- Gravelly deposits



ATV drill

- o high mobility
- o Increase borehole production
- o adapted to CRREL augers
- o can diamond drill and auger
- o adapted to transport with fixed wing aircraft used in remote areas (Twin Otter) and helicopter moves

Somerset Island

All components including the mast fits into the loading doors of a Twin Otter

Unloaded and assembled by two persons in a day



Positioning with fixed wing aircraft





High mobility



- Mast movement electrical
- Several holes in same area
- Helicopter moves across major topographical obstacles



1977 ATV drill upgraded to all-hydraulic operation

Used mainly for geotechnical work in non permafrost areas

L.Dyke, M.Nixon

Main results

- Development work led to design parameters for light-weight power drills using CRREL barrels:
- Successful coring of frozen soils require power drills producing maximum torque at low (< 50) rpm.
- Moderate torque (< 200 ft-lb) sufficient for most soils
- Bit load is the main limitation for hand-held drills
- Stony low-temperature permafrost can be cored with high rpm light-weight drills using chilled drilling fluid

Suggestions for future work

- Permafrost coring kit; reduce weight, for gravelly soils experiment with cutters other than carbide
- Improve bit load, reduce labor (Stinkie)
- For stony permafrost: experiment with chilled drilling fluid compatible with environmental regulations, and
- experiment with sedimentation equipment to clarify drilling fluids, hydrocyclones
- Field work in late winter-early spring when possible, colder permafrost, no mosquitoes

Selected publications

Calmels, F., Gagnon, O. and Allard, M. (2005) A portable Earth-drill system for Permafrost Studies. *Permafrost and Periglacial Processes*, **16**, 311-315.

CEN, Université Laval. Uses thin-walled bits with no drilling fluid

Nørberg, T., Goodsite, M.E. and Shotyk, W. (2004) An improved Motorized Corer and Sample Processing System for Frozen Peat. *Arctic*, **57**, no 3, 242-246.

University of Southern Denmark and Heidelberg. Improvements by Blake, Targets frozen peat

Veillette, J.J. and Nixon, F.M. (1980) Portable drilling equipment for shallow permafrost sampling. Geological Survey of Canada, paper 79-21, 35 p.

Covers a variety of drilling equipment, aimed at core production



Soil Augering

almost anyone can do it



by
Stephen Wolfe



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Canada 



Two techniques:

1. Soil augers – regular, mud and sand
2. Soil core sampler – slide hammer



Soil augers



Regular



Mud



Sand



Ideal all-purpose
auger

GSC Northern owns auger kit with multiple auger
types and extensions



Natural Resources
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Suitable for sandy and fine-grained sediments



Ideal where exposures are absent



Can penetrate wet and saturated silts and clays



Good alternative if vibra-coring is not viable





One-to-two persons



Quick-connect or threaded options



Very portable



5-metre depths (and more) feasible





Lacustrine
sediments



Buried soil



Wet sand



Dry soil
and sand

Moist
sand

Aeolian
sediments





Hand augering summary:

Advantages

- Very portable
- Fast
- Excellent depths and recovery (~100%)
- Good for obtaining basic stratigraphy
- Good for bulk sampling (e.g. moisture content, grain size, munsell, radiocarbon dating)

Dis-advantages

- Disturbed samples
- Coring will terminate in weakly-consolidated saturated sediments
- Difficult in very dry, loose sediment





Slide hammer - soil core sampler



GSC Northern does not own a sampler
(as far as I know)



Short, undisturbed samples are ideal for optical dating



Utilizes existing auger-hole to obtain core sample



Slide-hammer for coring



T-bar for extraction





Ideal methodology is to combine auger sampling and slide-hammer coring





Slide-hammer coring summary:

Advantages

- Very portable
- Fast
- Excellent depths and recovery (~100%)
- Good for obtaining basic stratigraphy
- Good for undisturbed sampling
- Ideal for optical dating
- Can be used vertically or horizontally (for sampling sections)
- Excellent when combined with hand augering

Dis-advantages

- Coring will terminate in weakly-consolidated saturated sediments
- Difficult in very dry, loose sediment
- Can be difficult to extract undisturbed sample from tube





Footnote: option available for a split-tube sampler





For further assistance
contact Stephen Wolfe



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Canada 