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

G.R. Brooks (Editor)

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

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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 |
| *Break* | | |
| 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 |
| *Lunch* | | |
| 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 *et al.* |
| 14:00-14:30 | Variations on a theme of gravity coring | Sam Alpay *et al.* |
| 14:30-15:00 | Aquatic soft sediment sampling methods: freeze coring and grab/hand coring | Paul Gammon and Sam Alpay |
| *Break* | | |
| 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 ( ≤1m) 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 is 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 0ºC) 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. GCS 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 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** | - Coring in snow, ice, fine-grained organic and mineral soil<br>- Used with a STIHL power auger that has a high (150:1) engine to boring spindle reduction ratio.<br>- Can be used with a handheld unit or frame mounted (the Stinkie system) | - TFSS has 5 modified CRREL kits called "Coring auger kits"<br>- TFSS has 6 STIHL O38 auger power heads (2-person handheld)<br>- 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; 2-½" 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 corers**[2] | 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 sampler**[3] | 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 |

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[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.