



Vibracoring from lake ice with a lightweight monopod and piston coring apparatus

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Abstract

A monopod and piston coring apparatus for coring water-saturated sediment is described. The lightweight apparatus can be used from either an ice platform or the ground surface and can be transported by aircraft. Using a piston, core recovery is increased to better than 90%, and depending upon the monopod height, 7 m-long cores can be obtained. Tips for coring in freezing temperatures are also given.

Introduction

Vibracoring is a relatively common procedure for extracting sediment cores from a variety of depositional environments. However, sediment compaction is often viewed as a deterrent for using vibracorers. In this short paper, I describe how a piston apparatus in conjunction with a monopod can be used to significantly increase sediment recovery and provide a safer working environment on lake ice.

Working from Lanesky et al. (1979) and Hoyt and Demarest (1981), Smith (1984, 1987, 1992, 1998) suggested a series of equipment modifications and Thompson et al. (1991) provide additional suggestions. Glew et al. (2001) recently reviewed the vibracoring technique and described one of its greatest advantages as being the variety of sediment types that can be recovered. For example, I have cored through various combinations of saturated pebble-sized gravel, peat, gyttja, marl, muck, sand and till, and have recovered sediment after coring through a 12 cm thick cedar log. Besides its inability to core non-saturated sediment, a disadvantage to vibracoring (and other types of coring (Glew et al. 2001)) is sediment compaction. Up to 60% compaction from

vibracoring was reported by Thompson et al. (1991) and I have experienced values of over 300% from gyttja-dominated lakes in northern Saskatchewan (Fisher and Souch 1998). With more experience, I now suspect that much of what is called sediment compaction may instead be sediment bypassing, rodding (Hoyt and Demarest 1981), or thinning (see Glew et al. (2001) for a short review). My monopod system is designed to increase safety while coring from lake ice, and to reduce sediment bypassing by using a piston. With this apparatus, recovery rates have consistently been greater than 90%, and considerably less effort is required to hoist the core tube from the sediment. Lanesky et al. (1979) report success with using a piston, but Hoyt and Demarest (1981) report only limited success. This coring apparatus is designed to fit into small aircraft (e.g., De Havilland Beaver) and to be used from a lake-ice platform or on the ground.

Monopod masts, used for hoisting, have been used before in coastal environments (Lanesky et al. 1979), and tripods are often used (e.g., Hoyt and Demarest 1981; Thompson et al. 1991), however the plate at the top of the tripod usually does not extend above the core tube, which is required to

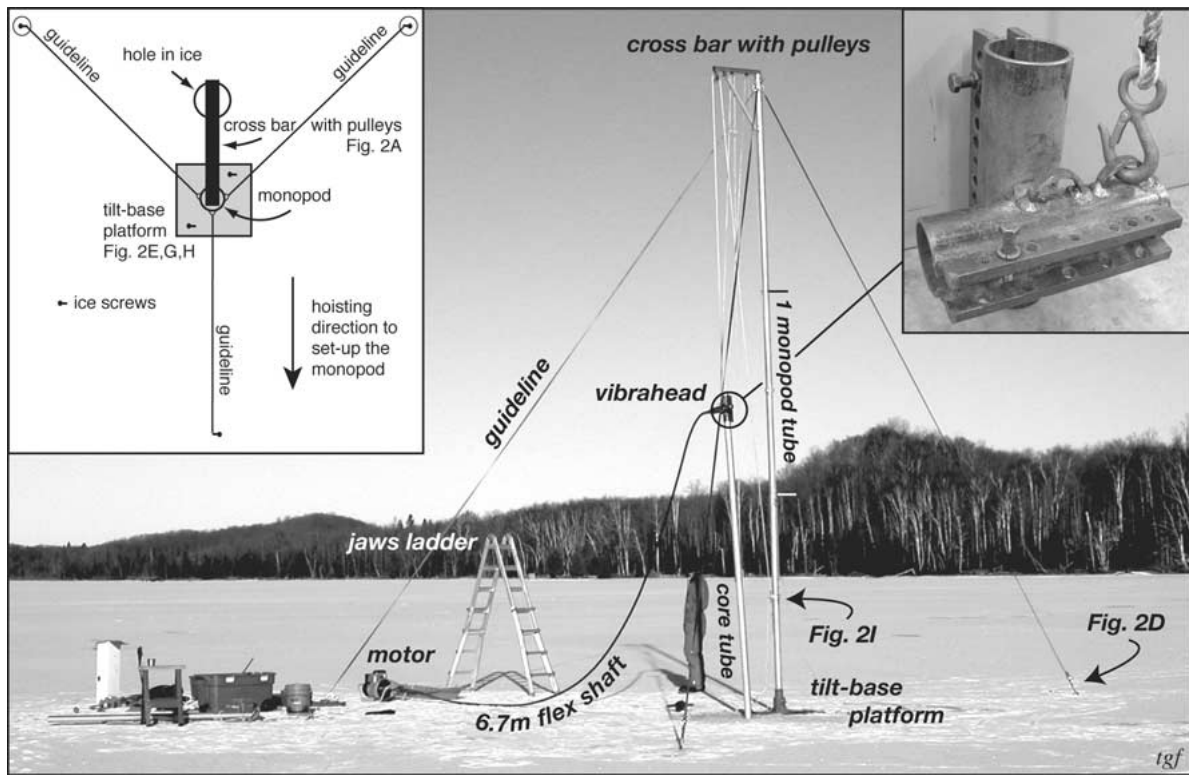


Figure 1. Monopod set-up on a lake-ice platform. Inset diagram shows the same set-up, but in plan view, and inset photograph shows how ropes are attached to the vibrahead. Guidelines are first attached to the circled ice screws, and the monopod is then raised in the direction indicated by the arrow.

anchor the piston. In the set-up described below, a 7.4 m-high monopod with a braced cross-bar outfitted with pulleys is the stable platform from which the piston is anchored and the coring apparatus can be raised and lowered.

Materials and methods

Monopod

The monopod was designed to be lightweight and collapsible enough to transport in small aircraft to

remote areas. The monopod (Figure 1) with all its fittings costs \$1000 US (2001) and consists of three 2.44 m long aluminum tubes (6.3 cm-ID, 7.6 cm-OD) joined using a flange with a pin through each tube (Figure 2B). A cross bar with pulleys (Figure 2A) is inserted into the upper tube and fastened with a pin and braced. The lowest tube fits into a tilt base (8.2 cm ID) that is bolted to a plywood platform (Figure 2E). The tilt base is designed for setting up the monopod on the ice before hoisting the monopod into position. Details of this procedure are described below. The plywood platform is anchored to the lake ice using

Figure 2. (A) Braced cross bar with pulleys. Note cleats just below the pin to attach the guidelines with snap link connectors. (B) Monopod is assembled by joining three 2.5 m aluminum tubes with two of them outfitted with inner flanges. A pin is placed through the holes and secured with a cotter pin. (C) The piston is attached to a plastic-coated steel cable running through all of the core tubes. (D) The guidelines are attached to the lake ice using ice screws and tightened using a simple ratchet tightener. (E) The tilt-base is bolted to plywood and allows the monopod to be set-up on the lake ice before it is hoisted into position. The wedge is set in after the monopod is vertical to help stabilize it. (F) View up the bottom core tube at the piston where core catcher 'fingers' are pop-riveted to the core tube. (G) The tilt-base platform is anchored to the lake ice with two ice screws. (H) View of the tilt-base with the wedge in place. (I) Cleats part way up the lowest section of the monopod used for securing the hoist rope, safety rope, and piston cable. See Figure 1 for its location on the monopod.

two ice screws that can be set and removed by hand (Figure 2G). Ice screws are available at any sporting goods store that carries climbing equipment (~\$35 US each). Three (2.54 cm–1") nylon-webbing guidelines are attached to cleats at the top tube (Figure 2A) with snap links (e.g., Figure 2C) and anchored to the lake ice using ice screws (Figure 2D). Cleats near the base of the monopod provide additional anchoring capabilities. A ratchet tightener is used to draw the guidelines taut.

The cross bar at the top of the monopod can be outfitted with numerous pulleys. Three pulleys are shown in Figure 2A. One pulley is used for a plastic coated steel cable that is attached to the coring piston (described below). To keep the piston cable taut during coring, it is connected with a snap link at the other end to a figure-8 knot, and attached to a cleat (Figure 2I). The rope attached to the vibrahead (Figure 1 inset photo) uses the larger pulley (Figure 2A) and is used to raise and lower the vibrahead/core tube assembly. The middle pulley (Figure 2A) is for a safety rope also attached to the vibrahead and tied-off with a snap link on the mast (Figure 2I). Because the hoist rope is not always attended to while coring, a safety rope is used to prevent the vibrahead from falling onto workers below should it shear off from the core tube while coring. Its length is set during set-up so that it becomes taut when the vibrahead is 2.5 m above the ice. While coring, and just before the safety rope becomes taut, the snap link is released so that coring can continue.

Piston and core catchers

The piston is assembled with two grounded #14 rubber stoppers centered on a threaded eyebolt. Two 4 mm thick, flat washers are on either end of the rubber stoppers, with the upper one welded to the eyebolt (Figure 2C). Either a nut and a lock washer, or two nuts are used to tighten and lock the rubber stoppers, and from experience; the piston should be very tight within the core tube. If silt or other non-cohesive sediment is expected, then a core catcher is recommended. The brass core catcher described by Smith (1987) is particularly effective at retaining sediment, but its width and roughness may prevent maximum penetration. Reddering and Pinter (1985) described a relatively simple core catcher system, however, I have found that pop riveting 2–4 metal ‘fingers’ (Figure 2F) at the base

of the tube is quicker, simpler, less expensive, and does not require advance planning.

Jaws ladder hoist beam

A variety of methods are used to remove the core from the ground or lake bottom. One device described by Smith (1992) is an aluminum hoist beam that fits over the top of a telescoping ladder with a jaws hinge. I have modified the hoist beam to use with a jaws ladder so that the core tube can pass through the hoist beam (Figures 3A and B). Otherwise, the tube must pass to one side of the ladder that tends to bend the core tube and cause binding problems. The advantage of using the monopod at this stage is that once the endless-chain hoist and ladder are not required to raise the core tube, the tube can be easily lifted up from the jaws ladder using the lifting rope attached to the vibrahead and lowered to the ice surface in a controlled manner.

Coring procedure

The plywood platform with the tilt base is anchored to the ice with two ice screws. The monopod is assembled on the lake ice and set into the tilt base. The two ropes and piston wire are fed through the pulleys and tied to the cleats (Figure 2I). Ice screws to anchor the three guidelines are set within the ice in a triangular arrangement, ensuring that they do not interfere with the cross bar (Figure 1 inset). The horizontal distance between the tilt platform and ice screws is measured with a piece of rope tied to the tilt base, and its length determined using trigonometry or trial and error. All three guidelines are attached to the top of the monopod, and the two guidelines closest to the hole in the ice are attached to ice screws (circled ice screws on Figure 1 inset). The monopod is now ready to be raised.

The monopod is raised with one person pulling on the remaining guideline with the attached ratchet tightener, and a second person(s) lifting the monopod in a hand over hand fashion above ones head (arrow in Figure 1 inset shows the direction of lift). If the ice screws are set the proper distance from the tilt platform, they should be relatively tight (once the monopod is vertical), and the monopod cannot fall in the direction in which it was raised. The third guideline is now

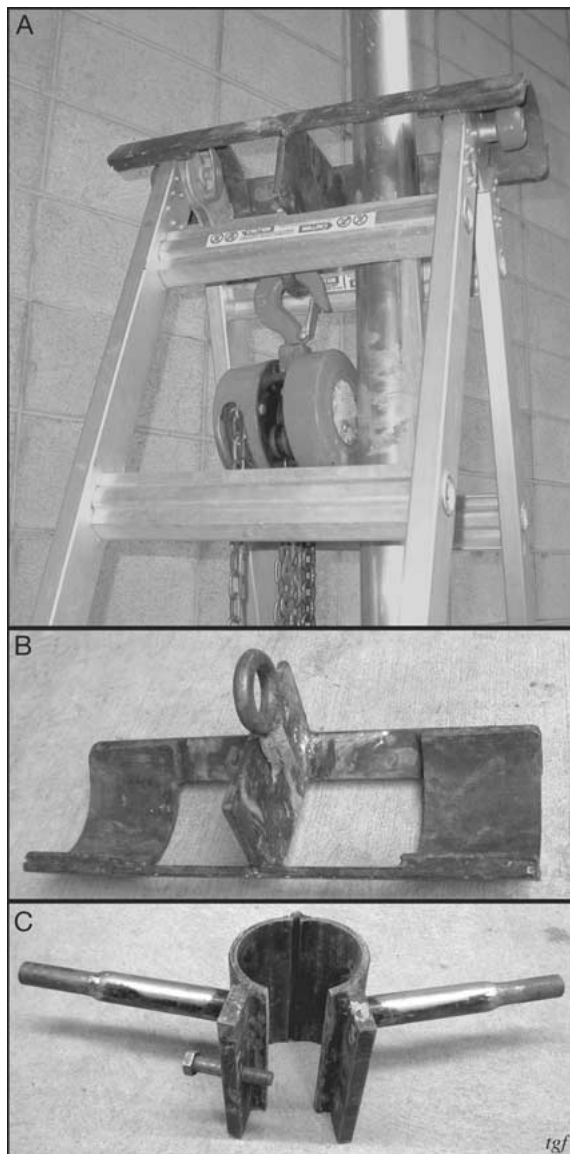


Figure 3. (A) Set-up for hoisting the core tubes. A steel hoist beam rests on the jaws ladder supporting the endless chain hoist. The hoist beam has openings to allow the core tube to pass through it while it is lifted. (B) Close-up of the hoist beam upside down. (C) Hinged long-handled clamp fashioned after Smith (1992). ID when closed is slightly less than the diameter of the core tubes.

attached to the third ice screw and the wedge (Figure 2E) is placed into position (Figure 2H) so that the weight of the monopod is not resting solely on the pin. The monopod is orientated vertically by alternatively loosening and tightening the guidelines. This same procedure is used if the monopod

is used on land, except metal stakes instead of ice screws are used.

After making an 18 cm diameter hole in the ice with an ice auger, the depth to lake bottom is determined using a line and weight. Once the depth is known, the core tubes are arranged on the ice with the piston cable running through all of them. The piston is then placed in the lowest tube (which should also be the longest) and a core catcher added if needed. At this point, the lowest tube is filled with water using a bucket with a funnel or a siphon hose. The weight of the water serves two purposes. First, it tests the piston's seal, and second, it prevents the piston from creeping up the core tube when it is inserted into the lake. The first tube is placed into the lake at this point with a long-handled clamp to prevent it from going under the ice (Figure 3C; see Smith 1992 for details). Assuming more tubes are to be used (i.e., the water depth is greater than the core tube length), the first tube is held above the hole with a long-handled clamp and another tube attached with a core coupler (Smith 1992—his Figure 3). This process is repeated until the last tube is ready to be added. There should be a narrow gap between tubes to allow water to enter then drain from the tubes (Smith 1992). To maximize core length, tube lengths need to be adjusted so that when the final tube is added, and raised into position with the vibrahead attached, the vibrahead is just below the cross bar. Before raising the last tube, the safety rope and main hoist rope are attached to the vibrahead.

Before coring starts, the piston cable must be tied off to the tilt-base platform or the cleats on the monopod to prevent the piston from moving downwards while coring. The main hoist rope keeps the core tube assembly vertical while the motor is started, and controls the descent of the core tube, which is especially important in the uppermost loose sediment. The safety rope will have to be detached once the vibrahead lowers to 2.5 m above the ice. With this set-up, a 7 m core can be recovered. The longest core recovered with this system has been 6.95 m after a 7.25 m core drive. For example (Figure 1) the vibrahead is about 3.5 m above the lake ice, which resulted in a 3.3 m core. If longer cores are required then the monopod can be made higher by adding another section, or additional core tubes can be coupled on, although I have not attempted this. If more tubes are added,

then the piston cable will have to be run through them before coring can continue with the piston.

Once coring is completed, the piston cable is released from the mast to facilitate hoisting of the core tubes. After the vibrahead is removed from the core tube, the piston cable is pulled through the vibrahead and each core tube as they emerge from the hole. Next, the jaws ladder with the beam hoist and endless-chain hoist is placed over the tube, and the core tubes are pulled from the hole. Once the core tubes can be pulled manually from the hole, only the hoist rope on the monopod is required. The long-handled clamp resting on lake ice is used beneath the core couplers while removing the upper core tube. In the final tube containing the core and piston, the piston cable can be kept taut using vice grips to clamp the cable against the core-tube wall. However, I have found that the piston does not move once the coring is complete.

While coring during particularly cold weather (-20°C) or when it is snowing, various difficulties are experienced. Long-handled clamps are more effective than prusik ropes because the knots freeze up and do not grip the core tubes. Occasionally, there is black ice on the lake that is very slippery. Having along sand bags to spread sand on the lake ice is one solution. Most fishing supply stores also sell slip-on cleats over your boots, but I have not found these to be particularly effective. The last difficulty experienced is the layer of ice that builds up on the core couplers, clamps, nuts/bolts, and on core tubes emerging from the lake. Having along a propane torch efficiently melts and sublimates away this ice. It is particularly important to ensure that initially there is no ice between the core tubes and the couplers otherwise coupler failure will occur. Another method to prevent coupler failure is to drill pilot holes in the couplers before using them (8 holes/coupler) and attach the coupler to the tube with self-tapping sheet metal screws. The downside of this technique is piston laceration as the couplers pass by, necessitating piston replacement after a few uses. However, the above modifications and precautions have yielded successful coring in cold snowy conditions. Placing sand between slightly undersized core tubes and the couplers is another effective means of preventing coupler failure (Todd Thompson, pers. comm. 2003).

The technique of vibracoring has had variable success rates over the years, and is limited by the

capabilities of the equipment itself. The monopod system described here improves sediment recovery rates, increases safety and is transportable in small aircraft, thus making vibracoring with a monopod and piston a particularly attractive technique for collecting a variety of sediment types from ground or lake ice platforms. A limitation of this system is that the maximum length of core is determined by the height of the monopod, and the extra time required setting it up.

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References

- Fisher T.G. and Souch C. 1998. Northwest outlet channels of Lake Agassiz, isostatic tilting and a migrating continental drainage divide, Saskatchewan, Canada. *Geomorphology* 23: 57–73.
- Glew J.R., Smol J.P. and Last W.M. 2001. Sediment core collection and extrusion. In: Last W.M. and Smol J.P. (eds), *Tracking Environmental Change Using Lake Sediments. Volume 1: Basin Analysis, Coring, and Chronological Techniques*, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 73–105.
- Hoyt W.J. and Demarest J.M. II 1981. *Vibracoring in Coastal Environments: A Description of Equipment and Procedures*. SeaGrant College Program, University of Delaware, Newark, DEL-SG-01-81, pp. 20–31.
- Lanesky D.E., Logan B.W., Brown R.G. and Hine A.C. 1979. A new approach to portable vibracoring underwater and on land. *J. Sed. Petrol.* 49: 654–657.
- Reddering J.S.V. and Pinter R. 1985. A simple, disposable core catcher for vibracoring tubes. *J. Sed. Petrol.* 55: 605–606.
- Smith D.G. 1984. Vibracoring fluvial and deltaic sediments: tips on improving penetration recovery. *J. Sed. Petrol.* 54: 660–663.
- Smith D.G. 1987. A mini-vibracoring system. *J. Sed. Petrol.* 57: 757–758.
- Smith D.G. 1992. Vibracoring: recent innovations. *J. Paleolim.* 7: 137–143.
- Smith D.G. 1998. Vibracoring: a new method for coring deep lakes. *Palaeogeogr. Palaeoclim. Paleoec.* 140: 433–440.
- Thompson T.A., Miller C.S., Doss P.K., Thompson L.D.P. and Baedke S.J. 1991. Land-based vibracoring and vibracore analysis: tips, tricks, and traps. *Ind. Geol. Surv. Occ. Pap.* 58: 13 pp.