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Drilling Frozen Soils in Siberia

by Sebastian Zubrzycki[1]

INTRODUCTION

The main objective during a spring field campaign in April and May 2011 to Siberia was to sample frozen material from undisturbed drilling cores of 1 m length from permafrost-affected soils. Samples from depths of more than 0.5 m are rare from those regions due to difficult access to the currently perennially frozen soil layers. Though, these layers are of high interest because progressive thawing by climate change has already been observed, and with projected amplification of thawing, permafrost-affected soils will undergo fundamental property changes including deepening of the seasonally thawed active layer (KOVEN et al. 2011). As an essential effect of these changes, higher turnover and mineralization rates of the organic matter are expected to result in increased climate-relevant trace-gas release to the atmosphere (DUTTA et al. 2006, WAGNER et al. 2007, SCHUUR et al. 2009). With frozen and undisturbed samples from these rare depths, detailed pool estimations not only of organic matter contents but also of many interesting chemical soil properties such as nutrients or heavy metals concentrations can be performed. Such investigations can help to increase the quality of future permafrost and climate models.

This field campaign was performed in central and north-east Siberia in alasses on the river terraces of river Lena near the town of Yakutsk and on Samoylov Island in the Lena River Delta to collect a sample pool for future laboratory soil analyses (Fig. 1).

METHODS

During this field campaign, a new portable Snow-Ice-Permafrost-Research-Establishment (SIPRE) auger set was used. The sampling set consisted of an engine power head STIHL BT 121 by ANDREAS STIHL AG and a SIPRE coring auger by Jon’s Machine Shop in Fairbanks, Alaska (Fig. 2). Here I want to share my detailed practical experience and to assemble all information needed for a successful work with this auger set in the field.

SIPRE coring auger

The equipment set used was designed to retrieve sediment cores of up to 3 m in length. It was packed in a plastic Pelican 1750 shipping case and consisted of a 1 m coring barrel with an external auger conveyer, a quick change drive head, two one meter and one half meter drive extensions, a T-handle, six carbide tipped cutting bits, fife extension ball detent pins, an adapter to drive motor output shaft, a core retriever with drive head and two connector pins, a core pusher and a frost probe. The total weight incl. the Pelican box was 29.4 kg. The price in fall 2010 was about USD 10,000 including shipping from Alaska to Europe, customs and import turnover tax. Due to the auger’s use for scientific purpose, it is possible to get the shipment exempt from customs fees, though because of its “commercial“ appearance the process is unnerving and protracted. The user choosing this procedure has to complete the declaration for scientific instruments ("Erklärung für wissenschaftliche Instrumente oder Apparate") and to satisfactorily demonstrate the scientific purpose of its operation.

Another problem can occur when the SIPRE auger has to be transported abroad to the country of its ultimate use. The usage of the international custom document ATA carnet (probably) will be refused by the Chamber of Commerce of the country where your field work is planned because of the auger’s role as a tool for exploration of soils. So all key benefits the ATA carnet provides are unattainable. One should therefore be prepared to purchase temporary import bonds and to pay applicable duties and taxes once more.

In order to avoid custom problems when coming back home from field work abroad (without the ATA carnet), the home custom office should be visited before leaving to the field to complete the form for returned goods (INF 3) (Auskunftsblatt “Rückwarenregelung”). A *pro forma* invoice is needed with a detailed list of the equipment and prices. Pictures of all equipment pieces should be included. The custom office will keep one original form for its record, and a second original will be handed out. It should be shown to the custom officers when crossing the border back to Europe.

Auger engine

The STIHL BT 121 engine, we used, is available worldwide. For our field study the engine was bought from an official STIHL dealer in Yakutsk, Russia. Besides the specific details of the engine (Tab. 1), it is important to know that the STIHL BT 121 is a two-stroke engine; hence a 1:50 gasoline oil ratio is required for operation. The fuel tank capacity is about 0.6 L. The gasoline consumption during the spring field trip was low and amounted to an average of 0.5 L per 1 m sediment core from deeply frozen ground. The STIHL BT 121 engine has a “QuickStop drill brake” including a release lever. This mechanism will interrupt the power flow from the engine to the spindle in case the drill jammed in the ground by turning the release lever towards the operator's thigh. The connected SIPRE coring auger will stop rotate immediately. Due to the fact that air transportation of gasoline driven engines is

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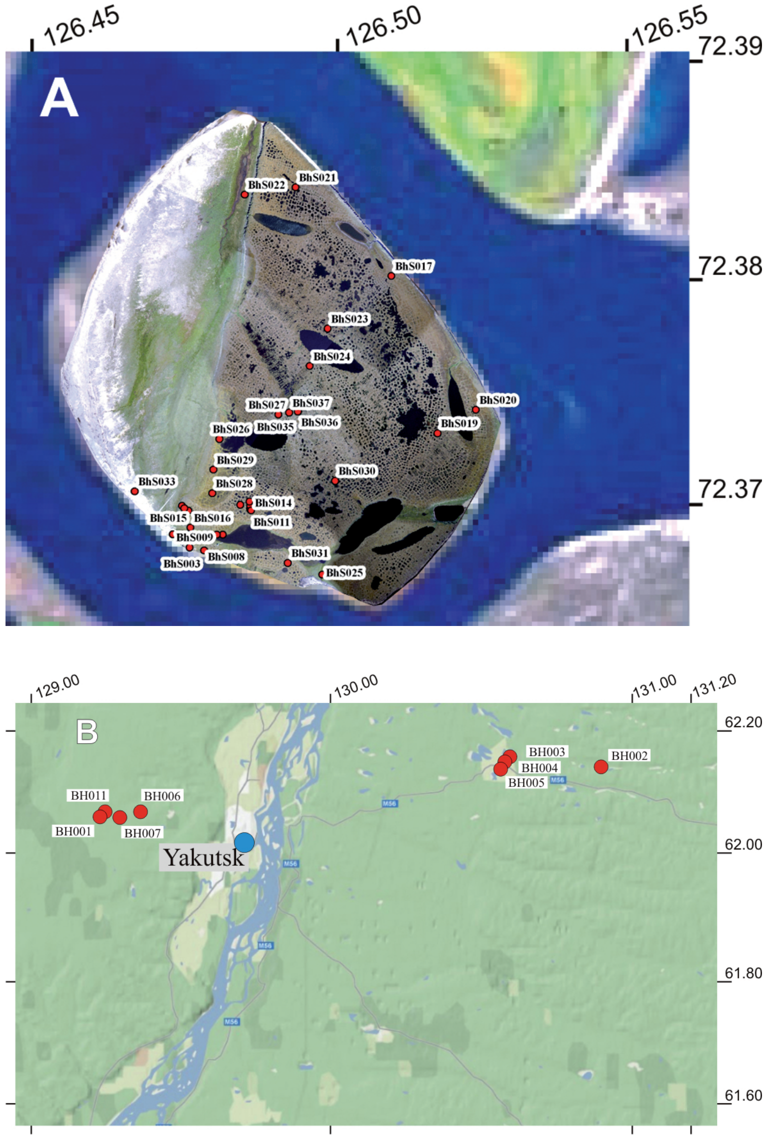

Displacement:	30.8 cm^3
Power:	1.3 kW/1.8 bhp
Spindle speed:	190 rpm
Vibration level (left/right):	2.2/2.5 m s^{-2}
Sound power level:	109.0 dB(A)
Sound pressure level:	103.0 dB(A)
Weight:	9.4 kg
Price in fall 2010:	approx. 1,000 EUR

Tab. 1: Important specific details of the engine.

Tab. 1: Wichtige Spezifikationen des Motors.

Fig. 1: Investigation areas in northern central Siberia with the sampling sites marked by red dots and core numbers. A = Samoylov Island within the Lena River Delta (width of photo approx. 4.5 km; photo: J. Boike, AWI). B = sampling sites on the eastern and western terraces of river Lena River near the town of Yakutsk (marked with a blue dot; width of photo approx. 120 km; based on Google & Geocentre Consulting 2012).

Abb. 1: Arbeitsgebiete im nördlichen Zentralsibirien mit Beprobungslokationen (rote Punkte mit Bohrkernnummern). A = Insel Samoylov im Lenadelta (Bildbreite ca. 4,5 km; Foto: J. Boike, AWI). B = Untersuchungsgebiete auf den östlich und westlich der Lena gelegenen Flussterrassen in der Umgebung der Stadt Jakutsk (blauer Punkt; Bildbreite ca. 120 km; basierend auf Google & Geocentre Consulting 2012).

strongly restricted, it is a big advantage buying the STIHL BT 121 at the place of work. Above all, it should be taken into account that two-stroke engine oil and the required unleaded gasoline with a minimum of 89 octane rating could not be available everywhere. In its instruction manual, STIHL does not recommend using fuel additives to increase octane rating because doing so can create running problems or even damage of the engine.

Working with the auger set

In the field, work with the auger set is satisfactory and productive. During our field campaign, the STIHL engine worked well without any problems. Starting the engine at temperatures of minus 10 °C caused no big effort. To start the engine during cold mornings, cranking up to 15 times was enough.

Since the weight of the whole set is about 40 kg, the equipment for a day trip should be limited to the essential pieces if no vehicle is available. It proved successful to pack among the engine, the coring barrel and the adapter connecting both, the core catcher with one 1 m extension and the T-handle. The core pusher was needed to avoid core destruction when weakly cemented ground was expected. A toolbox and approx. 2 L of gasoline oil mix were very helpful. Constructed as a one-man auger the set really fulfilled expectations (Fig. 3A-C) although working in a two-men team was more helpful. Working as a team is especially important after the work day when additional to the equipment of around 25 kg the sample's weight was added and all had to be transported to the base camp. The weight of a 1 m core was about 5 to 6 kg (Fig. 3D).

A further advantage of working in a pair was the easier handling of the coring barrel and engine set for coring. The total weight of this set was about 18 kg, and this weight had to be lifted up regularly while coring to avoid jamming in the frozen ground. Furthermore, the weight of two operators was of additional benefit, especially when initiating the drill into the frozen surface with the auger not yet stabilized in the borehole.

The external auger conveyer has performed excellently (Fig. 2A). The borehole debris was easily transported upward and usually preserved the auger from jamming. To avoid jamming, lifting up the auger was required while coring to help the

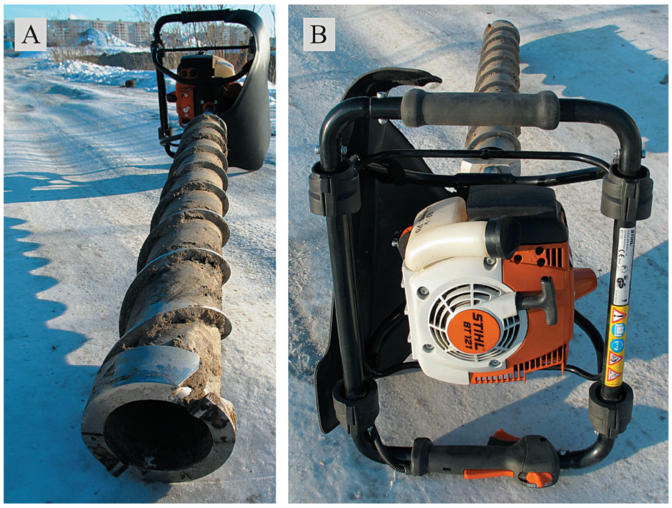

Fig. 2: The auger set used for sampling during the spring field campaign. A = SIPRE coring auger by Jon's Machine Shop, Fairbanks, Alaska. B = STIHL BT 121 engine power head (Photo: Alexey R. Desyatkin).

Abb. 2: Das während der Feldarbeiten eingesetzte großkalibrige Erdbohrer-System. A = Kernrohr des SIPRE-Systems von Jon's Machine Shop in Fairbanks, Alaska. B = STIHL BT 121 Motorkopf (Foto: Alexey R. Desyatkin).

conveyer transporting upward the debris, especially when fine-grained ground was drilled. The few times it jammed in the ground, the "Quick stop drill brake" mechanism worked well and stopped the auger immediately. Once the auger jammed into the ground and stopped, the brake should be disengaged and the auger run slowly when trying to lift it up. Acting quickly can prevent the debris from freezing to the auger barrel. Recovery from such an event will be time-consuming and power-intensive.

Additionally, the total height of the set used should be mentioned; it has been about 150 cm which resulted in a disadvantageous angle between the equipment and the operator (Fig. 3A) limiting handling and transmission of manpower. The initiation of a new borehole arose as the most crucial moment when full power was needed. A great enhancement could be the addition of a coring barrel of around 50 cm for starting a new borehole. This short barrel could be replaced by the longer one once coring depth increases.

Usually, the cores were retrieved without problems, but in a few cases hard work was needed to retrieve the core from the barrel. The heat generated during the coring process can melt frozen water at the outer face of the core. When drilling was interrupted or completed, this water sometimes refroze rapidly, and the core jammed in the barrel. In that case a small gas-driven laboratory burner was beneficial to heat up the barrel and then the core pusher was used to remove the core from it.

Despite the few solvable problems described, the equipment is worth a recommendation and the samples recovered were of high quality (Fig. 3D). For analyses in the field, the cores were sawed into pieces collecting six small samples from each core while the frozen major remains were kept for future analyses. Coring should be performed while the entire ground is frozen to get good quality samples throughout the entire core from surface to bottom. Additionally, the impact to the natural environment is lower when the ground is frozen, especially when a vehicle is used for transportation.

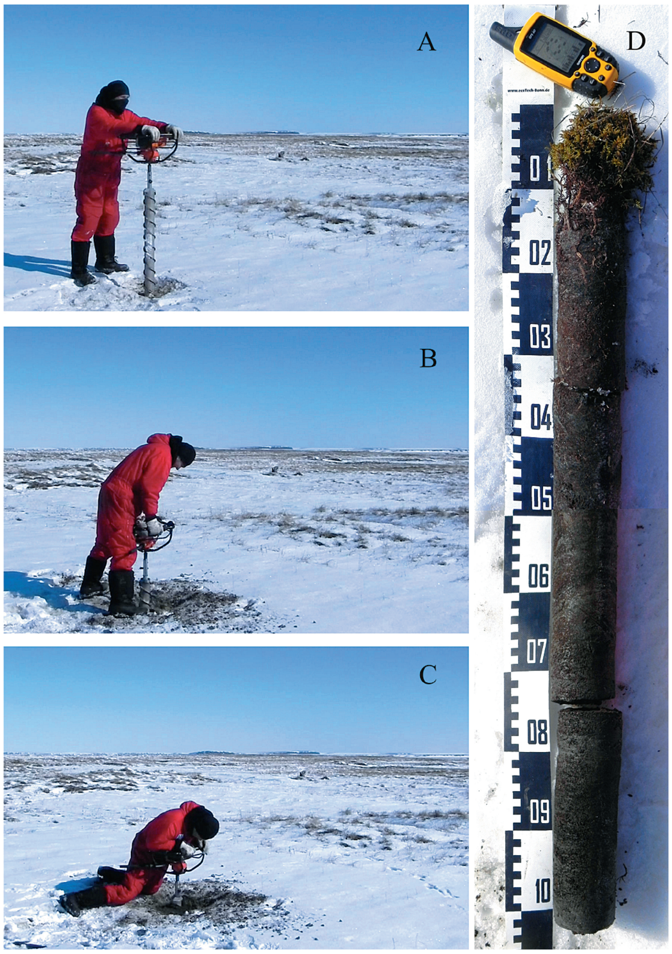

Fig. 3: Fieldwork with the SIPRE auger on Samoylov Island, Lena River Delta, North-East Siberia in April 2011. A, B and C = different stages of drilling progress. D: The result of the hard work – 1 m long core of organic rich permafrost-affected soil.

Abb. 3: Feldarbeit mit dem SIPRE Bohrer auf der Insel Samoylov im Lena-Delta in Nordost-Sibirien im April 2011. A, B und C: Die unterschiedlichen Arbeitsabschnitte beim Bohren. D = Das Ergebnis harter Arbeit – ein ca. 1 m langer Bohrkern eines von Permafrost beeinflussten Bodens mit hohem Anteil an organischem Material.

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