Geophysical Research Abstracts
Vol. 15, EGU2013-2410, 2013
EGU General Assembly 2013

New approaches to subglacial bedrock drilling technology

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Drilling to bedrock of ice sheets and glaciers offers unique opportunities to research processes acting at the bed for paleo-climatic and paleo-environmental recording, basal sliding studies, subglacial geology and tectonics investigations, prospecting and exploration for minerals covered by ice. Retrieving bedrock samples under ice sheets and glaciers is a very difficult task. Drilling operations are complicated by extremely low temperature at the surface of, and within glaciers, and by glacier flow, the absence of roads and infrastructures, storms, winds, snowfalls, etc.

In order to penetrate through the ice sheet or glacier up to the depth of at least 1000 m and to pierce the bedrock to the depth of several meters from ice – bedrock boundary the development activity already has been started in Polar Research Center at Jilin University, China.

All drilling equipment (two 50-kW diesel generators, winch, control desk, fluid dumping station, etc.) is installed inside a movable sledge-mounted warm-keeping and wind-protecting drilling shelter that has dimensions of 8.8 $\times$2.8 $\times$ 3.0 m. Mast has two positions: horizontal for transportation and vertical working position (mast height is 12 m). Drilling shelter can be transported to the chosen site with crawler-tractor, aircraft or helicopter. In case of carriage by air the whole drilling shelter was designed to be disassembled into pieces “small” enough to ship by aircraft. Weight and sizes of each component has been minimized to lower the cost of transportation and to meet weight restrictions for transportation. Total weight of drilling equipment (without drilling fluid) is near 15 tons. Expected time of assembling and preparing for drilling is 2 weeks. If drilling shelter is transported with crawler-tractor (for example, in Antarctic traverses) all equipment is ready to start drilling immediately upon arrival to the site.

To drill through ice and bedrock a new, modified version of the cable-suspended electromechanical ice core drill is designed and tested. The expected average daily production of ice drilling would be not less than 25 m/day. The lower part of the drill is adapted for coring bed-rock using special tooth diamond bit.

Deep ice coring requires a drilling fluid in the borehole during operation in order to keep the hole open and to compensate the hydrostatic pressures acting to close it. At present there are no ideal low-temperature drilling fluids as all of them are environmental and health hazardous substances. The new approaches of subglacial bedrock drilling technology are connected with utilization of environmental friendly, low-toxic materials, e.g. low-molecular dimethyl siloxane oils or aliphatic synthetic ester of ESTISOL^{TM} 140 type. They have suitable density-viscosity properties, and can be consider as a viable alternative for drilling in glaciers and subglacial bedrock.