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Cable-suspended Ice and Bedrock Electromechanical Drill: Design and Tests

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Directly obtaining the subglacial bedrock samples is one of the most important tasks of Antarctic exploration in the future, which has great significance to research the formation and evolution of the Antarctic ice sheet, research the environment at the junction of the ice and bedrock, and research the geologic structure in Polar Regions. To drill through ice and bedrock, a new modified version of the cable-suspended Ice and Bedrock Electromechanical Drill 'IBED' is designed. IBED drill has modulus construction. The upper part includes four sections: cable termination, slip rings section, antitorque system, electronic pressure chamber. The motor-gear system is differed by rotation speed of the output shaft of the gear-reducer. All modulus contain 3 kW AC3 $\times$ 380 V submersible motor. Gear-reducer for drilling in ice lowers the drill bit rotation speed to 100 rpm; gear reducer for subglacial drilling lowers the drill bit rotation speed to 500 rpm. In addition, module for dry core drilling contains vacuum pump for near bottom air reverse circulation instead of liquid-driven pump that is installed into other two variants. The rotation speed of air-driven pump is increased by the gear to 6000 rpm. In modules for drilling with liquid the gear pump is used with capacity of 38-41 L/min and maximal pressure of 0.2 MPa. IBED lower part for drilling in ice consists from two parts: chip chamber for filtration of drilling fluid and collecting chips, and core barrel with the drill bit. The outer/inner diameter of the ice core drill bit is 134/110 mm. Length of the core barrel is 2.5 m. Lower part of the bedrock drill is adapted for coring bedrock and contains standard 2-m length core barrel borrowed from conventional diamond drill string, chip chamber for gravity separation of rock cuttings and dead weights (appr. 200 kg) for increasing of the load on the diamond drill bit. The outer/inner diameters of the diamond bit are 59/41 mm. The IBED drill was tested in order to solve three different tasks: 1) dry core drilling of upper snow-firn layer with bottom-air reverse circulation; 2) fluid core drilling of glacial ice with bottom-fluid reverse circulation; 3) bedrock core drilling. The preliminary tests showed that sawtooth-shape impregnated diamond bit could penetrate into the granite with average rate of 3.18 m/h at low load (3 kN) and torque (28.8 Nm), and the groove-shape impregnated diamond drill bit could penetrate into the same rock with rate of 1.1 m/h at load of 2.3 kN. Moreover, the special control and measurement system of the drill was designed and tested to ensure the safety of drilling.