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# RAPID ICE DRILLING AND CONTINUOUS CORING WITH AIR REVERSE CIRCULATION IN ANTARCTUCA: SYSTEM DESIGN AND RESEARCH PROGRESS

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The acquisition of polar ice cores is of great significance for researching global climate change, searching for ancient biological life forms, analyzing the characteristics of biogeochemical cycles, and revealing the evolutionary laws of glaciers and ice sheets. Currently, there are numerous challenges in polar ice core drilling. To address the bottleneck of low efficiency in traditional polar ice core drilling technologies, a Continuous Coring with Air Reverse-Circulation (CCARC) drilling system has been designed and developed. Through the optimized design of the gas-solid two-phase flow field in the entire borehole, it enables the simultaneous removal of ice chips and rapid coring without stopping the drilling. By integrating core technologies such as reverse-circulation top-drive automated drilling, precise guidance and automatic addition of double-wall drill pipes, adaptive continuous cutting of ice cores at the borehole bottom, intelligent sorting, non-destructive testing, and anaerobic encapsulation and automatic storage of ice cores on-site, it is expected to increase the drilling efficiency by 5 times to 100 meters per day, with the continuous coring depth of 500-1000 meters. This system can achieve the non-destructive preservation of the original structure of ice cores, preliminary dating of ice cores on-site, and quantitative inversion of climate change. It provides key technical support for hot point of polar research, such as revealing the climate change mechanism of the Last Interglacial, analyzing current climate abrupt changes, predicting future global changes, and exploring ancient ice core drilling target areas at the bottom of ice sheets.

This CCARC drilling system uses air, an easily obtainable and environmentally friendly medium, as the circulating fluid for polar ice layer drilling, thus avoiding the harm of low-temperature drilling fluids to humans and the polar environment. By developing the reverse-circulation drilling technology with double-wall drill pipe in polar ice layers, compressed air reaches the borehole bottom through the annular gap of the double-wall drill pipe. It then carries ice chips and ice cores into the central channels of the drill bit and the inner tube of the double-wall drill pipe and quickly returns to the surface, realizing a closed-loop flow of compressed air in the double-wall drill pipe throughout the borehole. This overcomes problems such as the leakage of the circulating medium in the firn layer and the collapse of the borehole caused by the scouring and disturbance of the borehole wall, thereby ensuring safe drilling. By developing CCARC system and process for polar drilling fluids, ice cores can be automatically cut off and quickly transported by pneumatic force, eliminating the need to stop drilling for coring during the entire drilling process and achieving the goal of rapid and continuous coring in the deep polar ice sheets. By developing non-destructive ice physical testing technologies and methods such as ice core spectral scanning, dielectric constant (DEP) testing, and CT scanning in the extreme on-site polar environment, as well as multi-stage ice core deceleration devices, intelligent sorting devices, anaerobic nitrogen-filled protection devices, and automatic storage devices, digital imaging, intelligent sorting, protecting and storing of ice cores on the polar site can be realized.

The CCARC drilling system mainly consists of seven subsystems: The full-bore air reverse-circulation continuous coring drilling tool system; The surface rapid drilling system; The rapid drill pipe addition system; The real-time drilling status detection system; The compressed air delivery and post-processing system; The on-site ice core digital imaging, intelligent sorting, and automatic storage system; The mobile working cabin system.

Regarding the key technologies of rapid drilling, ice core breaking and transportation in the CCARC drilling system, preliminary theoretical and experimental research has been completed: established a mechanical model for ice cutting and analysis of factors influencing cutting torque based on ice core drilling process; explored the influence mechanism of cutter structure and drilling parameters on cutting depth of rotary ice-core drill bits; got the regularity of particle size distribution of ice chips produced under various drilling conditions in the process of ice core drilling; obtained key parameters and mechanisms of ice cores autonomously breaking with air reverse-circulation drill systems; acquired the mechanism of ice core transportation with air reverse circulation.

References

Xinyu Lv, Zhihao Cui, Ting Wang, Yumin Wen, An Liu, and Rusheng Wang (2024) Research into mechanical modeling based on characteristics of the fracture mechanics of ice cutting for scientific drilling in polar re-

gions. The Cryosphere 18: 3351–3362. https://doi.org/10.5194/tc-18-3351-2024
Wang R, Lv X, Fan X, Gong D, Liu A (2024) Key parameters and mechanisms of ice cores autonomously breaking with air reverse-circulation drill systems. Cold Regions Science and Technology:104053. https://doi.org/10.1016/j.coldregions.2023.104
Xinyu Lv, Zhihao Cui, Ting Wang, Yumin Wen, Rusheng Wang (2025) Particle size distribution of ice chips produced under varies drilling conditions in the process of ice core drilling. Polar Science 43 (2025):101136. https://doi.org/10.1016/j.polar.2024.101136
Wang R, Liu A, Cao P, Chen B, Sysoev M, Fan D, Talalay PG (2017) Rapid ice drilling with continual air transport of cuttings and cores: General concept. Polar Science 14: 21-29. https://doi.org/10.1016/j.polar.2017.09.004

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