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STUDY ON THE FORMATION MECHANISM OF DEEP HOT-WATER DRILLING BACKWATER CAVITY

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For explore and sample subglacial lakes in polar regions, hot-water drilling has emerged as the most rapid and efficient penetration method（P. G. Talalay et al. 2024）. In a deep polar hot-water drilling system, the backwater system is an essential component , with the backwater cavity playing a pivotal role（Zhipeng Deng et al. 2025）. Located at a specific depth beneath the ice sheet surface, this ice-enclosed void is crucial for storing and recycling water during the drilling process. It also ensures hydraulic equilibrium upon reaching subglacial lakes, thereby enhancing overall drilling efficiency significantly. This study employed scaled-down laboratory model experiments to systematically investigate the formation of backwater cavities under various parameters. The research comprised two initial test series: (1) examining cavity formation using nozzles of different diameters, and (2) analyzing cavity formation with different nozzle divergence angles. These tests identified the optimal nozzle specifications for cavity generation. Subsequently, four sets of experiments were conducted using the selected nozzles, including the formation of backwater cavities with multiple nozzles, the formation of backwater cavities with different hot water temperatures, the formation of backwater cavities at varying flow rates, and the formation of backwater cavities with different nozzle installation angles. By exploring the influence of these parameters on the backwater cavity formation process, the study aimed to determine the parameter settings most suitable for field operations in Antarctica. Based on the experimental findings, the study deduced the appropriate nozzle parameters for Antarctic fieldwork and designed the corresponding nozzle types. The test results indicated that the optimal water spraying speed for backwater cavity formation is 37.23 m/s. For single-row, six-nozzle configurations, fan-shaped nozzles with a diameter of 4.4 mm and a scattering angle of 80° are recommended; for five-row, six-nozzle setups, fan-shaped nozzles with a diameter of 2.0 mm and a scattering angle of 80° are deemed most effective. In summary, this research provides valuable insights into optimizing the design and operation of hot-water drilling systems for polar exploration, laying a solid foundation for future subglacial lake exploration projects.

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