Contribution ID: **45** Type: **Poster preference**

# Model construction and mechanism analysis on subglacial bedrock core breaking during hydraulic reverse circulation continuous coring

*Monday 15 September 2025 15:10 (5 minutes)*

In the field of polar research, acquiring bedrock samples from beneath polar ice sheets is of great significance for reconstructing ancient climates, exploring ancient life, and studying subglacial geological structures, among other related applications. However, subglacial bedrock core drilling is extremely challenging, and to date, there have been few successful cases, with insufficient subglacial bedrock samples obtained. In comparison with conventional rock core drilling methods, hydraulic reverse circulation continuous coring offers significant advantages. To ensure its successful implementation, rock core breaking is a critical issue.

This research systematically investigates the synergistic effects of splitter angle, core diameter, and core length on the breaking force of subglacial bedrock cores during hydraulic reverse circulation continuous coring. A multi-factor coupling model was established based on elastic mechanics and the maximum tensile stress theory, decomposing the breaking force into radial and axial components. The model accounts for the combined effects of bending moment and eccentric compression at the critical cross-section of the rock core, where tensile stress from Fx and compressive/bending stress from Fy determine failure initiation. Nonlinear regression of experimental data revealed high goodness-of-fit for both radial and axial breaking forces, validating the theoretical framework. Fitting parameters showed consistent trends inversely proportional to the rock core's ultimate stress, confirming the model's accuracy in describing the dependency between geometric parameters and breaking force. The results of experimental validation and microstructural characterization show that: (1) As splitter angle increases, breaking force exhibits a non-linear upward trend due to reduced radial bending stress and increased axial compressive stress. Smaller angles promote radial tensile cracking, while larger angles shift the failure mode to mixed-mode (tensile-shear) cracking, requiring higher F to overcome frictional resistance and stress concentration at mineral interfaces. Microstructural analysis via polarizing microscopy showed that mineral grain interfaces act as preferential crack nucleation sites, aligning with theoretical predictions of stress concentration effects. (2) The core diameter demonstrates a positive correlation with radial and axial breaking forces, primarily governed by geometric size effects. Radial breaking follows flexural mechanics. Axial failure originates from combined shear-tensile stress, showing nonlinear enhancement in load threshold through section modulus and moment of inertia. Smaller diameters favor low-energy fracture propagation along mineral interfaces, while larger diameters override interface density effects through geometric superiority. Material strength degradation rates remain negligible compared to the core diameter-driven geometric reinforcement, ensuring geometric mechanisms predominantly govern failure thresholds. (3) The core length exhibits a negative correlation with radial and axial breaking forces, governed also by three mechanisms: Mechanical leverage, eccentric compression and microstructural effects. Increased moment arm in longer rock cores reduces the peak force required for crack initiation via enhanced bending moment. Stress superposition in extended rock cores promotes mixed-mode (tensile-shear) fracture propagation while lowering failure energy thresholds. Mineral heterogeneity amplified by length scales synergistically degrades material ultimate strength through combined mechanical leverage and microstructural weakening. (4) Polarizing microscopy revealed that the material ultimate stress is influenced by mineral composition and grain interfaces in the breaking section. Quartz-rich regions exhibited higher due to their rigid stress-bearing framework, while biotite-rich interfaces, characterized by low shear strength, acted as weak points reducing critical stress thresholds. This microscale insight validated the inverse proportionality between fitting coefficients and the material ultimate stress, bridging macroscopic mechanical behavior with microscopic failure mechanisms.

In conclusion, this research bridges theoretical modeling with experimental and microstructural analysis, clarifying the subglacial rock core breaking mechanism. The findings provide a theoretical basis for designing reliable, efficient hydraulic reverse circulation continuous coring drilling tools that are suitable for polar extreme and complex conditions, addressing critical challenges in subglacial bedrock core drilling. It paves the way for establishing systematic, standardized coring theories in extreme environments, as well as achieving technological breakthroughs in "automatic isometric rock core breaking during hydraulic reverse circulation continuous coring, enabling the acquisition of more and higher-quality subglacial bedrock cores".

**Primary authors:** Dr CUI, Zhihao (Jilin University); Prof. WANG, Rusheng (Jilin University)

**Co-authors:** Dr LV, Xinyu; Ms HONG, Siqi (Jilin University); Prof. TU, Guigang (Jilin University); Prof. PAVEL, Talalay (Jilin University); Prof. FAN, Xiaopeng (Jilin University); Prof. GONG, Da (Jilin University)

**Presenters:** Dr CUI, Zhihao (Jilin University); Prof. WANG, Rusheng (Jilin University)

**Session Classification:** Poster sessions oral introduction

**Track Classification:** Subglacial drilling and sampling