Evaluating the impact of overbreak zone representation on pore pressure distributions

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1. Context

- Reliable **pore pressure estimates** are critical for open pit slope stability analysis.
- Open pit excavation modifies the near-slope rock creating an **overbreak zone** behind the pit face.
- This study evaluates how alternative **overbreak geometries and hydraulic property enhancements** influence simulated pore pressure distributions.

2. Overbreak Review

Conceptual basis: The overbreak zone is a mining-induced damaged shell behind the pit face, generated by blasting and stress relief. It may be separated into a near-face **Blast-Damaged Zone (BDZ)** and a broader **Zone of Relaxation (ZOR)** associated with stress-relief /relaxation domain that develops as the pit deepens [1][2]

Geometry: Reported BDZ thickness varies with blasting practice, bench height and rock mass condition. Alteration may range from <5 m in small controlled-blasted slopes to >40 m in large pit faces [1]. Broader excavation-induced relaxation/damage zones may extend farther into the slope, with reported ZOR widths of approximately 10–30% of pit depth under moderate conditions. [2] [5]

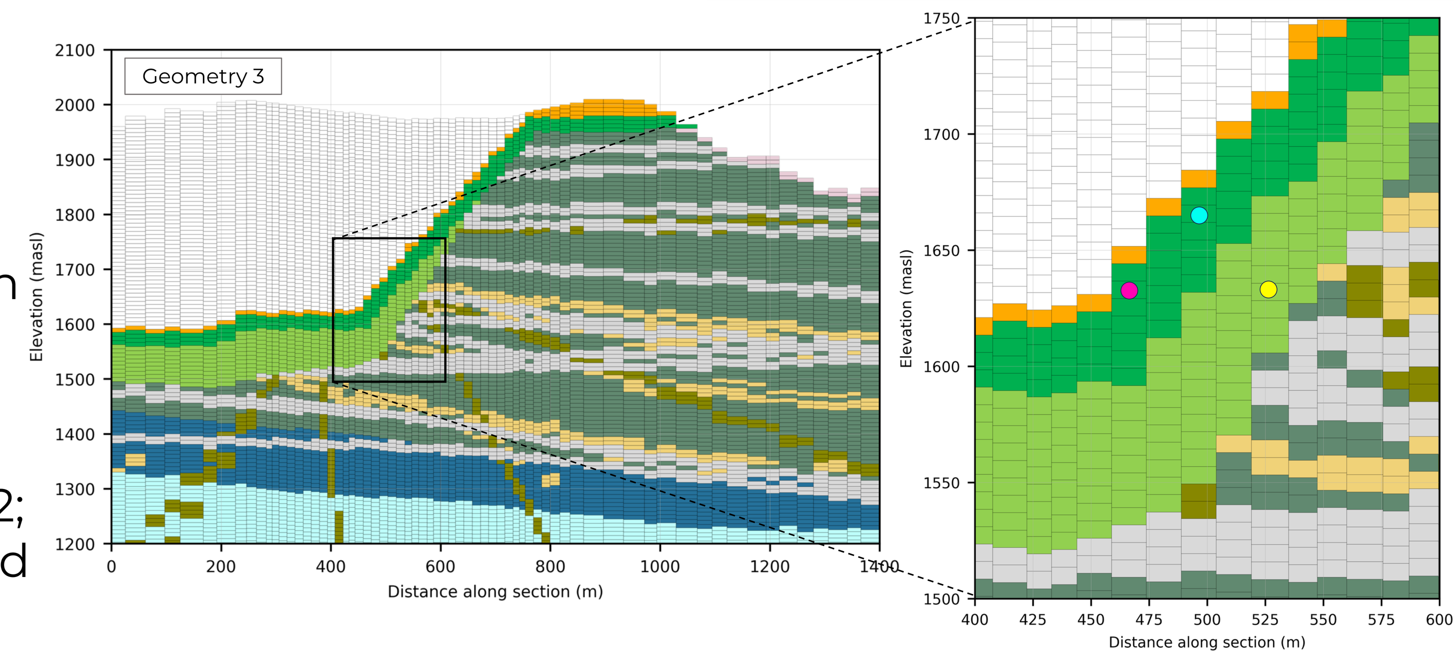
Hydraulic enhancement: Damage and dilation increase fracture frequency, aperture and connectivity, producing higher hydraulic conductivity and enhanced drainable porosity near the pit face. Some conceptual understanding commonly assign blast-damaged zones permeabilities up to ~10^3 times higher than the undisturbed rock mass [1] Others describe the BDZ as a near "free-flow" domain, transitioning outward into a progressively lower-K ZOR [2].

Modelling approach: Practical modelling approaches include assigning enhanced hydraulic properties to the overbreak/relaxation shell (according to pit stage, rock mass quality, structural orientation and faults), using pit-wall drain or zero-pressure boundaries [1]. Explicitly simulate a propagating ZOR by increasing hydraulic conductivity in the rock mass as mining advanced [3].

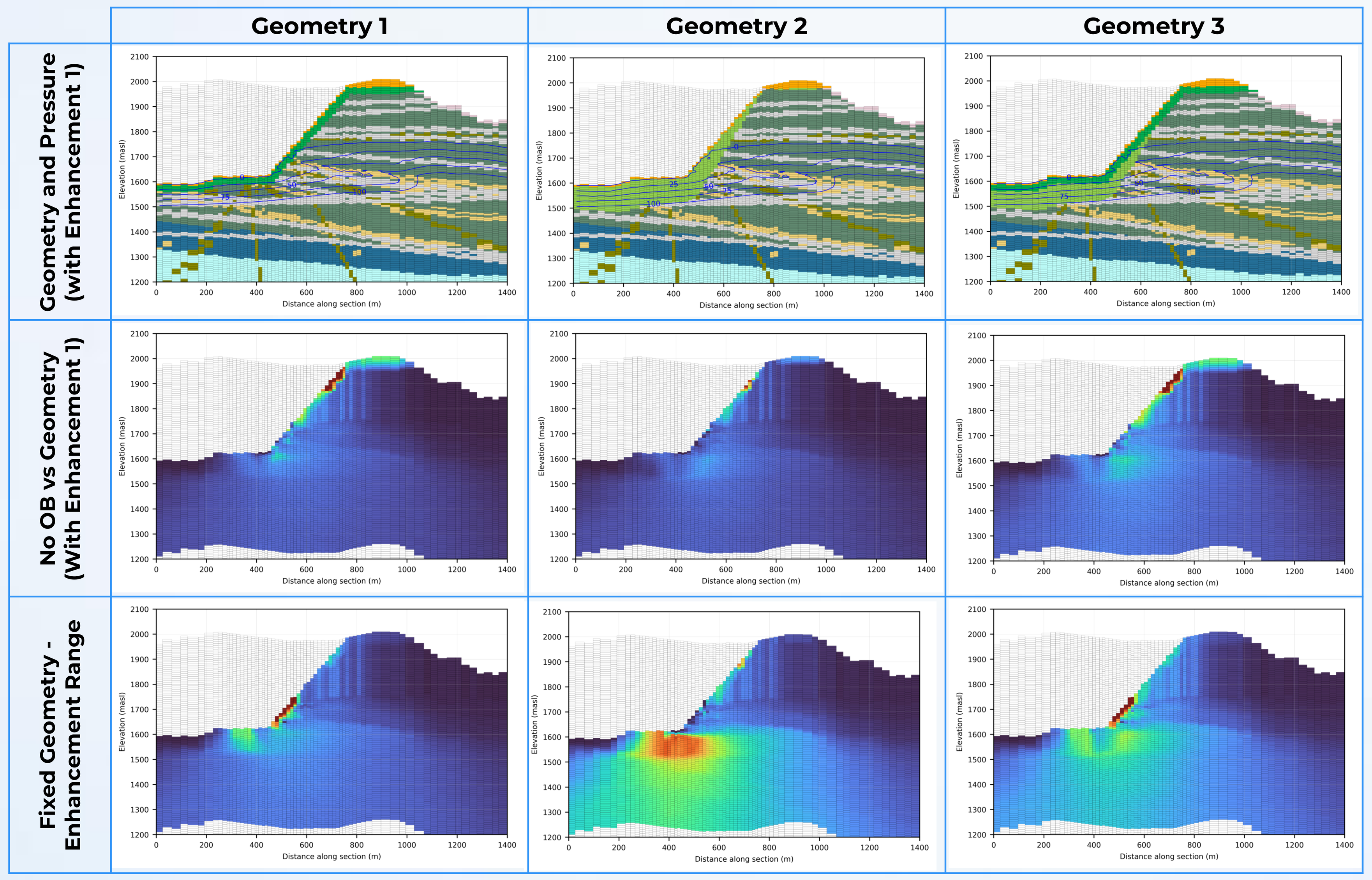
Case evidence: At Diavik, blasting produced rapid VWP responses, including head drops of 12 m and up to 45 m, interpreted as blast-induced drainage and fracture deformation [1]. At Rainy River, VWP data and hydraulic testing showed blast-related pressure responses, and an order-of-magnitude increase in hydraulic conductivity in one area [4].

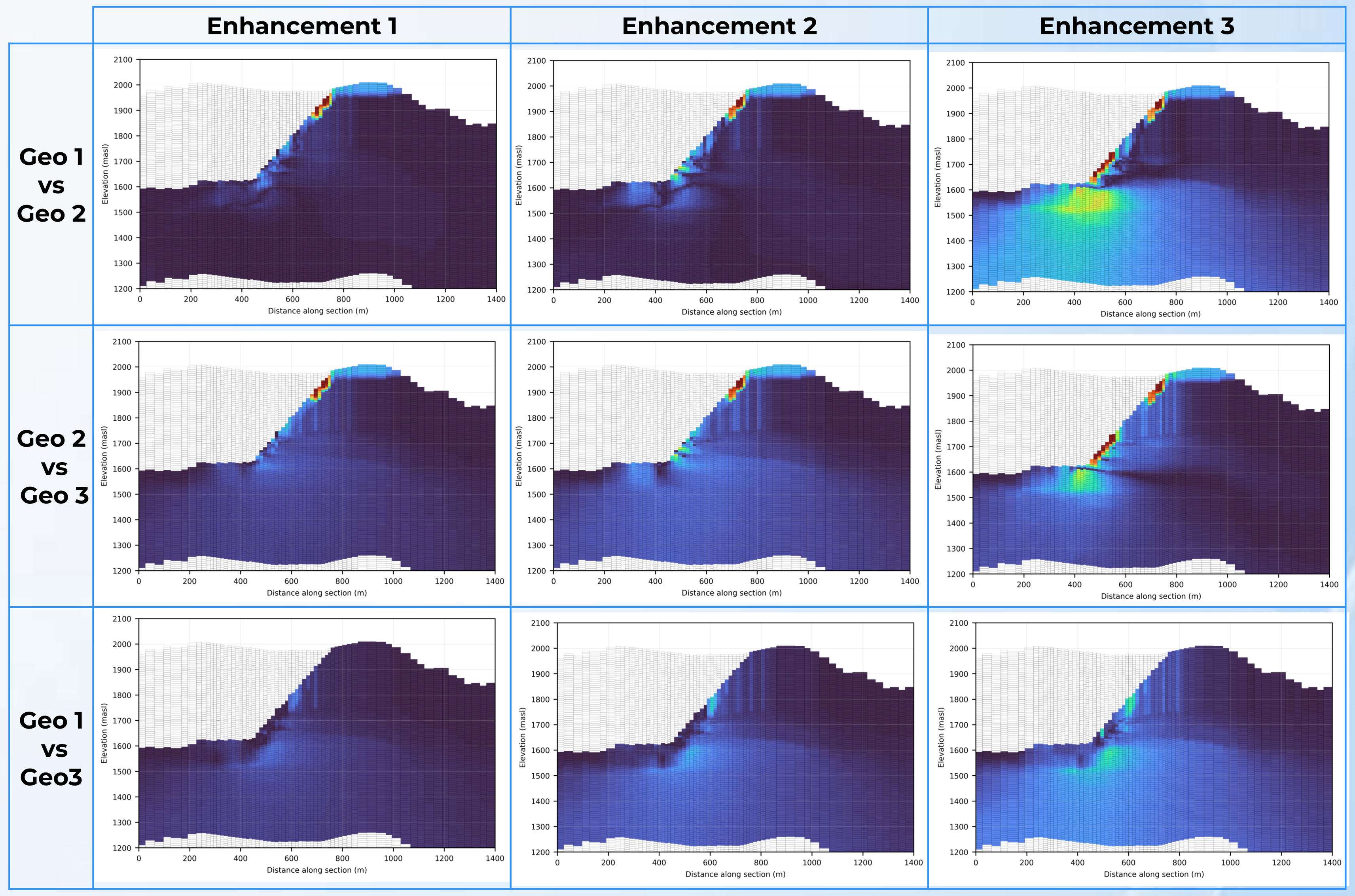
3. Case Study

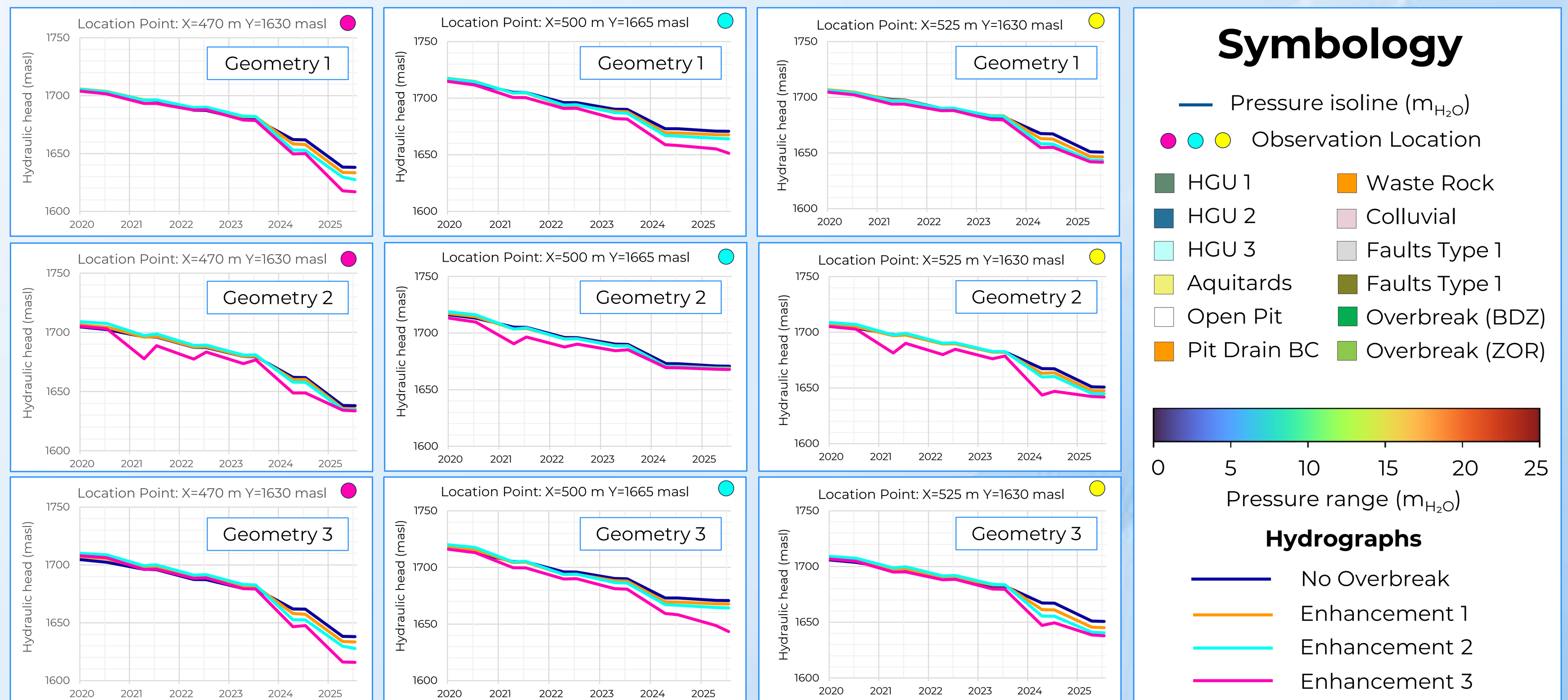
- **Large open-pit mine** in a layered sedimentary sequence, with semi-continuous **aquitards controlling pore pressures through bedding, faults and structural connectivity**.
- **Pit depth ~400 m**; model vertically discretized with 2 layers per bench (**7.5 m resolution**) to capture near-slope pore pressure gradients.
- **Geometry cases** tested: **No overbreak** (No OB), **BDZ-only** (Geo1; 30 m / 2 benches), **ZOR-only** (Geo2; 30% of pit depth), and **BDZ + ZOR** (Geo3), combined with **three hydraulic enhancement** scenarios.



Case	Hydraulic Property Enhancement			
1	BDZ	K = x10 Sy = x2	ZOR	K = x2 Sy = x1.5
2	BDZ	K = x100 Sy = x5	ZOR	K = x5 Sy = x2
3	BDZ	K = x1000 Sy = x10	ZOR	K = x10 Sy = x5







4. Remarks

- **Ignoring overbreak effects** may significantly overestimate pore pressures at the pit face, resulting in **unrealistic slope stability assessments**.
- The highest geotechnical sensitivity to pore pressure assumptions occurs near the pit wall, where excavation-induced stress relief reduces lateral confinement and potential failure surfaces are most likely to develop (at observation locations for case study).
- **Differences of up to ~25 m_{H_2O} in pore pressure estimates** may translate into Factor of Safety variations of approximately 0.1–0.2, potentially impacting mine planning **decisions worth tens to hundreds of millions of dollars**.
- **Multiple overbreak** geometries and hydraulic enhancement scenarios should be evaluated to **quantify uncertainty** associated with BDZ/ZOR representation.
- BDZ-dominated cases produce localized near-face changes, while ZOR configurations control the wider depressurization pattern.

5. References

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