Enguri power tunnel leakage

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The Enguri Dam (Georgia) is one of the highest arch dams in the world, located at Enguri river in the Caucasus, supplying ca. 40% of the Georgian power. In mountainous areas hydropower reservoirs use topography to improve power generation and separate the reservoir and the powerhouse by so-called powertunnels. At Enguri , a 15 km long pressure tunnel with a slope of 0.6° connects the reservoir to the power station. The tunnel is located in karstic limestones with a maximum overburden of 300 m. It was flooded in 1978 with flow rates up to 450 m^3/s. Annual water level changes in the reservoir can reach up to 100 m. The hydraulic pressure generates internal water pressure. Water losses of more than 10 m^3/sec have required extensive rehabilitation work in 2021.
The pressure tunnel is lined by concrete segments separated by construction joints. During the rehabilitation in Spring 2021, a ca. 40 m section of one longitudinal construction joint with a gaping fissure and several smaller cracks have been observed in the tunnel. To explain why only one construction joint was leaking, we combined field observations with numerical modelling of the stress state around the pressure tunnel. To infer the regional tectonic stress-field various stress indicators have been used like borehole observations (borehole televiewer data) in the field, hydraulic fracturing, earthquake focal mechanisms.
The first approach is based on a static linear-elastic 2D cross section model of the tunnel at km 13.7 within a limestone of homogeneous material properties. The profile is parallel to the direction of the maximum horizontal stress, which corresponds to maximum principal stress. The vertical stress is the minimum principal stress. The results show a symmetrical distribution of tensile and compressive stresses around the tunnel, with the axis of symmetry tilted by ca. 30°. Therefore, tangential tensile stresses are observed on the downslope side in the region of the construction joint, while compressive stresses are expected for the upslope construction joint.
Therefore, it can be concluded: (A) the initial stress state is an important parameter for the positioning of underground installation like pressure tunnels especially in areas of high topography. (B) that geomechanical numerical modelling can help to design and dimension safe constructions.
This kind of investigations can help to omit leakage which can lead to a reduction of the capacity of the power plant and to prolongate the integrity of the tunnel statics. Further investigations could consider the hydraulic situation of the Karst rock in the surrounding of the tunnel.

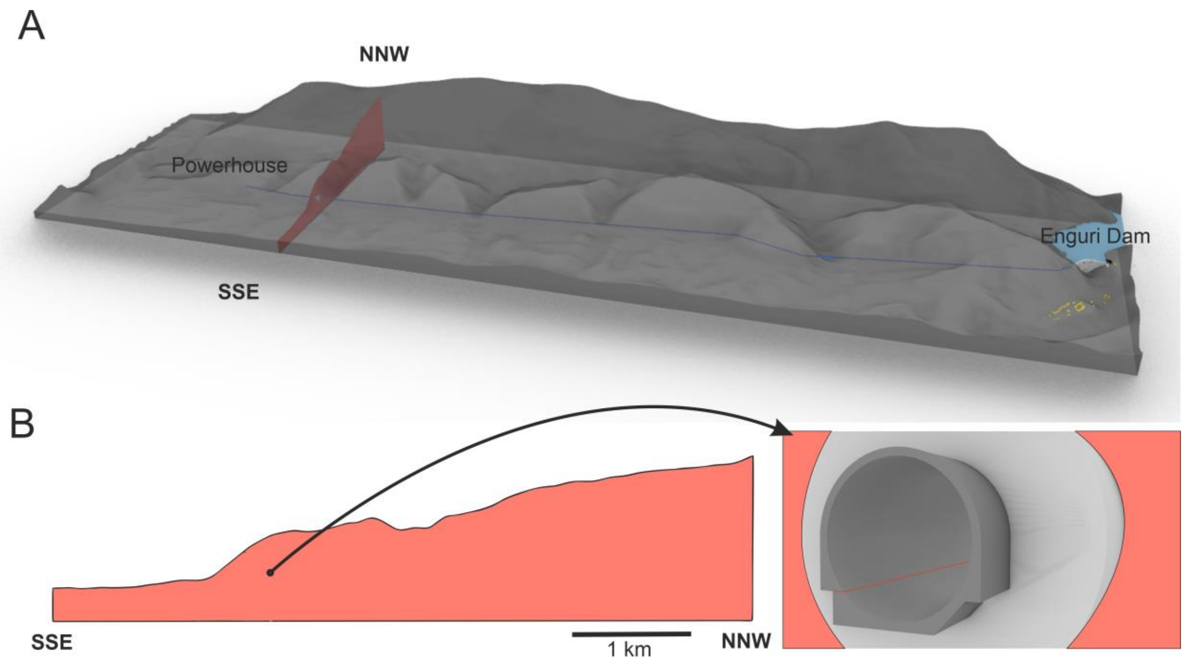

Figure: A) The blue line indicates the power tunnel trajectory. B) modelled cross section with the power tunnel (dark grey: cemented lining, light grey: grouting area, red line: open longitudinal construction joint)