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Tidal characterization of the Liappey fractured aquifer, Bagnes (VS)

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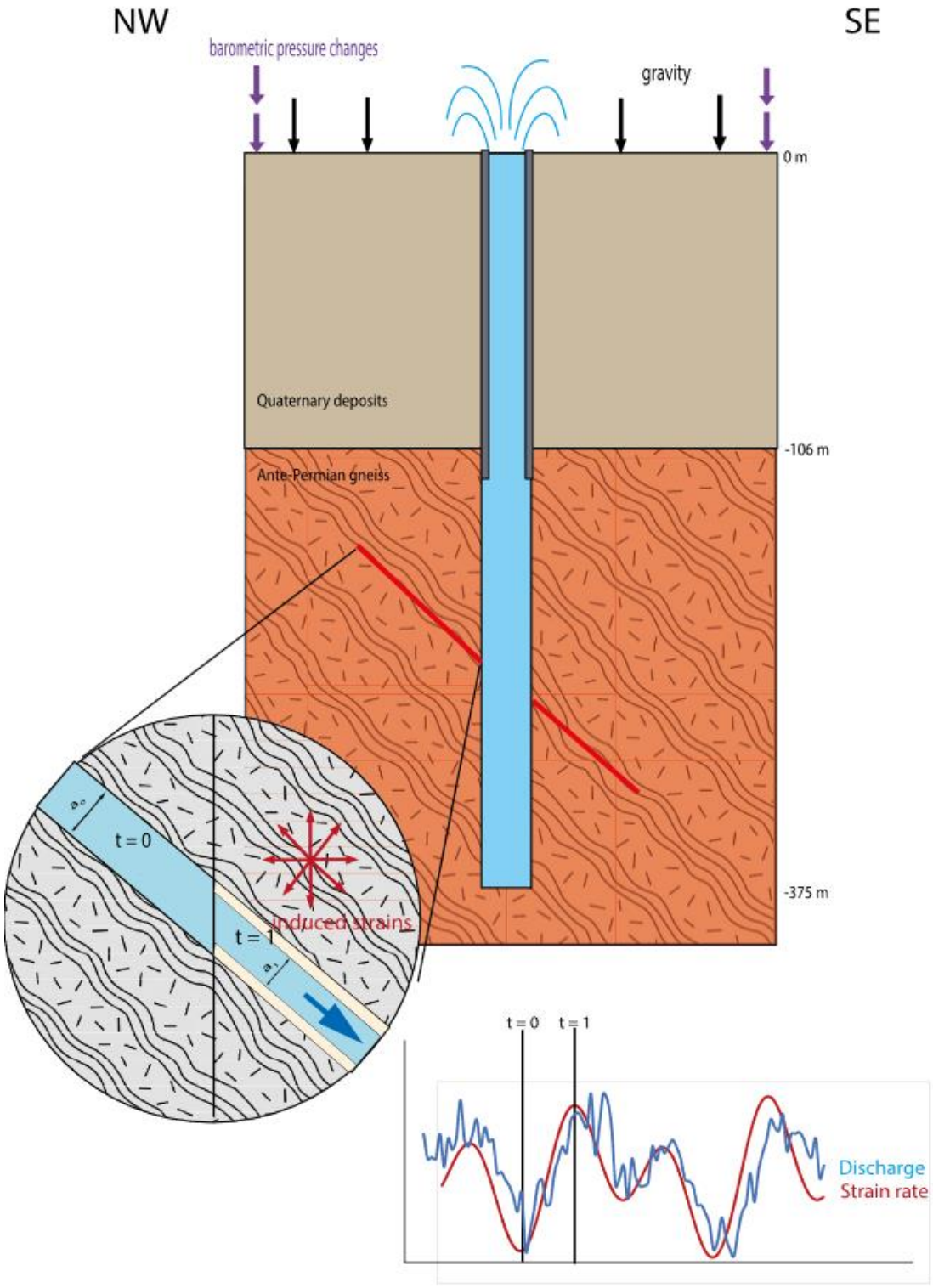
This master's degree work aims at characterizing the deep fractured aquifer of Liappey in Bagnes (VS), using its strong response to solid Earth tides. The Earth tides strain cyclically closes and opens up the fractures, increasing and decreasing pore pressure. The increase in pore pressure causes higher discharge at the well.

The aquifer, a fractured ante-Permian gneiss, was the object of geothermal investigations by the Bagnes commune, and the artesian CHA-1 bore was drilled. Moreover, the wellbore was examined in another master's thesis by Michael Dorner (2017). This work's main focus is the use of tidal analysis to infer aquifer properties, fracture orientation and understand the flow dynamics. The goal is to explore different models and methods in tidal analysis and verify their use for the CHA-1 well. To this end, the discharge of the flowing well was continuously monitored for a 6 month duration, and logging (optical and flow log) was performed in the well.

The logging exhibits a well with importantly damaged walls, as well as large collapses; and a general SE dip direction of the fracturation, with principally subvertical fractures. The tidal analysis reveals that there is a large discrepancy between the discharge response to tides in 2017 against 2023, including the phase shift going from negative to positive. Moreover, the use of tidal analysis permitted the estimation of the orientation of the average hydraulic transmission in the aquifer, yielding results congruent with the fracturation analysis, demonstrating that the method is promising for fracture orientation estimation. In the end, the analysis leads to the interpretation that the flow in the Liappey well-aquifer system has evolved from a horizontally dominated permeability to a bi-directional permeability, with a sharp increase in vertical flow, probably associated with degradation of the cementing around the well, resulting in an increase in vertical exchanges between the waters of the Quaternary sediments and those of the fractured aquifer.



Single-fracture response conceptual model of the CHA-1 borehole. At t = 0 (extension), the fluid pressure decreases and at t = 1 (compression), the fluid pressure increases with normal stress on the fracture, increasing flow into the well following the tidal strain. The fact that the fracture reacts to the tidal stress normal to it allows for fracture orientation estimation.