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Storage of nuclear waste underground in Forsmark, Sweden

There are many issues one has to consider when faced with long-time storage of radioactive waste underground. For example, how will future earthquakes and possible leakage of nuclear waste affect the waste storage? And what is the importance of deformation zones (weak zones in rock) in safety assessments regarding the storage? A team of geologists has been working for decades at the nuclear power plant in Forsmark, Sweden to answer such questions.

A critical aspect is to know the nature of major deformation zones within and around the target area since they directly affect the feasibility and the safety of underground radioactive waste storage. A deformation zone is in essence a 2-dimensional plane along which the bedrock has been weakened and deformed. One can assume that when new stress is applied to a rock volume where pre-existing deformation zones are present, the new deformation will preferentially be partitioned along these zones, basically following the rule of 'least resistance'. Depending on the prevailing pressure and temperature (both mainly a function of depth) during deformation, the deformation zones may be plastic (ductile) or brittle. In a rock volume at Forsmark dominated by crystalline rocks, the nuclear waste will be stored within a tectonic lens that until now largely has escaped deformation. A 'tectonic lens' that is bordered by older zones of deformation will thus represent a suitable volume for storage of nuclear waste. After decades of modelling work and geophysical investigations, we know a lot about the deformation zones in the rock volume at Forsmark. However much less is known about the deformation zones outside the main target area and to what extent these deformation zones can be linked to the existing regional model.

My master-project is integrated in an extensive research project lead by Jesper Petersson (GEOS) & Peter Hultgren (SKB). During two periods of field work in the area around the planned underground repository for nuclear waste, I have investigated and characterized different type of deformation zones outside the main target area. In the area near the deformation zone that borders the Forsmark tectonic lens to the north strongly banded deformation zones are found, indicating a high ductile strain partitioning. Locally, these zones have brittlely reactivated cores. On the island of Gräsö which lies in another tectonic lens north of the Forsmark lens, broad mostly brittle zones of deformation are found which are responsible for broad topographic lows that cross-cut the island. A narrower ductile fabric is locally present at their core. Steeply dipping purely brittle deformation zones which consist of red-stained fracture networks are found on coastal outcrops on western Gräsö. These are suggested to be formed as a result of a much younger tectonic event than the beforementioned ductile-brittle deformation zones.

Purely brittle deformation zone (red-coloured broken-up rock) in a rock exposure on Gräsö's western shore.

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