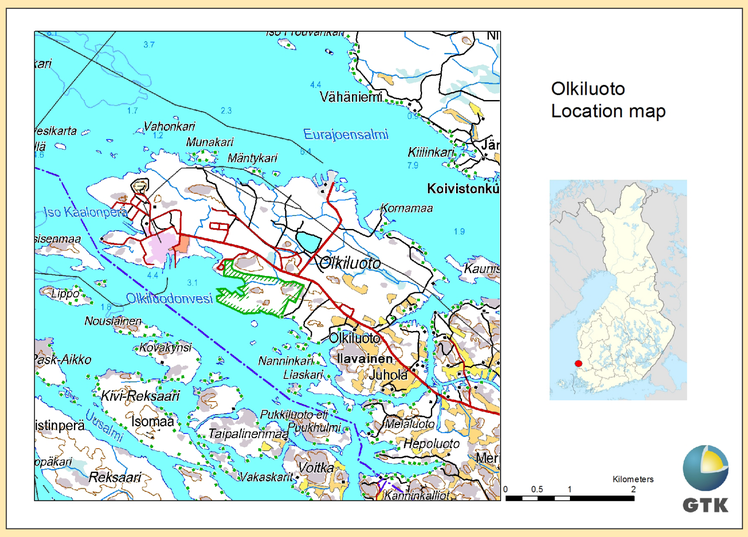
Geophysical studies serving the brittle deformation model of Olkiluoto

Introduction

In Finland, Posiva Oy is preparing for the final disposal of spent nuclear fuel waste deep in the crystalline bedrock of Olkiluoto, Eurajoki, SW Finland. Site characterisation studies in Olkiluoto have been continued for over 25 years. In addition to extensive geological investigations, a wide range of geophysical methods have been applied as airborne and ground surveys as well as in 57 deep drillholes and in ONKALO underground facility. Geophysical surveys have provided an important tool in locating brittle deformation zones and in assessing their properties, orientations and extents in Olkiluoto. The methods discussed are different applications of reflection seismics (VSP, 2D and 3D reflection on the ground surface and tunnel seismics) and electrical mise-a-la masse. The geophysical results are examined in 3D and correlated with existing geological data.



Location of Olkiluoto Site.

Vertical seismic profiling

Vertical seismic profiling (VSP) surveys have been carried out as several campaigns in 14 drillholes in Olkiluoto, starting from year 1990 (Original references in Aaltonen et al. 2016). The most systematic feature in the single-hole VSP results is the majority of gently dipping reflectors (dip commonly < 30° to SSE). Since many different geological features may induce seismic reflectors, they have been geologically validated. Using the determined reflector orientations, they have been extrapolated to neighbouring drillholes and checked against geological and single-hole geophysical data.

3D and 2D reflection seismics

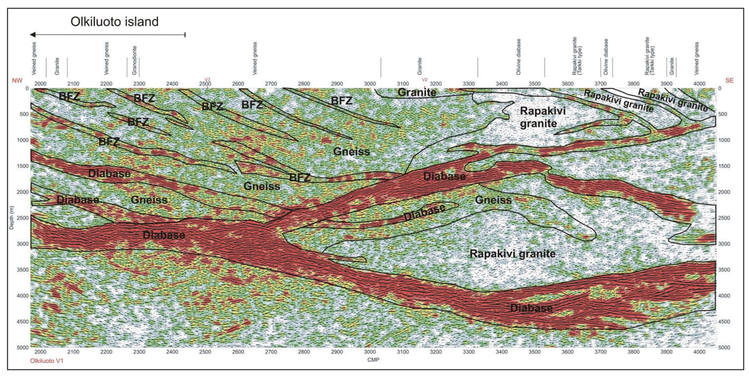
In Olkiluoto, 3D seismic reflection studies on the ground surface have been done as two separate campaigns in 2006 (Juhlin & Cosma 2007) and 2007 (Cosma et al. 2008). In 2008, supplementary high-resolution seismic information was gathered from Olkiluoto and its surroundings, when three HIRE vibroseismic lines were surveyed along the nearby roads (Kukkonen et al. 2009).

Tunnel seismics

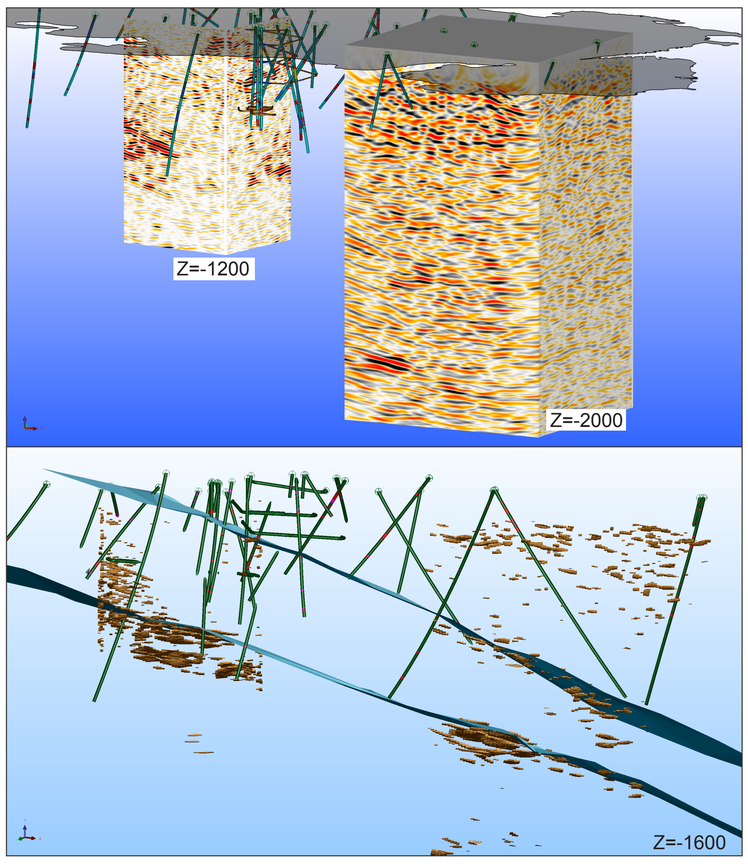
A high-resolution seismic reflection survey in ONKALO tunnel was carried out in 2009 at the chainage of 3350 – 3600 m with 3-component geophones (Cosma et al. 2011). Comparison of the seismic data with geological, geophysical and hydrological features observed in the tunnel indicates that several known structures can be detected as seismic reflectors. However, there were numerous reflectors that could not be unambiguously explained.

Electrical Mise-a-la masse

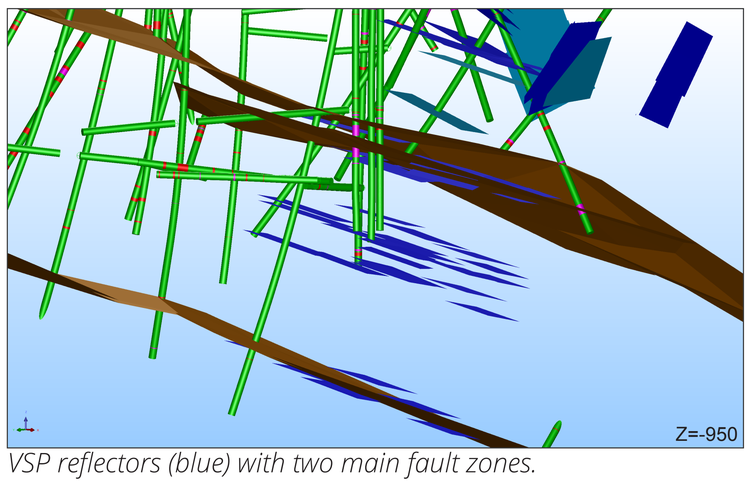
Mise-a-la-masse (MAM) surveys have been carried out in Olkiluoto as several separate campaigns. They have been used in mapping numerous fracture zones, but they also give information on sulphide minerals and possible deformation zones related to sulphide-rich locations. Interpretation of the MAM results includes also extensive numerical modelling.



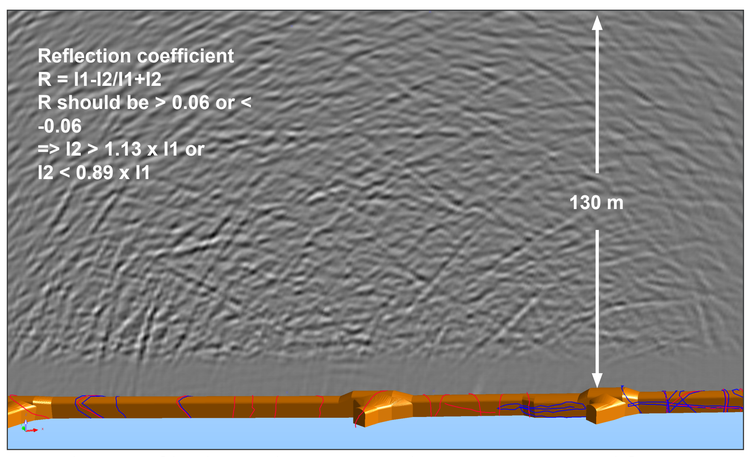
2D seismic reflectors and their interpretation (Kukkonen et al. 2010)



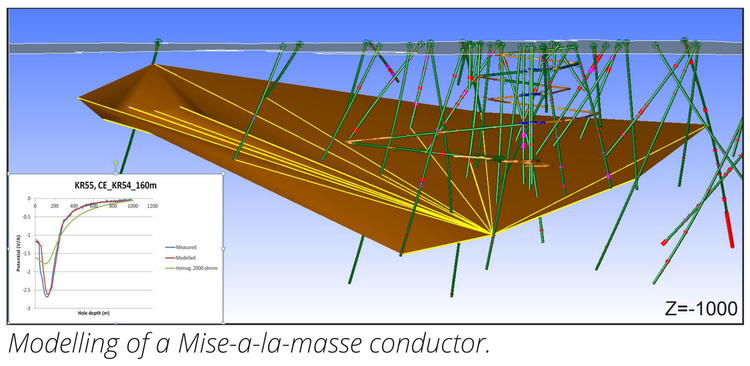
3D seismic reflectors: Amplitude models and blocks of high reflectivity with two main fault zones.



VSP reflectors (blue) with two main fault zones.



Correlation of high-resolution tunnel seismics to tunnel fracturing.



Modelling of a Mise-a-la-masse conductor.

References

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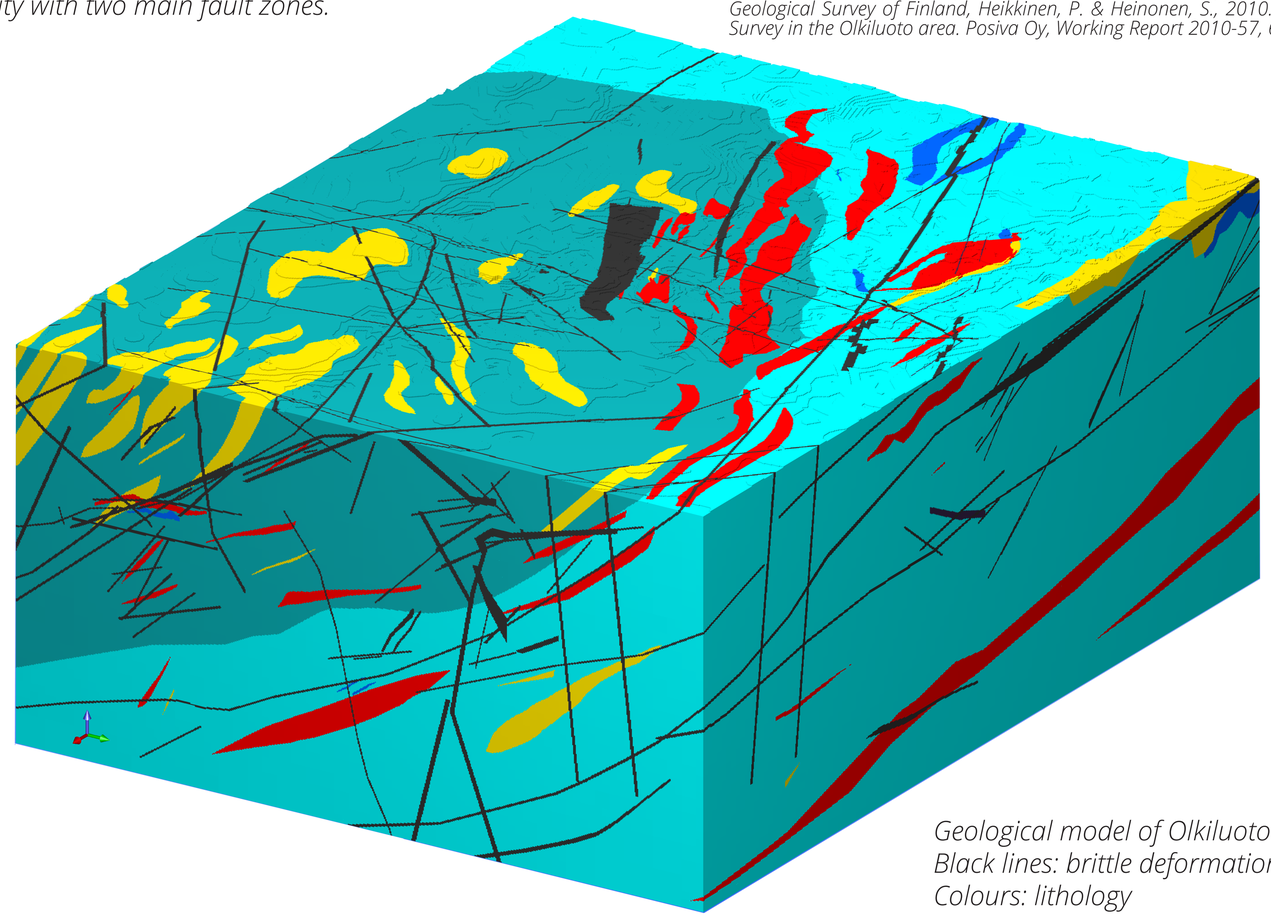

Geological model of Olkiluoto.
Black lines: brittle deformation zones
Colours: lithology

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