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Determination of stress orientation in the Outokumpu deep drill hole, Finland

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A deep borehole in the Outokumpu ore belt served to shed new light on geological-structural setting and on the potentiality of the ore deposits in this area. In the framework of the International Continental Scientific Drilling Program (ICDP) a 2516 m deep borehole was drilled with continuous coring in 2004 in Finland. The main purposes of the Outokumpu Deep Drilling Project were to understand the deep structure of the Outokumpu ore belt, to evaluate the composition of fluids and gases, to investigate the variation in geological and geophysical parameters along the borehole and core samples and to determine the geological nature of strong seismic reflectors in the Outokumpu ore belt in the upper crust at 2-2.5 km depth. In 2006 and 2011 two downhole logging campaigns were performed to acquire a set of geophysical data. Here we present the analyses of borehole televiewer data carried out to (1) constrain the orientation of the maximum stress by mapping the occurrence of stress-induced deformation features (borehole breakouts, induced fractures) essential to determine the local and current stress field and (2) to investigate whether any time dependent deformation of the borehole wall has occurred (creep).

The two primary stress indicators used in this study are borehole breakouts and drilling induced tensile fractures (DIFs). Borehole breakouts and DIFs are stress-induced enlargements of a borehole cross section. For vertical boreholes, borehole breakouts form in the direction of minimum horizontal stress, where the compressive stress concentration is greatest. On the other hand, DIFs form where the tensile stress concentration around a vertical borehole is greatest, in the direction of the maximum horizontal stress.

Results show that stress-induced features (and core disking) start to appear below 1800 m, with roughly a N-S orientation of the maximum horizontal stress. These data offer a unique opportunity to characterize the orientation of the present-day stress field in an area where vanishingly few points are available, as shown also in the World Stress Map. A detailed understanding of the regional stress field is a fundamental contribution in several research areas such as exploration and exploitation of underground resources, geothermal reservoir studies, etc. We discuss the observed stress observations in terms of other results from Outokumpu Deep Drilling project.