

## Outokumpu Deep Drill Hole: Window to the Precambrian bedrock

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Outokumpu Deep Drill Hole is located in eastern Finland, at latitude 62°43'4" N and longitude 29°3'43" E. This 2516 m long and fully cored deep hole has been utilized as a geolaboratory open for researchers worldwide since it was drilled in 2004-2005. The 220 mm diameter drill hole is open without a casing (excluding the uppermost 40 m) and thus provides a direct access to in situ conditions to 2.5 km depth. There is a wide range of wire-line logs carried out by the drilling contractor and later by ICDP (International Continental Scientific Drilling Program) in several logging sessions for geothermal, hydrogeological and deep biosphere studies. Lithology, metamorphism, fluid inclusions, density, magnetic properties, seismic velocities and thermal properties of the drill core have been studied by several international groups. The hole has kept open since the end of drilling enabling future studies to be conducted in it.

The drill hole is situated in the southwestern part of the Outokumpu historical mining district famous for its Cu-Co-Zn sulfide deposits. These sulfide deposits are hosted by 1.96 Ga old ophiolitic rock types, known as the Outokumpu assemblage, also penetrated by the deep drill hole at 1314-1515 m depth. Laboratory and in situ petrophysical measurements have provided valuable information about physical properties of the typical rocks of the area that can be utilized in the mineral exploration efforts.

The drill site of Outokumpu was chosen based on strong reflectivity observed in the high resolution seismic profiles acquired earlier in the area. Outokumpu Deep Drill Hole revealed that these reflections originate from the acoustic impedance variations caused by the ore hosting Outokumpu assemblage. In 2006, surface seismic reflection and vertical seismic profiling (VSP) data were measured in the drill site, and these data show that not only is Outokumpu assemblage rocks reflective but also water bearing fracture at 965 m depth is observed as a strong reflector. This fracture, as well as other fractures penetrated by the drill hole, contains saline water and gases, mainly methane, nitrogen, hydrogen and helium. Salinity of water in the deeper part (>1000 m) of the drill hole has continuously increased since the drilling. Gas-rich water slowly seeps upward and bubble out at the water table. In total, five different water types have been discerned along the drill hole by geochemical and isotopic methods and residence times up to 58 Ma indicated by the accumulation of noble gases. Microbiological studies in the Outokumpu Deep Drill Hole show that not only do different fracture zones act as places for shift in groundwater chemistry but also in the microbial communities.

After a decade of research, Outokumpu drill hole site is geologically well known and thus provides a good environment to test new tools developed for exploration, microbiological or hydrogeological purposes, for example. Geological Survey of Finland is open for new research collaboration projects related to the drill site.