

Ancient ecosystems in crystalline bedrock fractures

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The Fennoscandian crystalline bedrock fractures host microbial communities with versatile features. These communities thriving in isolated environments are possibly forming the oldest known ecosystems on Earth, as they are likely as old as the fracture fluids, up to 58 Ma. Low cell numbers but high diversity is characteristic to the microbial communities of the Outokumpu deep subsurface in Finland. Comamonadaceae, Peptococcaceae and Anaerobrancaceae are prevalent bacterial members of the bacterial communities in the fracture fluids. Archaea are vertically distributed in Outokumpu fracture zones as they are in other Precambrian shields deep sites. Archaeal species with versatile carbon metabolism are more abundant above 1500 m depth, as the hydrogenotrophic *Methanobacterium* dominates the communities below this depth. Both bacterial and archaeal communities in Outokumpu fractures share features with other deep ecosystems. Dominant members of bacterial communities are similar to those detected from serpentinization-driven subterrestrial and surface aquifers. Sulfate-reducing microbial community shares features especially with Witwatersrand deep biosphere. SAGMEG archaea first characterized from gold mines in South Africa are especially abundant in the 967 m fracture in Outokumpu. In addition, Outokumpu fractures present numerous phylotypes with low abundance, i.e. members of the rare biosphere with vast genetic potential to respond to possible environmental changes.