Biogeochemical processes in submarine mine tailings and the impact on benthic fauna

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Mine tailings containing organic process chemicals (e.g. tall oil) from TiO_2 production were disposed inside Jøssingfjorden (1960-1984) and at the fjord mouth at Dyngjadjupet (1984-1994), SW-Norway. As new submarine disposal areas are currently evaluated, it is urgent to investigate the environmental effects of the historical deposits. The amount of organics was significantly reduced after 1984, and this study aims to evaluate how the difference presently affects the benthic environment and fauna. In 2017 and 2018, sediment cores from each deposit, background sediment and water column samples were collected for analyses of geochemistry, microbial community structure and benthic fauna.

At all sites O_2 decreased to below detection within 1-2 cm sediment depth. The pore-water sulfate decreased to below detection at 20-30 cm depth in Jøssingfjorden, but only to 2500 ppm at this depth at Dyngjadjupet. Microbial sulfate reducers were detected in both deposits. High sulfate reduction rates and successive precipitation of sulfides account for low concentrations of dissolved heavy metals inside Jøssingfjorden. At Dyngadjupet and in background sediment, pore-water geochemistry indicates that Mn and Fe reduction dominates and likely explains the higher dissolved Ni content at Dyngadjupet. In Jøssingfjorden, white microbial mats on the seafloor and gas bubble structures in the tailings, together with high methane concentrations in tailings and bottom seawater, indicate leakage of sulfide and methane. This suggests that the use of more organics results in a more reducing bottom environment.

In Jøssingfjorden, biodiversity was low, and more than 90% of the fauna were found in the top 5 cm. The site was heavily dominated by a pollution tolerant brittle star, and the ecological status was poor and very poor. In comparison, at Dyngjadjupet diversity was low but significantly elevated, ecological status was moderate and fauna was detected down to 15 cm. The change in geochemical conditions is thought to account for the differences between the two sites, and these results show that the bottom environments are not restored to natural conditions 30 and 40 years after deposition ceased.