

A natural analogue of enhanced rock weathering: microbial communities in the olivine-rich Papakōlea Beach (Hawaii, USA)

BENJAMIN VANHEURCK¹, DIANA VASQUEZ CARDENAS¹, DR. ASTRID HYLÉN¹, EMILIA JANKOWSKA^{2,3}, DEVON B. COLE^{2,3}, FRANCESCO MONTSERRAT^{2,4}, MATTHIAS KREUZBURG^{1,5}, STEPHEN J. ROMANIELLO⁶ AND FILIP J. R. MEYSMAN¹

¹University of Antwerp

²VESTA

³Hourglass Climate

⁴ARK Rewilding Nederland

⁵Leibniz-Institute for Baltic Sea Research

⁶Vesta, PBLCC

Carbon dioxide removal (CDR) at a gigaton scale is needed within the next 20 years to achieve climate stabilization. Enhanced weathering of silicate minerals, such as olivine, in coastal environments is a promising CDR strategy, as it enhances the ocean's alkalinity and therefore increases CO₂ uptake. In addition to alkalinity, olivine weathering also releases Mg- and Fe-ions, silica, and trace metals (notably Ni & Cr). These weathering products may potentially impact local sediment microbial communities via pH shifts, fertilization, or metal toxicity. To investigate these effects, we studied microbial communities at Papakōlea Beach, a natural olivine-rich beach (~70% olivine) located in an exposed embayment at Big Island (Hawaii). We compared them to Richardson Ocean Park, a nearby sheltered embayment with lower sediment olivine content. At both sites, we characterized the sediment mineralogy and porewater geochemistry, and analyzed the microbial community via 16S rRNA amplicon sequencing (up to 21 cm deep).

Both beaches harbored predominantly aerobic, heterotrophic bacteria, but their microbial community structure differed significantly. Within each beach, microbial community structure remained stable across depths, suggesting a well-mixed sediment matrix due to strong advective flushing, typical of coarse sediments. Papakōlea exhibited lower diversity, with *Bacillus* dominating (50%) and only five genera providing over 80% of the community. In contrast, Richardson had no dominant taxa at genus level and supported more phototrophic organisms, which coincided with higher sediment chlorophyll-*a* concentrations. Despite Papakōlea's high olivine content, we found no clear link between sediment mineralogy and microbial community structure, as similar communities were observed across stations with varying olivine content. We propose that differences in hydrodynamic disturbance —Papakōlea's high wave energy and exposed setting versus Richardson's sheltered conditions—along with variations in primary production, are the main drivers of microbial community structure in these two beaches. Our findings highlight the role of coastal hydrodynamics in shaping