Geomorphic Contexts Drive Divergent Microbial Succession in Antarctic Glacier Forefields

Abstract

Long-term glacier recession is closely linked to post-glacial geomorphic evolution, resulting in distinct landscape types—such as Holocene raised beaches formed through isostatic rebound and exposed slopes or hilltops revealed by glacier recession in highland regions. To determine whether the temporal succession of soil microbial community differs between these geomorphic contexts, we assessed bacterial and fungal community changes along the chronosequences of two typical post-glacial landscapes in Antarctica: Ardley Island (AI), featuring soils ranging from 200 to 7,200 years, and the Barton and Weaver Peninsulas (BP), with soils spanning 1,000 to 15,500 years in age. Although both regions exhibited clear temporal gradients in soil development, microbial successional trajectories differed significantly across geomorphic backgrounds. On Ardley Island, bacterial communities showed distinct, directional shifts in diversity and composition over time, whereas no clear temporal trends were observed in the Barton Peninsula. Fungal communities in both regions displayed no significant temporal changes. At both sites, elevation emerged as a stronger predictor of microbial community variation rather than soil age. The assemblies of microbial communities at both sites were consistently dominated by stochastic processes, with their relative contributions remaining stable over time. Yet, as pedogenesis processes, species interactions within microbial communities became increasingly complex—except for fungal communities in BP—and microbial functional profiles exhibited predictable changes with advancing soil age across both glacier retreat areas. Our findings highlight the role of geomorphic differences in shaping the patterns and mechanisms underlying microbial community succession in post-glacial landscapes, providing a new perspective for understanding microbial dynamics across diverse glacial landforms.