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Age and geomorphological controls on geo-bio successions in a sub-Arctic glacial forefield.

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Recently deglaciated areas are unique environments to study the initial development of soils through the alteration of exposed rocks due to weathering and microbial processes. Carbon (C) and nitrogen (N) contents as well as soil pH and soil elemental compositions are thought to be important controls of variations in microbial communities in the early stages of soil ecosystem development. However, the functional linkages between C and N contents, soil composition and microbial community structures remain poorly understood. To address this gap, we studied the correlations between weathering progression, C and N distributions and microbial community structures along a well-dated, 113 years chronosequence in the glacier forefield of the sub-Arctic Fláajökull in south-eastern Iceland. Besides terrain-age since deglaciation, post-deglaciation hydrological and / or slope-related geomorphological disturbances have often been reported to exert a strong influence on patterns of soil development succession in glacial forefields in previous studies. Yet, the relative effect of these two parameters on soil development patterns in glacier forefield has not been quantitatively compared previously. To address this gap, we quantified the relative effects that geomorphological disturbances have on soil development along a shorter transect across a flow channel in the forefield.

Along the chronosequence, we documented a decrease in pH, and soil grain size, accompanied by an increase in clay fraction, soil organic carbon and nitrogen contents. We also observed a progression of weathering along the chronosequence via the relative depletion in silica contents as well as olivine. Additionally, we observed an increasing relative abundance in iron oxides and chlorites as well as an increasing abundance of trace elements (e.g., Cr, Ni and Zn) and a decreasing relative abundance of Sr. Our result showed a concurrent increasing abundance and diversity in the microbial community structures along the chronosequence. Multivariate analyses indicate strong correlations between the microbial community structure and the main geochemical and physical soil characteristics.

Our results show clear correlations between changing geomorphological disturbance levels and physical and chemical soil properties. The changes include variations in soil water contents, soil bulk density and soil grain size distribution, elemental and mineralogical patterns, C and N contents as well as bacterial and fungal community abundance and diversity.

Overall, our complementary and interdisciplinary dataset allowed us to develop a generic framework for how co-succession of microbial and geochemical changes lead to soil development in a sub-Arctic glacial forefield. In this contribution, we also discuss to what extent soil development along our chronosequence can be explained as the result of both terrain age since deglaciation and post-deglaciation geomorphological disturbances.