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Chemical weathering on the glacial foreland of Storbreen, Jotunheimen Mountains, Norway

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Storbreen is a cirque glacier in the Jotunheimen Mountains of Norway. Its Little Ice Age maximum occurred about 1750 when it deposited a well-defined end moraine. Since then it has retreated leaving a series of recessional moraines. All of these moraines have been dated lichenometrically by Matthews (see Matthews, 1992 for a comprehensive summary). We used this series of dated moraines to investigate the early stages of pedogenesis, the early stages of the chemical weathering of cobbles, and the impact of variation between 1750 moraine crest and moraine proximal base positions upon soil chemistry and mineralogy.

The overall pedological research design (Darmody et al. 2005) embraced three distinct elements. First, there was a constant elevation sequence undertaken on the southern flank of glacier foreland with triplicate soil pits excavated at the present glacier snout, on the crests of the AD 1750, 1810, 1870, and 1928 moraines, and finally upon an approximately 10 000 year-old surface beyond the glacier foreland. Second, there was a vertical sequence investigated up and down the 1750 moraine (low = approximately 1165 to 1180 m a.s.l.; middle = approximately 1310 to 1330 m a.s.l.; high = approximately 1400 to 1465 m a.s.l.). This sequence included matched triplicate pits on the 10 000 year-old surface, the 1750 moraine crest, and the 1750 moraine proximal base at all three elevations. Third, there was a skeletal matching of 1750 moraine crest pits on the southern and northern flanks of the foreland at the three aforementioned elevation levels. Within the overall pedological study a reduced set of the moraine-crest sites was used to study the development of chemical weathering within surficial lichen-free-free, surficial lichen-covered, and buried cobbles. Porosity within feldspar minerals was determined with backscatter electron microscopy. The third element of the study compared and contrasted clay mineralogy and soil chemistry up and down the 1750 moraine to determine if the published identification of a 'green zone' had measurable significance beyond the lichenometric one already demonstrated in the literature.

Soils were mostly frigid or isofrigid, coarse textured, and poorly developed Cryorthents (American Soil Taxonomy). There were differences between same-age soils at different elevations, same-elevation soils of differing ages, and soils from moraine crest and base pairs. Primary minerals, quartz, mica, feldspar, and amphibolites dominated soil mineralogy. However, secondary minerals, in particular hydrobiotite, increased with age and elevation. Despite the generally poor soil development, detectable topochronosequence differences in soil and associated weathering trends emerge in this young, cold environment.

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The initial stages of cobble weathering, measured as increasing porosity, were calculated for sets of cobbles taken from in front of the 1998 glacier snout, the 1928, 1870, 1810, and 1750 moraine crests, and from the 10 000 year-old land surface beyond the Neoglacial foreland limit. Findings indicate that cobbles close to the glacier snout are largely unweathered, also weathering is generally weak in the 1928, 1870, and 1810 positions, but statistically significantly higher in the 1750 and 10 000 year-old positions. Weathering of buried cobbles always exceeds weathering of exposed cobbles and may possibly reach a value beyond which it cannot progress while retaining surface cohesion. The degree of weathering on lichen-free and lichen-covered cobble surfaces is not initially distinguishable, but diverges sharply after ~250 years when lichen-covered surfaces experience significantly higher totals. Overall, the weathering trends in cobbles match those found in soils at the same sites.

Haines-Young (1983) demonstrated that there was a clear statistically occurrence of larger lichen thalli, Rhizocarpon geographicum spp., along the base of the 1750 moraine at Storbreen when compared to matching moraine-crest positions. We investigated crest-proximal base pairings to determine if this lichenological phenomenon had a matching soil and/or chemical weathering pattern. Our results were variable, in many instances, e.g., loss on ignition, organic matter, and carbon content, there was no statistically distinguishable results. However, in a limited number of instances, e.g., percentage of the secondary mineral hydrobiotite, statistically different results emerged between matching pairs. We take such differenced to reflect the fact that positional differences that have prevailed for approximately 250 years are sufficient to establish microenvironmental differences in chemical weathering. Such differences are presumed to be associated with ground moisture and temperature variability derived from different, but repetitive, seasonal snowcover differences between moraine crests and bases.

Literature

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