

The white streaks of Kärkevage

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Conventional wisdom once held that weathering in cold climates was overwhelmingly due to physical processes. Rapp (1960) challenged that convention with his publication on landscape denudation in Kärkevage, Swedish Lapland where he made the startling discovery that chemical weathering exceeded any single measured physical denudation process. His interpretation was based on limited analyses of water chemistry where he found total flux of dissolved solids accounted for most mass loss from the watershed. The dominant anion he observed was sulfate. He also observed other features of chemical weathering in the valley including “white streaks of lime” in stream channels on the valley flanks (Fig. 1). While insightful, Rapp offered no mechanism to explain these findings. Our subsequent work in Kärkevage has revealed the driving mechanism of chemical weathering to be acid production from pyrite oxidation.

In this work, we used scanning electron microscopy (SEM) and energy dispersive x-ray fluorescence (EDXF) to examine a variety of coatings found in the valley. Analyses revealed that the “lime coats” are primarily an amorphous aluminum oxyhydroxide sulfate such as basaluminite $[\text{Al}_4(\text{SO}_4)(\text{OH})_{10}\cdot\text{H}_2\text{O}]$, which “paints” surfaces it contacts (Fig. 2). That this is an active process is demonstrated by efflorescence on seasonal vegetation in stream channels. We found no systematic spa-

tial patterns along the valley axes or up the valley wall, either of the coating appearance under SEM or of chemistry by EDXF. Although the “white stripes” were not crystalline and did not contain appreciable amounts of Fe or Ca, in sheltered overhangs among boulders on the valley floor we found other well crystallized secondary sulfate minerals commonly associated with pyrite oxidation, including white crusts of gypsum $[\text{CaSO}_4\cdot 2\text{H}_2\text{O}]$, yellowish coatings of jarosite $[\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6]$, and rust-colored amorphous Fe compounds $[\text{Fe}(\text{OH})_3]$. This difference is due presumably to the pH of the associated waters, because Fe compounds tend to precipitate only at $\text{pH} < 5$, and Al compounds at $\text{pH} > 5$, the pH of the stream water. We believe that pyrite oxidation may be an important early weathering process in many environments. It largely goes unrecognized because it occurs rapidly and typically is only identified in recently disturbed landscapes associated with mining and other large-scale earth-moving activities. An additional implication of our findings is that Rapp may have unknowingly chosen an environment to do his work where the particular geochemistry evokes accelerated chemical weathering. In short, Kärkevage demonstrates that sub-arctic conditions do not preclude intense chemical weathering where other conditions are favorable, but does not establish that strong chemical weathering is a widespread attribute of sub-arctic conditions.

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Fig. 1. View of eastern cliff face of Kärkevagge showing “white streaks” of efflorescence along stream courses

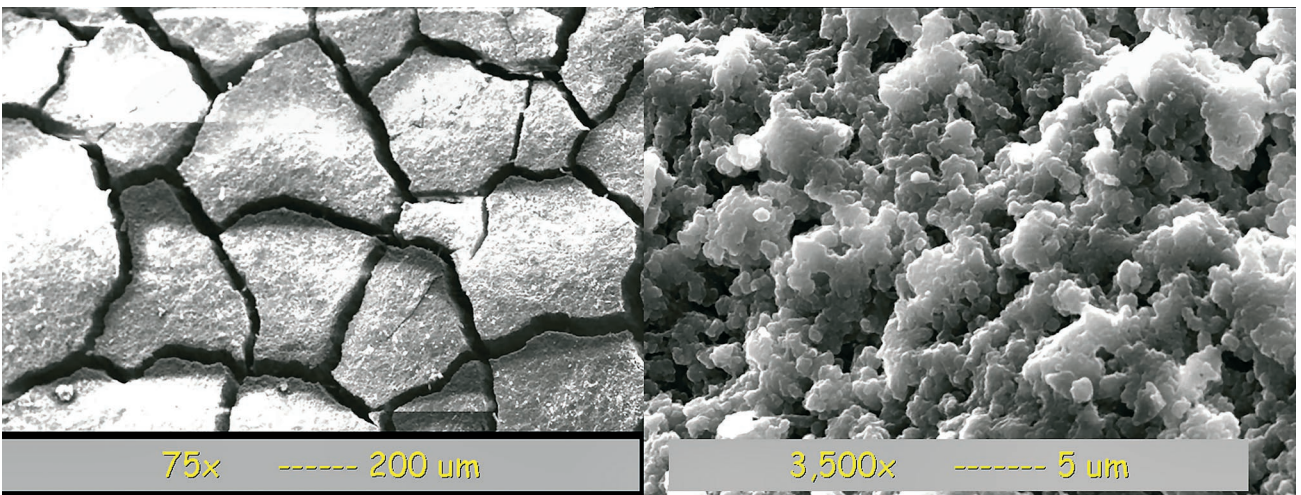


Fig. 2. SEM micrographs of “white streak“ coating a rock outcrop in stream

Literature

Rapp, A., 1960. Recent development of mountain slopes in Kärkevagge and surroundings, Northern Scandinavia. *Geogr. Ann.*, 42: 65–200.