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Rock control on microweathering of bedrock surfaces in a periglacial environment

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ABSTRACT

Microweathering of ice-smoothed bedrock surfaces was investigated in the Røldal area of Hardanger Plateau (60°), southern Norway. Postglacial rates of weathering were determined from surface lowering using quartz veins as reference surfaces. Weathering processes are inferred from assessment of weathering rind formation, surface hardness, and the preservation of small-scale glacial erosional features.

Surface lowering rates for a range of metamorphic rocks vary from 0.05 to 2.20 mm ka^{-1} and are broadly comparable with those obtained from crystalline rocks in other periglacial environments. The mean rate of surface lowering at 0.55 mm ka^{-1} is low and demonstrates the relatively small impact of microweathering on postglacial landscape evolution. Variations in bedrock microweathering can be explained by lithological variation. Amphibolite and mica-rich bedrock surfaces experience greater denudation and weakening, least weathering rind formation, and abundant preservation of glacial striae, despite greater surface lowering. Conversely, quartz-rich bedrock surfaces are most resistant to denudation and weakening, but have greater weathering rind formation and fewer preserved striae. Postglacial microweathering is achieved primarily through granular *disintegration* involving detachment and removal of mineral grains and weakening from increased porosity. Granular *decomposition* is manifest in the formation of weathering rinds. Analysis of interactions between weathering indices indicates that rind accumulation is limited by microerosion.

A conceptual model is proposed that illustrates the temporal interrelationships between in situ and erosional facets of microweathering in two contrasting mineral assemblages. The model proposes that cyclic processes of in situ disintegration, decomposition, and erosion are at work. The relative balance between these processes varies with lithology so that in more resistant quartz-rich rocks the net effect is minimal surface lowering and accumulation of weathering rind. In weaker, amphibolitic and micaceous rocks, the net effect is greater surface lowering and minimal accumulation of weathering rind. The results of the research demonstrate the important influence of rock properties, notably mineral composition, in postglacial microweathering of crystalline bedrock in a periglacial environment.

1. Introduction

Since Yatsu (1966) advocated greater attention to rock control in geomorphology, a call he later reiterated specifically in relation to weathering (Yatsu, 1988), many studies have explored the interrelationships between rock properties, breakdown rates, and landform evolution. Earlier work is reviewed by Matsukura (1994), but examples include the determination of bedrock weathering rates using reference features (Dahl, 1967; André, 2002; Owen et al., 2006) and the role of intrinsic rock properties in microweathering processes (e.g., Matsuoka et al., 2006). The latter include investigations of weathering rind formation (e.g., Chinn, 1981; Colman and Pierce, 1981; Etienne, 2002) and the influence of lithological and structural properties on landform evolution (e.g., Tuğrul, 1997; Glasser et al., 1998; Olvmo and Johansson, 2002). External controls on bedrock weathering processes have also been examined (e.g., Hall et al., 2002) including the role of thermal stresses (e.g., Hall, 1999; Hall and André, 2001) and enhanced weathering associated with late-lying snow-patches (e.g., Thorn, 1975; Ballantyne et al., 1989; Berrisford, 1991; Nyberg, 1991). An understanding of microweathering processes and their effect on rock properties has also been used to aid interpretation of mass movement (Selby, 1980; Douglas et al., 1991) and to reconstruct Quaternary environments (e.g., Ives, 1966; Ballantyne et al., 1998; Sumner et al., 2002; Rae et al., 2004). Nevertheless, few studies have been conducted of postglacial microweathering of crystalline rocks in active periglacial environments. Also, few examples exist of studies that have taken a multiple weathering index approach to provide a more holistic evaluation of process–lithology–environment interactions, though such studies are increasing (e.g., Rae et al., 2004; Matsuoka et al., 2006).

Studies have suggested that postglacial rates of microweathering on crystalline bedrock are low (Dahl, 1967; André, 2002), but that lithological controls can explain much of the variability in weathering rates (André, 2002; Matsuoka et al., 2006) and surface wear characteristics (Thorp, 1981; Glasser et al., 1998). However, gaps

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Fig. 1. Ice-scoured roches moutonnées at Rekkingeskara looking westward toward Valldalsvatnet.

remain in our understanding of the extent to which bedrock lithology has affected rates and processes of microweathering during the postglacial period. For example, to what extent is it possible to link susceptibility to postglacial bedrock microweathering to particular mineral assemblages? Is it possible to identify any patterns in the nature of microweathering (e.g., through surface weakening or in situ rind formation) in relation to rock type and mineral composition? What are the temporal patterns of microweathering during the postglacial period?

This paper presents the findings of a study of rock control on microweathering rates and processes on ice-scoured crystalline bedrock surfaces in an active periglacial environment. The objectives

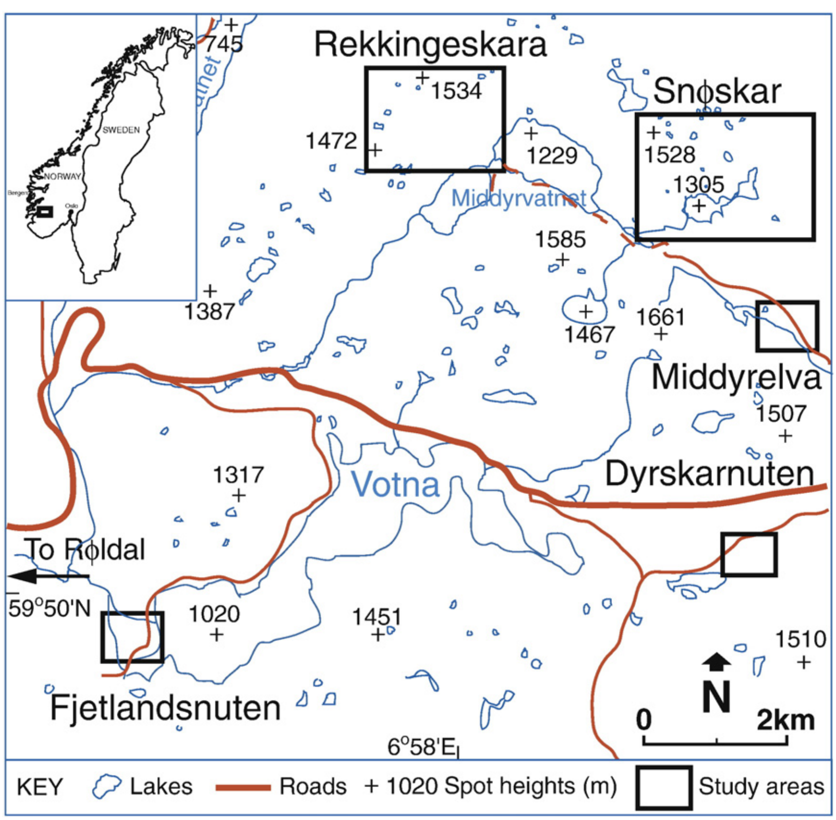

Fig. 2. Location of study localities at Rekkingeskara, Snøskar, Middyrelva, Dyrskarnuten and Fjetlandsnuten and location of the Røldal area in Norway (inset).