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Glacial survival of blockfields on the Varanger Peninsula, northern Norway

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Abstract

For more than hundred years it has been debated whether blockfields in mountain summit areas can be used to delimit the vertical extent of Pleistocene ice sheets. In this study the relationship between blockfields, developed in quartzites and sandstones on the Varanger Peninsula, northern Norway, and glacially derived features have been evaluated. Erratics and circular ablation moraines are superimposed on the blockfields and lateral meltwater channels are eroded into them. Glacial striations and other signs of glacial sculpturing are restricted to low-lying areas with channelled ice flow. Relative ages of the blockfields and the features in them are inferred, and the first measurements of in-situ produced cosmogenic nuclides from the Varanger Peninsula are reported. We conclude that the blockfields have survived underneath at least one thick, cold-based ice sheet. Thus, these blockfields cannot be used as indicators of ice-free conditions as previously suggested for southern Norway. Our results have implications for the potential for land surface preservation beneath ice sheets and for glacial reconstructions in northern Fennoscandia.

Keywords: Blockfields; Weathering; Surface exposure dating; Glacial environment; Varanger Peninsula

1. Introduction

Blockfields as delimiting features on Pleistocene ice sheets have been the subject of debate among geoscientists and botanists in Scandinavia for more than a century. Discoveries of endemic plants and plants with peculiar distributions within Scandinavia or within the northern hemisphere have led to postulations that blockfield-covered summit areas and areas along the coast of Norway acted as refugia during the last glaciation (Blytt, 1876; Sernander, 1896; Nordhagen, 1936; Dahl, 1955; Gjærevoll, 1963; Nordhagen, 1963; Gjærevoll and Ryvarden, 1977; Dahl, 1992). Severe weathering and finds of minerals like gibbsite and kaolinite, indicating pre-glacial development of detritus and blockfield material (Sørensen, 1949; Grønlie, 1953; Dahl, 1955; Mangerud et al., 1979; Roaldset et al., 1982; Rea et al., 1996; Whalley et al., 1997, 2004), were regarded as supporting evidence for ice-free areas. Because high mountains (potential nunataks) are situated close to the coast in the north-western part of southern Norway the majority of previous work has been focused there. Several authors have suggested that the regional distribution of the

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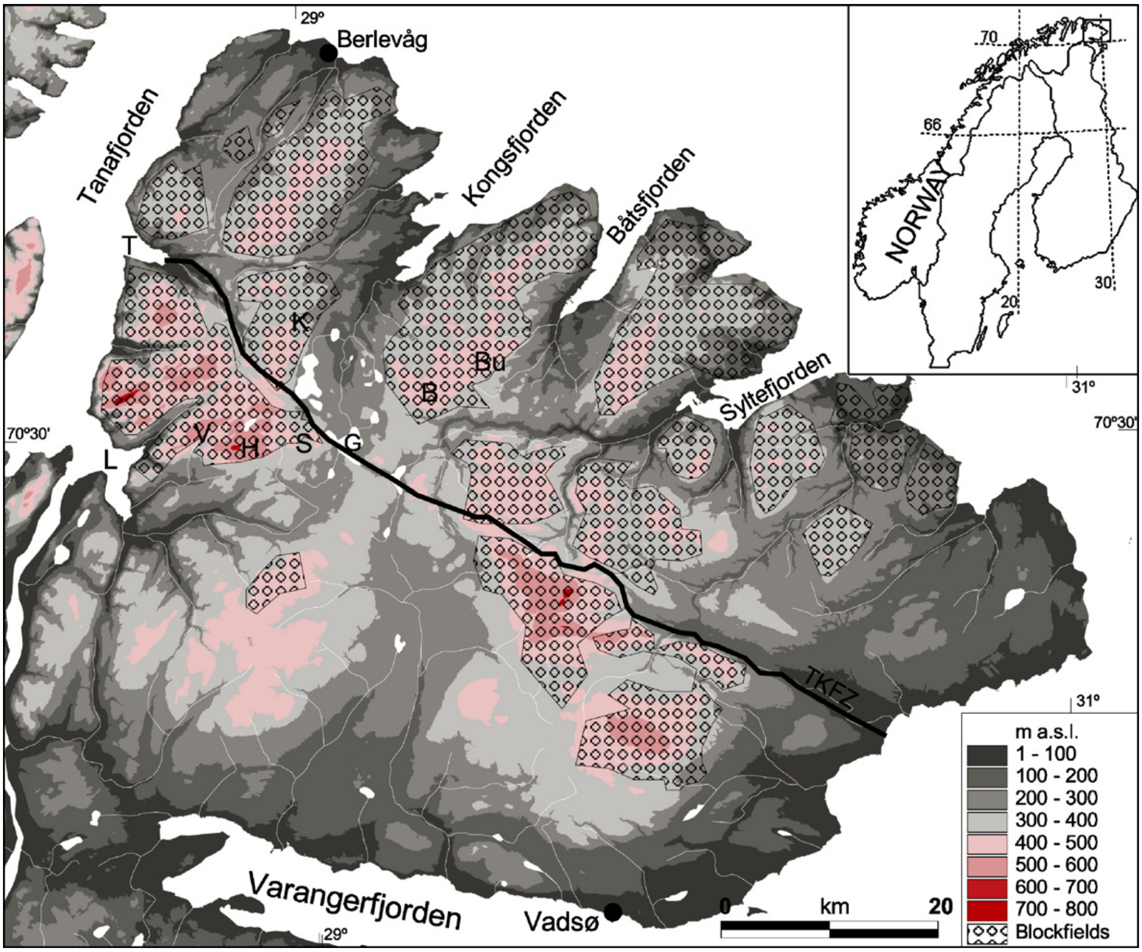

Fig. 1. Map of the Varanger Peninsula showing topography and blockfield distribution. Modified after Malmström and Palmér (1984) and Olsen et al. (1996). B = Baseèearru Mt., Bu = Buhkkaèearru Mt., G = Geatnjajávri Lake, H = Haknalanèearru Mt., K = western side of Kongsfjorden Valley, L = Leirpollen, S = Skuuèohkka Mt., T = Trollfjorden, V = Vag'geèearru Mt.

lower boundary of blockfields represent the upper limit of the last Pleistocene ice sheet (Dahl, 1948; Ives, 1978; Sollid and Sørbel, 1979; Nesje et al., 1987; Rye et al., 1987; Dahl, 1992; Ballantyne, 1997). Exposure dating of bedrock below weathering limits has supported the interpretation of trimlines representing the upper limit of glacial erosion (e.g. Brook et al., 1996; Stone et al., 1998; Stone and Ballantyne, 2006) without providing conclusive evidence regarding the possible existence of nunataks during the Late Glacial Maximum (LGM). Nesje et al. (1988) suggested that the 'lower limit' model could be applied for all of southern Norway implying a rather thin ice sheet in the eastern inland areas. It would also imply erosive (temperate) conditions up to the ice surface even in the interior parts of the ice sheet.

However, growing evidence of cold-based conditions within Fennoscandia (Sollid and Sørbel, 1982, 1984, 1988; Kleman and Borgström, 1990; Kleman, 1994; Sollid and Sørbel, 1994; André, 2002) suggested that blockfields may have survived underneath thick ice sheets. Recent studies utilizing paired cosmogenic nuclides confirm that tors and blockfields can be preserved under ice sheets (e.g. Fabel et al., 2002; Briner et al., 2003; Marquette et al., 2004; Sugden et al., 2005; Phillips et al., 2006). This allows a horizontal and vertical extent of the Late Weichselian ice sheet more in accordance with most glacial reconstructions (Denton and Hughes, 1981; Elverhøi et al., 1993; Lambeck, 1995; Landvik et al., 1998; Näslund et al., 2003; Siegert and Dowdeswell, 2004) as well as with the present glacio-isostatic uplift pattern in Fennoscandia (Mörner, 1979; Fjeldskaar et al., 2000). Furthermore, in a review of modern biological molecular data and fossil evidence Brockmann et al. (2003) concluded that refugia within