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Postglacial seismic activity along the Isovaara–Riikonkumpu fault complex

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ABSTRACT

Analysis of airborne LiDAR-based digital elevation models (DEMs), trenching of Quaternary deposits, and diamond drilling through faulted bedrock was conducted to characterize the geological structure and full slip profiles of the Isovaara–Riikonkumpu postglacial fault (PGF) complex in northern Finland. The PGF systems are recognized from LiDAR DEMs as a complex of surface ruptures striking SW–NE, cutting through late-Weichselian till, and associated with several postglacial landslides within 10 km.

Evidence from the terrain rupture characteristics, the deformed and folded structure of late-Weichselian till, and the ^{14}C age of 11,300 cal BP from buried organic matter underneath the Sotka landslide indicates a postglacial origin of the Riikonkumpu fault (PGF). The fracture frequency and lithology of drill cores and fault geometry in the trench log indicate that the Riikonkumpu PGF dips to WNW with a dip angle of 40–45° at the Riikonkumpu site and close to 60° at the Riikonvaara site.

A fault length of 19 km and the mean and maximum cumulative vertical displacement of 1.3 m and 4.1 m, respectively, of the Riikonkumpu PGF system indicate that the fault potentially hosted an earthquake with a moment magnitude $M_W \approx 6.7$–7.3 assuming that slip was accumulated in one seismic event. Our interpretation further suggests that the Riikonkumpu PGF system is linked to the Isovaara PGF system and that, together, they form a larger Isovaara–Riikonkumpu fault complex. Relationships between the 38-km-long rupture of the Isovaara–Riikonkumpu complex and the fault offset parameters, with cumulative displacement of 1.5 and 8.3 m, respectively, indicate that the earthquake(s) contributing to the PGF complex potentially had a moment magnitude of $M_W \approx 6.9$–7.5. In order to adequately sample the uncertainty space, the moment magnitude was also estimated for each major segment within the Isovaara–Riikonkumpu PGF complex. These estimates vary roughly between $M_W \approx 5$–8 for the individual segments.

1. Introduction

Postglacial faulting occurs when the excess horizontal lithospheric stresses accumulated in Earth's crust during glacial periods are released during deglaciation and postglacial rebound (Wu et al., 1999; Lund et al., 2009). Recent efforts have been undertaken to discover and investigate postglacial faults (PGFs) or potential PGFs in northern Fennoscandia (Lagerbäck and Sundh, 2008; Juhlin et al., 2010; Juhlin and Lund, 2011; Olesen et al., 2013; Sutinen et al., 2014a, 2014b; Ahmadi et al., 2015; Smith et al., 2014; Berglund and Dahlström, 2015; Lindblom et al., 2015; Mikko et al., 2015; Palmu et al., 2015; Malehmir et al., 2015). This is partly due to the availability of new high-resolution digital elevation models (DEMs) derived from light detection and ranging (LiDAR) data, allowing detailed geomorphological analysis and enhancing the discovery of PGF scarps as well as other seismically-induced features, such as paleolandslides and subglacial deformation patterns (Sutinen et al., 2014a, 2014b). Based on their distribution, rupture lengths, and offset heights, Arvidsson (1996), Lund et al. (2009), Kukkonen et al. (2010) and Olesen et al. (2013) suggested that the Baltic Shield is not uniformly quiet and stable in the continental-crustal area as was previously generally assumed, and that the data from larger PGFs in northern Fennoscandia indicate much stronger intraplate seismicity ($M \approx 7$–8) than instrumentally observed ($M \leq 4$) (Ahjos and Uski, 1992; Lund et al., 2009).

The majority of studies have indicated that the PGFs in northern Fennoscandia generally strike SW–NE, are often thrust faults, and represent the reactivation of pre-existing fault zones (Olesen et al., 1992; Kuivamäki et al., 1998; Munier and Fenton, 2004). However, details of

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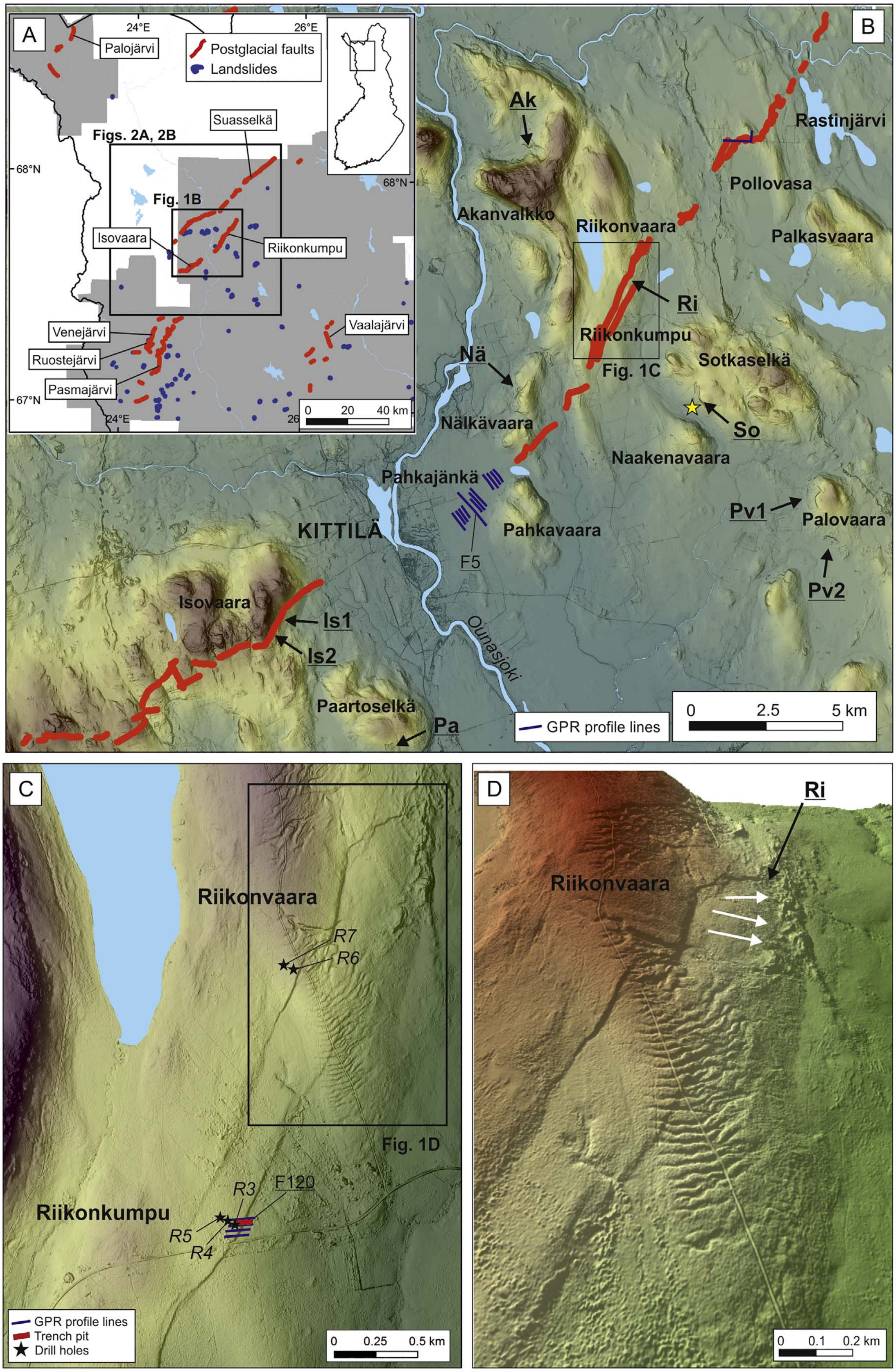

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