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New constraints for the source characteristics, deposition and age of the 2.1–1.9 Ga metasedimentary cover at the western margin of the Karelian Province

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ABSTRACT

The Paleoproterozoic cover sequence at the 100–150 km wide western margin of the Archean Karelian Province is dominated by deep water Lower and Upper Kaleva metasediments. We present here an interpretation of Sm–Nd isotope and geochemical data on 36 samples, TIMS multi-grain U–Pb zircon analyses on nine samples, and ca. 100 SIMS analysis of detrital zircon grains from four Upper Kaleva and one Lower Kaleva samples.

The Lower Kaleva is characterized by autochthonous–parautochthonous, lithologically heterogeneous metaturbidites showing common enrichment in quartz. All the analysed detrital zircons are of a local Neoarchean source but t_{DM} variation up to 2.4 Ga combined with geochemical data indicate abundant mixing of Paleoproterozoic mafic material, presumably from 2.1 Ga plateau lavas and dykes, in most of the Lower Kaleva samples.

The Upper Kaleva is dominantly allochthonous with tectonically enclosed fragments of ophiolite bodies, and it is characterized by lithological and geochemical-isotopic homogeneity. Geochemical, isotopic and detrital zircon data favour material derived from an orogenic domain, comprising both Archean and Proterozoic units, followed by effective mixing during the transport. The Archean zircon grains (25%) are mostly Neoarchean. The Paleoproterozoic grains lack zircons at 2.5–2.2 Ga and plot dominantly (92%) between 1.92 and 2.05 Ga. The indicated maximum deposition ages vary from 1.95–1.94 Ga to 1.92 Ga. The main source area proposed is the Himalaya-type Lapland-Kola orogen (now) in the northeast, which experienced mountain building and erosion at 1.95–1.91 Ga.

The western margin of the Karelian Province shows evidence of rifting and lithosphere thinning from 2.1 to 1.95 Ga but it is still under debate whether the craton breakup occurred at 2.06 Ga in a volcanic or later at 1.95 Ga in a non-volcanic margin setting. One hypothesis is that the onset of collision in the northeast changed plate motion and lead to a new spreading within the pre-existing passive margin at 1.97–1.95 Ga. Thus, both a volcanic margin at 2.06 Ga and a non-volcanic margin at ca. 1.95 Ga could have been operated at the western margin of the Karelian Province.

1. Introduction and general geological setting

The Kalevian (ca. 2.1–1.9 Ga) deep water clastic metasedimentary rocks form the westernmost part of the Paleoproterozoic cover sequence on Archean basement in the eastern part of the Fennoscandian Shield. The depositional age, provenance and, especially, tectonic setting of the Kalevian turbiditic rocks have been debated since the pioneer works by Wegmann (1928) and Väyrynen (1933).

Geochemical and isotopic compositions of sedimentary rocks are widely used in provenance studies, including the tectonic and climatic conditions in the source area (e.g. Nesbitt et al., 1997). U–Pb dating of detrital zircon grains is a tool in establishing the zircon age distribution of the source and also the maximum deposition age of the sedimentary rock. Sedimentary rocks may derive from a local source or may record a complex and long transportation history before the final deposition. The combined use of geochemical and isotopic data with detrital zircon data is a useful method in study of the source characteristics, deposition and age of Precambrian metamorphosed sedimentary rocks.

The northern and eastern part of the Fennoscandian Shield is composed of Archean crust and the central part of the Archean

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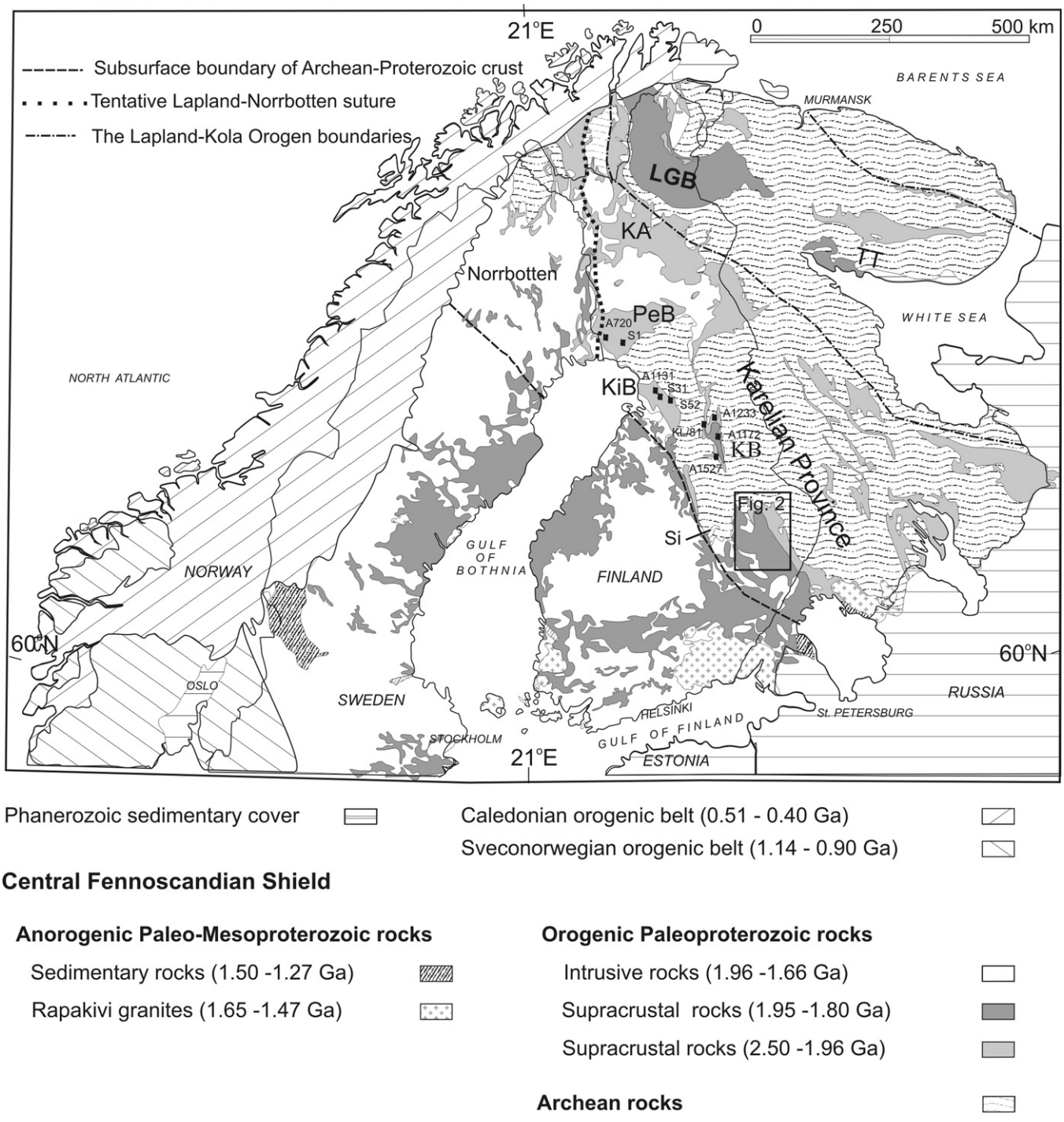

Fig. 1. A simplified geological map of the central Fennoscandian Shield, based on Koistinen et al. (2001). Legend: geological domains: KA, Kittilä allochthon; KB, Kainuu belt; KiB, Kiiminki belt; PeB, Peräpohja belt; TT, Tersk terrane. Locality: Si, Siilinjärvi. Sample numbers refer to Table 1. The subsurface A–P boundary in Sweden modified after Öhlander et al. (1999); Lapland-Norrbotten suture from Lahtinen et al. (2005); outline of the Lapland-Kola orogen from Lahtinen et al. (2009).

block is the Karelian Province (Fig. 1; Hölttä et al., 2008). The Archean rocks are partly, especially in the west, covered by remnants of the Paleoproterozoic (ca. 2.5–1.9 Ga) cover, the Karelian formations. The Archean block is in the west bound across a cryptic suture zone (Koistinen, 1981) to the Paleoproterozoic crust (ca. 1.9–1.8 Ga) forming the composite Svecofennian Orogen (Lahtinen et al., 2005).

As part of a larger Archean continent, possibly the supercontinent Kenorland (Williams et al., 1991), the Karelian Province experienced multiple rifting events between 2.45 and 2.1 Ga finally leading to 2.1–2.05 Ga breakup at the western margin (Lahtinen et al., 2008). The early rifting stages in the Karelian Province are represented by the intracratonic coarse clastics and minor mafic volcanics whereas the final stage at 2.1–1.9 Ga included also deeper water Kaleva sediments (Laajoki, 2005). The transition from shallow water into marine conditions at ca. 2.1 Ga was associated with eruptions of pillow basalts in basins and deposition of turbidite wackes in the continental margin basins. The Jormua and Outokumpu ophiolites formed along the western edge at 1.95 Ga (Kontinen, 1987; Peltonen et al., 1996).