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Preservation of Palaeoproterozoic early Svecofennian structures in the Orijärvi area, SW Finland—Evidence for polyphase strain partitioning

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Abstract

The predominantly migmatitic Palaeoproterozoic Uusimaa belt preserves early lower-grade Svecofennian structures in the Orijärvi area in SW Finland. This study aims at explaining the deformational history responsible for its preservation and also at defining the age of the early Svecofennian deformation. Detailed structural analysis reveals that the preservation was enabled by polyphase strain partitioning, which initiated during the early Svecofennian D_2 deformation, ~1875 Ma ago, as revealed by ion microprobe U–Pb data on zircons from granodioritic and intermediate syn-D_2 intrusive dykes. The D_2 structures were low-strain upright folds at high crustal levels and sub-horizontal high-strain folds at deeper crustal levels. The sub-horizontal D_2 structures were refolded into upright folds during the subsequent late Svecofennian D_3 deformation, whereas the upright D_2 structures behaved as almost rigid blocks that caused strain partitioning into high-strain zones along the block margins. This accounts for the low cumulative strain in specific parts of the Orijärvi area. Further strain partitioning during D_4 caused reverse dip-slip movements along regional-scale shear zones. Crustal depth controlled the metamorphic grade during D_2, when local migmatisation took place at deep crustal levels. Later metamorphic overprint during D_3 deformation is evident from post-D_2 growth of sillimanite and a second generation of andalusite.

Similarities in the structural patterns between the Orijärvi area and the Tampere-Vammala area (~100 km to the north) suggest that irrespective of the age of the later overprint, subsequent deformation was localised along the margins of the early formed upright domains, while the low-grade rocks within the domains were preserved.

Keywords: Structural geology; Tectonics; Fennoscandian Shield; Ion microprobe; Zircon; U–Pb

1. Introduction

The poly-deformed bedrock of southern Finland plays a key role in understanding the Palaeoproterozoic tectonic evolution of the Fennoscandian Shield. Within the present study area, two major events deformed the crust during a period from ~1.89 to 1.81 Ga: The early Svecofennian event at ~1.89–1.86 Ga (Hopgood et al., 1983; Ehlers et al., 2004), and the late Svecofennian tectono-thermal event at ~1840–1815 Ma (Ehlers et al., 1993; Korsman et al., 1999; Levin et al., 2005; Mouri et al., 2005) when high heat flow and associated crustal melting effectively destroyed the older deformation structures. However, the early stages without migmatisation, are well preserved in places such as the Orijärvi area within the Uusimaa belt (Fig. 1;

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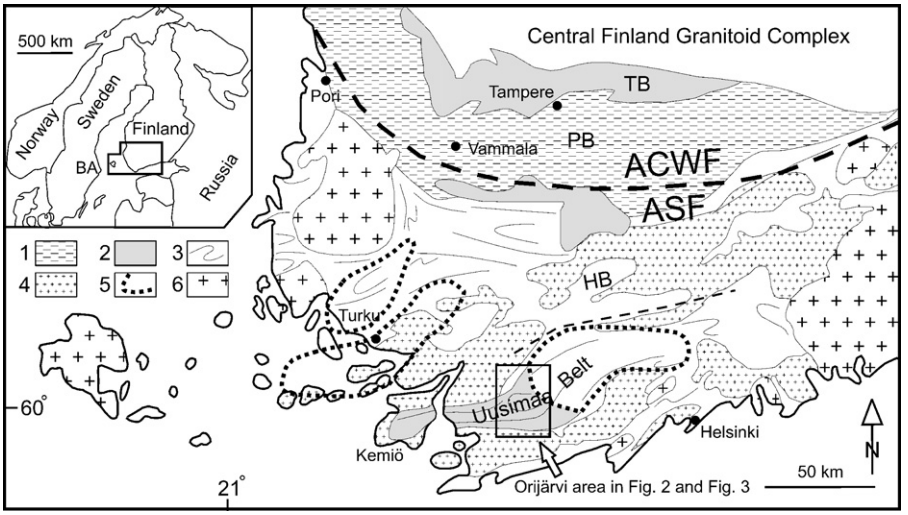

Fig. 1. Generalised geology of southern Finland after Korsman et al. (1997) and Väisänen and Hölttä (1999). Key: (1) tonalitic migmatites, (2) lower amphibolite facies schists, (3) granitic migmatites and other upper amphibolite facies gneisses, (4) late Svecofennian granites ca 1.85–1.81 Ga, (5) granulites, (6) Rapakivi granites (Mesoproterozoic); ACWF = Arc Complex of Central and Western Finland, ASF = Arc Complex of Southern Finland, TB = Tampere belt, PB = Pirkanmaa belt, HB = Häme belt, BA = Bergslagen area (inset). The suture line separating the ACWF and ASF by Lahtinen (1996).

Ploegsma and Westra, 1990; Stel et al., 1999; Väisänen and Mänttäri, 2002; Skyttä et al., 2005), also known as the classical area of metamorphic facies studies by Eskola (1914,1915). Localised preservation of the early Svecofennian structures led to an interest in studying the contrasting tectonic evolution within the well-preserved parts of the Orijärvi area and within the predominantly migmatitic surroundings. Recognition of the different structural domains is particularly important as the two main tectonic events, the early Svecofennian D_1–D_2 and the late Svecofennian D_3–D_4, share approximately the same geometrical properties in many places. The mutual geometrical relationships of the domains are used to provide some tectonic constraints on the preservation of the early structures and regional kinematics of the deformations. These will then be applied in correlating the specific well-preserved, low-strain parts of the Orijärvi area in a wider regional context. Two regional-scale shear zones, the Kisko shear zone and the Jyly shear zone (Fig. 2), have a major significance on the structural evolution of the study area as they separate the early, lower grade and the migmatitic domains. In addition, characteristics of the early tectonic events will be further specified. Another main aim of this investigation was to determine the age of the early Svecofennian deformation within the preserved area. The methods of this study include structural and lithological field mapping, structures in thin sections, and ion microprobe dating of two samples by U–Pb system on zircons.

2. Geological setting

The Fennoscandian tectonic evolution during the Palaeoproterozoic has earlier been attributed to semi-continuous, protracted Svecofennian orogenesis (Gorbatschev and Bogdanova, 1993). The recent model by Lahtinen et al. (2005), however, includes five separate orogens between 1.92–1.79 Ga; the orogenic evolution was divided into microcontinent accretion stage (1.92–1.87 Ga), continental extension stage (1.86–1.84 Ga), continent-continent collision stage (1.84–1.79 Ga) and orogenic collapse and stabilisation stage (1.79–1.77 Ga). The Uusimaa and Häme belts of the Arc Complex of Southern Finland experienced early Svecofennian event at ~1.89–1.87 Ga (Fennian orogeny by Lahtinen et al. (2005)), related to N–S collision (Väisänen et al., 2002; Ehlers et al., 2004) towards the Arc Complex of Central and Western Finland (Korsman et al., 1997). A suture zone separates the Arc Complexes (Fig. 1; Lahtinen, 1996). The collision also involved the Bergslagen area rocks (Lahtinen et al., 2005), which may be correlated with the Uusimaa belt (Allen et al., 1996; Nironen, 1997). The early Svecofennian event was locally associated with partial melting in southern Finland (Hopgood et al., 1983).

Subsequent tectonic evolution involved crustal extension at ~1.86–1.84 Ga (Lahtinen et al., 2005), as revealed by metadiabase dykes cross-cutting early Svecofennian deformation structures (Ehlers et al., 2004),