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Hallandian 1.45 Ga high-temperature metamorphism in Baltica: P–T evolution and SIMS U–Pb zircon ages of aluminous gneisses, SW Sweden

Jan Ulmius[a,*], Jenny Andersson[b], Charlotte Möller[a]

[a] Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden
[b] Geological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden

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ABSTRACT

The southernmost Baltic Shield exposes polymetamorphic continental crust that was largely formed and accreted during a series of 1.92–1.66 Ga Paleoproterozoic orogenic events and later reworked during the 1.14–0.90 Ga Sveconorwegian orogeny. An intermediate period of metamorphism, deformation and magmatism at 1.47–1.38 Ga has been attributed to the Hallandian orogeny, but due to overprinting by Sveconorwegian high-grade metamorphism and deformation, the P–T-t evolution and deformation of the Hallandian event have remained obscure. This study presents the first quantitative P–T model of the Hallandian event using high-temperature aluminous gneisses in the south-easternmost marginal part of the Sveconorwegian orogen. The high-grade metamorphism and spatially associated granite magmatism are dated using U–Pb SIMS analysis of zircon. Petrography, bulk and mineral geochemistry, and pseudosection models demonstrate prograde staurolite-sillimanite-grade metamorphism reaching granulite-facies temperatures (700–750 °C) at low pressures (4–5 kbar), with the formation of Crd + Sil + Grt + K-fsp + Ilm + Melt ± Bt. The rocks followed a clockwise P–T path. Later stages involved the formation of sillimanite + biotite at the expense of garnet and cordierite. Local low-temperature and fluid-assisted retrogression also caused the formation of chlorite and muscovite at the expense of cordierite. Both granite and aluminous gneisses contain complex zircon with inherited 1.70 Ga igneous cores and high-U, secondary zircon, mainly formed by reworking of protolith cores. The latter date the Hallandian high-grade metamorphism at 1451 ± 6 Ma and the granite magmatism at 1445 ± 8 Ma. The presence of 1.70 Ga igneous zircon cores in both metamorphic and magmatic rocks suggests that they formed from similar protoliths. The protolith ages correlate with the youngest generation of magmatic rocks of the Transscandinavian Igneous Belt. The aluminous gneisses are of supracrustal origin, and may have formed by chemical alteration of magmatic rocks. Hallandian regional metamorphism took place under a strongly elevated geotherm and was associated with granitic magmatism, suggesting an accretionary orogenic setting. The Hallandian event may demonstrate an 1.47–1.38 Ga Andean-type continental margin at the SW margin of Baltica.

1. Introduction

Accurate resolution of different metamorphic and magmatic components in Precambrian polymetamorphic shield areas is a challenge that needs to be met to understand evolution of continents (e.g., Hand et al., 1992, 1994; Engvik et al., 2000; Clark and Hand, 2010). The southwest Baltic Shield is an example of a large tract of composite polymetamorphic continental crust, which received its youngest metamorphic imprint during the 1.14–0.90 Ga Sveconorwegian orogeny (Bingen et al., 2008a). Large volumes of crust first formed and accreted during the Paleoproterozoic at 2.0–1.7 Ga (e.g., Stephens et al., 2009), and several later periods of metamorphism and magmatism between 1.6 and 1.2 Ga are recognised in different Sveconorwegian terranes (Bingen et al., 2008b, and references therein).

In the case of the Baltic Shield, the introduction of SIMS spot dating of zircon (Nordsim laboratory, late 1990's), with its capability of pin-pointing single stages of igneous and metamorphic zircon growth, meant a huge step forward. For example, the Eastern Segment of the Sveconorwegian orogen (Fig. 1) changed status

* Corresponding author. Tel.: +46 709490212.
E-mail address: jan.ulmius@telia.com (J. Ulmius).

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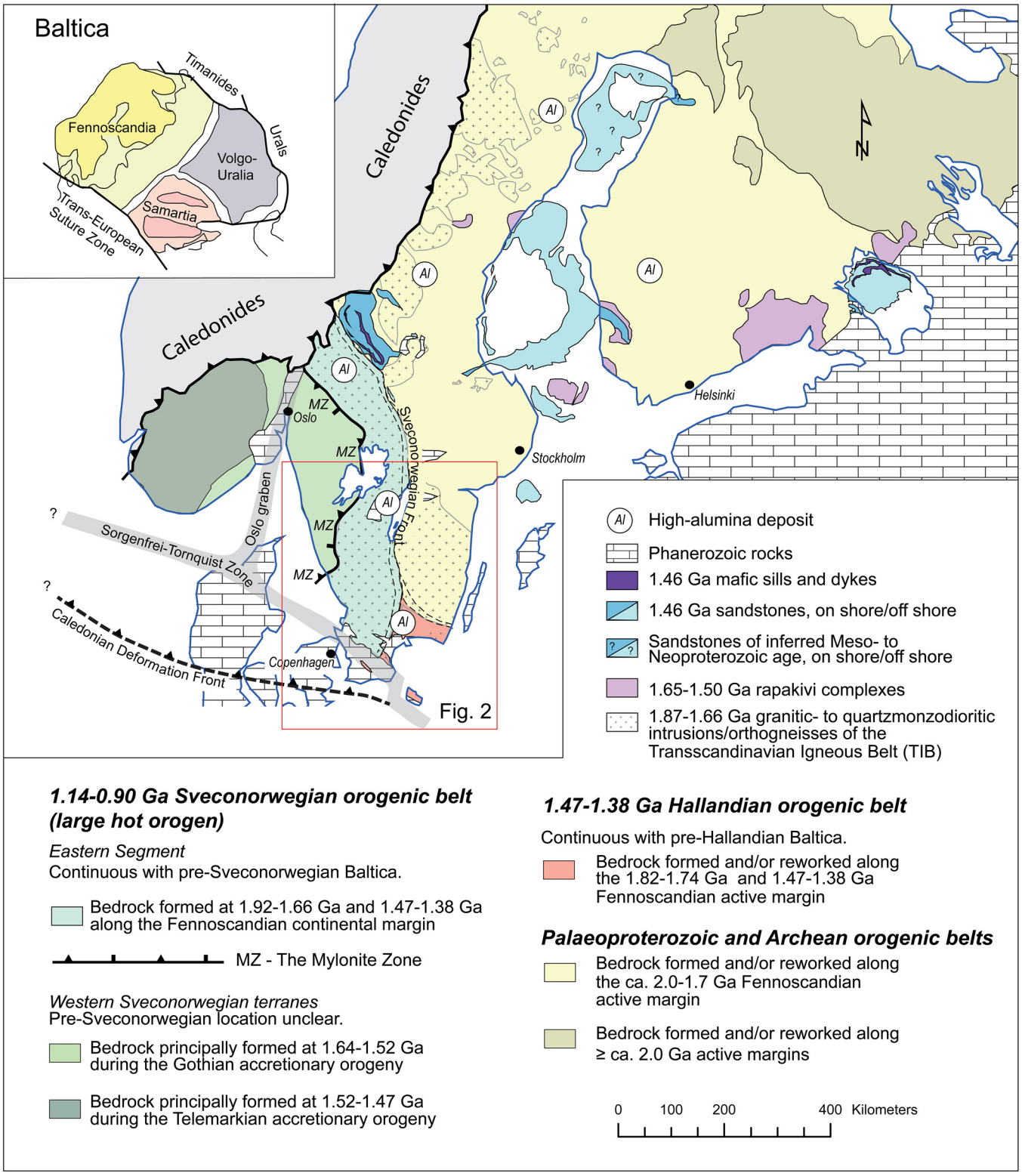

Fig. 1. Schematic overview of relict orogenic belts in the southern and central Baltic Shield including outline of 1.7–1.5 Ga rapakivi complexes and unmetamorphosed Mesoproterozoic igneous and sedimentary rocks in the central shield area. Figure based on 1:5 M Fennoscandian map database, and Geological Survey of Sweden 1:1 M Bedrock map database. Outline of the Oslo graben, the Sorgenfrei-Tornquist Zone and the southern Caledonian Deformation Front based on Erlström et al. (2004). Inset of Baltica from Bingen et al. (2008b).