



## 1.8 Ga magmatism in the Fennoscandian Shield; lateral variations in subcontinental mantle enrichment

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Dedicated to the memory of Matti Vaasjoki

### Abstract

The ca. 1.8 Ga post-collisional magmatism in the southern part of the 2.1–1.86 Ga Svecofennian domain of the Fennoscandian Shield have been studied with particular reference to the character and sources of the mafic rocks in a traverse from the Archaean craton margin in east, across the juvenile Svecofennian domain to its western margin. For this purpose three key areas were selected in the eastern, central and western parts of the domain: (i) in the western part of the domain, the Tjällmo-Vättern zone (southern Sweden) of the Transscandinavian Igneous Belt (TIB) consists of extensive areas of dominantly alkali-calcic granitoids associated with calc-alkaline to tholeiitic mafic rocks. Initial  $\epsilon_{\text{Nd}}$  for the mafic rocks vary from around 0 to above +3. (ii) In the central part of the domain (SW Finland), the post-collisional rocks are represented by small intrusions consisting of calc-alkaline high-Ba–Sr granites associated with shoshonitic lamprophyres and their plutonic equivalents. Initial  $\epsilon_{\text{Nd}}$  for the rocks in this series vary between 0 and +1. (iii) In the easternmost part of the Svecofennian domain (Russian Karelia and SE Finland) shoshonitic associations occur, comprising lamprophyres and their plutonic equivalents (apatite and magnetite-rich monzodiorites), which are related to syenites and high-Ba–Sr granites by fractional crystallization. All the rock types in this shoshonitic association have strongly elevated contents of  $\text{P}_2\text{O}_5$ , LREE and LILE. Initial  $\epsilon_{\text{Nd}}$  for all rocks in Karelia fall between 0 and –1.

Geochemical and isotopic results indicate that the post-collisional rocks in the central and eastern part of the domain stem from lithospheric mantle sources that were enriched during the preceding Svecofennian orogeny. The HFSE depletion, combined with the strong Sr, LILE and LREE enrichment, recall signatures of increasingly carbonate-dominated metasomatism of the mantle eastwards towards the craton margin. In contrast, the mainly LILE enriched mafic rocks from TIB in the west signal sources subjected to  $\text{H}_2\text{O}$ -dominated metasomatism, that could in part be coeval with the magmatism. In all areas the rocks carry a subduction type chemistry with continental arc affinity, however, with strongly increasing enrichment levels eastwards.

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Rocks in the west are derived by relatively larger degrees of melting at shallower levels, from previously depleted spinel–phlogopite–amphibole lherzolites/harzburgites, while going eastwards successively smaller melt fractions were tapping deeper, more enriched mantle sections in the garnet stability field. The enrichment agents are interpreted to be LILE-bearing H<sub>2</sub>O-dominated fluids from dewatering slabs in the west, changing to an increasing role for CO<sub>2</sub>-dominated fluids/melts derived mainly from subducted Svecofennian metasediments eastwards.

A convergent continental margin setting with transpressional shearing was active during TIB formation in the west. Whether this shearing was instrumental in the formation of the 1.8 Ga magmatism further continentwards, or if the magmatism in the central and eastern areas was the result of extensional collapse or plume activity is presently not known.

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## 1. Introduction

The Fennoscandian Shield consists of an Archaean cratonic nucleus in the northeast, in NE Finland and Russia (e.g. Gaál and Gorbatshev, 1987). In the

Palaeoproterozoic large amounts of new, mostly juvenile, crust grew and successively accreted onto the SW margin of the old craton and the extensive Svecofennian (2.1–1.86 Ga) Domain was formed (e.g. Nironen, 1997). Continued westward growth added

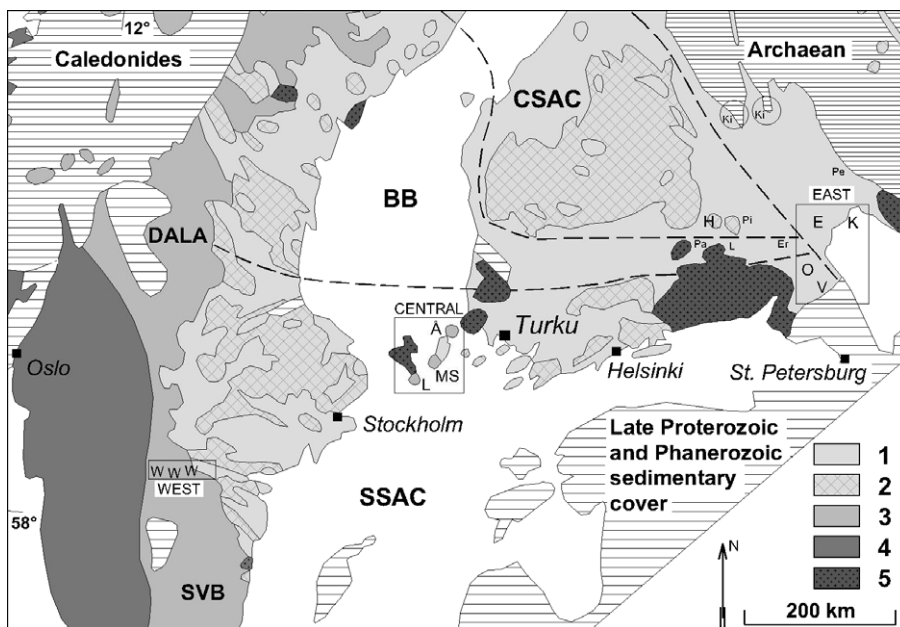


Fig. 1. The south-central part of the Fennoscandian Shield with the three areas of investigated ca. 1.8 Ga mafic rocks marked by frames. The western area is represented by the Tjällmo-Vättern zone of the Transscandinavian Igneous belt (cf. Andersson, 1997b). W=the principal sampling sites of the mafic rocks from this area. The central area is represented by the Åland islands with the investigated intrusions: L=Lemland, MS=Mosshaga and Seglinge, Å=Åva. The eastern area is represented by the post-collisional intrusions in Russian Karelia. V=Vuoksi, E=Elisenvaara, K=Kalto island. Other post-collisional intrusions are: O=Ojajärvi, Pe=Petraavaara, Er=Eräjärvi, Pi=Pirilä, L=Luonteri, Pa=Parkkila, H=Halpanen carbonatite. Ki=kimberlite provinces. Inferred sutures are marked by broken lines separating the following terranes in the Svecofennian domain: CSAC=central Svecofennian arc complex; BB=Bothnian basin; SSAC=southern Svecofennian arc complex (after Nironen et al., 2000). Lithological units are: (1) roughly 1.9 Ga Svecofennian supracrustal rocks. (2) ca. 1.88 Ga syn- and 1.84–1.77 Ga late orogenic granitoids. (3) The Transscandinavian Igneous Belt (TIB). (4) Post-Svecofennian rocks of the Southwest Scandinavian Domain. (5) Rapakivi granites (1.6–1.5 Ga). SVB=Småland-Värmland belt in TIB. Dala=the Dala volcanic province (Dalarna).

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