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Migratory tectonic switching, western Svecofennian orogen, central Sweden: Constraints from U/Pb zircon and titanite geochronology

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Abstract

The Forsmark area, in the western part of the Svecofennian orogen, central Sweden, is situated between two major Palaeoproterozoic tectonic domains that show contrasting histories with respect to timing of igneous activity, ductile deformation and metamorphism. Geological features common to both the adjacent domains are found at Forsmark, which, consequently, is a key area for understanding the tectonic evolution of the Svecofennian orogen in this region.

New SIMS and TIMS geochronological data from several samples in a limited area at Forsmark constrain the timing of igneous activity, ductile deformation and metamorphism in this area. U/Pb zircon dating, in combination with field studies, reveals the existence of two calk-alkaline igneous suites at Forsmark. The older and most voluminous plutonic suite intruded at 1.89–1.87 Ga and is affected by penetrative, yet variably intense ductile deformation, with the development of a ductile grain-shape fabric under amphibolite facies metamorphic conditions and folding. The younger and less voluminous hypabyssal suite intruded at 1.86–1.85 Ga, during the waning stages of this penetrative deformational phase. Furthermore, U/Pb titanite dating shows that the area has been affected by one or more tectonothermal events after regional fabric development, and possibly even after 1.83 Ga. The deformation during these events involved more restricted strain along discrete zones.

The Forsmark data, in combination with a compilation and evaluation of available geochronological data from the time interval 1.91–1.84 Ga in central Sweden, points to the existence of at least two major tectonic cycles in this region. Each cycle is characterised by igneous activity associated at least partly with extension, a short interval of compressional deformation and migration of the tectonic activity. In this paper, we discuss two highly contrasting tectonic models that may explain the cyclic tectonic evolution of the western part of the Svecofennian orogen in central Sweden. The favoured model involves continuous subduction, with a constant polarity, beneath a single active continental margin, combined with alternating subduction hinge retreat and advance. The model involves migration of what has been described as tectonic switching in the younger, accretionary orogenic systems of eastern Australia (Palaeozoic Lachlan orogen) and New Zealand.

Keywords: Svecofennian; Zircon; Titanite; Tectonic cycles; Tectonic model; Fennoscandian Shield

1. Introduction

Since the first attempt to explain the evolution of the Svecofennian orogen in the Fennoscandian Shield in terms of plate tectonics (Hietanen, 1975), several complex models have been put forward, for example by Park (1985), Baker et al. (1988), Lahtinen (1994), Korja and Heikkinen (1995) and Nironen (1997). The most recent tectonic models for the Palaeoproterozoic rocks in this orogenic belt involve multiple collisions, accretion and continent–continent collision (Korja and Heikkinen, 2005; Lahtinen et al., 2005). A wide range of geological, geochemical and geophysical data is needed for the construction of tectonic models in an orogen. However, quality geochronological data are crucial when constructing such models and, since published radiometric age data from the western part of the orogen in central Sweden are limited, the mentioned models remain tentative for this area.

The Forsmark area, approximately 150 km north of Stockholm in the central part of Sweden (Fig. 1), is a key area for understanding the igneous and tectonic history of the western

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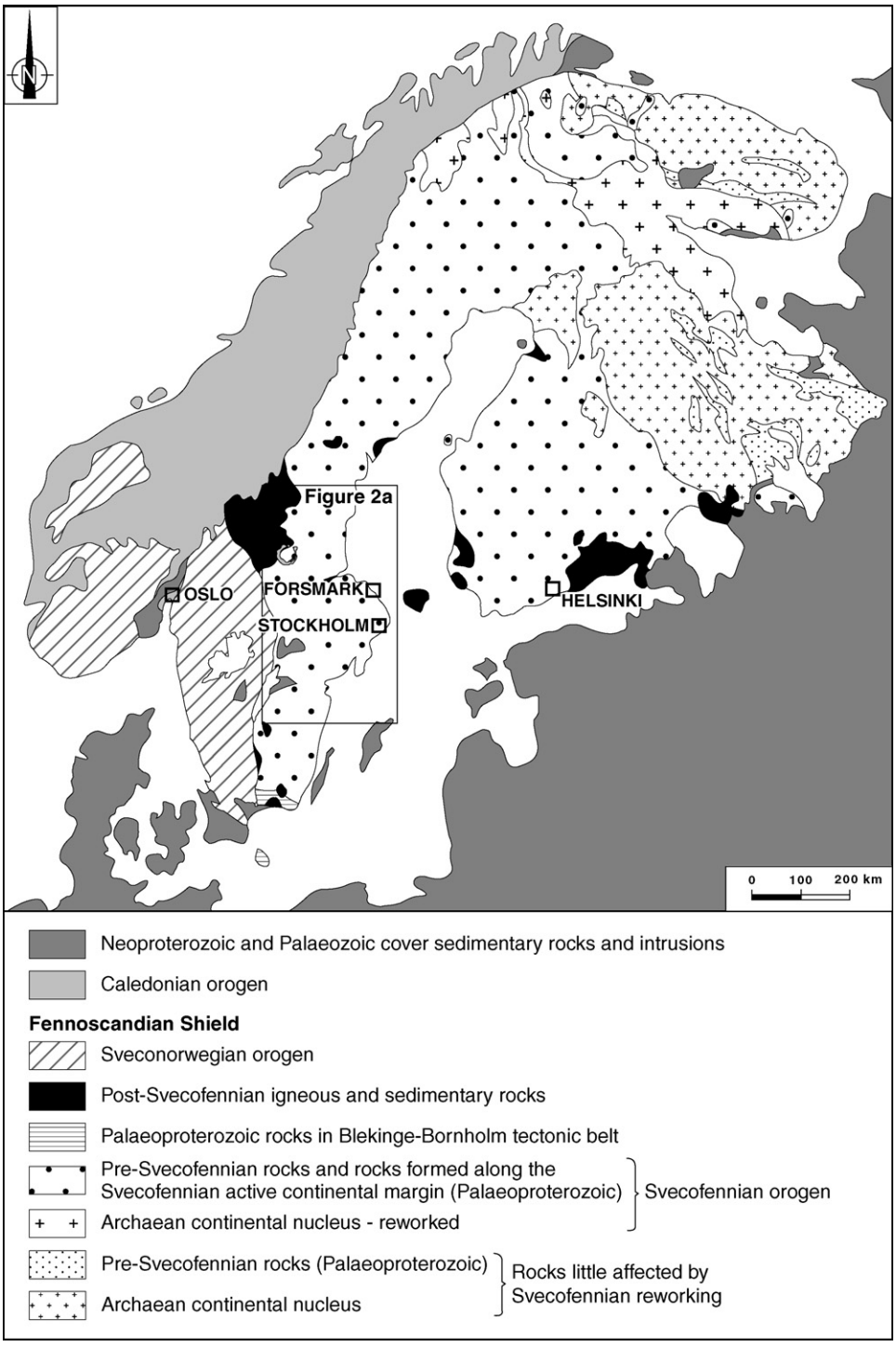

Fig. 1. Major tectonic units in the Fennoscandian Shield (modified after Koistinen et al., 2001). The location of the Forsmark area is also indicated.

part of the Svecofennian orogen. It is situated within a tectonic domain (domain 2; Fig. 2a), which consists of several belts of highly deformed rock, up to a few kilometres wide, that anastomose around tectonic lenses generally with lower ductile strain (Hermansson et al., 2007). This domain forms a tectonic discontinuity between tectonic domains 1 and 3, to the north and south, respectively (Fig. 2a). As will be illustrated here, the Forsmark area contains geological features common to both of the adjacent domains.

Hermansson et al. (2007) reported the ages of two, structurally discordant, granite dykes at Forsmark that constrain the minimum age for the early, penetrative ductile deformation at 1851 ± 5 Ma. In this paper, the Svecofennian igneous and deformational history is addressed, revealing successive cycles of extension and compression accompanying a changing magmatic evolution. The identified events are integrated with the compiled 1.91–1.84 Ga age data from central Sweden, resulting in the development and discussion of two contrasting tectonic