Precambrian Research 252 (2014) 39–52

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

Hafnium isotope evidence for early-Proterozoic volcanic arc reworking in the Skellefte district (northern Sweden) and implications for the Svecofennian orogen

Martin Guitreau [a,b,*], Janne Blichert-Toft [a], Kjell Billström [c]

[a] Laboratoire de Géologie de Lyon, Ecole Normale Supérieure de Lyon and Université Claude Bernard Lyon 1, CNRS UMR 5276, 46 Allée d'Italie, 69007 Lyon, France
[b] CEPS-Department of Earth Sciences, University of New Hampshire, 56 College Road, James Hall, Durham, NH 03824-3589, USA
[c] Department of Geological Sciences, Swedish Museum of Natural History, Box 50007, 10405 Stockholm, Sweden

ARTICLE INFO

Article history:
Received 27 January 2014
Received in revised form 16 June 2014
Accepted 10 July 2014
Available online 18 July 2014

Keywords:
Zircon
Hf isotopes
Proterozoic
Skellefte district
Volcanic arc

ABSTRACT

The Skellefte district is a seemingly juvenile and heavily mineralized crustal domain in northern Sweden that formed between 1.90 and 1.87 Ga. It is commonly interpreted as a volcanic arc deposited on a basement (known variously as the Bothnian or the Knaften-Barsele group) that could be represented by older rocks (1.96–1.94 Ga) found in the vicinity. In order to understand the potential genetic relationship between the arc and the basement, Hf and Pb isotopes in magmatic zircons from key lithologies were measured by solution multi-collector inductively coupled plasma mass spectrometry. It is shown that both geological groups display similar Hf isotope compositions, which translate into decreasing ε_{Hf} with time. Overall, the data are compatible with reworking of the Knaften-Barsele arc to produce the Skellefte rocks over a short time interval from 1.90 to 1.87 Ga in a context of crustal extension with ongoing subduction. When the data presented here are integrated with general models of tectonic evolution of the Svecofennian orogen, they fit a scenario in which the juvenile Knaften-Barsele arc formed between 1.96 and 1.94 Ga and became accreted onto the Karelian continent located further north at about 1.92–1.91 Ga. Systematic north to south variations in Pb, Nd, and Hf isotope compositions throughout the Svecofennides, interpreted as resulting from an increase in Archean crust involvement toward the south, indicate a genetic link between the Proterozoic crustal domains of Sweden and Finland.

Published by Elsevier B.V.

1. Introduction

The early Proterozoic is a time of intense continental crust formation observed notably in North America and Scandinavia (e.g. Patchett and Arndt, 1986; Hoffman, 1988; Gaál and Gorbatschev, 1987). The reasons for this rapid growth are debated but principal hypotheses include acceleration of subduction (e.g. Patchett and Arndt, 1986) and accretion of volcanic arcs (e.g. Lahtinen et al., 2005). Studies of the formation and evolution of such crustal domains, which are clearly visible as peaks in the global zircon record (Condie et al., 2009), are essential to understanding the worldwide crustal growth pattern. Major mineralizations often associated with these large crustal provinces further make them important targets of investigation.

The Skellefte district in northern Sweden is a seemingly juvenile early Proterozoic province interpreted variously as a volcanic arc, a back-arc, or a marginal basin (e.g. Claesson, 1985; Weihed et al., 1992; Skiöld and Rutland, 2006). Most of the rocks found in the Skellefte district are calc-alkaline felsic volcanic or plutonic rocks associated mainly with detrital sediments and subordinate mafic rocks (Claesson, 1985; Weihed et al., 1992; Allen et al., 1997). The Skellefte district formed between 1.90 and 1.87 Ga (Wilson et al., 1985, 1987) and is thought to be related to a poorly defined basement represented by older rocks found in the vicinity in the Barsele and Knaften areas (Wasström, 1993, 1996; Eliasson et al., 2001).

The early evolution of the Svecofennian orogeny, notably the period between 2.0 and 1.9 Ga, which corresponds to the opening of the Svecofennian sea and the formation of the Skellefte district, is a topic of long-standing debate. Extensive Nd and Pb isotope studies have been undertaken on Proterozoic Sweden and have shed new light on some old problems concerning the

* Corresponding author at: CEPS-Department of Earth Sciences, University of New Hampshire, 56 College Road, James Hall, Durham, NH 03824-3589, USA.
Tel.: +1 603 862 4793.
E-mail address: martin.guitreau@unh.edu (M. Guitreau).

http://dx.doi.org/10.1016/j.precamres.2014.07.005
0301-9268/Published by Elsevier B.V.

Svecofennides (e.g. Hietanen, 1975; Wilson et al., 1985; Patchett and Kouvo, 1986; Patchett et al., 1987; Hallberg, 1989; Billström, 1989, 1990; Öhlander et al., 1993; Billström and Vivallo, 1994; Billström and Weihed, 1996; Lahtinen et al., 2002). Sm–Nd isotope studies in particular have shown the Proterozoic terranes from northern Sweden, south of the Archean-Proterozoic border (Öhlander et al., 1993), to be essentially purely juvenile (e.g. Wilson et al., 1985), while in the south of Sweden substantial amounts of pre-existing crust (up to ~30%) have been recycled (Patchett et al., 1987). Similar conclusions have been reached for the corresponding domains in Finland (Patchett et al., 1981; Vaasjoki, 1981; Huhma, 1986; Patchett and Kouvo, 1986; Billström, 1989; Lahtinen and Huhma, 1997).

The potential relationship between the Skellefte district and its assumed basement (here referred to as the Knaften-Barsele group but also often referred to as the Bothnian or sometimes the Robertsfors group; Rutland et al., 2001a) is a key issue that bears directly on the evolution of the Proterozoic Svecofennian crust. Compared with Nd isotopes, only little work has been done in Sweden using Hf isotopes. Additionally, most of the Hf isotope work undertaken so far has focused on central and southern Sweden (Andersen et al., 2009; Andersson et al., 2011) leaving northern Sweden yet to be portrayed.

The present study is a first attempt to alleviate the scarcity of Hf isotope data for northern Sweden by presenting Lu–Hf as well as Pb isotope compositions of igneous zircons from the well-characterized early-mid Proterozoic (ca. 1.9 Ga) Skellefte volcanic arc and adjacent older rocks (the 1.94 Ga Knaften porphyry and the 1.96 Ga Barsele dacite) in northern Sweden (Fig. 1). While the Pb isotope data document the local chronology and provide a check on previous dating results for these rocks, the Hf isotope data are used to constrain the nature of the source region and model the interaction and timing of subduction and seafloor spreading in the Skellefte area. The early history of Svecofennian crust formation further is discussed in light of the new and other available isotope data as well as geological and geophysical information on the Svecofennides, and it is suggested that a major genetic link exists between the Proterozoic crustal domains of Sweden and Finland.

2. Background geology

The Fennoscandian (or Baltic) Shield (Fig. 1) has an Archean core (3.7–2.6 Ga) in eastern Finland, northernmost Sweden, and northwestern Russia. It is surrounded to the west and southwest by Paleoproterozoic accreted terranes of the Svecofennian Domain (1.91–1.87 Ga) (e.g. Park, 1985; Gaál and Gorbatschev, 1987; Nironen, 1997). The ~1.95 Ga rocks in the Knaften and Barsele areas (Wasström, 1993; Eliasson et al., 2001), south and west of the Skellefte district in Sweden, and the 1.92 Ga primitive island arc rocks in the Savo Belt (Korsman et al., 1997), adjacent to the Archean craton in Finland, are the oldest documented Svecofennian units in the shield, but older protoliths (~2.1–2.0 Ga) have been inferred from Nd isotope data and detrital zircon studies (e.g. Claesson et al., 1993; Lahtinen and Huhma, 1997).

The Skellefte district is a heavily mineralized (120 × 30) km belt of 1.90–1.87 Ga volcanic, intrusive, and sedimentary rocks, which comprises base metal (VMS-type) and epigenetic gold mineralisations. The stratigraphy consists of a >3 km thick volcanic unit with intercalated sedimentary rocks (the Skellefte Group), which hosts the most massive sulfide ores of the Skellefte district. This sequence in turn is overlain by a >4 km thick sediment-dominated succession including intercalated largely mafic volcanic rocks (the Vargfors Group; Allen et al., 1997). The mineralized belt, which is dominated by moderately to strongly deformed, diagenetically and hydrothermally altered marine volcanic rocks, has an apparently conformable boundary with a large basin in the south (the Bothnian basin), which is characterized by extensive meta-sedimentary rocks (the Bothnian Supergroup) and abundant granitoids. To the north, the Skellefte district is delimited by a poorly defined boundary characterized by an extensive region of less deformed and less altered subaerial felsic volcanic rocks, intrusions, and minor sediments (the Arvidsjaur Group). Both regions (south and north of the Skellefte district) formed contemporaneously, and this is the case also for the Bergslagen belt in central-southern Sweden (Weihed et al., 2005). Intrusive rocks are common in the Skellefte district and adjacent areas, and a number of different intrusive suites can be defined, ranging in age from ca. 1.96 to 1.79 Ga. For example, I-type intrusions of calc-alkaline affinity are common in the age span 1.96–1.88 Ga. A key lithological unit is the 1.89–1.86 Ga Jörn intrusive complex, interpreted as a synvolcanic to early orogenic intrusion (Wilson et al., 1987; González-Roldán, 2010; Bejgarn et al., 2013), which comprises four distinct magmatic phases (GI-GIV) based on geochemistry and geochronology. S-type minimum melt (the Skellefte-Härnö suite) and mixed I/A-type (the Revsund suite) coarse-porphyritic granitoids intruded in the interval between ca. 1.82 and 1.79 Ga.

The deposition of the Skellefte Group is supposed to have taken place during extension along a continental margin arc or, alternatively, in an extensional intra-arc region on a continental or mature arc crust at 1.89 Ga (c.f. Allen et al., 1997; Billström and Weihed, 1996; Allen et al., 2002; Juhlin et al., 2002; Weihed et al., 2005). An alternative interpretation was presented by Rutland et al. (2001a,b) and Skiöld and Rutland (2006), who suggested that the rocks in the Skellefte district were deposited in a rift setting on the Bothnian Basin metasedimentary rocks (their Robertsfors Group); an episode of crustal extension related to a contemporaneous active margin located west of the present exposure of Svecofennian rocks was inferred. The ε_{Nd} signatures of rocks of the Skellefte Group suggest that they formed from a juvenile magma with little or no input from older Proterozoic (or Archean) material (Wilson et al., 1985, 1987; Rickard and Svensson, 1984; Billström and Weihed, 1996; González-Roldán, 2010) in contrast to surrounding domains (the Karelian continent, the Bothnian basin, and the Bergslagen belt; Wilson et al., 1985; Skiöld and Öhlander, 1989; Öhlander et al., 1993).

Rocks from the Knaften and Barsele areas lie to the south and west of the Skellefte district, respectively, and have been dated to between 1.96 and 1.94 Ga for Knaften (Wasström, 1993, 1996) and 1.96 Ga for Barsele (Eliasson et al., 2001). In a region adjacent to these areas, Bergström (2001) distinguished an older unit composed of MORB-like metabasalts and a younger unit corresponding to a basalt–andesite–dacite–rhyolite (BADR) sequence that likely formed in a volcanic arc environment.

Metamorphic conditions in the northern part of the Skellefte district are characterized by greenschist facies (1.8 kbar and 360 °C, Nicholson, 1993), whereas to the south and east, the metamorphic grade increases and reaches upper amphibolite facies conditions, including partial melting, at about 1.82 Ga (Weihed et al., 1992, 2002; Billström and Weihed, 1996; Weihed, 2001; Kathol and Weihed, 2005). Several lines of evidence indicate that the earliest tectonic deformation in the Skellefte district proper took place between 1.89 and 1.87 Ga (Lundström et al., 1997, 1999; Lundström and Antal, 2000; González-Roldán, 2010; Skyttä et al., 2012); however, an older 1.92–1.90 Ga event in the region also has been suggested (Skiöld and Rutland, 2006).

3. Analytical techniques

Single zircons were handpicked, leached, and dissolved in Parr® bombs, and Lu, Hf, and Pb separated by ion-exchange

Download English Version:

https://daneshyari.com/en/article/4722945

Download Persian Version:

https://daneshyari.com/article/4722945

Daneshyari.com