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# Apatite fission track thermochronology of Khibina Massif (Kola Peninsula, Russia): Implications for post-Devonian Tectonics of the NE Fennoscandia

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ABSTRACT

The thermal history of the Kola Peninsula area of NE Fennoscandia remains almost fully unknown because of the absence of any thermochronological data such as apatite and/or zircon fission track or (U—Th)/He ages. In order to fill this gap and to constrain the post-Devonian erosion and exhumation history of this region, we present the results of apatite fission track (AFT) dating of eleven samples selected from the cores taken from different depths of the northern part of the Khibina intrusive massif. The Rb—Sr isochron age of this alkaline magmatic complex which is located at the center of Kola Peninsula is 368 + 6 Ma (Kramm and Kogarko, 1994). Samples were analyzed from depths between +520 and −950 m and yielded AFT ages between 290 and 268 Ma with an age uncertainty (1$\sigma$) of between ±19 Ma (7%) and ±42 Ma (15%). Mean track lengths (MTL) lie between 12.5 and 14.4 μm. Inverse time–temperature modeling was conducted on the age and track length data from seven samples of the Khibina massif. Thermal histories that best predict the measured data from three samples with the most reliable data show three stages: (1) 290–250 Ma—rapid cooling from >110 °C to 70 °C/50 °C for lower/upper sample correspondingly; (2) 250–50 Ma—a stable temperature stage; (3) 50–0 Ma—slightly increased cooling rates down to modern temperatures. We propose that the first cooling stage is related to late-Hercynian orogenesis; the second cooling stage may be associated with tectonics accompanying with opening of Arctic oceanic basin. The obtained data show that geothermal gradient at the center of Kola Peninsula has remained close to the modern value of 20 °C/km for at least the last 250 Myr. AFT data show that the Khibina massif has been exhumed not more then 5–6 km in the last 290 Myr.



## 1. Introduction

Results of thermochronological studies on Precambrian and Phanerozoic rocks within Scandinavian countries (Sweden, Finland, and Norway) have been recently summarized by Hendriks et al. (2007). Their quantity and quality make possible reconstruction of the thermal and tectonic history of western and central Fennoscandia from the Late Precambrian with high reliability and detail. However, such data for NE part of Fennoscandia, including the Kola Peninsula and Karelia, are almost absent. Only a few ages are published in publications with restricted access (Green et al., 1996; Rohrman, 1995). To understanding more fully the tectonic and thermal history of the Precambrian basement or Phanerozoic intrusions in the Kola area, more thermochronologic data are clearly required. Moreover, reliable thermochronological data could provide additional information for understanding of the nature and estimation of the timing of an enigmatic, possibly metachronous natural magnetization component that has been found in many Devonian and, particularly, Proterozoic dykes and Precambrian host rocks over the entire the Kola Peninsula (Veselovskiy and Arzamastsev, 2011; Veselovskiy et al., 2013). These studies have proposed that the metachronous component could be related with previously unknown remagnetization event, that was estimated to be Early Jurassic in age, but based on paleomagnetic data only. According to microprobe and petrographic results, the origin of the metachronous component was connected with changes of magnetic and originally non-magnetic minerals during low-temperature hydrothermal alteration (Veselovskiy et al., 2013).

This hypothetical Early Jurassic hydrothermal event is intriguing in that paleomagnetic and, particularly, petrographic data have established that it occurs on the Devonian dykes mostly and quite rare

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on the Precambrian dykes. The K—Ar isotope system in mica, amphibole, and feldspar is the most sensitive to secondary reheating (up to 200 °C and more), but no resetting of K—Ar ages are observed after emplacement of the studied dykes in Devonian (Veselovskiy et al., 2013).

Apatite fission track dating is affected by heating to 60–110 °C and thus offers an alternative, more temperature-sensitive method to test the hypothesis of a Jurassic remagnetization event and, if it really existed, for understanding its nature and timing. Among all of studied Devonian intrusive rocks of the Kola area, the presence of the metachronous magnetization component is observed best in the magnetic record of melanephelinite and phonolite dykes, which cut foyaites of the earliest phases of intrusion on the west and southwest zones of the Khibina massif, as well as in tinguaite dykes, which cut Proterozoic schist on the south exocontact zone (Fig. 1b). So, if the Khibina massif, as well as the cross-cutting dykes, were affected by a hypothetical Jurassic remagnetization event, this should be reflected in the fission track age and/or track lengths of apatite grains from these rocks.

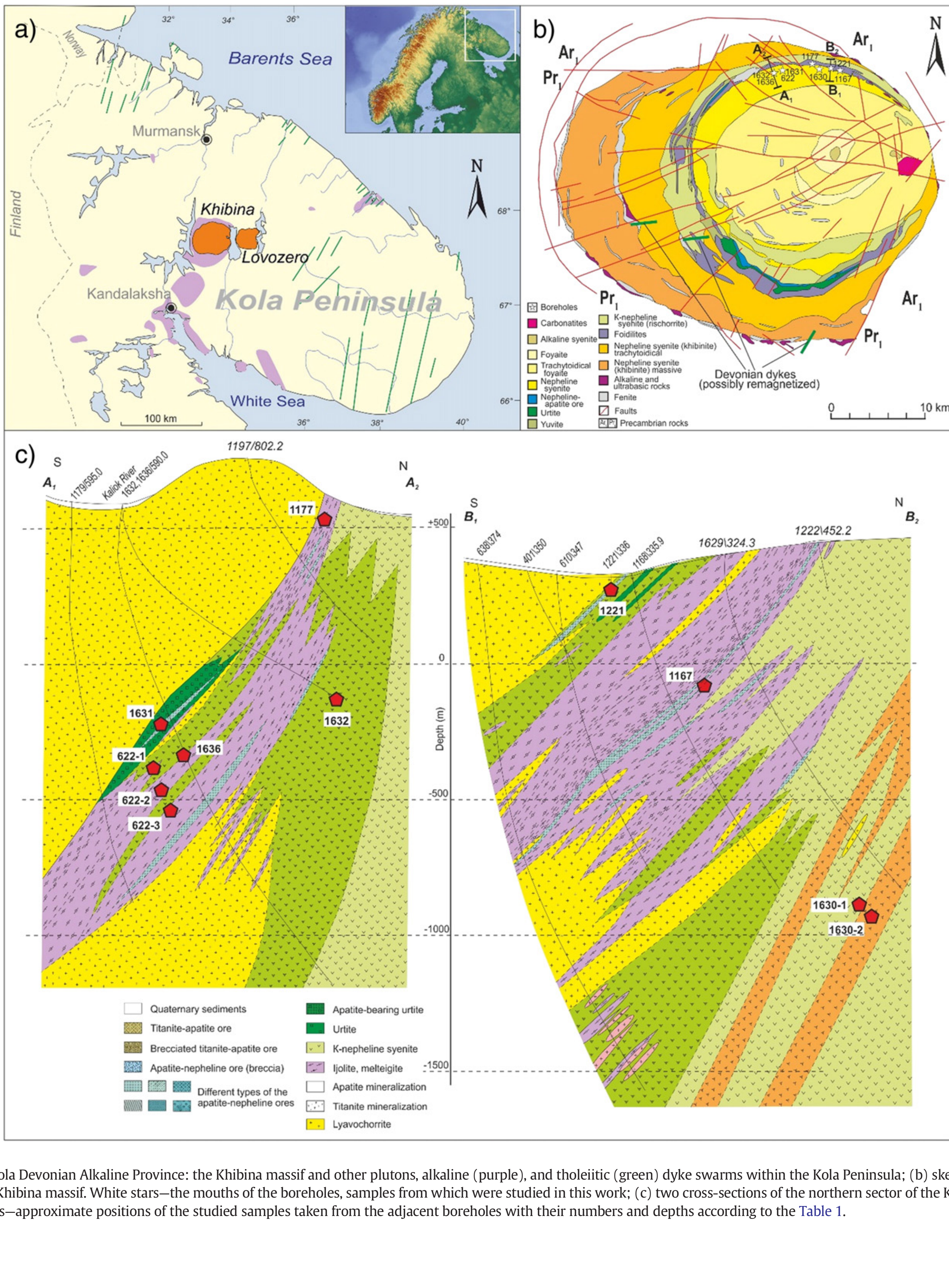


**Fig. 1.** (a) Kola Devonian Alkaline Province: the Khibina massif and other plutons, alkaline (purple), and tholeiitic (green) dyke swarms within the Kola Peninsula; (b) sketch geological map of the Khibina massif. White stars—the mouths of the boreholes, samples from which were studied in this work; (c) two cross-sections of the northern sector of the Khibina massif. Red poligons—approximate positions of the studied samples taken from the adjacent boreholes with their numbers and depths according to the Table 1.