Tectonophysics 615–616 (2014) 142–153

Contents lists available at ScienceDirect

Tectonophysics

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

Late Cretaceous–Cenozoic thermal evolution of the northern part of the Central Western Carpathians (Slovakia): revealed by zircon and apatite fission track thermochronology

Silvia Králiková [a], Rastislav Vojtko [a,*], Paul Andriessen [b], Michal Kováč [a], Bernhard Fügenschuh [c], Jozef Hók [a], Jozef Minár [d,e]

[a] Department of Geology and Palaeontology, Faculty of Natural Sciences, Comenius University, Mlynská dolina G, SK-842 15 Bratislava, Slovak Republic
[b] Faculty of Earth and Life Sciences, Section Isotope Geochemistry, Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands
[c] Institute of Geology and Palaeontology, University of Innsbruck, Innrain 52, A-6020 Innsbruck, Austria
[d] Department of Physical Geography and Geoecology, Faculty of Natural Sciences, Comenius University, Mlynská dolina B1, SK-842 15 Bratislava, Slovak Republic
[e] Department of Physical Geography and Geoecology, University in Ostrava, Chittussiho 10, 71000 Ostrava, Czech Republic

ARTICLE INFO

Article history:
Received 1 March 2013
Received in revised form 22 December 2013
Accepted 2 January 2014
Available online 10 January 2014

Keywords:
Western Carpathians
Cretaceous and Cenozoic
Burial
Exhumation
Fission track thermochronology

ABSTRACT

Tectono-thermal evolution of the northern part of Central Western Carpathians (Slovakia) was revealed by zircon and apatite fission track thermochronology of Neogene deposits, volcanic rocks, and crystalline basement. New fission track ages combined with previous geochronological data are correlated with main tectonic events and important palaeogeographic changes. (1) The palaeo-Alpine burial to more than 10 km depths, heating (>320 °C) and low-grade metamorphism of the crystalline basement was caused by crustal thickening due to nappe stacking driven by the collisional processes (~90–75 Ma). (2) Extensional collapse and exhumation of basement complexes during the Late Cretaceous to Middle Eocene (~75–40 Ma). (3) The extension process resulted in a new sedimentary cycle of the Central Carpathian Palaeogene Basin (~40–25 Ma) in the northern part of the Central Western Carpathians. During the ensuing burial under the thick sedimentary cover, the crystalline basement of the northern zone resided at 'hotter' conditions (ca. >120 °C and <200 °C) which led to full annealing of apatite single-grain ages. In the meanwhile the southern zone of the crystalline basement was gradually exhumed to the depth of 5–3 km and occasionally appeared at the erosion surface. (4) Disintegration of the Central Carpathian Palaeogene Basin (~25–20 Ma) was closely connected with a partial exhumation of the Central Western Carpathians and intensive denudation. (5) The Middle to Late Miocene (~20–9 Ma) subduction of the Outer Carpathians substratum had crucial consequences for the tectonic evolution of the hinterland that was located in the upper crustal plate. The most external zone of the hinterland basement domain (Lúčanská and Krivánska Fatra Mts.) was exhumed to the 5–3 km depth and the intramontane basins were opened. (6) New fission track data and geomorphological criteria refer to the Pliocene–Quaternary mountain building processes in the external zones of the Central Western Carpathians.

1. Introduction

The Western Carpathians are located in the north-easternmost orocline of the European Alpides and form approximately 500 km long and 300 km wide mountain arc in the central Europe. In the west, the Western Carpathians are linked to the Eastern Alps and in the east to the Eastern Carpathians. The study area is situated in the north-western part of the Western Carpathians. It is a unique natural laboratory to study source-and-sink system during the Cenozoic era especially with regards to erosion, transport, and deposition of sediment related to burial and exhumation of rock masses.

Much progress has been made in recent years to understand the tectonic and sedimentary characteristics of the Turiec Basin (TB), located in the Central Western Carpathians (CWC), in relation to surrounding orogenic belts (Fig. 1) (e.g., Gašparik, 1989; Gašparik and Halouzka, 1989; Gašparik et al., 1991, 1995; Hók et al., 1998; Kováč et al., 2011). A new tectonic model based on palaeo-stress analysis was presented by Hók et al. (1998). Recently, the Neogene and Quaternary basin evolution, as well as mass balance analysis was carried out by Kováč et al. (2011), suggesting a new lithostratigraphic classification of the basin fill. The most recent and detailed age assessment of the TB fill succession, based on biostratigraphy of endemic fauna, has been published by Pipík et al. (2012). The TB therefore is a unique intramontane basin to study the coupling between sedimentation in the basin and exhumation/denudation in the surrounding belts. The surrounding Žiar, Lúčanská, Krivánská, and Vel'ká Fatra Mts. are source areas of the sedimentary infill of the TB (Fig. 1).

The tectono-thermal evolution of this area is less well known and still debated (Danišík and Kohút, 2009; Danišík et al., 2008, 2010;

* Corresponding author.
E-mail address: kralikova@fns.uniba.sk (S. Králiková).

0040-1951/$ – see front matter © 2014 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.tecto.2014.01.002

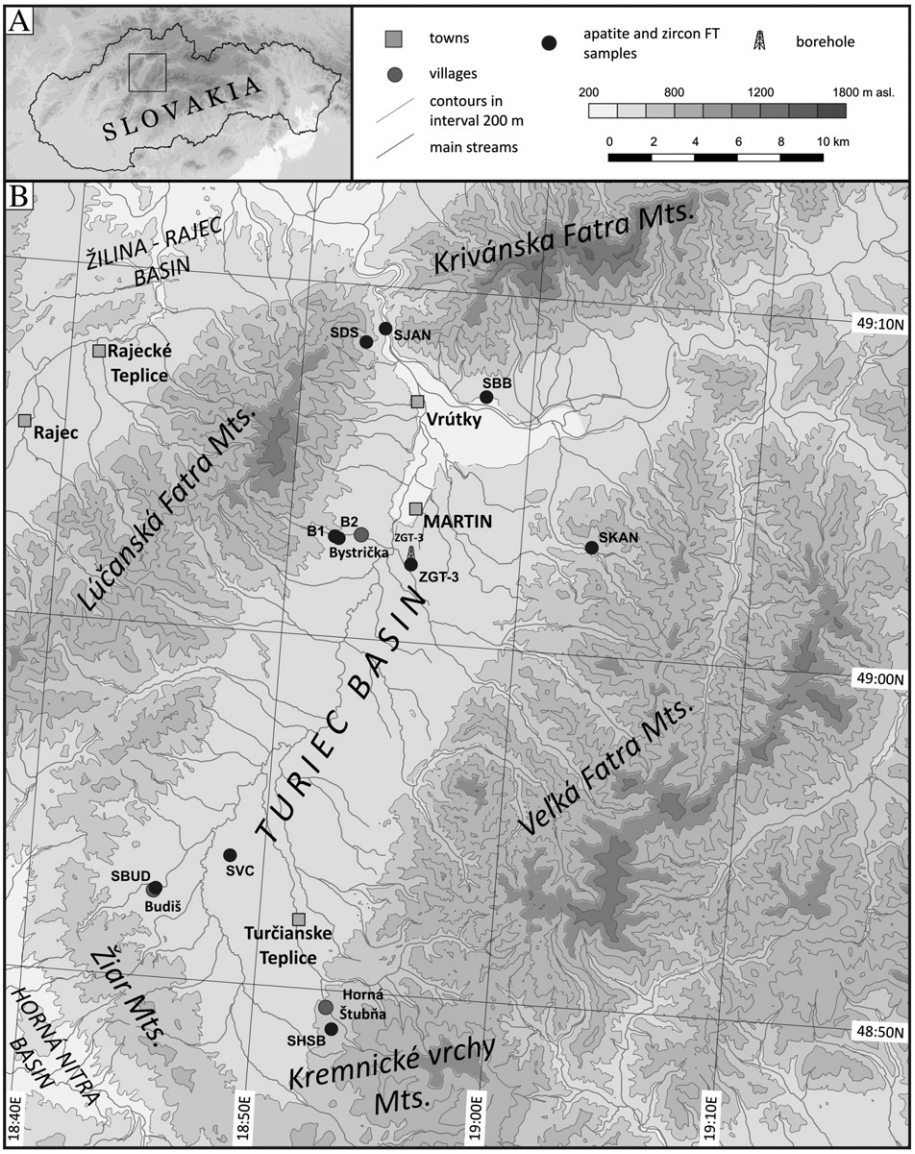

Fig. 1. Geographical position of the study area with localization of the main outcrops and studied sites.

Kováč et al., 1994, 2011; KráĽ, 1977; KráĽ et al., 2007). Therefore the fission track study on zircon and apatite grains has been performed to better constrain the basin-mountain evolution (source-and-sink system) and tectono-thermal history, respectively. Our study was applied to both basement rocks surrounding and underlying the TB and sedimentary rocks from the Cenozoic basin sequence (detrital samples). This approach allows constraint the cooling and exhumation histories of the source areas as well as the relationship between exhumation, landforms, uplift, and sedimentation in the TB. Zircon and apatite detrital grains from basin sedimentary sequences that did not experience a post-depositional thermal history with temperatures high enough to cause fission track annealing, do preserve a record of the thermal history experienced by the source rock. In such a case, obtained data can be interpreted in terms of exhumation/denudation of the source rocks, providing constraints on the tectono-thermal events causing exhumation processes. Thus, combined fission track data of basement (potential) source rocks and sediments are important for understanding the temporal relationships between developing source region and sedimentation in the adjacent basin (Bernet and Spiegel, 2004; Carter, 1999, 2007; Matenco and Andriessen, 2013; Matenco et al., 2013; Reiners and Brandon, 2006; von Eynatten and Dunkl, 2012).

The purpose of this study is to infer low-thermal evolution of the northern portion of the CWC using combined fission track source to sink data in combination with data obtained by sedimentology, structural geology as well as geomorphology. Main aims are: (*i*) to determine age(s) of detrital grains of the sedimentary rocks in order to trace the sediment provenance; (*ii*) to investigate exhumation processes of the surrounding source basement rocks; and (*iii*) to propose a model of younger stages of tectono-thermal evolution of the CWC.

2. Regional geological setting

The TB, an impressive intramontane depression located in the northern part of the CWC, is bounded by high relief mountains of the Tatra-Fatra Belt (Fig. 1). Structurally, the mountains are formed by the palaeo-Alpine nappe stack which is composed of the Tatric, Fatric, and Hronic units (e.g., Froitzheim et al., 2008; Plašienka et al., 1997).

The lowermost Tatric tectonic unit is formed by the Variscan crystalline basement and its Mesozoic sedimentary cover. The basement consists of Lower Palaeozoic metamorphosed sequences which were intruded by the Late Palaeozoic, predominantly Carboniferous granitoid rocks (Bagdasaryan et al., 1992; Hók et al., 2000; Scherbak et al., 1990).