Tectonophysics 712–713 (2017) 643–662

Contents lists available at ScienceDirect

Tectonophysics

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

Post-Variscan thermal history of the Moravo-Silesian lower Carboniferous Culm Basin (NE Czech Republic - SW Poland)

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ARTICLE INFO

Article history:
Received 22 December 2016
Received in revised form 26 June 2017
Accepted 28 June 2017
Available online 30 June 2017

Keywords:
Thermochronology
Zircon
Apatite
Moravo-Silesian Culm Basin
Rheno-Hercynian Zone
Variscides

ABSTRACT

Apatite fission track analysis (AFT) and zircon (U-Th)/He thermochronology (ZHe) have been carried out for a lower Carboniferous greywacke succession of the Moravo-Silesian Culm Basin in the Nízký Jeseník Mountains. The range of apparent zircon helium ages is 303–233 Ma (late Carboniferous to Early Triassic) in the eastern part of the basin, whilst they are significantly younger in the western part, ranging from 194 to 163 Ma (Early-Middle Jurassic). Apatite fission track central ages range from 152 (Latest Jurassic) to 44 Ma (Eocene), with the majority being grouped between 114 (Aptian) and 57 Ma (Paleocene). All samples experienced substantial post-depositional thermal reset; both the AFT ages and the ZHe are considerably younger than the depositional ages. The mean track length varies in the range between 12.5 and 15.4 μm. The unimodal track length distribution, the relatively short mean track length (in most samples), and their rather low standard deviation values (1.2 to 2.1 μm) indicate that their thermal history was determined by Variscan and post-Variscan heating event(s) followed by a prolonged residence in the apatite partial annealing zone in the Mesozoic and finally by cooling in the Paleogene. Geological evidence combined with thermal modeling based on AFT and ZHe data indicate that the lower Carboniferous strata had already reached maximum palaeotemperatures in the late Carboniferous, however, they were presumably later re-heated during the Permian-Triassic. Post-Variscan extensional tectonics events were responsible for high heat flow that together with Carboniferous burial could account for the reset of both thermochronometers. A major phase of cooling occurred in the Late Cretaceous. Finally, exhumation was probably faster in the Paleogene, causing the present-day exposure of the studied rocks.

1. Introduction

The Moravo-Silesian Zone (MSZ) is located in the eastern part of the Czech Republic and south-western Poland, at the eastern margin of the Bohemian Massif (Fig. 1). MSZ is often considered the eastward continuation of the Rheno-Hercynian Zone of the European Variscides (e.g., Dvořák and Paproth, 1969; Franke, 1995; McCann et al., 2006; Kroner et al., 2008). The lower Carboniferous Moravo-Silesian Culm Basin, being part of the MSZ, represents the outcrop of the Variscan foreland basin that was deformed and partly included in an orogenic accretionary wedge (Čížek and Tomek, 1991; Dvořák, 1994; Kumpera and Martinec, 1995; Kalvoda et al., 2008).

The orogenic evolution of the MSZ is relatively well constrained by high-temperature geochronometers (e.g., Schulmann et al., 1991; Štípská and Schulmann, 1995; Schulmann and Gayer, 2000; Schulmann et al., 2005; Jastrzębski et al., 2013). However, its low-temperature, post-orogenic history is still a matter of debate, particularly due to the sparsely preserved post-Carboniferous geological record (Maluski et al., 1995; Danišík et al., 2012; Sobczyk et al., 2015; Botor et al., 2017). Previous low-temperature studies in the Bohemian Massif and adjacent areas were mostly based on AFT data. They identified several cooling events throughout the Mesozoic and Cenozoic (Wagner et al., 1997; Hejl et al., 1997, 2003; Coyle et al., 1997; Thomson and Zeh, 2000; Glasmacher et al., 2002; Ventura and Lisker, 2003; Aramowicz et al., 2006; Martinek et al., 2006; Filip et al., 2007; Ventura et al., 2009; Vamvaka et al., 2014). However, Danišík et al. (2012) and Sobczyk et al. (2015) proposed significant sedimentary burial during the Late Cretaceous that caused resetting of ZHe ages in the middle part of the Sudetes. These studies suggest that the Bohemian Massif experienced a complex postorogenic thermal evolution that may have been influenced by various processes: burial under Mesozoic sediments, Late Cretaceous exhumation related to far field compression from the Alpine Orogen and/or reheating and exhumation related to Mesozoic extensional tectonics and the opening of the European Cenozoic Rift System in the Eocene-Oligocene. The aim of this study is to fill the gap in understanding of the regional thermal history by employing fission-track and helium

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http://dx.doi.org/10.1016/j.tecto.2017.06.035
0040-1951/

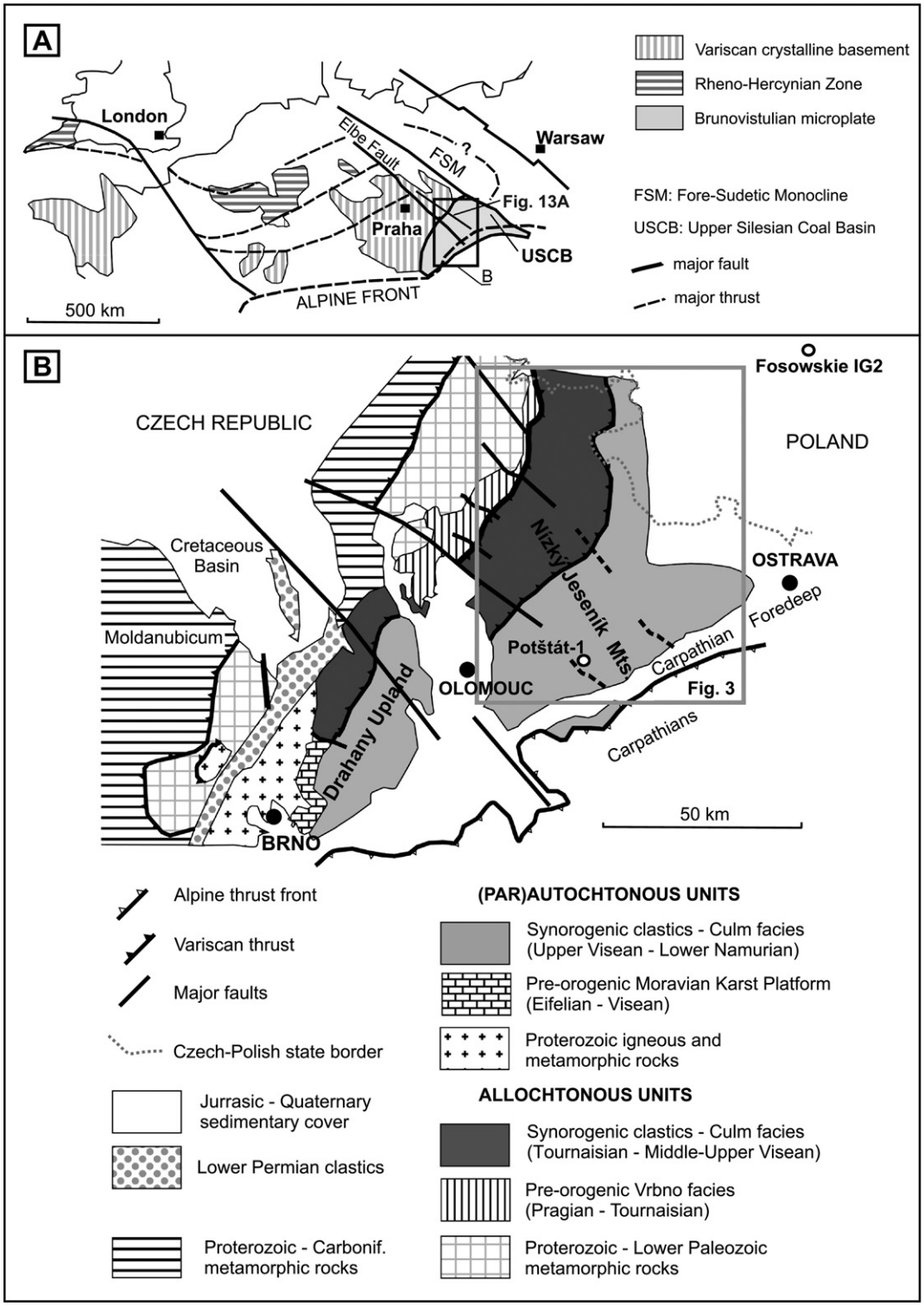

Fig. 1. A: Position of the study area in the European Variscides. B: Simplified geological map of the study area (based on Unrug, 1977; Unrug and Dembowski, 1971; Dvořák, 1989; Kumpera and Martinec, 1995; Kalvoda et al., 2008).

thermochronology to constrain the late and post-Variscan thermal history of the eastern margin of the Bohemian Massif in the Moravo-Silesian Culm Basin (MSCB), where no such data exist so far.

2. Geological setting

The Moravo-Silesian Fold-and-Thrust Belt (MSFTB; Mazur et al., 2006) represents the western, highly deformed allochthonous part of the MSCB that extends in the N-S direction along the NE margin of the Bohemian Massif (Fig. 1; Dvořák and Paproth, 1969; Unrug and Dembowski, 1971; Schulmann et al., 1991; Franke, 1995; Fritz and Neubauer, 1995; Schulmann and Gayer, 2000; Franke and Żelaźniewicz, 2000). The MSFTB corresponds to the eastern part of the Moravo-Sileasian Zone (Dallmeyer et al., 1992; Franke and Żelaźniewicz, 2000; Hartley and Otava, 2001; Mazur et al., 2006) and it is composed of unmetamorphosed to slightly metamorphosed