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Alpine metamorphic evolution and cooling history of the Veporic basement in northern Hungary: new petrological and geochronological constraints

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Abstract Petrological and geochronological investigations were carried out on metamorphic rocks of the Veporic unit (Inner Western Carpathians) in northern Hungary. K/Ar and Ar/Ar data on micas and amphiboles show only Alpine ages (mostly in the range of 87–95 Ma) in this basement unit. Thermobarometric calculations yield lower amphibolite facies peak conditions (ca. 550±300 °C and 9±1 kbar) for the Eoalpine metamorphic event. Complex evolution of gneissic rocks is reflected by the presence of discontinuously zoned garnets, the cores of which may represent relics of a pre-Alpine (presumably Variscan) thermal event. Zircon fission track (FT) data in the narrow range of 75–77.5 Ma indicate that this portion of the Veporic unit was emplaced to shallow crustal levels already during the Senonian time. The relative minor difference between zircon FT and K/Ar or Ar/Ar ages suggests very rapid cooling during the Late Cretaceous, most probably related to the extensional unroofing of the Veporic core complex. The obtained cooling ages do not support previous models of Tertiary uplift and exhumation of the Veporic unit along the Hurbanovo-Diósjenő Line.

Keywords Alpine metamorphism · Geothermobarometry · Geochronology · Veporic unit · Carpathians

Introduction

Recently, numerous detailed geochronological and petrological works (Thöni and Jagoutz 1993; Török 1998; Plašienka et al. 1999) have proven the widespread and pronounced presence of Alpine metamorphism within the ALCAPA region (internal Eastern Alps–Carpathians-Pannonian Basin; Neubauer 1992). This is in contradiction to ideas from the past decades (see Balogh and Kőrössy 1974; Jantsky et al. 1988), emphasizing its very subordinate extent and intensity in comparison to earlier metamorphic events (Variscan, Caledonian, Cadomian, etc.).

In this contribution we consider the Alpine metamorphic evolution and cooling history of the Veporic unit (Fig. 1), which is one of the most important tectonic elements of the Inner Western Carpathians (IWC). Earlier works considered the crystalline rocks of this unit – exposed only in boreholes in northern Hungary – as a Variscan (or even older) medium-grade metamorphic sequence which underwent only “weak (sub)greenschist facies retrogression” during the Alpine orogeny (Ravasz-Baranyai and Viczián 1976; Fülöp 1990). Our new petrological and geochronological investigations allow us to constrain the P–T–t conditions of the Alpine tectonometamorphic evolution in the Veporic unit. These results unambiguously prove the presence of Eoalpine medium-grade
Fig. 1 Structural overview map of N Hungary and S Slovakia in the southern part of the Veporic unit. *Inset* shows the location of the study area in the Carpathian orogeny. (Slightly modified after Fülöp 1990)

metamorphism and enable the reconstruction of the cooling path in this unit.

**Methods**

Chemical analyses of minerals were carried out with a JEOL JXCA-733 electron microprobe in the Laboratory for Geochemical Research, Hungarian Academy of Sciences, Budapest. The measuring conditions were: 15 kV acceleration voltage; 40 nA sample current; electron beam with a diameter of 5–10 μm and 5 s counting time. Matrix effects were corrected using the ZAF method. The following standards were used for quantitative analysis: orthoclase (K, Al, Si), synthetic glass (Fe, Mg, Ca), spessartine (Mn), rutile (Ti) and albite (Na).

K/Ar measurements were performed in the Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), Debrecen. The interlaboratory standards Asia 1/65, HD-B1, LP-6 and GL-0 as well as atmospheric Ar were used for controlling and calibration of analyses. Details of the instruments, the applied methods and results of calibration have been described by Odin et al. (1982) and Balogh (1985) K/Ar ages were calculated using the constants proposed by Steiger and Jäger (1977).

For Ar/Ar dating samples were irradiated in the 229/3 position (out of the centre of the core) of the nuclear reactor of the Central Institute of Physics, Budapest, along with interlaboratory standard biotite LP-6. Particulars of the experimental method used in this work are described by Balogh and Simonits (1998).

For fission track dating, neutron irradiations were made at the RISØ reactor (Denmark). The FT ages were determined by the zeta method (Hurford and Green 1983) using zircon from the Fish Canyon Tuff, Buluk Member Tuff and Tardree Rhyolite. Reference ages of 27.8±0.2 Ma for the Fish Canyon Tuff, 16.2±0.6 Ma for Buluk Member Tuff and 58.7±1.1 Ma for Tardree Rhyolite have been adopted, following Hur-