tal fractionation within main meso-Hercynian (350–330 Ma) period as a part of S-type granite suite of the Western Carpathian basement complexes or as a result of continental collision during Missisipian (Lower Carboniferous).

The second group show less evolved geochemical character, biotite tonalite with hornblende and granodiorite prevail. Typical is enrichment in Ti, Sr, Zr and incompatible elements; normalized REEs are plotted with steep pattern ($La_N/Yb_N \sim 29$; Kohút et al. 2003). The main rock-forming minerals of these granitoids are represented by plagioclase (An_{34}) + quartz + K-feldspar + biotite. Biotite is defined by low Fe/(Fe+Mg) ratio (0.47 apfu) and total Al content reaches maximal 2.79 apfu. Significant abundance of titanite in an investigated rocks is compensated by lower TiO_2 content in biotite (1.89 to 2.73 wt.%). Typical accessories are zircon ($S_{12,16,17}$ subtypes), allanite, titanite, apatite and magnetite. The accessory mineral assemblage indicates an oxidation conditions in magma and geochemical aspects of investigated granodiorites suggest their competence to I-type suite of granitic rocks. This magmatism, similarly as in the other core mountains of the Western Carpathians, is rooted in the low crust and emplaced rather high to the middle crustal level. I-type plutonism in Western Carpathians is interpreted as an independent pulse during extension or transtensional regime within meso-Variscan orogenesis (Broska and Gregor 1992, Broska and Uher 1991, 2001, Haunschmid et al. 1997, Petrík et al. 1994, Petrík and Kohút 1997, Petrík et al. 2001 and other). Consequently, we assume that granitoids in Branisko crystalline complex of S and I-type affinities are genetically joined with two separate tectonomagmatic events.

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Attempt to Dating of Accretion in the West Carpathian Flysch Belt: Apatite Fission Track Thermochronology of Tuff Layers

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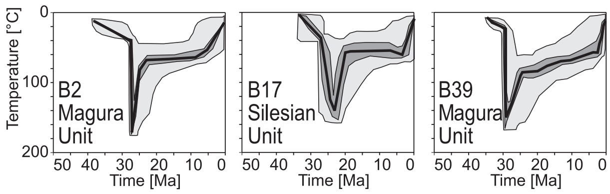
The Carpathians are a part of the European Alpine chain created by convergence and collision of the European and African plates (Golonka et al. 2000). The Outer Western Carpathians are a north-verging fold-and-thrust belt composed largely of Lower Cretaceous to Lower Miocene flysch sediments arranged into stacked complex of several nappes (from top to bottom: Magura, Dukla and Fore-Magura, Silesian, Sub-Silesian and Skole nappes. The tectonic evolution of the Outer Carpathians is subdivided into two successive shortening events: 1) NNW-(N) directed and 2) NE-(NNE) directed (Aleksandrowski 1989, Decker et al. 1997). During the first event the folding and thrusting started in the most inner, southern nappe (Magura nappe) and were propagated to the north. During the next event the previous thrust faults and folds were overprinted and refolded. According to Decker et al. (1999a), the first shortening event was taking place from the Eocene to Early Miocene time. The second shortening event started in the Early/Middle Miocene and lasted probably during the early Late Miocene time (Decker et al. 1999b, Wójcik et al. 2001). Organic maturation, clay diagenesis and fluid inclusion (Swierczewska et al. 1999, Hurai et al. 2002, Jarmolowicz-Szulc and Dudok 2005) of the different flysch units of Western Carpathians indicates that the nappes underwent some thermal overprint during their burial and/or the tectonic stacking.

We have performed apatite fission track (FT) thermochronology on ash layers and vitrinite reflectance measurements on organic rich pelites of Western Carpathian flysch in order to reconstruct the thermal and structural evolution of the flysch belt. The apatite FT dating were completed by the investigation of kinetic parameters in each dated crystals by Dpar measurements (Donelick 1995) and in some samples also by the determination of chlorine content using electron microprobe. The fission track results and Dpar measurements show rather homogeneous mineralogical composition of the dated grains and also indicate that the apatites of the samples derived form single sources. The only exception is sample B17, where we could identify two components, but by their separation it was possible to perform thermal modelling on a homogeneous sub-population. All FT ages are younger than the age of sedimentation or the dated age of the volcanic event. Geographically/structurally the age pattern is complex: the apparent FT ages are between 20 and 30 Ma in the Podhale Flysch (Inner Carpathians), along the PKB and the innermost part of the Magura nappe. In the Silesian nappe the ages cover a wider ranger between 9.7 and 29.5 Ma. The track length distributions are rather variable; the mean track lengths are between 13.6 and 15.2 µm. Mean track lengths do not show evident correlation with the apparent ages. Geochemically, these ash-layers apatites are usually chlorine-rich. The mean Dpar are between 2.6 and 3 µm and except sample B17 the chlorine content is always above the typical composition of Durango apatite (~0.4 wt%), thus both kinetic parameters indicate rather high closure temperature for the dated apatites.

The reset of fission track ages and the temperature indicators are evidently indicating that all investigated tectonic units have experienced significant burial. The post-sedimentary maximum temperature was around or above 100 °C. The apparent ages are different and the character of track length distributions is very variable, thus we can conclude that the investigated tectonic slices had rather different thermal histories. Considering the new data and Tmax determinations by clay mineralogical constraints further the results of fluid inclusion studies we have modelled the thermal evolution by HeFTy software (Ketcham, 2005). The input parameters of the thermal modelling are fission track apparent age, track length distribution, kinetic parameters (Dpar and chlorine content), formation age of the ash layer, time of the termination of sedimentation (by the overriding accretional wedge), temperature of sedimentary burial and maximum temperature. A very characteristic feature of the input data is the closeness of the end of sedimentation and the apparent FT age in case of every sample. The modelling resulted in slightly different time-temerature paths for the different structural units (Fig. 1). What is common in the thermal evolutions of the samples is the presence of the rather rapid increase of the burial temperature. After the end of sedimentation the temperature has reached the total reset conditions of apatite FT chronometer usually within 2 to 3 million years. The effective heating time is usually short, and soon after the thermal climax the flysch nappes were already cooling. The cooling rates are variable, but sometimes rather rapid (up to 50 °/Ma). We interpret these common characters of the thermal histories as the manifestation of the accretion process in the thermal history: (i) the rapid warming was related to the accretion of the flysch related with subduction process; (ii) the abrupt turn in the thermal histories were related to the collision process; (iii) the cessation of the increasing of temperature indicate the termination of the vertical displacement; (iv) the rapid cooling is probably related to normal faulting that exhumed some slabs of the accretionary complex faster than usual surface erosion.



■ **Fig. 1.** The results of thermal modelling of some charakteristic samples performed by HeFTy software of Ketcham (2005). Light gray fields represent the envelope of acceptable time-temperature paths, while dark gray belts are the enveloped by the runs of modelling with very good fitting to the measured data.

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REE Accessory Minerals in the Gneiss and Granulite Clasts from the Silesian Unit (Western Outer Carpathians, SE Poland) as Indicators of Metamorphic Processes

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Introduction

REE accessory minerals play the important role in metamorphic petrology. Their significance is related to their hosting of trace elements in metamorphic rocks and, therefore, providing important information about evolution that these rocks experienced. Phosphates (especially apatite, monazite and xenotime) are probably the most important group of metamorphic minerals, because they might be used in wide range of investigations, including geochronology and geothermobarometry (see e.g. Spear and Pyle 2002 and references therein). Moreover, reactions in which these minerals took part might provide significant information about history a rock experienced (e.g. Finger et al. 1998, Wing et al. 2002).

Gravel size extrabasinal clasts (so-called "exotics") of gneisses and granulites, which are present in the Silesian Unit (Western Outer Carpathians), preserve mineral assemblages, as well as structural relationships between minerals, that might provide important information about evolution of their source area – the Silesian Ridge. Monazite-(Ce), xenotime, apatite, zircon, uraninite and unidentified Th-phases as the main host of REE in studied rocks are roughly described in this report.

Sample selection and methods of investigation

Twenty one samples of gneisses and four samples of granulites collected in six localities (Bukowiec, Gorlice, Izdebnik, Krzesławice, Siekierczyna and Skrzydlna regions) in the Silesian Unit were studied. Transmitted light microscopy and SEM-EDS method were used during investigations. Samples are considered to be derived from the Silesian Ridge.

Chemical compositions of minerals were determined using cold field emission scanning electron microscope (FESEM) Hitachi S-4700 coupled with energy dispersive spectrometer (EDS) NORAN Vantage. Analyses were performed in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University, Kraków.

Results

Gneisses are mainly composed of plagioclase (ranging from oligoclase to andesine), quartz, biotite, muscovite and K-feldspar.