STRATIGRAPHIC EVIDENCE OF PYROCLASTIC LAYERS IN MIOCENE BASINS OF THE EASTERN ALPS (AUSTRIA)

F. EBNER[1], I. DUNKL[2], H. MALI[1] and R. F. SACHSENHOFER[1]

[1]*University of Leoben, Department of Geosciences, A–8700 Leoben, Austria*
[2]*University of Tübingen, Institute of Geology, D–72076 Tübingen, Germany*

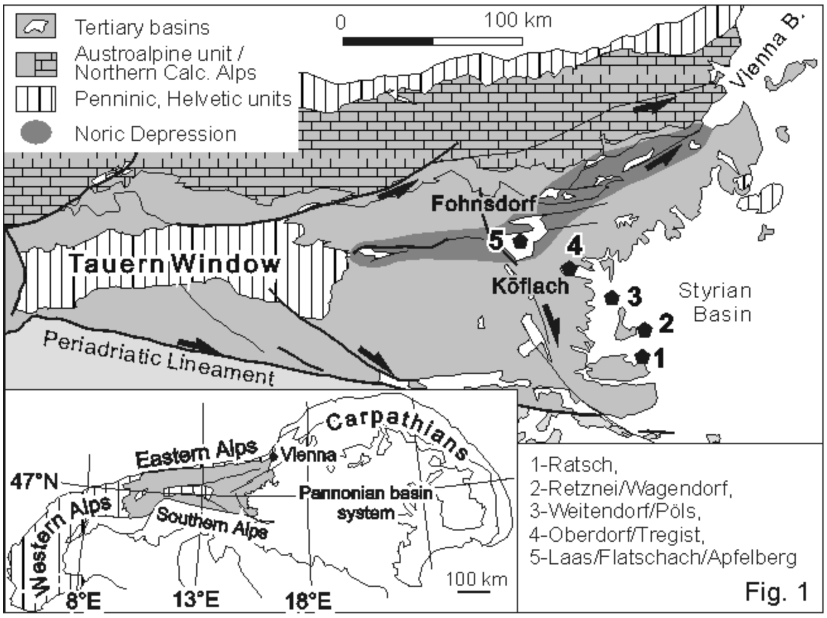
Abstract: The stratigraphic position of Miocene pyroclastic layers from the western Styrian Basin and the Noric Depression were investigated applying lithostratigraphy, biostratigraphy and radiometric (fission track) age dating. Most of the dated tuffs are of early Badenian age but Ottnangian to ?post early Badenian ages occur as well.

Key words: Styrian basin, Miocene, tuff, tephrochronology, fission track dating

Introduction

Pyroclastic layers are widespread in the Styrian Basin and in Miocene strike slip basins within the Alps (Noric Depression, Lavant Valley; EBNER et al. 2000). In the present study we investigate Miocene tuffs from the western Styrian Basin and the Noric Depression (Fig. 1). The pyroclastic layers are up to 5 m thick. Generally they contain a basal layer of bentonite overlain by more or less altered fine grained vitric tuff. Sometimes coarse grained crystal tuffs occur as well. Fine grained layers are interpreted as far transported fallout tephras. Bulk chemistry of pyroclastic rocks is strongly influenced by the grade of bentonitisation and detrital influx. The petrographic/geochemical features indicate rhyolithic/andesitic sources.

A multidisciplinary approach is used for tephrochronology considering fission track (FT) data, biostratigraphy, heavy minerals (espec. magmatic phenocrystals), sedimentary and geochemical features. The morphological characterisation of zircon crystals follows PUPIN (1980). The FT measurements of the zircons were performed by the external detector method using zeta calibration (GLEADOW, 1981). Results are presented in Tab. 1; sample locations are shown in Fig. 1.



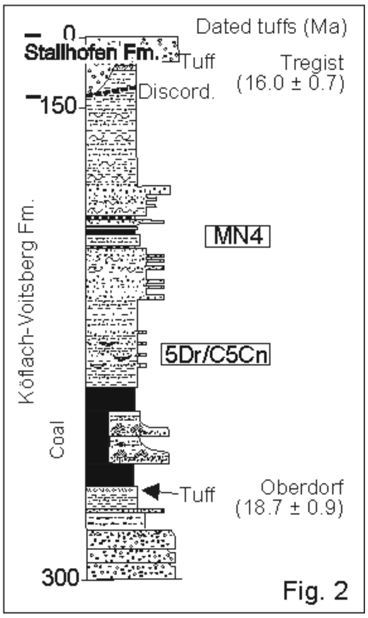


Fig. 1: Position of investigated tuffs in the Styrian Basin and the Noric Depression.

Fig. 2: Stratigraphic section of the Köflach/Voitsberg Basin with the position of tuffs (locality 4 in Fig. 1).

Results

The southern margin of the Styrian Basin is dominated by fine grained marine rocks (Karpatian to Badenian "Styrian Schlier"). At *Ratsch* volcanogenic contaminated sandstones yield different populations of zircons: colorless rounded zircons with pre-Miocene FT ages (108 Ma) and colorless and red euhedral zircons, which occupy the central part of the Miocene age cluster and indicate a central age of 15.4 ± 0.5 Ma (Fig. 3A).

The lower Badenian coralline algae build up of *Retznei* interfingers with and is overlain by marls. They form part of the biostratigraphically dated lower Badenian Weißenegg Fm. At the slope of the build up there is an intercalation with bentonite and coarse crystal tuff ~2 m thick. At *Wagendorf* a strongly altered pyroclastic layer up to 30 cm thick was drilled. The tuff is mixed with marine sediment. It was dated by a rich foraminifera fauna as early Badenian (Lagenide zone¸ RÖGL, unpubl.).

At least two pyroclastic horizons with bentonite and vitritic tuff exist in lower Badenian lagoonal marls in the western Styrian Basin. At *Weitendorf* a shoshonite sill (16.8 - 14.0 Ma; BALOGH et al., 1994) is underlain by marls rich in molluscs of the Lagenide zone and is overlain by marine Badenian rocks. Both inculde tuff layers, which are not related to the shoshonite. At *Pöls* two tuff layers are intercalated within the Florian Fm. The biostratigraphic age (molluscs, foraminfers) agrees with K/Ar biotite datings (16.6 ± 0.6 and 15.1 ± 0.5 Ma; BALOGH et al., 1994).

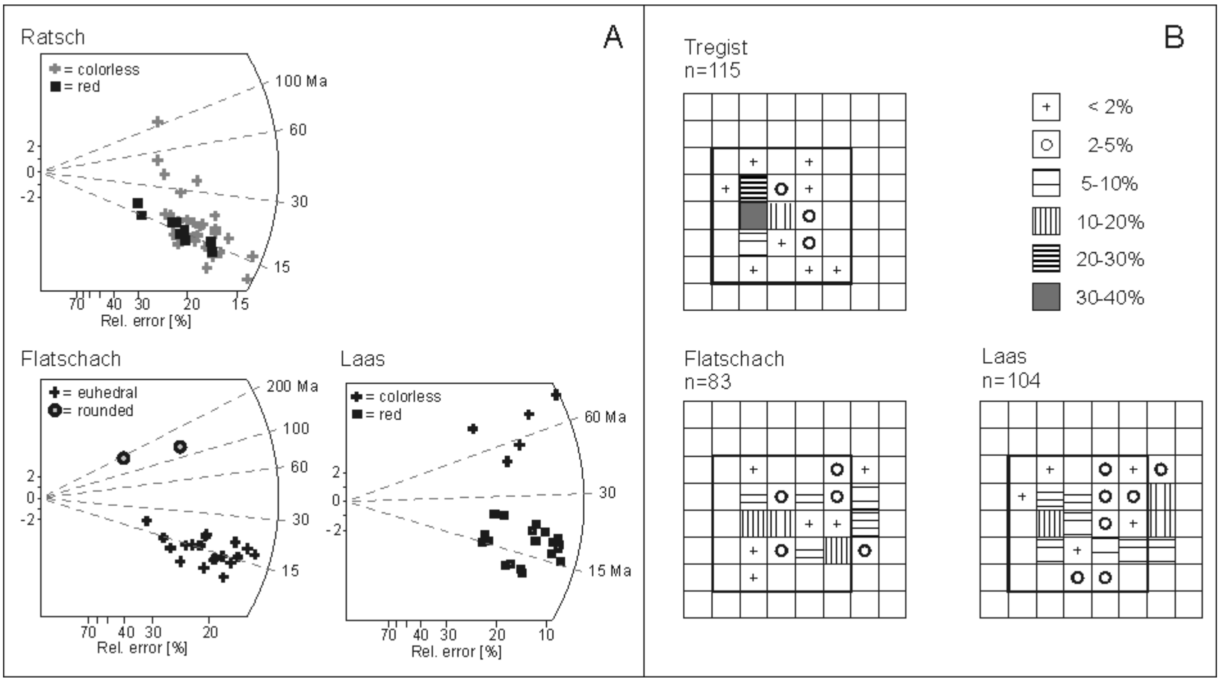


Fig. 3: A – Radial plot of zircon fission tack ages from Ratsch, Flatschach and Laas.

B – Zircon morphologis (according to PUPIN, 1980) from Tregist, Flatschach and Laas.

In the *Köflach/Voitsberg* a thin layer of tuff altered to kaolinite was found below the Oberdorf lignite seam of the Köflach-Voitsberg Fm. (STEININGER et al., 1998 ; Fig. 2). The zircon FT age is 18.7 ± 0.9 Ma (Ottnangian). This fits well with the position of the tuff ~50 m below the magnetic polarity change 5Dr/C5Cn (17.6 Ma) and ~75 m below a horizon dated by micromammals as MN 4 (STEININGER et al., 1998). The Köflach-Voitsberg Fm. is overlain by the limnic/fluvial Stallhofen Fm. including the pyroclastic Lobmingberg SbFm. at its base (EBNER et al., 2000). The zircon morphotypes form a characteristic cluster around the S12 field (Fig. 3B), indicating a single volcanic source of presumably calc-alkaline character. The grain FT age distribution is compact and indicates the age of the volcanic activity at 16 ± 0,8 Ma (early Badenian).

The *Fohnsdorf basin* in the Noric Depression is filled by the fluvio-deltaic Fohnsdorf Fm., the brackisch to limnic Ingering Fm., and the alluvial Apfelberg Fm. (Fig. 4). Tuff layers are situated within the coal seam at the top of the Fohnsdorf Fm., five layers occur within the Ingering Fm., and at least three layers in the *Apfelberg*-Fm. Another tuff was found near *Laas* in a remote part of the basin (SACHSENHOFER et al., 2000; Fig. 4). The FT age from Laas is 17.1 ± 0.7 Ma (early Karpatian). Some detrital, zoned, colorless zircons gave ages between 100 and 200 Ma. The age from the uppermost tuff horizon in the Ingering Fm. (*Flatschach;* Fig. 4) with 14.9 ± 0.7 Ma is similar to that from *Apfelberg* (15.5 ± 0.8 Ma). This contrasts with field observations, suggesting an older age of the Flatschach tuff. Micromammals date the Apfelberg Fm. into MN 6 (post-early Badenian; DAXNER-HÖCK, unpubl.). Red zircons with a Miocene age dominate the spectra from Laas and Flatschach, but morphotypes show that detrital zircons occur as well. One population is very similar to those from Tregist, but the crystals have morphologies along the P-fields (loose clusters at the right) and derived probably from more alkaline rocks. Crystals plotting into the S-fields are usually colorless, whereas P-type crystals are mainly red (Fig. 3A).

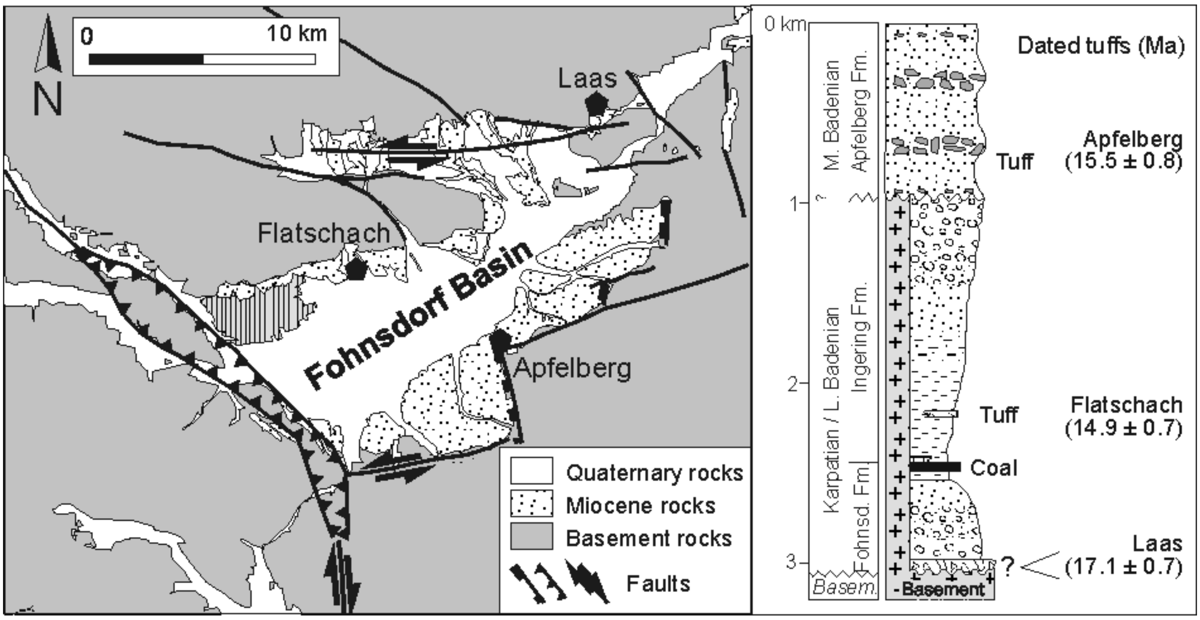


Fig. 4: Geologic map and stratigraphic section of the Fonsdorf Basin with the position of tuffs.

Conclusions

- Zircon morphology and single grain age distributions indicate that the components of Flatschach, Laas and Ratsch are oligomict in origin. Beyond the Miocene volcanogenic components rounded grains of pre- and late Cretaceous and Paleogene zircon FT were detected. These are considered as contaminations and the result of mixing during “cool” Miocene sedimentation/resedimentation processes.
- The volcanogenic influence in the Miocene basins is constrained by the dating of pyroclastic layers from 18.7 ± 0.9 (? Ottnangian) to ?post early Badenian ages. This implies that the source of the tuffs may partly be outside the Styrian Basin, where Miocene volcanic events are dated from late Karpatian to early Badenian.
- The lower Badenian age of several pyroclastic layers is well constrained by radiometric, biostratigraphic and lithostratigraphic methods. These levels are contemporaneous with the climax of the Miocene volcanic activity in the Styrian Basin.

- The isolation of the syn-sedimentary volcanogenic components was possible using phenomenological criteria like morphology, color, zoning and inclusion, and also by using statistical tests. According to this, a calc-alkaline source was indicated beside another of alkaline character. The mixture of the two components can happen either in the magmatic phase, during the explosions, or during sediment transport.
- The character of Miocene volcanogenic zircons is often similar. They are always strongly elongated, crowned frequently by the {101} pyramid. The color is often red, sometimes color-zoned, but there is no zoning in the uranium content. The crystals are very rich in elongated crystal inclusions and c-parallel glass inclusions.

Locality	Code	Petro-graphy	Cryst.	Spontaneous ρs (Ns)	Induced ρi (Ni)	Dosimeter ρd (Nd)	$P(c^2)$ (%)	FT age* (Ma ± 1s)
Apfelberg		tuff	20	41.2 (556)	114.7 (1545)	6.73 (4543)	**100**	**15.5 ± 0.8**
Tregist		bentonite	20	44.0 (836)	80.0 (1517)	4.54 (8928)	**21**	**16 ± 0.8**
Köflach	0-13	tuff	20	66.1 (1040)	149.5 (2351)	6.67 (4543)	**9**	**18.7 ± 0.9**
Flatschlach		bentonite	22	52.9 (905)	88.7 (1517)	4.54 (8928)	<1	18.1 ± 2.4
				20 volcanogenic population			**25**	**14.9 ± 0.8**
				2			-	142.4 ± 30
Laas		tuff	25	52.3 (1507)	102.1 (2940)	6.70 (4543)	<1	23.1 ± 2.8
				20 volcanogenic population			**10**	**17.1 ± 0.8**
				2			-	51.6 ± 6.6
				3			-	81.6 ± 8.1
Ratsch	6-2	sandstone	41	49.4 (1594)	123.2 (3973)	6.58 (12943)	<1	17.8 ± 1.2
				36 volcanogenic population			**84**	**15.4 ± 0.5**
				4			-	36.2 ± 4
				1			-	~108

Cryst: number of dated zircon crystals. Track densities (ρ) are as measured ($\times 10^5$ tr/cm^2); number of tracks counted (N) shown in brackets.
*: Central ages calculated using dosimeter glass: CN 2 with ζ_{CN2} = 127.8 ± 1.6.
$P(\chi^2)$: probability obtaining Chi-square value for n degree of freedom (where n = no. crystals-1).

Tab. 1: Fission track ages.

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