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Petrographical, geochemical and geochronological constraints on igneous clasts and sediments hosted in the Oligo-Miocene Bakony Molasse, Hungary: evidence for a Paleo-Drau River system

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Abstract The provenance of igneous clasts and arenitic sediment enclosed within the Bakony Molasse was studied using geochemical and geochronological methods. The majority of igneous clasts were eroded from the Oligocene Periadiatic magmatic belt. A part of the andesite material has Eocene formation age. Rhyolitic pebbles originated from Permian sequences of the Greywacke zone or the Gurktal Alps. Apatite fission track (FT) ages from the sandstone matrix (age clusters at ~75 and ~30 Ma) are typical for the Austroalpine nappe pile and for the cooling ages of Periadiatic magmatic belt. Variscan detrital zircon FT ages indicate source areas that had not suffered Alpine metamorphism, such as the Bakony Mountains, Drauzug and the Southern Alps. Another group of detrital zircon grains of Late Triassic–Jurassic FT age (mean: ~183 Ma) marks source zones with Mesozoic thermal overprint such as the Gurktal Alps and some Austroalpine regions. Zircon grains with Oligocene FT age (mean: ~34.7 Ma) were derived from the Periadiatic intrusives and their contact zones. On the basis of the new data, we propose that the ancestor of the recent Drau River had already existed in Oligo-Miocene time and distributed eroded material of the southern Eastern Alps to the east.

Keywords Alpine Molasse · Fission track dating · K/Ar dating · Geochemistry · Provenance analysis · Pannonian Basin · Oligocene–Miocene

Introduction

The Alpine collision and subsequent uplift resulted in the formation of numerous alluvial systems during Oligo-Miocene time in the Alpine–Carpathian region. Although the deposits of these systems exhibit diverse sedimentary characteristics, they all share in common the presence of similar Oligocene igneous clasts (e.g. tonalites, andesites, dacites, rhyolites) in their coarse debris (Gelati et al. 1988; Stingl and Krois 1991; Rahn et al. 1995; Mair et al. 1996; Ruffini et al. 1997; Brügel 1998; Brügel et al. 2000).

In the Pannonian Basin, Late Oligocene–Early Miocene coarse sands and conglomerates with the same characteristics are exposed between the cities of Sümeget Mór in the area of the Bakony Mountains (Fig. 1). The lack of a suitable fossil record makes precise biostratigraphic subdivision impossible. The identification of the source area of the magmatic clasts was previously uncertain due to the lack of suitable constraints (Korpás 1981; Báldi 1986).

In this paper we show new petrographic and geochemical results for representative igneous clasts derived from this alluvial system, known as the Csatka Formation. We present detailed petrographic descriptions and geochemical analyses of the clasts and highlight features that are characteristic of the magmatic source. Fission track (FT) and K/Ar geochronology of
Fig. 1 Locations of Paleogene magmatic rocks in the western Pannonian Basin with a compilation of published geochronological data (Baksa 1975; Balogh 1985; Nagyamarosy et al. 1986; Darida-Tichy 1987; Horváth and Tari 1987; Körössy 1988; Dunkl and Nagyamarosy 1992). The Velence Hills and surrounding areas towards the Csatka Basin can be ruled out as a source area for igneous clasts (after Korpás 1981)

magmatic clasts and sandstone samples allow us to identify the dominant ages of the eroded materials and suggest likely source areas.

**Geological setting**

The Bakony Mountains (Fig. 1, hereafter referred to as BM) comprise a complete Variscan–Alpine sequence situated in the Alcapa microplate, Western Hungary. Pre-Late Carboniferous rocks of the unit underwent low-grade, regional pre-Westphalian metamorphism (Árkai and Lelkes-Felvári 1987), and were unaffected by Alpine metamorphism (Lelkes-Felvári et al. 1996). The Variscan sequence includes: (1) Ordovician–Devonian metaitslstones, quartz phyllites, metasandstones and metaquartzites, (2) Early Carboniferous marine molasse, and subsequent (3) Carboniferous granite plutons and Permian dacitic volcanics. Triassic sedimentation was dominantly shallow marine and produced carbonates and claystones accompanied by volcanoclastics (for details see Haas et al. 1995; Harangi et al. 1996). The Jurassic to Early Cretaceous sediments are mainly pelagic and include condensed and incomplete sequences (Vörös and Galácz 1998). Due to Cretaceous orogenic movements there is a stratigraphic gap taking the form of subaerial exposure and deep erosion into the Triassic strata (D’Argenio and Mindszenty 1995).

The Cenozoic sedimentary sequence began in the Eocene (Lutetian). Deepening upward sediments, such as bauxite and coal layers, basal conglomerates, sandstones, nummulitic limestones and marls, accumulated in the basins (Royden and Báldi 1988), occasionally interlayered with tuff horizons (Székéné and Barabás 1953; Balogh 1985; Dunkl 1990). Eocene andesite and calc-alkaline tonalite magmatic rocks intruded into these sediments (Balázs et al. 1981) and have been interpreted on the basis of their chemistry to be subduction-related (Downes et al. 1995). Following this, the western side of the BM was uplifted, partly eroded and an E–W facies polarity initiated (Báldi and Báldi-Beké 1985). In the west, much of the BM was covered by alluvial–brackish sediments, whereas in the east