# PETROGENESIS OF THE MIOCENE SILICIC MAGMAS IN THE PANNONIAN BASIN – A CASE STUDY IN THE EASTERN BÜKKALJA VOLCANIC FIELD, NORTHERN NUGARY.

R. LUKÁCS and S. HARANGI

*Department fo Petrology and Geochemistry, Eötvös University, H-1117 Pázmány Péter sétány 1/C, Hungary;*
*lrekuska@freemail.hu, harangi@iris.geobio.elte.hu*

**Abstract:** Detailed geochemical study of the phenocrysts and separated pumices of the 13.5 Ma old ignimbrite from the eastern Bükkalja Volcanic Field, Northern Hungary suggests that mantle-derived magmas played an important role in the genesis of the silicic magmas. The bimodal character of the zircon morphology and trace element composition of pumices indicates mingling of two separate rhyolitic magma batches in the shallow level magma chamber.

**Key words:** silicic magma, ignimbrite, petrogenesis, Pannonian basin, Bükkalja

## Introduction

The Neogene volcanic activity of the Carpathian/Pannonian Region commenced with extensive silicic volcanic eruptions. This volcanism partly predates the main - Mid-Miocene - extensional period of the Pannonian Basin, but most of the volcanic eruptions occurred contemporaneously with the thinning of the lithosphere beneath the region. Thus, this volcanic activity has great geodynamic implications. Yet, origin of the silicic magmas is a subject of debate. Most researchers suggested that these magmas were originated by anatexis of the lower continental crust either due to the delamination of the whole mantle lithosphere (Downes, 1996) or due to the intrusion of mantle-derived magmas into the crust-mantle boundary zone (Lexa and Konecny, 1999). In addition, Póka et al. (1998) proposed that most of the silicic magmas generated by melting of the upper crust. In contrast, Harangi (2001) emphasized the important role of mantle-derived magmas in the genesis of the silicic volcanic rocks and invoked

variable amount of lower crustal contamination. Magma mixing was also an important petrogenetic process in the evolution of the Middle Miocene silicic magmas as pointed out by Póka et al. (1998), Czuppon et al. (2001) and Lukács et al. (2002). Here, we present a case study on the Late Badenian silicic volcanic rocks from the eastern Bükkalja Volcanic Field. Based on mineral chemical data and major and trace element composition and radiogenic isotope ratios of the pumices we propose that the silicic magmas evolved from mantle-derived magmas, which was contaminated by metapelitic lower crust and underwent further differentiation. We emphasize also the role of magma mixing process, where distinct rhyolitic magmas were mingled before the eruption.

**Geologic background**

The volcanic products of the silicic volcanism are usually covered by Late Miocene to Quaternary sediments in the Pannonian Basin that makes difficult their complex studies. However, scattered but well-preserved outcrops of the silicic pyroclastic rocks in the southern foreland of the uplifted Bükk Mts. (Fig. 1) provide an excellent opportunity to do both detailed volcanologic and petrogenetic studies (e.g., Szakács et al., 1998; Harangi et al., 2000). They are mostly unwelded to welded pumice-rich pyroclastic flow deposits (ignimbrites), whereas scoria-bearing pyroclastic flow and pyroclastic fall deposits occur subordinately. In the Bükkalja Volcanic Field (BVF) silicic pyroclastic rocks cover a formation age from 21 Ma to 13.5 Ma (Márton and Pécskay, 1998). They are divided into three main units based on paleomagnetic data (Márton and Pécskay, 1998). However, geochemical data suggest that the Upper Ignimbrite Unit is not homogeneous and can be divided into further subunits. One of these is exposed in the eastern BVF, whereas the other one occurs in the western BVF. Trace element patterns of glass shards of these rocks clearly indicate distinct geochemical character (Harangi and Mason, 2002). In this study we are focusing on the eastern part of the BVF and call this volcanic series Harsány Ignimbrite Unit (HIU).

## Volcanology and geochemistry of the Harsány Ignimbrite Unit

The silicic volcanic suite of the HIU overlays the scoria-bearing pyroclastic flow deposit of the Middle Ignimbrite Unit and includes phreatomagmatic fall layers, ash flow deposits and intercalated reworked volcaniclastic deposits. The upper part of this volcanic series is represented by a pumice-rich pyroclastic flow deposit. It is at least 15 meter thick and contain large amount of coarse lapilli- and block-sized pumice clasts. The K/Ar radiometric age dating on separated biotite of this rock from two localities yielded 13.5 Ma. The phenocryst assemblage includes quartz, plagioclase, biotite and sporadic K-feldspar. Zircon is a common accessory mineral, which shows bimodal morphology (Szabó and Harangi, 2001). One of the zircon population has typical hybrid calc-alkaline character with dominant $S_8$ and $S_{13}$ morphology, whereas the other has mantle-derived alkaline character with $P_{2-3}$ morphology. Plagioclases are both homogeneous and show complex zoning, but most of them are oligoclase in composition. Biotites have distinct composition compared with those occurs in other ignimbrite units of the BVF. The HIU biotites are typically iron-rich and reflect alkaline host magma based on the classification scheme of Abdel-Rahman (1994). Trace element composition of pumices reflects also bimodal feature (Fig. 2) in spite of their realtive homogeneous major element chemistry ($SiO_2$=75-77 wt%, K2O=3.8-5.2 wt%, in unhydrous basis). The 'anomalous' pumices are enriched in light rare earth elements, Sr, Zr and Ti, whereas are depleted in heavy rare earth elements relative to the dominant 'normal' pumices. They have also smaller negative Eu-anomaly (Eu/Eu*=0.57) than the 'normal' pumices (Eu/Eu*=0.38). The two pumice types show also slightly different Sr and Nd isotopic ratios.

## Petrogenesis

Mineral chemical data (composition of plagioclase and biotite) of the HIU ignimbrites differ significantly from those of the other ignimbrite unit of the BVF suggesting distinct genesis. The initial $^{87}Sr/^{86}Sr$ ratios of the pumices (0.7073-0.7079) are smaller than those of the pumices from the older BVF ignimbrites

and fall in the trend of the Miocene calc-alkaline volcanic rocks of the Northern Pannonian Basin. This implies similarities in their petrogenesis as supported also by several trace element ratios (e.g., La/Y, Nb/Y). We propose that geochemical character of the HIU pumices can be best explained by derivation from mantle-derived parental magmas, which contaminated by low amount of lower crust. The two types of pumice cannot be derived by fractional crystallization from one another, but should represent distinct rhyolitic magmas, which were mingled in the shallow level magma chamber just prior the eruption. Morphology of zircons and composition of biotites suggest the presence of an alkaline-type host magma in the genesis of the HIU volcanic rocks. The 'anomalous' pumices, which have high La/Y and Nb/Y ratios might represent this magma batch.

In summary, we propose that mantle-derived magmas had an important role in the genesis of the Late Badenian HIU ignimbrite. Parental magma could have generated in the thinning metasomatized lithospheric mantle and was contaminated by low amount of lower crust. Contemporaneously melt generation could have occurred also in the enriched asthenosphere and this magma incorporated also melts from the metasomatized lithospheric mantle. This 'alkaline' hybrid magma was contaminated by the lower crust and intruded into the shallow level magma chamber. The two rhyolitic magmas could not homogenize completely as shown by the bimodal pumice composition although their phenocrysts mixed together. Finally, considering also the geochemical character of the 13.5 Ma old ignimbrite from the western BVF, it is remarkable that this period was characterized by generation of fairly distinct silicic magma batches in the Northern Pannonian Basin.

**Acknowledgements**

Geochemical analyses were carried out in the Institute of Petrology, University of Vienna under a cooperative research study supported by the Austrian-Hungarian Action Foundation (43öu7). We thank Friedrich Koller, Theo Ntaflos and Peter Nagel for their help in the analytical work. The fieldwork was

supported by the Pro Renovanda Culturae Foundation (DT.2000.okt./6 and DT.2001.nov./17.).

## References

Abdel-Rahman, A.M. 1994: Nature of biotites from alkaline, calc-alkaline, and peraluminous magmas. - Journal of Petrology 35, pp. 525-541.

Czuppon, Gy., Sz. Harangi, T. Ntaflos, R. Lukács, Cs. Szabó, F. Koller 2001: Mixed andesite-rhyolite ignimbrite from the Miocene Bükkalja Ignimbrite Volcanic Field, Northern Hungary: evidence for magma mixing. - Mitteilungen der Österreichischen Mineralogischen Gesellschaft, 146, pp. 61-63.

Downes, H. 1996: Neogene magmatism and tectonics in the Carpatho-Pannonian region. - In: Decker. K. (Ed.): PANCARDI Workshop 1996, Dynamics of the Pannonian-Carpathian-Dinaride System - Mid. Ges. Geol. Bergbaustud. Österr., 41., pp. 104-105.

Harangi, Sz. 2001: Neogene to Quaternary Volcanism of the Carpathian-Pannonian Region - a review - Acta Geologica Hungarica, 44, pp. 223-258.

Harangi, Sz., R. Lukács, Zs. Szabó, D. Karátson 2000: The Miocene Bükkalja Ignimbrite Volcanic Field, Northern Hungary: Volcanology, mineralogy, petrology and geochemistry. - Vijesti Hrvatskoga Geološkog Društva, 37, p.51.

Harangi, Sz., Mason, P.R.D. 2002: Correlation and petrogenesis of Miocene silicic pyroclastic rocks in the Pannonian Basin from the analysis of single glass shards – Geology, under review

Lexa, J., V. Konečný, V. 1999: Geodynamic aspects of the Neogene to Quaternary volcanism. – In: M. Rakús, (Ed), Geodynamic development of the Western Carpathians - Geological Survey of Slovak Republik, Bratislava, pp. 219-240.

Lukács, R., Czuppon, Gy., Harangi, Sz., Szabó, Cs., Ntaflos, T., Koller, F. 2002: Silicate melt inclusions in ignimbrites, Bükkalja Volcanic Field, Northern Hungary – texture and geochemistry – Acta Geologica Hungarica, under review

Márton E., Z. Pécskay 1998: Complex evaluation of paleomagnetic and K/Ar isotope data of the Miocene ignimbritic volcanics in the Bükk Foreland, Hungary. - Acta Geol. Hung., 41/4, pp. 467-476.

Póka, T., T. Zelenka, A. Szakács, I. Seghedi, G. Nagy, A. Simonits 1998: Petrology and geochemistry of the Miocene acidic explosive volcanism of the Bükk Foreland; Pannonian Basin, Hungary. - Acta Geol. Hung., 41/4, pp. 437-466.

Sun, S.-S., and McDonough, W.F., 1989: Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes, *in* Saunders, A.D., and Norry, M.J., eds., Magmatism in the oceanic basins, Geological Society Special Publications, No.42, p. 313-345.

Szabó, Zs., Harangi, Sz. 2001: A zircon morphology study on the Miocene silicic pyroclastic rocks of the Bükkalja Volcanic Field, Northern Hungary. – PANCARDI 2001, Abstract Volume, PP-12

Szakács, A., T. Zelenka, E. Márton, Z. Pécskay, T. Póka, I. Seghedi 1998: Miocene acidic explosive volcanism in the Bükk Foreland, Hungary: Identifying eruptive sequences and searching for source locations. - Acta Geol. Hung., 41/4, pp. 413-435.

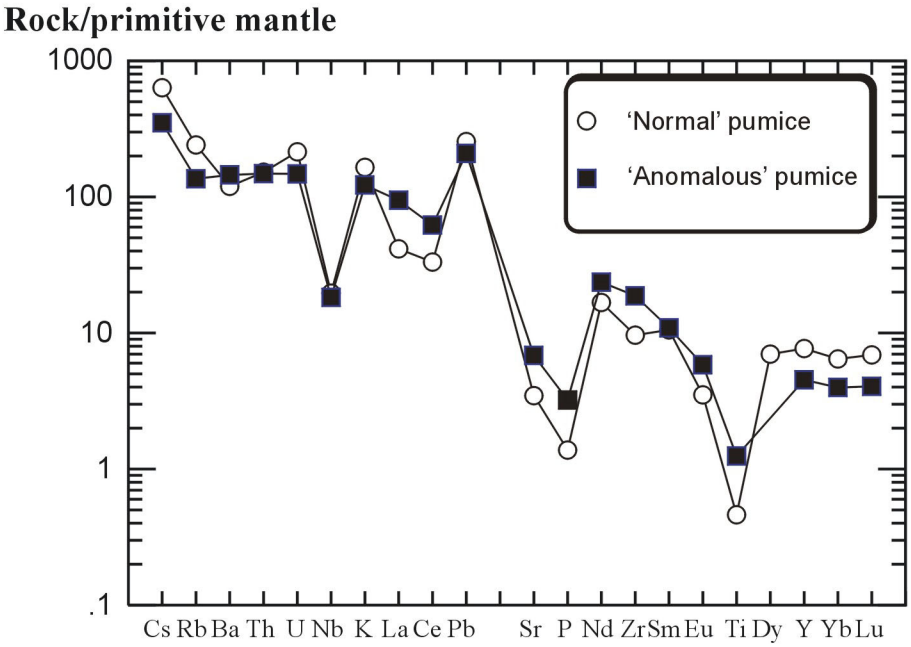


Figure 1. - Primitive mantle-normalized (data from Sun and McDonough, 1989) trace element patterns of the two types of pumices from the HIU ignimbrite