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MYRMEKITE-BEARING GNEISS FROM THE SZEGHALOM DOME (PANNONIAN BASIN, SE HUNGARY). PART II.: ORIGIN AND SPATIAL RELATIONSHIPS

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ABSTRACT

The metamorphic basement of the Pannonian Basin consists essentially of diverse types of amphibolite and gneiss. Due to the rather complicated structural evolution since the Variscan orogeny, the basement is at present a mosaic of crystalline blocks of incompatible evolution. That is why an exact identification of each rock type is crucial for being able to correlate wells spatially. Myrmekitic feldspar is an important constituent of one gneiss type, which is inferred to be of igneous origin. The orthogneiss zone seems to be an extensive part of the basement.

Key words: myrmekite, orthogneiss, Pannonian Basin

INTRODUCTION

Myrmekitic feldspar is a very common phase in diverse igneous and metamorphic rocks. To explain its origin and development, dozens of theories were constructed in the last century. In the first part of our end-to-end papers (Zachar, M Tóth, 2002) we attempted to compile a close to entire conclusion about these models in order to create the right conditions for understanding the role of myrmekitized feldspar in the metamorphic rocks of the basement of the Pannonian Basin.

Several authors reported presence of myrmekite from diverse rock types in this crystalline basement (e.g. Szalay, 1977; Balázs et al., 1986). Although they describe the textural details of the myrmekite occurrences, they do not pay much attention to the genetic relationship. Zachar (2000) found myrmekitized feldspar an essential constituent in gneiss samples from the northern flank of the Szeghalom crystalline high. In what follows we study whether myrmekite can be relevant in specifying certain stages of the metamorphic evolution in this area of the metamorphic basement.

GEOLOGICAL SETTING

Due to the complex Neogene evolution of the Pannonian Basin (for details see Tari et al, 1999 and references therein), in its basement several deep sub-basins formed with elevated crystalline highs among them. One of the deepest and largest sub-basins is Békés-basin surrounded by a series of highs from the north (Fig. 1). Although, Szeghalom dome (SzD) is not the largest one among them because of the boring activity of the hydrocarbon industry in the last three decades several dozens of wells penetrated the metamorphic basement making a detailed petrological study possible. For this reason Szeghalom dome is a good candidate for being a reference area throughout the geological examination of the basement.

Previous studies about the evolution and structure of the SzD inferred co-existence of rocks of significantly different history. These rock types define at least four homogeneous blocks, which got juxtaposed due to the subsequent tectonic events of the Pannonian Basin (M Tóth et al., 2000). Following this model, there are three blocks in the central and southern part of the SzD, while the northern flank of the high consists of one single block. In addition to amphibolite, different gneiss varieties and granite are essential constituents in all blocks. They differ both in protolith and metamorphic evolution. While Szederkényi (1984) suggests a uniform protolith of sedimentary origin for them, Szepesházy (1973) assumes the presence of an orthogneiss belt from the Jánoshalma high in the SW towards the SzD. Based on the geochemical discrimination method of Bhatia (1983), paragneiss represents active continental margin sediments (Zachar, 2000, M Tóth et al. 2000).

Concerning mineralogy, gneiss in the central and the southern part of the SzD usually contains sillimanite, while there in the northern flank sillimanite is missing, and in several samples also amphibole occurs. Most gneiss samples in the north contain myrmekitized feldspar grains. Feldspars in gneisses of the SzD can be divided into two basic categories; strongly altered sericitic and fresh feldspars, respectively. Typical examples of the latter are chessboard and polysynthetic twinning, myrmekitic plagioclase and perthitic K-feldspar. In the paleosome part of metatexite (biotite plagioclase gneiss), Szalay (1977) observed two generations of plagioclase. The first is $An_{15\text{-}20}$ in composition; the second is lower in *An* and replaces the original grains. Quartz that crystallized after plagioclase is xenomorphic and emplaced in the space between the feldspar grains. Its recrystallization resulted in replacement reactions. Three generations of myrmekitic plagioclase in granodioritic diatexites were observed in the metamorphic basement of the SE part of the Pannonian Basin. The first generation is sericitic and kaolinic $An_{15\text{-}20}$ oligoclase. Resorption occurs generally on the edge of the crystals where fresh albite (second generation) can be observed. The fresh or slightly sericitic plagioclase crystals of the third generation are An_{17} in composition. Myrmekite is abundant on all three generations. The latest generation can be observed in contact with microcline.

Here, myrmekite-bearing gneiss samples from the northern flank of the SzD are examined (e.g. wells Sz-4, 6, 7, 15, 16 and 50). Samples studied are epidote and chlorite bearing biotite, amphibole two-feldspar gneisses. Several specimens also contain relics of a previous HT event, which is thought to have been igneous based on preserved poligonal textures as well as idiomorphic accessory phases, like zircon, turmaline and allanite. Based on thermobarometric calculations and modelling (DOMINO/THERIAK, de Capitani, 1994), the stable paragenesis of the gneiss suggests an upper greenschist, lower amphibolite facies metamorphism (well Szeghalom-15; T~550 °C, P<6 kbar) (M Tóth et al., 2000). Following the peak metamorphism, the metamorphic basement was intruded by a postkinematic granite body and crosscut by several granitoid dykes and sills.

METHODS

Microprobe measurements were carried out at the Johannes Gutenberg University at Mainz on a Camecabax microbeam machine at 15 kV acceleration voltage and 12 nA using natural standards.

PETROGRAPHY

In the gneiss samples studied there are different textural positions where myrmekite occurs. At some places myrmekite can be observed on the common edge of matrix plagioclase and K-feldspar grains (Fig. 2a), while the most common myrmekite type forms sericitic inclusions in fresh K-feldspar grains (Fig. 2b). At these places apophyses of the fresh host mineral (microcline) are advancing into the sericitic myrmekite (Fig. 2c) separating relics of the 'old' myrmekitic feldspar, which are of the same lattice orientation (Fig. 2d). Quartz blebs can be found in fresh K-feldspar only close to the myrmekitic islands (Fig. 2e). Myrmekitic inclusions generally are xenomorphic in shape, but in many instances they also may be hipidiomorphic with well-developed straight grain boundaries (Fig. 2f).

In the rock studied myrmekitic and non-myrmekitic grains are situated adjacent to each other. The grain boundaries usually are wiggly and the latter often surround myrmekitic grains without any definite grain boundary between myrmekite and K-feldspar (Fig. 2g). The arrangement of myrmekite in the samples studied does not indicate any orientation. Several feldspar grains are perthitic with lamellae oriented subparallel to the bitoite and amphibole defined foliation.

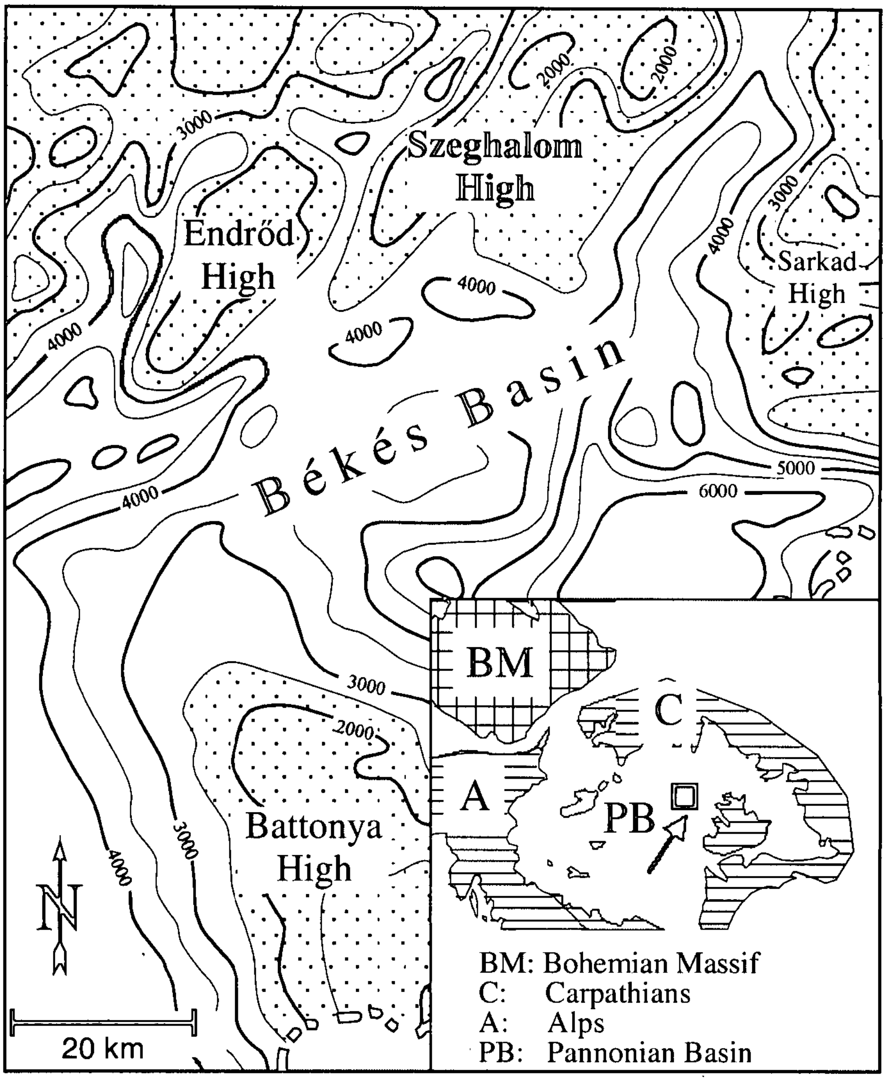

Fig. 1. Map of the Békés basin and the surrounding metamorphic highs. Present-day depth of the pre-Neogene basement is shown. Inset: Location of the Pannonian Basin in the Alpine-Carpathian-Pannonian system.

MINERAL CHEMISTRY

Compositions of several myrmekitic feldspar grains were measured form the northern SzD orthogneiss samples. Each grain measured exhibits similar structure with myrmekitic plagioclase inclusions of around An_{22} and a pure K-feldspar host mineral. At the contact between the relic plagioclase and the microcline a thin zone of pure albite (An_1) occurs. Some grains are also zoned with increasing K towards the rim. Representative data are given in Table 1.

Table 1. Representative compositions of myrmekitic plagioclase grains (Pl1), albitic rim (Ab) and microcline host mineral (Kfp) of the well Sz-15.

	Plmx1	Plmx1	Pl1	Pl2	Pl3	Ab1	Kfp1	Kfp2
SiO_2	63.67	60.56	65.73	65.38	64.97	71.09	66.11	66.26
Al_2O_3	22.71	23.06	21.42	19.46	20.74	18.93	17.01	17.57
CaO	3.5	3.98	4.61	3.91	4.21	0.23	0.00	0.00
Na_2O	7.59	8.58	8.53	8.05	7.94	9.82	0.64	0.23
K_2O	0.4	0.23	0.17	0.33	0.22	0.29	15.34	16.02
Total	97.87	96.41	100.51	97.22	98.21	100.49	99.20	100.14
An	20	20	23	21	22	1	0	0
Ab	78	78	76	77	77	97	6	2
Or	3	1	0	2	1	2	94	98

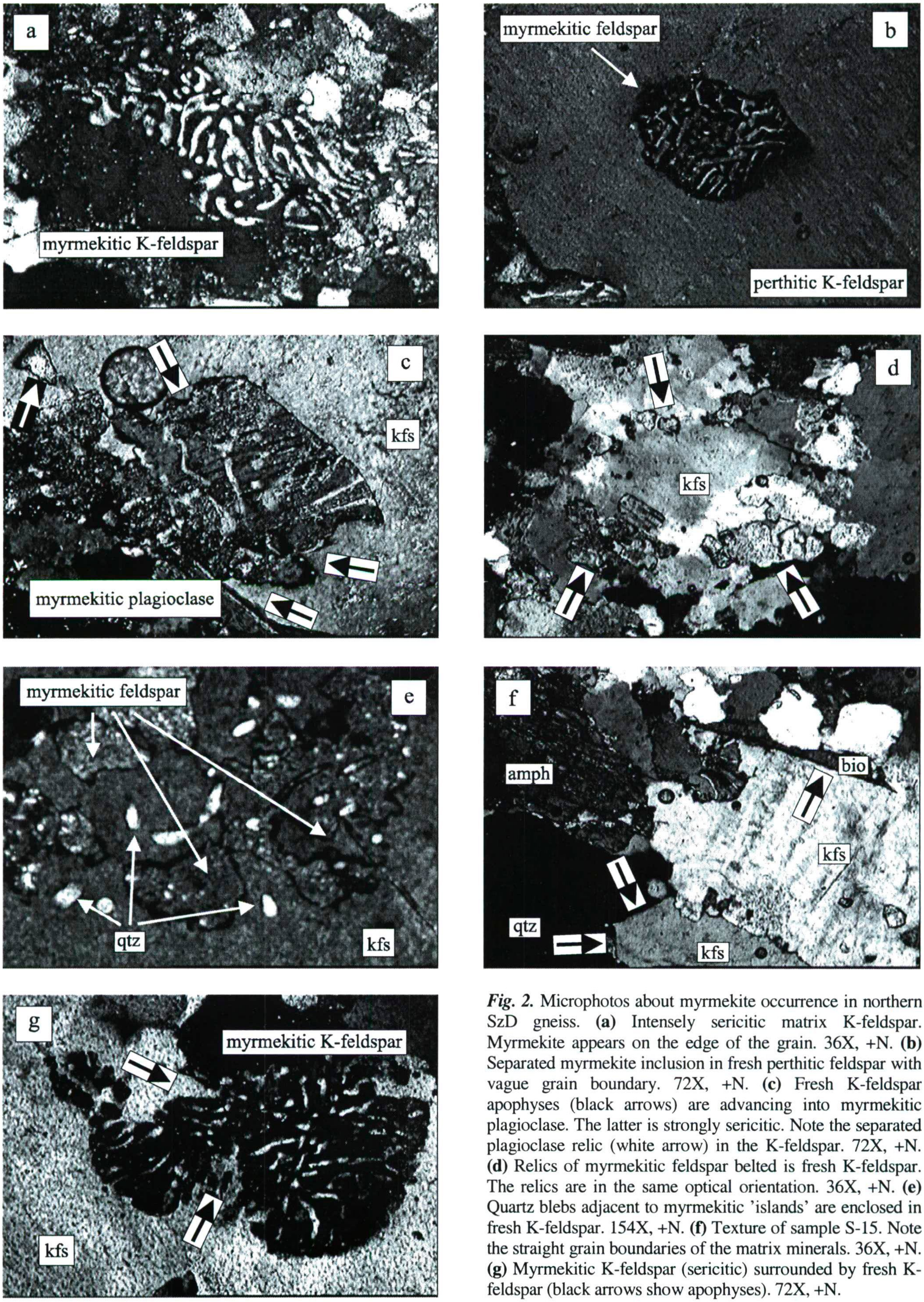

Fig. 2. Microphotos about myrmekite occurrence in northern SzD gneiss. **(a)** Intensely sericitic matrix K-feldspar. Myrmekite appears on the edge of the grain. 36X, +N. **(b)** Separated myrmekite inclusion in fresh perthitic feldspar with vague grain boundary. 72X, +N. **(c)** Fresh K-feldspar apophyses (black arrows) are advancing into myrmekitic plagioclase. The latter is strongly sericitic. Note the separated plagioclase relic (white arrow) in the K-feldspar. 72X, +N. **(d)** Relics of myrmekitic feldspar belted is fresh K-feldspar. The relics are in the same optical orientation. 36X, +N. **(e)** Quartz blebs adjacent to myrmekitic 'islands' are enclosed in fresh K-feldspar. 154X, +N. **(f)** Texture of sample S-15. Note the straight grain boundaries of the matrix minerals. 36X, +N. **(g)** Myrmekitic K-feldspar (sericitic) surrounded by fresh K-feldspar (black arrows show apophyses). 72X, +N.

DISCUSSION: ORIGIN OF THE MYRMEKITE IN THE SZD GNEISS

Comparing our observations with those made by diverse authors concerning myrmekite formation, we attempt to delimit genetic circumstances of the myrmekite of the SzD gneiss samples. Textural data suggest the presence of strongly sericitized myrmekitic feldspar inclusions in fresh K-feldspar, usually microcline. Such a relationship indicates the replacement of myrmekite by a secondary K-feldspar and infers that myrmekite must have formed earlier. Approving the results of the previous calculations concerning metamorphic history of the SzD, one can state that gneiss of the northern flank reached peak conditions at around 550 °C. Myrmekitic texture is usually unstable above greenschist facies because at slightly elevated temperature the feldspar system tends to achieve equilibrium by static recrystallization. In the present case myrmekite grains formed either during the low-temperature stage of the progressive metamorphism and started to consume afterwards, or they are relics of an even older process. Keeping also the composition of the inclusions (An_{22}) to be similar to the matrix plagioclase grains (Table 1), as well as their altered appearance within a fresh host mineral into account, formation of the myrmekitic feldspar due to the last progressive metamorphic event can be excluded.

Although intensely deformed gneiss is rather common in the study area, these mylonitized samples generally miss undeformed myrmekite grains. Present studies (Schubert, M Tóth, 2002) suggest, that the ductile event followed the peak metamorphism and developed mylonite along the retrograde pathway. It also coincided with significant gain in Si, Al and K in the most sheared zones; metasomatism, however, resulted in crystallization of mica instead of feldspar. Because there is no indication of any orientation in the myrmekite studied, we exclude deformation-induced origin. Formation due to silica infiltration also is improbable because there is no clear evidence for deformation in myrmekitic plagioclase.

Several post-kinematic granitoid dykes and sills crosscut the gneiss terrane in question, which may be a potential source for post-metamorphic metasomatic fluids. The presence of myrmekite and sericitic feldspar remnants in fresh microcline seems to corroborate the hypothesis of Collins (1998) that plagioclase can be replaced by microcline, and myrmekite produces during the metasomatic alteration. Drescher-Kaden (1948) also suggests that myrmekite forms during the reaction, in which K-feldspar metasomatically replaces plagioclase. The fact that relic quartz blebs of an old myrmekite are present in the fresh, replacing feldspar contradicts both theories as myrmekite does not grow but consumes in the observed reaction. Granite-related fluids, on the other hand, may be responsible for carrying extra K and Si to form secondary microcline.

Where myrmekitic plagioclase recrystallizes, the quartz lobes of the myrmekite are consumed in the K-feldspar producing reaction, or a more sodic plagioclase forms lacking polysynthetic twinning. Where myrmekitic K-feldspar recrystallizes, quartz lobes cannot consume in the reaction, and one can recognize separated quartz lobes in the fresh feldspar grains adjacent to the replacement front. These grains are in the same lattice orientation forming myrmekite-like intergrowth. In this case we cannot speak about myrmekite, because quartz lobes are relics and are not in a genetic connection with the host recrystallized K-feldspar. The fact that in some cases myrmekite is absent can be interpreted with the advanced state of the reaction. Generally 'old' sericitic myrmekite is situated on the edge of the grains. Where the replacement reaction is advanced, the myrmekitic edge of the 'old' grain is consumed in the reaction progress and no myrmekite can be found in the sericitic feldspar grain.

All textural reasons consequently suggest that myrmekite must be older than the last deformation, metamorphic and metasomatic events, and seems to represent a relic phase in the recrystallized feldspar grains. We conclude, that it formed in the pre-metamorphic igneous protolith either due to igneous crystallization or by subsolidus exsolution. Replacement of myrmekitic plagioclase and K-feldspar by non-myrmekitic fresh feldspar grains can be interpreted as metamorphic recrystallization under lower amphibolite facies conditions with or without utilization of granite-related K-, and Si-bearing fluids.

Either the external or an internal K-source also can be responsible for perthite formation in the SzD feldspar. One can assume the presence of a HT ternary myrmekitic feldspar characteristic of the original magmatic rocks. Consuming free K and Si from the quartz blebs of the myrmekite, magmatic feldspar recrystallizes as LT, pure K-feldspar. The Ca and Na content remains in the newly formed grain and may form perthitic lamellae.

CONCLUSIONS

The aim of this study was to investigate the connection between myrmekite formation and metamorphic evolution of gneiss in the northern flank of the SzD. Using textural and mineral chemical data and comparing our observations to the most commonly accepted myrmekite models we concluded that myrmekite did not form due to metamorphic, deformation and metasomatic processes. We appointed that myrmekite is a relic phase, which represents the original igneous protolith and so developed due to magmatic crystallization. Thus the studied type of myrmekite is not appropriate in determining the metamorphic evolution, but it can be of great significance in recognizing the magmatic origin of the protolith.

Analysis of the myrmekite-bearing feldspar suggests an evolution analogous to that deduced for the northern SzD gneiss previously (M Tóth et al., 2000). After intrusion the igneous protolith cooled down and altered significantly, the originally myrmekitic plagioclase partially altered to sericite. Metamorphic overprint produced orthogneiss under lower amphibolite facies conditions that caused recrystallizaton of unstable feldspar to microcline. Whether during this reaction also an external K-source was needed and the intrusion of the post-kinematic granite bodies coincided to this event or not, needs further chemical consideration.

Putting back the study area to a more regional context, we can conclude, that the northern flank of the SzD should be a part of the orthogneiss zone, first mentioned by Szepesházy (1973). In recognizing this rock type throughout the metamorphic basement of the Pannonian Basin, the presence of myrmekite we discussed in the present paper may be of basic importance.

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