XENOLITHS AND ENCLAVES FROM THE MIOCENE VOLCANIC ROCKS OF TOKAJ MTS.

ATTILA HORVÁTH–FERENC KRISTÁLY–GYÖRGY LESS

University of Miskolc, Institute of Mineralogy and Geology, H-3515 Miskolc-Egyetemváros
attila0514@gmail.com; askkf@uni-miskolc.hu; foldgy@uni-miskolc.hu

1. Abstract

Little information is available about the petrology and mineralogy of pre-Tertiary basement of the Tokaj Mts. In the NE area of the mountains the basement is in uplifted position and data from boreholes are also available. But in the western part of the mountains no boreholes have reached the footwall of the Neogene volcanic succession. The aim of this study is to get more detailed information about the basement. Earlier publications about drill cores and xenoliths were reviewed, and new xenoliths collected by the authors were investigated by petrologic-mineralogic methods.

Xenoliths provide a useful tool to evaluate the composition and nature of the basement in less accessible areas. Based on the xenoliths occurring on the surface or in drill cores, the Tokaj Mts. can be divided into several segments. Limestone xenoliths appear in the East (around Sárospatak), while at the other locations of the Eastern part metamorphic and molasse type xenoliths can be found. The Western area of the mountains is underlain by Szendrő type (Bükkkium) rocks based on slate xenoliths. Metamorphic, mainly gneiss xenoliths suggest Veporic type basement in the Northeastern part.

We found that enclaves formerly described as biotite gneiss are in fact opaque mineral and biotite containing enclaves. Opaque minerals are probably the high-temperature alteration products of pelitic rocks ripped up by the ascending magma. Further typical high-temperature mineral assemblages occur in other xenoliths such as sandstone in metaclaystone transformed from a clayey (illite) protolith and cordierite+labradorite+hercynite+corundum in cordierite hornfels.

Keywords:
xenolith, enclave, Bükkkium, Veporicum, Zemplinicium, hercynite, symplectite, cordierite hornfels, sandinite

2. Geological outline of the Tokaj Mountains

The Tokaj Mts. in NW Hungary is the Hungarian part of Eperjes (Prešov)-Tokaj Mts. It is bordered by the Hernád Fault from W, by the Szamos Fault from E and by the Bodrog Fault from S. Other important structural line is the fracture system parallel to the Radvány Stream, along which large-scale subsidence occurred similarly to the faults bordering the mountains. These and other larger faults played a crucial role by determining the place of effusive centres, linear volcanic and postvolcanic activity (GYARMATI 1977).

The igneous rocks of the Tokaj Mts. fill a NE-SW striking volcano-tectonic graben. Orographically the mountains can be divided into the area of the central volcanic range, the Vilyvítány Block and the Szerencs Hills (GYARMATI 1977).

Large-scale tectonic movements took place along the Mid-Hungarian Line in the Miocene that caused local transtensional environment at this area. This extension opened the pull-apart basin which contains the Miocene igneous rocks (HORVÁTH 1993). The magmatic rocks formed during two volcanic cycles. Eight effusive centres and two large
linear volcanic zones can be identified in the region (GYARMATI 1977). Sedimentary formations in the Badenian Tokaj Mts. are rare and sporadic, mainly of marine origin. In the Badenian mostly rhyodacite tuff and dacite formed cropping out on the NE part of the mountains. After a short pause a rhyolite, rhyodacite, dacite, pyroxene andesite sequence formed in the Sarmatian (GYARMATI 1977).

Igneous rocks exhibit calc-alkaline character and contain relatively high amounts of SiO₂, Fe and Al (GYARMATI 1977). Accordingly, the geochemical character of the volcanism of Tokaj Mts. represents a transition between island arc and active continental margin (SZABÓ et al. 1992).

3. The basement of the Tokaj Mountains

Neogene igneous rocks fill a 15–20 km wide, 100 km long tectonic graben. The depth of the graben may reach 1.5–2 km at the Western side of the mountains (Fig. 1). Here, no drillhole has reached the basement, which becomes shallower moving eastward until it crops out at the Vilyvitány Block.

In the area bordered by Pálháza, Nagyhuta, Makkoshotyka, Sárospatak and Sátoraljaújhely (Fig. 1) the basement is in an uplifted position (less than 1000 m depth) which is indicated by the gravity maximum (ZALAI 1991) and also by the abundance of xenoliths here.

3.1. Zemplinicum. Most information from the basement comes from Zemplinicum, because it is in uplifted position and it crops out at the NE part of the mountains and in a large area in Slovakia, too (Fig. 1) (Zemplín Mts. s.s.). The Zemplinicum is part of the Central Western Carpathians along with Tatricum, Veporicum and Hronicum; and thought to be the continuation of the Veporicum (VOZÁR et al. 2010, VOZÁROVÁ & VOZÁR 1988).

The Zemplinicum consists of two main parts: the Proterozoic and Early Palaeozoic metamorphic complex and the unconformably overlying Carboniferous, Permian and Mesozoic succession. Part of these sequences crops out at Vilyvitány, which is often called the Vilyvitány Block (BÓCZÁN et al. 1966, PENTÉLÉNYI 1972a).

The metamorphic part is dominantly made up by ortho- and paragneisses and mica schists. The unmetamorphosed molasse-type Carboniferous and Permian sediments (continental sandstone, conglomerate and shale) are the erosion products of former surface formations and are present in boreholes Felsőregmec-1., Füzérkajata-2., Sátoraljaújhely-8. Siliciclastic sedimentation continued in the Early Triassic, too. Middle Triassic carbonate rocks (Lúžna Fm, Ladmovce Fm) from Hungary are only known from borehole Sátoraljaújhely-8 (PENTÉLÉNYI et al. 2003).

3.2. Bükkium. The Bükkium (Szendrő Unit) consists of Palaeozoic (Silurian to Carboniferous) black shale, platform carbonate to pelagic limestone and shale sequences. These rocks were epimetamorphosed during Alpine orogenesis. They occur in several drillholes outside of the Tokaj Mts. (Alsóvadász-1., Felsőgagy-1., Lak-1., Hidasnémeti-1. and Abatújdevecser-1. – Fig. 1), but from the area of the mountains only slate xenoliths are known (Fig. 8–9.).

3.3. Veporicum. Veporicum is made up by various rock types. Metamorphic rocks (mica schists, gneisses) form the basal parts of the succession. At the upper sections various Mesozoic shallow and deep water sediments and terrigeneous rocks dominate, which do not occur in the basement of the mountains. According to PENTÉLÉNYI (1972a), boreholes Füzérkajata-2. and Felsőregmec-1. expose Veporic-type metavolcanic rocks and phyllites (greenschist facies) beside Zemplinicium-type succession.

3.4. Silicicum. In the area of Sárospatak boreholes Sárospatak-5., Sárospatak-7., Végardó-2., Végardó-4. and Karos-2. expose Upper Triassic Wetterstein- and Dachstein-type limestones which do not show genetic relation with any of the former units (PENTÉLÉNYI et al. 2003). Xenoliths from these formations occur at Megyer Hill, Sárospatak, in the area of Rudabányácska and in borehole Rudabányácska-1. This limestone sequence is assumed to represent Silicicum-type (s.l.) basement (Fig. 8–9.)
4. Enclaves – previous studies

Enclaves are divided into two main groups: the ‘cognate enclaves’ and the ‘ xenoliths’. The term ‘cognate enclave’ is used for enclaves which have the same parental magma as their host rock (Sollas 1894). On the other hand, xenoliths do not show any genetic relation with the host rock.

Former researchers (Bóczán et al. 1966, Gyarmati 1977, Gyarmati & ZeLENKA 1968, Pentelenyi 1968, 1972a, b) mentioned numerous enclaves and xenoliths but no special research was focused on them.

Cognate enclaves occur in dacies and andesites in the whole area of the mountains. They are mainly holocrystalline. Their colour is lighter than the host rock because of the high plagioclase content. The main constituents are plagioclase, pyroxene and volcanic glass (Gyarmati 1977), magnetite and apatite are accessorial. Three cognate enclave types are separated. Volcanic glass is present between phenocrysts in the glomeroporphyric cognate enclaves, crystals reaching into the host rock. The microdiorite and porphyryic texture cognate enclave subtypes are entirely holocrystalline. Plagioclase phenocrysts are not zoned and form columnar crystals in contrast to the plagioclase of the host rock. Based on microprobe analyses, the chemical composition of the plagioclase crystals is the same in the enclaves and in the host rock.

The xenoliths of Miocene age are sediments formed during the volcanic cycles in bays of the Pannonian Sea or in subaerial environment: claystone, siltstone, sandstone, marl, tuffite or earlier Miocene igneous rocks.

Pre-Tertiary xenoliths show various types of lithology at the different parts of the mountains. Most xenoliths can be found in the area bordered by Pálháza, Nagyhuta, Makkoshotyka and Sárospatak, which coincides with the surface extension of Badenian igneous rocks. Here, the basement is close to the surface (Fig. 1). Gneiss (biotite, cordierite or muscovite gneiss subtypes), sandstone, slate, siltstone, limestone, mica schist and quartzite schist were described from this area (Gyarmati 1977 112, Pentelenyi 1972b). Most frequently biotite gneiss is mentioned (Bóczán et al. 1966, Gyarmati 1977, Gyarmati & ZeLENKA 1968, Pentelenyi 1968, 1972a, b).

Sandstone, slate and quartzite xenoliths occur in the area of Füzérkomlós (Fig. 8). Pentelenyi (1972a) found slate and quartzite xenoliths at Kánya Hill, Telkibánya. Gyarmati (1977) reported slate xenoliths from the Baskó-3 drillhole. Limestone fragments are abundant on Megyer Hill, Sárospatak. Amphibolite xenolith occurs on Mandulás Hill, Sárospatak. In the area of Szerencs sandstone, granite and quartzite schist lithotypes were observed by Gyarmati & ZeLENKA (1968). The rhyolite tuff at Meredek Hill, Abaújszántó hosts sericitic dark grey slate xenoliths (Pentelenyi 1968). Sandstone, slate and quartzite xenoliths are frequent in the area of Bodrogkeresztúr and Tokaj (Pentelenyi 1972a).

5. Enclaves investigated in the present study

5.1. Classification of enclaves. We divided enclaves into four groups: (i) the cognate enclaves, (ii) the opaque mineral and biotite bearing xenoliths, (iii) the Miocene xenoliths and (iv) the xenoliths from the Tokaj Mts basement. Cognate enclaves consist of early crystallized minerals in the magma chamber. Opaque mineral and biotite bearing xenoliths have parts that may have crystallized from the magma and parts of supposed extraneous origin. We separated further two groups of xenoliths: the Miocene sediments and the
Xenoliths and enclaves from the Miocene volcanic rocks of Tokaj Mts.

Pre-Tertiary basement xenoliths. The latter group comprises of metamorphic and carbonate or clastic sedimentary rocks.

In the spring of 2013 numerous enclaves and xenoliths (~100 pieces) were collected during several field trips which covered the whole area of the mountains. More than half of the collected samples were found to be cognate enclaves; xenoliths are most abundant in felsic tuffs.

The enclaves of the (i) group were found exclusively in andesite and dacite (Fig. 2 A–B). Their border with the host rock is sharp, alteration traces (except for surface alteration) or reaction coronas were not observed. We classified a diorite enclave also as cognate from Hársas Hill, Gönc, although there are uncertainties regarding its origin (Fig. 2 B).

The enclaves of (ii) group consist of plagioclase and significant amount of biotite and opaque minerals. These enclaves contain dark patches. They resemble intact or partly melted biotite gneiss examined by the naked eye (Fig. 2 C–D).

The (iii) group is composed mainly of Miocene xenoliths which are generally unconsolidated sediments thermally altered by the hot magma. We found mostly light-coloured clay fragments as in the white rhyolite tuff at Fehér-kő, Füzérkomlós (Fig. 2 E). As an exception a completely altered andesite xenolith was found in zeolitized rhyolite tuff near Rátka.

Most of the (iv) group xenoliths were found where Badenian rocks are cropping out (NE part, Fig. 8). Mica schist, siltstone and sandstone were identified at Felsőregméc, next to the Vílyvátány Block. Here, light grey coloured, garnet-bearing (Fig. 2 F) and grey more coarse-grained mica schist (Fig. 3 A) subtypes can be separated. Siltstone xenoliths are hard and grey-coloured. Siltstone, mica schist and siliceous xenoliths occur close to Vágáshuta (NE part of the mountains). The xenolith shown on Fig. 3 C is very hard, homogeneous and has conchoidal fracture resembling a siliceous rock by the naked eye. The mica schist xenolith reaching 5 centimetres from Cseresznyés, Vágáshuta is green-coloured and shows good schistosity (Fig. 3 B). A small xenolith of granitic composition was found at the same place. These data are mainly well in agreement with the former findings (GYARMATI 1977: 112, PENTÉNYI 1972b). At Megyer Hill, Sárospatak numerous grey siltstone xenoliths occur (Fig. 3 D) but we have not observed limestone xenoliths. At the NW part of the mountains, on the Hársas Hill near Gönc – not mentioned by former researchers – gneiss xenoliths are abundant (SZAKÁLL, oral communication, 2013, Fig. 3 E). Their fabric is oriented; they can reach 5 centimetres. We found organic matter bearing dark grey slate xenoliths on Fekete and Kassa Hills near Ónd (Fig. 3 F–G). This is in accordance with former observations from the environment of Mód, Baskó, Abaújszántó (GYARMATI & ZELENKA 1968).
6. Petrographic and mineralogical results

6.1. Applied analytical methods. After macroscopic grouping, the enclaves were subjected to petrographic and mineralogical investigations. The fabric-structural characteristics were investigated by polarization microscopy (PM) in transmitted light (Zeiss AX10 Imager A2m). The chemical analysis of individual grains in the samples was carried out with scanning electron microscopy (SEM) and energy dispersive spectrometry (EDX) (JEOL JXA-8600 Superprobe microprobe with RemX driving control, 15 kV, 20 nA). X-ray diffraction (XRD) analyses were performed on some enclaves with Bruker AXS D8 Advance diffractometer (Cu Kα, 33 kV, 50 mA), 2–70°(2θ) range, Bragg-Brentano geometry, Vantec-1 detector with 2° window, 0.007°(2θ)/155 sec).

6.2. Cognate enclaves. The most typical compound of the cognate enclaves is plagioclase, but pyroxene crystals and their alteration products also occur. According to SEM+EDX analyses the chemical composition of plagioclase and pyroxene is identical to the phenocrysts of the host rock.

Some cognate enclaves exhibit glomeroporphyritic texture. Such enclave was collected from the subvolcanic laccolith of Kopasz Hill, Tálya, but similar enclaves are present at Bába Hill, Füzérkajata and at Préda Hill, Vágáshuta. The main mineral phase is plagioclase (about 50-75%) (Fig. 4 A–B), its size is between 80-700 µm. The amount of volcanic glass as groundmass is about 20-25%. Volcanic glass occurs in the pycnotaxitic groundmass of the host rock, too. In the enclave from Kopasz Hill the space between columnar plagioclase and augite porphyritic crystals is filled up by brown volcanic glass (ca. 30%). Here, volcanic glass is replaced by radial-fibrous siderite both in the enclave and in the host andesite as a result of carbonatization.

Holocrystalline enclaves are mainly microdiorites. Their fabric is equigranular; the size of the main constituent plagioclase (~70%) is ~0.5 millimetres on the average (Fig. 4 C–D). Another important phase is pyroxene. Such enclaves appear in the dacite of Hársas Hill near Gönc. A diorite enclave turned up from this place, too (Fig. 4 E–F), its mineral composition is dominated by neutral plagioclase (~65%) and biotite (~25%), which is the alteration product of augite (~10%).

The enclaves with porphyritic texture contain plagioclase phenocrysts as porphyric grains. Some enclaves in dacite from Nagy-Kopasz, Tokaj belong to this group. Petrographic analyses from this group were not carried out.

6.3. Opaque mineral and biotite bearing xenoliths. Biotite and opaque mineral bearing xenoliths macroscopically resemble biotite gneiss or biotite schist (Fig. 2 C). We assume that some of the former researchers have described this type of xenoliths as biotite gneisses. However we have not found any biotite gneiss xenoliths in the Tokaj Mountains.

Xenoliths containing opaque minerals and biotite are made up mainly by plagioclase (Fig. 5 A, B, C), which have a composition similar to the phenocrysts of the host rock. The inner parts of the enclaves are frequently enveloped by an outer coarse-grained plagioclase rim (up to 0.5 millimeters size, Fig. 5 B–C). In some cases xenoliths do not have a distinct rim; plagioclase is coarse-grained throughout the enclave. Generally fine-grained plagioclase, sometimes volcanic glass is present in the inner part of the xenoliths.
Xenoliths and enclaves from the Miocene volcanic rocks of Tokaj Mts.

Figure 5. A) PM images of the opaque mineral and biotite bearing enclave from Cseresznyés, Vágáshuta, also on Fig. 2 C). Parallel nicols. B) Opaque mineral and biotite enclave from Bába Hill, Füzérkajata. Parallel nicols. C) Crossed nicols. D) Scanning Electron Microscope (SEM) view, spinel symplectite in opaque mineral and biotite enclave from Bohár-tető, Kovácsvágás. Also on Fig. 2 D. E) SEM image, spinel symplectite in the enclave from Cseresznyés, Vágáshuta. Also on Fig. 2 C) and Fig. 5 A). Notes: An: anorthite. Bt: biotite. Gl: volcanic glass. Hc: hercynite. Mag: magnetite. Op: opaque mineral. Pl: plagioclase. Px: pyroxene.
Here, scattered biotite crystals, opaque mineral crystals and opaque grain aggregates are located. In contrast to the plagioclase, the opaque minerals and biotite are considered to be the alteration products of extraneous material. The opaque minerals are hercynite (Fe$_2$Al$_2$O$_4$) and magnetite, according to SEM+EDX results. Textural relations show that magnetite is often grown at the expense of hercynite. Magnetite generally, hercynite rarely contains exsolved ilmenite plates. The xenoliths always contain much biotite. Hercynite was identified in seven opaque mineral and biotite xenoliths. It occurs in two forms: the larger (20–500 µm) single crystals are subhedral or anhedral. The outline of the aggregates of small (10–40 µm) droplet-shaped (in one case euhedral-subhedral crystals) hercynite crystals together with magnetite and anorthite mostly resembles of isometric or stubby crystals (Fig. 5 A, E). The shape of the opaque mineral aggregates can be rounded, drop-like, too (one enclave). The hercynite aggregates occur in four thin-sections. This is a typical symplectitic fabric. Single hercynite crystals do not show symplectitic structure or reaction rims.

A biotite and opaque mineral containing xenolith studied in detail is shown on Fig. 5 A. The marginal part consists of neutral plagioclase with basic core. The inner part of the xenolith is composed of coarse-grained labradorite together with much biotite and hercynite-magnetite symplectites. Scattered pyroxene pseudomorphs filled with clay mineral are also present. Small monazite crystals (30–100 µm) occur in plagioclase unlike in the phenocrysts of the andesite. The opaque mineral symplectites (Fig. 5 D, E) consist of hercynite, magnetite and anorthite between the spinels. Magnetite contains ilmenite plates oriented along crystallographic directions.

One biotite and opaque xenolith is composed of basic plagioclase. The small space between the plagioclase tables is filled up by volcanic glass. The enclave is bordered by a narrow glass rim (~0.1 mm). The opaque minerals and biotite are accumulated in dark grey spots surrounded by a light grey edge of microcrystalline plagioclase and glass mixture (Fig. 2 D). Hercynite occurs in symplectitic groups. It is interesting that pyroxene can also form symplecticites beside single crystals (only in this enclave).

### 6.4. Xenoliths from the basement.

Petrographic studies revealed that beyond macroscopically isolated rock types, cordierite hornfels, leucogranite and biotite schist also appears. These xenoliths stem probably from Vilyvitány Block.

The leucogranite xenolith collected from Vágáshuta is not mentioned in former publications. It is composed of alkaline feldspar (~45%), plagioclase (~40%), subordinate amounts of quartz (~10%) and scarce relics of former biotite crystals. Its fabric is equigranular with 500 µm average grain size. The granite shows metamorphic signs as indicated by peritetic feldspar crystals and undulatory extinction of quartz (Fig. 6 F).

An altered claystone xenolith from Vágáshuta appears to be a silicified fine-grained rock by the naked eye (Fig. 3 C). SEM+EDX analyses revealed that it consists of the intergrowth of very fine-grained quartz and alkaline feldspar (sanidine, based on XRD analysis) which is responsible for the great strength of the rock. Sanidine may have been formed from illite during thermal reaction with magma. It contains tiny albite spots. Weak banding of the rock fragment is observable which is due to minor changes in porosity and in the K/Na ratio of feldspar.

Muscovite schist, found at the same location, is made up of quartz and muscovite (Fig. 6 A, B). Some plagioclase porphyroblasts and few, lengthwise dissected tourmaline crystals are also present. Quartz forms thin, elongated fine-grained bands, lenses or rounded
porphyroblasts which often have small tails (σ-clasts). The fabric of the rock indicates strong shear during formation.

A xenolith made up dominantly of cordierite (Mg₂Al₄Si₅O₁₈) and plagioclase was found in pyroxene-andesite near Kovácsvágás and was classified as cordierite hornfels (Fig. 6 C–E). Cordierite grains form slightly elongated lenses which are poorly oriented. Plagioclase laths are smaller (10–50 µm) than cordierite crystals (30–150 µm).

Hercynite appears (~10%) as single crystals or in the form of symplectites with magnetite and anorthite, as experienced in other biotite and opaque xenoliths.

Symplectic hercynite contains significantly more Ti, V, Cr and Zn than single crystals. Some corundum crystals (several hundred µm sized) occur in the xenolith in association with single hercynite crystals (Fig. 6 E). Hercynite replaces corundum as shown by their fabric-structural relations. The cordierite+corundum+plagioclase+hercynite mineral assemblage may result from the high temperature metamorphism of the xenolith (amphibolite facies, HEIMANN et al. 2006) preceding ascending in the hot magma which may have caused relatively minor alterations compared to metamorphism. The altered rock was probably a fragment of iron rich, clayey sediment. NITOLI et al. (2002) reported similar mineral parageneses in the xenoliths from Eastern Carpathians.

They have found corundum+spinel+alkaline feldspar+cordierite high temperature mineral assemblages, too.

Biotite schist, found at Nagy-Milic, NE from Hollóháza, is not mentioned in former publications. The schist is composed of basic plagioclase, biotite and hercynite (Fig. 7 A–C). Plagioclase contains numerous apatite needles. The xenolith shows basic composition unlike the phenocrysts in the host rock. The fragment does not show reaction rim, recrystallization did not happen. The clear plagioclase rim around the xenolith is of neutral composition similarly to the phenocrysts in the host rock indicating that the xenolith was a cooling centre for the plagioclase rim to crystallize onto. This phenomenon is observed in several biotite and opaque containing xenoliths, too.

The main constituents of the gneiss xenoliths from Hársas Hill, Gönc are ~35–40% plagioclase, ~35% quartz, ~15% biotite and ~15% cordierite. Cordierite replaces biotite in the central parts of the xenolith. The edge of the xenolith contains more biotite giving a darker colour here (Fig. 3 E, 7 E–F).

Slate xenoliths are abundant in the felsic rocks near Ond (Fig. 3 F–G). They show perfect schistosity, sometimes crenulation (Fig. 7 D) which is determined by the sericite like fine-grained material. The grain size of the xenoliths falls into the silt and clay range. The xenoliths have grey, dark grey colour due to the organic matter content. Thus the edge of several xenoliths is white as a result of organic matter oxidation (Fig. 3 G). The xenoliths consist of quartz and muscovite with minor kaolinite, monazite and Ti-dioxide. The slate xenolith from Kassa Hill, Ond (Fig. 3 F) has light parts with coarse-grained muscovite, while the darker lenses consist of quartz that indicate anchi- or epimetamorphic origin. The zeolitization of the host rhyolite tuff did not have any effect on the slate xenoliths.
7. Discussion

The basement of the mountains consists of mosaics of blocks with different origin. Most of the basement of the Tokaj Mountains is not known because direct evidences (borehole data) are mostly missing from this area. However, xenoliths provide a useful help to evaluate the type of rocks underlying Miocene igneous rocks.

Xenoliths from the basement constitute the most various group among enclaves and xenoliths. Based on them and drillhole evidences, we assume the basement units depicted on Fig. 9.

The presence of Zemplinicum at the NE part is well documented, since the basement is in relatively elevated position here.

The biotite schist xenolith collected at Nagy-Milic near Hollóháza may represent Zemplinicum extending north-westwards from Vilyvitány Block. Metamorphic xenoliths (mica schist, gneiss) and the newly found granite, cordierite hornfels and sanidinite xenolith from the environment of Vágáshuta may originate from the Vilyvitány Block, while the sandstone and siltstone xenoliths are fragments from the Permian-Carboniferous sedimentary sequence overlying this metamorphic assemblage. Both successions belong to the Zemplinicum (VOZÁR et al. 2010, VOZÁROVÁ & VOZÁR 1988). Therefore, in accord with the previous observations, the extension of Zemplinicum is assumed southward from Vilyvitány Block (PENTELÉNYI 1972a).

As a small unit, upper Triassic Dachstein type limestone appears in the environment of Sárospatak (PENTELÉNYI et al. 2003), as witnessed by several drillholes. The origin of these upper Triassic carbonate rocks is uncertain; they may represent Silicicum s.l., since Dachstein Limestone does not fit into the Veporic-related Zemplinic succession.

Bükkium (Szendrő Palaeozoic) occupies the Western segment of the mountains. This statement is based only on xenoliths, although their lithological character is sharply different from the xenolith types occurring elsewhere in the mts.

The lithology of the metamorphic xenoliths at the North-western part of the mountains excludes Szendrő-type basement. Based on structural considerations and on the lithology of xenoliths we suggest the presence of Veporicum-type basement although we cannot exclude the presence of Zemplinicum, either.

During the investigation of the xenoliths several signs of xenolith-magma interaction were encountered. Many xenoliths contain mineral assemblages characteristic for high temperature environment.

Sanidine formed from a pelitic, illite rich protolith (GRAPES 2006) together with quartz and albite is also the product of high temperature alteration (Fig. 3 C). Banding of the xenolith crossing its boundary excludes the possibility of formation only by the interaction with the magma, high temperature metamorphic origin is supposed instead.

The hercynite+biotite+opaque mineral paragenesis in the opaque mineral and biotite bearing xenoliths is a typical high temperature, low pressure metapelitic assemblage (NIŢOI et al. 2002, VÁSQUEZ et al. 2009, MARIGA et al. 2006a). Partial melting of these xenoliths cannot be excluded because their hercynite and other opaque mineral content is high as observed in other restitic xenoliths, too (MARIGA et al. 2006a, VÁSQUEZ et al. 2009). The similar composition of plagioclase both in xenolith and in host rock indicates that the plagioclase may have crystallized from the magma in both cases. Hercynite is always associated with minor magnetite which refers to a genetic connection between these two minerals.
Figure 8. Borehole and xenolith data depicted on the geological map of the Tokaj Mountains (Geologic map modified after KUTI & PENTELÉNYI 2000a, b; PENTELÉNYI & KAISER 2000; SCHAREK & PENTELÉNYI 2000).
Figure 9. Schematic map of assumed basement units under the Miocene volcanic succession of the Tokaj Mountains.
The two hercynite types in these xenoliths (separated according to their fabric) are the result of two different processes or the alteration products of two different minerals based on the trace element content. Symplectic hercynite may have been formed by the solid phase reaction (recrystallization) of corundum and magnetite, or mass transfer between magma and corundum (MARIGA et al. 2006b), formed in an earlier stage during thermal interaction with magma. Also a possible mode of formation is by the reaction between corundum of former pyrometamorphism and Fe (±Mg) released from a clayey matrix. We cannot rule out the thermal breakdown of garnet, sillimanite or pyroxene producing hercynite and plagioclase symplectites either (HIROI et al. 1997, MARIGA et al. 2006a), as the alteration was complete and has not left mineral relics. Cordierite and corundum are also common constituents in high temperature alteration processes (HEIMANN et al. 2006), but they are observed only in two samples one of which is the cordierite hornfels from Vágáshuta and Kovácsvágás. The other xenolith found between Telkibánya and Bózsva contains cordierite, plagioclase and quartz.

The biotite → cordierite process in the biotite-cordierite gneiss xenolith from Hársas Hill (Gönc) is of metamorphic origin (YOUNG et al. 1989). The second generation of biotite accumulating at the edge of the xenolith was formed by the thermal influence of the magma.

According to the fabric and mineral composition of the slate or phyllite xenoliths from Ond, the basement has undergone small grade metamorphism here.

8. Conclusions

Our investigations showed the presence of biotite schist, hornfels, sanidinite and diorite as new xenolith material types originating from the basement of Tokaj Mts. The hornfels xenolith may indicate regional metamorphism before getting into the magma or high-temperature pirometamorphism by the magma, this problem requires further research to be solved.

The biotite and opaque mineral bearing xenoliths were not investigated by previous researchers. Our results are the first which show their sedimentary origin strongly overprinted by recrystallization in contact with magmas.

Based on former findings and xenoliths collected during this work we assume Zemplinicum type basement at the E part of the mountains with a small nappe unit of the Silicicum (s.l.). The basement of the W part is divided from the E part by a supposed lateral strike-slip fault, and is composed of Bükkium- and Veporicum-type successions. Our results also support the minimal occurrence of limestone in basement xenoliths, restricted to the region of Sárospatak – Sátoraljaújhely.

9. Acknowledgments

This work was carried out as a part of Well Ahead (KÚTFŐ) project: TÁMOP-4.2.2.A-11/1/KOV 2012-0049. We are grateful for the important help of Norbert Zajzon, Tibor Zelenka, Péter Fuchs, György Szakmány, Réka Horváth and Sándor Szakáll.
10. References


