The hot spring deposits near Magyarkút and their paleobotanical analysis (Börzsöny Mountains, Hungary)

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Abstract

The clarification of the location and origin of the siliceous-calcareous deposits north of Magyarkút can lead to noteworthy conclusions in connection with the geological evolution in the environment of the Szokolya Basin.

Utilizing the already available bibliography, this research separated the discussed deposits from the other types of sediments detectable in their environment. The presence of the siliceous-calcareous deposits on the south-eastern edge of the Börzsöny, near the settlement of Magyarkút was already partly known. Nevertheless, the lately found terrestrial plant fossils provided novel knowledge.

According to the researches based on geomorphological and paleobotanical methods, the study assumes that a hot spring activity of postvolcanic origin took place in a time interval during the Middle to Late Miocene, in a subtropical environment. Besides the already known calcareous spring deposits embedded into the diatomaceous environment, in the side of the Szalamandrás Hill rocks of presumably terrestrial origin were also recognised and described based on the flora present in them. Completing the former knowledge, the study can claim, that among the hot spring deposits of Magyarkút, the terrestrial deposits of Szalamandrás Hill can definitely be separated from the rock complex of limnic origin – the latter being similar to the spring deposits of the Szokolya Basin. The flora remnants prove or specify the chronological results of earlier researches regarding the Middle to Late Miocene age of the deposits.

Keywords: siliceous-calcareous deposits, geyserite, paleobotanical evidence, *Podocarpium podocarpum*

Introduction

The investigation of sediments on the south-eastern margin of the Börzsöny Mountains dates back to more than one hundred years. Former studies fre-

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quently mentioned the sediments covering volcanites near the settlement Magyarkút, even though their names and their proposed origin often proved to be highly different and contradictory. The most recent references define them as a sediment complex produced both by volcanic and non-volcanic processes (Karátson, D. 2002, 2007). However, the sedimentary complex still lacks an adequate description.

From the really varied deposits near Magyarkút sequences of calcareous-siliceous deposits were selected for more detailed analysis, which are significantly different from all other sequences of the area. Composition and morphology of their bedrock outcrops refer to postvolcanic activity. The fossilized plant remnants found here are of exceptional importance for dating.

This study aims at the structural description of the rocks, the identification of the plant remnants found in the calcareous spring deposits, finally dating and reconstruction of the conditions of their formation.

The calcareous spring-deposits at Magyarkút are referred to in several instances in literature. The earliest reference is written by Böckh, H. (1899), who mentioned the formations only peripherally:

„Let me refer to those travertine and siliceous deposits, which can be found around Verőcze (near Magyarkút) and in the Puncz Trench (Szokolya Basin). They are the most closely connected to the underlying andesite breccia and tuffs. Superimposing the lignite seams the tuff breccia layers change into extremely fine tuffs, in some places the transition into sandy, marly, siliceous and calcareous layers is almost undetectable.…"

Böckh was the first to realize the importance of calcareous and siliceous deposits, and unambiguously associated them with the neighbouring volcanic products.

In his geological study about the Börzsöny Mountains, Ferenczi, I. (1935) mentioned the deposits of the small stream extending upwards the western slope of Borbély Hill (located south-east of Magyarkút). He describes a so-called "*andesite agglomerate*", the grain size of which gradually decreases from the bottom of the stream upwards, and is covered by rounded andesite gravel and finally by "*travertine, geyserite and opaline spring-products*" in the higher regions. These spring-products are to be found in the line of the gully on Borbély Hill. They represent the southernmost, mainly fragmented section of the occurrences near Magyarkút, and are identical with the samples taken from the bedrock. According to Ferenczi's description, in this section the sediment covers agglomerate with a thickness of 50–60 metres. The sediment was identified as *„a fresh-water sediment group composed of diatomaceous shale, geyserite, chalcedony, and produced by postvolcanic activities"*.

Báldi, T.–Kókai, J. (1970) mentioned the area of Magyarkút in relation to the dating of the andesite-volcanic activity in the Börzsöny. Their study highlighted the role of limnic/marine calcareous cover deposits filling the

Szokolya Basin, and briefly mentioned the sporadically present travertines in the diatomaceous succession at Magyarkút, primarily on Borbély Hill. Authors supposed that the limnic formations at Magyarkút can be correlated with those of the Szokolya Basin, which were considered to be Lower Badenian.

Based on morphological characteristics and the records of airborne magnetic surveys and in accordance with the findings of Jámbor, Á.–Moldvay, L.–Rónai, A. (1982), a geological map was constructed. Its explanatory text claims that *"based on their outcrop the presence of diatomite, geyserite and travertine at Magyarkút can be classified as part of the Tortonian (Badenian)"*, i.e. the Rákos Limestone Formation.

There is Ól Hill on the northern side of Szokolya Basin (*Figure 1*). Nagy, B. (1983) found here siliceous sediments containing limonite. In his opinion, these are hot spring deposits.

In conclusion, the calcareous spring deposits near Magyarkút were found at the turn of the 19th and 20th centuries and referred to as *„geyserite"* and *„travertine"* up until the 1980's. Many studies connected them to the deposits of the Szokolya Basin. More detailed analyses were not carried out in the last two decades of the last century; moreover, the deposits neither were considered during the mapping of the area (Korpás, L.–Csillag-Teplánszky, E. 1999), nor for the reconstruction of the geological evolution of the Börzsöny Mountains (Korpás, L. ed. 1998).

Description of the study area

The hot spring deposits, as earlier described, can be found near the settlement Magyarkút (*Figure 1*).

The settlement of Magyarkút is located on the south-eastern margin of the Börzsöny Mts., on a widening of a valley bottom, where the Keskeny-Bükk Stream flows into the Les Stream (*Figure 2*). The eastern and southern margins of the area of 8 km^2 represented on the terrain model is marked by the curved crest of the Keskeny-Bükk–Csapás Hill–Magas Hill–Borbély Hill ridge, while the northern margin is indicated by the andesitic Kis-Kő Hill and by the Nagyhársas formed by Oligocene deposits.

The most significant occurrences in the area are undeniably represented by the rocks found in the hillside of the Szalamandrás Hill. These rocks enclosed paleobotanical rests, with the help of which a dating of good accuracy can be carried out. During a field trip 35 samples were taken from the rocks near Szalamandrás Hill, out of which 27 contained flora residues. The paleobotanical analysis was carried out by Hably, L. in the Department of Botany, Hungarian Natural History Museum.

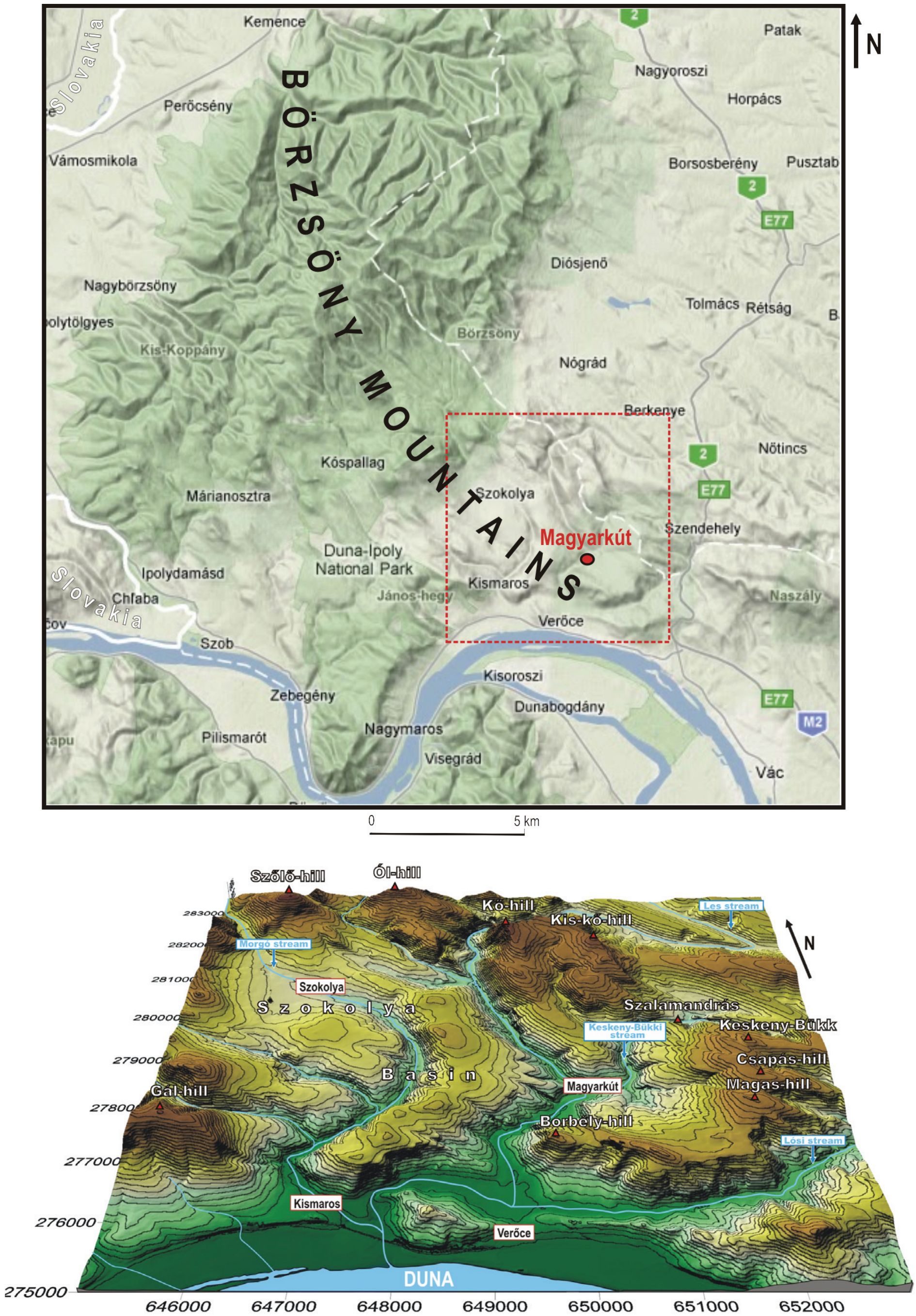


Fig. 1. Magyarkút and environs

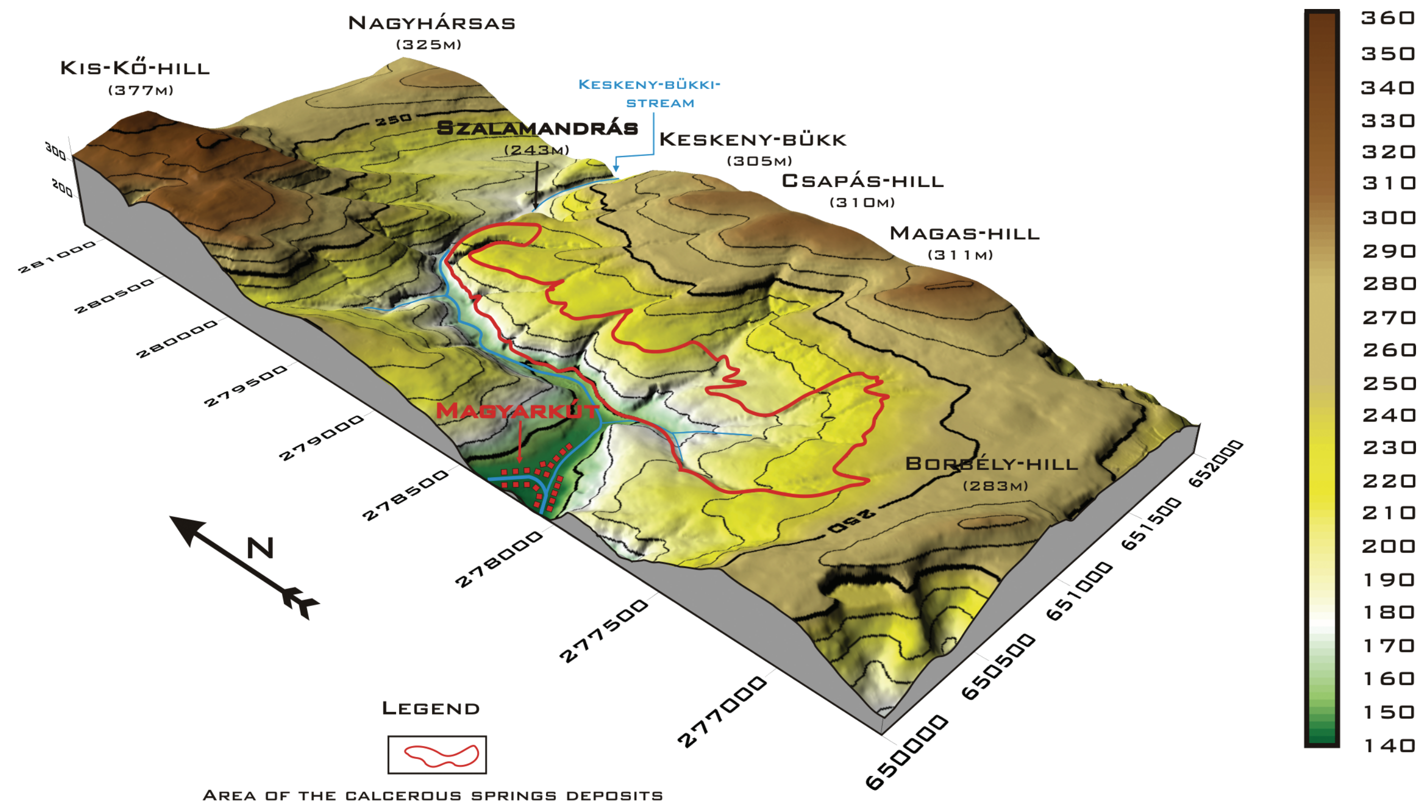


Fig. 2. Surrounding of Magyarkút on the Digital Elevation Model

Although previous researchers (Böckh, H. 1899; Ferenczi, I. 1935; Báldi, T.–Kókai, J. 1970) described several occurrences in the inner side of the crest of the Keskeny-Bükk-Borbély Hill, the present study discusses the deposits on the side of the Szalamandrás Hill exclusively. This is the very place where the paleobotanical rarities to be introduced later on were revealed.

This locality represents by all means a novelty, since there were no other findings of similar quality and condition detected nearby.

The Szalamandrás Hill (243 m) is one of the elevations prepared by weathering of the slope gently descending towards the stream valley flanked by the Keskeny-Bükk–Borbély Hill's ridge (*Figure 2*). From the north and the west, it is bordered by the Keskeny-Bükk Stream, while its southern and eastern borders are marked by the line of steep gullies. In the southern and western side of the Szalamandrás Hill a significant amount of hot spring deposits can be detected (*Figure 3*).

These calcareous spring deposits directly superimpose the andesite weathering products of gravel-sand size. The bedrock outcrops on the surface can be primarily related to the terrain at 210–230 m above sea level, where several, clearly isolated, porous, hollow limestone blocks are present (*Figure 3 (1); photos 2–3*), presumably marking the sites where water of springs issued. Stratified calcareous spring deposits can be found at several places near the bedrock blocks (*Figure 3 (2); photos 4–5*). The two rock types frequently occur together, developing from each other.

Thus the porous calcareous spring deposits undoubtedly emerge from a stratified environment of rocks. One can assume that the once operating springs could develop the whole formation. Stratified calcareous material precipitated from stagnant water or from water pouring down along the sides of the cones and accumulating in the area between them.

Description of the rocks

The samples taken from the surface outcrops appear in their natural occurrence as moss-grown, greyish-white or dark-grey, hard, resistant rocks. The colour of their fresh fracture is generally beige-, greyish-, yellowish-white. As the effect of hammering, they give a siliceous scent frequently accompanied by sparks, which is due to silicification of the limestone.

In many cases quartz and calcite also occur as inclusions. Regarding their structure massive, porous and stratified rocks can be distinguished.

The weathered surface is greyish-white *(1)*, at some places having traces referring to corrosion (*Photo 1*). The fresh fracture features a mixture of light-brown to beige and darker brown patches *(2)*. The irregularly-shaped, in some cases angular cavities are filled out by white calcite crystals *(3)*.

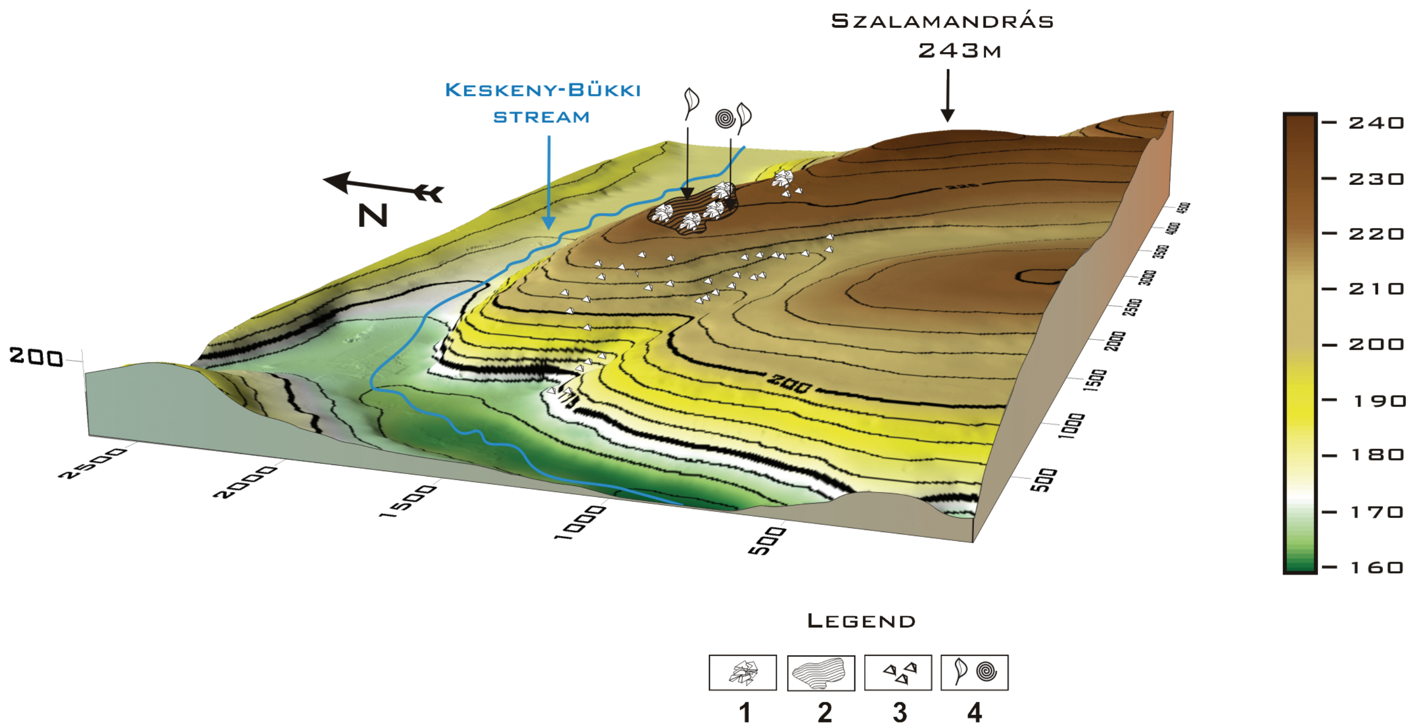


Fig. 3. Calcareous spring deposits on the Szalamandrás Hill. – 1= Porous spring deposit rocks; 2= stratified rocks; 3= debris; 4= locality of flora and fauna

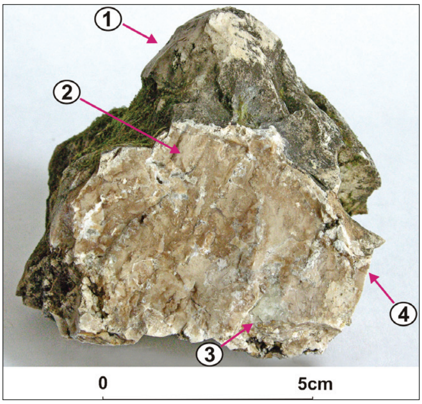


Photo 1. Massive calcareous spring deposit. – 1 = surface; 2 = fresh fracture; 3 = calcite crystal; 4 = sharp rims

Photo 2. In situ occurrence of a 3 m high, porous spring deposit on the slope of the Szalamandrás Hill

There are 0.5 mm wide, 2–5 mm long, curved, narrow holes filled out by white calcite crystals. The rock often contains quartz as inclusion, and is chipping with sharp rims *(4)*. Porous-structured rocks can be recognised in the hillside of the Szalamandrás Hill (*photos 2*, *3a* and *3b*). Their weathered surface is greyish-white, the fresh fracture is white or beige-white. The layers of the rocks are built up from 0.5 mm thin sheets (*Photo 3b, (1)*), and construct a complex structure, in which the components of irregularly twisting layers look similar to a „crumpled wet sheet of paper".

The thickness of the layers varies between 1 and 5 mm. There are smaller and larger cavities within the rocks, ranging also between 1 and 5 mm in size (*Photo 3a, (1)*), the inner side of which is sometimes covered by calcite crystals. The rock is chipping, and breaks along angular rims.

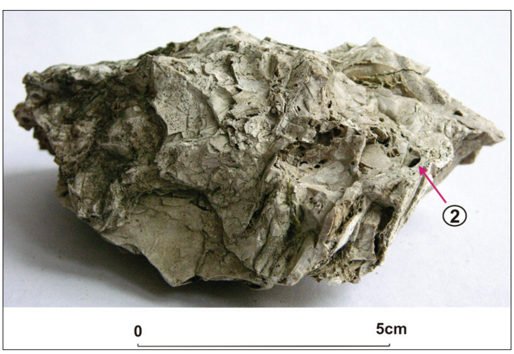


Photo 3a. Porous spring deposits. – 1 = cavities in the rock

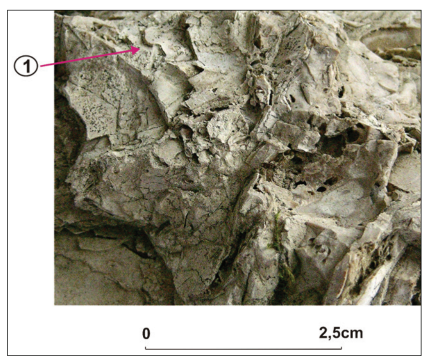


Photo 3b. Enlarged picture of porous spring deposits. – 1 = 0.5 mm thin sheets

In the case of stratified rocks, various kinds of occurrences are possible, and are to be found in the side of Szalamandrás Hill, north of the gully of Medve-kút and of Hosszú gully. They are detectable always near the massive or porous rocks, in some cases they alternate with the latter. Their decomposition surface is white, sometimes with a yellowish-greyish tint.

A special variety of it can be characterized by wispy layers thinner than 0.5 mm (*Photo 4*). Generally grey and white layers alternate. There are at every 4–5 mm regularly repeating, very thin, rusty brown layers *(1)* which probably refer to the periodical activity of the hot spring. The rock does not break up along the layers, the latter cannot be separated from each other by a chisel (*Photo 4a*).

The illustrated rocks of alternating layers are continuously developing on the surface of the porous-structured rocks. Based on the outlook of the stratified deposit, it could be the precipitation from some kind of water running down on an uneven surface (*Photo 4b*); here the rock can be split along the layers by a chisel. The layers are wavy, rough surfaces *(2)*.

The other variety of stratified rocks involves much more rougher, even 0.5–1 cm thick layers (*Photo 5*). Though the paper-thin, uneven surface of strati-

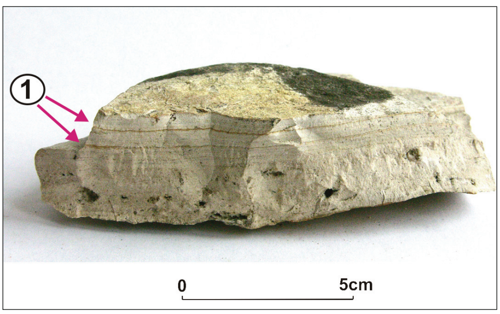


Photo 4a. Microstratified spring deposit, continuously developing on the surface of the porous rock, on the side of the Szalamandrás Hill (243 m). – 1= rusty brown layers

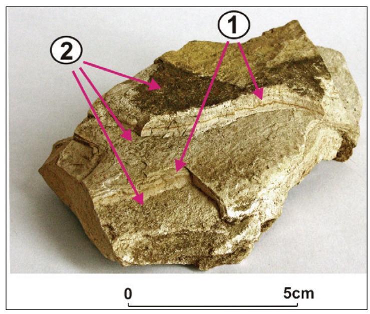


Photo 4b. Microstratified spring deposit. – 1= rusty brown layers; 2= wavy, rough surfaces of the layers

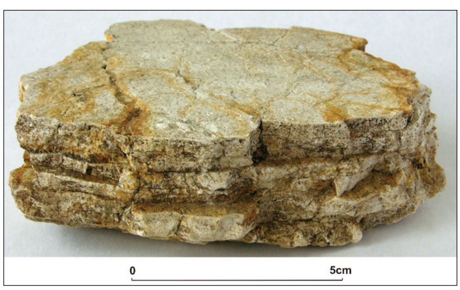


Photo 5. Macrostratified spring deposit

fication frequently occurs in this case as well, it can be definitely separated from the above described version, since the rocks can easily be taken apart. Often plant remnants, sometimes even calcareous snails can be found among the layers (*pictures 6, 7*). Regarding the number and preservation of the finds, the plant remnants have a greater significance in this case. The fossils include mainly silicified stems or carbonized remnants of leaves (*Photo 6*).

The veins are visible even to the naked eye, in some cases the material of the leaves was preserved as well. The material of such conserved leaves is always extremely crumbling and poorly preserved. These remnants could be found exclusively in white coloured layers.

Paleobotanical description

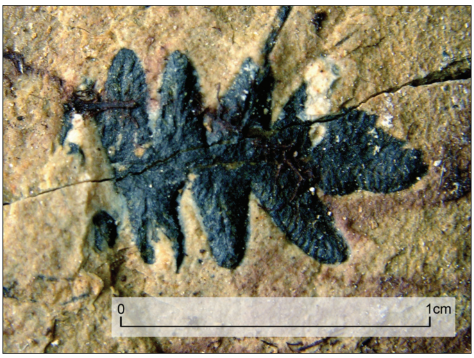
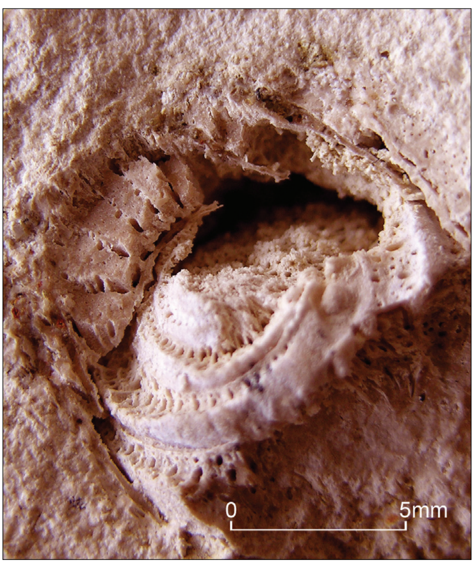


Photo 6. Fossilized fern remnant



Pteridophyta

„Pteris" oeningensis Unger, F. (*Photos 8, 9*).
1847 Pteris oeningensis Unger, F., Unger, F. 124 p. Pl. 37, *figures 6, 7.*
1855 Pteris oeningensis Unger, F., Heer, O. 39 p. Pl. 12, *Figure 5.* (a-i) – Öningen.
1990 Pteris oeningensis Unger, F., Kovar-Eder, J.–Krainer, B. 18 p. Pl. 1, figures 7–10, Pl. 3. *Figure 7.* – Wörth bei Kirchberg/Raab.
1998 Pteris oeningensis Unger, F., Krenn, H. 174 p. Pl. 1, *Figure 3.*
2004 Pteris oeningensis Unger, F., Kovar-Eder, J. 165 p. Pl. 1, *figures 1–3.* – Mataschen Pteris oeningensis Unger, F., Meller, B. and Hably, L. – Gratkorn, in progress.

Description: Only 1.2–1.3 cm small fractions of the secondary wings of the leaf blade are preserved. The length of the secondary winglets varies between 0.2–0.8 cm, their width is between 0.1–0.2 cm, their size decreases towards the leaf apex section of the wings. Their location alternates on the spur. The wings grow narrow in the rounded leaf apex; their basis section broadens out, and joins the petiole as well as partly the other wings. There is a strong midrib in the middle of the blade, which has a dense vein system. The winglets have a smooth edge.

Photo 7. Silicified gastropod

Photo 8. „Pteris” oeningensis Unger, F.; leaf apex of the secondary winglet

The majority of the plant remnants in the quarry belong to this species. More than 20 fractions were found, which were originally parts of the leaf apex or the middle section of the secondary winglets. In some cases, the rims of the winglets were fossilized turned up, and the leaf seems to be narrower than its actual size is. The occurrence of the species was recorded at numerous Austrian Late Miocene quarries, at several places it is accompanied by *Podocarpium podocarpum*. Its occurrence refers to autochthonous environment on the one hand, and to wet habitat on the other.

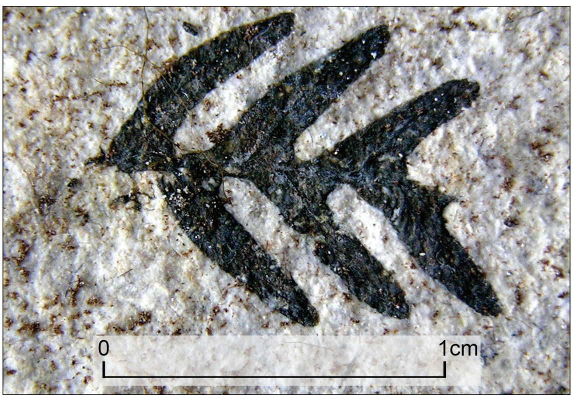


Photo 9. „Pteris” oeningensis Unger, F.; medial section of the secondary winglet

Leguminosae

Podocarpium podocarpum (Braun, A.) Herendeen, P.S. *(Photo 10)*
1992a Podogonium knorrii (Braun, A.) Heer, O.; Herendeen, P.S., 4 p. *figures 1–5.*
1992b Podocarpium podocarpum (Braun, A.) Herendeen, P.S. 732 p.
1995 Podogonium knorrii (Braun, A.) Heer, O., Erdei, B. 1995. 15 p. *figures 10, 11.*
2004 Podocarpium podocarpum (Braun, A.) Herendeen, P.S., Kovar-Eder, J.–Kvaček, Z.–Ströbitzer-Hermann, M. 2004. 74 p. Pl. 9. *figures 8–11.*

Description: The length of the leaflets varies between 2.2–2.4 cm, their width ranges between 0.8–1.0 cm. They are oval-shaped, the leaf base is slightly asymmetric, and the leaf apex is sharp. The vein

Photo 10. Podocarpium podocarpum (Braun, A.) Herendeen, P.S. leaflet

system is brochidodrom, camptodrom. The midrib is strong, the secondary veins are thin but dense, they run nearly parallel, and finally join each other noose-like near the rim of the leaflet. A basal vein starts from the petiole – exclusively on one side –, which can be followed till the lower third-half of the layer. The leaflet has a smooth edge.

The quarry involved three leaflets of this subtropical species of tree. It first occurred in Central Europe in the Carpathian (Magyaregregy; Hably, L. 2002; Parschlug; Kovar-Eder, J. *et al.* 2004), later became dominant in the Sarmatian, and was an important element of almost every Sarmatian quarry (Hably, L. 1992). Like many other Sarmatian components, it also disappeared from the Pannonian Basin during the Pannonian, and did not return in the Pliocene, not even to places, where other dominant Sarmatian species, e.g. the Quercus kubinyii, Zelkova zelkovifolia occurred in the Pliocene of Gérce and Pula (Hably, L.–Kvaček, Z. 1997). It became an additional component of a reasonably rich flora in the Carpathian, while it frequently accompanied the principal or characteristic species of Quercus kubinyii, Zelkova zelkovifolia, „Parrotia" pristina in the Sarmatian. It can be found as a member of a subtropical flora-complex at every of its known quarries.

Ulmaceae

cf. Ulmus sp. (*Photo 11*)

Description: The length of the leaf is 2.6 cm, its width takes about 1.5 cm. Its base, leaf apex and edge are fragmented. The vein system is craspedodrom. The secondary veins leave the strong midrib in acute angle, at some places branch out in a Y–shape.

Only a single fragmented print was found at the quarry. Based on the low amount of taxonomic characteristics, it could be a leaf of an elm tree, which was quite widespread together with the various species of the Neogene edaphic associations. It was generally located in the grove forests of the high flood area. It most frequently occurred only as an additional component, the dominant stock of the Ulmus braunii is known from the Sarmatian, and Pliocene.

Photo 11. cf. Ulmus sp.; leaf

Monocotyledonae gen. et sp. – 2 small fragments (*Photo 12*)

Description: The fragments are somewhat longer than 1 cm, their width is 0.7–0.8 cm. They have a dense system of fine veins, running parallel.

Only two small fragments are known from the quarry. According to the parallel vein system, they can be the members of this class. Their occurrence refers to autochthonous environment on the one hand, and to a neighbouring wet habitat on the other.

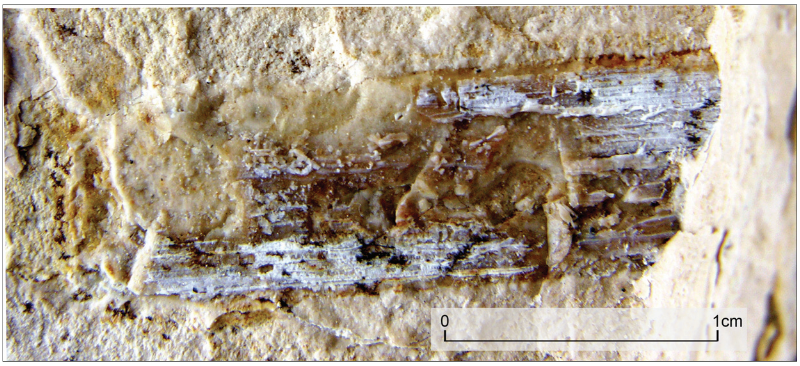


Photo 12. Monocotyledonae gen. et sp.; leaf fragment

Conclusions

Based on the quite scant flora remnants, one can assume the presence of an edaphic association strongly related to water: the monocotyledons and the ferns could be located in the direct neighbourhood of water, the elm-trees were in the high flood area, while the *Podocarpium podocarpum* forest could be found somewhat further apart, supposedly accompanied by other species, which were not fossilized. The *Podocarpium* can be detected in the Carpathian Basin from the Carpathian to the Sarmatian, therefore, the age of the quarry can be between the Middle and Late Miocene. Regarding its climatic requirements, this species provides the most amount of information as well, since its known occurrences all prove a subtropical climate.

REFERENCES

Báldi, T. and Kókai, J. 1970. A kismarosi tufit faunája és a börzsönyi andezitvulkánosság kora. (The fauna of the tuffite at Kismaros and the age of the andesite volcanic activity in the Börzsöny Hills.) *Földtani Közlöny* 100: 274–284.

Böckh, H. 1899. Nagy-Maros környékének földtani viszonyai. (Geological relations of the surrounding of Nagy-Maros.) *Annals of the Hungarian Royal Geological Institute* 13: 1–58.

Erdei, B. 1995. The Sarmatian flora from Erdőbénye-Ligetmajor, NE Hungary. *Annales Historico-Naturales Musei Nationalis Hungarici* 87: 11–33.

Ferenczi, I. 1935. Adatok a Börzsöny-hegység geológiájához. (Data to the geology of the Börzsöny Hills.) *Annual Report of the Hungarian Royal Geological Institute 1925–28.* 131–142.

Hably, L. 1992. Distribution of legumes in the Tertiary of Hungary. In *Advances in Legume Systematics, Part 4. The Fossil Record 169–187.* Eds. Herendeen, P.S. and Dilcher, D.L. Kew, Royal Botanic Gardens.

Hably, L. 2002. The Middle Miocene flora of Magyaregregy – as shown by a study of recent collections. *Book of Abstracts.* Athens, 6th European Paleobotany-Palynology Conference, 91–92.

Hably, L. and Kvaček, Z. 1997. Early Pliocene plant megafossils from the volcanic area in West Hungary. *Studia Naturalia* 10: 5–151.

Heer, O. 1855. *Die tertiäre Flora der Schweiz I.* Winterthur, J. Wuster-Comp. 118 p.

Herendeen, P.S. 1992a. A reevaluation of the fossil genus Podogonium Heer, O. In *Advances in Legume Systematics, Part 4. The Fossil Record 3–18.* Eds. Herendeen, P.S. and Dilcher, D.L. Kew, Royal Botanic Gardens.

Herendeen, P.S. 1992b. Podocarpium podocarpum comb. nov., the correct name for Podogonium knorrii Heer, O. nom. illegit. (fossil Fabaceae). *Taxon* 41: 731–736.

Jámbor, Á., Moldvay, L. and Rónai, A. 1982. *Magyarázó Magyarország 200 000-es földtani térképsorozatához (Explanatory notes to the geological map series of Hungary). L-34–II.* Budapest, MÁFI (Hungarian Institute of Geology), 358 p.

Karátson, D. 1997. Vulkáni működés és kalderakérdés a Börzsönyben. (Volcanic activity and the caldera issue in the Börzsöny Mountains.) *Földrajzi Közlemények* 121. (3–4): 151–172.

Karátson, D. 2002. A Börzsöny. (Börzsöny Mts.) In *Magyarország földje, kitekintéssel a Kárpát-medence egészére. (The territory of Hungary, with a perspective on the whole Carpathian Basin.)* Ed. Karátson, D. Budapest, Magyar Könyvklub, 358–362.

Karátson, D. 2007. *A Börzsönytől a Hargitáig. Vulkanológiai tanulmányok a Kárpátok miocén-pliocén tűzhányóláncából. (From the Börzsöny to the Hargita. Volcanologic studies in the Miocene-Pliocene volcanic line of the Carpathians.)* Budapest, Typotex, 462 p.

Korpás, L. ed. 1998. *Magyarázó a Börzsöny és Visegrádi-hegység földtani térképéhez (Explanations to the geological map of the Börzsöny and the Visegrád Mountains) 1 : 50 000.* Budapest MÁFI (Hungarian Institute of Geology), 216 p.

Korpás, L. and Csillag-Teplánszky, E. 1999. *A Börzsöny–Visegrádi-hegység és környezetének fedetlen földtani térképe (The uncovered geologic map of the Börzsöny–Visegrád Mountains and their environment) 1: 50 000*. Budapest, MÁFI (Hungarian Institute of Geology).

Kovar-Eder, J. 2004. Die obermiozäne Flora von Mataschen bei Fehring, Steiermark. *Joannea Geologie und Paläontologie* 5: 163–175.

Kovar-Eder, J. and Krainer, B. 1990. Flora und Sedimentologie der Fundstelle Reith bei Unterstorcha, Bezirk Feldbach in der Steiermark (Kirchberger Schotter, Pannonium C, Miozän). *Jahrbuch der Geologischen Bundesanstalt,* 134. (4): 737–771.

Kovar-Eder, J., Kvaček, Z. and Ströbitzer-Hermann, M. 2004. The Miocene Flora of Parschlug (Styria, Austria). Revision and Synthesis. *Ann. Naturhist. Mus. Wien* 105: 45–159.

Krenn, H. 1998. Die obermiozäne (pannone) Flora von Paldau, Steiermark, Österreich. *Mitt. Geol. Paläont. Landesmuseum Joanneum* 56*:* 165–271.

Nagy, B. 1983. Metallogenetic, mineralogical and geochemical results on ore mineralizations in the Börzsöny Mountains, North Hungary. *Acta Geologica Hungarica* 26. (1–2): 149–165.

Unger, F. 1847. *Chloris protogaea. Beiträge zur Flora der Vorwelt*. Leipzig, Wilhelm Engelmann, 150 p.