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STRATIGRAPHY AND ORIGIN OF THE KISFENNSÍK NAPPE (BÜKK MOUNTAINS, NE HUNGARY). IS THE SILICA UNIT REALLY PRESENT IN THE BÜKK MOUNTAINS?

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Abstract: The Kisfennsík Nappe is the uppermost tectonic unit of the Bükk Mountains (NE Hungary). The nappe consists of slightly metamorphosed platform limestones with dolomites at the base, and intercalating metavolcanites. On the basis of lithological character and macrofossils (Megalodontidae and Gastropoda) of uncertain age, the Kisfennsík Limestone was considered to be Ladinian–Carnian or Norian. The earlier and the here published results of microfacies investigations and Foraminifera and Dasycladaceae assemblage prove a Carnian lagoonal depositional environment, for the greater part of the Kisfennsík Limestone. In an eastern site (Galya-tető) reef facies was determined. Metavolcanites show different petrographic characters: acidic pyroclastics, andesitic lavas and basic tuffs, amygdaloidal basalts are present. Acidic-transitional metavolcanites appear at different stratigraphic horizons, below and above the basic ones. Based on stratigraphic position and petrographic features, the basic ones can be correlated with the Carnian extensional magmatism of the Bükk area (Szinva Metabasalt Formation). Considering the lithological features (presence of Triassic volcanites) of the Kisfennsík Nappe, and the structural pattern of the larger area, its W-Carpathian Silicic Unit origin can be excluded. The above mentioned features support an intra-Bükkian origin.

Key words: Carnian, Western Carpathians, Silicic Nappe, Bükk Mts, Kisfennsík Limestone, Bükkian-type succession, microfossils, metavolcanite.

Introduction

The Kis-fennsík (Little High Plateau) is situated in the northern part of the Bükk Mts (N Hungary), W of Miskolc, and N of Garadna Valley (Fig. 1). This areal of ca. 25 km^2 is partly covered with successions of debated origin. New investigations during the previous decades confirmed the nappe origin of the upper unit (Kisfennsík Nappe, Less 1986). But the extra- versus intra-Bükkian origin of the nappe still remained uncertain (Csontos 1988; Plašienka 1997). The aim of this paper is to present new stratigraphic data from the Kisfennsík Nappe, which, together with re-evaluated tectonic conditions, allows us to consider the origin of the succession. We would like to answer the long-standing question: Is the Silicic Unit really present in the Bükk Mts?

The light, massive limestone bodies (Kisfennsík Limestone) identified by Schréter (1916), were regarded as Middle–Upper Triassic. These are thrust over older sequences (Schréter 1943). Jámbor (1959) mapped a diabase tuff horizon, dividing the Kisfennsík Limestone into a lower (Ladinian) and an upper (Upper Triassic) part with megalodontids. In his monograph, based on macrofossils (*Margarosmilia confluens* Volz, *Naticopsis* cf. *hoernesi* Blaschke) Balogh (1964) established a Ladinian–Late Triassic age. Dolomites and metaandesites found in the NW sector of the Kis-fennsík area were correlated with the Bükkian Anisian dolomites and with the older volcanic horizon in its cover (Balogh 1964). The detailed mapping of Gy. Less confirmed the nappe position of the Kisfennsík Limestone, which, together with the above mentioned dolomites and volcanites, are grouped into an up-

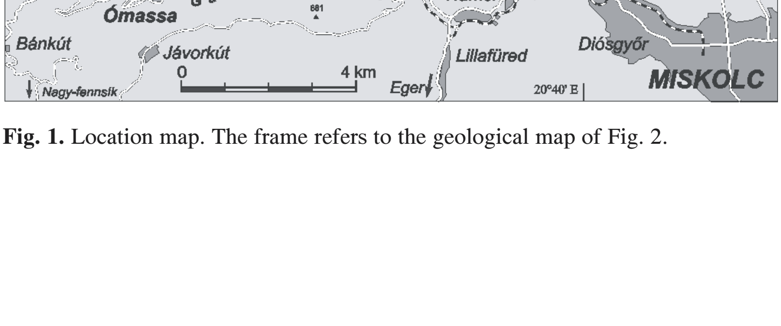

Fig. 1. Location map. The frame refers to the geological map of Fig. 2.

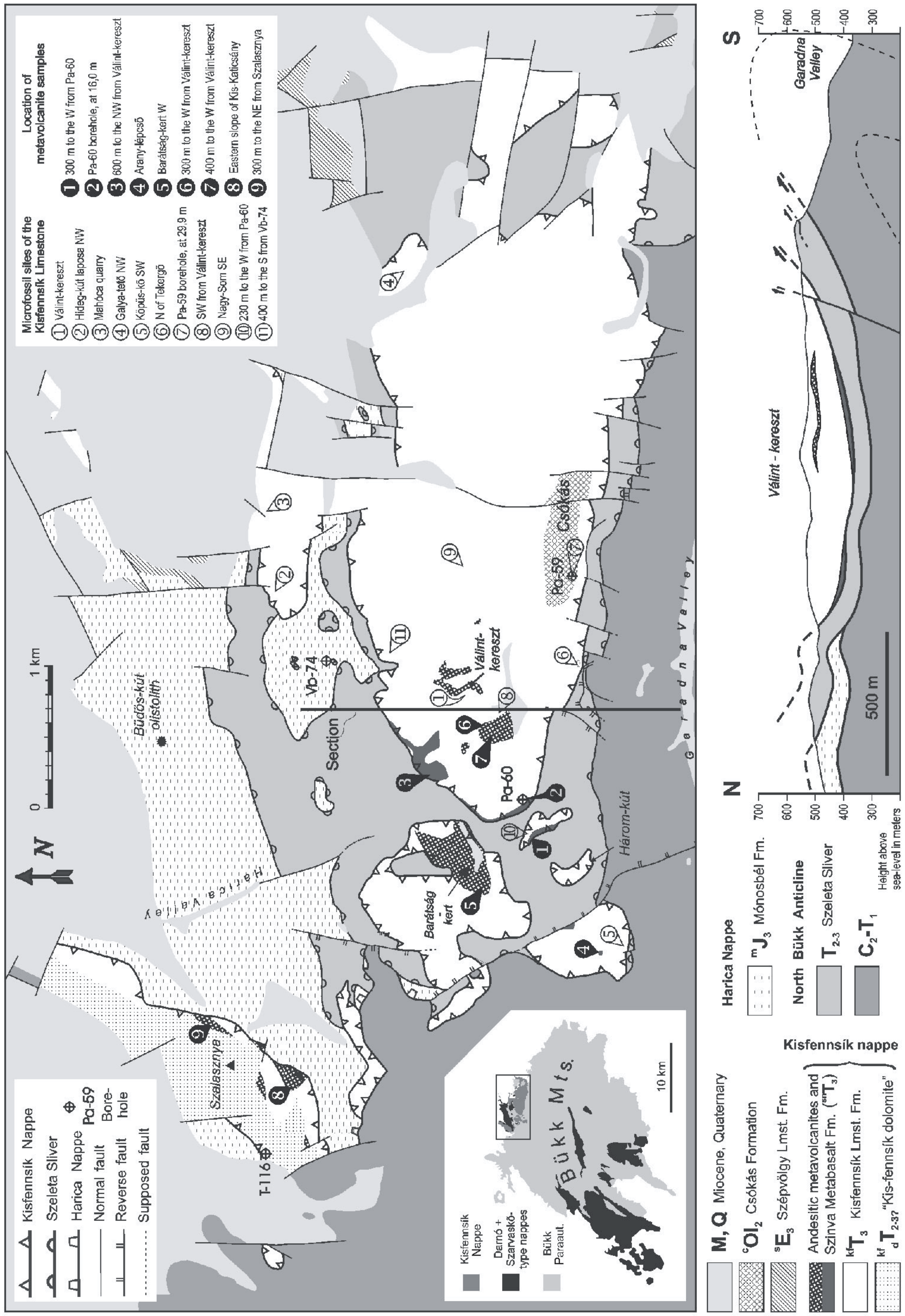

Fig. 2. Geological map (simplified from Forián-Szabó & Csontos 2002; Less 1986, 1988) and cross-section of the Kis-fennsík area. For location see also Fig. 1.

permost Bükkian nappe (Kisfennsík Nappe — Less 1986, 1988; Less et al. 2002). On the basis of megalodontid determination by E. Végh-Neubrandt (pers. comm.), Csontos (1988) supposed a probably Silicic-type nappe fragment, comprising non-metamorphic Dachstein-type (Kisfennsík) limestone. Together with the recent investigations (comprising microfacies analysis and detailed structural mapping) of the authors, the following structural model can be outlined. (The structural features of the Kis-fennsík area, including the stratigraphy of the lower tectonic units and the structural evolution of the NE-Bükk Mts, are discussed in Forián-Szabó & Csontos (2002).) The nappe outliers of the Kisfennsík Nappe are superimposed onto nappes and slivers overthrust onto the North Bükk Anticline (Bükk Parautochthonous, Fig. 2). In the SW nappe outliers can be found directly upon the Paleozoic to Lower Triassic formations of the North Bükk Anticline, while in the N and NW the Kisfennsík Nappe is thrust upon younger shales forming the Harica Nappe (Mónosbél Formation, Fig. 2). The Jurassic age of the shale is proven by radiolarian finds (Kozur 1984) and by Jurassic foraminifers found in neptunian dykes of an olistolith in the shale (Büdös-kút olistolith, Fig. 2; Velledits 1998). In the central and western part of the area the tectonic underlayer of the Kisfennsík Nappe is mainly an Upper Triassic, anchimetamorphic cherty limestone belonging to a sliver of the North Bükk Anticline (Fig. 2). The structural mapping of the investigated area and the geometry of the intercalated volcanite bodies indicated, that the sole thrust of the Kisfennsík Nappe cuts off even younger formations towards the SE (Fig. 3; Forián-Szabó & Csontos 2002). The original sedimentary cover of the Kisfennsík Limestone is unknown; at the southern nappe margin the Oligocene Csókás Formation lies transgressively on its eroded surface (Fig. 2–3; Less 1991).

In the followings we give the descriptions of different formations belonging to the Kisfennsík Nappe, including new stratigraphic results.

Stratigraphy of the Kisfennsík Nappe

"Kis-fennsík dolomite"

In the NW part of the investigated area, the NE-SW striking belt of Szalasznya (Fig. 2) is mainly composed of grey-coloured, often brecciated dolomites. Scattered occurrences of dark-grey limestones and some cherty limestone are also associated with this dolomite. Unexposed contacts with the white Kisfennsík-type limestone and with metavolcanites, and the lack of any biostratigraphic data from this belt allow different interpretations (Fig. 3). Previous mappers identified it with the Anisian Hámor Dolomite (Balogh 1964). The mapping result of Less 1986 established a Hámor Dolomite, Szentistvánhegy Metaandesite (Anisian-Ladinian), Fehérkő (Kisfennsík) Limestone succession for this thrust fragment. Considering the Carnian age of the Kisfennsík Limestone at the central part of the area (see below), and the NW dipping ramp-model of the Kisfennsík Nappe (Fig. 3 and Forián-Szabó & Csontos 2002), the above mentioned grey dolomite and limestone could be the underlayer of the Kisfennsík Limestone. According to P. Pelikán (pers. comm.) siliciclastics in the upper part of the borehole Tardona-116 (Fig. 2) are attributed to the Scythian underlayer of the Hámor Dolomite. If it is so, the below described andesitic metavolcanites can be the products of the Anisian-Ladinian volcanic event (Szentistvánhegy Metaandesite — Less 1986). Because of the already mentioned stratigraphic uncertainities (regarding the metavolcanites as well) it is also possible to evaluate sediments in the NW as a lower part of the Wetterstein-type Kisfennsík platform, which contains scattered or continuous dolomitized segments. The lack of fossils and the deficient stratigraphic data do not allow certain identification of the "Kis-fennsík dolomites" with any of the described dolomite formations; therefore we do not assign it to any formation.

Kisfennsík Limestone Formation

This is the most voluminous rock type of the nappe, its larger and smaller blocks and fragments are widespread in the Kisfennsík area (Fig. 2). The colour of the Kisfennsík Limestone is white, white-grey, pale red, or yellowish. It is a massive, platform limestone, deposited partly in a lagoonal, partly in a reef environment. In the lagoonal environment the different members of the Lofer cycle are present. In several samples outlines of reef building organisms (corals, sphinctozoans) can be observed, representing the reef environment. Microfossils: Dasycladaceae (Fig. 4i–j and o) and Foraminifera (Fig. 4a–h and n) of the Kisfennsík Limestone identified from thin

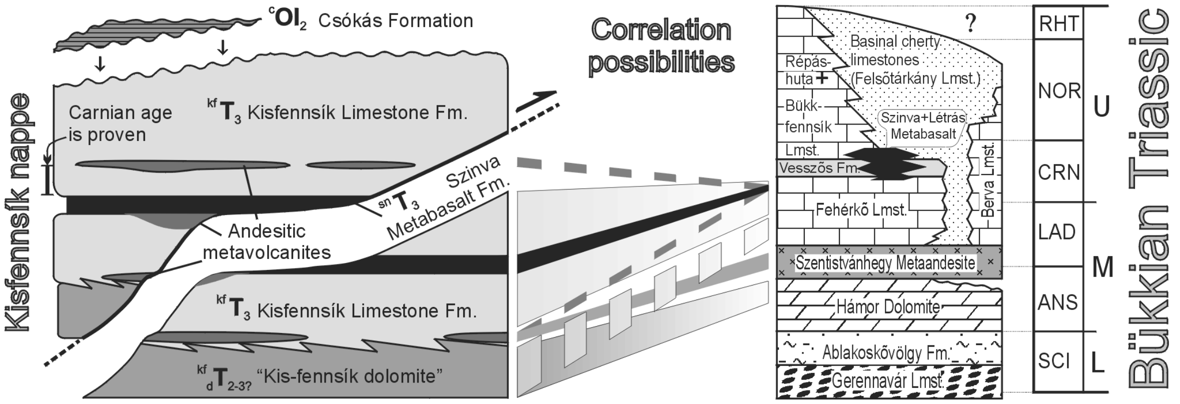

Fig. 3. Stratigraphic scheme of the Kisfennsík Nappe, and its correlation possibilities (continuous and broken stripes) with the Bükkian Triassic. See text for explanation. The simplified stratigraphic column of the Bükkian Triassic is compiled after Pelikán et al. (1993) and Velledits (1998).

Table 1: Microfossils and microfacies types of the Kisfennsík Limestone Formation fossil sites. Microfossils of locality 2, 3 and partly of 1 are from Velledits et al. (1999). The microfacies codes refer to the classification found in the text. The fossil sites are shown on Fig. 2.

Fossil group	Fossil	Number of pieces by localities											
		1	2	3	4	5	6	7	8	9	10	11	Tot.
Dasycladaceae	*Griphoporella sp.*			2									2
	Gyroporella sp.			1									1
	Physoporella heraki BYSTRICKÝ		4				10						14
	Poikiloporella duplicata (PIA)		2	1		1	11						15
	Teutloporella herculea STOPPANI							1					1
	Thaumatoporella parvovesiculifera RAINERI			1									1
Foraminifera	*Agathammina sp.*									1			1
	Ammobaculites sp.		1	1									2
	Ammodiscus sp.						1						1
	Aulotortus sinuosus WEYNSCHENK		1				2			1			4
	Aulotortus sp.	1								1			2
	Diplotremina astrofimbriata (KRISTAN-TOLLMANN)		1										1
	Diplotremina sp.		4	14			1						19
	Earlandinita sp.		1									3	4
	Endothyra sp.	1		4								1	6
	Endothyra brassica (TRIFONOVA)		1										1
	Endothyranella sp.	2	1	6					1				10
	Endothyranella tricamerata SALAJ										1		1
	Gaudryina? sp.	1											1
	Gaudryinella sp.		1										1
	Glomospirella sp.	1					4			1			6
	Gsollbergella sp.		2										2
	Gsollbergella spiroloculiformis (ORAVECZ-SCHEFFER)		15	4									19
	Nodosaria sp.		4				1						5
	Nodosinella libera TRIFONOVA		5	4									9
	Oberhaueserellidae sp.		1	4									5
	Ophthalmidium tori ZANINETTI et BRÖNNIMANN		2	1						1			4
	Spirillina sp.	1	2										3
	Textularia sp.		2	8									10
	Trochammina almtalensis KOEHN-ZANINETTI	2		1									3
	Trochammina alpina KRISTAN-TOLLMANN	2	2	1									5
	Trochammina sp.	3	5	11									19
	Variostoma acutoangulata KRISTAN-TOLLMANN			1								1	2
	Variostoma sp.						1						1
	?Reophax sp.			1									1
Characteristic microfacies types *(see text for classification)*		I.			II.	I.							
		3,4,5	1,3,6,7	1-4 6-8	1,2	7,3	3,4	7	3	3	1,2	6,3	

sections are listed in Table 1. The fossil sites are shown on Fig. 2. At first sight the Kisfennsík Limestone appears to have mainly non-metamorphic character, containing well preserved algal mats, green algae, gastropods, and megalodonts, which are observable also with naked eyes (Pelikán et al. 1993; Fig. 4p). However, most of the mapped limestone bodies contain more or less recrystallized or brecciated zones. The spatial distribution of recrystallization is very complex, it seems very hard to limit. Around the contacts with the intercalating metavolcanites (Válint-kereszt, Pa-60 borehole; Fig. 2) a stronger recrystallization can be observed due to the heat transmission. In other areas without volcanites the degree of the recrystallization can vary from metre to metre.

According to Velledits et al. (1999) and the new results, the types of microfacies are the following:

I. Lagoonal facies

I.1 Oncoidal wackestone: in micritic matrix oncoids with 0.5–2 cm diameter, foraminifers, peloids, and recrystallized mollusc shells, gastropods can be seen. The coatings of the oncoids are thick consisting more layers. Polygonal mud cracks, some centimetres in diameter and smaller birdseyes (fenestral fabrics) filled with brown-grey ostracod micrite are very frequent in this microfacies type. In a thin section in the dissolved place of a gastropod shell (moldic porosity) a huge number of ostracod shells can be observed (Fig. 4k–l). The depositional environment is the shallow subtidal part of a lagoon. During diagenesis the deposited carbonate mud with oncoids and foraminifers got to an emerged position, where polygonal desiccations cracks were generated. Due to the influence of freshwater the aragonitic shells of the gastropods were also dissolved. An ostracod lime mud was infiltrated into the moldic pores, which has been recrystallized later on. The ostracod bearing lime mud is a characteristic sediment for the ponds on the tidal flat.

I.2 Mudstone with desiccation cracks: the micritic, pelmicritic matrix is rich in foraminifers, porostromata algae fragments, oncoids, and coated lithoclasts. Birdseyes can be found in the entire rock: their lower part is filled with ostracodal mi-

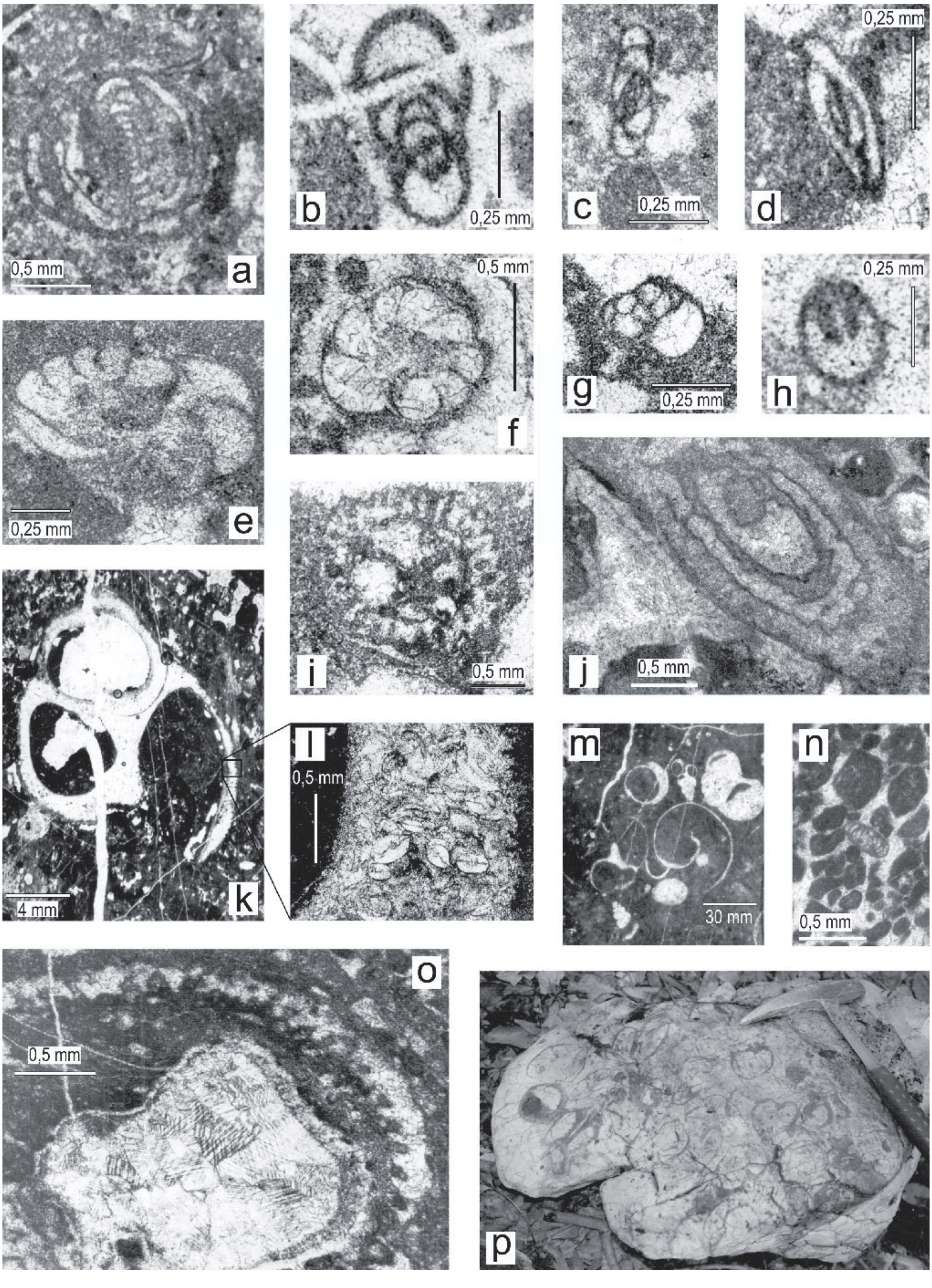

Fig. 4. Microfossils and facies of the Kisfennsík Limestone. Fossil site numbers (see Fig. 2 for location and Table 1) are in brackets. Photos a), c), f), g), i), k), l), m) and o) are from Velledits et al. (1999). **a)** *Aulotortus sinuosus* Weynschenk (2); **b)** *Endothyra brassica* (Trifonova) (2); **c)** *Gsollbergella spiroloculiformis* (Oravecz-Scheffer) (2); **d)** *Ophthalmidium tori* Zaninetti et Brönnimann (2); **e)** *Variostoma acutoangulata* Kristan-Tollmann (3); **f)** *Diplotremina astrofimbriata* (Kristan-Tollmann) (2); **g)** *Trochammina alpina* Kristan-Tollmann (3); **h)** *Nodosinella libera* Trifonova (2); **i)** *Physoporella heraki* Bystrický (2); **j)** *Poikiloporella duplicata* (Pia) (6); **k)** Gastropod section in micritic-pelmicritic matrix (3); **l)** Enlarged part of the dissolved gastropod shell of Fig. 4k: the ostracod-bearing lime mud infiltrated into the moldic pore was recrystallized later on (3); **m)** Wackestone with different types of gastropods: some of them include geopetal structure (2); **n)** Grainstone with peloids and with *Glomospirella* sp. (1); **o)** *Griphoporella* sp. (3); **p)** Macroscopic view of the Kisfennsík Limestone rich in megalodontids (1).

crite, while the upper part is filled with sparite. The carbonate mud was deposited in the subtidal lagoon environment. Due to subsequent desiccation and dissolution of freshwater cavities, desiccation and entgassing pores originated, which were partly filled with ostracod mud.

I.3 Grainstone with peloids, and with bio- and lithoclasts (Fig. 4n): this microfacies type develops from the previous type. In some thin sections it can be observed, that the dense and extensive net of the mud cracks isolates the peloids. If these sediments are affected by agitated water, then the peloids will be rounded, and the bioclasts coated. In some thin sections two generations of cements can be observed. The grains are covered with rim cement, and the space between the grains is filled with sparite. Sometimes the entire space between the rim cement is filled with calcisilt. Depositional environment: the high-energy part of the platform, and the winnowed platform edge sands. Diagenesis: in some thin sections the grainstone and the mudstone textures occur together. The transition between these two types is continuous. We can conclude, that the sediment deposited in the subtidal environment (wackestone), after that it was desiccated and cracked in the supratidal zone. Later this sediment was redeposited (grainstone).

I.4 Algal mat: some mm thick laminae with birdseyes. The cavities are 3×15 mm, and follow the layering, their inner parts are filled with two generations of sparite. The material of the algal lamina is pelmicrite, which represents the sediments captured by blue-green algae. Some foraminifers occur as well. Depositional environment: intertidal lagoon.

I.5 Limestone beds with megalodontids: medium grey, thick bedded limestone layers, densely packed with double megalodontids: they measure 5–10 cm (Fig. 4p). Depositional environment: subtidal lagoon.

I.6 Wackestone with gastropods: gastropods (5 %), ostracods (1 %), and some foraminifers in micritic matrix. The different types of gastropod sections can be even 12 mm in diameter. Geopetal structures are also observable (Fig. 4m). Depositional environment: subtidal environment of the lagoon.

I.7 Wacke-packestone with dasycladacean algae:

The preservation of this material is very bad. Longitudinal and cross-sections of green algae: *Poikiloporella duplicata* (Pia) (Fig. 4j), *Physoporella heraki* Bystrický (Fig. 4i), *Teutloporella herculea* Stoppani, *Gyroporella* sp., *Griphoporella* sp. (Fig. 4o) can be seen in micritic matrix. In the matrix polygonal cavities were generated, which are filled with brown grey ostracodal micrite. The ostracodal micrite can fill the cavity entirely, or it fills only the lower part of the cavity (libella structure). Depositional environment: dasycladacean algae prefer the tropical, subtropical lagoonal seawater. They live in the subtidal environment, generally at depths of 3–5 m (Flügel 1982). Later, in the tidal flat in the desiccated lime mud polygonal mud cracks were formed, which were enlarged by dissolution of freshwater. These cavities were filled with the typical deposits of intertidal ostracodal mud.

I.8 Wackestone with coral fragments: In micritic matrix recrystallized fragments: foraminifers, echinoderms, ostracods, radiolarians?, and corals. Ostracod cavity filling can also be observed.

Depositional environment: subtidal lagoon, the coral fragments show that there was a reef, or a patch reef in the neighbourhood.

II. Reef

This environment can be identified in slightly metamorphosed limestones, where the inner structure of the fossils disappeared. Only the outlines of the fossils can be observed on the weathered surface, and in thin sections.

II.1 Rudstone:

The rock is dark grey. It contains 1–3 cm big lithoclasts, the space between them is filled with sparite. The lithoclasts are not (or only slightly) rounded. If the space between the lithoclasts is bigger, it is filled with sparite with more generations. The lithoclasts are composed of recrystallized material, in which some recrystallized biogenic components: corals, bryozoans, and echinoderms can be observed.

II.2 Bafflestone:

The rock is light grey. In micritic matrix outlines of fossils can be observed: corals, bryozoans, sphinctozoans?. The inner structure and the incrustation of these primary reef builders cannot be observed. Both microfacies types are characteristic of the reef environment. In the Bükk Mountains these occur in the reef facies of Hór Valley (Flügel et al. 1992) and Mész Valley (Velledits & Péró 1987), too. The bafflestone microfacies represents the autochthon reef, the rudstone is typical for the detritus belt around the reef, and the reef slope.

Age of the Kisfennsík Limestone: The dasycladacean *Physoporella heraki* Bystrický (Fig. 4i) lived only during the Carnian. Among the forams *Gsollbergella spiroloculiformis* (Oravecz-Scheffer) (Fig. 4c), *Ophthalmidium tori* Zaninetti et Brönnimann (Fig. 4d) and *Nodosinella libera* Trifonova (Fig. 4h) indicate Carnian.

Metavolcanites

Macro- and microscopic petrography allows us to distinguish two main types of metavolcanites: a basaltic (1) and an acidic-transitional type (2). Type (1) seems to occur in a certain, ca. 10–30 m thick "stratigraphic" horizon within the Kisfennsík Limestone (Jámbor 1959) of Carnian age, along and above a flat section of the sole thrust of the Kisfennsík Nappe (Forián-Szabó & Csontos 2002 and Fig. 2, 3). Volcanites belonging to type (2) occur at different stratigraphic levels. In the surroundings of the Válint-kereszt they appear in the Kisfennsík Limestone over the metabasalts, while metaandesites to the NW are considered to occupy a stratigraphic horizon below the metabasalts (Fig. 3). Petrologic characters of the two main types are as follows:

Metabasalt

Petrographically similar metabasalts were described from the Carnian of the Bükk Mts (Szinva Metabasalt, Pelikán et al. 1993; Szoldán 1990), therefore we assign the Kis-fennsík metabasalts to the above mentioned formation (Fig. 3). It is intercalated with the Kisfennsík Limestone. Toward the massive platform limestone small angular limestone clasts and lenses

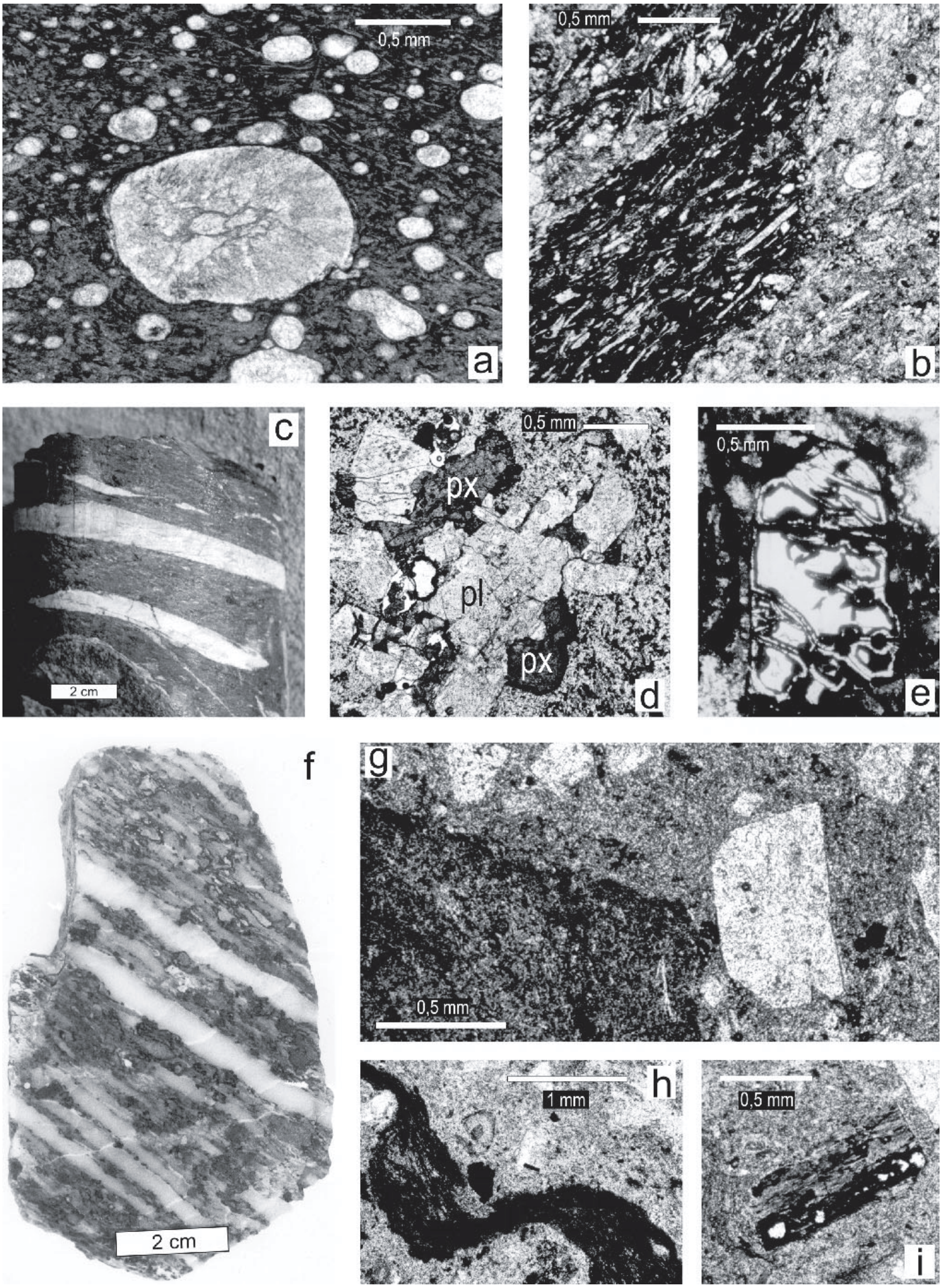

Fig. 5. Macro- (**c** and **f**) and microscopic view of metavolcanites from the Kis-fennsík area. Location numbers in brackets refer to Fig. 2. **a)** Metabasalt with amygdales filled with calcite, 1N (1); **b)** Opacitized metabasalt lithoclast with well oriented, thin albite laths in basaltic pyroclastite, 1N (3); **c)** Basaltic pyroclastite with interfingering, recrystallized limestone lenses. From Pa-60 borehole, at 12.0 m (2); **d)** Plagioclase and glauconitized-chloritized pyroxene phenocrysts in cumuloporphyric metaandesite, 1N (8); **e)** Pseudomorphic pyroxene in andesitic pyroclastite, 1N (7); **f)** Foliated mixture of crystalline Kisfennsík Limestone and andesitic metavolcanite (photo of Cs. Péró) (7); **g)** Tabular plagioclase crystal and opacitized basic metavolcanite clast in andesitic pyroclastite 1N (8); **h)** Deformed, wavy, opacitized lithoclast in andesitic pyroclastite 1N (8); **i)** Opacitized biotite crystalloclast in andesitic pyroclastite 1N (8).

appear first, then even thicker bands of recrystallized limestones are interlayered in the metabasalt (Fig. 5c). In thin section at the margins of the limestone clasts subsequently crystallized, thick albite laths are observable. Macroscopically the metabasalt is dark-green coloured, with a weakly developed cleavage. Frequent alteration changes its colour into brownish. In thin sections closely packed, irregular, elongated basaltic clasts occur in some fine matrix with flow texture. The very fine-grained matrix is mainly composed of chlorite, and possibly also of pumpellyite (appearing in some samples as fibrous patches with radial structure). Basaltic clasts are strongly chloritized, opacitized and calcitized, and they are often amygdaloidal (Fig. 5a). Amygdales are filled with calcite, chlorite and albite. Several basaltic clasts contain well-oriented, thin albite laths (Fig. 5b). Crystalloclasts are rare: they are represented by apatites, large plagioclase tables and also large (up to 2 mm) magnetites, titanomagnetites and spinels.

Acidic-transitional metavolcanites

Rocks of this type occur at Válint-kereszt above the metabasalts, and are also intercalated with the Carnian Kisfennsík Limestone (Fig. 2), while metavolcanites to the NW are deposited most probably below the basaltic horizon, close to the dolomitic underlayer of the Kisfennsík Limestone (see Chapter "***Kis-fennsík dolomite***"). Acidic-transitional metavolcanites are present as badly outcropping, scattered, small bodies. At Válint-kereszt the transition between the metavolcanite and the Carnian limestone has similar texture to that observed between the metabasalts and the same limestone (Fig. 5f). Macroscopically the volcanites are reddish, sometimes grey- or brown-coloured, fine-grained, mostly altered and often foliated. In thin section pyroclastics and extrusives can be distinguished. The matrix of the pyroclastics is often wavy and pumiceous (Fig. 5i). It contains a large quantity of fine-grained opaque minerals (magnetite, hematite and limonite). The former glass is totally altered to sericite and chlorite. Lithoclasts are partly represented by acidic volcanites. Subtypes of acidic volcanoclasts are: pumiceous, sometimes with flow and/or felsitic texture, the material of which is totally recrystallized to chlorite, sericite and quartz (1) and extrusives with microholocrystalline groundmass (2). The above described acidic volcanoclast types contain porphyric altered plagioclase and biotite, and irregular shaped amygdales. More basic lithoclasts similar to the metabasalts described in Chapter "*Metabasalt*" are also present in pyroclasts: they contain thin albite laths and in some cases amygdales in mostly opacitized, fine-grained matrix (Fig. 5g). There are the following crystalloclasts of pyroclastics: feldspar, few quartz, biotite (Fig. 5h) and opaque minerals. Some spinel crystalloclasts of unclear origin were found in acidic pyroclastics near Válint-kereszt (Location 7, Fig. 2). Extrusives (locality No. 5, 7, 8, 9 on Fig. 2) are represented mainly by metaandesites with cumuloporphyric texture (Fig. 5d). The microholocrystalline to glassy groundmass contains large plagioclases and chlorite-glauconite pseudomorphs after euhedral pyroxenes (Fig. 5e). Both in matrix and porphyric minerals fine-grained pumpellyite occurs. Despite the upper stratigraphic position, the above described acidic pyroclastics and metaandesites and the Anisian–Ladinian Szentistvánhegy Metaandesite (Szoldán 1990) have similar petrographic features.

Consequently, based on observations described in Chapter **"Stratigraphy of the Kisfennsík Nappe"**, the examined slice of the Kisfennsík Nappe fits to the Bükkian sequence (Fig. 3).

The origin of the Kisfennsík Nappe

On the basis of the frequent occurrences of large-sized megalodontids in the Kisfennsík Limestone (Fig. 4p) not found elsewhere in the Bükk Mts, Csontos (1988) considered it to be a Norian Dachstein-type limestone. In the surrounding area this formation can be found in the Silicicum, therefore he assumed such an extra-Bükkian origin for the nappe. Referring to Csontos (1988), in more recent publications (e.g. Plašienka 1997) the Kisfennsík Nappe is still assigned to the Silicic nappes. However, the nappe rests upon the Bükk Parautochthonous and partly on a Szarvaskő-type nappe (Harica Nappe), the units of which are displaced fragments of the Internal Dinaridic system (Haas & Kovács 2001). Do we have a Silicic Nappe emplaced over these Dinaridic blocks?

The presence of volcanites has a crucial importance in considerations of nappe origins. In the Bükkium a thick Triassic volcanic sequence was preserved due to the intense polycyclic, calc-alkaline and basic-neutral extensional volcanism in the Anisian–Carnian period (Harangi et al. 1996; Fig. 3). According to Pelikán et al. (1993), the older, Anisian–Ladinian, calc-alkaline volcanic period (Szentistvánhegy Metaandesite) resulted in a thickness of up to ca. 500 m of volcanic material. On the other hand, in the Silicicum the Bükkian-type intense Triassic volcanism is almost completely missing: only thin layers of green tuffs and tuffites can be found locally in the basal part of the Wetterstein limestones, N of Silická Brezová (Early Ladinian, Bystrický 1973). The stratigraphic content of the Upper Triassic platform limestones and dolomites of the Kisfennsík Nappe, including intercalated metavolcanites fits well into the Bükkian evolution history. The frequent occurrences of megalodontids in Upper Triassic platform developments in the Bükk Mts are restricted to the Kis-fennsík area. The difference in the abundance of megalodontids between Kis-fennsík and other platform areas in the Bükk Mts can be a consequence of either an original biofacies differentation, or of an apparent lack of fossils due to the relatively higher metamorphic grade of the rocks outside the Kis-fennsík area. The Carboniferous to Triassic sequence of the Bükkium was recently compared and successfully correlated with successions in the Dinarides (Protić et al. 2000). Both the Kisfennsík Limestone of the Bükkium and the corresponding Upper Triassic platform limestones of the Jadar and Sana-Una Units (Serbia, Lelić and Podvidača Formations) are rich in megalodontids (Protić et al. 2000).

From a structural point of view the Kisfennsík Nappe is also hardly explainable as an extra-Bükkian nappe. According to the structural investigations of Forián-Szabó & Csontos (2002), in the Kis-fennsík area the already emplaced Kisfennsík Nappe — together with rocks of the lower structural units — suffered an intensive, large and mid-scale folding. The emplacement of the Kisfennsík Nappe cannot be dated, but the intensive subsequent shortening, and the position of Paleogene formations with different facies — fitting well in to the exhumation history of the Bükkium — suggests, that thrusting can probably be related to the most intensive and considerably ductile, Cretaceous tectogenetic period of the Bükk Unit (Forián-Szabó & Csontos 2002). K-Ar and zircon fission track measurements on mylonites from the Eastern Bükk Mts showed that the age of the last ductile deformation is around 80 Ma (Árkai et al. 1995). There is clear structural-sedimentological evidence for the sinistral strike-slip movement along the Darnó Zone during the Miocene (Márton & Fodor 1995; Sztanó & Józsa 1996). However, this belt is also supposed to function as a left lateral shear zone during the Cretaceous (Csontos 1999). Unfortunately, we do not know, whether the Kisfennsík Nappe was already emplaced at the time of the northward shift of the Bükk Unit in the Cretaceous. Anyway, considering the post-Senonian structural convergence (that is the Miocene sinistral strike-slip movement along the Darnó Zone), in comparison with the present-day position (Fig. 6), the even longer distance between Bükkium and Silicicum at the time of the possible nappe emplacement makes the Silicic origin of the Kisfennsík Nappe less probable. One can speculate that they represent outliers of an out-of-sequence nappe transported from an extra-Bükkian root zone and emplaced onto metamorphosed, partly eroded Bükkian substratum. Such a supposed (Silicic) cover nappe is expected to be non-metamorphosed (Csontos 1988), like the formations of the Silicic nappes and also their pebbles in the Upper Cretaceous Nekézseny Conglomerate (Gosau sediments; Brezsnyánszky & Haas 1984). In fact, rocks belonging to the Kisfennsík Nappe often have an anchimetamorphic character (Fig. 5f). The Kisfennsík Nappe is partly thrust upon

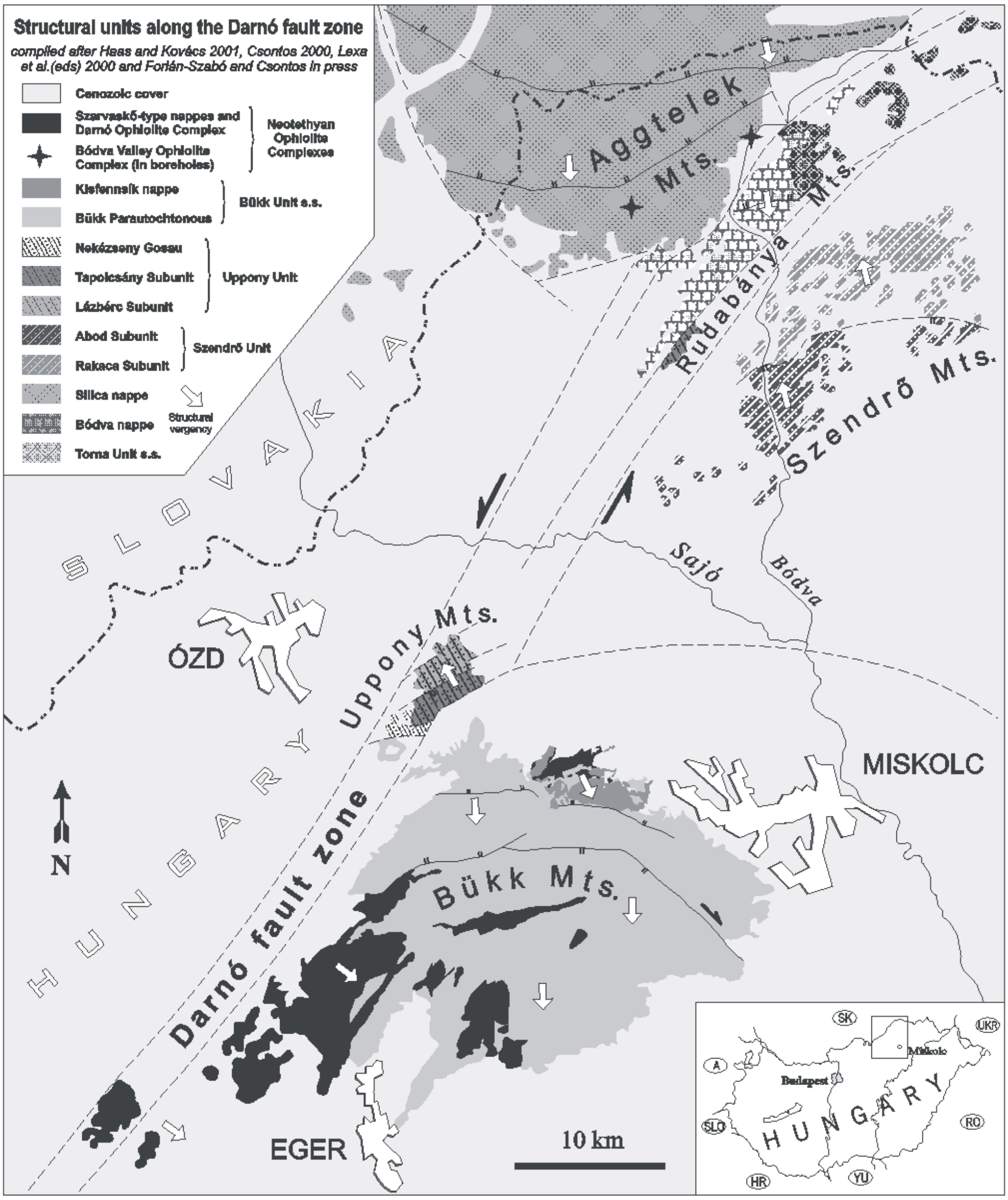

Fig. 6. Structural units in NE Hungary (after Haas & Kovács 2001; Lexa et al. (Eds) 2000; Csontos 2000; Forián-Szabó & Csontos 2002).

the upper members of the North Bükk Anticline (Upper Triassic cherty limestone), but its southern part is largely emplaced onto Carboniferous slates, and Permian sediments (Forián-Szabó & Csontos 2002). Some small-scale younger overthrusting onto the Paleozoic sediments is very likely, but — because of the intensive subsequent shortening of both the nappes and the Parautochthonous (they were re-folded together) — a major reactivation of the Kisfennsík sole thrust is not probable. Overthrusting of the Kisfennsík Nappe onto Carboniferous rocks of the Bükk Parautochthonous can be linked to an internal (intra-Bükkian) thrusting.

Conclusions

Microfacies investigations and biostratigraphy record a Carnian platform development in the Kis-fennsík area. The Kisfennsík Nappe is mainly composed of massive, platform limestone, deposited partly in a lagoonal, partly in a reef environment. At different levels in the Carnian limestone, intercalated anchimetamorphic metavolcanites of different petrologic character were recognized (metabasalts and metaandesites). The above described stratigraphic content of the Kisfennsík Nappe can be interpreted as a Bükkian-type succession. In the present structural position the nappe lies on different stratigraphic members (Carboniferous to Jurassic) belonging to Bükkian successions. All the units in the Bükk Mts are deformed by post-emplacement folding. Together with structural considerations, but mainly based on stratigraphic results, the Silicic origin of the Kisfennsík Nappe can be excluded.

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