Upper Anisian stratigraphy of the Balaton Highland

The geographical scope of this study goes beyond the Balaton Highland and covers some adjoining parts of the Southern and Eastern Bakony Mts. (Figure 1). However, the focus remains at the Balaton Highland, therefore, in the present monograph, this geographical term will be used for the whole above-mentioned, wider area of investigation.

From stratigraphical point of view the subject matter is restricted to the Upper Anisian (Illyrian) Substage, including the Trinodosus, Reitzi and Secedensis zones, as they were used by VÖRÖS (2014) (Table 1).

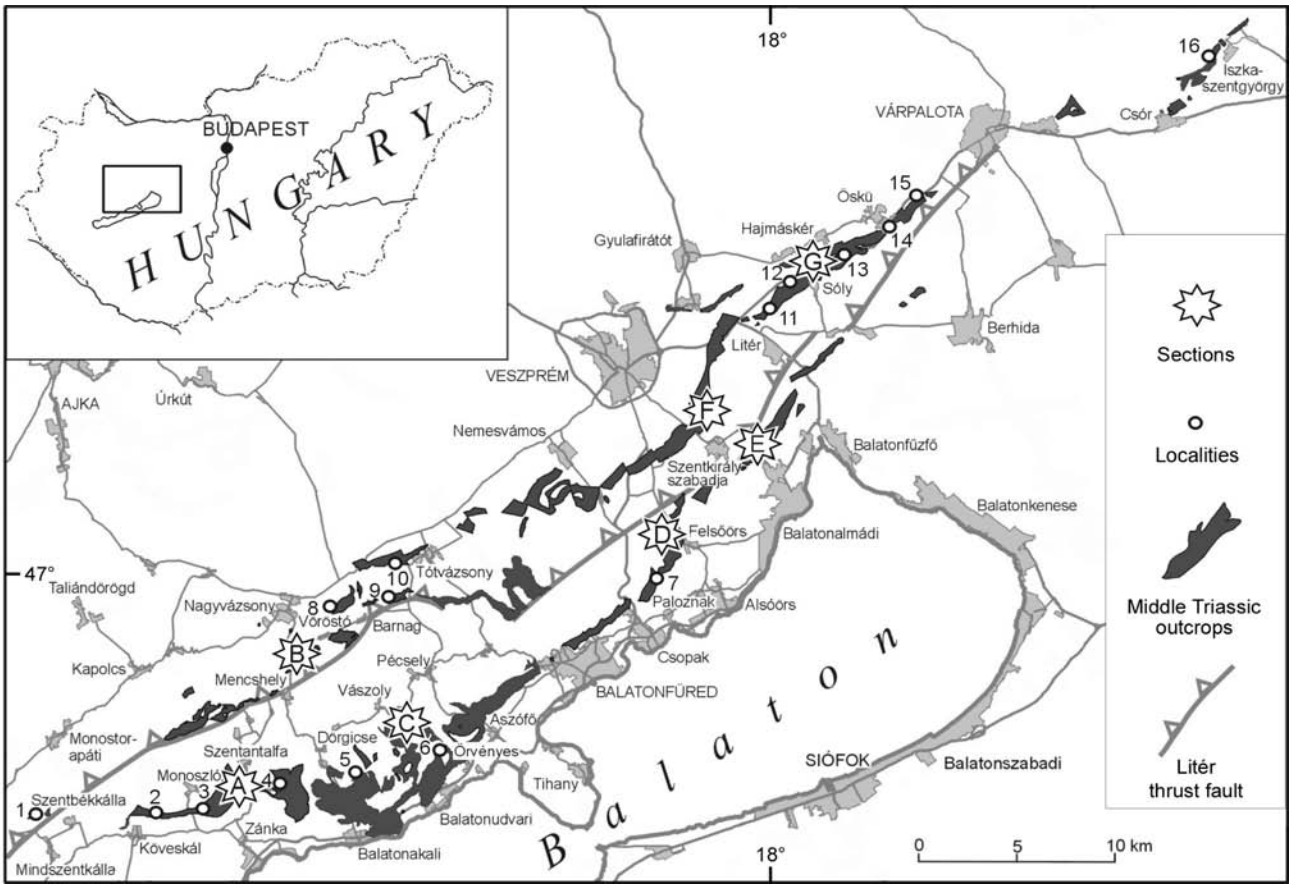

Figure 1. Situation map showing the most important measured and bed-by-bed collected sections and other localities of the Balaton Highland and the Eastern Bakony Mountains yielding Upper Anisian ammonoids (compiled from VÖRÖS et al. 2003a and BUDAI & VÖRÖS 2007)
Sections: A = Szentantalfa, B = Mencshely I, II and diverse localities, C = Vászoly, Öreg Hill, P–1a, P–2 and diverse localities, D = Felsőörs, E = Vörösberény, F = Szentkirályszabadja section and quarry, G = Sóly, Őr Hill. *Localities:* 1 – Szentbékkálla, 2 – Köveskál, Horog Hill, 3 – Monoszló, Hegyes-tű, 4 – Balatoncsicsó, ruins of St Balázs church, 5 – Dörgicse, Drt–1 core, 6 – Örvényes, Szakadás Valley, 7 – Paloznak, Pzt–1 core, 8 – Vöröstó, Akol Hill, 9 – Barnag, 10 – Tótvázsony, 11 – Litér, quarry, 12 – Hajmáskér, Hmt–3 core, 13 – Sóly, road-cut, 14 – Öskü, road-cut, 15 – Öskü, quarry, 16 – Iszkaszentgyörgy, Piramita Hill

The subzonal system and the lower boundary of the Upper Anisian were differently defined and used in a series of previous works. This concerns mainly the rank and position of the "Binodosus Zone/Subzone". The historical contradictions about the definition of this ammonoid taxon and its stratigraphical importance were not settled despite the efforts by ASSERETO (1971) and the new results of BALINI (1993), TATZREITER & BALINI (1993) and MIETTO & MANFRIN (1995). When defining the Pelsonian Substage, VÖRÖS et al. (2003a, p. 32) regarded the Binodosus Subzone as the uppermost subzone of the Pelsonian, and this was applied also by BUDAI & VÖRÖS (2007). On the other hand, the comprehensive study by MONNET et al. (2008) convincingly proved that the upper boundary of the Middle Anisian (Pelsonian) should be drawn above the zone with *Bulogites* (*zoldianus/mojsvari*) and, consequently, the zone with *Schreyerites binodosus* was transferred to the base of the Upper Anisian. This view was included to the recent summaries by BALINI et al. (2010) and JENKS et al. (2015) and was accepted also by VÖRÖS (2014). The subzonal scheme in Table 1 corresponds to this revised opinion.

Table 1. The ammonoid zonal and subzonal scheme used at the Balaton Highland. The scope of the present monograph is restricted to the Upper Anisian units marked as boldface

Stage	Substage	Zone	Subzone
Ladinian	*Fassanian*	*Eoprotrachyceras curionii*	*Eoprotrachyceras curionii*
Anisian	Illyrian	**Nevadites secedensis**	**Nevadites secedensis**
			Ticinites crassus
		Reitziites reitzi	**Aplococeras avisianum**
			Reitziites reitzi
			Hyparpadites liepoldti
			Kellnerites felsoeoersensis
		Paraceratites trinodosus	**Lardaroceras pseudohungaricum**
			Asseretoceras camunum
			Paraceratites trinodosus
			Schreyerites ? binodosus
	Pelsonian	*Balatonites balatonicus*	*Bulogites zoldianus*

The fauna of the Binodosus Subzone at the Balaton Highland is rather poor, and it was properly described by VÖRÖS (2003). Moreover its connection to the successive Trinodosus Subzone is not known in our area. Therefore the ammonoids of the Binodosus Subzone are left out from the scope of this study and the present monograph comprises the data only from the higher subzones of the Trinodosus Zone and the whole Reitzi and Secedensis Zones of the Upper Anisian.

The chronostratigraphical scheme of the Middle Triassic of the Balaton Highland, surveyed in the present work (Figure 2), shows the major lithostratigraphic units as defined by BUDAI et al. (1999) and HAAS & BUDAI (1999).

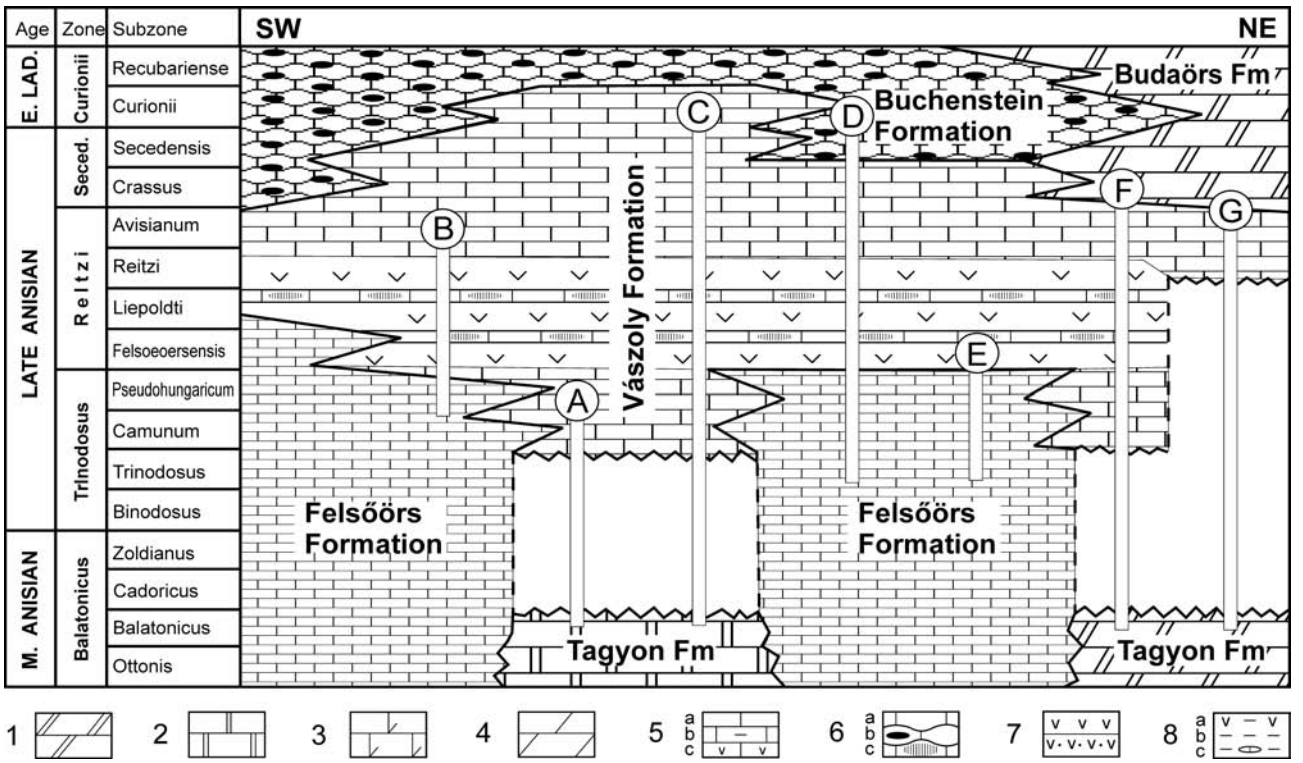

Figure 2. Chrono- and lithostratigraphic scheme of the Middle Triassic of the Balaton Highland, showing the facies relationships of the major formations, with the indication of the stratigraphic intervals recorded in the measured sections. (Only the Upper Anisian part of the formations was surveyed in the present work.)

A = Szentantalfa, B = Mencshely, C = Vászoly, D = Felsőörs, E = Vörösberény, F = Szentkirályszabadja, G = Sóly. 1 – platform dolomite, 2 – platform limestone, 3 – dolomitic limestone, 4 – dolomite, 5a – limestone, 5b – siliceous limestone, 5c – tuffaceous limestone, 6a – nodular limestone, 6b – nodular limestone with chert nodules, 6c – silicified limestone, 7 – fine and coarse grained tuff, 8a – tuffaceous clay, 8b – clay, 8c – clay with calcareous lenses or nodules. Blank represents stratigraphic gaps. M = Middle, E = Early, LAD = Ladinian, Fm = Formation

Lithostratigraphic units

Tagyon Formation. This formation belongs to the Middle Anisian (Pelsonian) Substage, but because it forms the direct underlying of the Upper Anisian layers in some sections, it will shortly be accounted. The Tagyon Formation is a massive carbonate rock, similar to the Alpine Steinalm Limestone, and in our interpretation it developed on isolated carbonate platforms (BUDAI & VÖRÖS 2007). The usually white, bedded limestone alternates with yellowish laminitic carbonates. The shallow subtidal fossiliferous limestone beds contain rich dasycladalean assemblages of Pelsonian age (BUDAI et al. 1993, VÖRÖS et al. 2003a). The typical (non-dolomitized) Tagyon Limestone is restricted to the middle part of the Balaton Highland where its thickness varies between 50–100 m. On the northeast lying carbonate platform, the formation is completely dolomitized secondarily (HAAS et al. 2014, 2016). The higher layers of this formation yielded a few specimens of *Balatonites balatonicus* proving the Pelsonian age (VÖRÖS 2003).

Felsőörs Formation. The lower, Pelsonian part of this formation accumulated in the intervening basins between the isolated platforms of the Tagyon Formation. The Upper Anisian (Illyrian) members of the Felsőörs Formation, representing the Trinodosus Zone, consist of various limestones of basin facies. The most widespread rock type is grey, bedded, nodular limestone with dark grey chert nodules and lenses. Flaser bedding and marl intercalations are frequent. Dark grey, well bedded, laminated, bituminous limestones, with numerous ammonites and thin-shelled, flat bivalves, are also common. Argillaceous and marly intercalations regularly occur; the topmost limestone beds are interlayered by tuffaceous clays. A definite asymmetric pattern was recorded in the thickness of the Felsőörs Formation, with a decreasing trend toward the NE (BUDAI & VÖRÖS 1993, 2007). Along the marginal zones of the basins, the topmost beds of the Felsőörs Formation (corresponding to the Camunum and Pseudohungaricum subzones) probably intercalates with the basal, limestone layers of the Vászoly Formation, but this was not seen in any outcrops. The upper boundary of the Felsőörs Formation is sharp almost everywhere: the first massive and widespread tuff layers of the Vászoly Formation (Felsoeoersensis Subzone) form a seal on the top of the dark limestone series.

Vászoly Formation. This extremely complex and heterogeneous formation includes the most part of the Upper Anisian (Illyrian) sedimentary rocks and it yielded the richest ammonoid faunas. The lower boundary of the Vászoly Formation is heterochronous. In many places on the territory of the former (Pelsonian) isolated platforms, its fossiliferous, ammonitic, crinoidal basal limestone beds (corresponding to the Camunum Subzone) rest unconformably on the eroded surface of the Tagyon Formation. This implies a hiatus between the Middle Anisian Balatonicus Subzone and the Upper Anisian Camunum Subzone.

The next, fundamental member of the Vászoly Formation starts with the first widespread and thick tuff layers corresponding to the Felsoeoersensis Subzone (the "reitzi tuff"; "pietra verde" auctt.). Then, up to the level of the Avisianum Subzone, the tuff layers of various thicknesses, interbedded with usually siliceous limestone layers determine the aspect of the sedimentary facies. A considerable lateral heterogeneity can be recorded in this middle member of the Vászoly Formation. The proportion of tuffaceous material is much higher in the basinal settings than in the sedimentary complexes of the areas of submarine highs (the former isolated carbonate platforms). Concurrently, in the latter areas the colours of the limestone layers tend to be reddish (pink to dark violet), in contrast to the yellow or grey limestone intercalations in the basinal settings. In the northeast, the tuffaceous material is very subordinate and the carbonate layers are rather dolomitic.

The uppermost member, the "Vászoly limestone", appears everywhere nearly synchronously in the Avisianum Subzone. It is a white or beige to purplish, almost pure, well bedded limestone in the areas of submarine highs and tends to be nodular and clayey in the basinal settings; it yielded a very diverse ammonoid fauna. In the north-eastern area (Sóly, Hajmáskér), it rests unconformably, with a great hiatus on the dolomitic Tagyon Formation (Pelsonian). In the Vászoly area (a submarine high) it persists up to the Ladinian Curionii Zone, elsewhere it does not surpass the Secedensis Zone and interfingers with the subsequent Buchenstein Formation.

Buchenstein Formation. The most common facies of this formation is a red or grey, nodular or thick bedded siliceous and cherty limestone ("Nemesvámos Limestone"). Its deposition started in the Secedensis Zone in most places; the major part of the formation belongs to the Ladinian.

Budaörs Dolomite Formation. In the north-eastern part of the study area (Veszprém Plateau, Eastern Bakony), the progradation of the easterly lying Budaörs platform can be recognized. The massive dolomitic rocks of the first prograding tongues of the Budaörs Formation were recorded just above the ammonite-bearing limestones of the Avisianum Subzone.

The facies relationships between the Upper Anisian formations of the Balaton Highland and their palaeogeography were discussed by BUDAI & VÖRÖS (1992, 1993), VÖRÖS et al. (1997), BUDAI & HAAS (1997), VÖRÖS (2002) and BUDAI & VÖRÖS (2007). Only the essential points of the palaeogeographic model are summarized here and illustrated in Figure 3. The more or less uniform Early Anisian carbonate ramp was segmented and partly drowned, and isolated carbonate platforms (Tagyon Formation) developed in the Middle Anisian (Pelsonian). Hemipelagic limestones and marls (Felsőörs Formation) accumulated in the intervening, partly halfgraben-type basins. Relative sea-level rise resulted in drowning of the isolated platforms which became pelagic plateaus (submarine highs) in the Late Anisian (Trinodosus Chron, Camunum Subchrone). Widespread volcanism started in the Reitzi Chron producing rather thick tuffaceous deposits in the basins and thinner inter-

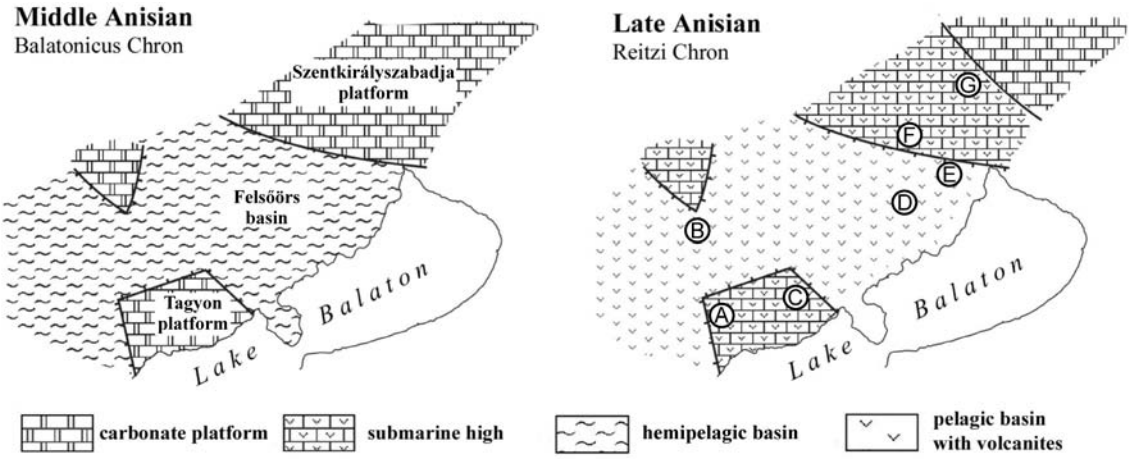

Figure 3. *Middle* Triassic palaeogeographic sketch maps illustrating the major basins and platforms/submarine highs of the Balaton Highland, and the significant change from the Middle to Late Anisian, showing the approximate positions of the key sections (modified from BUDAI & VÖRÖS 2006)
A = Szentantalfa, B = Mencshely, C = Vászoly, D = Felsőörs, E = Vörösberény, F = Szentkirályszabadja, G = Sóly

calations in the limestone layers on the submarine highs. Carbonate sedimentation prevailed again from the Avisianum Subchron onwards, both in the basins and on the highs, and a north-eastern carbonate platform (Budaörs Formation) started to prograde to the eastern part of the Balaton Highland in the Secedensis Chron.

Fossiliferous localities

Numerous fossil-bearing localities were sampled in the course of our field work in the last decades. From among them, only those, yielding valuable ammonoid material will be reported in the following. Their geographical locations are shown in Figure 1.

Measured sections

In this part, the Upper Anisian sections, where we made bed-by-bed collection of ammonoids, will shortly be described.

SZENTANTALFA

The 5 m long artificial trench lies at the southern outskirts of the village Szentantalfa, near the road to Tagyon (coordinates: x=46° 54'21", y=17°40'34"). At the southern end of the exposure the white, massive Tagyon Formation was seen, which was overlain, by a poorly bedded, brownish-grey ammonitic limestone of one metre thickness with a sharp, truncated contact (Vászoly Formation). The next, 50 cm thick bed is a brownish-red limestone full of ammonites, dipping 30° to the N. The uppermost exposed layer is a grey to violet coloured tuffaceous clay ("pietra verde"). The field sampling was carried out by T. BUDAI, L. DOSZTÁLY and V. HERMANN; the preparation of the ammonoids was done in laboratory by A. VÖRÖS. Preliminary description of the section and its biostratigraphy were published by BUDAI & VÖRÖS (1991), GAETANI (ed.)(1993) and VÖRÖS (1993, 1998); the taxonomical and biostratigraphical data presented in these papers needed a minor revision. The stratigraphic column of the Szentantalfa section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown in Figure 4. The basal part of the section belongs to the Pelsonian; after a large stratigraphical gap, the ammonoid bearing layers represent the Camunum and Pseudohungaricum subzones of the Trinodosus Zone.

The ammonoid fauna is diverse and abundant; the uppermost level (Bed 1) is a kind of ammonite coquina. The preservation of the fossils is rather poor. The host rock usually splits along the sparry calcite substituting the ammonite shells, thus the outer surface of the

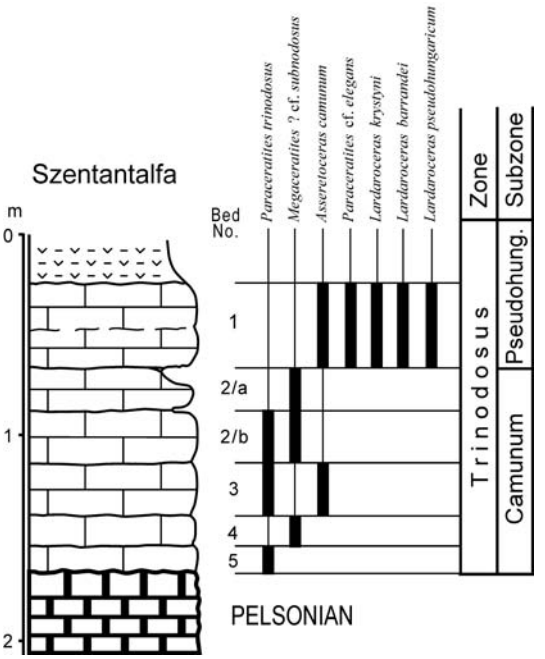

Figure 4. The stratigraphic column of the Szentantalfa section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision (modified from VÖRÖS 1998)
Legend as in Figure 2. Pseudohung. = Pseudohungaricum

Table 2. List of the ammonoid taxa collected from the Szentantalfa section and their number of specimens per beds

	1	2/A	2/B	3	4	5	sum
Norites cf. *gondola*	1						1
Beyrichites cf. *reuttensis*	4						4
Lardaroceras krystyni	6						6
Lardaroceras barrandei	4						4
Lardaroceras pseudohungaricum	8						8
Paraceratites trinodosus			6	2		9	17
Paraceratites cf. *elegans*	4						4
Semiornites ? cf. *aviticus*	24	1	1	1			27
Semiornites cf. *cordevolicus*		4	5	2	1	1	13
Asseretoceras camunum	10			1			11
Megaceratites ? cf. *subnodosus*		8	3		3		14
Longobardites zsigmondyi	1						1
Longobardites breguzzanus	1						1
Flexoptychites angustoumbilicatus	1		2				3
Flexoptychites cf. *acutus*	2	9	2				13
Flexoptychites flexuosus	6			2			8
sum	72	22	19	8	4	10	135

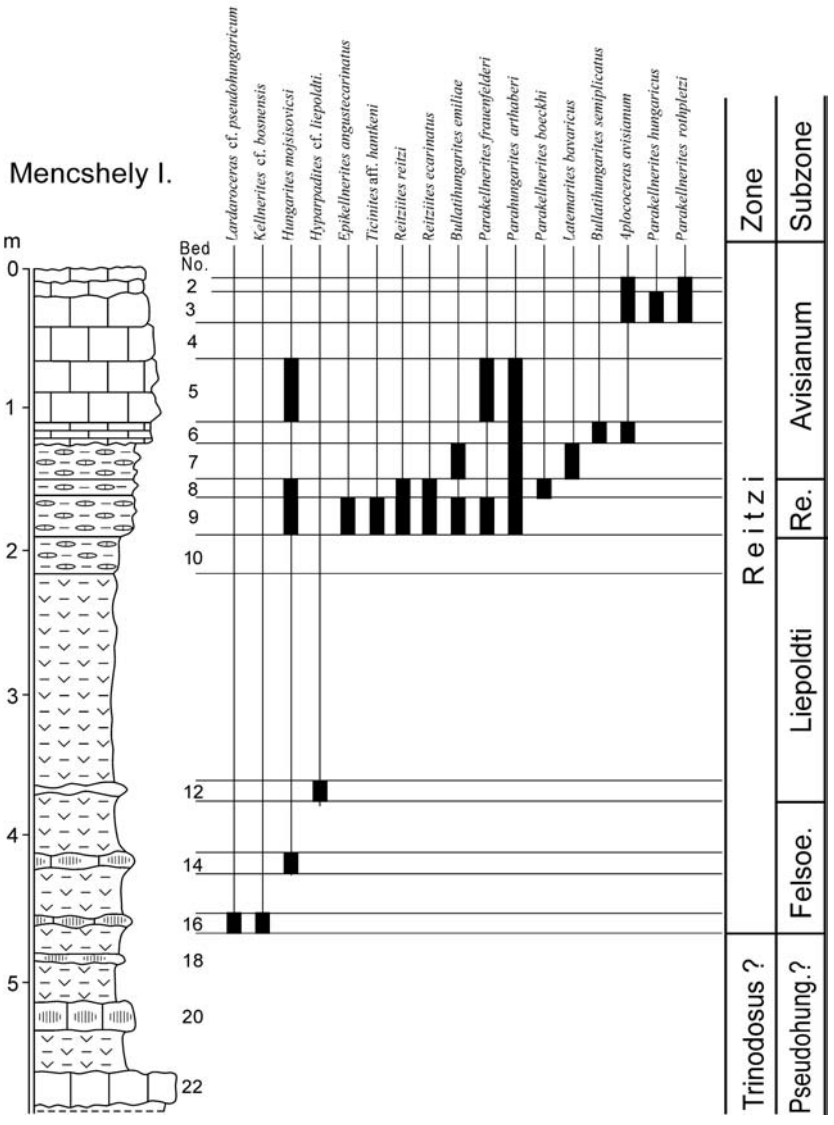

Figure 5. The stratigraphic column of the Mencshely I section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/ subzonal subdivision (modified from VÖRÖS 1998)
Legend as in Figure 2. Pseudohung. = Pseudohun gari cum, Felsoe. = Felsoeoersensis, Re. = Reitzi

ammonites are seldom visible. In most cases only the body chambers were filled by micritic limestone, and the spar-filled phragmocones regularly were crushed into pieces during hammering. Very frequently, the ammonites were primarily fossilized as fragments of body chambers. From the nearly 900 collected specimens, 135 were identified at least on species level; the number of identified taxa is 16. The revised list of ammonoid taxa and the specimen number data by beds are shown in Table 2.

MENCSHELY, CSER HILL

The Cser Hill, 2 km to the north of the village Mencshely, is one of the classical sites at the Balaton Highland, yielding Upper Anisian ammonoids. In the 1850's, J. KOVÁTS and F. RÓMER collected here "numerous, mainly small, intact ammonites" (RÓMER 1860, p. 180).

Due to the samplings by D. LACZKÓ at the end of the 19th century, the stratigraphical importance of this locality was stressed in the "Balaton monograph" of LÓCZY (1913, 1916), and the collected ammonoids were described by DIENER (1899, 1900) and ARTHABER (1903).

In the course of the detailed geological mapping, in the 1980's, two artificial trenches were excavated on the Cser Hill.

The **Mencshely I** section lies 200 m to the east from the top of the Cser Hill (coordinates: x=46°57'32", y=17°42'32"). The trench was around 23 m long, 1 m wide and its depth varied between 0.2 and 2 m. The first bed-by-bed collection of ammonoids was made by T. BUDAI, G. CSILLAG, L. DOSZTÁLY, V. HERMANN and A. VÖRÖS in 1990.

The lowermost member of the section is an ochre-yellow clay, overlain by a 25 cm thick, grey, flaser-bedded limestone bank (Bed 22, Felsőörs Formation). This unfossiliferous limestone layer is followed by two metres thick tuffaceous clay, intercalated with greyish-yellow, siliceous limestone layers of 5 to 20 cm thickness (Beds 12–21, Vászoly Formation). Some of these limestone layers yielded a few poorly preserved ammonoids. The next member is a more than 150 cm thick, light yellow, tuffaceous clay, followed by a violet to greenish-yellow clay with scarce ammonoids (Bed 10). The next, 30 cm thick layer, a more consolidated, reddish-brown clay with tuff lenses, is the most fossiliferous part of the section with diverse ammonoid fauna (Bed 9). The next layers of similar lithology (Beds 7 and 8) vary only in colour, from yellow to brownish-red. The

Table 3. List of the ammonoid taxa collected from the Mencshely I section and their number of specimens per beds

Bed	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	sum
Norites gondola					1			1	1								3
Lardaroceras cf. *pseudohungaricum*																1	1
Kellnerites cf. *bosnensis*																2	2
Epikellnerites angustecarinatus									1								1
Epikellnerites vaszolyensis								1	3								4
Epikellnerites spinatus									1								1
Epikellnerites pseudocholnokyi									1								1
Hyparpadites cf. *liepoldti.*												3					3
Hyparpadites cf. *szaboi*														1			1
Parakellnerites frauenfelderi					1				4								5
Parakellnerites boeckhi								1									1
Parakellnerites stuerzenbaumi			9	1													10
Parakellnerites aff. *hungaricus*			1														1
Parakellnerites hungaricus			1														1
Parakellnerites rothpletzi		3	1														4
Parahungarites arthaberi					6	1	13	2	8								30
Reitziites reitzi								1	14								15
Reitziites reitzi morphotype *cholnokyi*									6								6
Reitziites ecarinatus								5	18								23
Latemarites bavaricus							1										1
Stoppaniceras cf. *hermanni*			1														1
Stoppaniceras cf. *budaii*						1											1
Ticinites ? aff. *hantkeni*									2								2
Hungarites mojsisovicsi					7			1	4					1			13
Bullatihungarites emiliae							2		5								7
Bullatihungarites semiplicatus						1											1
Hungarites sinuosus						1											1
Aplococeras avisianum		2	3			2											13
Lecanites misanii					6												
Celtites sp. A							1										1
Longobardites zsigmondyi								1									1
Discoptychites cf. *megalodiscus*						9		1									10
Gymnites sp.	1																1
Epigymnites ecki		1	1														2
Flexoptychites cf. *angustoumbilicatus*			1		1				19	2		1		2			26
Flexoptychites cf. *acutus*		3						2	5	6				1			17
Flexoptychites cf. *flexuosus*		5	1		6	2	12	8	13					1			48
Parasturia cf. *emmrichi*			2														2
Proarcestes sp.		2	9	7	9			1	1								29
sum	1	16	30	8	37	17	29	25	106	8		4		6		3	290

clayey succession of the section is sharply terminated by a dark red, platy, crinoidal limestone of 15 cm thickness (Bed 6). The overlying, more than one metre thick calcareous succession (Beds 1 to 5) consists of thick beds of light grey, violet- and green-spotted limestones. The lower and thicker beds contain accumulations of crinoids and ammonoids; the upper, thinner layers are flaser-bedded with fewer amounts of fossils.

In an auxiliary excavation, a similar succession with similar fossil content was revealed, more or less corresponding to the Beds 1 to 8 of the main (Mencshely I) section.

Preliminary description of the section and its biostratigraphy were published by BUDAI et al. (1991) GAETANI (ed.)(1993) and VÖRÖS (1993, 1998); the taxonomical and biostratigraphical data needed a minor revision. The stratigraphic column of the Mencshely I section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown in Figure 5. The four subzones of the Reitzi Zone are well demonstrated. The presence of the Trinodosus Zone and its uppermost unit, the Pseudohungaricum Subzone is only inferred.

The ammonoid fauna of the 17 fossiliferous beds of the section is mostly very abundant and diverse. The state of preservation is widely variable, according to the lithology of the host rock. The ammonoids of Beds 6 to 9 are usually well-preserved. From the more than 1200 collected specimens, 290 were identified at least on species level; the number of identified taxa is 39. The revised list of ammonoid taxa and the specimen number data by beds are shown in Table 3.

The **Mencshely II** section was exposed in a ten metres long artificial trench, near the top of the Cser Hill, about 200 m west of the site Mencshely I (coordinates: x=46°57'33", y=17°42'17"). The bed-by-bed collection of ammonoids was made by L. DOSZTÁLY, I. FŐZY, P. VINCZE and A. VÖRÖS in 1991.

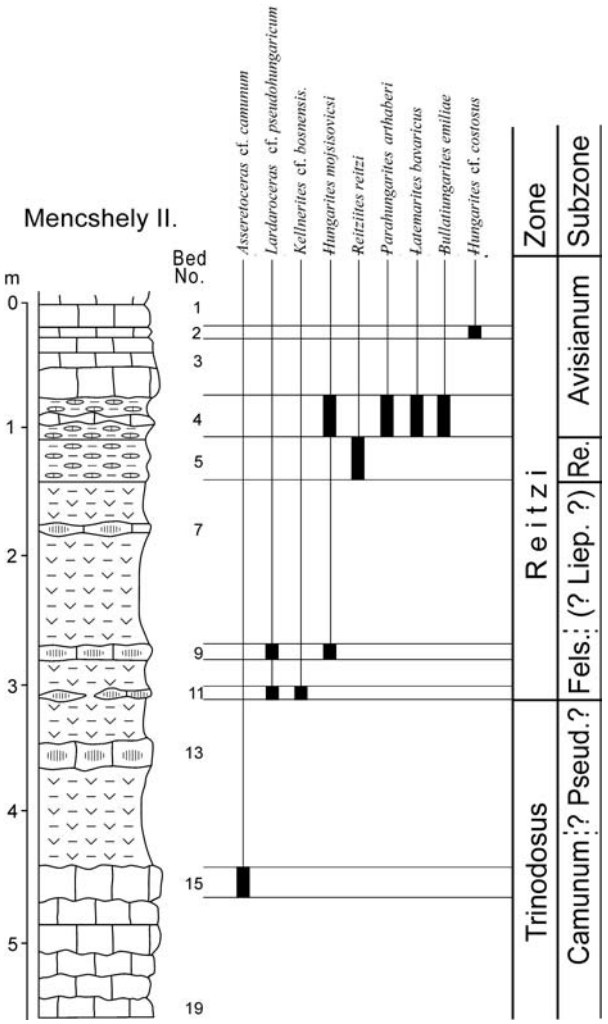

Figure 6. The stratigraphic column of the Mencshely II section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision (modified from VÖRÖS 1998) Legend as in Figure 2. Pseud. = Pseudohungaricum, Fels. = Felsoeoersensis, Liep. = Liepoldti, Re. = Reitzi

The lowermost, more than one metre thick member of the section consists of 15 to 40 cm thick layers of grey, nodular limestone (Beds 15–19, Felsőörs Formation). The overlying, light-grey to ochre-yellow tuffaceous clay of 70 cm thickness (Bed 14, Vászoly Formation) is covered by a 20 cm thick, grey to yellow, siliceous limestone (Bed 13). The next member, a variegated (light-grey, yellow, light-green, pale-violet) tuffaceous clay of two metres thickness, includes thin (less than 10 cm) light-grey, siliceous limestone layers (Beds 7, 9, 11). Higher in the tuffaceous clay, ammonite-bearing calcareous nodules appear (Bed 5), upwards the colour of the clay changes to reddish-brown and includes a coquina-like, friable crinoidal limestone (Bed 4). The tuffaceous complex is overlain, with a sharp contact, by pure, light-violet, green-spotted, solid limestone layers (Beds 1–3).

Preliminary description of the section and its biostratigraphy were published by VÖRÖS (1998); the taxonomical and biostratigraphical data needed a minor revision. The stratigraphic column of the Mencshely II section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown in Figure 6. It has to be noted that in this section, probably because of the limited number of diagnostic ammonoids, only the Camunum, Reitzi and Avisianum subzones can be proved definitely. The presence of the Pseudohungaricum and Felsoeoersensis subzones is obvious but their delimitation from the neighbouring subzones is not possible. The Liepoldti Subzone is not proved at all.

The ammonoid fauna of the nine fossiliferous beds of the section is moderately abundant and diverse. The state of preservation is usually rather poor; well-preserved ammonoids were collected only from Beds 4 and 5. From more than 400 collected specimens, 105 were identified at least on species level; the number of identified taxa is 17. The revised list of ammonoid taxa and the specimen number data by beds are shown in Table 4.

Table 4. List of the ammonoid taxa collected from the Mencshely II section and their number of specimens per beds

Bed	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	sum
Lardaroceras cf. *pseudohungaricum*									2		1					3
Semiornites ? *falcifer*									1							1
Asseretoceras cf. *camunum*															1	1
Kellnerites cf. *bosnensis*											2					2
Epikellnerites cf. *vaszolyensis*									2							2
Parahungarites arthaberi				49												49
Reitziites reitzi					2											2
Reitziites reitzi morphotype *cholnokyi*					2											2
Latemarites bavaricus				1												1
Hungarites mojsisovicsi				3					2							5
Bullatiungarites emiliae				2												2
Flexohungarites cf. *costosus*		1														1
Longobardites zsigmondyi				2	1											3
Flexoptychites cf. *angustoumbilicatus*				4					4							8
Flexoptychites cf. *acutus*				4	2											6
Flexoptychites cf. *flexuosus*	3	5		4	1				3							16
Proarcestes sp.		1														1
sum	3	7	0	69	8		0		14		3				1	105

VÁSZOLY, ÖREG HILL

The Öreg Hill, between the villages Vászoly, Pécsely and Örvényes, is one of the most important fossil sites of the Balaton Highland yielding perhaps the richest Upper Anisian ammonoid assemblage. Strangely, this wealthy locality escaped the attention of the classical, pioneering geologists, and was revealed only in the 1950's by Imre SZABÓ.

At that time, uranium-ore exploration was performed on the Balaton Highland and an unexpected uranium enrichment was found connecting to phosphorite horizons in the Middle Triassic succession (=Vászoly Formation) at the Öreg Hill. For detailed studies of the sequence, led by I. SZABÓ, trenches and shafts were excavated and boreholes were drilled on the hill and surroundings. Based on these studies the outlines of the Middle Triassic sequence of the area was outlined by SZABÓ (1972). It was demonstrated that the tuff-bearing successions and the phosphorite horizons, connected to pelagic limestones (Vászoly Formation), are full of ammonoids. (The current sedimentological and palaeo-environmental evaluation of this phosphorite enrichment in terms of monsoon-driven upwellig is given in BUDAI et al. 2017).

In the course of the uranium-ore explorations hundreds of ammonoids were collected. The extensive, but unfortunately not bed-by-bed, collections of ammonoids, made by I. SZABÓ and the detailed stratigraphy of the Middle Triassic formations remained mostly unpublished. Many data can be found in interim and mostly confidential reports prepared by I. SZABÓ for the uranium ore company. The only exception was the publication by KOVÁCS et al. (1990), where the geological map and section of the Öreg Hill, furthermore stratigraphic columns of two trenches and two shafts were figured and photographs of two conodont and four ammonoid specimens were given. However, valuable information on the ammonoid biostratigraphy was not presented.

In the eighties of the last century a geological mapping project was carried out on the Balaton Highland (BUDAI 1992, BUDAI et al. 1999). The new observations raised doubts on the structural geology and stratigraphy of the Öreg Hill (BUDAI & DOSZTÁLY 1990), therefore two abandoned trenches (P–11a and P–2) were excavated again by the team of the Geological Institute of Hungary.

The revised geological map (based on field observations by T. BUDAI) and the sites of the most important ammonite-bearing localities of the Öreg Hill (based on manuscript map by I. SZABÓ) are shown in Figure 7. The signs of the localities are prefixed by "P", because the area of the Öreg Hill (now Vászoly), at the time of the uranium-ore explorations was regarded as belonging to the district of the village Pécsely.

The **Vászoly P–11a section** 3 metres wide and 10 metres long trench, directed to SW–NE direction, was excavated in more than two metres depth, near the top of the Öreg Hill, in a grassy belt between two wooded areas (coordinates: x=46°55'45", y=17° 47'05"). The more than 6 metre thick sequence of beds has the dip of 30 to 40° towards the SW. The bed-by-bed collection of ammonoids was made in the frame of the Laczkó Dezső Fossil Hunting Camp with the participation of J. PÁLFY, A. VÖRÖS, L. DOSZTÁLY, A. DULAI, A. GALÁCZ, M. KÁZMÉR, I. SZENTE and P. VINCZE in 1988. Subsequently, occasional collections were made by T. BUDAI, V. HERMANN and L. KERCSMÁR.

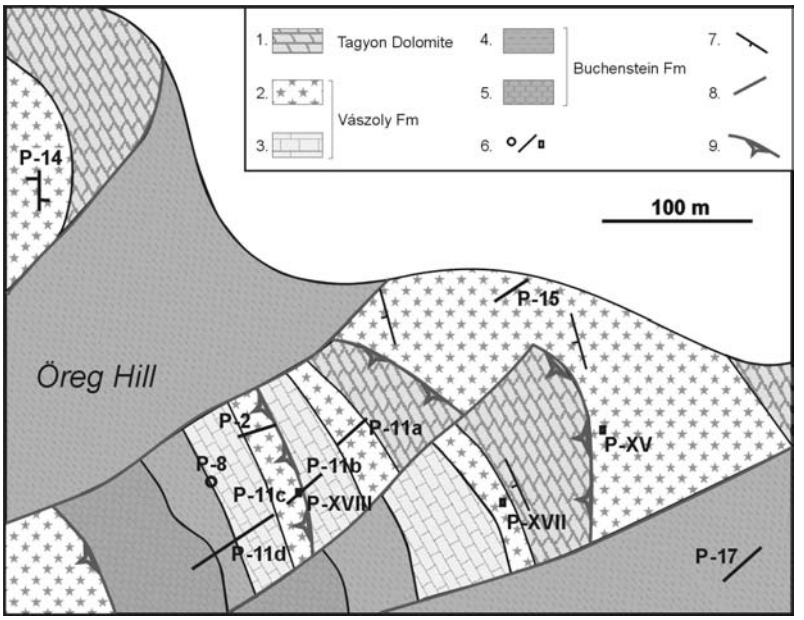

Figure 7. Geological map of the Öreg Hill, Vászoly, showing the artificial exposures yielding Upper Anisian ammonoids (modified from BUDAI et al. 2017)
Middle Anisian (Pelsonian): 1 – thick-bedded dolomite, *Upper Anisian (Upper Illyrian):* 2 – tuff, limestone, dolomitic limestone, *Ladinian:* 3 – light grey, bedded limestone, 4 – laminated, siliceous tuff, radiolarite, 5 – nodular cherty limestone, 6 – borehole, trench, shaft, 7 – dip, 8 – fault, 9 – thrust fault

The lowermost exposed member of the section, the Tagyon Dolomite, is overlain by a 15 cm thick, brown crinoidal limestone with scarce fossils. The next layer, a light yellow tufaceous and calcareous sandstone (Bed 2/A), is followed again by brownish crinoidal limestone with poor fossil content. The overlying 30–35 cm thick calcareous, tuffaceous sandstone (Bed 3/A) yielded a rather rich ammonoid and brachiopod fauna. The next two layers of partly siliceous, dolomitic limestones (Beds 3 and 4) contain a few poorly preserved ammonoids and brachiopods and thin horizons of *Daonella* coquinas. Above a thin calcareous coarse grained tuff sandstone interlayer, a 25 cm thick, massive, biodetrital, phosphatized limestone bank (Bed 5) follows, with abundant fossils. The lower part of the next layer (Bed 6) is a few cm thick calcareous coarse grained tuff; the upper part is a thicker brownish-grey limestone bank. The Bed 7 consists of greenish-grey calcareous marl with compressed ammonoids. From the 80 cm thick Bed 8 upwards, the tuffaceous lithology prevails in the section. The Bed 9, of 50 cm thickness, is dominated by tuffaceous sandstone and clayey interbeds, and contains calcareous concretions and compressed ammonoids. The 10–15 cm

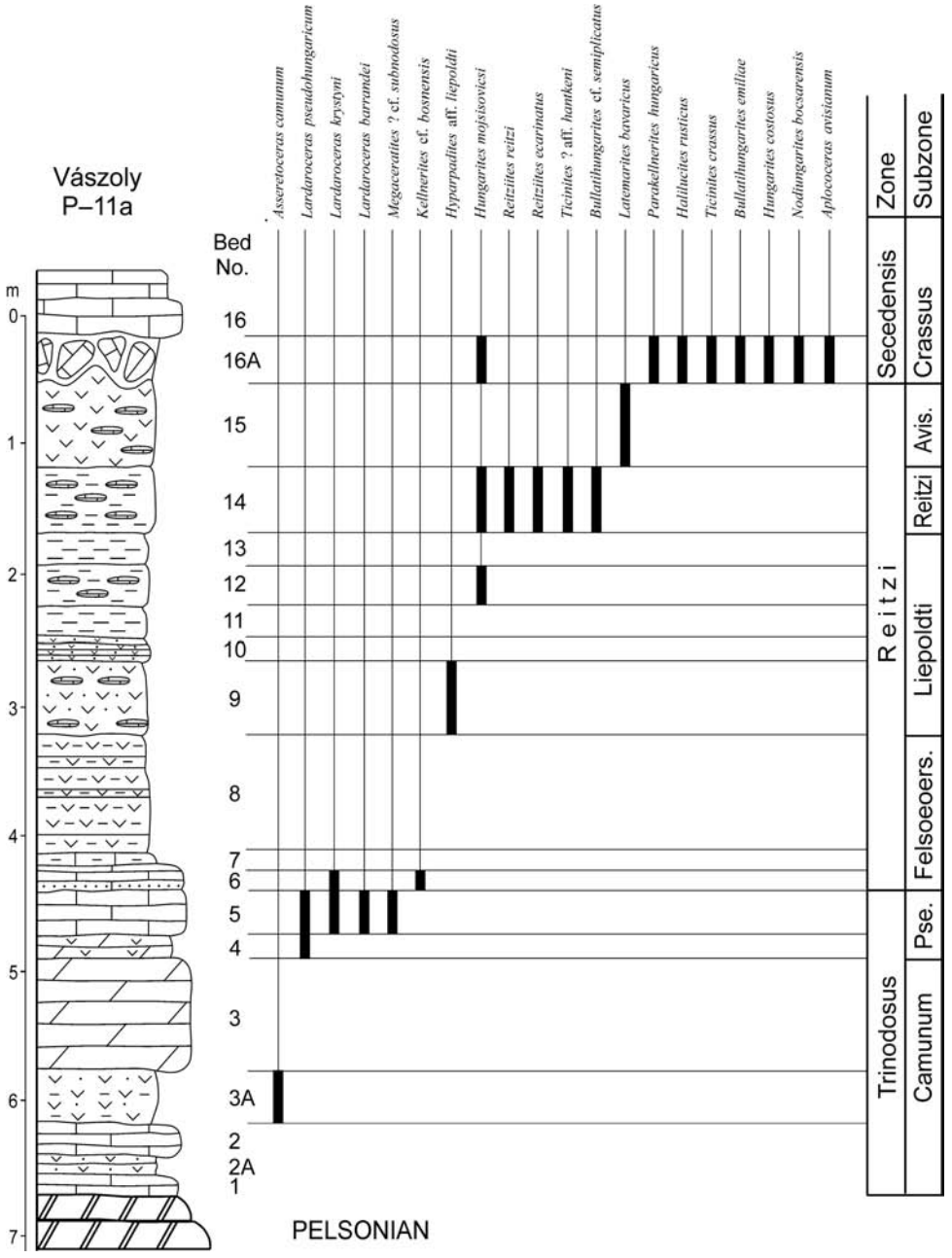

Figure 8. The stratigraphic column of the Vászoly P–11a section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision (modified from VÖRÖS & PÁLFY 1989) Legend as in Figure 2. Pse. = Pseudohungaricum, Felsoeoers. = Felsoeoersensis, Avis. = Avisianum

thick Bed 10 is a well-bedded, red, tuffaceous sandstone, and the overlying, 20 cm thick loose, greyish-violet tuffaceous clay (Bed 11) are devoid of fossils. The next layer (Bed 12), a yellow clay of around 30 cm thickness, contains calcareous lenses and surprisingly rich fauna. Above an unfossiliferous, greyish-brown, soft, tuffaceous sandy clay (Bed 13) follows around 50 cm thick, yellow clay with calcareous nodules (Bed 14) which yielded a diverse ammonoid fauna, although in a fragmentary state of preservation. The lithology and fossil content of the next layer (Bed 15) is similar but it differs by its olive-green brown-spotted colour.

The boundary between the uppermost clayey-tuffaceous layer and the overlying thick-bedded Vászoly Limestone Member (Bed 16) is heavily disturbed. In the SW wall of the trench it was visible that the thickness of the uppermost tuffaceous clay (Bed 15) varies between 40 and 80 cm. This is caused by the huge blocks and banks of the overlying limestone which sunk into the rather soft, plastic clay and, by overburdening, produced diaper-like deformation. At the same time, the lowermost limestone beds were separated into tilted banks and isolated blocks. Despite of this disturbance, the Bed 16 can be traced in regular deposition in the surroundings of the trench, and the same lithology (light-grey to white, massive micritic limestone) is observed in the higher overlying beds. On the other hand, in the disturbed boundary level, we found several big blocks of a light-yellow, partly nodular and crinoidal limestone with extremely rich ammonoid fauna. This rock type was inferred as representing the disintegrated fragments of the lowermost layer of the overlying massive limestone complex and was labelled as the Bed 16/A.

Previous descriptions of the section and its biostratigraphy were published by VÖRÖS & PÁLFY (1989), SZABÓ & VÖRÖS (1990), KOVÁCS et al. (1990), VÖRÖS (1993, 1998), GAETANI (ed) (1993) and VÖRÖS et al. (1996). It is important to note that the ammonoid taxonomy and the biostratigraphy given in the above papers needed a major revision. The stratigraphic column of the Vászoly P–11a section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown in Figure 8. This is one of the most complete Upper Anisian sections of the Balaton Highland, from biostratigraphical point of view. The topmost two subzones of the Trinodosus Zone and all four subzones of the Reitzi Zone are proved and, although in the form of a single, probably condensed layer (16/A), the Crassus Subzone of the Secedensis Zone is also present.

The ammonoid fauna of the nine fossiliferous beds of the section is very variable in abundance and diversity. The state of preservation is also variable, according to the lithology of the host rock. The ammonoids of Beds 5 and 16/A are usually well-preserved. From the more than 800 collected specimens, 194 were identified at least on species level; the number of identified taxa is 32. The revised list of ammonoid taxa and the specimen number data by beds are shown in Table 5.

Table 5. List of the ammonoid taxa collected from the Vászoly P–11a section and their number of specimens per beds

Bed	16A	15	14	12	9	6	5	4	3A	sum
Norites gondola						1	2			3
Lardaroceras krystyni						2	21			23
Lardaroceras barrandei							8			8
Lardaroceras pseudohungaricum							13	1		14
Asseretoceras camunum									26	26
Megaceratites ? cf. *subnodosus*							5			5
Kellnerites cf. *bosnensis*						1				1
Hyparpadites aff. *liepoldti*					6					6
Hyparpadites szaboi					2					2
Parakellnerites stuerzenbaumi	2									2
Parakellnerites hungaricus	1									1
Reitziites reitzi			1							1
Reitziites ecarinatus			1							1
Reitziites morphotype *cholnokyi*		1	3							4
Latemarites bavaricus		1								1
Halilucites rusticus	1									1
Stoppaniceras hermanni	1									1
Stoppaniceras budaii	1									1
Ticinites ? aff. *hantkeni*			1							1
Ticinites crassus	2									2
Hungarites mojsisovicsi	5		1	3						9
Bullatihungarites emiliae	1									1
Bullatihungarites cf. *semiplicatus*			1							1
Hungarites costosus	1									1
Nodihungarites bocsarensis	1									1
Nodihungarites vinczei	1									1
Aplococeras avisianum	1									1
Longobardites zsigmondyi							1	1	1	3
Flexoptychites angustoumbilicatus	2		5			2	6			15
Flexoptychites cf. *acutus*	1	2	8	3						14
Flexoptychites flexuosus	13			4		3	18	2		40
Proarcestes sp.	3									3
sum	37	4	21	10	8	10	74	4	27	194

The **Vászoly P–2** section was excavated in a trench around 80 m to the west from the section P–11a (coordinates: x=46°55'45", y=17°47'02"). The bed-by-bed collection of ammonoids was made in the frame of the Laczkó Dezső Fossil Hunting Camp with the participation of J. PÁLFY, A. VÖRÖS, M. KÁZMÉR, I. SZENTE and P. VINCZE in 1988.

The SW–NE directed, 10 m long and 1–2 m deep trench exposed the tuffaceous rocks of the Vászoly Formation and, in both ends, terminated in the thick-bedded Vászoly Limestone Member. At the eastern end of the trench, the contact surface between the tuffaceous complex and the Vászoly Limestone is nearly vertical; therefore this contact is probably tectonic and may be interpreted as a thrust fault.

At the western end of the trench the topmost layers of the tuffaceous complex and the overlying, thick-bedded Vászoly Limestone was clearly seen. Here the deepest (unnumbered) layer was an ochre-yellow, tuffaceous clay. The first fossiliferous layer (Bed 4) was a 50 cm thick, reddish-violet clayey tuff with calcareous nodules and lenses and many ammonoids of fragmentary state of preservation. The next two layers (Beds 3 and 2) of 50 cm and 30 cm thickness, respectively, consisted of grey to violet coloured tuffaceous clays and did not yield any valuable ammonoids. The lowermost, 50 cm thick bank of the Vászoly Limestone Member (Bed 1) was a light-grey to beige, massive micritic limestone, with very few, poorly preserved ammonoids. It has to be mentioned that in the section P–2 we did not find any piece of the very fossiliferous, yellow limestone what we traced along the boundary between the tuffaceous complex and the Vászoly Limestone (Bed 16/A), in the section P–11a.

Preliminary descriptions of the section P–2 and its biostratigraphy were published by KOVÁCS et al. (1990), VÖRÖS (1993, 1998) and GAETANI (ed.)(1993). The ammonoid taxonomy and the biostratigraphy given in these papers needed a major revision. The stratigraphic column of the Vászoly P–2 section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown in Figure 9. In this auxiliary section the Reitzi Zone, with the Reitzi Subzone was well documented. The presence of the Avisianum Subzone is only inferred, and there was not any proof of the Secedensis Zone. The Ladinian Curonii Zone was indicated by a single specimen of an *Eoprotrachyceras* sp. in the overlying, massive Vászoly Limestone.

The ammonoid fauna of the section is rather poor in abundance and diversity: only the Bed 4 yielded valuable ammonoids and a fragment of an *Eoprotrachyceras* sp. was found in Bed 1. The state of preservation is also poor. From the

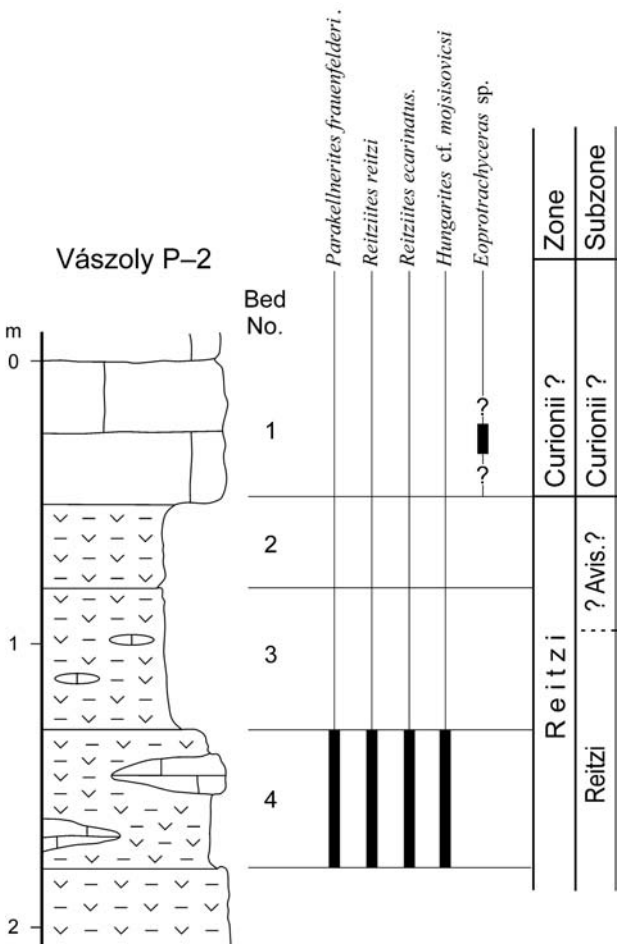

Figure 9. The stratigraphic column of the Vászoly P–2 section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision (modified from VÖRÖS 1998) Legend as in Figure 2. Avis. = Avisianum

Table 6. List of the ammonoid taxa collected from the Vászoly P–2 section and their number of specimens per beds

	Bed4	
Norites gondola	1	1
Parakellnerites frauenfelderi	1	1
Reitziites reitzi	1	1
Reitziites reitzi morphotype *cholnokyi*	1	1
Reitziites ecarinatus	3	3
Hungarites cf. *mojsisovicsi*	2	2
Flexoptychites cf. *studeri*	1	1
Flexoptychites angustoumbilicatus	8	8
Flexoptychites flexuosus	2	2
sum	20	20

more than 70 collected specimens, 20 were identified at least on species level; the number of the identified Upper Anisian ammonoid taxa is 9 (excluding the Ladinian *Eoprotrachyceras* sp.). The revised list of the Upper Anisian ammonoid taxa and the specimen number data by beds are shown in Table 6.

FELSŐÖRS

The Middle Triassic section at Felsőörs is one of the most famous geological localities of Hungary, known since the historical times by the descriptions of ROTH (1971), BÖCKH (1872, 1873, 1874) STÜRZENBAUM (1875) and MOJSISOVICS (1882). Owing to its outstanding scientific value, and a possible interest for the public, the section was recently re-excavated and preserved from erosion, and was partly covered by shelters. Now it is a protected geological conservation site and an educational nature walk. The lower, Pelsonian part of the section consists of natural outcrops on the hillside (also known as Forrás-hegy or Malom-völgy); whereas the higher, more fossiliferous strata were exposed by artificial trenches. The latter part of the section represents the Upper Anisian Trinodosus, Reitzi and Secedensis Zones and ends with the base of the Ladinian Curionii Zone. Only this latter part is described in details in the present monograph (coordinates: x=47°01'04", y=17°56'34").

The recent, bed-by-bed collection of ammonoids was made during several campaigns by I. SZABÓ and A. VÖRÖS in 1989; in the frame of the Laczkó Dezső Fossil Hunting Camp with the participation of J. PÁLFY, A. VÖRÖS, M. GASPARIK and P. VINCZE in 1992; by T. BUDAI, L. DOSZTÁLY, I. SZABÓ and A. VÖRÖS in 1995; and by T. BUDAI, I. SZABÓ and A. VÖRÖS in 2005.

The lower part of the trench/cut exposes the grey, flaser-bedded, marly limestones of the Felsőörs Limestone (Beds 84/F to 87) with poorly preserved ammonoids, including a 1 m thick whitish tuffaceous clay horizon just below Bed 87. The overlying well-bedded sequence (Beds 88 to 99/C) consists of 8–20 cm thick, grey limestone layers, with 5–30 cm thick, yellow clay interlayers. Ammonoids are frequent, but hard to extract from the limestones or preserved in compressed state in the clayey interlayers. The Felsőörs Limestone abruptly terminates with a thick limestone bank (Bed 99/C), showing undulated top surface.

The overlying tuffaceous succession of the Vászoly Formation starts at the top of the exposed bedding surface of Bed 99/C. The lower (around 18 m thick) part of this sequence consists of greenish-white, sometimes brownish-yellow potassium-trachyte tuffs ("pietra verde", "reitzi-tuff"). Limestone appears only in thin cherty interlayers or rows of lenses of ochre-yellow colour. The first limestone interlayer (Bed 100/E) yielded important ammonoids; further, significant ammonoids were collected from Beds 102 and 105. In the higher part of the Vászoly Formation, the carbonate sedimentation returns in the form of pinkish-grey, nodular limestones; tuffaceous clay becomes subordinate. These beds (from Bed 110 to 111/K) were previously interpreted as debris flow (KOVÁCS 1993, VÖRÖS et al. 1996), however, the new excavations and repeated sampling proved that this is a continuous pelagic flaser-bedded basinal limestone containing an ordinary succession of ammonoid assemblages. Starting with the next, massive, cherty limestone bed (Bed 112), the tuffaceous material becomes subordinate and appears only in altered form, as clayey interlayers.

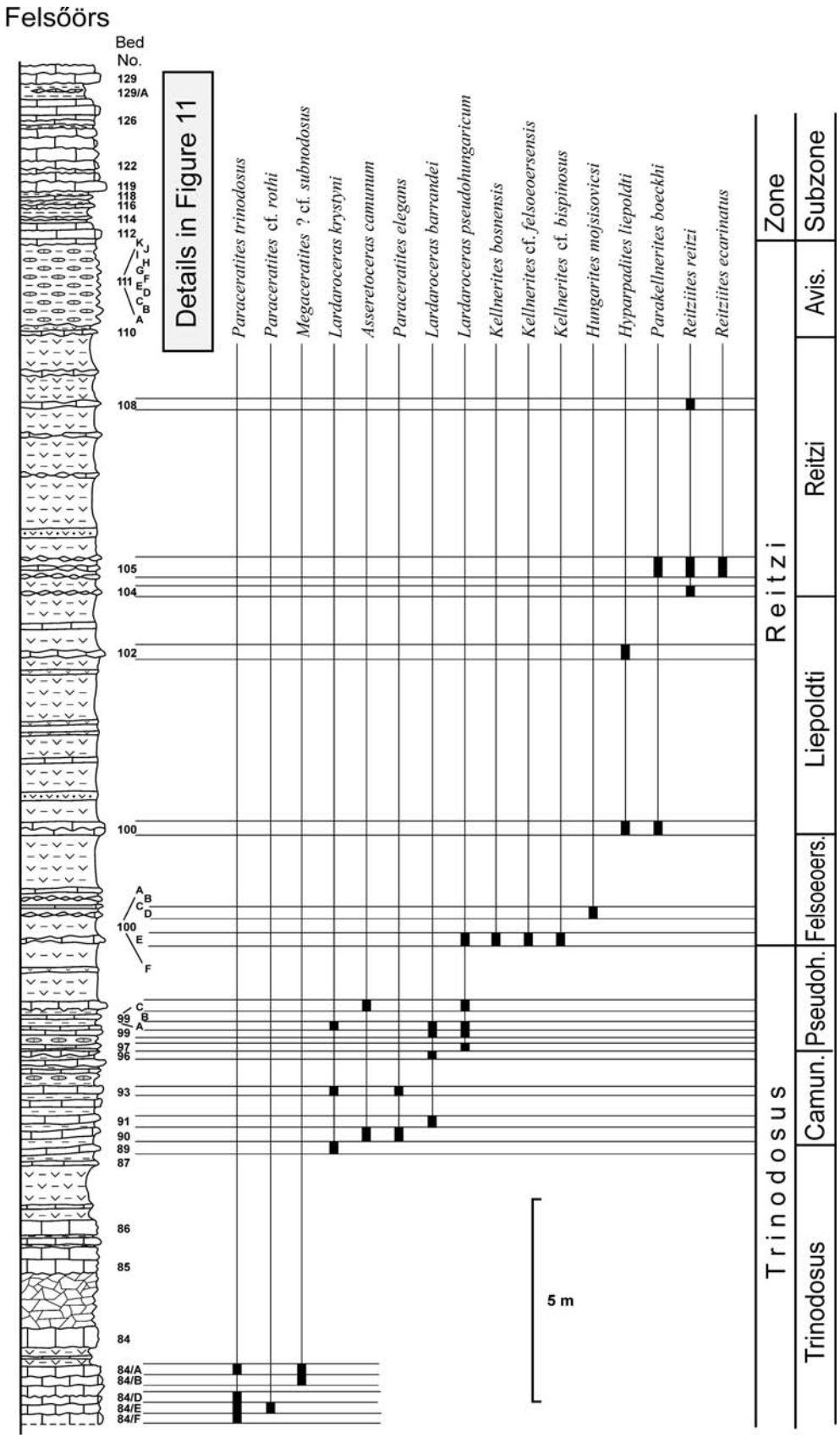

Figure 10. The stratigraphic column of the Felsőörs section with the zonal/subzonal subdivision and the ranges of the stratigraphically significant ammonoid taxa in the interval of the Trinodosus to Reitzi subzones (modified from VÖRÖS 1998). The ammonoid ranges of the *higher* part is shown in Figure 11
Legend as in Figure 2. Camun. = Camunum, Pseudoh. = Pseudohungaricum, Felsoeoers. = Felsoeoersensis, Avis. = Avisianum

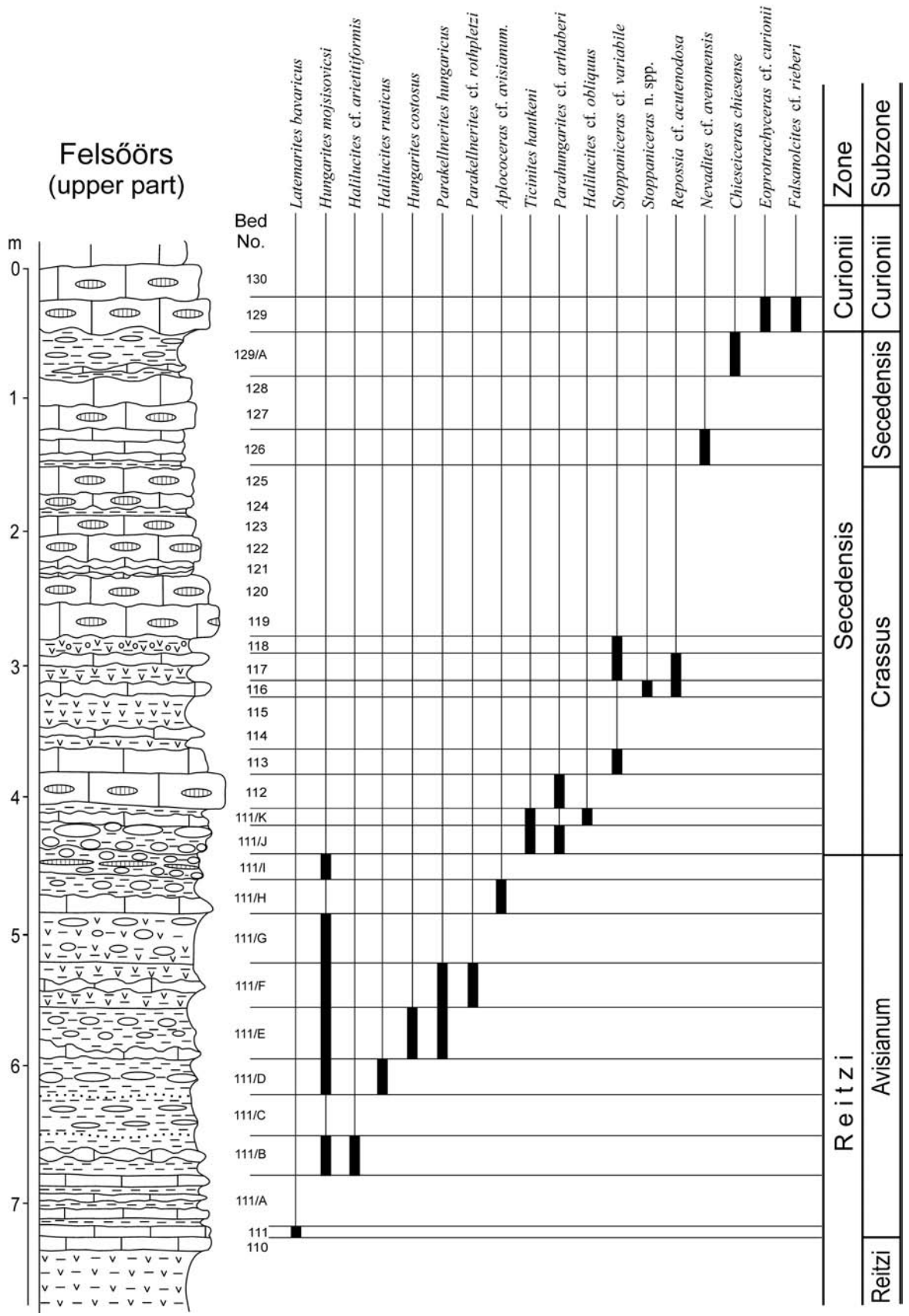

Figure 11. The stratigraphic column of the upper part of Felsőörs section with the zonal/subzonal subdivision and the ranges of the stratigraphically significant ammonoid taxa in the interval of the Avisianum to Curionii subzones (modified from VÖRÖS et al. 2009)

(The occurrences of *Eoprotrachyceras* and *Falsanolcites* species are shown only as proving the base of the Curionii Zone; they are not described in the systematic part of the monograph.) Legend as in Figure 2

From Bed 119 upward, the dominant lithology is cherty limestone forming 10 to 40 cm-thick beds with rare clayey interlayers of variable thickness (Buchenstein Formation). The limestone beds, gently (20 to 30°) dipping to the NW, contain reddish or light-grey chert nodules, or even large lenses; the bedding surfaces are uneven or nodular. This interval (Beds 119–129) proved to be extremely poor in fossils. The recent excavations exposed the section up to a massive cherty limestone bank (Bed 129). Just below this bank, the Bed 129/A, a 40 cm thick clay bed with limestone nodules yielded valuable ammonoids proving the topmost horizon of the Anisian.

Previous descriptions of the Felsőörs section, or certain parts of it, were published by SZABÓ et al. (1980), KOVÁCS et al. (1990), KOVÁCS (1994), VÖRÖS (1993, 1998), VÖRÖS et al. (1996, 2003b, 2009). Magnetostratigraphic results and the integrated stratigraphy of the Felsőörs section were described by MÁRTON et al. (1998). Sampling of several tuff layers for zircon crystals was made from the "reitzi-tuff" and U-Pb radiometric data were published by PÁLFY et al. (2003). The ammonoid data and the biostratigraphy given in these papers needed a moderate revision.

The stratigraphic column of the Felsőörs section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown (for technical reasons) in two separate figures (Figures 10 and 11). Due to its biostratigraphic significance, this is the most important Middle Triassic section of the Balaton Highland. All Upper Anisian ammonoid zones (Trinodosus, Reitzi, Secedensis) and subzones (from the Trinodosus to the Secedensis) were well documented, moreover, the lowermost part of the Ladinian (with the Curionii Subzone) was also proved (VÖRÖS et al. 2009).

Table 7. List of the ammonoid taxa collected from the lower part (Trinodosus to Reitzi Subzone) of the Felsőörs section and their number of specimens per beds

	108	105	104	102	100	100/A	100/C	100/D	100/E	99/C	99/A	99	97	96	93	92	91	90	89	88	84/A	84/B	84/D	84/E	84/F	sum
Norites gondola												1														1
Beyrichites ? sp.																							1			1
Lardaroceras krystyni											1				1				2							4
Lardaroceras barrandei											1	1		2			4									8
Lardaroceras pseudohungaricum									15	13	2	4	1													35
Paraceratites trinodosus																					1		5	8	2	16
Paraceratites elegans															4			1								5
Paraceratites cf. *rothi*																								2		2
Semiornites aviticus															10	1	4	2								17
Asseretoceras camunum										12								2								14
Megaceratites ? cf. *subnodosus*																					2	2				4
Kellnerites bosnensis									2																	2
Kellnerites cf. *felsoeoersensis*									1																	1
Kellnerites cf. *bispinosus*									1																	1
Epikellnerites ? sp.							1																			1
Hyparpadites liepoldti				2	1																					3
Parakellnerites boeckhi		2			1																					3
Reitziites reitzi	1	1	1																							3
Reitziites ecarinatus		1																								1
Hungarites mojsisovicsi								1																		1
Longobardites zsigmondyi														1	1											2
Longobardites breguzzanus											2	1														3
Japonites sp.		1																								1
Discoptychites cf. *megalodiscus*																									2	2
Ptychites oppeli																		17						1		18
Flexoptychites angustoumbilicatus		8					1	3	2			4	1	3				4		1						27
Flexoptychites flexuosus		3				1								5				7								16
sum	1	16	1	2	2	1	2	4	21	25	6	11	2	11	16	1	8	33	2	1	3	2	6	11	4	192

The ammonoid fauna of the 44 fossiliferous beds of the Felsőörs section is partly very abundant and diverse. The state of preservation is widely variable, according to the lithology of the host rock. From the more than 1000 collected specimens, 332 were identified at least on species level; the number of identified taxa is 49 (excluding the Ladinian *Eoprotrachyceras* and *Falsanolcites* species). The revised list of the Upper Anisian ammonoid taxa and the specimen number data by beds are shown in two separate tables (Tables 7 and 8).

Table 8. List of the ammonoid taxa collected from the upper part (Avisianum to Secedensis Subzone) of the Felsőörs section and their number of specimens per beds

	129/A	126	118	117	116	114	113	112	111/K	111/J	111/I	111/H	111/G	111/F	111/E	111/D	111/B	111/A	111	sum
Parakellnerites stuerzenbaumi										2	1	1	6	2	2					14
Parakellnerites aff. *hungaricus*											1									1
Parakellnerites hungaricus														1	1					2
Parakellnerites cf. *rothpletzi*														1						1
Parahungarites cf. *arthaberi*								2		1										3
Latemarites bavaricus																			3	3
Halilucites rusticus																1				1
Halilucites cf. *arietitiformis*																	1			1
Halilucites cf. *obliquus*									1											1
Stoppaniceras cf. *variabile*			1	1			1													3
Stoppaniceras rieberi					2			2			1									5
Stoppaniceras aff. *rieberi*					1															1
Repossia cf. *acutenodosa*				9	1															10
Ticinites hantkeni									7	5										12
Nevadites cf. *avenonensis*		4																		4
Chieseiceras chiesense	7																			7
Chieseiceras sp.	2	1			1															4
Hungarites mojsisovicsi											4		1	1	9	4	2			21
Hungarites costosus															1					1
Aplococeras cf. *avisianum*												1								1
Celtites ? sp. A						1														1
Gymnites sp.												1								1
Flexoptychites angustoumbilicatus				2					2			1	5	7	7	1		1		26
Flexoptychites flexuosus													3							3
Proarcestes sp.	3	3				3			2		1			1						13
sum	12	8	1	12	5	4	1	4	12	8	8	4	15	13	20	6	3	1	3	140

VÖRÖSBERÉNY

This section is a road-cut between Vörösberény (part of Balatonalmádi) and Szentkirályszabadja, in the slope of the Megye Hill (coordinates: x=47°03'25", y=17°59'32"). Here the uppermost part of the Felsőörs Formation (limestone beds with clay seams) and the lower part of the tuffaceous Vászoly Formation is exposed in about 10 m thickness. Bed-by-bed bulk samples have been collected by the workers of the Geological Institute of Hungary in 1987, the detailed preparation of the ammonites was done in the laboratory. The rich ammonoid fauna concentrated in the lower, yellowish, flaser-bedded layers (Beds 26 to 29) of the Felsőörs Limestone. Higher up (Beds 7 to 25) the collecting of ammonoids from the hard limestone was very difficult. The Vászoly Formation (Beds 1 to 6) was almost barren, except a few ammonoids.

Preliminary descriptions of the section and its biostratigraphy were published by BUDAI & VÖRÖS (1989), VÖRÖS (1993, 1998) and GAETANI (ed.)(1993). The ammonoid taxonomy and the biostratigraphy given in these papers needed a major revision. The stratigraphic column of the Vörösberény section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown in Figure 12. Only the Trinodosus Subzone of the Trinodosus Zone is well documented in this section. The two higher subzones (Camunum and Pseudohungaricum) are present but, due to the scarce fossil content, they can not be delimited. From the Reitzi Zone, only the lowermost, Felsoeoersensis Subzone is proved. It should be noted that a loose specimen of *Latemarites bavaricus* was found, higher up in the non-measured part of the section, which points to the presence of the Avisianum Subzone.

The ammonoid fauna of the 15 fossiliferous beds of the Vörösberény section is variable in abundance and diversity. The state of preservation is generally rather poor. From the more than 1000 collected specimens (most of them from the Trinodosus Zone), 148 were identified at least on species level; the number of identified taxa is 19. The revised list of ammonoid taxa and the specimen number data by beds are shown in Table 9.

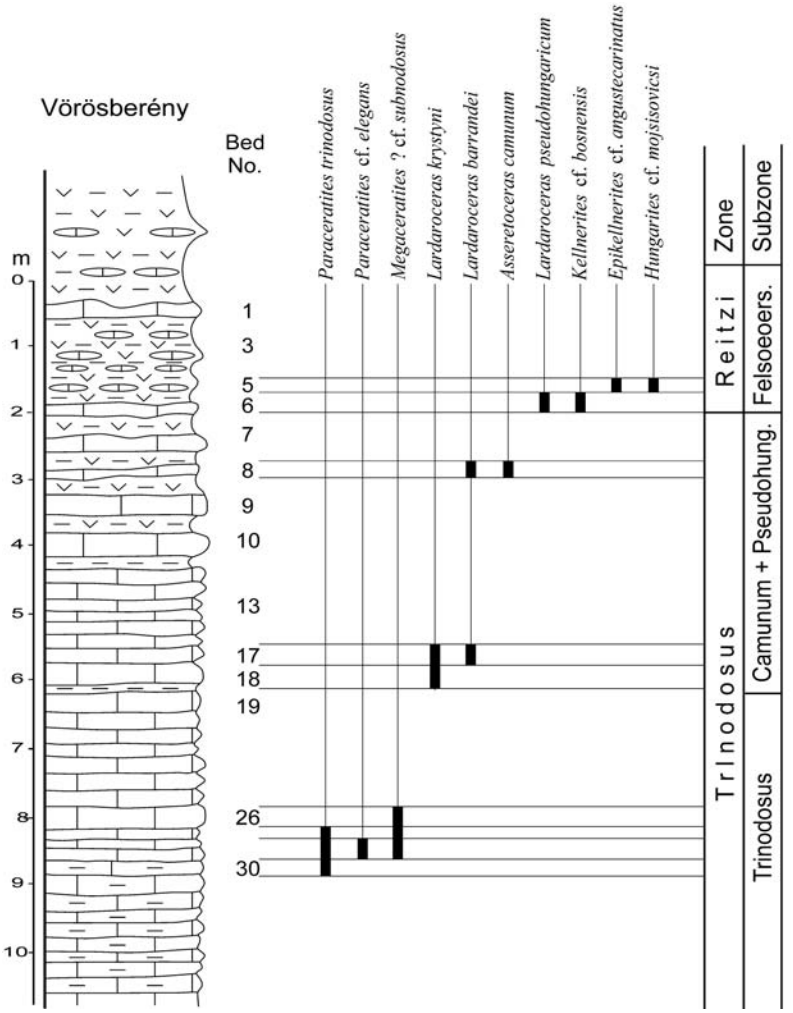

Figure 12. The stratigraphic column of the Vörösberény section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision (modified from VÖRÖS 1998)
Legend as in Figure 2. Felsoeoers. = Felsoeoersensis

Table 9. List of the ammonoid taxa collected from the Vörösberény section and their number of specimens per beds

Bed	1	3	5	6	8	12	17	18	19	22	26	27	28	29	30	sum
Norites cf. *gondola*							1									1
Beyrichites ? sp.											1	1				2
Lardaroceras barrandei					6		4									10
Lardaroceras krystyni							1	1								2
Lardaroceras pseudohungaricum				1												1
Paraceratites trinodosus												3	1	9	2	15
Paraceratites cf. *elegans*													2	1		3
Semiornites cf. *cordevolicus*												9	13			22
Asseretoceras camunum					2											2
Megaceratites ? cf. *subnodosus*											1	3	30	6		40
Kellnerites cf. *bosnensis*				1												1
Epikellnerites cf. *angustecarinatus*			1													1
Epikellnerites cf. *vaszolyensis*			1													1
Hungarites cf. *mojsisovicsi*			2													2
Discoptychites cf. *megalodiscus*													2	8		10
Ptychites cf. *oppeli*		1														1
Flexoptychites angustoumbilicatus						2										2
Flexoptychites cf. *acutus*				2	1							2	5	1		11
Flexoptychites flexuosus	2		3		2	2	1		3	1				7		21
sum	2	1	7	4	11	4	7	1	3	1	2	18	53	32	2	148

SZENTKIRÁLYSZABADJA

The fossiliferous beds of the section, representing an unusual, partly dolomitic facies of the Vászoly Formation, are exposed in a pit, excavated and used formerly for military purposes, about one hundred metres to the west of a large abandoned quarry (coordinates: x=47°04'24", y=17°57'18"). The pit was extended to dip-direction by a narrow trench. The bed-by-bed collection of ammonoids was made by L. DOSZTÁLY, P. VINCZE and A. VÖRÖS in 1991.

The lower part of the section (Beds 22 to 25) consists of thick dolomite beds alternating with yellow clays. Higher up the dolomite becomes thin-bedded and crumbly and contains volcanoclastic admixture; here we collected the first ammonoids. Then (Beds 11 to 18) the dolomite alternates with limestone, but the crumbly and tuffaceous character remains constant throughout the sequence. Bed 14 is an ochre-yellow to brown, crinoidal limestone with extremely rich ammonoid fauna. Higher up the tuff content increases gradually, and in Bed 9, a characteristic, coarse grained tuff layer appears. Above some further tuffaceous, dolomitic layers, the uppermost beds are again massive dolomites (Beds 1 and 2) but since they contain a few ammonite "ghosts", these layers are interpreted as pelagic limestones dolomitized secondarily. Recent excavations revealed further two, partly dolomitic, fossiliferous layers (Beds –1 to –2) (VÖRÖS et al. 2015). (The ammonoids of these beds are in the private collection of K. TAMÁS and G. FÖLDVÁRI, and are not taken into account in the present monograph.)

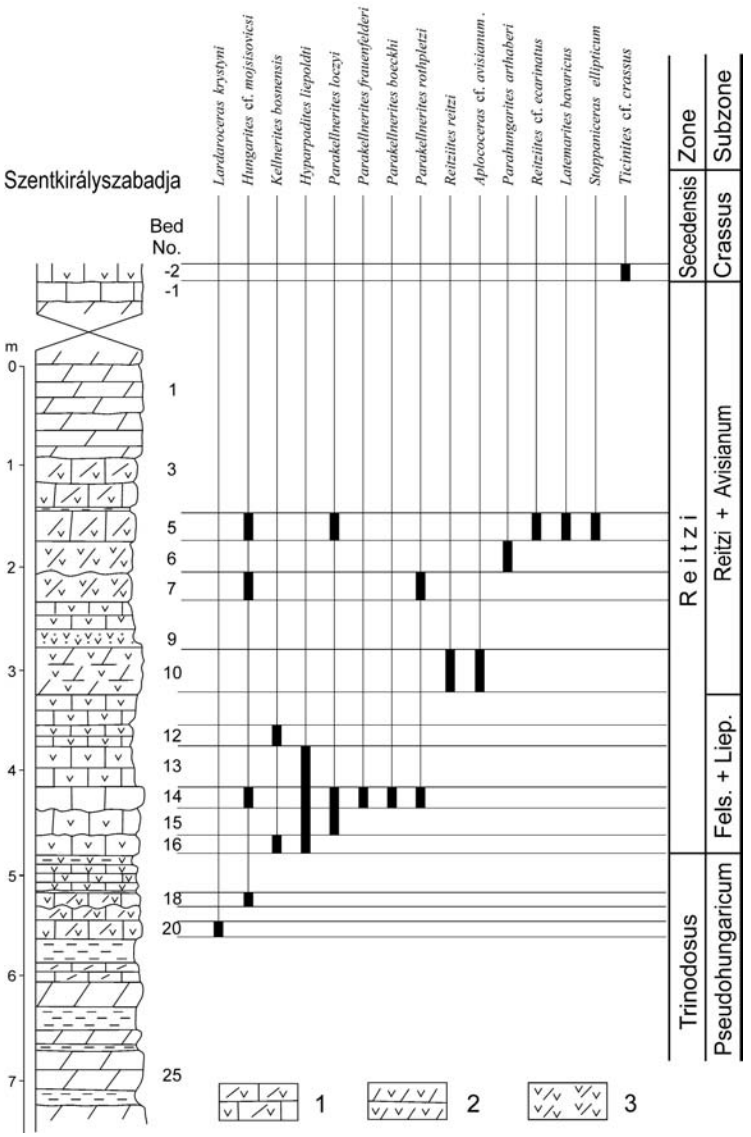

Figure 13. The stratigraphic column of the Szentkirályszabadja section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision. (The occurrence of *Ticinites* cf. *crassus* is shown only as proving the Crassus Subzone; the specimen, illustrated in VÖRÖS et al. 2015, is in private property and is not described in the systematic part of the monograph.) (modified from VÖRÖS et al. 2015)
1 – dolomitic limestone with tuff, 2 – tuffaceous dolomite, 3 – dolomitic tuffite. Further legend as in Figure 2. Fels. = Felsoeoersensis, Liep. = Liepoldti

Preliminary descriptions of the section and its biostratigraphy were published by VÖRÖS (1993, 1998) GAETANI (ed.) (1993) and BUDAI et al. (2001a). The ammonoid taxonomy and the biostratigraphy given in these papers needed a moderate revision. A recent description of the complemented section was given by VÖRÖS et al. (2015). The stratigraphic column of the Szentkirályszabadja section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown in Figure 13. This section provided good documentation of the Reitzi Zone, and somewhat less reliable proof of the base of the Secedensis Zone. On the other hand, regrettably, the subzonal subdivision within the Reitzi Zone was only partly possible. The subzonal index taxa of the Felsoeoersensis and the Liepoldti subzones appeared simultaneously in Bed 16, and their ranges seemed to overlap. Similarly, the first appearances of the index species of the Reitzi and the Avisianum subzones (*Reitziites reitzi* and *Aplococeras avisianum*) were both recorded in Bed 10. This is the single section at the Balaton Highland, where the subzones of the Reitzi Zone were not well differentiated. The explanation may be sought in the special palaeogeographical position (carbonate platform rim) and sedimentary regime (pelagic incursions to dolomitic sedimentation) of this locality; intermittent reworking and condensation might occur here.

The ammonoid fauna of the 13 fossiliferous beds of the Szentkirályszabadja section is variable in abundance and diversity. The state of preservation is variable, according to the lithology of the host rock. From the nearly 800 collected specimens, 166 were identified at least on species level; the number of identified taxa is 23. The revised list of ammonoid taxa and the specimen number data by beds (excluding the ammonoids in the private collection of K. TAMÁS and G. FÖLDVÁRI) are shown in Table 10.

Table 10. List of the ammonoid taxa collected from the Szentkirályszabadja section and their number of specimens per beds

Bed	5	6	7	8	10	12	13	14	15	16	17	18	20	sum
Lardaroceras krystyni													2	2
Semiornites cf. *aviticus*													1	1
Kellnerites bosnensis						1				2				3
Hyparpadites liepoldti							3	3	2	13				21
Hyparpadites szaboi											1	1		2
Parakellnerites frauenfelderi								6						6
Parakellnerites boeckhi								1						1
Parakellnerites cf. *stuerzenbaumi*	1													1
Parakellnerites rothpletzi			4					1						5
Parakellnerites loczyi	1							2	1					4
Parahungarites arthaberi		3												3
Parahungarites aff. *arthaberi*		1												1
Reitziites cf. *ecarinatus*	3													3
Reitziites reitzi					2									2
Latemarites bavaricus	6													6
Stoppaniceras ellipticum	1													1
Hungarites cf. *mojsisovicsi*	4		2					3				1		10
Hungarites szentei	1	1												2
Aplococeras cf. *avisianum.*					1									1
Discoptychites cf. *megalodiscus*			1					1						2
Flexoptychites angustoumbilicatus		2		1			6	27			2	1	2	41
Flexoptychites cf. *acutus*									1					1
Flexoptychites flexuosus	1	2	5		5			23	5	6				47
sum	18	9	12	1	8	1	9	67	9	21	3	3	5	166

SÓLY, ŐR HILL

The hilly area between the villages Sóly and Hajmáskér, called Berek Hill, or Berekalja in the "Balaton Monograph" by LÓCZY (1913, 1916), belongs to the classical Middle Triassic ammonoid localities of the Balaton area. The yellow to pinkish, tuffaceous and crinoidal, very fossiliferous limestones were discovered in the last years of the 19th century and were reported later by LACZKÓ (1911). The exposures of this area yielded the rich fauna described by DIENER (1899, 1900) and ARTHABER (1903). This "Hajmáskér fauna" received importance in the synthesising paper on the "Zona ad Avisianus" by ASSERETO (1969).

Our section was excavated on the SW slope of the Őr Hill, north of the village Sóly and 200 m to the south of the main road No. 8 (coordinates: x=47°08'18", y=18°02'03"). The bed-by-bed collection of ammonoids was made by T. BUDAI, G. CSILLAG, L. DOSZTÁLY, I. SZABÓ and A VÖRÖS in 1995 and 1996.

The eight metres thick, variable, tuffaceous, clayey, fossiliferous limestone series lies between two dolomite bodies. The underlying, fragmented dolomite probably belongs to the Middle Anisian Tagyon Formation, while the overlying cellular dolomite is considered a prograding tongue of the Late Anisian – Ladinian carbonate platform (Budaörs Formation).

Previous descriptions of the section and its biostratigraphy were published by VÖRÖS (1998) and BUDAI et al. (2001a). The ammonoid taxonomy and the biostratigraphy given in these papers needed a minor revision. The stratigraphic column of the Sóly section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision are shown in Figure 14. Only the higher part of the Reitzi Zone is represented in this section. The Avisianum Subzone is especially well documented by a diverse ammonoid assemblage corresponding to the classical "Hajmáskér fauna".

The ammonoid fauna of the 15 fossiliferous beds of the Sóly section is rather abundant and diverse. The state of preservation is variable. From the almost 900 collected specimens, 312 were identified at least on species level; the number of identified taxa is 22. The revised list of ammonoid taxa and the specimen number data by beds are shown in Table 11.

Other localities

KÖVESKÁL, HOROG HILL

The Horog Hill, two km ENE of the village of Köveskál, is perhaps the oldest known Middle Triassic localities of the Balaton Highland, from the time of ZEPHAROVICH (1856) and BÖCKH (1872, 1873). The Pelsonian ammonoid fauna and stratigraphy of the poorly exposed area was described by VÖRÖS & PÁLFY (2002) and VÖRÖS (2003). Upper Anisian ammonoids were also collected here, at several occasions, by T. BUDAI, L. DOSZTÁLY, J. PÁLFY, I. SZENTE and A. VÖRÖS from

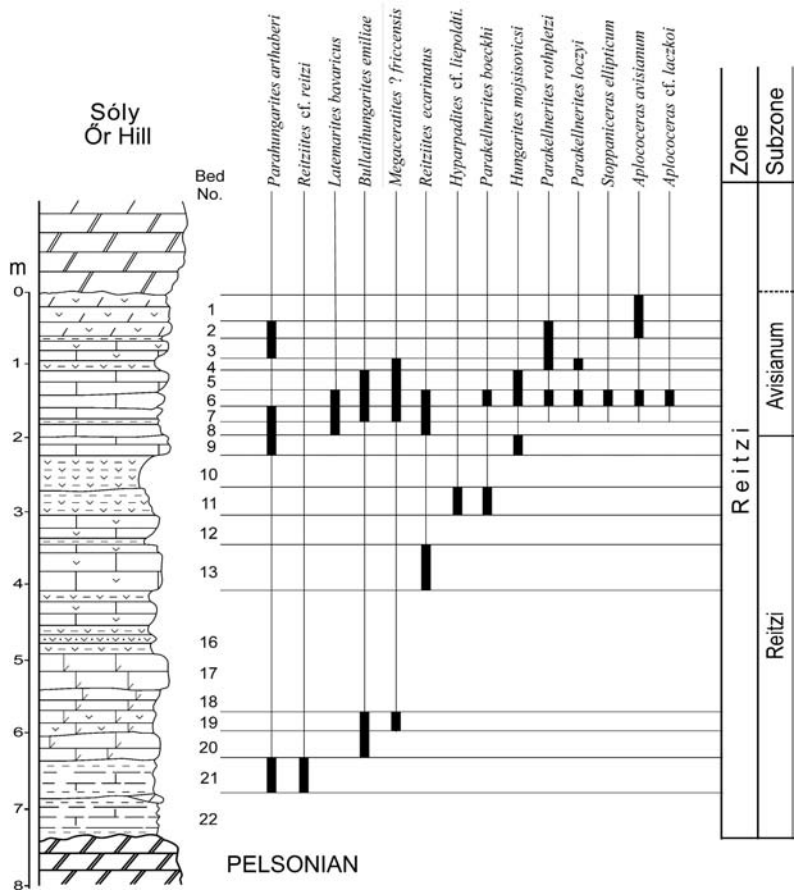

Figure 14. The stratigraphic column of the Sóly section with the ranges of the stratigraphically significant ammonoid taxa and the zonal/subzonal subdivision (modified from VÖRÖS 1998)
Legend as in Figure 2 and 13

Table 11. List of the ammonoid taxa collected from the Sóly section and their number of specimens per beds

Bed	1	2	3	4	5	6	7	8	9	11	13	18	19	20	21	sum
Norites gondola						1										1
Megaceratites ? friccensis				2	1	4	7						1			15
Hyparpadites cf. *liepoldti*										6						6
Parakellnerites boeckhi						4				2						6
Parakellnerites stuerzenbaumi															1	1
Parakellnerites rothpletzi		10	5	1		4										20
Parakellnerites loczyi				2		6										8
Parahungarites arthaberi		5	4				4	5	51						1	70
Parahungarites solyensis					1	6			1							8
Reitziites cf. *reitzi*															2	2
Reitziites ecarinatus						1	12	1			2					16
Latemarites bavaricus						3	31	15								49
Detoniceras ? sp.							1									1
Stoppaniceras ellipticum						1										1
Hungarites mojsisovicsi					3	4			1							8
Bullatihungarites emiliae					3	8	2						7	2		22
Aplococeras avisianum	2	1				3										6
Aplococeras cf. *laczkoi*						1										1
Longobardites zsigmondyi						18	6		6	5			1			36
Longobardites breguzzanus			1		3	12						2				18
Flexoptychites angustoumbilicatus						2										2
Flexoptychites flexuosus							12									12
sum	2	16	10	5	11	78	75	21	59	13	2	2	11	2	5	312

the detritus of the grey Felsőörs Limestone (coordinates: x=46°53'29", y=17°37'44"). The ammonoids prove the presence of the Trinodosus and Pseudohungaricum subzones. The list of ammonoid taxa and the specimen number data are shown in Table 12.

MONOSZLÓ, HEGYES-TŰ N

A few ammonoids were collected by T. BUDAI, G. CSÁSZÁR, L. KOLOSZÁR, J. PÁLFY and A. VÖRÖS in the 1980's, from loose pieces of limestone on a bushy plateau (coordinates: x=46°53'43", y=17°39'16"). The host rock was the greyish-beige Felsőörs Limestone, which, according to the ammonoids, represents the Trinodosus Subzone. The locality and its ammonoids were shortly reported by VÖRÖS (1998); the ammonoid taxonomy and the biostratigraphy given in that paper needed some revision. The revised list of ammonoid taxa and the specimen number data are shown in Table 12.

BALATONCSICSÓ, RUINS OF ST. BALÁZS CHURCH

Ammonoids were collected by T. BUDAI, V. HERMANN and A. VÖRÖS, partly from an abandoned trench, partly from the scree in a vineyard nearby (coordinates: x=46°54'43", y=17°41'50"). The host rock, a brownish-violet, finely crinoidal limestone belongs to the Vászoly Formation. The ammonoids represent a narrow stratigraphical interval of the Reitzi Zone, namely the Avisianum Subzone. The locality and its ammonoids were shortly reported by VÖRÖS (1998); the ammonoid taxonomy and the biostratigraphy given in that paper needed some revision. The list of ammonoid taxa and the specimen number data are shown in Table 12.

DÖRGICSE, DRT–1 CORE (73.4–75.2 m)

The drill-core (coordinates: x=46°55'31", y=17°43' 45") revealed an ochre-yellow, fine-grained crinoidal, biodetrital limestone, very similar to the lithology known from the Szentantalfa section, and represents the lower member of the Vászoly Formation (for details of the lithostratigraphy and sedimentology of the drilled core see BUDAI et al. 1999). The ammonoids, collected by T. BUDAI and A. VÖRÖS, point to the Camunum and/or the Pseudohungaricum Subzone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

VÁSZOLY, ÖREG HILL (DIVERSE LOCALITIES)

As it was mentioned in the detailed description of this area (p. 19), in the course of the uranium-ore explorations dozens of trenches and shafts were excavated on the Öreg Hill. Many of these outcrops yielded valuable, taxonomically very important ammonoids, although mainly collected as loose pieces in the scree around the shafts by I. SZABÓ and his co-workers in the 1960's. Subsequently, a few further loose ammonoids were found by E. VÉGH-NEUBRANDT, T. BUDAI, ZS. KERCSMÁR, I. SZENTE and A. VÖRÖS. The ammonoid bearing localities are shown in Figure 7. It is impossible to give detailed descriptions of their stratigraphy, because all of the trenches and shafts were filled up and buried completely still in the 1960's. Only KOVÁCS et al. (1990), on the basis of manuscript data by I. SZABÓ, illustrated the lithological logs of two shafts (XVII and XVIII) but without valuable information on the ammonoid biostratigraphy. From Shaft XVIII the ammonoid taxa *Parakellnerites* sp., "*reitzi*-group", and *Hungarites bocsarensis* were mentioned. As a summary, we may state that the rock material of the ammononoids, described in the present monograph from diverse localities of Vászoly, Öreg Hill, represents variable lithological types of the Vászoly Formation. The ammonoids coming from these diverse localities prove the presence of the Felsoeoersensis, Liepoldti, Reitzi, Avisianum and the Crassus subzones in the area. The list of ammonoid taxa and the specimen number data are shown in Table 13.

ÖRVÉNYES, SZAKADÁS VALLEY (coordinates: X=46°55'13", Y=17°48'39")

A few pieces of ammonoids were collected by I. SZABÓ in 1966, from the light-grey tuffaceous layers of the Vászoly Formation; they point to the presence of the Liepoldti and/or the Reitzi Subzone. Later T. BUDAI found a *Flexoptychites* specimen in a red limestone exposed in an artificial trench. The list of ammonoid taxa and the specimen number data are shown in Table 12.

PALOZNAK, PZT–1 CORE (105.0 m) (coordinates: X=46°59'53", Y=17°55'34")

A single specimen of *Megaceratites* cf. *subnodosus* (MOJSISOVICS, 1882) was collected by T. BUDAI, from the Felsőörs Formation (dark-grey, marly limestone). The ammonoid proves the presence of the upper part of the Trinodosus Zone.

FELSŐÖRS, 111/A–K BEDS

A single specimen of *Stoppaniceras budaii* n. sp. was found by I. SZABÓ, in the scree of the Felsőörs section (coordinates: x=47°01'04", y=17°56'34"). The rock-type infilling the body chamber of the ammonoid hints to the upper part of the Vászoly Formation, i.e. the nodular layers between Beds 111/A to 111/K (Avisianum to Crassus subzones).

VÖRÖSBERÉNY, ROAD-CUT (coordinates: X=47°03'25", Y=17°59'32")

In addition to the detailed bed-by-bed collection, the scree along the road-cut between Vörösberény (Balatonalmádi) and Szentkirályszabadja, yielded some further ammonoids. T. BUDAI and J. PÁLFY collected a few specimens from the Felsőörs

Table 12. List of the ammonoid taxa collected from diverse localities of the Balaton Highland and their number of specimens per localities

	Köveskál, Horog Hill (2001, 2012)	Monoszló, Hegyes-tű N	Balatoncsicsó, ruins of St. Balázs church	Dörgicse, Drt-1 core (73.4-75.2 m)	Örvényes, Szakadás Valley	Paloznak, Pat-1 core (105.0 m)	Vörösberény, road-cut (loose)	Szentbékkálla, vineyards (loose)	Mencshely, Cser-tető (1990, loose)	Mencshely, Cser-tető (2011, 2013, reitzi beds)	Vörstó, Akol Hill	Barnag E (loose)	Tótvázsony W (loose)	Felsőörs, 111 beds (loose)	Szentkirályszabadja, quarry N	Litér, Murva-quarry E	Hajmáskér, Hmt-3 core (113.4-115.8 m)	Sóly, road-cut S	Öskü, road-cut	Öskü, Murva-quarry E	Iszkaszentgyörgy, Piramita Hill
Norites gondola									1	2			1								
Lardaroceras krystyni	1							5			1		1		4						1
Lardaroceras pseudohungaricum	1							1	1						2						8
Paraceratites trinodosus	8	5					2					2									
Paraceratites elegans		2					2														
Semiornites aviticus				1																	
Asseretoceras camunum											1				2						1
Megaceratites ? cf. *subnodosus*	5			1		1	2	1	2			2									
Epikellnerites angustecarinatus										4											
Epikellnerites tamasi								1													
Epikellnerites vaszolyensis					2			1	1	1											
Epikellnerites pseudocholnokyi										9											
Parakellnerites boeckhi			2							2											
Parakellnerites hungaricus			1																		
Parakellnerites aff. *hungaricus*									2												
Parakellnerites cf. *rothpletzi*			1													1					
Parahungarites arthaberi			10						4	19							2	15		2	
Parahungarites cf. solyensis																		1			
Reitziites reitzi									1	18											
Reitziites reitzi morphotype *cholnokyi*									2	12											
Reitziites ecarinatus								1	2	16							2		1		
Latemarites bavaricus							1			3							1	2			
Stoppaniceras budaii														1							
Stoppaniceras ellipticum																		1	1		
Ticinites ticinensis												1									
Ticinites aff. *hantkeni*										1											
Hungarites mojsisovicsi												1					2		2		
Bullatihungarites cf. *semiplicatus*										1											
Hungarites cf. *costosus*			1																		
Hungarites szentei										2								1			
Aplococeras avisianum			4																		
Lecanites misanii									2												
Celtites ? sp.			1																		
Longobardites zsigmondyi		1								1											3
Longobardites breguzzanus																	1			1	
Ptychites oppeli								16													
Flexoptychites angustoumbilicatus			3					1	2												
Flexoptychites cf. *acutus*			1		2			1			2						1				1
Flexoptychites flexuosus			13					3	3		1										6
Proarcestes sp.			2																		
sum	15	8	39	2	4	1	7	31	23	91	5	6	2	1	8	1	9	20	4	3	20

Formation, and A. VÖRÖS found a single, loose specimen in the higher part of the tuffaceous Vászoly Formation. The list of ammonoid taxa and the specimen number data are shown in Table 12.

SZENTBÉKKÁLLA, VINEYARDS

The poor exposures and the scree in the Szentbékkálla vineyards seem to represent a continuous series of Anisian to Ladinian formations of basin facies (between coordinates x=46°53'28", y=17°33'01" and x=46°53'33", y=17°33'06"). The loose blocks and pieces of mostly siliceous limestones lying around the vineyards came from the Felsőörs Formation and the Vászoly Formation. Numerous ammonoids were collected here, at several occasions, by T. BUDAI, ZS. KERCSMÁR, J. PÁLFY, K. TAMÁS and A. VÖRÖS. A few specimens were shortly described and illustrated by VÖRÖS et al.

(2015). The list of ammonoid taxa, incorporated in the present monograph, and their specimen number data are shown in Table 12.

MENCSHELY, CSER HILL (PRELIMINARY COLLECTIONS)

In 1990, before starting the detailed bed-by-bed collections in the Mencshely I section (coordinates: x=46° 57'32", y=17°42'32"), numerous ammonoids were collected from the detritus coming from variable rock-types of the Felsőörs Formation and the Vászoly Formation, by T. BUDAI, G. CSILLAG, L. DOSZTÁLY and A. VÖRÖS. The ammonoid species point to the presence of several upper Anisian horizons, from the Pseudohungaricum Subzone to the Avisianum Subzone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

MENCSHELY, CSER HILL (SUPPLEMENTARY COLLECTIONS)

In 2011 and 2013, well after the detailed bed-by-bed collections in the Mencshely I section (coordinates: x=46°57'32", y= 17°42' 32"), T. BUDAI, I. SZENTE, P. VINCZE and A. VÖRÖS collected supplementary ammonoid material from the red, tuffaceous limestones of the Vászoly Formation, in order to increase the taxonomical knowledge on the fauna of the Reitzi Subzone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

Table 13. List of the ammonoid taxa collected from diverse localities of the Öreg Hill (Vászoly) and their number of specimens per localities

	Trench P-11/a (loose)	Trench P-11/b (loose)	Trench P-11/c (loose)	Trench P-11/d (loose)	Trench 14 (loose)	Trench 15 (loose)	Trench 17 (loose)	Shaft XIII.	Shaft XV.	Shaft XVII.	Shaft XVIII.	Vászoly, loose	sum
Lardaroceras krystyni										1		1	2
Lardaroceras barrandei												1	1
Kellnerites felsoeoersensis									1				1
Epikellnerites angustecarinatus							1			1		1	3
Epikellnerites tamasi			1										1
Epikellnerites vaszolyensis			3								2	1	6
Hyparpadites liepoldti	1		1			2					1		5
Hyparpadites szaboi										2			2
Parakellnerites frauenfelderi			1							1			2
Parakellnerites boeckhi	1		5				1						7
Parakellnerites stuerzenbaumi					1								1
Parakellnerites aff. *rothpletzi*			1										1
Parakellnerites loczyi											1		1
Parakellnerites cf. *zoniaensis*					1								1
Parahungarites arthaberi			1										1
Parahungarites solyensis							1						1
Reitziites reitzi			4	3			6	1		1	2	1	18
Reitziites reitzi morphotype *cholnokyi*							1						1
Reitziites ecarinatus							1						1
Stoppaniceras hermanni							1						1
Hungarites mojsisovicsi	1		1		1								2
Bullatihungarites emiliae										1			1
Bullatihungarites semiplicatus			1										1
Hungarites costosus												1	1
Hungarites szentei					2								2
Hungarites sinuosus			1									2	3
Nodihungarites bocsarensis	2												2
Nodihungarites vinczei	1												1
Aplococeras laczkoi	1												1
Flexoptychites angustoumbilicatus		2	8		3		3			1	5	2	24
Flexoptychites acutus			1		2		1			1	1		6
Flexoptychites flexuosus	1	2	6	2								2	13
sum	8	4	35	5	10	2	16	1	1	9	12	12	115

VÖRÖSTÓ, AKOL HILL

This locality probably corresponds to one of the classical fossiliferous sites near Nagyvázsony, mentioned by HAUER (1861) and LÓCZY (1913, 1916). A small artificial trench, excavated in the early 1980's, exposed a few layers of reddish-yellow limestone (Vászoly Formation) resting on the Tagyon Formation (stratigraphic column of the section is in the manuscript of BUDAI 2006) (coordinates: x=46°57'57", y=17°43'01"). Ammonoids, collected by T. BUDAI, G. CSILLAG, V. HERMANN and A. VÖRÖS, prove the presence of the Camunum and/or the Pseudohungaricum Subzone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

BARNAG EAST

On the meadows to the east of the village Barnag (coordinates: x=46°58'57", y=17°45'11"), loose ammonoids were collected by G. CSILLAG and A. VÖRÖS from grey siliceous limestones (Felsőörs Formation) and, at another place, from red limestones (Vászoly Formation). The ammonoids point to the Trinodosus and the Avisianum (or perhaps the Secedensis) subzones, respectively. The list of ammonoid taxa and the specimen number data are shown in Table 12.

TÓTVÁZSONY WEST

West of the village Tótvázsony, along the roads (coordinates: x=47°00'19", y=17°46'32"), loose ammonoids were collected by G. CSILLAG and A. VÖRÖS from greyish-beige siliceous limestones (Felsőörs Formation). The ammonoids point to the higher part of the Trinodosus Zone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

SZENTKIRÁLYSZABADJA, QUARRY N

Dolomitized algal limestones of the Tagyon Formation were quarried in several large pits two kilometres north of the village Szentkirályszabadja (coordinates: x=47°04'25", y=17°57'26"). This shallow marine carbonate platform of Pelsonian age is unconformably overlain by brownish-yellow to grey limestones of the Vászoly Formation (BUDAI et al. 1993, 1999, 2001a; GAETANI [ed.] 1993). In the northernmost part of the quarry, from the lowermost beds of the Vászoly Formation, T. BUDAI, L. DOSZTÁLY and A. VÖRÖS collected some poorly preserved ammonoids which prove the presence of the Camunum Subzone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

LITÉR, QUARRY E

In the eastern rim of the quarry (coordinates: x=47°06'56", y=17°59'19"), poorly exposed layers of brownish-yellow, tuffaceous, crinoidal limestone (Vászoly Formation) were found between Middle Anisian and Upper Anisian – Ladinian dolomite bodies (for more details of the lithostratigraphy and sedimentology of the studied section see BUDAI et al. 2001a). A. VÖRÖS collected here a few ammonoids, e.g. *Parakellnerites* cf. *rothpletzi* (SALOMON, 1895), which points to the Avisianum Subzone.

HAJMÁSKÉR, HMT–3 CORE (113.4–115.8 m)

The drill-core (assigned by GY. RAINCSÁK) (coordinates: x=47°08'10", y=18°01'09") revealed a brownish-yellow to pink, fine-grained, tuffaceous crinoidal limestone, very similar to the lithology known from the Sóly section, and represents the upper member of the Vászoly Formation. A simplified lithological column of the core was figured by VÖRÖS (1993) and a more detailed one by BUDAI (2006). In spite of the small diameter of the cores, numerous ammonoids were collected in 1980 by GY. RAINCSÁK and A. VÖRÖS. The fauna is comparable to the classical "Hajmáskér fauna" (DIENER 1899, 1900; ARTHABER 1903) and proves the presence of the Avisianum Subzone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

SÓLY, ROAD-CUT S

In the road-cut along the southern side of the main road No. 8, at the Őr Hill (coordinates: x=47°08'20", y=18°02'03"), brownish-yellow, tuffaceous, crinoidal limestones were exposed in a few metres thickness, between the underlying Pelsonian and the overlying Upper Anisian – Ladinian massive dolomite complexes (description and lithologic column of the section were published by BUDAI et al. 2001a). These layers represent a reduced lateral continuation of the beds sampled in the Sóly section about 100 m southward. The ammonoids, collected by L. DOSZTÁLY and A. VÖRÖS, are also very similar to those known from the Sóly section, and prove the presence of the Avisianum Subzone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

ÖSKÜ, ROAD-CUT N

Very close to the village Öskü, the road-cut along the northern side of the main road No. 8 (coordinates: x=47°08'17", y=18°04'36"), exposed the yellowish-red, tuffaceous, crinoidal-brachiopodal limestone of the Vászoly Formation, resting unconformably on Middle Triassic dolomites (Tagyon Formation). The section was described and figured by KOVÁCS et al. (1990, p. 180). According to the usage of that time, they qualified the dolomite as Megyehegy Dolomite and the fossiliferous layers as Buchenstein Formation. They made extended collecting work and listed (without illustrations) more than a dozen of ammonoid species, mostly known also from the classical "Hajmáskér fauna" (DIENER 1899, 1900; ARTHABER 1903). The ammonoids, collected by I. SZABÓ, were presumably deposited in the collections of the Mining and Geological Survey of Hungary, where we attempted to find the material. As a partial success, we found specimens collected by I. SZABÓ from Öskü from the reddish, crinoidal limestone, but regrettably, we were not able to verify the mentioned long list of ammonoid species. We could identify only four ammonoid taxa from that collection by I. SZABÓ. The list of ammonoid taxa and the specimen number data, resulted from our recent investigation, are shown in Table 12.

ÖSKÜ, QUARRY

The quarry (also known as Kikeri Quarry) (coordinates: x=47°09'57", y=18°05'26"), is mined for crumbly and pulverized dolomites belonging to the Middle Anisian Tagyon Formation. Brownish-red, tuffaceous, crinoidal limestones (Vászoly Formation) are deposited on the uneven, eroded surface of the dolomites in the south-western end of the quarry (description and lithologic column of the section were published by BUDAI et al. 2001a). A detailed description of the geolo-

gy and the tectonic interpretation of the Kikeri Quarry were published recently by CSICSEK & FODOR (2016). Ammonoids were collected from here by T. BUDAI, G. CSILLAG, L. DOSZTÁLY, I. SZABÓ and A. VÖRÖS in the 1990's. The lithology of the fossiliferous layers and the ammonoid taxa are akin to those known from the upper part of the Sóly section, i.e. point to the Avisianum Subzone. The list of ammonoid taxa and the specimen number data are shown in Table 12.

ISZKASZENTGYÖRGY, PIRAMITA HILL

Upper Anisian ammonoids were collected by T. BUDAI, L. DOSZTÁLY and A. VÖRÖS from the poor exposures of the Felsőörs Limestone (coordinates: x=47°14'08", y=18°17'05"), apparently forming a bed complex between two massive, platform carbonate formations. A short description and a drawing of the section were published by BUDAI et al. (2001b). The ammonoids prove the presence of the Camunum and Pseudohungaricum subzones. The list of ammonoid taxa and the specimen number data are shown in Table 12.