The Ammonoid Fauna

The monographic description is supposed to incorporate all pieces of Upper Anisian ammonoids known from the Balaton Highland; in the present case this intention remains admittedly an approximation to an obviously impossible task.

The overwhelming majority of the Upper Anisian ammonoids described in this monograph, collected recently and systematically by the author and his colleagues, is deposited in the collection of the Department of Paleontology and Geology of the Hungarian Natural History Museum (Budapest).

Another, very important collection of Upper Anisian ammonoids from the Balaton Highland is found in the Museum of the Mining and Geological Survey of Hungary (Budapest). The originals of the classical papers and monographs by ROTH (1871), BÖCKH (1872, 1973, 1974), STÜRZENBAUM (1875), MOJSISOVICS (1882), DIENER (1899, 1900), ARTHABER (1903) and FRECH (1903) are kept here. A considerable part of the ammonoid fauna collected by Imre SZABÓ from Vászoly in the 1960's was also deposited in this museum. The comprehensive nature of the present monograph necessitated and justified to include the photographs taken from certain type specimens described in the classical publications and from some other diagnostic specimens of this collection.

Additionally, a few private collections reached the scope of the present study. The largest and most important of these is in the property of Károly TAMÁS and Gabriella FÖLDVÁRI, in Kővágóörs. Following the source data in VÖRÖS (1998), they developed enormously large ammonoid collections from some Anisian localities at the Balaton Highland. A few of their specimens are also illustrated in this monograph. The private collection of László VARGA (Úny) received a few ammonoids collected by Imre SZABÓ from Vászoly, whose photographs were appropriate to be included to the present work.

Several thousand Upper Anisian ammonoid fossils were encountered in the course of preparing this monograph. From among them, 2104 specimens were identified at least on species level. The 85 taxa represent 37 genera. Four of the genera and 14 of the species are described here as new taxa. Further five species are considered to be new, but in the lack of sufficient material, they are described under open nomenclature prefixed by "aff.". In eight cases, the generic attribution was certain but the identification of the taxa are indicated only as "sp." The taxa are listed in Table 14, with the indication of the specimen number data.

Table 14. List of the Upper Anisian ammonoid taxa of the Balaton Highland, with their species numbers

Norites gondola (Mojsisovics, 1869)	15
Beyrichites cf. *reuttensis* (Beyrich, 1867)	4
Lardaroceras krystyni Balini, 1992	50
Lardaroceras barrandei (Mojsisovics, 1882)	28
Lardaroceras pseudohungaricum Balini, 1992	75
Paraceratites trinodosus (Mojsisovics, 1882)	65
Paraceratites cf. *elegans* (Mojsisovics, 1882)	16
Paraceratites cf. *rothi* (Mojsisovics, 1882)	2
Semiornites cf. *cordevolicus* (Mojsisovics, 1882)	35
Semiornites cf. *aviticus* (Mojsisovics, 1882)	46
Semiornites ? cf. *falcifer* (Hauer, 1896)	1
Asseretoceras camunum (Assereto, 1963)	58
Megaceratites cf. *subnodosus* (Mojsisovics, 1882)	77
Megaceratites ? cf. *friccensis* (Arthaber, 1916)	15
Kellnerites bosnensis (Hauer, 1887)	11
Kellnerites felsoeoersensis (Stürzenbaum, 1875)	2
Kellnerites cf. *bispinosus* (Hauer, 1896)	1
Epikellnerites angustecarinatus (Hauer, 1896)	9
Epikellnerites tamasi n. sp.	2
Epikellnerites aff. *tamasi* n. sp.*	1*
Epikellnerites vaszolyensis n. sp.	18
Epikellnerites pseudocholnokyi n. sp.	10
Epikellnerites spinatus n. sp.	2
Reitziites reitzi (Böckh, 1872)	63
Reitziites reitzi (Böckh, 1872) morphotype *cholnokyi*	28
Reitziites ecarinatus (Hauer, 1896)	70
Latemarites bavaricus (Reis, 1901)	68
Detoniceras ? sp.	1
Hyparpadites liepoldti (Mojsisovics, 1882)	38

Hyparpadites aff. *liepoldti* (Mojsisovics, 1882)	6
Hyparpadites szaboi n. sp.	7
Parakellnerites frauenfelderi Rieber, 1973	14
Parakellnerites boeckhi (Roth, 1871)	22
Parakellnerites hungaricus (Mojsisovics, 1882)	4
Parakellnerites stuerzenbaumi n. sp.	30
Parakellnerites aff. *hungaricus* (Mojsisovics, 1882)	4
Parakellnerites cf. *rothpletzi* (Salomon, 1895)	32
Parakellnerites aff. *rothpletzi* (Salomon, 1895)	1
Parakellnerites loczyi (Arthaber, 1903)	13
Parakellnerites cf. *zoniaensis* Brack & Rieber, 1993	1
Parahungarites arthaberi (Diener, 1899)	209
Parahungarites solyensis n. sp.	10
Halilucites rusticus (Hauer, 1896)	2
Halilucites cf. *arietitiformis* (Hauer, 1896)	1
Halilucites cf. *obliquus* (Hauer, 1896)	1
Stoppaniceras cf. *variabile* Rieber, 1973	3
Stoppaniceras rieberi n. sp.	5
Stoppaniceras aff. *rieberi* n. sp.	1
Stoppaniceras cf. *ellipticum* (Hauer, 1887)	4
Stoppaniceras hermanni n. sp.	3
Stoppaniceras budaii n. sp.	3
Repossia cf. *acutenodosa* Rieber, 1973	10
Ticinites cf. *ticinensis* Rieber, 1973	1
Ticinites hantkeni (Mojsisovics, 1882)	12
Ticinites ? aff. *hantkeni* (Mojsisovics, 1882)	4
Ticinites crassus (Hauer, 1896)	2
Nevadites cf. *avenonensis* Brack & Rieber, 1993	4
Chieseiceras chiesense (Mojsisovics, 1882)	7
Chieseiceras sp. A	1
Hungarites mojsisovicsi (Roth. 1871)	79
Hungarites costosus Mojsisovics, 1882	5
Hungarites sinuosus n. sp.	6
Hungarites szentei n. sp.	4
Bullatihungarites emiliae (Mojsisovics, 1882)	33
Bullatihungarites semiplicatus (Hauer, 1896)	4
Nodihungarites bocsarensis (Arthaber, 1903)	3
Nodihungarites vinczei n. sp.	2
Celtites ? sp. A	2
Celtites ? sp. B	1
Aplococeras avisianum (Mojsisovics, 1882)	20
Aplococeras laczkoi (Arthaber, 1903)	2
Lecanites misanii (Mojsisovics, 1882)	8
Longobardites zsigmondyi (Böckh, 1874)	51
Longobardites breguzzanus Mojsisovics, 1882	24
Japonites ? sp.	1
Discoptychites cf. *megalodiscus* (Beyrich, 1867)	24
Gymnites sp.	2
Tropigymnites sp. **	1**
Epigymnites ecki (Mojsisovics, 1882)	2
Ptychites cf. *oppeli* Mojsisovics, 1882	35
Flexoptychites cf. *studeri* (Hauer, 1857)	1
Flexoptychites angustoumbilicatus (Böckh, 1872)	188
Flexoptychites flexuosus (Mojsisovics, 1882)	252
Flexoptychites cf. *acutus* (Mojsisovics, 1882)	76
Parasturia cf. *emmrichi* (Mojsisovics, 1882)	2
Proarcestes sp.	48
	2104

* MFGI collection (Budapest).
** K. Tamás collection (Kővágóörs).

The **state of preservation** of the ammonoid fossils was very variable, according to the lithology of the host rock. In the pure limestones, the originally aragonitic ammonoid shells were substituted by sparry calcite, or appeared only as imprints on the moulds of the shells. In these cases the host rock usually split along the sparry calcite substituting the ammonite shells, thus the outer surface of the ammonites were rarely visible. In many cases only the body chambers were filled by micritic limestone, and secondary calcite precipitated in the open spaces of the phragmocones. Very frequently, the ammonites were primarily fossilized as fragments of body chambers. In the clayey interlayers, and in some thin-bedded tuffaceous layers, the ammonoids were preserved in compressed state. In the siliceous limestones, the ammonoid shells were substituted by silica, but usually the fossils unbreakably coalesced with chert nodules. In all cases, the ammonoid fossils were extremely hard to extract from the host rock, and frequently were crushed into pieces during hammering. Consequently, entire remains of ammonoid specimens were extremely seldom found. More or less complete body chambers with imprints of seemingly intact aperture were recorded on a few specimens (Plate XL: 1; Plate XLIII: 1).

Diverse aspects of the Upper Anisian ammonoid fauna of the Balaton Highland were evaluated and published in the last decades.

The **biostratigraphical** results will be presented in a separate chapter.

The **palaeoenvironmental distribution** of the Late Anisian ammonoids was analysed and evaluated previously in two papers.

VÖRÖS (1996) compared the distribution of two special morphogroups of ammonoids and pointed out that the proportion of „coronates" (strongly ornamented ceratitids) was consistently lower in the basins than in the pelagic plateaus, whereas „sphaerocones" (Ptychitidae + Arcestidae) showed inverse relationship. During the studied interval, the proportion of "coronates" decreased, whereas the proportion of "sphaerocones" increased in time in the whole territory of the Balaton Highland (both in the basins and on the pelagic plateaus). This relationship was used to estimate water depth and changes in bathymetry. The depth of the pelagic plateaus and the basins was estimated as around 100 m and 200 m, respectively, for the Camunum Subchron. The depth difference slightly increased during the Late Anisian: the plateaux subsided to about 220 m, while the basins almost reached the 400 m depth for the Avisianum Subchron.

VÖRÖS (2002) studied the environmental distribution of ammonoid genera in the higher part of the Reitzi Zone (considered Ladinian at those times). Several genera showed definitive patterns of distribution according to palaeoenvironments.

Remarkably, in most cases the shell morphology of the ammonoids did not show direct correlation with the palaeoenvironment. It turned out that these results need to be revised.

The new analysis, presented here, used an improved data base, taking into account the newly available ammonoid finds and the new results of the taxonomical revision. The material is restricted to a narrower stratigraphical interval (Reitzi + Avisianum subzones) and to the ammonoid fauna of four representative localities/sections: Vászoly (including the sections P–11a and P–2, and diverse localities at the Öreg Hill), Felsőörs, Szentkirályszabadja and Sóly. The Mencshely sections were left out from the comparison because here the fauna of the Reitzi Zone is definitely mixed from palaeoecological point of view. The mentioned four localities and their ammonoid faunas are thought to represent different palaeoenvironments, as shown in Figure 15.

The percentage of *Flexoptychites*, as compared to the whole ammonoid assemblages of the respective localities, shows gradual increase towards the open sea, i.e. moving away from the shallow water carbonate platform. Remarkably, the percentage of *Flexoptychites* reaches a maximum at the submarine high and not in the deeper basin.

Five ammonoid genera (*Reitziites, Hungarites, Parakellnerites, Latemarites and Parahungarites*) were selected to demonstrate their distinctive palaeoenvironmental distribution. The criteria of selection were the relatively high specimen

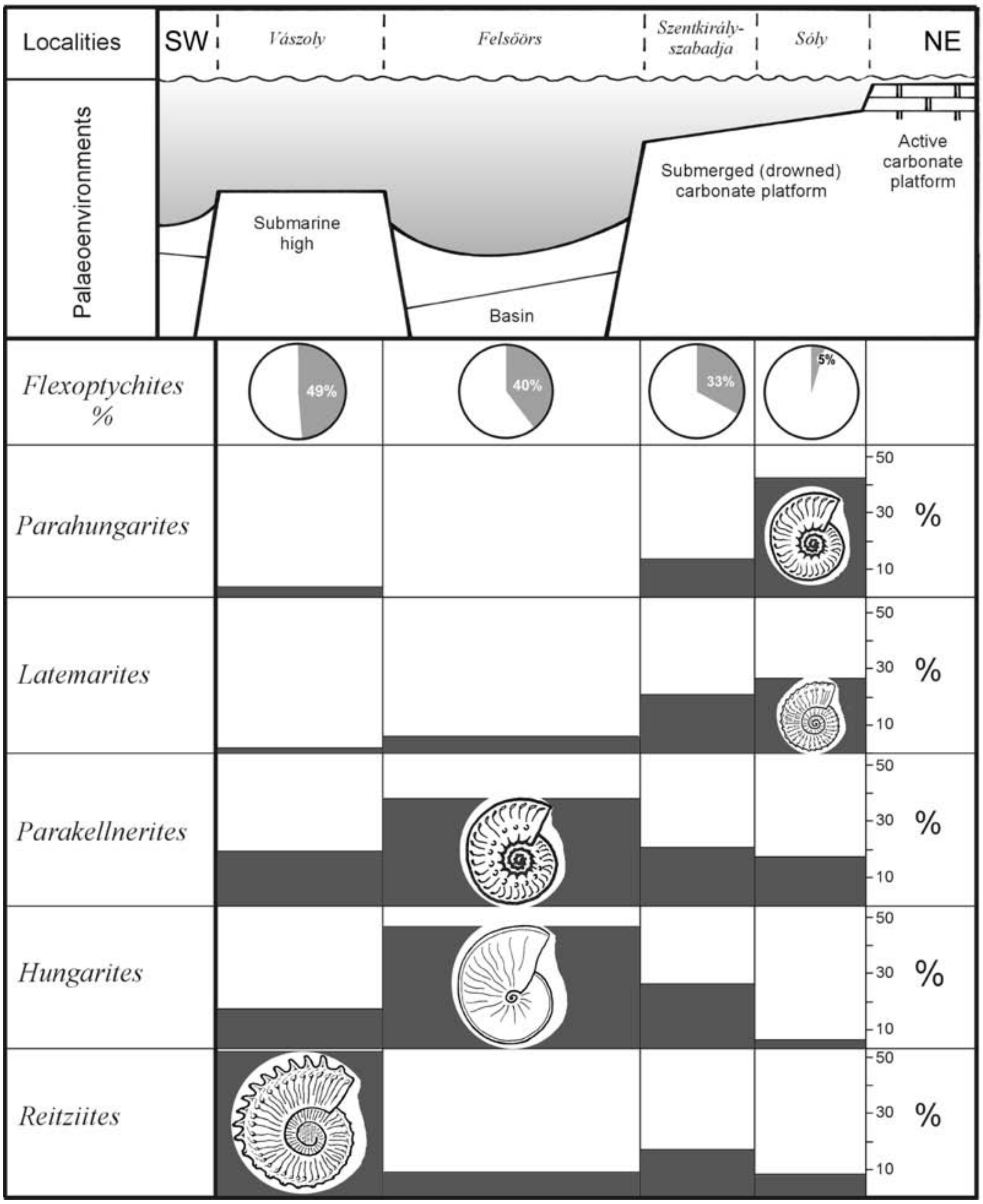

Figure 15. Late Anisian palaeoenvironmental model along the strike of the Balaton Highland (Reitzi + Avisianum Subchron), showing the variation of the percentages of *Flexoptychites* in the whole fauna, and the mutual proportions of selected ceratitid genera within the respective locality

numbers and the wide occurrence in different settings. The mutual percentages of the distinctive genera were counted for each locality, i.e. the base of percentage counting (the total) was not the whole local ammonoid fauna but the sum of the specimens of the five genera occurred on the respective locality.

The new results only partly endorse those of the previous study (Vörös 2002): the genus *Latemarites* is definitely abundant in the peri-platform areas. The new genus *Parahungarites* (which was previously included in *Hungarites*) shows similar palaeoenvironmental preference. On the other hand, and on the contrary to the previous analysis (Vörös 2002), *Parakellnerites* and *Hungarites* (s.s.) seem to characterize the deeper basinal setting, and *Reitziites* is definitely dominant at the submarine high. It is worth mentioning that the smooth oxycone *Longobardites* seemed to be positively linked to the peri-platform area, but it was not included to the present numerical comparison because (in the studied interval) it occurred exclusively in the Sóly locality.

The **diversity trends and dynamics** of the Anisian ammonoids, with emphasis on the Late Anisian fauna of the Balaton Highland, were analysed recently by Vörös (2010b, 2014). Two pulses of diversification were outlined: one in the Middle Anisian (Pelsonian) and another, near the end of the Late Anisian (Late Illyrian). In the western Tethys, and especially in the Balaton Highland, the Late Illyrian diversity peak was very prominent: the ammonoid generic richness, the turnover rate and the proportion of originations were very high. This explosive peak was interpreted in terms of major changes of two regional environmental factors: the coeval volcanic activity and the control of nearby carbonate platforms. The Late Illyrian volcanic ash falls provoked a dramatic increase of ammonoid generic richness by fertilization i.e. supplying nutrients and iron, thus increasing the primary productivity in the ocean. Carbonate platform margins offered diverse habitats with new, empty niches; the microbial mats supplied suspended organic matter for the higher trophic levels and eventually the ammonoids. A co-evolution of the regional carbonate platforms and the ammonoids was suggested.

The **palaeobiogeography** of the Anisian ammonoids of the Balaton Highland was investigated by Vörös (1992) by plotting the distribution of “distinctive taxa” on present day tectonic map. The Late Illyrian palaeobiogeographical pattern showed marked faunal belts: the “German” fauna was strongly endemic; in the deeper, pelagic outer shelf areas of the Tethyan region the extremely rich “Schreyeralm–Dinaric” fauna appeared; the shallower shelf regions were characterized by the “South-Alpine” fauna (including the plots of the Balaton Highland). It was suggested that the Illyrian sea-level fall resulted in increasing endemism between the “German” and the Alpine–Tethyan faunas.

The results of the present study were not attempted to be analysed by advanced numerical methods either, instead, the occurrences of the Late Anisian ammonoid taxa of the Balaton Highland in certain, well-documented coeval faunas of the neighbouring western Tethyan (Alpine and Dinaric) regions were counted (Table 15). In this comparison the new taxa and the taxa with open nomenclature (sp., aff.) were left out from the Balaton Highland fauna, what eventually resulted in 54 items. The relationship seems the strongest with western Lombardy and the Giudicarie region (28 shared taxa, each) and

Table 15. Number of late Anisian ammonoid species shared between the Balaton Highland and certain coeval faunas of the neighbouring Alpine and Dinaric regions

Balaton Highland	North Tirol	Salzkammergut	West Lombardy	Giudicarie	Dolomites	Dinarides
54	12	8	28	28	25	24

with the Dolomites (25) and rather weak with the Northern Calcareous Alps (Tirol and Salzkammergut: 14 altogether). The apparent similarity with the Dinaridic faunas (24 shared taxa) is somewhat surprising and seems to contradict partly to the previous assumptions (Vörös 1992). If we add up the occurrences of the three South Alpine faunal regions, the merged list of species counts 52, indicating an almost complete identity between the species composition of the Late Anisian ammonoid faunas of the Balaton Highland and the Southern Alps.