

Previous research

The first, doubtful report on probably Late Anisian ammonoids from the Balaton Highland is due to the Hungarian Benedictine monk, F. RÓMER (1860), in his book devoted to the archaeological finds of the Bakony region. When travelling from Vásony (= Nagyvázsony) to Mencsel (= Mencshely), he collected “numerous, mainly small, intact ammonites from the boulders of the Cserjés-hegy” (RÓMER 1860, p. 180). [“Cserjés-hegy”, in present usage corresponds to the place Cser Hill near Mencshely, what is one of our most important localities of Late Anisian ammonoids.]

The next, also doubtful, report on an Upper Anisian ammonoid is connected to HAUER (1861) who noted that J. KOVÁTS collected “*Ceratites binodosus* Hau.” near Nagyvázsony. This specimen was not found in the old collections in Budapest, and the species was not listed later by LÓCZY (1916, p. 116) from KOVÁTS’ locality (Alsócsapel-Kiserdőhegy, near Barnag). [New collections at the locality (nowadays called Vöröstó, Akol Hill) restricted the age of the exposed strata to the upper part of the *Trinodosus* Zone; the alleged “*Ceratites binodosus*” specimen would probably correspond to *Lardaroceras barrandei*.]

Ten years later, the detailed geological mapping of the Southern Bakony (including the Balaton Highland) by J. BÖCKH, brought about the superb ammonoids which could be regarded as definitely Upper Anisian, according to our present usage. In 1870, near Felsőörs, J. BÖCKH discovered the “yellow, siliceous limestones of Forráshegy” with a plenty of peculiar ammonoids. The fossils, as loose siliceous nodules, were weathered out from a tuffaceous rock on the grassy hillside. On the request of J. BÖCKH, in order to reveal the bedding sequence, L. ROTH carried out excavations and systematically collected ammonoids in 1871. In the same year he gave the first meaningful palaeontological descriptions of two new ammonoid species: “*Ceratites*” *boeckhi* and “*C.*” *mojsisovicsi*, regrettably only in Hungarian, and without illustration (ROTH 1871). Most of the newly collected ammonoids, besides some brachiopods, were soon described and illustrated in the volumes of the substantial monograph by BÖCKH (1872, 1873a, 1874). The new nominal ammonoid species, recorded from the “Kalk mit *Ceratites Reitzi*”, were the following:

“*Ceratites*” *zalaensis* (=“*C.*” *mojsisovicsi* ROTH, 1871)

“*Ceratites*” *reitzi*

“*Arcestes*” *angustoumbilicatus*

“*Arcestes*” *batyolcus*

“*Ammonites (Sageceras)*” *zsigmondyi*

(The above listed species were found in the course of the recent collections, except “*Arcestes*” *batyolcus*. The original specimen was examined in the collections of the Mining and Geological Survey of Hungary and, according to the rock matrix, it does not belong to the “Reitzi beds” [=Vászoly Formation] but must come from the overlying “Nemesvámos Limestone” [Buchenstein Formation] of Ladinian age.)

Further digging and bed-by bed collections at Felsőörs were done by J. STÜRZENBAUM in 1874, who described an additional new ammonoid species, namely “*Ceratites*” *felsoeersensis* (STÜRZENBAUM 1875). (It turned out so early, that at the vegetation- and soil-covered plateaus of the Balaton Highland, significant biostratigraphical results can not be achieved without excavation of artificial trenches.)

The peculiar ammonoids of Felsőörs roused the interest of the international scientific community, and the whole fauna was revised and included to the magnificent monograph of MOJSISOVICS (1882) who defined his “Zone des *Trachyceras Reitzi*” partly by the ammonite finds at Felsőörs. MOJSISOVICS (1882) described and re-figured all ammonoids introduced previously by ROTH (1871), BÖCKH (1872, 1873a, 1874) and STÜRZENBAUM (1875) from Felsőörs, and considerably complemented the fauna of the “Reitzi beds” with the following, newly collected elements:

“Ceratites” hungaricus
“Arpadites (Ceratites)” liepoldti
“Ceratites” hantkeni
“Ceratites” zezianus (~ *“Trachyceras” chiesense* MOJISOVICS, 1882)
Hungarites costosus
Joannites trilabiatus

(These species were found also in the course of the recent collections, except *Joannites trilabiatus*. The original specimen was examined in the collections of the Mining and Geological Survey of Hungary and, according to the rock matrix, it does not belong to the “Reitzi beds” [=Vászoly Formation] but must come from the overlying “Nemesvámos Limestone” [Buchenstein Formation] of Ladinian age.)

Furthermore, MOJISOVICS (1882) described several ammonoid species from Felsőörs, from the deeper part of the section, belonging to the Trinodosus Zone: *“Ceratites” rothi*, *“C.” cordevolicus*, *“C.” aviticus*, moreover *“C.” trinodosus*, *“C.” subnodosus* and *“C.” barrandei* from other, only partly defined localities of the Balaton Highland.

Up to the end of the 19th century, the knowledge of the Upper Anisian ammonoids of the Balaton Highland was restricted principally to Felsőörs.

New fossil collections were carried out in the course of the ambitious international project entitled “Wissenschaftliche Erforschung des Balatonsees” (Scientific Research of the Lake Balaton) led and supervised by L. LÓCZY at the turn of the twentieth century. The Scholae Piae monk and teacher D. LACZKÓ, who was one of the most talented field geologists and productive fossil hunters of those times, gave an important stratigraphical contribution as well (LACZKÓ 1911). Ammonoids were collected by him from diverse, mainly Upper Anisian, localities along the Balaton Highland, and the collected ammonoids were identified and described by outstanding European specialists.

DIENER (1899, 1900) listed and partly described dozens of Upper Anisian ammonoids from Köveskál, Mencshely, Vöröstó, Barnag, Nemesvámos, Balatonfüred, Felsőörs and Hajmáskér. This fauna was complemented and taxonomically revised by ARTHABER (1903). The localities of Mencshely and especially of Hajmáskér yielded the most important new elements for the Upper Anisian ammonoid fauna of the Balaton Highland. The complete list, considering ARTHABER’s revision is the following:

“Norites” dieneri ARTHABER
“Hungarites” arthaberi DIENER
“Hungarites” emiliae MOJISOVICS
“Hungarites” bocsaensis ARTHABER
“Ceratites” perauritus DIENER
“Ceratites” conspicuus DIENER
“Ceratites” ecarinatus HAUER
“Ceratites” loczyi ARTHABER
“Dinarites” laczkoi ARTHABER

The contribution by FRECH (1903) was restricted to Felsőörs, from where he recorded *“Ptychites” acutus* Mojsisovics and *“Hungarites arietiformis”* Hauer, and described and figured the following new species:

“Ptychites (Beyrichites)” loczyi (~ *Hungarites* sp.)
“Balatonites” margaritatus
“Trachyceras” cholnokyi
Lecanites sibyllinus (~ *Lecanites misanii* [MOJISOVICS, 1882])

(The above mentioned species were found also in the course of the recent collections, except *“Balatonites” margaritatus*. The original specimen was examined in the collections of the Mining and Geological Survey of Hungary and, according to the rock matrix, *“Balatonites” margaritatus* might not come from the “Reitzi beds” [=Vászoly Formation]. It is a true *Balatonites* (close to the “*egregius* group”) and it seems that it was derived from a quite another locality, from the deeper part of the Felsőörs Limestone of Pelsonian age.)

In the closing volume of the “Balaton Monograph”, LÓCZY (1913, 1916) summarized the palaeontological results and gave lists of the ammonoid taxa determined by the above mentioned authors. Most of the listed Upper Anisian ammonoids (including MOJISOVICS’ originals) have been kept in the collections of the Geological Institute of Hungary (now Mining and Geological Survey of Hungary, Budapest).

After several decades, important excavations have been established at the Balaton Highland. The new geological mapping project by the Geological Institute of Hungary resulted in significant improvements in the knowledge of Middle Triassic ammonoids of the Balaton Highland. In the early 1980’s, field work done by I. SZABÓ and T. BUDAI (and many others) stimulated new, systematic collections of fossils. The excavation and bed-by-bed collection of several key sections were carried out under the supervision of the present author and yielded several thousand ammonoid specimens. The international quest for the Ladinian GSSP invoked the modern re-evaluation of the Middle Triassic ammonoid biostratigraphy of the Balaton Highland (SZABÓ et al. 1980; VÖRÖS & PÁLFY 1989; KOVÁCS et al. 1990; VÖRÖS 1993, 1995). The region (namely the

Felsőörs section) was a strong candidate for the Ladinian GSSP, supported not only by biostratigraphy but also by magnetostratigraphy and geochronology (VÖRÖS et al. 1996, 2003b; MÁRTON et al. 1998; PÁLFY et al. 2003). The especially diverse Anisian and Ladinian ammonoid faunas of the Balaton Highland were illustrated in a comprehensive volume (VÖRÖS 1998). The re-evaluation of the Felsőörs section and the short description of some new ammonoid finds were published by VÖRÖS et al. (2009, 2015). All the Upper Anisian ammonoids, collected in the last decades from the Balaton Highland, are aimed to be taxonomically revised and describe and illustrated in the present monograph.