A New Marine Triassic-Jurassic Boundary Section in Hungary

J. Pálfi¹ and L. Dosztály²,³

¹Hungarian Natural History Museum, PO Box 137, HU-1431 Budapest, Hungary
E-Mail: palfy@paleo.nhmus.hu

²Hungarian Geological Institute, Stefánia út 14., HU-1143 Budapest, Hungary
³Deceased

Keywords: Triassic, Rhaetian, Hettangian, System Boundary, Ammonoids, Radiolarians, Biostratigraphy

Abstract: Reasonably continuous and fossiliferous marine sections across the Triassic–Jurassic boundary are rare; less than ten are known world-wide, and this scarce record has hampered the correlation, selection of a GSSP, and our understanding of biological and geological events at the system boundary. We report preliminary results from a newly recognized boundary section near Csővár, Hungary. There, the Csővár Limestone Formation, a carbonate unit several hundred metres thick, was considered entirely Upper Triassic. However, discoveries of Rhaetian ammonoids (Choristoceras) and conodonts (e.g., Misikella) in a quarry suggested the presence of uppermost Triassic beds well below the top of the formation, and Hettangian radiolarians from the upper part of the succession indicated that it extends into the Lower Jurassic. We located a nearly 60m thick section in intermittent natural outcrops that contains the Triassic–Jurassic System boundary. Excavation produced a continuous exposure of the boundary interval and permitted macro- and microfossil collection. Latest Triassic ammonoids found in place include Choristoceras spp.; these are separated by nearly 20m of strata which have not yet yielded macrofossils, from the lowest Jurassic ammonoids which comprise phylloceratids and psiloceratids with, higher up, Wachneroceras indicating the presence of Lower and Middle Hettangian, respectively. Radiolarians are poorly preserved in this part of the section but stratigraphically important Hettangian assemblages were recovered from above the measured section, where chert lenses become more common.

Introduction

Much stratigraphic research effort has been focussed recently on the Triassic–Jurassic System boundary. A primary goal is the designation of a Global Stratotype Section and Point (GSSP) and four GSSP proposals have been made (Kunga Island, Canada; Utucumbia Valley, Peru; St. Audrey’s Bay, England; and New York Canyon, USA). Worldwide, there are few other sections which preserve a continuous, fossiliferous marine record of the transition (e.g., Kendelbachgraben, Austria; Sierra Aspera, Chile and others in the proximity to the candidate GSSPs listed above). We report the discovery of an easily accessible section at Csővár (Hungary), which offers opportunities for correlation and a multifaceted study of the system boundary.

Mesozoic rocks were first reported from the vicinity of Csővár by Szabó (1860) who tentatively suggested a Liassic age for “brown shales” in the area. A Jurassic age was confirmed in several reports in the late 1800’s but Vadász (1910) assigned the entire Mesozoic package to the Upper Triassic. A Carnian age for the well-bedded brown limestone, based on its alleged correlation with the “Raibl beds” in the Alps, became firmly entrenched in the Hungarian geological literature for several decades. A revision of the age of this unit was first suggested by Kozur and Mostler (1973) who found Late Norian microfossils in the Pokol Valley quarry (Fig. 1). From the same locality, Detre et al. (1988) reported the first finding of an ammonoid (Choristoceras) confirming the Late Norian age. Other conodonts (e.g., Misikella spp.) and ammonoids (e.g., Choristoceras cf. marshi) from the highest beds exposed in the quarry indicated a Rhaetian age (Kozur and Mock, 1991; Haas et al., 1997). On Várhegy (Castle Hill), less than 500m from the quarry, Kozur (1993) found Early Jurassic radiolarians which suggested that the formation ranges up into the Hettangian
or Sinemurian. It therefore seemed worthwhile to search for the Triassic–Jurassic boundary on Várhegy.

![Map of Várhegy area](image)

**Figure 1.** Location of the section at Csővár (A-A': excavated Triassic-Jurassic boundary section). Contour interval is 10m.

**Description of the Section**

The village of Csővár is located some 50km northeast of Budapest. The south-facing slope of Várhegy (Castle Hill; Fig. 1) is underlain by the Csővár Limestone Formation. Intermittent natural outcrops on the north side of the Pokol Valley have been connected by a newly excavated trench to produce a continuous exposure 0.8km west of Csővár. At present more than 57m of strata are exposed and 124 beds distinguished; some of these are discrete beds, but others are groupings of thinly bedded or laminated strata. The uppermost part of the Csővár Limestone Formation, between the top of the studied interval and the top of the hill (at the the ruins of a medieval castle), is at least 60m thick. The lower, entirely Triassic, part of the formation is best known from the Pokol Valley quarry, located on the other side of the valley, some 150m from the base of our excavated section (Fig. 1). There is strong similarity between the lithologies exposed at the top of the quarry and at the base of the studied section but a precise correlation has not been made. The Triassic part of the Csővár Limestone Formation, exposed in the Pokol Valley quarry, was described in detail by Haas et al. (1997), who recognized channelized calciturbidites, debris flows and slump structures as well as intervals of laminated, organic-rich mudstone. A toe-of-slope facies, representing the transition from a carbonate platform to a restricted basin was inferred.
Figure 2. Simplified lithology and biostratigraphy of the Csővár Limestone Formation in the measured stratigraphic section on the south slope of Várhegy at Csővár. Key to lithologic symbols: 1- Well-bedded limestone with slumps; 2- Laminated calcareous marl alternating with thin-bedded limestone; 3- Ooidal limestone.
The lithological features of the section reported here (Fig. 2) are similar to those observed in the Pokol Valley quarry. The lower 11m comprise alternations of laminated calcareous mudstones and thin- to medium-bedded limestones (Fig. 3). Above a nearly one-metre-thick bioclastic limestone bed, laminated calcareous mudstone predominates in the next 3m. Conspicuous slumps are preserved higher upsection for nearly 20m (Fig. 4). Between 32 and 34m, ooidal limestone with abundant brachiopods and bivalves was likely derived from platform environments. The upper half of the measured section is characterized by alternations of laminated calcareous mudstones, bedded limestones and limestones with slump structures. The sedimentological features indicate that deposition was controlled by the interplay of turbidity currents carrying platform-derived carbonate sediments, and a background sedimentation of calcareous mud with a high organic content, perhaps indicating oxygen-depleted bottom conditions. During the time represented by the studied section, the site remained close to the interface of slope, toe-of-slope and basinal depositional environments.

Above the measured section, chert nodules, lenses and layers become increasingly common. The upper part of the formation consists of well-bedded cherty limestone. This resistant, cliff-forming unit is exposed near the top of the hill and is interpreted as a more basinal facies.

![Figure 3. Rhaetian (Upper Triassic) laminated limestone, approximately 10m above the base of the Várhegy section.](image1)

![Figure 4. Photograph of a prominent sedimentary slump, interbedded with regularly layered and locally laminated strata in the Triassic-Jurassic transition, approximately 25m above the base of the Várhegy section.](image2)

**Ammonoid and Radiolarian Faunas**

Triassic ammonoids were previously known from the Pokol Valley quarry. Detre et al. (1988) reported *Choristoceras nobile*, and Haas et al. (1997) listed and figured *Choristoceras cf. marshi* and *Vandaites stuerzenbaumi*. The first was interpreted as Upper Norian (Sevjan), whereas the others suggested the presence of Rhaetian, indicating the presence of both ammonite zones of the highest Triassic Stage. Although no direct, bed-to-bed correlation has been established between the Pokol Valley quarry and the southern slope of Várhegy, the lithological similarity and the age constraints suggest a broad correlation.
Ammonites occur only sporadically throughout the measured section (Fig. 2). Preservation is commonly poor with the marly, laminated beds containing only flattened specimens; three-dimensional, but often fragmentary, internal moulds are found in the less thinly-bedded strata. Several levels in the lowest 10m yielded specimens of Choristoceras spp. (Fig. 5.1, 5.4). A whorl fragment found together with this fauna is tentatively identified as Cladiscites sp. (Fig. 5.2). This interval is assigned to the Rhaetian; a more precise age determination awaits the specific identification of the Choristoceras.

![Image of ammonites](image)


The first ammonoid of Jurassic affinity was found in the scree, 19m from the base of the measured section (Fig. 5.7). The local topography and the lithology of the adhering rock matrix suggest an origin from only a few metres above the level where the specimen was found. The specimen is a phylloceratid closely resembling Phylloceras trisicum vadász, although about three times larger in diameter than the holotype, which was described from the vicinity of Csóvár by Vadász (1910). We provisionally apply this rarely used species name, although the taxon is probably a junior synonym of another phylloceratid; a comparison can be made to Phylloceras psilomorphum Neumayr but further taxonomic studies are needed to establish whether synonymy exists. The lowest Jurassic ammonoid found in place is a finely ribbed body chamber fragment of an evolute form tentatively identified as Psiloceras sp. (Fig. 5.5). A comparison to Psiloceras pacificum (see Guex 1995), based on the style of ribbing, would imply correlation with the standard
Planorbis Zone. A loose specimen found some 5m higher possesses parabolic nodes and is compared to *Pleuroacanthites* (Fig. 5.6), which ranges from the Planorbis Zone to the Liasieus Zone. Ammonoids found in place at the same level include poorly preserved psilloceratids and phylloceratids that cannot be identified more specifically. A bioclastic limestone bed at the top of the measured section yielded *Waehneroceras* sp. (Fig. 5.8), which indicates the presence of the middle Hettangian. Several intriguing ammonoid specimens, including *Euphyllites*? sp. (Fig. 5.3), *Caloceras*? sp. and *Fergusinotites* sp., were found in the talus. These provide further evidence for the presence of the Lower and Middle Hettangian and indicate the potential for further systematic collecting.

Radiolarians were observed in thin sections from the studied section. In the 30 samples processed so far, the tests were secondarily replaced by calcite and could not be separated by acid dissolution. A more abundant and better preserved fauna was reported by Kozur (1993) from the cherty limestone on the upper slope of Vârhegy. Two of our spot collections, made several tens of metres above the measured section, yielded identifiable radiolarians. Several of the genera and some species are common to the fauna documented by Carter et al. (1998) from the Lower Jurassic of the Queen Charlotte Islands. A comparison with the integrated radiolarian and ammonoid biostratigraphy from western Canada, which is currently the best studied region in this regard, allows a more accurate radiolarian dating of the Csóvár section. Based on the overlap of taxon ranges from the upper slopes of Vârhegy, the age of the cherty limestone could range from the early Late Hettangian to the Sinemurian.

Other macrofauna includes, in order of decreasing abundance, bivalves, brachiopods and gastropods. The major faunal turnover caused by the end-Triassic mass extinction allows a gross distinction of Triassic and Jurassic strata based on their bivalve and brachiopod assemblages. Rhaetian beds near the base of the section contain coleoid hooks. Algal filaments, commonly several millimetres in length, are abundant on some bedding planes, and plant macrofossils also occur.

**The Triassic–Jurassic Boundary**

The Triassic–Jurassic boundary has long had a working definition based on ammonoid biostratigraphy; the first appearance of *Psiloceras* is taken to mark the beginning of the Jurassic. *Psiloceras* is rarely found in succession with the zonal index ammonite of the topmost Triassic, *Choristoceras* (Hallam, 1990) but, if our tentative identifications are correct, this occurs in the Csóvár section. Undoubted *Choristoceras* occur at three levels in the basal 10m of the section, and *Psiloceras* if *pacificum*? was recovered nearly 30m above the base of the section; this is the lowest Hettangian ammonoid found in place so far. Therefore the Triassic–Jurassic boundary is constrained to a 19m interval that has not yet yielded ammonoids, except for an *ex situ* phylloceratid of probable Jurassic affinity. Further collecting may refine the position of the Triassic–Jurassic boundary in the section.

**Discussion**

The Csóvár section is a significant addition to the small number of marine Triassic–Jurassic boundary sections. Its major advantages include easy access and good exposure, which is partially man-made but can be easily maintained. No obvious hiatus or significant change in lithology has been observed and the section apparently provides a continuous record of sedimentation. The inferred slope-to-basin transitional depositional environment offers potential for correlating bioevents on the platform and in the basin. However, the paucity of ammonoids prevents the section from being proposed as a candidate GSSP for the base of the Jurassic.

This report is based on the first phase of an integrated stratigraphic study. Apart from the work reported here, a detailed sedimentological study by J. Haas is in progress, and magnetostratigraphic investigations have been started by E. Szalay-Márton. Further biostratigraphic work is planned in the near future, including more detailed macrofossil collecting (ammonoids, bivalves and brachiopods), additional sampling for radiolarians, and sampling for conodonts in the lower part of the section. Further work is expected to lead to a refinement of the position of the Triassic–Jurassic boundary in the section. Establishing a stable isotope profile across the boundary will also be attempted.

Apart from its biostratigraphic significance, the section is expected to provide important information bearing on the paleogeographic and tectonic problems of the Mesozoic in Hungary. The study of resedimented, platform-derived components of the bioclastic limestone may shed light on the demise and re-establishment of carbonate platforms and platform-dwelling organisms at the
Triassic–Jurassic boundary. The faunal data will also be interpreted in the context of the end-Triassic mass extinction and subsequent Early Jurassic recovery.

Acknowledgments

We thank János Haas (Geological Research Group of the Hungarian Academy of Sciences) for fruitful discussions in the field and making his section measurements and lithologic log available. Careful reviews by Geoffrey Warrington and an anonymous reviewer improved the manuscript. Financial support through grants from the Hungarian Scientific Research Fund (OTKA Grant No. F23451 and T25991) is gratefully acknowledged. Presentation of this paper at the 5th Jurassic Symposium was made possible by travel grants to JP from the Soros Foundation and the National Committee for Technological Development (OMFB). JP benefited from a Junior Fellowship at Collegium Budapest at the time of writing the manuscript. Field assistance was provided by Krisztián Pálfi and Péter Solt.

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