Short communication

Clypeorbis? ultima n. sp. from the uppermost Maastrichtian of Austria: The youngest representative of the Clypeorbinae Sigal, 1952 (calcareous benthic foraminifera)?

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1. Introduction

In successions of shallow neritic carbonate rocks, the biotic turnover across the Cretaceous–Paleogene (K–Pg) transition still is comparatively poorly documented (e.g., Keller et al., 1995; Koutsoukos, 2005; Molina, 2015). In the western Tethyan domain, shallow-water K–Pg transitions are known from the Apulian Platform (Vecsei et al., 1998), the Adriatic Platform (Drobne et al., 1996; Caffau et al., 1998; Korbar et al., 2015), and from locations in Turkey (Sirel, 1998, 2015; Inan and Inan, 2014). The carbonate platform sections comprise shelfal to reefal environments and/or internal platform settings with typical benthic foraminifera (e.g., Cuneolina, Rhapydionina). In the Turkish Pontides, in contrast, a mixed siliciclastic-carbonate shelf to delta succession shows an association of red algae, orbitoids (Orbitoides, Lepidorbitoides) and Siderolites calcitrapoides, and is sharply overlain along a hardground by lower Danian limestones of similar facies, but different foraminiferal fauna. The Paleocene part of the Kambühel Formation (Piller et al., 2004) is the type locality of several taxa of dasycladalean algae (Tragelehn, 1996), brachiopods (Dulai et al., 2008: Basilicocostella kambuehelensis), and a decapod crustacean (Verhoff et al., 2008: Titanocarcinus kambuehelensis). The new clypeorbinid Clypeorbis? ultima n. sp. described hereunder is from the uppermost Maastrichtian part of the succession.

2. Geological setting and chronostratigraphy

In the Northern Calcareous Alps of Austria, at a location termed Kambühel, the K–Pg transition is located within a package of shallow neritic limestones (Fig. 1) (Plöchinger, 1967; Tragelehn, 1996). The uppermost Maastrichtian part of the succession is rich in orbitoidal foraminifera (Orbitoides, Lepidorbitoides) and Siderolites calcitrapoides, and is sharply overlain along a hardground by lower Danian limestones of similar facies, but different foraminiferal fauna. The Paleocene part of the Kambühel Formation (Piller et al., 2004) is the type locality of several taxa of dasycladalean algae (Tragelehn, 1996), brachiopods (Dulai et al., 2008: Basilicocostella kambuehelensis), and a decapod crustacean (Verhoff et al., 2008: Titanocarcinus kambuehelensis). The new clypeorbinid Clypeorbis? ultima n. sp. described hereunder is from the uppermost Maastrichtian part of the succession.
Alps (Wagreich and Faupl, 1994). The Gosau Group is preserved in numerous erosional remnants scattered mainly along the Northern Calcareous Alps (NCA, Fig. 1A) (cf. Wagreich and Faupl, 1994). In the Gosau Group, because of copious terrigenous input from emergent areas of the orogen, successions of shallow neritic carbonate rocks were confined to settings sheltered from clastic input (Sanders, 1998); carbonate deposystems included: (a) mixed lithic/bioclastic shore-zone to inner shelf systems, and (b) comparatively small inner-shelf systems with bioconstructions (corals, skeletal sponges, rudists, red algae), bioclastic sand bodies, and more protected backreef areas with typical biota (e.g., calcareous green algae, miliolines foraminifera) (Sanders and Höfling, 2000).

K-Pg transitions known so far from the Gosau Group are in deep-water successions or, where located in neritic sections, comprise significant hiatuses (Wagreich and Faupl, 1994). In the Gosau Group, because of copious terrigenous input from emergent areas of the orogen, successions of shallow neritic carbonate rocks were confined to settings sheltered from clastic input (Sanders, 1998); carbonate deposystems included: (a) mixed lithic/bioclastic shore-zone to inner shelf systems, and (b) comparatively small inner-shelf systems with bioconstructions (corals, skeletal sponges, rudists, red algae), bioclastic sand bodies, and more protected backreef areas with typical biota (e.g., calcareous green algae, miliolines foraminifera) (Sanders and Höfling, 2000). K-Pg transitions known so far from the Gosau Group are in deep-water successions or, where located in neritic sections, comprise significant hiatuses (Wagreich and Faupl, 1994). Plöchinger (1967) first identified the Paleocene shallow-water limestones, yet nearly all of these are present as pebbles to olistoliths in event deposits (debris to finer-grained turbidite beds) of deep-water successions (Lein, 1982). The presence of these clasts in several Gosau erosional remnants suggests a former Paleocene carbonate platform, or platforms, along the internal sector of the Eastern Alpine edifice (Tollmann, 1976; Träglehnen, 1996). The Kambühel location seems to be the only shallow neritic succession of the Alps with a K–Pg transition stratigraphically complete enough to warrant closer investigation. There is no evidence that the Kambühel K–Pg boundary is part of an olistolith: a gentle eastward dip of a few degrees of an overall intact, unconformity-bearing Lower Triassic/Maastrichtian to Thanetian succession provides no evidence for marked syndepositional tilting or internal deformation, as might be expected for an olistolith. In any case, even if it were an olistolith, this does not affect the K–Pg boundary within.

Kambühel is a flat-topped hill approximately 500 × 500 m in plan-view area (Fig. 1B). The hill’s pedestal is a truncated succession of Lower Triassic siltstones to claystones (Werfen Formation) that here pertain to the structurally highest nappe stack of the NCA (Juvavic nappes). Most of Kambühel, however, is part of the Gosau Group that onlaps and overlies the truncated rocks of the Werfen Formation. The lower part of the Gosau here is a gently east-dipping succession of medium- to fine-grained, bioturbated arenites of siliciclastic/bioclastic/lithic composition (Piesting Formation; PF). These arenites contain a late Maastrichtian foraminiferal assemblage (e.g., Orbitoides, Lepidorbitoides, Siderolites calcitrapoides), as well as fragments of rudists, colonial corals, branched bryozoans, red algae, brachiopods, and echinoids. The Piesting Formation, in turn, is followed up-section by a package of similarly gently E-dipping upper Maastrichtian to Paleocene shallow-water limestones (Kambühel Limestone; KL). Unfortunately, the boundary between the PF and the KL is nowhere exposed.

Over much of its vertical extent, the KL consists of faintly thick-bedded to medium-bedded, dark-red to grey weathering, lithobioclastic grainstones to packstones. The K–Pg boundary was spotted in a section along the southeastern flank of Kambühel; the
boundary is a hardground with a highly differentiated small-scale relief, and riddled with macro- and microborings (Figs. 1B–C). A, Upper Maastrichtian wackestone (see Fig. 3 for biochronostatigraphy) with larger benthic foraminifera (e.g., *Siderolites* – S), and riddled with borings (centre of photo). The K–Pg boundary is overlain by lowest Danian packstone with sandstone extraclasts (presumably of Lower Triassic Werfen beds). Thin-section 2015/9. B–C. Lower Danian grainstone to rudstone with red algae, bryozoans, and sandstone extraclasts, sharply overlying uppermost Maastrichtian wackestones with *Clypeorbis? ultima* n. sp. (white rectangles in B). The K–Pg boundary is an irregular surface with thin remains of a ferruginized crust. Thin-sections 2015/25 and 2015/26. D. Detail of ferruginized crusts at K–Pg boundary. Note mixture of upper Maastrichtian larger benthic foraminifera (orbitoidids, *Siderolites*) and planktonic foraminifera (white rectangle – *Heterohelix globulosa* (Ehrenberg); and two arrows). Thin-section 2015/27.

### 3. Material and repository

All illustrated specimens of the new taxon (Figs. 2B pars, 4–5) are from 13 thin sections numbered 2015/5 to 2015/18, and deposited at the Upper Austrian Federal Museum in the city of Linz. The microfacies is documented with three thin-sections (repository numbers 2015/25 to 2015/27) shown in Fig. 2.

### 4. Systematic description


Phylum Foraminiferida d’Orbigny, 1826  
Class Tubothalamea Pawlowski et al., 2013  
Order Rotaliina Delage & Hérouard, 1896  
Superfamily Orbitoidacea Schwager, 1876  
Family Lepidorbitidae Vaughan, 1933
Subfamily Clypeorbinae Sigal, 1952

Genus Clypeorbis Douvillé, 1915

Type species: Orbitoides mammillata Schlumberger, 1902

Clypeorbis? ultima n. sp.

Figs. 2B pars, 4–5

Etymology. ultima = Latin: last, final; referring to the youngest (last) representative of the Clypeorbinae.

Holotype. Axial section, slightly oblique, illustrated in Fig. 4K, thin-section with the number 2015/7 deposited at the Upper Austrian State Museum, Linz.

Paratypes. Sections illustrated in Figs. 4A–J, 5A–I, with differing orientations.

Type material. About 30 randomly oriented specimens in thin-sections.

Horizon and locality. Upper Maastrichtian Kambühel Formation (see Trägeln, 1996). The location with Clypeorbis? ultima n. sp. is located at 47°44′45″N/16°01′46″500″E at the southwestern slope of Kambühel hill (Fig. 1B).

Diagnosis. Small to medium-sized asymmetrical orbitoidiform test with the architectural characteristics of Clypeorbis, thin reduced ventral umbo, voluminous protoconch embraced by a larger deuteroconch positioned close to the ventral surface.

Description. Test asymmetrical in outline, subconical, and planoconvex, formed by main chamberlet layer. The megalospheric embryonic apparatus is bilocular: a subspherical protoconch encompassed by a larger second chamber (deuteroconch) both surrounded by individual thin walls. The deuteroconch encompasses about half of the protoconch. The embryonic apparatus is situated excentrically, close to the ventral test periphery. The embryo is followed by low-trochospiral early chamberlets and a thin median (equatorial) layer of chamberlets situated in a plane below the deuteroconch. The equatorial layer is surrounded laterally on both sides by numerous main chamberlets connected by stolons. In adult test part these chamberlets display radial diameters from 0.06 to 0.09 mm. Umbilicus reduced, and filled with umbilical piles, displaying indistinct vertical canals, and starting from the protoconch. Wall calcareous, perforate.

Dimensions (in brackets data for C. mammillata from Hottinger and Caus, 2007).

Test diameter: up to 2.3 mm (up to 8 mm)
Test height: up to 0.9 mm
Diameter protoconch: 0.11–0.24 mm (0.08–0.1 mm)
Diameter deuteroconch: 0.14–0.4 mm (“almost as voluminous as protoconch”)

The relationship of test diameter against test height is shown in Fig. 6.

Remarks. The orbitoidiform specimens described here from the upper Maastrichtian of the Northern Calcareous Alps clearly represent a taxon so far undescribed. The differences of the new form to Clypeorbis mammillata are here considered to be species-relevant at least, but might even be related to a new genus. Due to some recrystallization of the shell and lack of well-preserved equatorial sections, as well as insufficient detail of embryonic chambers and arrangement (see also Comparison below), the introduction of a new genus is avoided. The described specimens hence are tentatively assigned to the genus Clypeorbis Douvillé.

The general increase in the size of the embryonic chamber is a well-known phylogenetic trend in orbitoidids, such as Orbitoides, Omphalocyclus, or Lepidorbitoides and these size-differences are used beside others to discriminate different species (e.g., Caus et al., 1996; Özcan and Altimir, 1999; Özcan, 2007; Albrich et al., 2014); a similar trend is suggested for Clypeorbis (C. mammillata versus C.? ultima). The morphology of the megalospheric embryonic apparatus of Clypeorbis? ultima structurally compares to the seminephrolepidine orthophragmine embryo type of Paleogene Discocyclinidae (e.g., Özcan et al., 2007, their fig. 2A).

Comparison. The differences of C.? ultima to the type-species Clypeorbis mammillata can be summarized as follows. (1)
C. mammillata attained a larger size of the entire test, e.g., a diameter more than three times that of C.? ultima. Otherwise, we are aware that many of our specimens might belong to juvenile forms. (2) Conversely, the proto and deuteroconch of C.? ultima together are more than twice the width than that of C. mammillata (Fig. 7). (3) The embryonic chambers of the type-species of C. mammillata are located in a more central position of the test. In C.? ultima, these are positioned ventrally, thereby distinctly narrowing the umbilical piles, which form a protruding umbo in C. mammillata (cf. Hottinger and Caus, 2007). In C. mammillata, the arrangement of the initial embryonic chambers is not fully clear. In their revision of the Clypeorbinae, Hottinger and Caus (2007, p. 389) state that the embryo is “non-spiral or reduced to a few spiral chambers, consisting of protoconch and deuteroconch, with two, more-or-less symmetrically arranged auxiliary chamberlets”. Our recrystallized material and lack of adequate equatorial sections do not allow for the observation of any of these auxiliary (peri-embryonic) chamberlets and their arrangement, but just of the
protoconch and deuteroconch. Also details on the canal system are desired information that should be obtainable from better preserved material.

5. Conclusive remarks

The Kambühel Formation at its type-locality in Lower Austria (Eastern Alps) contains one of the rare K–Pg boundary sections in shallow-water carbonate facies. For several lineages and taxa, the K–Pg extinction marks the end of the Late Cretaceous Global Community Maturity (GCM) cycle of larger benthic foraminifera (Turonian to K–Pg boundary event) (Hottinger, 2001; Hottinger and Caus, 2007, 2009). The described Clypeorbis? ultima in uppermost Maastrichtian rocks is the youngest representative of the Clypeorbinae known so far that became extinct only at the end of the Late Cretaceous GCM cycle. Larger benthic foraminifera with

Fig. 5. Clypeorbis ultima? n. sp., uppermost Maastrichtian Kambühel Formation of Austria. Thin-sections 2015/12 (A), 2015/13 (B), 2015/14 (C), 2015/15 (D), 2015/5 (E, F), 2015/16 (G), 2015/17 (H), 2015/18 (I).

Fig. 6. Clypeorbis? ultima n. sp., test diameter against test height.
megalomospheric spherical protoconch embraced by a larger second chamber (deuteroconch), however, are again represented by the Discocyclinidae Galloway during the following Paleocene–Eocene GCM cycle (e.g., Özcan et al., 2007).

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References


