Biotic events around the Norian – Rhaetian boundary from a Tethyan perspective

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Introduction

This is a progress report on the Norian–Rhaetian boundary interval in marine strat of Austria thought to initiate and stimulate the GSSP discussion process and to facilitate the selection of a single boundary marker which - following the intentions of the Subcommission on Triassic Stratigraphy - might be choosen in between the ammonoid *Cochloceras*/*Paracochloceras*, conodonts of the genus *Misikella* (either *M. hernsteini* or *M. posthernsteini*) and the radiolarian *Parvicingula moniliformis* (Orchard, 2003).

The Austrian Salzkammergut region has been known for long as host of the most diverse Tethyan invertebrate faunas found in different basinal environments and lithofacies (Mojsisovics, 1873–1902). Knowledge of their temporal and spatial distribution is now well advanced and should soon arrive at a high-resolution correlation framework of the relevant biomarkers and other stratigraphic tools such as stable isotopes and magnetostratigraphy. Another major issue is the documentation and integration of marine and non-marine palynological events to allow a most widely applicable recognition of the boundary, from deeper offshore settings to marginal marine and terrestrial environments as the latter two are fairly common and cover large areas in the Arctic, in Europe and in south(east)ern Gondwana with presumably high economic potential. Equally of importance is an exact boundary intercalibration of the astrochronologically tuned time scale of the lacustrine Newark basin.

New section data

Search for boundary interval sections in the Salzkammergut has been concentrated on two different formations, which are extraordinary in the Tethys for their fossil record:

1) on the top of the *Hallstatt Limestone Fm.*, a relatively thin (up to 15m), pure calcareous, deeper marine facies with pelagic bivalves (*Monotis*), ammonoids and conodonts. Several classical places are known (e.g. Sommeraukogel, Steinbergkogel, Rossmoos, Millibrunnkogel, Schneckenkogel – Krystyn et al., 1971) most of them, however, without adequate detailed section description. Scheiblkogel is the only, recently bed by bed studied sequence with a conodont based biomagnetostratigraphy but a rather spotty ammonoid record (Gallet et al., 1996). To enlarge the ammonoid data base and reduce the problem of stratigraphic condensation (Scheibelkogel: thickness of boundary interval less then 2m) a restudy of classical sections has been started and has led to the discovery of a new, sedimentary more complete locality on Steinbergkogel with an unexpected rich ammonoid and conodont record.

2) on the basal *Zlambach Fm.*, a much thicker (up to 50m), grey limestone and marl intercalations comprising facies with some black (anoxic) shales, found widespread in ravines between Bad Goisern and Bad Aussee. It is less rich in conodonts and megafossils (with specific ammonoids and *Otapiria*? as pelagic bivalve) but important for the presence of radiolarians (under study by H. Mostler), and it provides an exceptional palynological record (Kürschner et al., 2004).

The **Steinbergkogel** is a small isolated summit located on the "Hallstätter Salzberg" about 2 km WNW of the town of Hallstatt (see fig. 1 in Krystyn et al., 1969). It is composed of a steeply (70°) northward dipping sequence of very thick whitish massive and unfossiliferous Lower Norian Hallstatt limestones overlain by about a 30 m thick, well bedded sequence of predominantly red and in the top grey, finegrained pelagic limestones (bioclastic wackestones) of Middle Norian to lowermost Rhaetian age (in new sense), followed by grey marls of the Zlambach Fm. The upper half of the grey limestones developes thin clay interbeds easing the quarrying of stones for dismantling the galleries of the nearby Hallstatt saltmine in the 19. century. As a result an old since more then 100 years abandoned quarry remained opposite of the Ferdinandstollen which exposes the here described section. Most of the classical Steinbergkogel ammonoid fauna may have resulted from that place but there is another locality about 100 m on strike to the W reported in the literature. This is of slightly younger age and nourishes the suspicion that the old faunal record could have been mixed.

A total thickness of 4m has been investigated and preliminary sampled for both megafossils and conodonts, with their vertical distribution illustrated in figure 1. A palaeomagnetic pilot study has shown good magnetic rock properties and should lead to reliable magnetostratigraphic

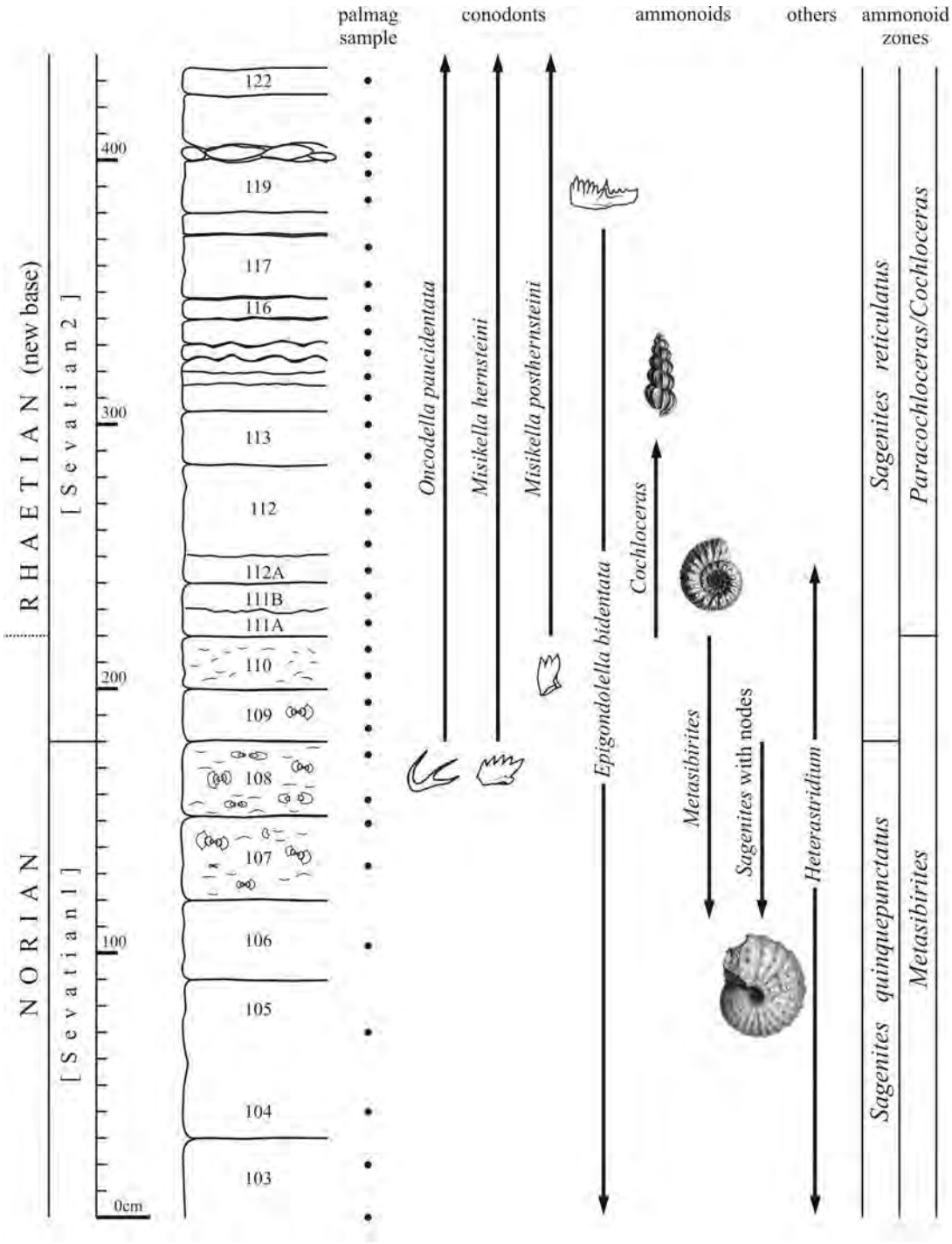

Figure 1: Observed stratigraphic distribution of ammonoids and conodonts in the new Steinbergkogel section.

results (Y. Gallet, pers. comm.). Stable isotope data will be performed from whole rock samples in 2005. With the next excavation campaign the section will be expanded both up- and downwards to

a) include the transition beds towards the Zlambach Fm. for a palynological cross-correlation,
b) integrate the *Cycloceltites* and *Vandaites* bearing fauna of the "White Crinoidal Limestone" from Steinbergkogel summit (Mojsisovics, 1873-1902) to demonstrate its stratigraphic position in relation to the FO of *Paracochloceras*
c) fit the *Monotis* level into sequence.

Of special interest is the 2 m thick interval from bed 107 to 112 where the co-occurence of all boundary-specific ammonoids and conodonts is recorded in sequence (fig. 1) and where the diagnostic biomarkers are fairly common. Two ammonoid zones/intervals are provisionally distinguished, a lower with *Metasibirites* (bed 107 to 110) and an upper with *Paracochloceras*/*Cochloceras* (from bed 111A to 112). Further common and represented in all beds are *Rhabdoceras suessi, Pinacoceras metternichi, Placites, Arcestes, Cladiscites, Rhacophyllites* and *Megaphyllites.* A nodose specimen of *Sagenites* (of *quinquepunctatus* group) in bed 108 testifies the presence of the q*uinquepunctatus*-Zone close to the FO of

Paracochloceras.

To achieve stratigraphically reliable conodont ranges at least 10 kg of limestone have been dissolved from each bed from 108 to 112. This intense search has led to p-element recoveries of 50-100 specimens per sample, with *Epigondolella bidentata* dominating up to bed 110 and replaced by a *Misikella* dominance above. *Norigondolella steinbergensis*, usually the leading faunal element in this time interval is fortunately rare as well as ramiform elements. A first conodont event is to be recorded in bed 109 where *Oncodella paucidentata* and *Misikella hernsteini* appear. The latter species is rare in 109 and 110 (5-10 spec.) but gets frequent from 111A (31) onwards. Bed 111A marks the FO of *M. posthernsteini*, as phylogenetic successor of the forementioned species responsible for the most diagnostic conodont datum in the section, and it is probably the worldwide best documented first appearance date of *M. posthernsteini* in co-occurrence with *Paracochloceras*. With just 2 specimens in 111A and 4 in 111B *M. posthernsteini* is unfortunately very rare at the beginning and becomes frequent (30 spec.) only 30 cm above the FO of the species in bed 112. The initial infrequence highlights the problem how to recognize the FAD of *M. posthernsteini* in biofacially less favourable environments. And application of this event without additional (bio)markers may cause uncertainties in regional or intercontinental correlations.

The **Kleiner Zlambachgraben** is located about 2 km east of Bad Goisern and exposes in an altitude of 860 to 880 m along its southern slope a more than 50 meters thick sequence of alternating deep water limestones (mudstones or sponge spicules and radiolarian bearing wackestones) and marls. The section is known since long for its specific ammonoid fauna dominated by choristoceratids (Krystyn, 1987) and has recently become interesting due to its suitability for palynological investigations. By missing of *Sagenites, Dionites* and *Epigondolella bidentata* a lower conodont and ammonoid diversity is recorded when compared with Steinbergkogel. But co-occurrence of biostratigraphically diagnostic ammonoid, conodont and radiolarian fauna coupled with a rich marine and terrestrial microflora is uncommon in time-equivalent rocks anywhere in the world and offers a unique opportunity to tie otherwise strongly separated zonal schemes or bioevents together.

From base to top the following FOs of diagnostic biomarkers (in meters above base) have been found: at 1m FO of *M. posthernsteini,* at around 25m occurrence of *Praecitriduma mostleri* and *Livarella densiporata*, at 27m FO of *Vandaites saximontanum* and *"Choristoceras" haueri*, at 35m FO of *Paracochloceras* (disappearing at 36m), at 39m FO of *Epigondolella slovakensis* (disappearing at 41m) and at 42m FO of *M. rhaetica.*

Preliminary results of the palynological study can be summarized as follows: Throughout the section the pollen and spore assemblages are dominated by *Granuloperculatipollis rudis, Corollina meyeriana, C. torosus*, and *Ovalipollis pseudoalatus*. Accompanying elements are *Rhaetipollis germanicus, Ricciisporites tuberculatus*, and *Tsugaepollenites pseudomassuleae*. However, two distinct palynological zones can be recognized: sporomorph assemblages from the lower part of the section still include a variety of typical older "Canian" elements (*Enzonalasporites vigens, Vallasporites ignacii, Patinasporites toralis, Ellipsovelatisporites rugosus, Partitisporites* spp., *Triadispora* spp.), whereas higher up in the section new elements, such as *Chasmatosporites* sp., *Quadraeculina anaeliformis, Limbosporites lundbladii* enter the record. Acritarchs are abundant in the lower part of the section whereas dinoflagellate cysts become more frequent in the higher part (*Rhaetogonyaulax,, Suessia, Dapcodinium*). Intriguingly, the transition between the two zones is characterized by a marked increased spore/pollen ratio, while the marine organic-walled phytoplankton record shows an acme of dinoflagellate cysts (*Rhaetogonyaulax, Noricysta, Heibergella*). These events in the palynological record coincide approximately with the *Cycloceltites – Vandaites* event in the ammonoid record mentioned above.

Biostratigraphic implications

Before discussing the preferred boundary option it may be pointed out that the data signal another correlation level previously not considered. Plotted against other bioevents (i.e. distribution of *M. posthernsteini*, *Cycloceltites* and *Vandaites*) occurrence of *Paracochloceras* is evidently different on Steinbergkogel and in the Zlambach. This difference is at best explained by locating them on opposite ends of the genus range and by assuming a stratigraphic range of *Paracochloceras*, which overlaps considerably with many choristoceratids. Joint appearance of *Cycloceltites, Vandaites* and *"Choristoceras" haueri* in the Zlambach (and in the Steinbergkogel-summit fauna) con-committant(?) with the disappearance of *Pinacoceras metternichi* and *Epigondolella bidentata* points to another N-R boundary option close to the *Praecitriduma mostleri* radiolarian date and is related to a significant palynological event that may allow far-reaching intercontinental correlations from the Tethys to the Boreal realm (Kuerschner et al., 2004) and Eastern Gondwana (?).

From Steinbergkogel it now seems clear that the FAD of *M. posthernsteini* correlates to the FO of *Paracochloceras* as it has been supposed by Kozur, 1996. Due to the position in a phylomorphogenetic cline the Steinbergkogel *posthernsteini* date is seen as robust. It is very close to the FO of *M. hernsteini* and obviously much closer then till recently thought (Kozur, 2003). Task of the near future should be to estimate the time duration of the interval between the FADs of the two *Misikella* dates and to figure out how other significant bioevents (FO of *P. monilis*, LO of the genus *Monotis* resp. of *M. salinaria/ ochotica* groups) correlate to one or the other of the two dates. In Canada, Carter (1993) for example used the *Monotis* disappearance as argument to correlate the *moniliformis* Zone with the *Paracochloceras amoenum* Zone and to propose their correlative base as new Norian-Rhaetian boundary. A further essential step is the

intercalibration of the two *Misikella* dates in palynostratigraphic scales based on marine and terrestrial taxa for reasons discussed at the beginning. From the viewpoint of ammonoid biochronology both boundaries are acceptable, the *hernsteini* base by maintaining the present *quinquepunctatus-reticulatus* zonal scheme and the *posthernsteini* date by replacing it through a *Metasibirites-Paracochloceras* zonal sequence.

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