Article

BASE OF THE RHAETIAN AND A CRITIQUE OF TRIASSIC CONODONT-BASED CHRONOSTRATIGRAPHY

Spencer G. Lucas

New Mexico Museum of Natural History, 1801 Mountain Road N. W., Albuquerque, NM 87104 USA. Email: spencer.lucas@state.nm.us

Abstract—Recent analyses render problematic a Rhaetian base defined by a GSSP at Steinbergkogel, Austria, that has the lowest occurrence of the conodont *Misikella posthernsteini* as its primary signal. This problem well exemplifies taxonomic issues and stratigraphic range extensions of Triassic conodonts that have rendered problematic the base Induan GSSP and proposals for the GSSPs of the bases of the Olenekian, Anisian and Norian. Triassic chronostratigraphy should abandon conodont biostratigraphy and return to the ammonoid biostratigraphy upon which the Triassic timescale was originally built.

INTRODUCTION

The Triassic chronostratigraphic scale was built primarily on two centuries of ammonoid biostratigraphy (Lucas, 2010). However, in the 1990s, a movement began to define Triassic chronostratigraphic (stage) boundaries that were correlated primarily by conodonts. At present, one stage boundary (Induan) has a GSSP and four (Olenekian, Anisian, Norian and Rhaetian) are likely to be defined by GSSPs that have their primary signals based on the LOs (lowest occurrences) of conodont species.

Nevertheless, I see diverse problems with conodont-based Triassic chronostratigraphy, including: (1) the relative youth of Triassic conodont taxonomy, which remains unstable for many taxa; (2) the youth of stratigraphic studies of Triassic conodont taxa, so that many Triassic conodonts do not have well-established stratigraphic ranges; (3) reworking of conodonts, which is not easily recognized and rarely addressed (Macke and Nichols, 2007); (4) problems of facies restrictions, diachroneity and provinciality, which do affect Triassic conodont distributions (Clark, 1984); and (5) the invisibility of conodonts on outcrop, so that they cannot be used in the field to determine the ages of strata (Lucas, 2010, 2013).

To a large extent, I believe that Triassic conodont-correlated GSSPs were an answer to longstanding disagreements over taxonomy and correlation among ammonoid specialists (Lucas, 2010, 2013). Thus, as a relatively newly studied taxonomic group (extensive study of Triassic conodonts did not begin until the 1970s), Triassic conodonts did not have the perceived drawbacks of ammonoids—a long history of taxonomic changes and disagreements as well as known provinciality and demonstrably diachronous distributions of some taxa. Furthermore, the ubiquity and perceived cosmopolitanism of conodonts as well as the retirement in the 1990s of the main Triassic ammonoid workers fueled the rise of Triassic conodont-based chronostratigraphy. Nevertheless, it is increasingly clear that Triassic conodonts have all of the drawbacks of the ammonoids and are not inherently superior biostratigraphic tools with which to define Triassic chronostratigraphy.

In the light of recently published work on Rhaetian conodonts, the proposal to use a conodont biostratigraphic datum as the primary signal for a basal Rhaetian GSSP (Krystyn et al., 2007a, b) exemplifies the drawbacks of using conodonts in Triassic chronostratigraphic definitions. These drawbacks support my contention that we should abandon conodonts as a tool for the chronostratigraphic definition of Triassic stages and continue to build the Triassic timescale using ammonoid biochronological events (Lucas, 2013).

SOME HISTORY

Gümbel (1859) used the term "Rhätische Gebilde" to refer to the uppermost Triassic strata (Kössen beds) in the Bavarian Alps. No type locality was specified, but Gümbel did refer to the "Schichten der *Rhaetavicula contorta*" (beds with the bivalve *R. contorta*). Thus, in the first "finished" Triassic chronostratigraphic scale, Mojsisovics et al. (1895) referred to the Rhaetian as the "Zone der *Avicula contorta*."

In ammonoid biostratigraphy, the Rhaetian was long considered equivalent to one or two ammonoid zones (see reviews by Krystyn, 1990 and Krystyn et al., 2007b). Because of this, Tozer (1967, 1988, among others) argued that the Rhaetian was "too short" to be recognized as a stage and should be reduced to a substage of the Norian, a proposal that was followed by some workers during the 1970s and 1980s. However, short stages are superior to long stages because they discriminate short intervals of geological time, one of the primary goals of timescale research (Lucas, 2010, 2013). Therefore, Tozer's argument to eliminate the Rhaetian as a stage because it is "too short" should have been immediately rejected. The real problems of the Late Triassic chronostratigraphic scale should focus on the Carnian and Norian, both very long stages that need to be subdivided. As I have already argued, elevating their substages (Julian, Tuvalian, Alaunian, etc.) to stage status would be a major step forward in development of a Triassic chronostratigraphic scale (Lucas, 2013).

The Subcommission on Triassic Stratigraphy (STS) began its published discussion (in the first issues of the STS journal *Albertiana*) with a lively debate over whether or not to recognize the Rhaetian as a separate stage. This effectively ended by the 1990s, when the STS agreed on a stage nomenclature of the Triassic that recognizes a distinct Rhaetian as the youngest Triassic stage (Visscher, 1992).

At present, the only fully published GSSP candidate for the Rhaetian base is the Steinbergkogel section near Hallstatt, Austria (Krystyn et al., 2007a, b). The favored definition of the Rhaetian base has as its primary signal the LO (lowest occurrence) of the conodont *Misikella posthernsteini* (Fig. 1). This produces a so-called "long" Rhaetian composed of two ammonoid zones. The youngest substage of the Norian, the Sevatian, is thereby reduced to one ammonoid zone.

CONODONTS AND THE BASE OF THE RHAETIAN

The proposal of Krystyn et al. (2007a, b) to define a GSSP for the Rhaetian base at Steinbergkogel offered two possible conodont biostratigraphic datums (and a stratigraphically higher, ammonoid-based level) as candidates for the primary signal of the GSSP--the LO of the conodont *Misikella hernsteini,* and the slightly higher LO of the conodont *M. posterhernsteini* (Fig. 1). The working group voted on the GSSP level, and a majority (61%) chose the *M. posthernsteini* datum (Krystyn, 2010). However, the formal proposal to ratify the base Rhaetian GSSP never went to the ICS.

Some would say that was a fortunate delay, as Giordano et al. (2010) concluded that the LO of *Misikella posthernsteini* is actually younger at Steinbergkogel than it is in the section they studied in the Lagonegro basin in southern Italy. Thus, the LO of *M. posthernsteini* at Steinbergkogel is not the FAD (first appearance datum) of the species. As part of their work, Giordano et al. (2010) presented a chronomorphocline of the species transition from *M. hernsteini* to *M. posthernsteini* (Fig. 2).

However, I see the chronomorphocline of *Misikella hernsteini* to *M. posthernsteini* presented by Giordano et al. (2010) as very incomplete (Fig. 2). Thus, unlike chronomorphoclines proposed in the paleontological literature for some other taxa, such as foraminiferans and fossil mammals (e.g., Hayami & Ozawa, 1975; Bookstein et al., 1978), Giordano et al.'s (2010) conodont chronomorphocline is known only from photographs of supposedly representative steps in the lineage. There are no data on sample sizes, no documentation of variation in samples, no metric data, indeed, none of the detailed information and analyses we should see to convince us that the data robustly support the hypothesized chronomorphocline. Indeed, the lack of any data on variation in the sample at each step in the chronomorphocline makes it an unconvincing portrayal of the evolution of the species.

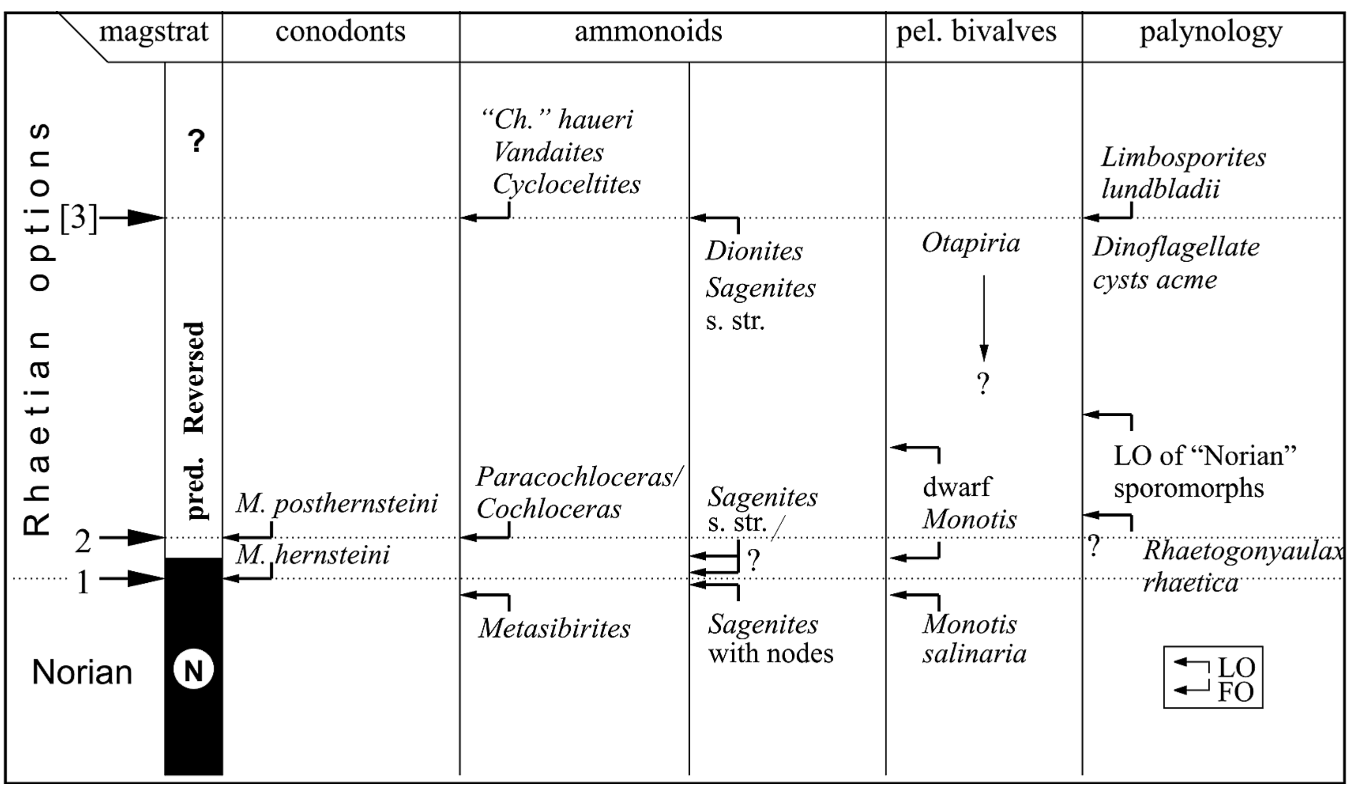

Figure 1–Possible GSSP levels (1, 2, 3) and proxies for the base of the Rhaetian Stage at the Steinbergkogel, Austria, section (from Krystyn et al., 2007a).

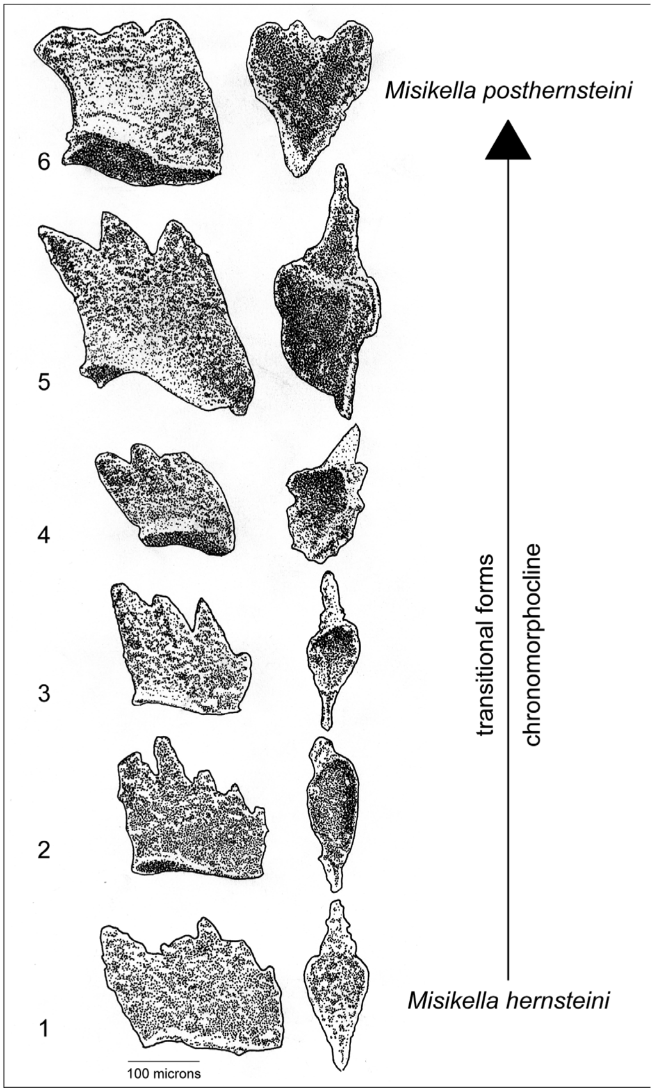

Figure 2 – Hypothesized chronomorphocline from *Misikella hernsteini* to *M. posthernsteini* from the Lagonegro basin in Italy. Conodont images redrawn by Tom Suazo and diagram slightly modified from Giordano et al. (2010, fig. 5). Conodont views on right are basal views of conodonts shown in lateral views on left.

Instead, all we are shown is a succession of ideal morphotypes that may capture the actual chronomorphocline, but without other data and analysis the chronomorphocline must be considered incompletely documented.

Because of this, it is easy to question various aspects of this chronomorphocline. For example, the fact that conodont 4 is similar to 5 (Fig. 2) but only about half its size raises interesting questions about possible conodont ontogeny and heterochronic evolution not addressed by Giordano et al. (2010). Also, why isn't the species-level change from *M. hernsteini* to *M. posthernsteini* between conodonts 4 and 5, and doesn't 4 more resemble 6 in certain morphology than does 5? Furthermore, because we don't know the range of variation at each step of the chronomorphocline, how can we evaluate whether the only conodont illustrated at each level well represents the sample from which it was taken?

In fairness to Giordano et al. (2010), I note that the chronomorphocline of *Misikella hernsteini* to *M. posthernsteini* they present is just as inadequate as conodont chronomorphoclines being proposed in conjunction with Permian stage GSSPs (e. g., Chernykh et al., 2014). To me, it seems that the "corporate culture" of conodont micropaleontologists is to produce chronomorphoclines akin to "connect-the-dots art," instead of the rigorously and metrically documented chronomorphoclines proposed in evolutionary studies of other taxonomic groups. I urge conodont micropaleontologists to document their chronomorphoclines more extensively and more rigorously before they are considered for use in chronostratigraphy.

PROBLEMATIC TRIASSIC CONODONT CHRONOSTRATIGRAPHY

The problems with using conodonts for Triassic chronostratigraphic definitions are growing rapidly. Thus, recent work on conodont records across the Permo-Triassic boundary indicate that the LO of *Hindeodus parvus* at Meishan in south China, which is the primary signal associated with the base of the Induan (= base Triassic) GSSP, is a relatively young occurrence of this taxon (Jiang et al., 2011; Brosse et al., 2015). Thus, the primary signal to correlate the base of the Triassic is diachronous.

In 2007, the working group of the STS voted to favor (though not by a significant majority) a basal Olenekian GSSP at the Mud section in Spiti with its primary signal the LO of the conodont *Neospathodus waageni*. Not long after the vote, *N. waageni* was found to have older occurrences at Mud than previously known, derailing the effort to define this GSSP (Zakharov, 2010).

For at least a decade, the LO of the conodont *Chiosella timorensis* at the Deşli Caira section in Romania was considered the primary signal for a base Anisian GSSP (e.g., Orchard et al., 2007). However, discovery of that species in Spathian strata (Goudemand et al., 2012) extended its stratigraphic range and has derailed definition of a basal Anisian GSSP.

Several conodont datums have been proposed as the primary signal for a GSSP for the Norian base (e.g., Orchard, 2014). Disagreements over conodont taxonomy in this interval seem to impede a decision here (e.g., Mazza et al., 2009, 2012). And, if you disagree with my assertion that Triassic conodont taxonomy is young and untested, examine how many new conodont taxa Orchard (2013, 2014) has just named in his monumental studies of the Carnian-Norian boundary GSSP candidate section at Black Bear Ridge in British Columbia, Canada.

As noted above, the conodont signal for a basal Rhaetian GSSP is problematic. Unfortunately, this has opened the door to those who propose non-unique events as primary signals for GSSPs, such as chemostratigraphy and magnetostratigraphy (e.g., Maron et al., 2015), proposals that should be summarily rejected.

In 2007, at the Global Triassic meeting in Albuquerque, the STS seemed very close to defining GSSPs with conodont signals for the bases of the Olenekian, Anisian, Norian and Rhaetian. Now, nearly a decade later, these GSSPs remain undefined because of stratigraphic range extensions and/or taxonomic problems with the conodonts. I think the time is long past due to abandon conodonts and return to ammonoids as the primary signals upon which to correlate Triassic chronostratigraphic boundaries.

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