



The Late Triassic timescale: Age and correlation of the Carnian–Norian boundary

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ABSTRACT

The Late Triassic timescale is poorly constrained due largely to the dearth of reliable radioisotopic ages that can be related precisely to biostratigraphy combined with evident contradictions between biostratigraphic and magnetostratigraphic correlations. These problems are most apparent with regard to the age and correlation of the Carnian–Norian boundary (base of the Norian Stage). We review the available age data pertaining to the Carnian–Norian boundary and conclude that the “long Norian” in current use by many workers, which places the Carnian–Norian boundary at ~228 Ma, is incorrect. The evidence supports a Norian stage that is much shorter than proposed by these workers, so the Carnian–Norian boundary is considerably younger than this, close to 220 Ma in age. Critical to this conclusion is the correlation of the Carnian–Norian boundary in nonmarine strata of Europe and North America, and its integration with existing radioisotopic ages and magnetostratigraphy. Three biostratigraphic datasets (palynomorphs, conchostracans and tetrapods) reliably identify the same position for the Carnian–Norian boundary (within normal limits of biostratigraphic resolution) in nonmarine strata of the Chinle Group (American Southwest), Newark Supergroup (eastern USA–Canada) and the German Keuper. These biostratigraphic datasets place the Carnian–Norian boundary at the base of the Warford Member of the lower Passaic Formation in the Newark Basin, and, as was widely accepted prior to 2002, this correlates the base of the Norian to a horizon within Newark magnetozone E13n. In recent years a correlation based solely on magnetostratigraphy has been proposed between the Pizzo Mondello section in Sicily and the Newark section. This correlation, which ignores robust biostratigraphic data, places the Norian base much too low in the Newark Basin section (~at the base of the Lockatong Formation), correlative to a horizon near the base of Newark magnetozone E8. Despite the fact that this correlation is falsifiable on the basis of the biostratigraphic data, it still became the primary justification for placing the Carnian–Norian boundary at ~228 Ma (based on Newark cyclostratigraphy). The “long Norian” created thereby is unsupported by either biostratigraphic or reliable radioisotopic data and therefore must be abandoned. While few data can be presented to support a Carnian–Norian boundary as old as 228 Ma, existing radioisotopic age data are consistent with a Norian base at ~220 Ma. Although this date is approximately correct, more reliable and precise radioisotopic ages still are needed to firmly assign a precise age to the Carnian–Norian boundary.

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1. Introduction

During the last 30 years, remarkable progress has been made in defining and refining a global timescale for the Triassic Period, particularly due to the efforts of the Subcommittee on Triassic Stratigraphy (STS) of the IUGS International Commission on Stratigraphy (Lucas, 2010a, 2010b). Traditionally, the biostratigraphy of conodonts and ammonoids has provided the foundation of the Triassic timescale (e.g., Mojsisovics, 1882a, 1882b; Mojsisovics et al., 1895; Mojsisovics, 1902; Tozer, 1967, 1971, 1974, 1984; Kozur, 1980; Krystyn, 1991; Kozur, 2003; Krystyn, 2008; Balini et al., 2010; Orchard, 2010), supplemented by other marine fossils. Most notable of these are radiolarians and bivalves (e.g., Dumitrică, 1978a, 1978b; Kozur and Mostler, 1979; Nakaseko and Nishimura, 1979; Pessagno et al., 1979; Dumitrică et al., 1980; Kozur and Mostler, 1981; Dumitrică, 1982a, 1982b, 1982c; Yao, 1982; Yao et al., 1982; Yao, 1990; Yeh, 1990; Carter, 1993; Kozur and Mostler, 1994, 1996; Tekin, 1999; DeWever et al., 2001; McRoberts, 2010; O'Dogherty et al., 2010), but there is a growing contribution from some nonmarine fossil groups, such as palynomorphs, conchostracans and tetrapod vertebrates (e.g., Schulz, 1962; Mädler, 1964; Schulz, 1965; Scheuring, 1970; Chang et al., 1976; Visscher and Brugman, 1981; Kozur and Seidel, 1983a, 1983b; Orłowska-Zwolińska, 1985; Lucas, 1998, 1999; Kozur and Weems, 2005; Schulz and Heunisch, 2005; Kozur and Weems, 2007; Lucas, 2010c; Kozur and Weems, 2010a; Cirilli, 2010; Kuerschner and Hergreen, 2010). The integration of Triassic biostratigraphy with radioisotopic ages and magnetostratigraphy also has advanced significantly during the past three decades (e.g., Szurlies, 2001; Bachmann and Kozur, 2004; Hounslow et al., 2004; Kozur and Bachmann, 2008; Ogg et al., 2008; Kozur and Bachmann, 2010b; Hounslow and Muttoni, 2010; Mundil et al., 2010).

Even so, serious problems remain with regard to the Late Triassic timescale due to a dearth of reliable radioisotopic ages that can be related precisely to biostratigraphy and also to some evident contradictions between biostratigraphic and magnetostratigraphic correlations. These problems are most apparent with regard to the age and correlation of

the Carnian–Norian boundary (base of the Norian Stage). Here, we review the age data that pertain to the Carnian–Norian boundary and conclude that the “long Norian” in current use by many workers, which places the Carnian–Norian at ~228 or 229 Ma (e.g. Krystyn et al., 2002; Gallet et al., 2003; Muttoni et al., 2004) lacks robust support and that the Carnian–Norian boundary is much younger, close to 220 Ma. Critical to this conclusion is the correlation of the Carnian–Norian boundary in nonmarine strata of Europe and North America (Fig. 1), and its integration with existing radioisotopic ages and magnetostratigraphy.

2. Carnian–Norian boundary in the marine section

At present, no Global Stratotype Section and Point (GSSP) has been established to define the base of the Norian Stage. The working definition for the Norian base has long been the base of the *Stikinoceras kerri* ammonoid zone in the North American succession (e.g., Silberling and Tozer, 1968; Tozer, 1994; Krystyn et al., 2002; Kozur, 2003; Ogg, 2004; Balini et al., 2010) (Fig. 2). In the Tethyan realm, this level is approximately equivalent to the boundary between the *Anatropites spinosus* and *Guembelites jandianus* ammonoid zones (Krystyn, 1980; Krystyn et al., 2002; Ogg, 2004; Balini et al., 2010). The STS appears likely to propose to define the Carnian–Norian boundary formally by a conodont datum at one of two proposed GSSP locations: Black Bear Ridge on Williston Lake in British Columbia, western Canada, or Pizzo Mondello in Sicily, Italy (e.g., Muttoni et al., 2004; Orchard, 2007; Nicora et al., 2007).

Orchard (2010) has provided the most recent summary of the current status of a conodont-defined Norian base, noting that at a combination of different sections in western Canada there is a good correspondence between ammonoid, bivalve, and conodont faunal changes at, or close to, the traditional boundary level (Orchard et al., 2001; McRoberts, 2007, 2010). However, the North American Norian conodont succession contains several endemic forms that are not present in the Eurasian Tethys. Moreover, although Black Bear Ridge has a good conodont and halobiid bivalve record across the Carnian–Norian boundary, it has no radiolarians, relatively few

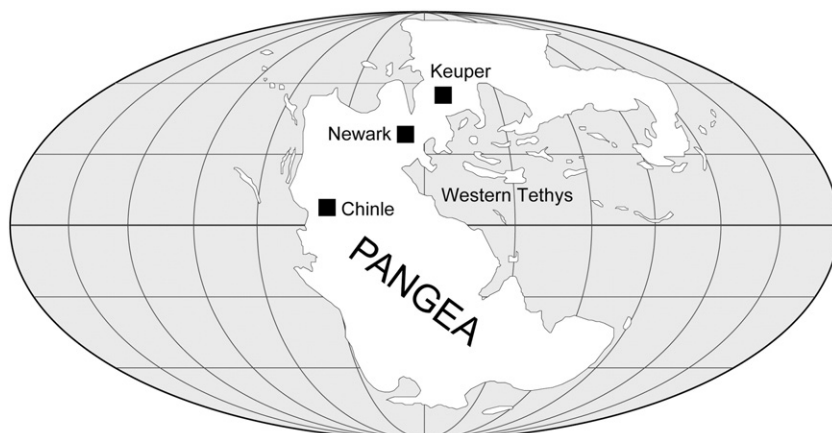


Fig. 1. Map of Late Triassic Pangaea (from McRoberts, 2010) showing locations of Chinle Group, Newark Supergroup and Keuper sections discussed in text. The marine Carnian–Norian boundary sections (including Pizzo Mondello) discussed in the text were located in western Tethys.

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