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Parafurnishius, an Induan (Lower Triassic) conodont new genus from northeastern Sichuan Province, southwest China and its evolutionary implications

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Abstract

A fundamental aspect of taxonomy at the generic level, critical to understand Early Triassic conodont evolution, is the composition of the multielement apparatus. In this paper, we document a platform-bearing new conodont genus, *Parafurnishius* n. gen., as well as its multielement apparatus from the Griesbachian Feixianguan Formation (Lower Triassic) in Xuanhan County, northeastern Sichuan Province, southwest China. The new conodont genus is characterized by numerous robust and irregularly distributed conical denticles with variable platform morphology that has a possible affinity with the P_1 elements of *Furnishius*. These genera have apparatuses similar to those of *Ellisonia* and are classified with the family Ellisoniidae. The strong intraspecific variation of P_1 elements and the growth series within the entire sample population suggest that *Parafurnishius* may have evolved from the Griesbachian *Isarcicella* by developing random denticle positioning away from the platform centre, and then possibly evolved into younger Triassic *Furnishius* by developing a stable blade configuration. This preferred interpretation implies an ellisonid apparatus for *Isarcicella*. Alternatively, *Parafurnishius* may have evolved from *Ellisonia* and developed a homeomorphic P_1 element with *Isarcicella*. This new taxon has strong intraspecific variation of denticle growth orientation during the Early Triassic.

Keywords: *Parafurnishius*; Conodonts; Apparatus; Lower Triassic; Evolution

1. Introduction

Conodonts are a fossil group that was less affected compared with other groups in terms of biodiversity decline during the end-Permian mass extinction interval. However, they were changed at species and genus level across the Permian–Triassic boundary (PTB) interval. *Clarkina*-dominated communities during the Lopingian (Late Permian) were replaced by *Hindeodus*-dominated communities just below the PTB. This community change generally marks the onset of the end-Permian mass extinction (Lai et al., 2001; Jiang et al., 2007; Orchard, 2007; Chen et al., 2008; Yuan and Shen, 2011; Wu et al., 2014; Yuan et al., 2014); both of these genera became extinct; however, at about the end of the Griesbachian (Henderson and Mei, 2007). Unlike many benthic fossil groups, conodont diversity rapidly increased during the Dienerian or late Induan to Smithian or early Olenekian (Orchard, 2007; Plasencia et al., in press) and many new Lower and Middle Triassic conodonts have been reported and systematically described by previous studies (Müller, 1956; Clark, 1959; Clark et al., 1964; Huddle, 1970; Hirsch, 1972, 1975, 1977; Bandel and Waksmundzki, 1985).

The evolutionary relationship of the Early Triassic conodonts is a very interesting topic and Orchard (2007) provided a thorough review of evolutionary and diversity changes for Lopingian and Early Triassic conodonts. It has been shown that three families, Gondolellidae, Anchignathodontidae, and Ellisoniidae, survived up to, and crossed the PTB without major change, and then became the ancestors of highly diversified conodonts

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in the Triassic. However, some taxonomic and evolutionary relationships within these three families are still unclear. For instance, it has been widely documented that the genus *Isarcicella* evolved from the genus *Hindeodus* (Kozur, 1989, 1996; Perri and Farabegoli, 2003; Orchard, 2007). However, further evolutionary lineages within this clade remain unknown. The phylogenetic relationship between the early Induan Ellisoniidae elements and a few genera during late Early and Middle Triassic such as *Furnishius* and *Parapachycladina* are also questionable (Orchard, 2007, fig. 1).

Previously, there are relatively few records of conodonts with ornate planate elements from the Lower Triassic sequence in South China except for surviving species of *Clarkina*. Elements with numerous denticles on the platform have rarely been reported from the Induan, but are more common during and after the Spathian. *Eurygnathodus* Staesche, 1964 is one genus with planate element that appears in the late Dienerian (Orchard, 2007) and possesses aligned nodes, ridges, and a broad basal cavity; some have regarded it as a synonym of *Platyvillosus* (Wang, 1987). Wang and Cao (1981) reported *Platyvillosus paracostatus* from the third member of the Feixianguan Formation above the *Neospathodus waageni* Zone in Lichuan, western Hubei Province, South China, which is early Smithian. Clark et al. (1964) also described the rounded platform conodont *Platyvillosus* from the lower Spathian in Nevada, western USA. Its type species *Platyvillosus asperatus* Clark, Sincavage and Stone, 1964 bears irregularly arranged nodes on the platform. *Eurygnathodus* and *Platyvillosus* are regarded as members of the Neogondolellidae by Orchard (2007). *Pseudofurnishius* with the type species *Pseudofurnishius murcianus* van den Boogaard, 1966 from the Middle Triassic has elements containing blade and ornate platform (van den Boogaard, 1966; van den Boogaard and Simon, 1973; Ramovs, 1977, 1978; Rakus, 1981; Marquez Aliaga et al., 1999; Plasencia et al., 2010, in press) and is considered as a gondolellid. Other ornate genera belonging to the Ellisoniidae include *Foliella* Budurov and Pantic, 1973, which is a node-bearing element that appears in the upper Smithian (Kozur and Mostler, 1982) and *Furnishius* (Clark, 1959; Mark, 1979), which is a genus with "Y" shape pattern, irregularly distributed denticles and a keel on the aboral surface. The evolutionary relationship of these platform-bearing conodonts was interpreted to have derived from the Early Triassic Ellisoniidae (Orchard, 2007). The genus *Ellisonia* originated from the Carboniferous based on a variable multielement apparatus that lacked a platform element. For example, according to von Bitter and Merrill (1983) Pennsylvanian species included 2 to 5 element types, Permian species had 3 element types and *Ellisonia triassica* (Induan) had up to 5 element types. Orchard (2007) indicated that some ellisonid elements referred to *Hadrodontina* or *Pachycladina* may actually be parts of apparatuses of other taxa. In the Treatise of Invertebrate Palaeontology (Clark et al., 1981), *Hadrodontina* is illustrated with two P_1 element-types including one with a secondary denticle row and one without; perhaps these would now constitute P_1 and P_2 elements respectively. In other words, the apparatus composition and evolutionary relationships of ellisonid taxa are poorly understood, largely because they typically occur in samples as rare elements in association with other taxa. Ellisonid elements are typically only common in samples from shallow, somewhat restricted marine environments (von Bitter and Merrill, 1983). Ellisonid taxa mostly have relatively robust apparatuses, but planate elements of many species are unknown. The apparatus includes S elements with widely spaced discrete denticles that are large and circular in cross-section (not compressed) and with an expanded recessive basal margin. The one natural bedding assemblage described by Koike et al. (2004) does not contain platform elements, but the eleven elements depicted could be interpreted as incomplete with the planate elements missing or not exposed.

Evolution of the multielement apparatus is a fundamental aspect of taxonomy to understand the evolution of conodonts and their recovery and radiation during the Early Triassic (Orchard, 2005). Previously, many Triassic apparatuses were regarded as different genera or species based on disjunct element collections. In this paper, we report a new ellisonid conodont genus on the basis of more than 200 specimens from a horizon of Griesbachian age in the Lower Triassic Feixianguan Formation at the Panlongdong Section in Xuanhan County, northeastern Sichuan Province, southwest China (Fig. 1). This sample is key because it is dominated by one platform-type and ellisonid ramiforms that we interpret as a single apparatus. We also discuss alternative evolutionary relationships for this new taxon.

2. Geological setting and stratigraphy

The Panlongdong Section is about 8 km from the Yanggudong Tunnel in Xuanhan County, northeastern Sichuan Province (Fig. 1). The Permian and Triassic sequences consist of the Lopingian (Upper Permian) Wuchiaping and Changhsing formations and the Lower Triassic Feixianguan Formation, which are the key horizons for exploration of oil and gas in this area (Mou, 2003). The Lopingian Wuchiaping and Changhsing formations are characterized by massive reef limestone that is regarded as a source rock for abundant natural gas (Mou, 2003; Ma et al., 2004, 2007). The Permian–Triassic transition is marked by a dolostone unit about 80 m thick. The PTB is placed at the lowest 5 m in the dolostone unit based on the first occurrence of the conodont *Hindeodus parvus*, extremely abundant lingulids, some Triassic bivalve such as *Claraia*, and *Eumorphotis*, and the negative carbon isotope excursion (Cao et al., 2010; Shen et al., 2013). The Feixianguan Formation is about 400 m thick. It consists of four members. They are the dolostone member, the purple mudstone and argillaceous limestone member, the thick-bedded massive oolite and limestone member and the upper purple mudstone and argillaceous limestone member in ascending order (Fig. 2). The lower Feixianguan Formation is represented by restricted and evaporate platform deposits during the early Early Triassic in this area, which is consistent with the occurrence of abundant elements of this new ellisonid taxon.

Ten samples were collected in an interval about 10 m thick in limestone interbedded with oolite of the Feixianguan Formation about 200 m above the base of the dolostone member from the Panlongdong Section; more than 200 conodont specimens were found from one sample (Sample −15.5 m) (31°45.190′N, 108°27.608′E). Other samples are mostly barren of conodonts