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A newly discovered earliest Triassic chert at Gaimao section, Guizhou, southwestern China

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ABSTRACT

The Permian–Triassic (PTB) boundary section at Gaimao (Huaxi District, Guiyang, Guizhou Province) records a unique lithological transition between the Permian and Triassic in South China. Thus, bioclastic limestones of the Changxing Formation are overlain by radiolarian-bearing siliceous rocks of the Dalong Formation and ultimately limestone/mudstone alternations of the Shabaowan Formation. Conodont sampling of the section revealed well-preserved elements that enabled a conodont biostratigraphy to be established. The occurrences of *Hindeodus julfensis* and *Hindeodus typicalis* in Changxing Formation bioclastic limestone indicate a Late Permian age. Four conodont zones have been established in Dalong and Shabaowan Formations. In ascending order those are the *Isarcicella isarcica* Zone, *Neogondolella* (or *Clarkina*) *planata* Zone, *Neogondolella krystyni* Zone and *Neospathodus dieneri* Zone. The presence of typical Griesbachian conodonts *I. isarcica* and *Isarcicella staeschei* in upper Dalong Formation indicates that this formation's radiolarian-bearing siliceous mudrocks are of earliest Triassic age and not restricted to the Permian as previously thought. Thin section analysis reveals that the upper Dalong Formation contains spheroidal radiolarians but not a diverse assemblage of Permian holdover taxa. The new data proves that, following the end-Permian mass extinction of radiolarian, the abundance of these siliceous planktons was maintained at least locally enabling chert deposition to persist. Thus, the Gaimao section provides an exception to the 'Early Triassic Chert Gap', the first of its kind in Palaeo-Tethys, and indicates that the end of chert deposition does not always mark the end-Permian mass extinction.

1. Introduction

The end-Permian saw the largest mass extinction in life's history with 80–96% of species disappearing (Sepkoski, 1981; Raup and Sepkoski, 1982; Jin et al., 2000; Erwin et al., 2002; Erwin, 2006; Kozur, 2007) with major groups such as rugose corals that were totally wiped out (Stanley, 2003) and others, such as the radiolarian and foraminifera nearly, so (Racki, 1999; Tong and Shi, 2000). Numerous extinction mechanisms have been suggested to explain the causes of the end Permian biotic extinction (Renne et al., 1995; Knoll et al., 1996; Isozaki, 1997; Becker et al., 2001; Kaiho et al., 2001; Wignall and Twitchett, 2002a; Grice et al., 2005; Riccardi et al., 2006; Knoll et al., 2007; Yin et al., 2007; Cao et al., 2009) with ocean anoxia/euxinia (anoxic/sulphidic conditions) proposed as one of the most important causes (Wignall and Twitchett, 1996; Isozaki, 1997; Wignall and Twitchett, 2002a; Riccardi et al., 2006; Meyer et al., 2008; Cao et al., 2009). The spread of anoxia coincides with the disappearance of chert deposition in many sections, notably the abyssal sections in Japan, British Columbia and Nevada (Isozaki, 1997; Wignall and Twitchett, 2002b; Wignall and Newton, 2003; Sperling and Ingle, 2006). Thus, an Early Triassic 'chert gap' follows on from the distinctive Permian Chert Event (PCE): a widespread episode of biogenic chert accumulation along the northwest margin of Pangaea, and possibly worldwide that lasted for 30 Myr from Middle to Late Permian (Murchey and Jones, 1992; Beauchamp and Baud, 2002). The Late Permian and Middle Triassic pelagic chert sections of Japan and British Columbia, Canada show a remarkably symmetrical change, from bedded chert to siliceous claystone to carbonaceous claystone at the Permian–Triassic boundary (PTB) followed by a return of the same succession of facies in the Early Triassic (Kakuwa, 1996; Isozaki, 1997; Kato et al., 2002). Similar lithologic change is also observed in pelagic sequences in Nevada (Sperling and Ingle, 2006), Russia (Sikhote–Alin) (Filippov and Kemkin, 2003), Oman and South China (Cordey et al., 1999; Isozaki et al., 2007). In eastern Palaeo-Tethys, the PTB occurs in a radiolarian-free carbonaceous black shale overlain by red to grey to variegated grey shale (Sashida et al., 2000; Sashida and Salyapongse, 2002). There is a similar absence of chert deposition in the Boreal shelf seas where spiculites are abruptly

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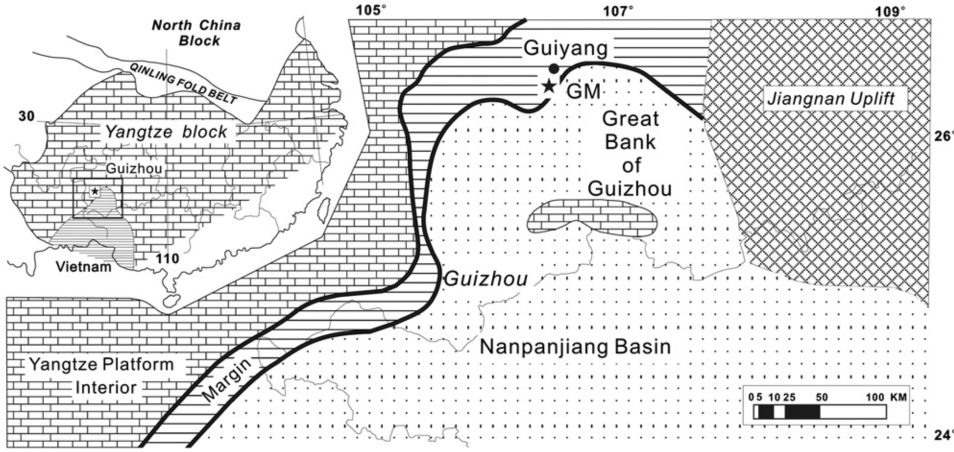

Fig. 1. Early Triassic palaeogeographic map of the Nanpanjiang Basin, modified from (Lehrmann et al., 2003). Inset is a tectonic map of South China modified from (Sun et al., 1989), ★ — location of Gaimao section.

replaced by shales in the end Permian (Wignall et al., 1998). Following the near-global absence of chert in the Early Triassic, siliceous deposition resumed in the pelagic realm during the early Middle Triassic (Anisian) after an 8–10 Myr hiatus (Beauchamp and Baud, 2002). Hitherto, only a pelagic section in New Zealand (Arrow Rocks) is known to record chert deposition across the PTB transition (Takemura et al., 2002; Yamakita et al., 2007) whilst elsewhere deep-water PTB transitional facies are in black shales and/or black claystone sections (Isozaki, 1994; Kakuwa, 1996; Isozaki, 1997; Sperling and Ingle, 2006; Takahashi et al., 2009). Some Japanese sections commonly have thin, interbeds of radiolarian chert and siliceous claystone within Early Triassic black shales that record transient recovery of radiolarian productivity in the earliest Triassic (Kakuwa, 1996; Takahashi et al., 2009; Sano et al., 2010).

Here we document the Gaimao section of southwestern China that contains an exceptional record of earliest Triassic chert deposition which contrasts uniquely with all other sections in China and most sections elsewhere in the world.

2. Geological background of Gaimao section

Gaimao section is located on a hillside, 100 m east of Gaimao village, Huaxi, Guiyang City, Guizhou Province, South China. Palaeogeographically, it is located on the north margin of Nanpanjiang Basin (Fig. 1). In the Early Triassic, the Huaxi District of Guiyang was situated in a transitional setting between a shallow-water carbonate platform and a deep-water basin (Enos et al., 1997). The entire Guizhou Province is a part of the South China Block, which was located in equatorial eastern Tethys during the Early Triassic (Tong and Yin, 2002).

In ascending order, the exposed strata at Gaimao section are: bioclastic limestones of the Late Permian Changxing Formation, black thin-

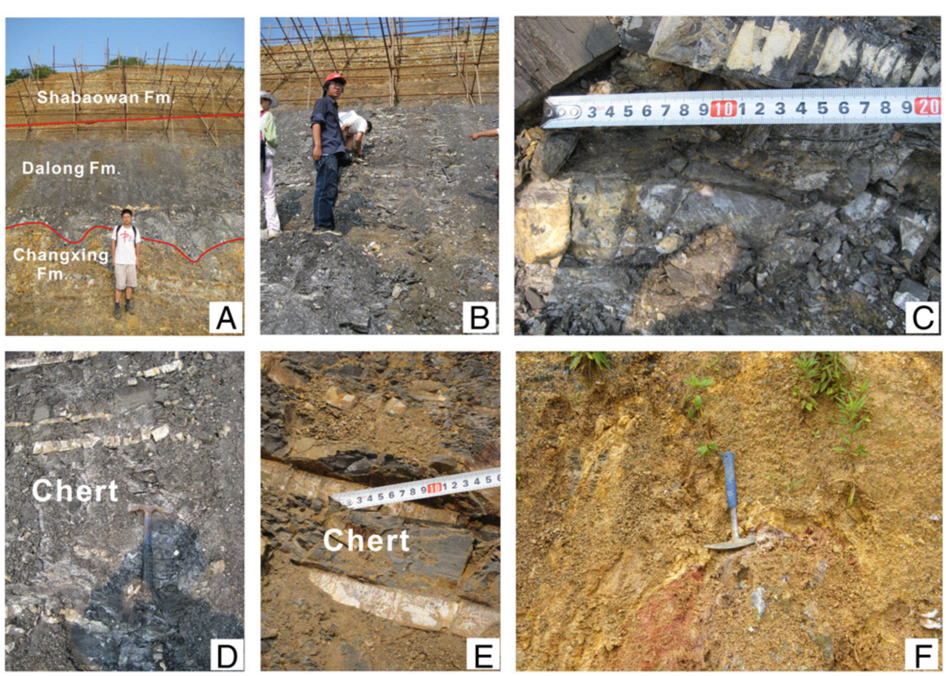

Fig. 2. Photos of field outcrop and rocks at Gaimao section in Huaxi, Guizhou Province.A, B, Panorama of Gaimao section; C, Location of sample GMC-4; D, chert with siliceous mudstone interbedded in the Bed 7 of Dalong Fm; E, bedded chert with siliceous mudstone interbedded in the Bed 9 of Dalong Fm; F, ferruginous crust of weathering between the interface of Changxing Formation bioclastic limestone and Dalong Formation chert.