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An integrated biostratigraphy (conodonts and foraminifers) and chronostratigraphy (paleomagnetic reversals, magnetic susceptibility, elemental chemistry, carbon isotopes and geochronology) for the Permian–Upper Triassic strata of Guandao section, Nanpanjiang Basin, south China

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ABSTRACT

The chronostratigraphy of Guandao section has served as the foundation for numerous studies of the end-Permian extinction and biotic recovery in south China. Guandao section is continuous from the Permian–Triassic boundary to the Upper Triassic.

Conodonts enable broad delineation of stage and substage boundaries and calibration of foraminifer biostratigraphy as follows. Changhsingian–Griesbachian: first *Hindeodus parvus*, and first appearance of foraminifers *Postcladella kalhori* and *Earlandia* sp. Griesbachian–Dienerian: first *Neospathodus dieneri*, and last appearance of foraminifer *P. grandis*. Dienerian–Smithian: first *Novispathodus waageni* and late Dienerian first appearance of foraminifer *Hoyenella* ex gr. *sinensis*. Smithian–Spathian: first *Nv*? *crassatus* and last appearance of foraminifers *Arenovidalina* n. sp. and *Glomospirella* cf. *vulgaris*. Spathian–Aegean: first *Chiosella timorensis* and first appearance of foraminifer *Meandrospira dinarica*. Aegean–Bithynian: first *Nicoraella germanica* and first appearance of foraminifer *Pilammina densa*. Bithynian–Pelsonian: after last *Neogondolella regalis*, prior to first *Paragondolella bulgarica* and first appearance of foraminifer *Aulotortus eotriasicus*. Pelsonian–Illyrian: first *Pg. excelsa* and last appearance of foraminifers *Meandrospira*? *deformata* and *Pilamminella grandis*. Illyrian–Fassanian: first *Budurovignathus truempyi*, and first appearance of foraminifers *Abriolina mediterranea* and *Paleolituonella meridionalis*. Fassanian–Longobardian: first *Bv. mungoensis* and last appearance of foraminifer *A. mediterranea*. Longobardian–C ordevolian: first *Quadralella polygnathiformis* and last appearance of foraminifers *Turriglomina mesotriasica* and *Endotriadella wirzi*.

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The section contains primary magnetic signature with frequent reversals occurring around the Permian–Triassic, Olenekian–Anisian, and Anisian–Ladinian boundaries. Predominantly normal polarity occurs in the lower Smithian, Bithynian, and Longobardian–Cordevolian. Predominantly reversed polarity occurs in the upper Griesbachian, Induan–Olenekian, Pelsonian and lower Illyrian. Reversals match well with the GPTS. Large amplitude carbon isotope excursions, attaining values as low as −2.9‰ $\delta^{13}C$ and high as +5.7‰ $\delta^{13}C$, characterize the Lower Triassic and basal Anisian. Values stabilize around +2‰ $\delta^{13}C$ through the Anisian to Carnian. Similar signatures have been reported globally. Magnetic susceptibility and synthetic gamma ray logs show large fluctuations in the Lower Triassic and an overall decline in magnitude of fluctuation through the Middle and Upper Triassic. The largest spikes in magnetic susceptibility and gamma ray, indicating greater terrestrial lithogenic flux, correspond to positive $\delta^{13}C$ excursions. High precision U–Pb analysis of zircons from volcanic ash beds provide a robust age of 247.28 ± 0.12 Ma for the Olenekian–Anisian boundary at Guandao and an age of 251.985 ± 0.097 Ma for the Permian–Triassic boundary at Taiping. Together, the new U–Pb geochronology from the Guandao and Taiping sections suggest an estimated duration of 4.71 ± 0.15 Ma for the Early Triassic Epoch.

1. Introduction

Guandao section occurs on the northern flank of an isolated carbonate platform, the Great Bank of Guizhou (GBG) in the center of the Nanpanjiang Basin in southern Guizhou Province (Fig. 1). The GBG and Guandao section hold importance as a key reference for correlation in the basin because the GBG is the best exposed and has the longest history among isolated carbonate platforms within the basin. The basin center position of the GBG, far from terrestrial influence, the high subsidence rates yielding a continuous record of marine sedimentation, and the presence of continuous exposures across the platform to basin profile make this area ideal for studies of platform evolution, the end-Permian mass extinction and Triassic biotic recovery.

Guandao section is composed primarily of deep-marine pelagic carbonates with abundant microfossils punctuated by carbonate turbidite and debris-flow breccia beds that contain shallow-marine biota shed from the adjacent platform. Physical and carbon isotope correlations tie the deep-marine record at Guandao with shallow-marine record of the GBG (Payne et al., 2004; Meyer et al., 2011; Kelley, 2014). Further advantages of Guandao section for chronostratigraphy include the presence of numerous volcanic ashes, preservation of magnetic reversals, and record of high-magnitude carbon isotope excursions (Lehrmann et al., 1998, 2005, 2006; Payne et al., 2004).

Guandao has served as a key section for age calibration supporting a wide range of studies on carbonate platform evolution (Lehrmann et al., 1998, 2005; Kelley, 2014) patterns of reef evolution (Payne et al., 2006a), patterns of abundance, diversity and size of fossils during Permian extinction and recovery (Payne et al., 2006b, 2011; Tong et al., 2007; Song et al., 2011), and geochemical studies of carbon isotopes, strontium isotopes, and redox sensitive elements (Payne et al., 2004; Tong et al., 2007; Meyer et al., 2011, 2013; Schaal et al., 2011: Lau et al., 2013; Song et al., 2011, 2013). The section has been resampled several times for conodonts, and portions of the biostratigraphic data, magnetostratigraphy and geochronology have been published as a contribution to stage boundary definition (Lehrmann, 1993; Lehrmann et al., 1998, 2005, 2006; Payne et al., 2004; Wang et al., 2005; Orchard et al., 2007). Much of the available data however, has been published only in schematic form or remains unpublished. The purpose of this paper is to present the integrated conodont and foraminifer biostratigraphic data for the entire Guandao section and to provide integration with available paleomagnetic reversal, magnetic susceptibility and carbon isotope data. In addition to graphic plots the data is presented in a database in an online repository (http://dx.doi.org/10.1594/PANGAEA.836206). The calibration of the benthic foraminifer biostratigraphy with conodont stage/substage age assignment promises to improve age definition with foraminifers elsewhere. The integrated dataset provides new magnetostratigraphic data to supplement the GPTS especially for the Anisian–Ladinian portion of the section. Finally, publishing the entire Guandao data set should be a significant benefit to future studies of the Permian–Triassic history of the Guandao section and south China.

2. Geologic setting

The Guandao section occurs on the basin-margin slope on the northern flank of a Permian–Triassic platform, the Great Bank of Guizhou in the Nanpanjiang Basin of south China. The GBG is the northernmost of several isolated carbonate platforms within the basin (Fig. 1). The Nanpanjiang Basin was a deep-marine embayment in the southern margin of the south China tectonic block and is bordered by the Yangtze Platform, a vast shallow-marine carbonate platform that stretched across south China (Fig. 1). The south China block existed in the equatorial eastern Tethys during the Late Permian, and drifted northward crossing the equator and reaching approximately 12° north latitude by the Late Triassic (Enkin et al., 1992; Van-der-Voo, 1993). The GBG is dissected by two synclines that have exposed continuous cross-sections across the paleobathymetric profile from the shallow-marine platform top, margin, basin-margin slope and basin (Fig. 2). Guandao section occurs at the basin-margin slope position in the western syncline, on the north flank of the GBG, immediately south of the town of Bianyang (Fig. 2).

The GBG was initiated as a carbonate platform in the latest Permian during a major transgression that drowned much of the Yangtze Platform bordering the eastern Nanpanjiang Basin in the area from Luodian to Guiyang (Fig. 1). This drowning expanded the eastern part of the basin, as shallow-marine sedimentation persisted near the former margin of the Yangtze Platform and developed into an isolated carbonate platform (Lehrmann et al., 1998, 2005). During the Early Triassic the GBG developed a low-relief ramp like profile with oolite shoals developed at the margin, shallow-subtidal to peritidal interior and slopes dominated by pelagic carbonate mud deposition punctuated by thin carbonate turbidites and debris flows shed from the margin (Fig. 2). In the Middle Triassic, Anisian *Tubiphytes* reefs developed at the margin, peritidal conditions continued in the interior and basin margin slopes steepened (Fig. 2). By the Middle Triassic, Ladinian the platform margin had developed approximately 400 m of relief above the base of slope at Guandao and slope deposition shifted to grainstone breccia as slopes reached the angle of repose (Fig. 2). Finally,