Lower Triassic bio-magnetostratigraphy from the late Permian to the early Olenekian from the Daxiakou Section (Huibei Province, China)

→ Mark W. Hounslow[1], Zhiming Sun[2], Laishi Zhao[3], Junlin Pei[3] & Jinnan Tong[4]

[1] Lancaster Environment Centre, Lancaster Univ., UK; e-mail: m.hounslow@lancaster.ac.uk
[2] Inst. Geomechanics, Chinese Acad. Geological Sciences, Beijing
[3] State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan
[4] School of Earth Sciences, China University of Geosciences, Wuhan

The great advantage of using a supporting magnetostratigraphic marker for GSSP's is it allows correlation into non-marine, biostratigraphically ambiguous successions-advantages which have been clearly identified in Cenozoic GSSP's (Miller & Wright, 2017). The magnetic polarity stratigraphy for the Lower Triassic is fair well established in outline (Li et al., 2016), but it will probably grow in fine-detail over coming decades. Successions in China provide key data for this, but magnetostratigraphic data from South and central China for the Upper Permian and Lower Triassic is often compromised by partial remagnetisations which can hide the original Triassic magnetisation. In spite of many studies on Chinese Lower Triassic sections, there are few if any sections which combines high resolution biostratigraphy, magnetostratigraphy and carbon isotope geochemistry across the Permian-Triassic boundary and through the entire Induan. The Daxiakou section (near Xiakou town, Hubei province) from the northern carbonate-marl basin, is one of few sections in China in containing a conodont defined Permian-Triassic boundary (PTB) and Induan-Olenekian boundary (Zhao et al., 2013; Lyu et al., 2017). The section also displays the dual peaked $\delta^{13}C_{carb}$ isotopic excursion at the PTB (Shen et al., 2012; Zhao et al., 2013). The FO of *Hindeodus parvus* is in bed 11c. Bed 86 posses the first occurrence of *Novispathodus waageni eowaageni* (Zhao et al., 2013) and bed 89 *Nv. waageni waageni* (and *N. posterolongatus*) both levels possible markers for the base of the Olenekian; although these taxa probably need a better definition (Goudemand, 2014; Lyu et al., 2017). The early Olenekian $\delta^{13}C_{carb}$ excursion ranges across bed 88 to 96 peaking in bed 90 (Fig. 1).

The palaeomagnetic data from the Daxiakou section, covers the Changhsingian into the early Olenekian. The palaeomagnetic data define 3 magnetisation components, 1) a post-folding late Mesozoic remagnetisation, 2) a composite component comprising the post folding and pre-folding components, and 3) a dual polarity pre-folding magnetisation (passing the fold test) interpreted to represent the Triassic geomagnetic field. The mean virtual geomagnetic pole (VGP) is close to the expected Triassic VGP, based on other studies from S. China, indicating no tectonic rotation of the site. These indicate the reliability of the palaeomagnetic and magnetostratigraphic data at Daxiakou. Uncertainty in the magnetostratgraphy relate to the sampling resolution, and in some intervals (gray intervals in Fig. 1) the rocks preserve no evidence of the Triassic magnetic field.

The Lower Triassic magnetostratigraphy at Daxiakou is consistent with many other sections in the Tethyan and Boreal realms particularly Hechuan to the west and the West Pingdingshan section to the east. Like other sections in the argillaceous basin in the northern part of the South China Block, the Permian–Triassic boundary interval at Daxiakou is condensed, particularly the equivalent of magnetozone LT1n. The base of LT1n is within the *C. taylorae* conodont zone some 0.4 m above the apparent extinction event shown by the low in the $\delta^{13}C_{carb}$ isotopic excursion in the lower part of bed 9.

At Daxiakou the FO of *Nv. waageni waageni* (Zhao et al., 2013) and *Nv. posterolongatus* occur near the base of LT3n in bed 89. The uncertainty in the position (~0.25 m) of the base of LT3n is about ½ of a precessional cycle (~10 ka) using the cyclostratigraphy of Wu et al. (2012) or Li et al. (2016). The earlier subspecies has a FO of *Nv. waageni eowaageni* within the underlying magnetozone LT2r some 4.5 m lower (~1.5 eccentricity cycles; ~150 ka older using scale in Wu et al., 2012; Li et al., 2016).
The relative position of the first occurrences of *Nv. w. waageni* and *Nv. posterolongatus* and the base of magnetozone LT3n is similar to that seen at West Pingdingshan (Sun et al., 2009; Fig. 2). There the FO of subspecies *N. w waageni* is about 0.5 m above the top the reverse polarity LT2r magnetochron, some 0.8 m above the base of bed 25 (an age difference of ~20 ka according to cyclostratigraphy; Guo et al., 2008; Li et al., 2016). At West Pingdingshan the position of the base of LT3n is less clear due to remagnetisation in the specimens at this level (Fig. 2). However the base of LT3n is most probably ~0.5 m from the base of bed 25 (~0.7 m of uncertainty on its position) or with less likelyhood it maybe 1.8 m above the base of bed 25. The lower position is most similar to that seen at Daxiakou (Zhao et al., 2013), and more consistent with the carbon isotope stratigraphy. According to the magnetostratigraphy the FO of *Nv. waageni eowaageni* (and some other species) are diachronous between these two sections (Fig. 2).
Together these data demonstrate that the FO of *Nv. waageni waageni* and the base of LT3n provide a strong set of closely-tie markers for defining the base of the Olenekian. At Daxiakou the age difference between these two markers may range up to about 10 ka, with a similar scale of uncertainty at West Pingdingshan. Using the base of LT3n would therefore provide a level of uncertainty in any correlation comparable to many Cenozoic GSSPs. In their assessment of Cenozoic GSSPs Miller and

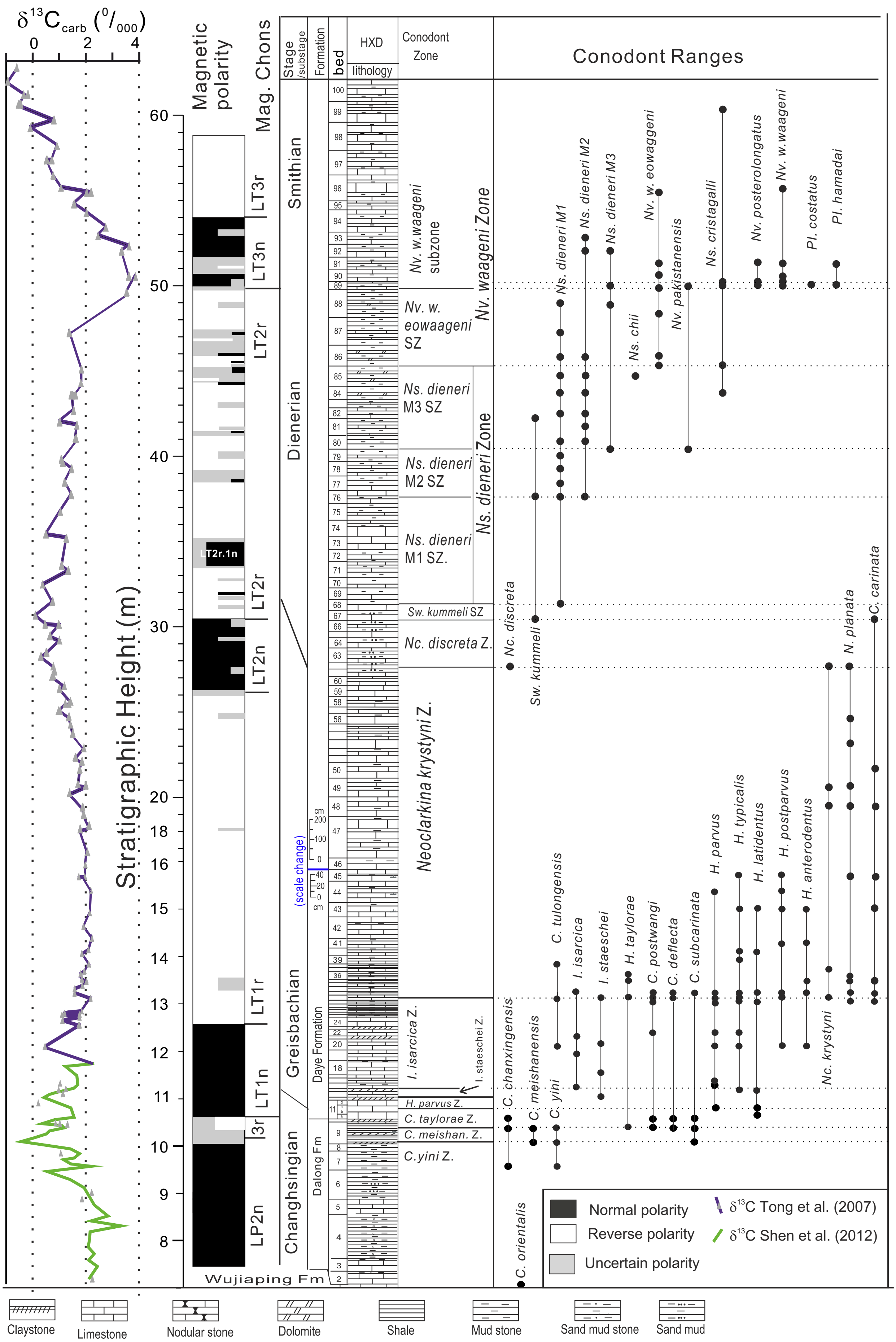

FIG. 1. Summary of the magnetostratigraphy, carbon isotope stratigraphy and key conodont biostratigraphy in the Daxiakou section. Conodont biostratigraphy from Zhao et al. (2013) and carbon isotope stratigraphy from Tong et al. (2007) and Shen et al. (2012).

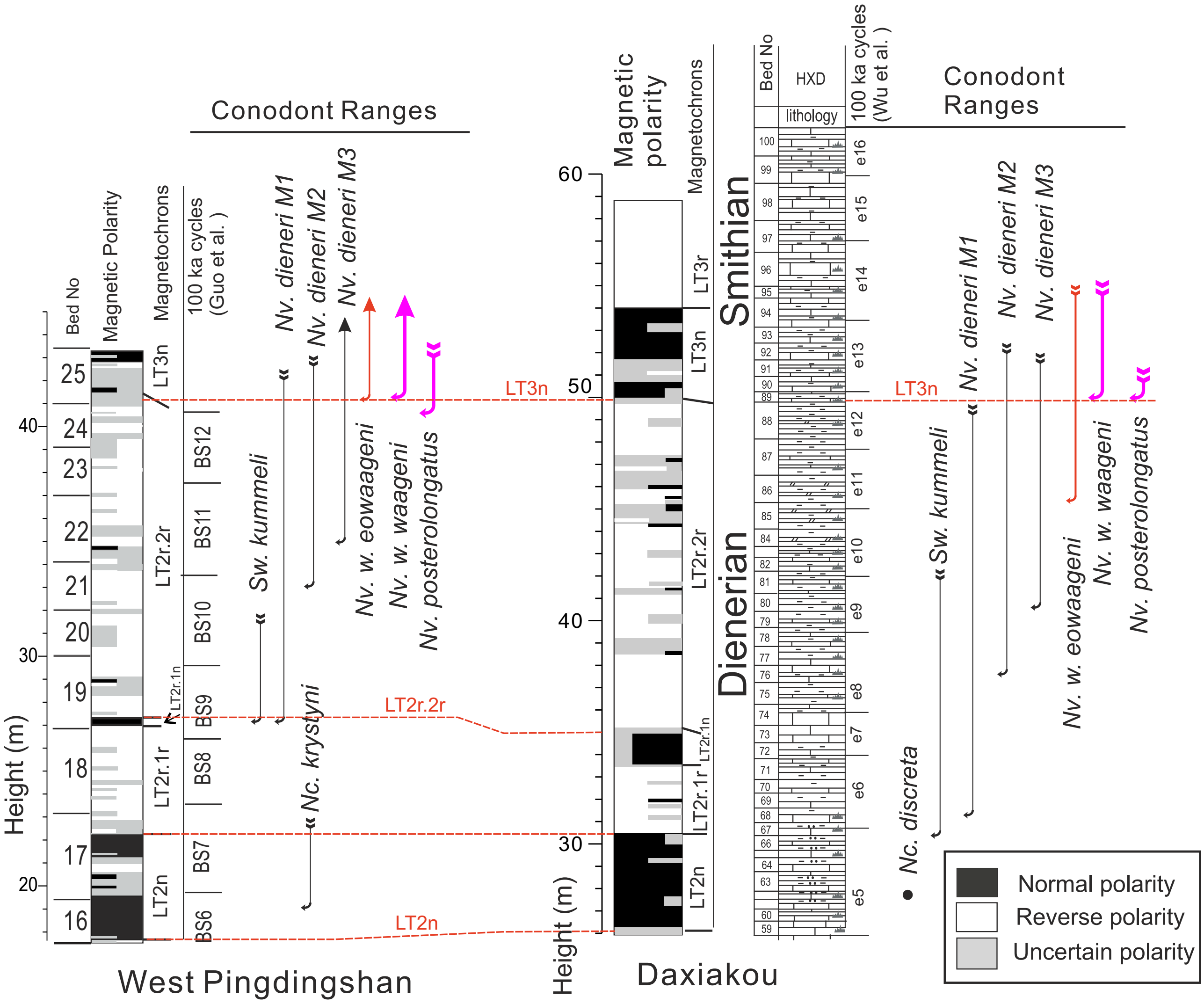

FIG. 2. Correlation of the stratigraphy across the IOB between Daxiakou and West Pingdingshan. Data from Sun et al. (2009), Guo et al. (2008), Wu et al. (2012) and Zhao et al. (2013).

Write (2017) conclude that "*Biostratigraphy remains essential for placing magnetostratigraphy and isotopic stratigraphy into a correct time frame, but* [biostratigraphy] *lacks the temporal precision and global dimension*" a hard reality which Triassic workers may wish to consider.

REFERENCES

Guo, G., Tong, J., Zhang, S., Zhang, J., Bai, L. (2008): Cyclostratigraphy of the Induan (Early Triassic) in West Pingdingshan Section, Chaohu, Anhui Province. – Science in China Series D: Earth Sciences, 51: 22–29.

Goudemand, N. (2014): Note on the conodonts from the Induan-Olenekian boundary. – Albertiana, 42: 49–51.

Li, M., Ogg, J., Zhang, Y., Huang, C., Hinnov, L., Chen, Z. Q., Zou, Z. (2016): Astronomical tuning of the end-Permian extinction and the Early Triassic Epoch of South China and Germany. – Earth and Planetary Science Letters, 441: 10–25.

Lyu, Z., Orchard, M. J., Chen, Z. Q., Wang, X., Zhao, L., Han, C. (2017): Uppermost Permian to Lower Triassic conodont successions from the Enshi area, western Hubei Province, South China. – Palaeogeography, Palaeoclimatology, Palaeoecology, https://doi.org/10.1016/j.palaeo.2017.08.015.

Miller, K. G., Wright, J. D. (2017): Success and failure in Cenozoic global correlations using golden spikes: A geochemical and magnetostratigraphic perspective. – Episodes, 40: 8–21.

Shen, J., Algeo, T. J., Hu, Q., Zhang, N., Zhou, L., Xia, W., Feng, Q. (2012): Negative C-isotope excursions at the Permian-Triassic boundary linked to volcanism. – Geology, 40: 963–966.

Sun, Z., Hounslow, M. W., Pei, J., Zhao, L., Tong, J., Ogg, J. G. (2009): Magnetostratigraphy of the Lower Triassic beds from Chaohu (China) and its implications for the Induan–Olenekian stage boundary. – Earth and Planetary Science Letters, 279: 350–361.

Tong, J., Zuo. J., Chen, Z.Q. (2007): Early Triassic carbon isotope excursions from South China: Proxies for devastation and restoration of marine ecosystems following the end-Permian mass extinction Geological Journal, 42: 371–389.

Wu, H., Zhang, S., Feng, Q., Jiang, G., Li, H., Yang, T. (2012): Milankovitch and sub-Milankovitch cycles of the early Triassic Daye Formation, South China and their geochronological and paleoclimatic implications. – Gondwana Research, 22: 748–759.

Zhao, L., Chen, Y., Chen, Z. Q., Cao, L. (2013): Uppermost Permian to Lower Triassic conodont zonation from Three Gorges area, South China. – Palaios, 28: 523–540.