Terrestrial End-Triassic Mass Extinction and the Triassic/Jurassic Boundary of the Junggar Basin, NW China: A Brief Review

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1 Introduction

The end-Triassic mass extinction event is one of the five global mass extinctions, and destroyed both the marine and terrestrial biological worlds. Though years the marine end-Triassic mass extinction (ETE) event has been widely studied and discussed, and the standard marine Triassic/Jurassic boundary (TJB) (base-Jurassic) has also been determined. However, regarding the terrestrial world there are still lot of unknowns, including the crisis pattern, causes, mechanisms and durations. Therefore, the global standard terrestrial TJB has not yet been established. Recently we found a well exposed terrestrial TJB section in the Hajiagou area, at the southern margin of the Junggar Basin, northwest China. The palaeolatitude of the Junggar Basin is about 60° N, which indicates the section is the southern most part ever studied presenting the ETE event (Sha et al., 2015; Sha, 2016).

An integrated multidisciplinary study including petrology, sedimentology, palaeontology, cyclostratigraphy, chemochronology, astrochronology, has been conducted on this section, and a close relationship between palaeoclimate and orbital cyclicity across TJB in the high palaeolatitude Junggar Basin has been discovered. The opening of Hispanic Corridor/ North Atlantic, as well as palaeogeographic conditions over China during the Triassic-Jurassic transition, is closely related to the eruption of the Triassic-Jurassic Central Atlantic Igneous Province (CAMP).

2 Terrestrial ETE and TJB

The last appearance datum (LAD) of the latest Rhaetian taeniate gymnosperm pollen Lunatisporites rhaeticus is near the top of the ETE interval in Europe, Greenland, and Eastern North America. In the Hajiagou section, L. rhaeticus appeared within the Rhaetian sporo pollen assemblage of Dictyophyllidites –Artrisporites–Cycadopites and disappeared with Limbosporites spp. below bed 52, when the abundant Retriritelles seminurus and Retriritelles austroclavatidites appeared in bed 53 suggesting a Hettangian age, as well as the end of the ETE. The LAD of L. rhaeticus could be regarded as the signal of the terrestrial ETE, of which the age is 201.5 Ma. The terrestrial TJB is in the position overlying the LAD of L. rhaeticus, sandwiched between the sporopollen assemblages of Dictyophyllidites–Artrisporites–Cycadopites and Alisporites–Osmundocites–Cyathidites, of which the age is 203.1 Ma. The time interval between ETE and TJB is very short, C.200 Ka, most likely representing the duration between ETE and the initial recovery (Sha et al., 2015; Sha, 2016).

3 The relationship between palaeoclimate and orbital cyclicity across the TJB in high palaeolatitude

There is a strong signal of modulation of the obliquity by a ~819-ka (~70-m) cycle in the upper Hajiagou to lower Badaowan Formations, according to the wavelet spectrum. This signal can barely be detected in the tropical area where a strong 1.6-to 1.8-Ma cycle could be got (g4-g5). This signal suggests the latest Triassic–Early Jurassic (~198–202 Ma), the continental climate variability of high latitudes was strongly paced by obliquity-dominated (~40 ka) orbital cyclicity. This is based on an age model using the 405-ka cycle of eccentricity. However, the low-latitude continental climate was much more strongly paced by climatic precession, with few hint of obliquity. Although the ratio of the frequencies of cycles of long orbital eccentricity to orbital inclination (as reflected in the modulation of obliquity) of present-day and the Late Triassic–Early Jurassic is 2:1, which is caused by the Earth–Mars secular resonance, the specific durations of their cycles are different. The Early Jurassic orbital eccentricity and inclination are ~1.6 Ma and ~0.8 Ma, respectively, but those of present-day are 2.4 Ma and 1.2 Ma. It suggests the duration of the cycles of long orbital eccentricity to orbital inclination might vary in the geological history as predicted by dynamical theory (Sha et al., 2015; Sha, 2016).

This study lays a foundation for establishing the early Mesozoic continental orbital cyclicity in the high-latitudes where the climate was dominated by obliquity-paced variations, and provides critical evidence onto the terrestrial ETE and TJB.

4 Palaeogeography through the Triassic–Jurassic transition

The temporal and spatial distribution patterns of the marine-brackish-water bivalve Waagenopenera reveal that it did not occur until the Late Triassic, and in the Early Jurassic several species belonging to it (i.e., W. illingensis, W. mytiloides and W. cf. illingensis) had a wide distribution in the area southwest to Shanghai–Altay Mountain Range, including Junggar Basin and

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parts of southern China. The sediments containing these bivalves are intercalated with non-marine strata including coal. Such geographic and stratigraphic distribution patterns of *Waagenoperna* can aid in the correlation of the nonmarine coal-bearing strata across TJB, and constrain their age. It also demonstrates the transgressions, including a flood, in the distributed area during Sinemurian period. These extensive transgressions brought significant influence to the climate and also palaeotopography. These ensured a humid climate and resulted in the formation of marsh and even palaeic swamp. The environment allowed the flora and fauna to thrive and led to the accumulation of large quantities of organic matter that eventually formed coal and probably oil as well (Sha et al., 2016).

5 Opening of Hispanic Corridor/North Atlantic

During the TJB period, pan-tropical cosmopolitan Jurassic epi-bysseipectinid, including epi-cemented ostreid bivalves, were restricted to the area between the 60° south and 60° north, suggesting the Hispanic Corridor/North Atlantic was open since the earliest Jurassic Hettangian, or even earlier (end-Triassic) (Sha, 2019). Such result provides a constraint to the eruption time of the Triassic–Jurassic Central Atlantic Igneous Province (CAMP), which has been accepted as the most important factor causing ETE.

**Key words:** terrestrial, end-Triassic mass extinction event, climate variability, orbital cyclicity, Junggar Basin

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