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Climate and biotic evolution during the Permian-Triassic transition in the temperate Northern Hemisphere, Kuznetsk Basin, Siberia, Russia

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ABSTRACT

The Siberian Traps volcanism is widely considered the main cause of the end-Permian mass extinction, the greatest biological crisis in the Earth history. While the extinction is interpreted as catastrophic and sudden with estimates of duration of approximately 35–40 thousand years from marine strata in South China, various lines of evidence have emerged for a more complex, prolonged, and diachronous extinction pattern. We present here the results of a multidisciplinary study of the Permian-Triassic continental transition in the Kuznetsk Basin, Russia. The region is proximal to the Siberian Traps LIP and the detrimental effects of the flood basalt volcanism in the Kuznetsk Basin may have been of similar scale as in the main area of the Siberian Traps distribution (Tunguska and Taymyr regions). Whereas earlier work has placed the Permian-Triassic boundary position between the coal-bearing Tailugan Formation and the volcanoclastic Maltsev Formation, here we revised the traditional model using three independent methods: radioisotopic CA-IDTIMS U-Pb zircon ages, $\delta^{13}C_{org}$ isotope values and paleomagnetic proxies. The regional extinction of the humid-dominated forest flora (cordaites) and the aridity-induced biotic turnover in the Kuznetsk Basin occurred 820 kyr earlier than the end-Permian extinction event recorded in South China at 251.94 Ma. The biota in Kuznetsk Basin at the turnover subsequently diversified (with some exceptions) across the Permian-Triassic transition.

By compiling a large taxonomic database, we find that marine and terrestrial biotic diversity in Siberia progressively increased from the beginning of the Permian up to the middle Roadian (early Guadalupian global glacial event). After that time, the diversity at the species and generic level progressively and slowly declined towards the aforementioned latest Changhsingian (252.76 Ma) biotic turnover. Starting from this time, the biota rapidly diversified in the latest Changhsingian and Early-Middle Triassic. We suggest that the Permian-Triassic mass extinction mostly occurred in the tropics and subtropics due to the strong climatic warming, which was relatively low in late Changhsingian and gradually but quickly extends in the latest Changhsingian to an abnormally high temperature and extremely low oxygenated water in the oceans that was deadly for most marine animals. The warm climate shift poleward during Permian-Triassic transition in the middle-high latitudes caused the replacement (turnover) of the humid-related biotas by the dry climate-related and more diverse communities, which continued to expand throughout the Triassic in both marine and terrestrial habitats. The pattern of the Permian-Triassic event in both marine and terrestrial habitats was more intricate in terms of extinction, turnover, and diversity of biota within the different climatic zones and environmental habitats than has been generally considered.

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