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New Early to Middle Triassic U-Pb ages from South China: calibration with ammonoid biochronozones and implications for the timing of the Triassic biotic recovery

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The most important mass extinction of the Phanerozoic at the end of the Permian is followed by a phase of biotic recovery in the Early Triassic. It is generally assumed that the Early Triassic recovery has had a longer duration than other post-extinction recovery phases. This assumption is based on very few available U-Pb age determinations so far (ranging from 253 Ma or 251 Ma for the Permian-Triassic boundary to 241 Ma for the Anisian-Ladinian boundary), and on the number of ammonoid zones. Due to the lack of absolute age constrains, the duration of the four Early Triassic substages (Griesbachian, Dienerian, Smithian, Spathian) was established based on assumption of an equal duration of ammonoid zones. Recent simulations have demonstrated that this assumption may be wrong, especially during extinction and recovery phases, which emphasizes the need for precise and accurate radio-isotopic age calibrations. As far as ammonoids are concerned, the major taxonomic group for correlation of Mesozoic marine rocks, they do not reach the equilibrium in a single-stage, smooth process. Ammonoid diversity curves in the lower Triassic underwent several fluctuations and recovery was severely set back at the end of Smithian. Calibrating such diversity fluctuations by means of U-Pb zircon ages on interbedded volcanic ash layers is critical for a better characterization of the tempo and systematics of recovery processes.

New zircon U-Pb ages are proposed for late Early and Middle Triassic volcanic ash layers intercalated with ammonoid faunas from the Luolou and the overlaying Baifeng formations (northwestern Guangxi, South China). These ages are based on analyses of single zircons. In order to minimize the effects of secondary lead loss, zircons were pretreated partly by air-abrasion and by thermal-annealing/leaching (so-called “chemical abrasion”) techniques. Calibration with ammonoid ages indicate a 250.6 $\pm$ 0.5 Ma age for the early Spathian Tirolites/Columbites beds, a 248.1 $\pm$ 0.4 Ma age for the late Spathian Neopopanoceras haugi Zone, a 246.9 $\pm$ 0.4 Ma age for the early middle Anisian Acrochordiceras hyatti Zone, and a 244.6 $\pm$ 0.5 Ma age for the late middle Anisian Balatonites shoshonensis Zone. The new dates and previously published U-Pb ages indicate a duration of ca. 3 m.y. for the Spathian, and minimal durations of 4.5 $\pm$ 0.6 m.y. for the Early Triassic. Having in mind already published data for the Anisian-Ladinian boundary with Nevadites secedensis Zone age of 241.2 +0.8/-0.6 Ma, a minimal duration of 6.6 +0.7/- 0.9 m.y. can be inferred for the Anisian. The new Spathian dates are in a better agreement with a 252.6 $\pm$ 0.2 Ma age than with a 251.4 $\pm$ 0.3 Ma age for the Permian-Triassic boundary. These dates also highlight the extremely uneven duration of the four Early Triassic substages (Griesbachian, Dienerian, Smithian, and Spathian), of which the Spathian exceeds half of the duration of the entire Early Triassic. The simplistic assumption of equal duration of the four Early Triassic subdivisions is no longer tenable for the reconstruction of recovery patterns following the Permian-Triassic boundary mass extinction.