Cyanobacterial blooms tied to volcanism during the 5 m.y. Permo-Triassic biotic crisis: COMMENT.

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In a recent paper Xie et al. (2010) elegantly demonstrate that cyanobacterial blooms recorded in Permian–Triassic (P–Tr) rocks are closely associated with local volcanic activity in South China and with the development of large negative global carbon isotope excursion. Using a compiled data set of published U/Pb and $^{40}Ar/^{39}Ar$ ages obtained on volcanic ash layers from south China and volcanic rocks of the Siberian Traps (ST), respectively, Xie et al. argue that the volcanism associated with the ST are predominantly younger than the P–Tr boundary age. Xie et al. (2010) note that the majority of ST $^{40}Ar/^{39}Ar$ ages (e.g., Reichow et al., 2009) are similar to U/Pb zircon ages for two Triassic boundaries, and consequently that ST volcanism was likely responsible for the prolonged stress in the Early Triassic ecosystems. However, the suggested age correlation is flawed and the purpose of this Comment is to challenge the comparison based on ages obtained by different methodologies and demonstrate that one of the conclusions drawn by Xie et al. is invalid.

Comparability between U/Pb and $^{40}Ar/^{39}Ar$ ages

Unlike U/Pb dating, which is an absolute radiometric method, the $^{40}Ar/^{39}Ar$ dating technique is a relative method and based on the knowledge of the age of a standard. The accuracy of an age is thus directly dependent on how accurately and precisely the age of a standard is known. A widely used standard is the Fish Canyon sanidine (FCs) whose age has been addressed frequently (e.g. Kuiper et al., 2008; Renne et al., 2010). The difference between U/Pb and $^{40}Ar/^{39}Ar$ has been reported in numerous studies (see Renne et al., 2010 and references therein) with $^{40}Ar/^{39}Ar$ ages being significantly younger than co-determined U/Pb ages in rapidly cooled rocks. Some of the bias may be accounted for by inaccuracies in the ^{40}K decay constants and/or the accepted ages for the $^{40}Ar/^{39}Ar$ standard minerals being too young (e.g., Renne et al. 2010). Schoene et al. (2006) and, most recently, Renne et al. (2010) demonstrate the importance of generating $^{40}Ar/^{39}Ar$ and U/Pb age data from the same rocks to distinguish systematic interlaboratory errors and geological complexities from inaccuracies in the U and ^{40}K decay constants. Kuiper et al. (2008) reported an astronomically tuned age for the FCs which was further refined by Renne et al. (2010) by improving the partial decay constants of ^{40}K and the $^{40}Ar^{*}/^{40}K$ ratio of the FCs standard. Using the newly recommended decay constants of ^{40}K and the age for the FCs standard suggested by Renne et al. (2010) reduces (but not eliminates) the discrepancy between the U/Pb zircon and $^{40}Ar/^{39}Ar$ ages to only 0.33% and 0.06% for the Meishan ash beds 28 and 25, respectively.

Age of the Permian-Triassic boundary events and the Siberian Traps

The age of the P–Tr boundary is interpolated from the age of bracketing ash Beds (25 and 28), using both $^{40}Ar/^{39}Ar$ and U/Pb techniques. On the basis of $^{40}Ar/^{39}Ar$ dates, the boundary age lies between 252.3 ± 0.2 Ma (Bed 25, Renne et al. 1995) and 251.7 ± 0.1 Ma (Bed 28, Reichow et al., 2009; both recalculated to the recommended FCs age of Renne et al., 2010). The corresponding U/Pb zircon ages are currently at 252.4 ± 0.3 Ma and 252.5 ± 0.3 Ma (Mundil et al., 2004, and references therein), respectively. From the above it will be apparent that there are in effect two sets of ages for the ashes and the P-Tr boundary. The main extinction and the first major negative $\delta^{13}C$ excursion occur at the top of Bed 24 and in Bed 25 (Jin et al., 2000). The number of U/Pb ages for the Siberian province is limited, whereas the $^{40}Ar/^{39}Ar$ database is much larger and the majority of dated samples show ages that overlap with the $^{40}Ar/^{39}Ar$ ages for Beds 25 and 28 from Meishan (Reichow et al. 2009). These ages were not considered by Xie et al. Furthermore, reliable older ages obtained on stratigraphically higher Noril'sk units imply that argon loss was in part responsible for the observed apparent Triassic ages and these younger ages can only be considered as a minimum (see Reichow et al., (2009) for discussion). $^{40}Ar/^{39}Ar$ ages obtained on volcanic rocks from Tunguska, the West Siberian Basin, Taimyr, Kuznetsk, and Vorkuta represent >90% of the ST area demonstrating that the majority of volcanism preceded the peak of the mass extinction. These age data provide strong evidence and support for a correlation between volcanism and the end-Permian mass extinction, with the majority of ages predating the onset of the shift to low $\delta^{13}C$ values recorded in the top of Bed 24 at Meishan, and in other P–Tr sections. A possible exception is the 245 Ma activity found in the Chelyabinsk area (Reichow et al., 2009), but this is arguably too late to account for the reported cyanobacterial blooms.

Concluding Statement

We do not dispute the observation made by Xie et al. that there appears to be an association between microbial mat development, local volcanism, and the carbon-isotope shifts in the Triassic sedimentary successions in southern China. However, because U/Pb dates give ages systematically older than $^{40}Ar/^{39}Ar$ dates, by using the U/Pb ages from the Meishan (and other Chinese) sections, and $^{40}Ar/^{39}Ar$ dates for rocks from Siberia, Xie et al. come to the (erroneous) conclusion that the Siberian volcanism significantly post-dates the P–Tr boundary. Local volcanism may well have been a causative factor. The role of the Siberian Traps in this post-extinction process, however, must be questioned.

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