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CRITICAL VIEW OF THE CALIBRATION OF THE TRIASSIC TIME SCALE

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The calibration of the geologic time scale by means of radio-isotopic dating techniques is instrumental for an accurate reconstruction of events and processes in Earth's history, including biotic evolution, climate and environmental change, tectonic and magmatic processes, et cetera.

In this contribution, the importance of high-quality radio-isotopic ages will be illustrated using examples of geologic events during Triassic times, for example the observed changes in ocean chemistry (Payne and Kump, 2007; Payne et al., 2004) and the recovery of life after the most severe mass extinction in the Lower Triassic (Ovtcharova et al., 2006), and the events leading to the End Triassic biotic crisis (Mundil et al., 2005; Olsen et al., 2003; Pálfy et al., 2000), including the timing of the Siberian Trap volcanism in latest Permian to earliest Triassic times (Renne and Basu, 1991; Renne et al., 1995) and the CAMP (Central Atlantic Magmatic Province) volcanism in latest Triassic times (Knight et al., 2004; Marzoli et al., 1999). In addition, different hypotheses on the timing and recording of purported climatic signals in Middle Triassic shallow marine carbonates will be discussed with respect to radio-isotopic ages from intercalated volcanic ash falls and resulting implications for the Triassic time scale (Kent et al., 2004; Mundil et al., 1996; Mundil et al., 2003; Preto et al., 2001; Zühlke et al., 2003).

This contribution is aimed at expanding the understanding of users of geologic time scale compilations, most of which are based on an often arbitrary selection of data and sometimes questionable interpretations (the latest for the Triassic being Ogg, 2004). It is to be expected that the quality of data, in this case radio-isotopic ages from different isotopic systems, is subject to change as new analytical techniques are discovered and applied (e.g. Mattinson, 2005), and the knowledge about primary input values such as decay constants is growing. For example, the accuracy of radio-isotopic ages mainly depends on two prerequisites: (1) a closed isotopic system of the analyzed mineral or rock, i.e., no gain or loss of the parent and/or daughter element, and (2) the quality of the calibration of reference materials (natural or artificial standards) and decay constants.

Whereas the former is often not given, resulting in ages which are slightly too young (due to the loss of the radiogenic daughter isotope), it has often either been ignored or was not recognized (see Mundil et al. (2001) for discussion). The latter imposes a problem if ages from different isotopic systems are compared. For example, recent studies show evidence that the decay constant for ^{40}K is substantially miscalibrated by as much as 1%, which vastly exceeds the currently attainable analytical precision of ca. 0.1% (Min et al., 2000; Mundil et al., 2006). In particular, research aimed at studying the synchronicity of events has to take this complication into consideration. A prime example is the age of the Permian-Triassic mass extinction, which is mostly constrained by U-Pb ages, in relation to the age of the Siberian Flood volcanism, which is primarily constrained by $^{40}Ar/^{39}Ar$ ages (Renne et al., 1995; Bowring et al., 1998; Kamo et al., 2003; Mundil et al., 2004).

Accounting for these complications and taking only radio-isotopic ages into consideration that pass specific criteria (no evidence of redeposition, closed isotopic system, adjustment for systematic biases), the proposed new time scale for the Triassic is significantly different from even the latest published compilation (Brack et al., 2005), which has severe implications for the interpretation of events associated with the Permian-Triassic and Triassic-Jurassic transition (Mundil et al., 2004; Pálfy and Mundil, 2006).

Recent community efforts are aimed at addressing some of these complications by resolving inter-laboratory biases (Condon and Members of the Earthtime U-Pb working group, 2005). In addition, the application of promising new isotopic dating techniques, such as Re-Os dating of black shales (Creaser et al., 2005; Selby and Creaser, 2005) and U-Pb dating of paleosols and carbonates (Rasbury et al., 1998), may provide additional valuable data for time scale calibration where traditional dating techniques fail, for example due to the lack of volcanic products in the Upper Triassic.

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