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Stratigraphical and palaeogeographical significance of the continental sedimentary transition across the Permian–Triassic boundary in Spain

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Abstract

The Permian–Triassic transition, a time of phenomenal palaeoenvironmental and palaeogeographical change, represents the largest episode of mass extinctions known to palaeontologists. This episode is, however, very poorly understood, and a lack of sediments and palaeontological data, particularly in the continental record, is a feature common to every basin. Despite compelling information on the continental Permian–Triassic boundary (PTB) emerging from recent efforts evaluating vertebrate evolution, fungal events and isotope curves, results are still insufficient to make any valuable correlations among continental basins and are even less appropriate for relating sediments of continental to those of marine origin. The present report discusses and attempts to locate the PTB in the basins of Iberia and Balearic Islands through an analysis of the palaeontological and sedimentary record across the Permian–Triassic transition. The aim of the paper is to contribute to our present knowledge of the palaeogeographical and stratigraphical significance of the Permian and Triassic continental units of Western Europe.

The present-day Iberian Ranges, Catalonian Ranges and Balearic Islands hold the most complete Late Permian–Early Triassic sedimentary record in Iberia. This record consists of alluvial sediments, mainly of braided fluvial systems, corresponding to the "Saxonian" and Buntsandstein facies. All the units examined so far have been dated through palynological associations. The two "Saxonian" facies formations are of Thuringian age, although the lower one shows some palynological elements of Autunian affinities. The Buntsandstein units range from Thuringian to Anisian in age, there being no evidence up to now of the Scythian in Iberia. The exact position of the PTB in Iberia is up to now impossible to pinpoint with the precision of the marine series. Sedimentary characteristics and palynological data in the Iberian Ranges point that it lies at the sedimentary interval, 10 to 30 m thick, formed by the upper member of the La Hoz del Gallo Formation and the lowermost beds of the Cañizar Formation or its time equivalent the Prades and Eramprunyá units in the Catalonian Ranges and the Asá and B-1 in the Balearic Islands. We compare a normalized standard Late Permian–Middle Triassic column of the Iberian Ranges with standards from Western and Central Europe and the Southern Urals using recent Permian time scales. A palaeogeographic

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essay map of the Permian–Triassic transition is provided for the Iberian Plate. The plate was located in a northern subtropical position, 200–400 km from the westernmost Tethys coast, as part of the Central Pangean Mountain Range comprised of the Appalachian–Mauretanide–Variscan orogenic belts of estimated altitudes 2000–4000 m. Based on this palaeogeographic location, sedimentary characteristics and the main wind flows established for the Tethys, we can infer conditions of high precipitation dominated by monsoon and seasonal regimes with isolated semiarid areas for the Iberian Plate during the transition.

Keywords: Late Permian; Triassic; Permian–Triassic boundary; Iberian Ranges; stratigraphy

1. Introduction

The end-Permian was for most palaeontologists the largest of five major Phanerozoic mass extinction episodes, and a time of considerable environmental change and lithosphere activity that triggered a chain of palaeogeographical changes affecting most of the planet. General recovery after the end of the Permian took most of the Triassic, although this recovery was only partial.

The exciting, enigmatic nature of the Permian–Triassic boundary (PTB) has prompted a plethora of recent works that have attempted to explore new ideas concerning the factor or factors that may have provoked the changes observed across the boundary (Renne and Basu, 1991; Erwin, 1993; Hallam and Wignall, 1997; Isozaki, 1997; Kozur, 1989, 1998; Visscher et al., 1996; Wignall and Hallam, 1992; Yin and Tong, 1998; Twitchett, 2001; Twitchett et al., 2001; Looy et al., 2001; Benton and Twitchett, 2003; Racki, 2003, among others). There are no clear arguments supporting a sudden mass extinction accompanied by drastic palaeogeographical or atmospheric change, but rather the balance of opinions seems to favour a more gradual chain of events with drastic consequences. Moreover, continental and marine environments respond differently to change and although extinctions were more severe in the latter, in which 95% of all marine animal species became extinct, terrestrial ecosystems were also severely affected.

Investigations of the PTB are met with the main stumbling block of accurately estimating the age of continental late Permian–Early Triassic sediments. Descriptions of the sedimentary units of most of the world's sedimentary basins close to this transition indicate a lack of sediments, and still worse, in many cases the palaeontological record provides no clues on the magnitude of these voids or even if sediments initially existed or not. A few examples of basins well described through their continental sediments during this transition have indicated very complete successions. However, these successions hardly permit correlations to be made among separate basins or even between neighbouring basins. The coincidence between faunistic (reptiles) changes and drastic variations in δ^{13}C excursion suggests that biological and palaeoenvironmental changes in the Karoo basin (South Africa) temporally coincided with others changes observed in the PTB of other regions and environments (MacLeod et al., 2000). In the same basin, a recent study established that mass extinctions of terrestrial fauna and flora around this boundary coincide with changes in the sinuosity of the river channel systems in the same sediments (Smith and Ward, 2001; Hancox et al., 2002). Many other reports on continental sediments have also indicated significant events or changes around the PTB, such as those related to the presence of fungi (Eshet et al., 1995; Visscher et al., 1996), the synchronous δ^{13}C record (Morante, 1996), abrupt micro- and macrofloral modifications (Poor et al., 1997; Lozovsky, 1998), ecological landscape shifts and changes in palaeosol characteristics (Retallack and Krull, 1999; Krull and Retallack, 2000) or vertebrate extinctions (Rubidge, 1995; Smith and Ward, 2001), among others.

Despite problems in locating the PTB in continental sediments, the stratigraphical and palaeogeographical significance of this boundary requires additional information for understanding the Permian–Triassic transition across vast expanses of the world, including very different ancient latitudes. Permian–Triassic boundary in continental sediments were generally formed under different palaeogeographic and palaeotectonic conditions, so they show clear lithological