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Late Permian continental sediments in the SE Iberian Ranges, eastern Spain: Petrological and mineralogical characteristics and palaeoenvironmental significance

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Abstract

A detailed mineralogical and petrological study and the analysis of paleosol profiles in continental alluvial sediments of the Late Permian in the SE Iberian Ranges (Spain) allow us to infer the significant environmental changes that occurred during this time period. Three parts have been distinguished in the Late Permian sediments (Alcotas Formation). The lower part includes abundant and well-preserved carbonate paleosol profiles and fine-grained sediments made up by quartz, feldspar, hematite and illite, with scarce kaolinite. The preservation of dolomicrite in some paleosols suggests that they originally developed as dolocretes in an arid to semi-arid climate with marked seasonality.

A change towards more humid and acid conditions can be deduced from the presence of siderite and goethite in paleosols in the middle part of the Alcotas Formation. Moreover, the presence of plant remains, coal beds and/or carbonaceous shales at the top of the middle part, and the lack of carbonate paleosols in the upper part of the formation would indicate a further step towards acid conditions. These conditions would increase until the Early Triassic, as indicated by the lack of carbonates and the presence of Sr-rich aluminium phosphate sulphates (APS minerals) at the base of the Triassic (Cañizar Formation), which clearly indicates extreme acid conditions during the Permian–Triassic transition of the study area.

Keywords: Late Permian; Acid conditions; Iberian Ranges; Continental sediments; Paleosols; APS minerals

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1. Introduction

During the Permian–Triassic transition, dated at 251 Ma (Menning, 2001), the Earth experienced the most severe crisis in its history. Both marine and terrestrial life suffered this crisis and it is estimated that 93–95% of all marine species (Raup, 1979) and about 70% of all vertebrate families (Maxwell, 1992) disappeared, which is twice as many groups as at the end-Ordovician marine mass extinction and many more than during the end-Cretaceous event.

Although the Permian–Triassic transition mass extinction and its possible causes are receiving far more attention now than in past decades, there are still controversies about the origin of the interrelated processes that resulted in that crisis. Furthermore, Late Permian sediments below the Permian–Triassic Boundary (PTB) already show clear evidence of stepwise mass extinctions (Stanley and Yang, 1994; Wignall et al., 1998; Kozur, 1998; Jin et al., 2000; Benton, 2003), which could support the idea of linked causes.

Interpretations about this crisis are not equally clear in all the Late Permian rocks since those of marine origin show more paleontological evidence. As adequate correlation between rocks of marine and continental origin has not been established for the PTB, it is difficult to determine whether the terrestrial events were exactly contemporaneous with those in the oceans. Studies of the continental record are crucial for determining whether the mechanisms of the crisis and extinction are the same as those observed in the marine record. Although there is growing evidence that tetrapods and insects also suffered considerable extinction, and that plant assemblages provide additional evidence of severe disturbance (Erwin, 1996), the geochemical and mineralogical response to the crisis on land was probably different from the one recorded in marine sediments. Detailed geochemical and mineralogical analysis such as those of Holster and Magaritz (1992), Retallack (1999), Krull and Retallack (2000) and Beauchamp and Baud (2002) may produce the key for a better understanding of the Permian–Triassic transition from a global perspective.

This paper intends to contribute to the better understanding of the environmental changes by means of the mineralogical characterization of fine-grained sediments and paleosol profiles of the continental Late Permian rocks of the SE Iberian Ranges, eastern Spain. A detailed study of a series of selected sections in a very complete succession of rocks in this area allows us to identify the changing mineral composition across this transition. These variations are discussed in terms of palaeoenvironmental changes and they are related to the mineralogical assemblages described in other regions.

2. Geological setting

During Late Permian–Early Triassic Iberia was a microplate located in the eastern part of Pangea in equatorial latitudes (Ziegler, 1990; Ziegler and Stampfli, 2001). By this time the western propagation of the Neotethys and the strike–slip motion of the Pyrenean and Gibraltar fault zones produced an extensional regime in the microplate, resulting in the creation of several extensional basins: the Iberian, Catalan and Pyrenean basins (Fig. 1).

The data presented in this paper have been obtained from the Permian–Triassic transition rocks of the southern Iberian Range. The present-day Iberian Range is a linear structure of Tertiary origin in central-eastern Spain, created by tectonic inversion of the Mesozoic Iberian Basin during compressional tectonic events mainly during the Late Oligocene–Early Miocene (Muñoz and Casas, 1997), which resulted in thin-skinned deformation with the detachment level in the evaporitic Keuper facies. The long and complex extensional story of the Iberian Basin started during the Early Permian with the extensional collapse of the Hercynian belt and westward propagation of the Neotethys, and continued during the Late Permian and the Triassic (Sopeña et al., 1988; Ziegler, 1990; López-Gómez et al., 1998).

As in the rest of the basins of the Iberian microplate, the Upper Permian–Lower Triassic rocks in the Iberian Basin are represented by alluvial sediments that lasted until Anisian times, when the Tethys Sea reached (Landete Formation) the eastern Iberian microplate margin (Fig. 2) (Arche and López-Gómez, 1999). The PTB is not represented in the study area. It is probably located somewhere from the contact between the lower and upper conglomerate subunits of the Hoz de Gallo Formation to the lower