

CHANGING FLUVIAL ENVIRONMENTS IN THE KAROO BASIN, SOUTH AFRICA, AS A RESULT OF THE PERMIAN-TRIASSIC MASS EXTINCTION

Peter Ward¹, David R. Montgomery¹, and Roger Smith²

1. *Dept. of Geological Sciences, Univ. Washington, Seattle, WA 98195*
2. *South African Museum, Cape Town, South Africa*

The Permo-Triassic transition in the Karoo Basin of South Africa was characterized by a rapid and apparently basin-wide change from meandering to braided river systems as evidenced by preserved sedimentary facies. This changeover has been hypothesized as a cause of the catastrophic extinction of Permian vertebrate taxa. Here we propose that rather than causing the extinction, the changeover in fluvial systems in the ancient Karoo Basin was a consequence of a major die off of plant life in the basin. Evidence from other basins containing fluvial P/T boundary sections suggests that a catastrophic terrestrial die off of vegetation produced a dramatic increase in sediment yield, recorded in the change in fluvial stratigraphy, as well as in the global • ¹³C excursion across the P/T boundary.

The Permian-Triassic extinction killed more than 90% of marine species and about 70% of terrestrial vertebrate families (Erwin, 1994). Numerous global causal mechanisms for the P/T mass extinction have been proposed, including asteroid/comet impact (Rampino and Haggerty, 1996; Bowring et al., 1998; Retallack, 1998), environmental shifts (Thackery et al., 1990; Stanley and Wang, 1994; Smith, 1995; Retallack, 1999), oceanic anoxia (Wignall and Twitchett, 1996; Isozaki, 1997) or overturn (Knoll et al., 1996), volcanism (Campbell et al., 1992; Renne et al., 1995) and synergistic combinations among the above (Erwin, 1993, 1994; Bowring et al., 1998; Morante, 1996; Retallack, 1999). Unraveling the ultimate cause of the chain of environmental change and stress preserved in the geologic record rests on the difficult and often under-constrained interpretation of causality from the sedimentary record.

To date most research into the cause of this mass extinction has taken place in marine facies. Far less is known about the pattern of extinction in non-marine facies, and especially among terrestrial vertebrate taxa. Perhaps the best studied record of vertebrate taxa across the Permo/Triassic boundary is found in the Karoo Basin of South Africa, which records an apparently complete stratigraphic record of the Permian through the Triassic in the interior of southern Pangea (King, 1991; Rubidge, 1995; Smith, 1995), and contains numerous, well-exposed P/T boundary sections with relatively abundant vertebrate fossils. The extinction among the Karoo vertebrate fauna was severe: Rubidge (1995) reported that only 6 of the 44 reptilian genera recovered to date from the highest Permian biostratigraphic zone (Dicynodon Assemblage Zone) are found in the succeeding lowest Triassic zone (Lystrosaurus Assemblage Zone). The plant fossil record is poorly known for the Karoo Basin because of diagenesis, but correlative strata elsewhere in Gondwanaland record a major floral extinction pulse at the boundary (Anderson et al., 1999).

There have been relatively few specific hypotheses attempting to explain the extinction of the Dicynodon Zone taxa in the Karoo Basin. King (1990) suggested that the extinction was protracted, and due to climatic cooling in the region. Smith (1995), on the other hand, made the seminal observation that a change in sedimentary facies that he observed across the P/T boundary in one region of the Karoo Basin is consistent with a changeover from a basin dominated by meandering rivers to one dominated by braided river systems. He suggested that this change in facies patterns was brought about by a pulse of tectonism along the southern margin of the basin,

CHANGING FLUVIAL ENVIRONMENTS: P. D. Ward et al.

which increased the slope of rivers flowing northward into the foreland, and concluded that this radical change in fluvial style in the Karoo Basin over an approximately 50,000 year interval during the Permian-Triassic transition was the ultimate cause of the extinction in the basin. According to this hypothesis, the actual killing mechanism would have been the changing flood-plain environment.

Subsequent to Smith's 1995 work, MacLeod et al. (1998; in press) correlated the paleontologically defined boundary at Smith's study site with marine P/T boundary sections in China and Europe by demonstrating the presence in the Bethulie section of a pronounced isotopic excursion, and also demonstrating synchronicity between the marine and non-marine extinctions at this time. This subsequent work also indirectly dates the P/T boundary in the Karoo as being approximately 250 million years in age (Renne, 1995; Bowring et al, 1999). Here we extend the observation of Smith (1995) by showing that a facies transition across the P/T boundary from meandering to braided river systems is nearly basin wide (and perhaps even a global phenomenon). We also show that such a large-scale facies change could have been brought about by elimination of deeply rooted plants in the basin. Because of the timing of this transition, we conclude that this environmental change was a consequence, rather than a cause of the P/T event in the Karoo Basin. The increased sediment yield that would have resulted from a basin wide change in vegetation sufficient to trigger such widespread and sustained fluvial response would have drastically increased terrestrial exports of organic and inorganic sediment (and therefore ^{13}C) to the oceans and contributed to the dramatic loss of shallow water marine taxa across P/T boundary sections.