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TESTING THE *DAPTOCEPHALUS* AND *LYSTROSAURUS* ASSEMBLAGE ZONES IN A LITHOSTRATOGRAPHIC, MAGNETOSTRATIGRAPHIC, AND PALYNOLOGICAL FRAMEWORK IN THE FREE STATE, SOUTH AFRICA

ROBERT A. GASTALDO,[1] JOHANN NEVELING,[2] JOHN W. GEISSMAN,[3] AND CINDY V. LOOY[4]
[1]*Department of Geology, Colby College, Waterville, Maine 04901 USA*
[2]*Council for Geosciences, Private Bag x112, Silverton, Pretoria, South Africa 0001*
[3]*The University of Texas at Dallas, Richardson, Texas 75080-3021 USA*
[4]*Department of Integrative Biology, Museum of Paleontology, University and Jepson Herbaria, University of California–Berkeley, 3060 Valley Life Sciences Building #3140, Berkeley, California 94720-3140 USA*
email: robert.gastaldo@colby.edu

ABSTRACT: **The vertebrate-fossil record in the Karoo Basin has served as the accepted model for how terrestrial ecosystems responded to the end-Permian extinction event. A database of several hundred specimens, placed into generalized stratigraphies, has formed the basis of a step-wise extinction scenario interpreted by other workers as spanning the upper *Daptocephalus* (=*Dicynodon*) to *Lystrosaurus* Assemblage Zones (AZ). Seventy-three percent of specimens used to construct the published model originate from three farms in the Free State: Bethel, Heldenmoed, and Donald 207 (Fairydale). The current contribution empirically tests: (1) the stratigraphic resolution of the vertebrate record on these farms; (2) whether a sharp boundary exists that delimits the vertebrate assemblage zones in these classic localities; and (3) if the *Lystrosaurus* AZ is of early Triassic age. We have used a multi-disciplinary approach, combining lithostratigraphy, magnetostratigraphy, vertebrate biostratigraphy, and palynology, to test these long-held assumptions.**

Previously reported vertebrate-collection sites have been physically placed into a litho- and magnetostratigraphic framework on the Bethel and Heldenmoed farms. The reported assemblage-zone boundary is used as the datum against which the stratigraphic position of vertebrates is compared and a preliminary magnetostratigraphy constructed. We find specimens of the *Daptocephalus* AZ originate in the *Lystrosaurus* AZ (as currently defined) and vice versa, and discrepancies between reported and field-checked stratigraphic positions below or above the assemblage-zone boundary often exceed 30 m. Hence, the utility of the data set in defining a sharp or abrupt biozone boundary is questionable. We further demonstrate the presence of a stratigraphically thick reverse polarity magnetozone that encompasses the reported assemblage-zone boundary, implying that these rocks are not correlative with the end-Permian event, which is reported to lie in a normal polarity chron. A latest Permian age is supported by palynological data from the *Lystrosaurus* AZ on the Donald 207 (Fairydale) farm, with equivalence to Australian (APP602) and Eastern Cape Province assemblages. We conclude that the turnover from the *Daptocephalus* to *Lystrosaurus* Assemblage Zones is more protracted than envisioned, it is not coincident with the end-Permian event as recognized in the marine realm, and little evidence exists in support of a three-phased extinction model based on vertebrate assemblages in the Karoo Basin.

INTRODUCTION

Turnover in the terrestrial fossil record from the *Daptocephalus* to *Lystrosaurus* Assemblage Zones in the Karoo Basin, South Africa, continues to be equated by many workers to the end-Permian extinction event (Ward et al. 2005; Smith and Botha-Brink 2014; Rubidge et al. 2016; Viglietti et al. 2016, 2018; MacLeod et al. 2017). This continental extinction model, which has been applied globally (Benton and Newell 2014), is based on vertebrate biostratigraphic trends placed in a generalized lithostratigraphic and environmental context from a limited number of localities in the basin (Smith and Botha-Brink 2014; Viglietti et al. 2016, 2018). The vertebrate biostratigraphy is reported to be augmented by both a magnetostratigraphic (DeKock and Kirschvink 2004; Ward et al. 2005) and a chemostratigraphic (MacLeod et al. 2000, 2017; Ward et al. 2005) record which, in combination, have been used as the basis for correlation with the end-Permian marine event at the Meishan section, Zhejiang Province, South China (Shen et al. 2011). All four independent data sets in the Karoo Basin, however, are not without their limitations.

Limitations of Previous Studies

The fully continental succession in the Karoo Basin begins with deposition of the Beaufort Group, following deglaciation of the Gondwanan continent in the Middle Permian (Johnson et al. 2006; Fig. 1). These landscapes are characterized by sandstone channels of various fluvial architectures (Wilson et al. 2014) draining provenance areas in the Cape Fold Belt, located to the east-southeast. Fine- to very fine siliciclastic sediments were deposited in bedload barforms, abandoned channels, and overbank fines, wherein interfluvial areas were colonized by a glossopterid-dominated flora (Gastaldo et al. 2005, 2014; Prevec et al. 2010). Various workers identify both a change in fluvial architecture and siltstone color in

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