

## Resolving the age of Madumabisa fossil vertebrates: Palynological evidence from the mid-Zambezi Basin of Zambia



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### ABSTRACT

Age estimates for Permian rocks in the mid-Zambezi Basin of Zambia have thus far yielded ambiguous results. Previously studied palynoassemblages from the Madumabisa Formation resemble spore-pollen suites from both the *Cistecephalus* Zone of North Luangwa (Lopingian) and the palynological Assemblage Sub-Zone IV H of Zimbabwe, proposed as Guadalupian. In order to improve age estimates and refine the biostratigraphy of the Madumabisa Formation, this formation together with the underlying Gwembe Formation, were sampled for palynomorphs. Assemblages from the Gwembe Formation are dominated by trilete spores with less common striate and non-striate bisaccate pollen, whereas the overlying Madumabisa Formation palaeoflora is composed predominantly of striate bisaccates. Ferns, pteridosperms, lycopods, sphenophytes, glossopterids and conifers are represented in the palynofloras. The upper Gwembe Formation palynoassemblage can be correlated with the *Didictriletes ericianus* Zone of Backhouse (1991), the *Guttulapollenites hannonicus–Protohaploxypinus rugatus* Zone (Zone VI) of Aitken (1998), Assemblage Zone III of the mid-Zambezi Basin, Zimbabwe and Biozone KK 3 in the Kalahari Karoo Basin, Botswana, suggesting a Guadalupian (Wordian–Capitanian) age. The upper Madumabisa Formation palynoassemblage can be placed in the upper *Dulhuntyispora parvithola* Zone of Backhouse (1991)/APP5 of Price (1997), dated as Wuchiapingian (Lopingian) and correlates with Assemblage 2 of the Moatize–Minjova Basin, Mozambique and the McKinnon Member palynofloras of East Antarctica. It also resembles *Daptocephalus* (formerly *Dicynodon*) Assemblage Zone palynofloras of the lower and middle Balfour Formation in the Karoo Basin, South Africa, and is suggested to be Lopingian (Wuchiapingian–Changhsingian) in age. Although these palynological assemblages place lower and upper age constraints on Madumabisa Formation vertebrate fossils, uncertainty remains as to the exact correlation between the Madumabisa vertebrate assemblages and the assemblage zones of the main Karoo Basin.

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### 1. Introduction and stratigraphic context

The diverse Permian and Triassic fossil vertebrates in the main Karoo Basin of South Africa have facilitated biostratigraphic subdivision of the Beaufort Group (Keyser and Smith, 1977–78; Kitching, 1977; Rubidge et al., 1995), and the Karoo fossil tetrapod record is regarded as the most complete of this age (Rubidge, 2005). The assemblage zones of the Beaufort Group in South Africa have been correlated with analogous faunal assemblages in similar-aged basins throughout southern and eastern Africa (Catuneanu et al., 2005). Karoo-equivalent deposits are

widespread in Zambia, occurring in the Luangwa, Luano and Zambezi basins (Drysdall and Kitching, 1962; Catuneanu et al., 2005). Angielczyk et al. (2014) correlated the upper member of the Madumabisa Formation in the Luangwa Basin to the *Cistecephalus* Assemblage Zone (AZ) of the main Karoo Basin based on its assemblage of dicynodont therapsids (Table 1). This work formed part of a broader, ongoing research project on the Permian and Triassic vertebrates of Zambia (e.g., Peacock et al., 2013; Sidor et al., 2014; Sidor, 2015; Huttenlocker et al., 2015).

Tetrapod fossils were first discovered in the mid-Zambezi Basin in the 1950s (Gair, 1959; Drysdall and Kitching, 1963), but only a small amount of material was collected, and the specimens appear to have been lost (Sidor et al., 2014). Recently, our team has conducted more extensive fieldwork in the Madumabisa Formation of the mid-Zambezi Basin, resulting in the discovery of numerous tetrapod fossils, including

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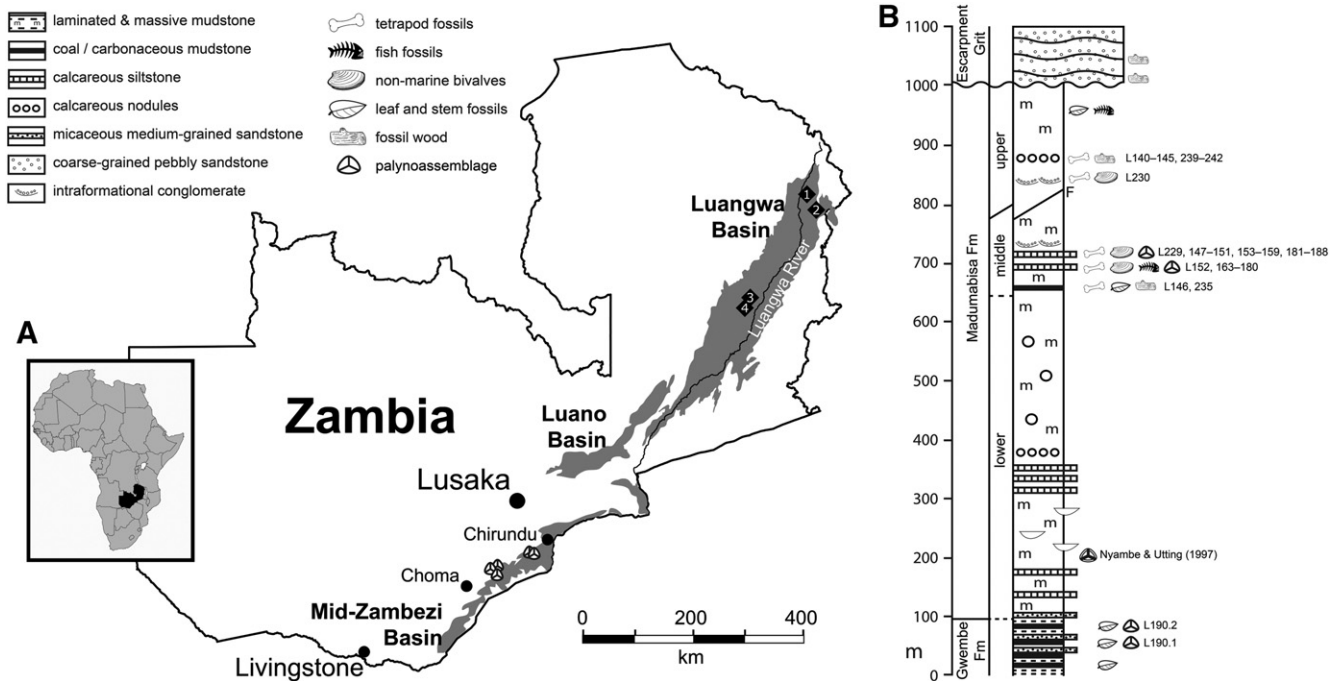
E-mail addresses: [natasha.barbolini@wits.ac.za](mailto:natasha.barbolini@wits.ac.za) (N. Barbolini), [rsmith@iziko.org.za](mailto:rsmith@iziko.org.za) (R.M.H. Smith), [ntabor@mail.smu.edu](mailto:ntabor@mail.smu.edu) (N.J. Tabor), [casidor@u.washington.edu](mailto:casidor@u.washington.edu) (C.A. Sidor), [kangielczyk@fieldmuseum.org](mailto:kangielczyk@fieldmuseum.org) (K.D. Angielczyk).

**Table 1**  
Previously proposed correlations of the Gwembe and Madumabisa formations in the mid-Zambezi Basin of Zambia to other southern African palynological and vertebrate assemblages (after Nyambe and Utting, 1997<sup>1</sup>; Angielczyk et al., 2014<sup>2</sup>; Utting, 1979<sup>3</sup>; Falcon, 1975<sup>4</sup>). Dotted lines represent uncertainty regarding how far zones extend. Not to scale.

Chronostratigraphy			Lithostratigraphy, mid-Zambezi Basin, Zambia	Palynozones, mid-Zambezi Basin, Zambia <sup>1</sup>	Main Karoo Basin, South Africa <sup>2</sup>	North Luangwa, Zambia <sup>3</sup>	mid-Zambezi Basin, Zimbabwe <sup>4</sup>
Permian	Lopingian	Changhsingian	Madumabisa Formation	Unnamed		Cistecephalus	
		Wuchiapingian					
	Guadalupian	Capitanian	?		Tapinocephalus		? Sub-Zone IV H ?
		Wordian					
		Roadian					
	Cisuralian	Kungurian	Gwembe Formation	<i>Brevitriletes levis</i> - <i>Scheuringipollenites maximus</i>			
		Artinskian					

temnospondyls, burnetiids, dicynodonts, gorgonopsids, and anteosaurid and tapinocephalid dinocephalians (Sidor et al., 2014). Dinocephalians are currently interpreted to be restricted to the Guadalupian worldwide (Lucas, 2004, 2006; Rubidge, 2005; Benton, 2012; Day et al., 2015b), and this has been confirmed by radiometric

dating, at least in the main Karoo Basin (Rubidge et al., 2013), although the recent discovery of two tapinocephalid dinocephalians from the lowermost Poortjie Member (Teekloof Formation) has extended the range of the *Tapinocephalus* AZ into the late Guadalupian (Day et al., 2015a).



**Fig. 1.** A, Map of productive palynology sample localities at existing vertebrate sites in the mid-Zambezi Basin, Zambia, with Karoo deposits shaded in dark grey. Tetrapod-bearing areas of the Luangwa Basin (after Angielczyk et al., 2014) are indicated by number: Area 1 = northern Permian localities of Dixey (1937); Boonstra (1938); Drysdall and Kitching (1962, 1963); Kitching (1963) and Attridge et al. (1964); Area 2 = Triassic localities of Drysdall and Kitching (1962, 1963); Kitching (1963) and Attridge et al. (1964); Area 3 = North Luangwa National Park localities of Kerr (1974) and Kemp (1975); Area 4 = Munyamadzi localities of Kerr (1974) and Kemp (1975). B, a generalised stratigraphic section of the Permian Gwembe and Madumabisa formations in the Bondo district. “L” numbers to the right of the section refer to fixed localities. Locality 281 is not marked on this stratigraphic section because it is situated in the Lusitu district, which comprises a slightly different stratigraphy to that of Bondo.

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