



A brief lithostratigraphic review of the Abrahamskraal and Koonap formations of the Beaufort Group, South Africa: Towards a basin-wide stratigraphic scheme for the Middle Permian Karoo



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ABSTRACT

The basal strata of the Beaufort Group of the South African Karoo Basin, comprising the western Abrahamskraal and eastern Koonap formations, contain the most time extensive record of Middle Permian fossil tetrapods and hold the key to understanding Middle Permian biodiversity change in the continental realm. To determine faunal stratigraphic ranges a reliable lithostratigraphic framework for Middle Permian Beaufort deposits is essential. Until now this has proved difficult to achieve, largely due to the homogeneity of the fluvial succession coupled with structural complexity as a result of Cape Fold Belt orogenesis. Accordingly, the Abrahamskraal Formation has been only locally subdivided on the basis of sandstone packages but regional stratigraphic subdivision has not yet achieved satisfactorily.

Collation of stratigraphic sections from around the Karoo Basin for this study demonstrates the presence of four sandstone packages are present within the Abrahamskraal Formation in the south-western corner of the basin. These sandstone packages are given member status, based upon the nomenclature of [Le Roux \(1985\)](#) with the addition of the newly recognised Grootfontein Member. The Combrinkskraal and Grootfontein Members occur in the lower half of the Abrahamskraal Formation and are laterally persistent along the southern margin of the basin. The Koornplaats Member is more restricted to the south west corner of the basin, where it quite thick, suggesting the narrowing of the highly channelized area. The overlying Moordenaars Member, more extensive towards the north than underlying packages, indicates subsequent northwesterly expansion of the locus of active channelization with time. Although thin sandstone packages in the more easterly positioned and stratigraphically equivalent Koonap Formation, this does not facilitate lithostratigraphic subdivision of this part of the stratigraphic succession and may indicate a different form of fluvial architecture. Our study provides a regional lithostratigraphic scheme for the Abrahamskraal Formation that will facilitate its biostratigraphic subdivision and the investigation of Middle Permian Gondwanan basin evolution.

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1. Introduction

The fluvio-lacustrine sedimentary rocks of the Beaufort Group were deposited within the main Karoo basin of South Africa between the Middle Permian and the Early Triassic and today outcrop over much of the country ([Fig. 1](#)). The Karoo basin itself is most commonly interpreted as a foreland basin, resulting from subduction along the southern margin of Gondwana beginning in the early Permian (e.g. [Catuneanu et al., 1998](#); [Cole, 1992](#)), although this has been challenged in recent years (e.g. [Tankard](#)

[et al., 2009, 2012](#)). Outside of South Africa, the Beaufort Group is primarily known for its abundant record of Permian and Triassic fossil tetrapods, which have allowed the Beaufort Group to be divided into tetrapod assemblage zones. These biozones are frequently employed for stratigraphic correlation by palaeontologists and geologists alike, as the relatively homogeneous fluvial sequence makes the recognition of lithostratigraphic units difficult within the Lower Beaufort Group. Despite this challenge, lithostratigraphic divisions of the Lower Beaufort Group have been accepted at the formation level (e.g. [Johnson, 1976](#); [Keyser and Smith, 1979](#); [SACS, 1980](#)). Attempts have been made to lithostratigraphically subdivide the lowest formation of the Beaufort Group (Abrahamskraal Formation) in the south west of the Karoo Basin ([Jordaan, 1990](#); [Le Roux, 1985](#); [Stear, 1980](#); [Turner, 1981](#)), but none

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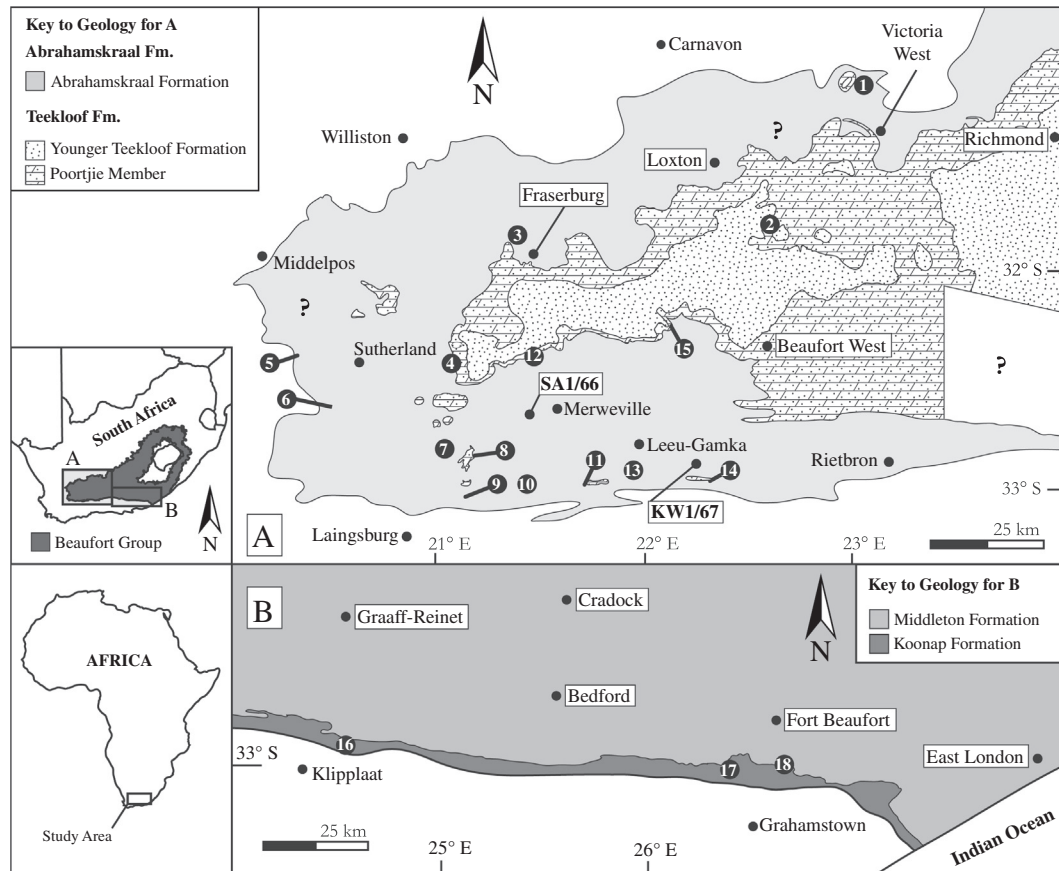


Fig. 1. Map of the lower Beaufort Group within the Karoo Basin, South Africa, and the localities of stratigraphic sections used in the interpretation of the lithostratigraphy. (A) Map of Abrahamskraal Formation exposure west of 24° E. (B) Map of Koonap Formation exposure east of 24° E. Numbers correspond to stratigraphic sections presented in Figs. 3 and 4. SA1/66 and KW1/67 refer to SOEKOR boreholes.

of these studies embraced the entire extent of the Lowermost Beaufort in the Karoo basin and as such none have yet achieved general acceptance.

When combined with the overlying Poortjie Member of the Teekloof Formation, the Abrahamskraal Formation currently comprises strata belonging to three tetrapod biozones: the *Eodicynodon*, *Tapinocephalus* and *Pristerognathus* assemblage zones (AZ) (Rubidge, 1995), all of which are considered to be of Middle Permian age (Rubidge, 2005; Rubidge et al., 2013). In light of the recent interest in the late Middle Permian (Guadalupian) extinction event in the marine realm (e.g. Bond et al., 2010; Wignall et al., 2009), the significance of biodiversity changes within this stratigraphic interval of the lower Beaufort Group has been greatly enhanced. Furthermore, debate surrounding the evolution of the Karoo basin has drawn into question the chronology of tectonism in the Cape Fold Belt and challenged the traditional model of the Karoo as a retro-arc foreland basin (Tankard et al., 2009, 2012). The chronology of deposition in the Lower Beaufort has also been vastly improved by radiometric dates from a number of horizons (Lanci et al., 2013; Rubidge et al., 2013) which has opened the way to link these with developments in the Cape Fold Belt.

In order to properly utilise depositional processes within the Lower Beaufort Group for the study of Karoo Basin evolution, and to link these with biodiversity trends during the Middle Permian, an understanding of the lithostratigraphy of the Lower Beaufort is essential. This paper reviews the existing broad stratigraphic observations of the Abrahamskraal and equivalent Koonap formations of the Lower Beaufort and provides further insight into their subdivision.

2. Stratigraphic history of the Abrahamskraal Formation

Much of the earliest stratigraphic work on this Karoo succession was conducted by geologists employed by the government of Cape Colony (e.g. Bain, 1856; Dunn, 1873, 1887; Wyley, 1859). The subdivisions proposed by these workers were very broad, and generally grouped rocks of what would become the Beaufort Group based on the presence of fossil tetrapods. Following the advent of the Geological Commission of the Cape of Good Hope in 1895, a more concerted effort was made to classify the 'Beaufort Beds' based on a suite of a lithological and palaeontological characteristics (e.g. Broom, 1906; du Toit, 1905; Rogers, 1903, 1905; Rogers and du Toit, 1909; Rogers and Schwartz, 1903).

Broom (1906) first described the 'Lower Beaufort Beds' as the fossiliferous strata that underlie the first appearance of *Lystrosaurus*, and which he attributed to the Late Permian based on the comparisons between its constituent tetrapod fossils and those known from the Russian Permian. Because of its lithological homogeneity, the Lower Beaufort Group, as it became known, was for many years subdivided solely on the basis of its variable fossil content. This first changed with the work of Johnson (1976), in which the Lower Beaufort Group east of 24° E was subdivided into the Koonap, Middleton and Balfour formations, primarily using the distribution of mudstone colours. In the south west of the Karoo Basin, it was the discovery of uranium in the Lower Beaufort Group that stimulated geologists to provide more lithologically defined formation level stratigraphic units (e.g. Keyser and Smith, 1979; Turner, 1981). SACS (1980) accepted the nomenclature of Keyser and Smith (1979), whereby the Lower Beaufort Group west of

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