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Lower Cretaceous deposit reveals first evidence of a post-wildfire debris flow in the Kirkwood Formation, Algoa Basin, Eastern Cape, South Africa

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ABSTRACT

The Algoa Basin is an onshore rift basin filled by an Upper Mesozoic non-marine and shallow marine sedimentary sequence. The middle unit of this clastic succession is assigned to the Lower Cretaceous Kirkwood Formation, known to host a wealth of plant and animal fossils together with poorly documented lignites, amber and charcoal clasts. This study is motivated by the growing interest in the impact of wildfires on the palaeoenvironment during the high-oxygen, Cretaceous world. It has been hypothesised that frequent and severe Cretaceous wildfires triggered large-scale non-marine denudation events, altering the sedimentation dynamics and influencing the evolution of ecosystems. In order to investigate this phenomenon, charcoal-bearing sedimentary rocks and plant fossil assemblages of the Kirkwood Formation have been studied at the Bezuidenhouts River locality, ~50 km north of Port Elizabeth (Eastern Cape, South Africa).

Detailed field observations of the sedimentary facies suggest that deposition occurred in a meandering fluvial environment with mature, vegetated floodplains. Depositional trends within a charcoal-rich bed (i.e., stratification, flattening and decrease in charcoal clast size down-current) indicate that a charcoal-rich debris flow, linked to a post-wildfire flood event, became diluted by fluvial flow. Palaeocurrent indicators (e.g., orientation of fossil logs) suggest unidirectional currents from SW to NE, which are somewhat inconsistent with the previously reported regional palaeocurrent directions in the Kirkwood Formation.

To gain insights into the fire-influenced dynamics of the Early Cretaceous ecosystems, the macro-plant fossil assemblages of the Kirkwood Formation were considered, with reference to the responses of modern plant analogues to wildfire. Of the plant orders reported from macrofossils of the Kirkwood Formation, the Cycadales, Pinales and Filicales, are known to have produced large woody or fibrous trunks and stems, or in the case of the Bennettitales more densely branched, divaricate architectures, and are likely to have provided the bulk of fuel for wildfires, with fern elements dominating groundcover niches. The particular role of these plants in the Early Cretaceous wildfire palaeoecology of the Algoa Basin is a topic for an ongoing study, but the Bezuidenhouts River locality appears to record the aftermath of a severe crownfire that led to mass tree mortality.

1. Introduction

The formation and evolution of the Mesozoic rift basins of South Africa (Fig. 1A) are poorly understood with most previous studies having relied on low-resolution seismic data with a focus on offshore hydrocarbon exploration (Du Toit, 1979; Leith and Rowsell, 1979; Broad, 1990). To date, no modern facies analysis has been undertaken on the sedimentary fill of these basins, the Uitenhage

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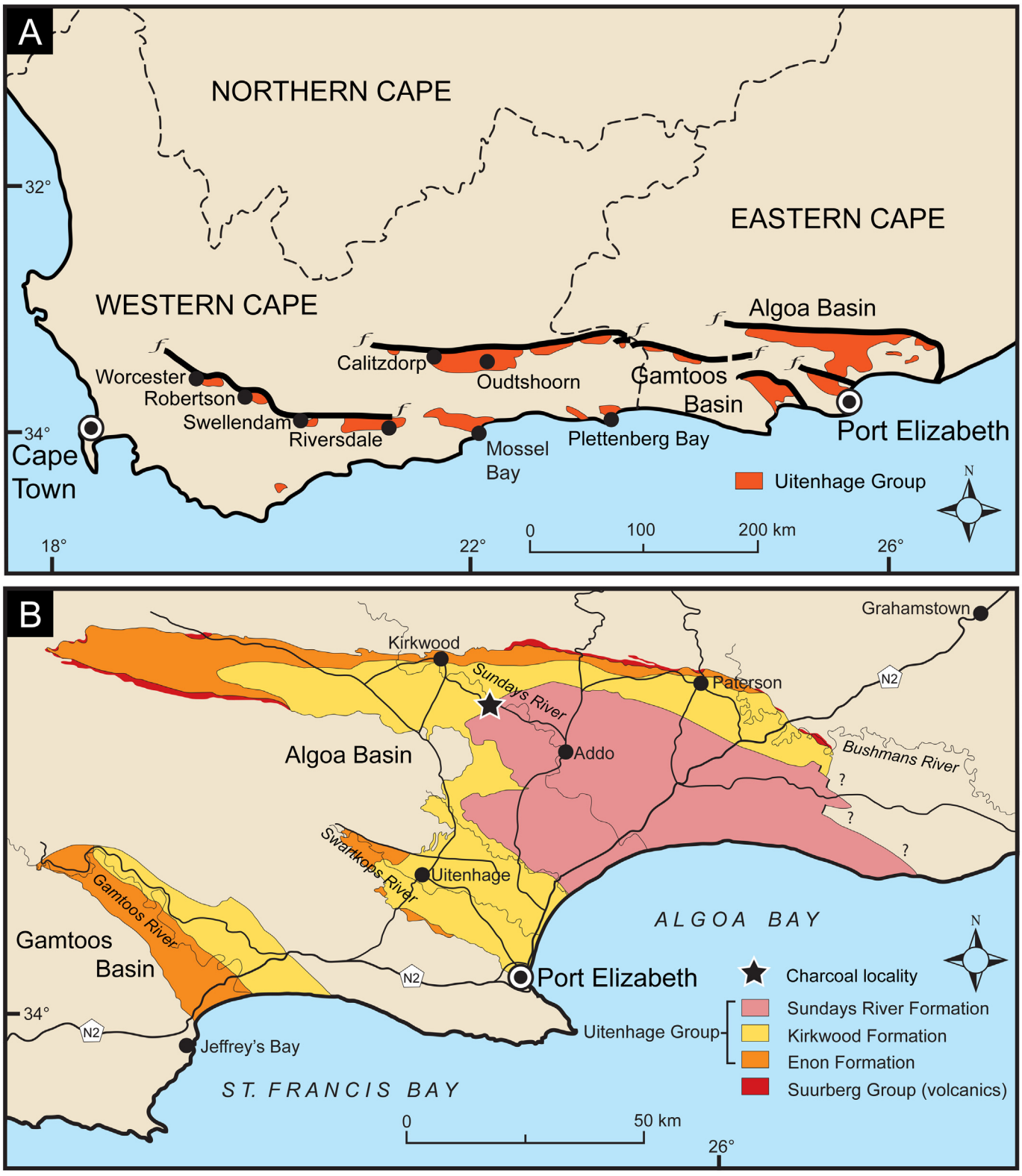

Fig. 1. **A**) Mesozoic basins of South Africa; **B**) simplified geological map of the Algoa Basin, with the study locality indicated by a black star.

Group, although it is known to record valuable information about the break-up of Gondwana, the evolution of life during the middle to late Mesozoic and the 3D geometry of potential hydrocarbon source, reservoir and seal rocks. In addition to there being a need for the application of modern sedimentological techniques in this region; this study is mainly motivated by the growing interest in the impact of wildfires on sedimentary dynamics and palaeoecosystems. It is hypothesized that during the Cretaceous the atmospheric oxygen concentrations were higher than currently observed (Bergman et al., 2004; Belcher and McElwain, 2008;