Geomorphology 219 (2014) 161–175

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Extensive Quaternary aeolian deposits in the Drakensberg foothills, Rooiberge, South Africa

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ARTICLE INFO

Article history:
Received 23 January 2014
Received in revised form 29 April 2014
Accepted 11 May 2014
Available online 16 May 2014

Keywords:
Aeolian
Sand ramp
Coversand
Periglacial
Drakensberg
Gullies

ABSTRACT

Deposits of aeolian sand are known to have accumulated in periglacial environments during the cold phases of the late Quaternary. In many instances, however, they form low-relief topographic units which may not be readily identified without detailed field survey. This study aims to use a multidisciplinary approach, combining remotely sensed data analysis and field survey, to investigate the extent and palaeoenvironmental significance of sand ramps in the Drakensberg/Rooiberge foothills of South Africa. Analysis of Google Earth™ imagery has demonstrated that gully systems are a common component of the landscape, and heterogeneously distributed across the landscape. Field investigation confirmed the hypothesis that the gullies are mainly eroding into sand ramps of fine sands and very coarse silts which mantle many of the lower hillslopes of the region. These sand units include palaeosols and occasional gravel lags, but are otherwise remarkable for their homogenous composition, cross-bedding and the complete absence of clasts. Much of the sediment is thus interpreted as aeolian in origin.

The deposits are sufficiently similar in many respects to the Masotcheni Formation, a late Quaternary colluvium which outcrops abundantly in the Drakensberg, to propose an assignation to this unit. However, an aeolian component in the Masotcheni has not previously been described. The distribution of aeolian accumulation in the region is consistent with southward transport during late Quaternary cold phases from a source on the Highveld to the north of the study area. The low relief and complex fluvial network in this region would concentrate sediment eroded from the Drakensberg/Rooiberge, which would subsequently be available for deflation when the balance between fluvial flow regime, seasonally frozen ground and north-westerly trade winds were optimal for aeolian entrainment. Deposition is primarily topographically controlled, and is in places sufficiently extensive that it may be better described as a discontinuous coversand. This study suggests that aeolian deposits may be overlooked in other environments subject to past periglacial landscape development, and develops a potential methodology by which this problem may be overcome.

1. Introduction

Southern Africa lies at the intersection of a complex range of climatic influences (Tyson, 1999). The history of how these have evolved during the late Quaternary, and the effect this has had on the landscape, remains contentious (e.g. Chase and Meadows, 2007; Gasse et al., 2008). Amongst the uncertainties that remain is the nature of the expression of glacial climates on the region's uplands, in particular the Drakensberg mountains, the highest range in southern Africa. Most attention has been focused on the question of glaciation in the high Drakensberg/Maluti; a debate which has lasted nearly half a century since the first suggestion of glacial landforms in southern Africa by Sparrow (1967a,b). Recent descriptions of moraines from the high Drakensberg of Lesotho (Mills and Grab, 2005; Mills et al., 2009, 2012) offer the most convincing evidence to date that niche glaciation occurred during the Last Glacial Maximum (LGM) in the highest regions of the Lesotho Highlands, but much of the geomorphological evidence accumulated over the past fifty years for lower altitude regions remains controversial (Boelhouwers and Meiklejohn, 2002; Mark and Osmaston, 2008).

Accompanying evidence of periglacial landforms has proven no less contentious. Marker (1989) drew attention to several aspects of the landscape interpreted as being periglacial in origin in the Golden Gate Highlands, namely nivation niches, rafted protalus boulders, solifluction lobes, and subdued upland topography. Alternative explanations (primarily structural control and temperate slope processes), which did not invoke periglacial conditions, for each of these were promptly proposed (Le Roux, 1990). The ensuing debate is well summarised by Boelhouwers and Meiklejohn (2002), who concluded that much of the uncertainty stemmed from the fact that the marginal nature of any past glacial/periglacial climatic regimes in the area would have led to poorly developed characteristic landforms. Recently, Telfer et al. (2012) identified two sand ramps in a side valley of the Little Caledon river, in the Golden Gate Highlands National Park (GGHNP), in the

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http://dx.doi.org/10.1016/j.geomorph.2014.05.006
0169-555X/

foothills of the Drakensberg/Maluti range. Sand ramps are topographically controlled accumulations of aeolian sediment which are interbedded with evidence of soil formation, slope processes and/or fluvial activity. These landforms, dated with Optically Stimulated Luminescence (OSL) to the last glacial (45–15 ka), were interpreted as evidence for increased potential for aeolian activity under periglacial conditions, presumably characterised by much-depleted vegetation cover. As such, they are a valuable geomorphic proxy of past environmental change in a region where such evidence can be scarce. It is not the first time that aeolian sands have been identified in the wider region – Marker and Holmes (1993) reported an isolated accumulation of aeolian sand in the North-eastern Cape, which was dated to ~20.5 ka – but the potential significance of such deposits is currently under-studied.

A large part of the reason that aeolian landforms have been overlooked in such environments is their subdued position within the regional topography, and identifying the extent of sand ramps is challenging (Bateman et al., 2012). This study aims to investigate the extent and palaeoenvironmental significance of sand ramps in the Drakensberg foothills, extending the study of Telfer et al. (2012). The specific research questions to be addressed are:

1) Can analysis of remotely sensed data help to identify sand-ramps, landforms with very subdued topographical expression?
2) Are sand ramps a widespread phenomenon in the northern Drakensberg/Rooiberge mountains and does their spatial distribution on the landscape help elucidate the mechanisms of formation?
3) Can the internal stratigraphy of the sand ramps (e.g. occurrence of palaeosols) be used to infer palaeoenvironmental information, and is the stratigraphy of the sand ramps spatially consistent across the region?

2. Study area

The study area lies in the north-eastern Free State of South Africa in the foothills of the Drakensberg/Rooiberge Mountains, and is bordered immediately to the south by Lesotho (Fig. 1). The Highveld plateau (1500–2100 m) which occupies the eastern central part of South Africa rises in this region to form the Drakensberg chain, which dominates Lesotho, and has numerous peaks above 3000 m. The geology of the area is relatively simple, with the late Triassic and early Jurassic sediments and extrusive volcanics of the upper Karoo Supergroup typically lying near-horizontally. Thus elevational change in the area typically sees a succession from the Molteno sandstones, through the mudstones, limestones and sandstones of the Elliot Formation (Bordy et al., 2004), and lastly the desert sandstones of the Clarens Formation. Above, the highlands of the region are dominated by up to 1400 m thickness of flood basalts (the Drakensberg basalt). The Quaternary is represented by the Masotcheni Formation, characterised by variably cemented colluvium and palaeosol development (Botha, 1996). Gullies, known locally as 'dongas' (Watson et al., 1984), are a common feature on the lower slopes of the region (Botha et al., 1994; Chaplot, 2013; Boardman, 2014), to the

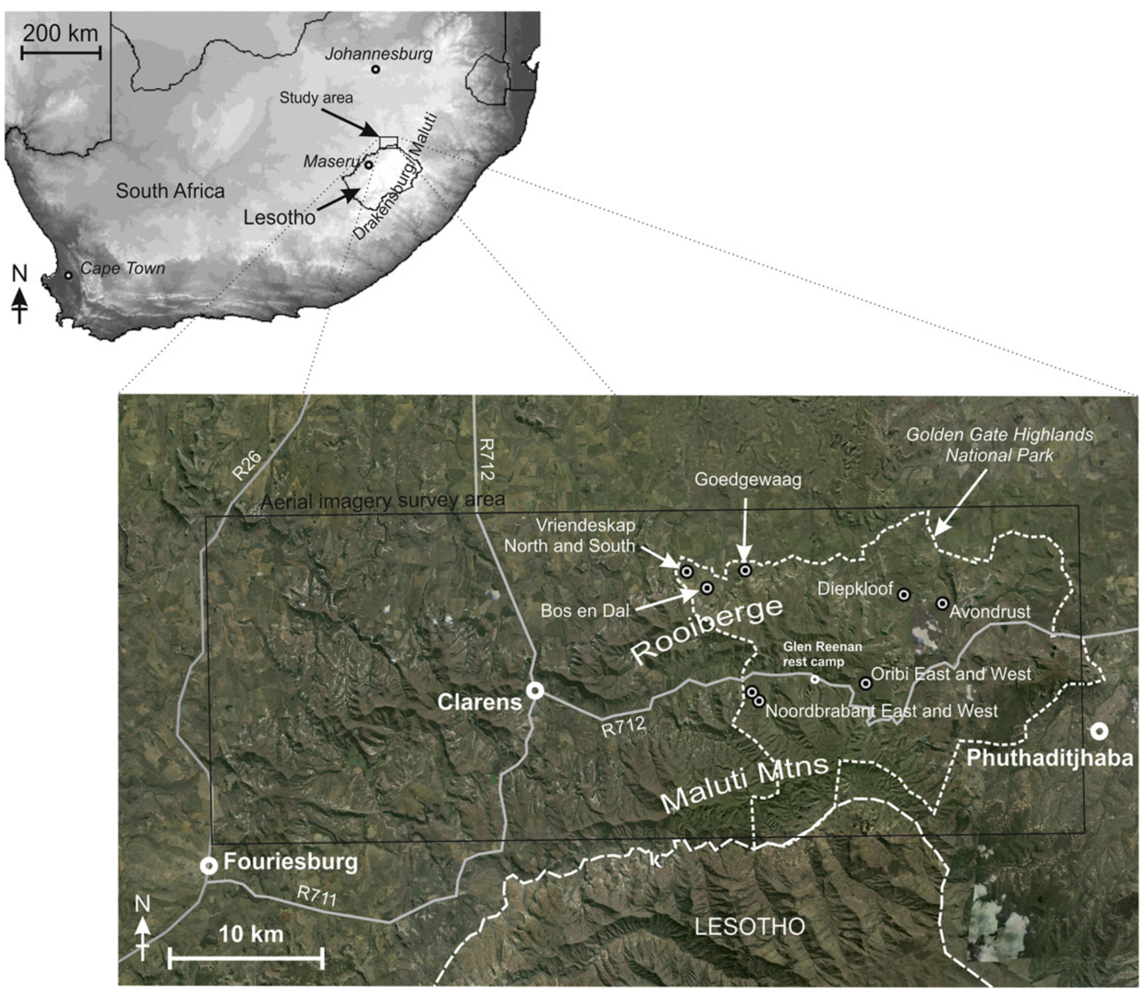

Fig. 1. a) Regional overview of the study area, showing the location of the NW foothills of the Drakensberg/Rooiberge chain, which form part of the E rim of the 'Great Escarpment' which encircles central South Africa, and which are the highest mountains in southern Africa. Greyscale topographic data derived from GTOPO30 dataset (U.S.G.S., 2004). b) The study area in detail, showing the extent of the remote sensing survey (black outline), major roads and towns, the outline of the Golden Gate Highlands National Park and the locations of exposures referred to in the text. Image courtesy of Google Earth Pro™, ©Digital Globe and ©CDNGI (image date: 2013).