The ground beneath our feet: A critical reflection on 135 years of landscape evolution models for southern Africa

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In his 1925 paper describing the Taung Child fossil, Dart makes various assertions about the landscape around Taung, inferring past climate dynamics, and the role these factors play in the evolution of our early prehuman relatives. He argues that this region of southern Africa is dry today and has been for much of the Cenozoic. This notion of long-term aridity and stability has dominated perspectives on southern African landscape evolution. Here, we present a review of this field, starting with the foundational studies from the late 1890s, which underpin Dart's hypothesis. We examine the work of 20th-century researchers who developed models of landscape evolution; however, almost all of these models have been qualitative. With technological advancements, new quantitative techniques have emerged to provide evidence of landscape evolution events and to test previous models, and we present a brief overview of these methods. We call for reflection on the framing and languaging of many of these landscape models, specifically the 'African land surface' model. While the evidence of a homogeneous and stable landscape is continually being challenged through scientific advancement, this terminology is rooted in outdated colonial thinking. We also note that the key narratives that have driven research on landscape evolution have been largely shaped by selected prominent Western-based scientists. As we mark the centenary of the Taung discovery, we look toward a new era of landscape evolution research: one characterised by technological advancements and more diverse, local teams that will produce more quantitative, nuanced models for southern Africa and create richer, more dynamic backdrops for our own human evolution.

Significance:

We provide a review of over 100 years of models used to characterise landscape evolution in southern Africa. We argue that it is essential to reconsider current models of landscape evolution and assess their relevance in the southern African context. With technological advancements, we must question whether these models remain applicable or require revision. As scientists, we should also re-evaluate the terminology used in scientific dialogue to ensure it accurately reflects evolving perspectives. Finally, while the use of qualitative and quantitative methods have their unique benefits, we consider the application of more quantitative methods of landscape dating to test the existing models and build new, more complex ones.

[Abstract in** Setswana**]

Introduction

The 1925 publication describing the Taung Child fossil in South Africa by Dart[1] marks the beginning of what we recognise today as the modern discipline of human evolution or palaeoanthropology. The role of the physical landscape in human evolution, including our understanding of where, how, and when our genus and species emerged, has been a central focus since the early days of the discipline. In the article, Dart[1] frequently references the landscape in which this, in his words, "ultra-similan and pre-human stock" existed and presenting several key points that have shaped much of the last 100 years of research into the landscape and palaeoenvironmental reconstructions associated with human evolution sites and key hominin fossils. He argues that the presence alone of the fossils of *Australopithecus africanus*, as well as the cercopithecid monkeys also recovered from Taung, is surprising given that,

> *at this extreme southern point in Africa [...] one does not associate with the present climatic conditions obtaining on the eastern fringe of the Kalahari Desert an environment favourable to higher primate life.*[1]

He goes on to argue that "it is generally believed by geologists that the climate has fluctuated within exceedingly narrow limits in this country since Cretaceous times"[1], implying that the current landscape and climate conditions in the Taung region have varied very little for hundreds of millions of years. He concludes that "it was only the enhanced cerebral powers possessed by this group [the australopithecines] which made their existence possible in this untoward environment"[1]. This assertion reveals the early link between hominin fossils and their environments, highlighting two key themes: first, the dryness of the regional landscape, and, second, that there has been very little climatic change for millions of years, implying equally little change in the physical landscape.

The southern African landscape is, at first order, determined by the extensive variety of its underlying geology, dating back as far as the Archaean. However, while the region has an undoubtedly long geological history, the present-day landscape and physical environment into which Dart's australopithecines evolved, have been shaped by a broad range of tectonic, topographic, and climatic events, both on the surface and subsurface.[2] Dart's 1925 assertion that there has been little change in the landscape and climate of the region is not without basis – for much of the Cenozoic (from 66 Ma to recent times), southern Africa was considered to have experienced a period of geomorphological stability, with only modest and localised uplift, subsidence, and erosion (see Andreoli et al.[3], Bierman et al.[4] and Glotzbach et al.[5]). Partridge and Maud[6], in their 1987 review of the geomorphic evolution of southern Africa, however, alluded to the mid-Miocene to late Pliocene minor and the late Pliocene to Holocene major uplifts that challenged the notion of the stability of the region[6], thereby contributing to the suggestion that the landscape is more dynamic than Dart inferred and that, during the Cenozoic, geomorphological processes of weathering, erosion, and deposition have contributed to the formation of most of the landscapes and landforms observed in southern Africa today[2].

Landscape evolution in southern Africa

Since the early 20th century, the evolution of the southern African landscape has been the subject of great geographic and geomorphological interest[7-12], with several ideas and models postulated about its development. The evolving climate and surface processes driven by the climate have shaped the landscape over various spatial and temporal scales and rates, exposing a variety of geologic time periods to the surface[2], such as the Late Jurassic-aged Great Escarpment[13] and 2.02 Ga Vredefort impact structure[14,15]. While we recognise the effects of topography on landscape development, resulting from dynamic uplift and subsidence due to mantle convection[16], we do not address this topic here.

Various studies have explored the development of the southern African landscapes over time, with a focused interest in mountain-building processes[17,18], river processes[19-23], slope development[23,24], soils and soil erosion[25-29] and alluvial fans[30,31]. Most of these studies have focused on the relationships between geomorphology and exogenic factors, such as climate and anthropogenic effects, and how they contribute towards shaping the evolving landscape. Unlike Dart's early declaration of a uniformly dry west, we now recognise considerable variations in moisture availability during different Quaternary phases, evidenced by the development of pans, lakes, caves, and springs in wet phases, and the formation of dunes in dry phases (e.g. Kalahari Desert), as determined from the dating of river and dune deposits using luminescence dating.[32] Other studies that have linked landscape development to the changes in climate and palaeoclimate include work done by Mills et al.[33] in the Eastern Cape Drakensberg area and the recognition of climate changes in the Neogene, as recognised to have had an effect on the landscape by Knight and Fitchett[34] (see also Fitchett[35] for more on the effects of climate on the environment in the Holocene).

In this contribution, to mark the centenary of the original Taung paper, we critically examine the longstanding theme of a dry, unchanging landscape as the backdrop for human evolution in southern Africa. We expand our focus beyond Taung, and assess the models invoked to describe and characterise the southern African landscape and its evolution. We look at how and where these intersected with the growing field of human evolution – as one thing Dart[1] was correct in predicting was that more fossils would be found. We go on to look at this review of the evolution of the southern African landscape through a lens of decolonisation and argue that it is time to both diversify the scope of the theoretical models and build local capacity in South Africa. Specifically, we emphasise the need for new geochronological tools and techniques to test these models and advocate for a broader, more inclusive base of researchers in this field.

Models of landscape evolution: An historical overview

Landscape evolution studies began in the 19th century and are associated with Western-based L. Agassiz, J.W. Powell, G.K. Gilbert, W.M. Davis and A. Penck.[36] In the 20th century, key South African geologist A. du Toit, Australian geomorphologist C. Twidale, Austrian geologists E. Seuss and W. Penck, as well as British geologists and geomorphologists J. Wellington, L.C. King, F. Dixey and A. Goudie, began using the southern African region to develop and test theories of long-term landscape evolution[37-39] (see Appendix A of Partridge and Maud[6] for an Africa-wide summary). Qualitative field observations dominated the earlier published literature[7–11,40], while, in later literature, analytical and quantitative approaches emerged[28,37-39,41-43]. Here, we present a review and summary of the last 135 years of landscape evolution in southern Africa, in chronological order and grouped into subsections, starting from the foundational publication in 1889.[44] This was done to achieve an overview of the various models presented and a sense of the evolution of scientific thought around landscape evolution. This special issue marking the centenary of the description and naming of the Taung Child is the ideal place to explore past landscapes and critically reflect on past practice, as well as to provide a base from which to look forward to future research directions.

1890s

One of the most commonly applied landscape evolution models in the South African context, the Davisian model of Davis, suggests that landscapes evolve in a sequential form after an initial uplift.[45] This initial uplift, as shown in Figure 1A, is then followed by age-related landform development (i.e. weathering and erosion processes) from youth, through maturity to old-age low-relief peneplains where, through the erosion and transport of weathered material, the landscape flattens into a low, featureless plain over time – a peneplain. Simply put, in this

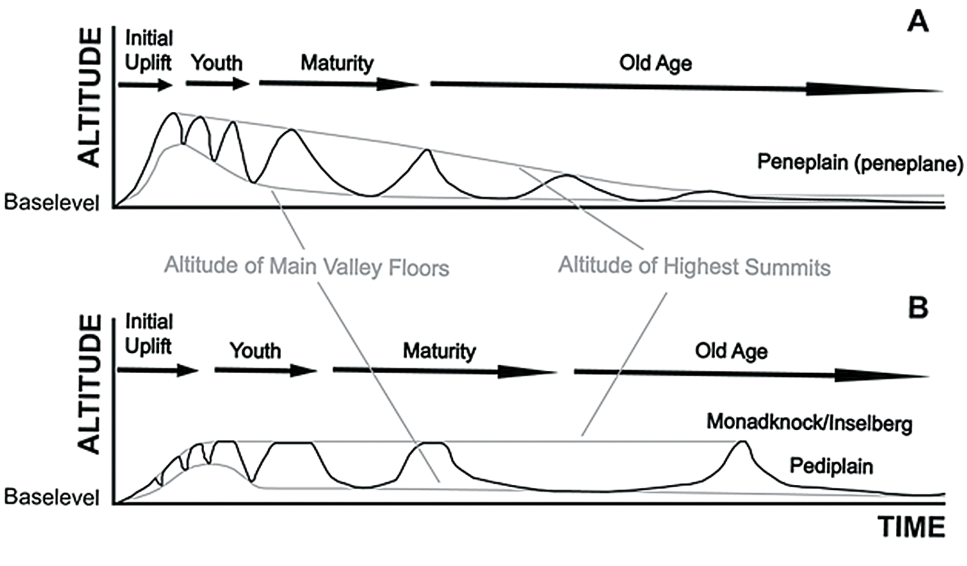


Figure 1: (A) The Davisian (peneplanation) model (the geographical cycle) based on descriptions by W.M. Davis (1899).[45] (B) The pediplanation model of erosion based on descriptions by L.C. King (1955).[10]

model, the landforms are seen as progressing through three stages: youth, maturity, and old age. According to Davis[45], these changes are well defined and work towards the surface process until they reach the end product development of the peneplain. The idea underlying this model is that, because of weathering and material transport along river valleys, land surface denudation widens with time, producing low-relief peneplain surfaces that represent the local land surface stability of the river system.[45]

In his model, Davis emphasises three crucial factors in shaping landforms: structure (lithological folding, faulting, jointing, and other such structural characteristics), process (weathering and erosion) and time. Changes in structure are related to geomorphic processes that occur over time. Time is somewhat of a complex factor in that it not only serves as a temporal metric but also as a process itself, driving the inevitable progression of landform changes, thereby necessitating the comparison of the landscape over a time process to decipher the evolution of the landscape.[45] Davis's theory posits that landforms change in an orderly manner under uniform external environmental conditions. He aimed to provide a basis for genetic classification and systematic description of landforms.

1900–1960s

Between the 1900s and 1960s, du Toit, Wellington, Dixey and King dominated southern African landscape evolution research. While mainly qualitative, their contributions remain foundational and underpin much of the subsequent quantitative research. Focusing mostly on the evolution of major drainage systems, du Toit[7], a geographer, excelled at field observations, a critical geological tool. His model of landscape evolution was dominated by qualitative field observations that involved describing and documenting landforms and landscapes. In 1954, he was the first to embrace Davis's concepts of cyclic periods of landscape evolution, which included tectonic uplift during the Neogene and Quaternary periods.

Like du Toit, Wellington relied on field observations.[11,46-49] He played an important role in the division of southern African regions, which he termed physiographic regions, and in describing regional drainage patterns and morphologies.[48] Wellington suggested that the South African physical landscape was the result of downwearing in a single, constant, and ongoing cycle of erosion and used the example of very large sequences of Karoo rocks that had been removed since the breakup of Gondwana. Wellington pointed out the significance of lithology and structure in his interpretation of the South African landscape – an observation which could explain only the conservation of landforms and not their origin.[11]

Dixey looked at erosion cycles in central and southern Africa, and, like King[7] after him, suggested multiple erosion cycles, different from those summarised by Partridge and Maud[6]. Dixey[50,51] identified two or more erosion surfaces in several central and eastern African countries, attributing these cycles to the varying erosion resistance of underlying lithologies. He suggested that the Jurassic cycle of erosion (later referred to by King as 'the African landsurface'; herein referred to as the African surface) seemed to have been more effective in eroding than subsequent cycles.[50] Dixey also recognised the stability of the African land mass and its exposure to periodic uplift.[51] In 1955, he was the first to acknowledge the applicability of the pediplanation model of landscape change in arid and semi-arid settings.

Through field observations, King[52] grouped erosion surfaces and referred to them as an older 'African surface' and younger 'post-African surfaces'. He compared sediment build-up in coastal regions to argue that the 'African surface' graded to sea level during the late Cretaceous to early Miocene, giving credibility to Dixey's proposed surfaces while proposing the new terms.[52] Additionally, he proposed that crustal erosion prompted isostatic uplifts of the continental margin, thus adding elevation to the Great Escarpment.[6,10,13] He proposed backwearing by pediplanation as an alternative process of landscape development.[10] King elaborated on the concepts and deliberated a pediplanation "landscape cycle" for the development of the southern African landscape (Figure 1B[10]). However, Wellington expressed reservations about King's idea of a peneplain of subcontinental extent inherited from Gondwana.

1980s–2000

In the development of landforms, Twidale explored the idea of etches, their development and how they contribute to the evolution of landscapes.[53] Etches develop in two stages: (1) solution, hydrolysis and hydration and (2) differential degradation of material and structurally controlled subsurface weathering at the base of granitic bedrock. As a result, the regolith is generated at the base of the rock.[54] Due to the southern African region being well known for its planation surfaces, a surface that implies stability and deep, intense weathering[54], from work done by Dixey[50,51,55] and King[52] and summarised by Partridge and Maud[6], it was accepted that etch surfaces would be well developed in the region. This was especially due to the evidence of planation surface development from laterite and silcrete surfaces, because of a passive period.[6] From the processes that promote etch development, we can assume that they are evidence of a quiescent time with little to no tectonic activity.

In their 1987 review, Partridge and Maud[6] suggested that the notable large-scale features of South Africa's landscape were a result of the development of irregular but continuous flat surfaces that occur at various altitudes throughout the region. While it was King[52] who coined the term 'the African landsurface', Partridge and Maud[6] went on to describe these main flat surfaces, based on observable lateral stratigraphy and degree of weathering across the region, as:

i. *The African surface* (85–42 Ma)*:* spanning between the late Jurassic/early Cretaceous to the end of the early Miocene.

ii. *Post-African I surface* (19–15 Ma)*:* spanning from the early to mid-Miocene to the late Pliocene, a minor uplift ranging between 150 m and 300 m.

iii. *Post-African II surface* (7–3 Ma)*:* spanning the late Pliocene to the Holocene and resulting in the uplift of approximately 900 m of the eastern margin.

While there is a 20-year gap in the literature review between the 1960s and 1980s, it is important to note that after King's model and until Partridge and Maud's adaptation, there have not been any more explicit landscape evolution models that have come out of southern African research.

2000s to present: Introduction of new quantitative methods

In 2012, Twidale[56] argued that every model that relied on Davisian deductions had either been altered, dropped, or replaced. However, certain landscape concepts, elements, or processes, some identified nearly two centuries ago, although incidentally, are still recognised as influential in shaping landscape characteristics.[56] These observations highlight the need for updated data and modern recommendations in landscape evolution studies. While past hypotheses developed through qualitative methods have contributed valuable insights, they often relied solely on field observations, without supporting quantitative data, limiting our understanding of landscape evolution. Recent advancements in quantitative geochronological research enable us to test these earlier ideas and analyse cause-and-effect relationships that qualitative research could not fully explore. For instance, the concept of the 'African surface' was initially grounded in qualitative observations without quantitative validation. We propose that such models can now be rigorously tested using advanced quantitative methods.

Over recent decades, various methods have emerged to investigate landscape evolution, allowing for empirical testing of some of the previously proposed qualitative models. Computer-based systems, for instance, have replaced handheld maps, although they still require ground-truthing. Geochronology has become a common approach for examining landscape change, and integrating these techniques provides a more comprehensive view of landscape dynamics. Chronologically constrained data enable us to quantify rates of landscape change (e.g. using cosmogenic radionuclides), allowing comparisons with known tectonic and climatic events rather than assigning these by inference.

Tinker et al.[57] investigated the balance between onshore erosion and offshore sediment accumulation in South Africa since the break-up of Gondwana. They hypothesised that the rate of onshore denudation matches the volume of offshore sediment accumulation. Using geological and sedimentological data, they quantified sediment flux from land to sea and found a significant correlation between hinterland erosion rates and offshore sediment deposition. This suggests that South African landscapes have been shaped by this dynamic, enhancing the understanding of geomorphological processes over geological time scales. Their work aligns with landscape evolution models in southern Africa such as the King and Davisian models, by providing empirical data on uplift and erosion rates. Tinker et al.[58] quantified Mesozoic exhumation in the Southern Cape using apatite fission track thermochronology, linking significant exhumation events during the Mesozoic to the current geomorphological landscape. This underscores the importance of historical geological processes in shaping contemporary geomorphology.

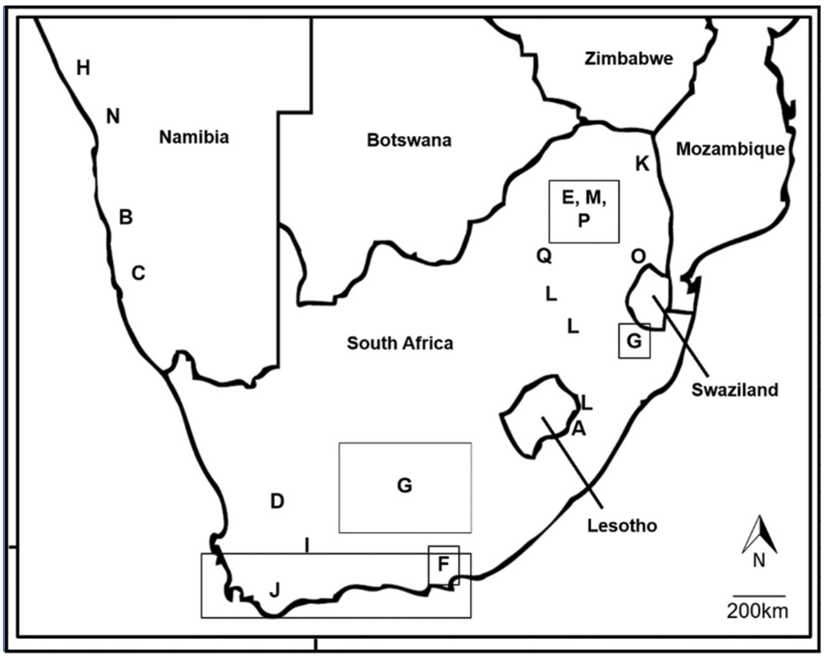
Recent geochronological data, particularly from cosmogenic radionuclides, show variable rates of landscape denudation across southern Africa. For example, average apparent cosmogenic ^{10}Be-derived denudation rates at the Cradle of Humankind's Rising Star Cave, a spatially extensive area, were determined to be at a range of $3.05 \pm 0.25 - 3.59 \pm 0.27$ m/Ma[59], while Dirks et al.[42,43] determined a range of landscape change between 0.86 ± 0.54 m/Ma (from chert dykes) and 4.15 ± 0.37 m/Ma (from river erosion). In the interior plateau, Keen-Zebert et al.[60] determined variable rates of dolerite bedrock erosion along river channels using ^{3}He with values ranging from 11 m/Ma to 255 m/Ma, a very wide range for a regional study. Along the eastern Great Escarpment, Makhubela et al.[61] determined variable rates of erosion with a wide range of 1.8–24 m/Ma along different sections of the same landform.

Scharf et al.[62] found steady-state topography comparable with low denudation rates on the unique alpine-like topography in the Cape, while Tinker et al.[58] identified periods of increased and decreased exhumation, indicating variable landscape responses using apatite fission thermochronology (see also Baby et al.[63-65] for examples of uplift history in the South African plateau and western margins). Decker et al.[66] and Makhubela et al.[67] provide summaries of the extent of cosmogenic radionuclide studies conducted in southern Africa. From these examples, we see that, while the southern African landscape has long been considered stable, rates of landscape changes within the same geomorphic landforms can exhibit a wide range.

The application of chronologically constrained data in determining landscape dynamics is relevant in many aspects of geo- and palaeoscience research, but here we draw attention to its relevance to human evolution. Contrary to earlier assumptions, our early prehuman relatives did not necessarily evolve in a steady, unchanging, dry landscape – it seems much more likely that southern Africa was a more dynamic place than previously recognised. Evidence from hominin-bearing caves in the Cradle of Humankind[42] suggests that this region experienced significant, and repeated, shifts in local hydroclimate, fluctuating between wetter and drier conditions. This finding suggests that hominins evolved in a dynamic, changing landscape, rather than a stable, arid environment as postulated by Dart[1].

Figure 2 shows the spatial extent of geochronological data (mostly from cosmogenic radionuclide studies) that exist for the southern African region, showing that, with such temporal differences determined for the region, there are still knowledge gaps that need to be filled in order to fully review, with confidence, whether some of the previously postulated models are still relevant and can still be applied to how the landscape has developed over time. This underscores the need to reconsider terms such as 'the African surface' and adopt terminology that reflects both spatial and temporal evidence.

Owing to advancements in geological disciplines such as lithostratigraphy, chronostratigraphy and even biostratigraphy, Botha[76] calls for an evolution of terminologies in the southern African landscape. He identifies shortcomings in the current South African mapping practices since geological records were started ~170 years ago. Noting the reliance on lithological descriptors and the lack of formal biostratigraphic units, he claims that these practices lead to inconsistencies and difficulties in correlating geological units across different regions, for example. To address these shortcomings, he proposes the use of formal nomenclature based on lithodemic stratigraphy, which characterises geological units based on lithological properties and terrain morphology, providing a more systematic and standardised approach to geological mapping. He emphasises the interdependence of geological processes and landform development, positing that geomorphological features are a direct reflection of underlying geological processes, believing that landscape evolution models aim to explain how historical geological events have shaped contemporary landscapes, highlighting the dynamic interactions between various geological agents over time.



	REFERENCE	DENUDATION RATES (m/Ma)
A	Fleming et al.[37]	1.4–62.3
B	Bierman and Caffee[39]	1.1–18.2
C	Cockburn et al.[68,69]	0.3–15.6
D	Kounov et al.[31]	0.95–4.82
E	Dirks et al.[42]	2.6–15
F	Erlanger et al.[70]	24.4–86
G	Decker et al.[28]	0.9–18.9
H	Matmon et al.[71]	1.2–19.2 (94.3 outlier)
I	Kounov et al.[31]	0.3–1.5
J	Scharf et al.[62] Bierman et al.[4]	1.98–7.95 3.4–6 (16.1 outlier)
K	Chadwick et al.[72] Glotzbach et al.[5]	3.3–7.8 2.2–9.7
L	Keen-Zebert et al.[60]	11–255
M	Dirks et al.[43]	0.9–8.3
N	Matmon et al.[73]	0.7–6.6
O	Makhubela et al.[61]	1.8–23.9
P	Makhubela et al.[59]	2.2–12.8
Q	Khosa et al., in prep.[74]	0.8–3.7
R	Khosa, in prep.[75]	13.1–45.7 1.0–18.9

Figure 2: Southern African map showing spatial extent and temporal data (denudation rates) of existing cosmogenic geochronological data on landscape evolution studies. Blocks show spatial extent of study reach, where some studies (e.g. J) share similar study reach boundaries.

Botha employs practical methodologies that include field surveys using systematic data collection from various geological formations and landforms, providing empirical evidence for his theoretical constructs and geospatial analysis, and utilising remote sensing and Geographic Information System technologies to analyse and visualise geological and geomorphological patterns, enabling detailed mapping of landscapes, and sedimentological studies, where there are investigations into sediment composition and distribution that inform on past environments and depositional processes.

Botha[76], in agreement with Partridge et al.[77], suggests that geomorphic provinces are necessary for geological interpretation. Here, each province reflects specific geological histories and processes, facilitating a better understanding of landscape evolution and natural resource management, where knowledge of geomorphic provinces aids in effective management and conservation of resources. This is because different provinces exhibit varying geological characteristics and stratigraphic correlation, where geomorphic provinces could serve as reference frameworks for correlating stratigraphic units, which enhances understanding of regional geological variations. Botha proposes changing terminologies to enhance the understanding and correlation of Cenozoic deposits across South Africa, for example.

Why it is time to move on from 'the African land surface'

Andreoli et al.[3], Bierman et al.[4] and Glotzbach et al.[5] have previously suggested that the southern African landscape is a relatively stable and tectonically passive region, and, as such, landscape evolution processes are assumed to be slow, steady, uniform and consistent throughout the Cenozoic. Geomorphological evidence for the so-called peneplains suggests their continued preservation in the southern African landscape.[34] Data from cosmogenic nuclides, thermochronology and the accumulation rates of offshore sediments, further suggest that the topography of southern Africa is ancient and has been stable since the end of the Cretaceous 66 Ma ago.[37,41,57,58,66,69] However, owing to post-formational denudation, these surfaces seem to occur in the landscape at varying altitudes[2], raising the question of the stability and passivity of this region. The concept of an 'African land surface' has existed since the late 1940s, and has arguably been the dominant theoretical framework within which most of southern African geomorphological research has been undertaken. We have traced this concept back to King[52] who grouped erosion surfaces and referred to them as an older 'African surface' and younger 'post-African surfaces'. While this framework has persisted over time, it is important to note that King's publication initially cited no prior research, and yet, while we cannot negate his contribution, the concepts have been accepted and are still considered as true 40 years later, even without quantitative data to support them.[4] Partridge and Maud[6] further examined the development of various erosion surfaces, establishing a connection between distinct uplift stages and localised modifications to the fluvial drainage pattern. Collectively, this became the basis for a long-held narrative that the southern African landscape could be interpreted spatially based on stratigraphic correlations using the evidence of surfaces with weathered profiles, for example, calcrete and laterite layers. This view posits that landscapes across southern Africa are old with irregular but continuous flat surfaces, so-called 'African surfaces'. Beyond these three episodes, the stability hypothesis further predicted that the landscape evolution of southern Africa was slow and steady, with minimal change over a long time period. This concept of landscape stability is also evident in Dart's 1925 publication, as referenced in our introduction.

The challenge of recognising the different 'African surfaces' lies in the assumption that surfaces of similar altitude share comparable ages and, consequently, have experienced the same tectonic activity.[4,56] According to Blumel and Eitel[78] and Marker et al.[79], the correlation of surfaces with these weathered profiles that formed over time by chemical and physical processes, would imply a greater likelihood that the surfaces are instead of composite ages.

Du Toit[80] and King[40,81] suggested a close relationship between geomorphology, topography and geology in southern Africa. This paints a picture of complexity, with the landforms and landscapes of different ages, inferring that they had evolved differently in multiple places and at various times, thus a single interpretation for their evolution would be an injustice to the processes.[60] Both tectonic and climatic processes have been ascribed as the driving factors behind the landscape evolution in southern Africa and echoed by Knight and Fitchett, respectively.[36,40]

Aside from the weak evidence for single, old, stable land surfaces, there is a further issue with the 'African surface' hypothesis: one of language. The term 'Africa' is used loosely here, as all the publications cited here focus solely on southern Africa, with many centred specifically on South Africa. Yet, this hypothesis has been generalised to encompass the entire continental landmass of Africa – an area of 30 million km^2, consisting of at least eight climatic regions and today comprising 54 countries – reducing it into a single, homogeneous mass. This simplification erases the continent's heterogeneity and loosely applies both scientific hypotheses and language, echoing the colonial era and colonial thinking. The expectation that an entire continent could be represented by a single or even three surfaces reflects an inadvertently colonial mindset. Notably, there is in fact *no* strong evidence for these so-called 'African surfaces', and existing models of landscape evolution remain largely qualitative. Examining these models requires moving beyond the scientific limitations of the time and considering the colonial context in which they were conceived and the lasting influence of colonial assumptions on theories of landscape evolution.

Once recognised, the impact of colonial thinking needs to be addressed. A straightforward and easily achievable measure is the evaluation and re-assessment of language used in fields such as geomorphology.[82] We argue that it is time, for many reasons, to move away from using phrases like 'the African land surface'. Employing regionally appropriate and specific terms, potentially informed by spatial extents of landforms and landscapes or quantitively derived temporal data, would represent a shift away from colonial frameworks. We are hopeful that an increase in quantitative studies on landscape evolution in southern Africa will inspire new models, such as those presented by Botha[76] and, with this, foster the adoption of more precise and contextually appropriate terminology and language.

The who of landscape evolution

Geologists and geomorphologists from the early 20th century have made an invaluable contribution to understanding the development of the southern African landscape. It is important to note, however, that these landscape evolution studies in the Global South, and particularly in southern Africa, have mostly been dominated by researchers from the Global North. We base this assertion on an analysis of 44 authors who have contributed to landscape evolution studies in southern Africa (using first name as an indicator of gender, last name as an indicator of ethnicity, and affiliation as a marker of geographical location), which indicated that this field is predominantly composed of male researchers, most of whom are based in the Global North, and only a minority of whom are affiliated with South African institutions (Figure 3).

Advancing the field of geomorphology requires that, as a science, it should be based on observable facts, robust hypotheses, and models based on quantifiable theory with repeatable and verifiable methods. Local experts have called for improved experimentation with radiometric experimental techniques.[31] We contend that, over longer time periods, radiometric methods have improved utility spanning over aeons. For the latter part of the Cenozoic, geochronological techniques, such as the measurement of terrestrial cosmogenic radionuclides using accelerator mass spectrometry, offer critical information.[82,83]

Conclusions

The southern African landscape has been a subject of interest for the last 135 years for multiple reasons, including the various drivers behind its evolution since the start of the Cenozoic. Several models to explain modern observations of the landscape and the processes driving their evolution have been put forward, all of which rely on qualitative, descriptive data. Beyond the three tectonic episodes of the so-called 'African surfaces', the stability hypothesis predicts that the landscape evolution of southern Africa is slow and steady, with little change over a long time period. However, the landscape and resultant landforms that we see today cannot be attributed

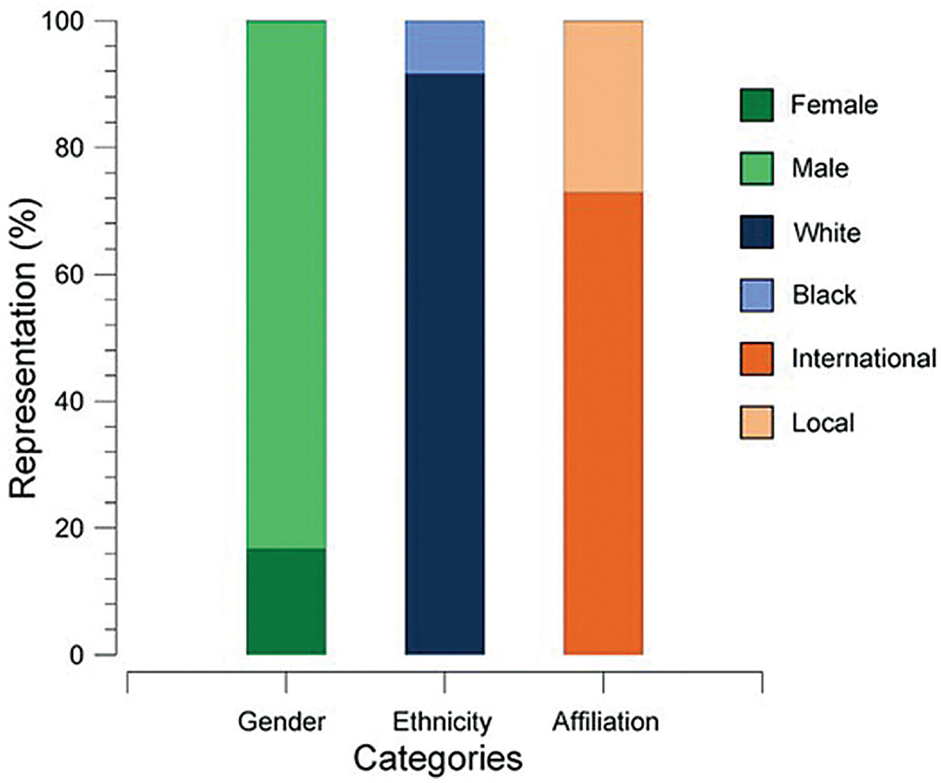


Figure 3: Stacked column chart showing the demographics of 'the who' of landscape evolution studies in southern Africa.

to either a single time period of formation or a single forcing mechanism, but ought to be viewed as transient features that change through time.[2] Detailed quantitative studies looking into the differences between rates of landscape change and factors contributing to landscape evolution across southern Africa have been undertaken for some regions, like the Cape[37,57,58,68] and the Cradle of Humankind[41,43,59], and we look forward to seeing more quantitative studies like these.

From Figure 2, we note that many of the studies conducted have focused on areas along the Great Escarpment and Cradle of Humankind, which is understandable based on their significance to the history of the southern African landscape and human origins. There are spatial gaps that are not being addressed and we strongly recommend considering studies within the interior plateau regions outside the Cradle of Humankind, perhaps from the Free State Province towards the Northern Cape region.

We also look forward to a diversifying of 'the who' of landscape evolution and more local teams doing more locally relevant work in southern Africa. This is not a new idea – there have been previous calls for the decolonisation of the practitioner landscape in geology in South Africa.[84] There is a growing body of thought and literature calling for an introspection of geosciences and articulating the need for change, especially change in the demographics of geoscientists.[85] We look forward to both a new generation of landscape models, based on measurable erosion rates and exposure ages, led by a new generation of more diverse, local geoscientists, to keep filling in the backdrop to the evolution of our own, distant, prehuman relatives.

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Data availability

There are no data applicable to this paper.

Declarations

We have no competing interests to declare. We have no AI or LLM use to declare.

Authors' contributions

R.K.: Conceptualisation, methodology, data collection, data analysis, validation, writing – the initial draft, writing – revisions, project leadership, project management. V.M.: Writing – revisions, student supervision, funding acquisition. K.K.: Writing – the initial draft, writing – revisions. R.P.: Conceptualisation, methodology, writing – the initial draft, student supervision, project leadership, project management, funding acquisition. All authors read and approved the final version.

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