Reply to reviews: Richardson et al.

'Constraining the timing and processes of pediment formation and dissection: implications for long-term evolution in the Western Cape, South Africa'

We would like to thank both reviewers for their positive reviews and very helpful suggestions to improve the manuscript. We have replied individually below.

Reviewer 1: R. Braucher

The paper of Richardson et al. clearly presents attempts to constrain the timing and processed involved in pediment formation in South Africa.

The authors present different models of pediment formation based on literature then they show their sampling sites, and their chronology based on ^{10}Be measurements and finally discussed their results.

I will have only some questions on the cosmogenic part.

- Top sample of depth profile is not at a different altitude than the other samples below (779 and 776 m); Is this correct? (table 1) Is the density of the top profile sample also set at 1.6 ?

Thank you for spotting this; the text has been updated accordingly for altitude and density in table 1.

- I was able to redo all calculations and agree with minimum ages and maximum denudation rates determined by the authors (see joined excel file).

Thank you for supplying an excel file and for independently cross-checking the denudation rate calculations.

- However, I disagree with their exposure ages determined with 0.3 m/My denudation rate. Based on ^{10}Be only I am sure that ages up to 4.6My can be determined (table 3 last column). Using the integration time formula of Lal (1991) involving neutrons only I have an upper age of 1.04 My (see excel All samples sheet)

We are happy to look into these issues. The ages reported in Table 3 are minimum exposure ages for non-eroding and slowly eroding profiles, with minimum ages of 0.315 My for non-eroding surfaces.

- Regarding the depth profile I suggest the authors to do some more investigations. From this depth profile, sample SA-LB-DP0 is an outlier compared to the other samples. Considering all samples I determined a "slope decrease" of 112 g/cm2 in disagreement with neutrons attenuation length (~160g/cm2); Removing the upper samples the "slope" is 155.6 g/cm2 in agreement with low denudation and neutrons attenuation.
- From this depth profile, minimum ages can be determined for each point as well as max denudation rates. This can show that the profile is almost at steady state state.
- Then it will be nice if the authors could model their depth profile to determine denudation rate and exposure time. I reach a minimum age of 360ka with no denudation.
- Now because the deepest sample exhibits the higher maximum denudation rate (5.47 m/My based-on my calculation), this sample can be used to better estimate the exposure age of the entire profile. To do so, I have considered a denudation of 3.1 m/My for all samples (based on max denudation rate of sample SA-LB_DP30) and infinite time for all samples except the deepest one. An exposure time of 867ka was achieved for the deepest. This age can better reflect the true age of the profile.

We thank the reviewer for these comments. We agree that the upper sample site from the depth profile represents an outlier, with the concentration of the sample reflecting a sample higher up on the depth profile. Because of this, we interpret that deflation has removed fine material, and that the sampled boulder is part of a deflation surface. We also agree that the 'slope' of the concentration-depth profile (after removing the sample from the deflation surface) is in very well agreement with the expected path attenuation length in these sediments. We will further elaborate this point in the revised manuscript.

Also, we will improve the concentration-depth model, and provide maximum denudation rates, and minimum exposure ages for the profile.

- The authors suggest a denudation change in the past; This has already be evidenced with cosmo but with two nuclides (^{10}Be and 16Al) (Jolivet et al. 2021 https://dx.doi.org/10.1016/j.geomorph.2021.107747 ; Godard et al 2021. ⟨1002/esp.5190⟩. I think that using one nuclide this is more difficult. I tried to model this with a denudation change from 0.3 m/My to 3.1m/Ma; I can reach a n age of 3My but the 30cm deep sample from the depth profile is not well modeled. Why did the authors not measure ^{26}Al? This can be a real nice input and help to see a denudation rate change. I will not ask for that measurements for this paper but if the authors still have some remaining fractions, I encourage them to test (eventually they can contact me if help is needed).

Thank you for the suggestions and comment. We have read the suggested citations and we will integrate these into the text in the appropriate places. At the moment that we processed the samples, we did not consider it relevant to measure in-situ 26Al concentrations, as complex burial was not expected. We will consider this for future work and thank you for your offer of help.

- I suggest accepting this paper with minor revisions

Thank you.

Reviewer 2: A. Kounov

Dear Editor,

I reviewed this manuscript a few years ago. Upon reading the recent version, I have noticed some positive improvements. Therefore, I can only reiterate what I concluded about the manuscript previously.

The manuscript is well written and scientifically interesting. I think that the presented in this study data generally well support the suggested conclusions and the presented sequence of events during the evolution of the studied geomorphological features (Fig. 14). This study brings important advances in the better understanding of the Cretaceous and Cenozoic landscape evolution of South Africa. It also takes a significant step forward in challenging the paradigm of the existence of old, singular, large-scale erosional surfaces in southern Africa.

I have annotated a PDF copy of the manuscript with some minor comments.

Finally, I would recommend the publication of this manuscript after only minor corrections.

Kind regards.

Alexandre Kounov

We would like to thank you for reviewing the updated version of manuscript, and for your constructive comments for both reviews that have led to improvements.

Annotated pdf comments:

We have updated the text, thank you for spotting the mistake [line 56-58]:

Tracked changes: Model type 1 acknowledges the occurrence of channelisneddiffusive processes and model type 2 acknowledges the occurrence of diffusivechannelised erosion processes, but each model argues these are subsidiary formation processes

Section 2.1 Geological setting comments – We have updated the text to include the information on: ages of supergroups, metamorphism history, intrusion information and date of tectonic shortening, location/timing of denudation, and why some studies exclude Cenozoic uplift [lines 98-118]:

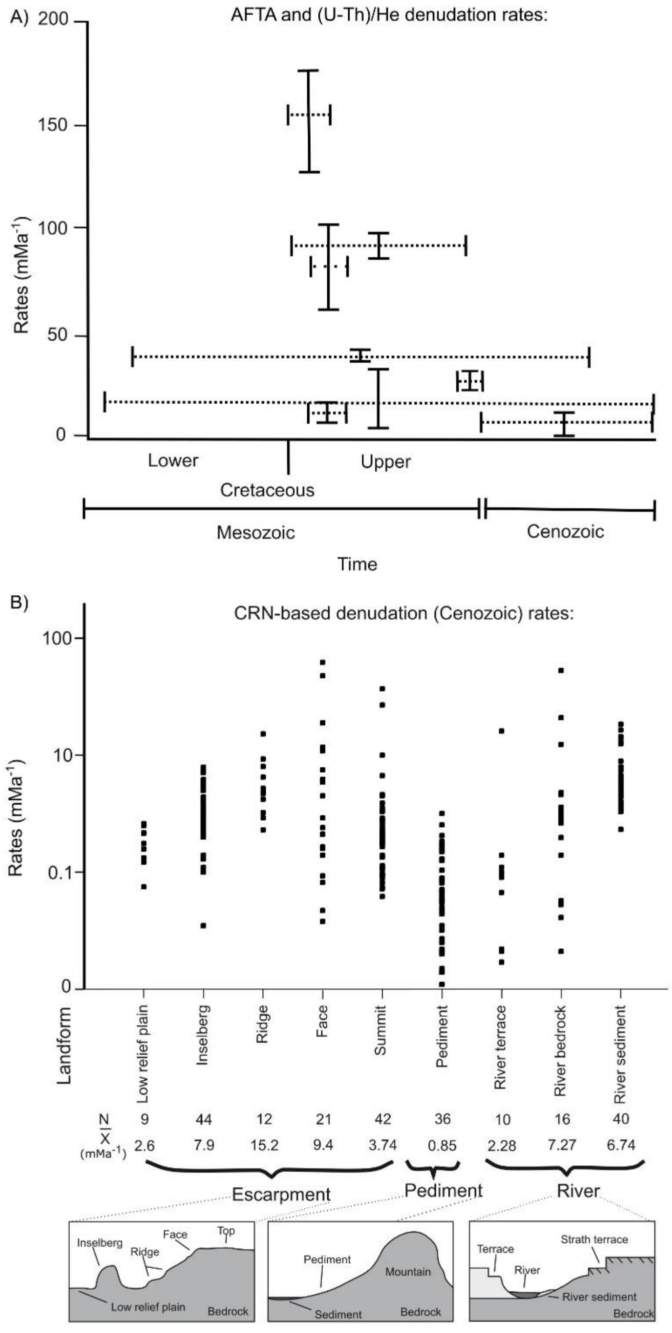
Tracked changes: In the area of study of Western Cape, Southern Africa, the geology is dominated by strata of the Cape (Early Ordovician to Early Carboniferous and Karoo Supergroups (Late Carboniferous to Early Jurassic) (Johnson et al. 1995, Frimmel et al. 2001) (Fig. 2), which are composed of various sandstone, siltstone and mudstone successions. Both supergroups have been subject to low-grade burial metamorphism (Frimmel et al., 2001), with localised contact metamorphism during Jurassic dolerite intrusion (Johnson et al.1995), and an estimated 6-7 km of exhumation during the Early Cretaceous (Tinker et al., 2008; Wildman et al., 2015).Both supergroups have been metamorphosed, and the Karoo Supergroup has) igneous intrusions. Tectonic shortening during the latest Paleozoic-to-early Mesozoic of the Cape and Karoo Supergroups of Cape and Karoo Supergroups (Tankard et al. 2008; Hansma et al. 2016) have resulted in with E-W trending, northward verging, and eastward plunging folds that decrease in amplitude northward and shorten northwards, and form the backbone of the exhumed Cape Fold Belt (CFB) (Paton, 2006; Tinker et al., 2008b; Scharf et al., 2013; Spikings et al., 2015). During the Mesozoic, the rifting of Gondwana initiated large-scale denudation across southern Africa. Using apatite fission track analyses of outcrop and borehole samples, Tinker et al.(2008a) concluded that the southern Cape escarpment and coastal plain underwent 3.3 to 4.5 km of denudation since the mid-late Cretaceous and potentially 1.5 to 4 km within the early Cretaceous, using a thermal gradient of ~20°C/km. Wildman et al. (2015) processed 75 apatite fission track and 8 zircon fission track data from outcrop and boreholes across the southwestern cape of South Africa (from coast to the escarpment). Using a thermal history model and a thermal gradient of 22°C/km, they obtained an average of 4.5 km of denudation in the Mesozoic since the Late Jurassic-Early Cretaceous. However, the estimates range between 2.2 and 8.8 km of denudation using the upper and lower ranges of the geothermal gradient and possible thermal histories bounded by 95% significance intervals, which provides uncertainty on the inferred model. Richardson et al. (2017) used reconstructed geological cross sections, tied to apatite fission track data, and drainage reconstruction to model up to 4-11 km of denudation across the Western Cape, with significant exhumation in the Early Cretaceous and lower amounts in the Late Cretaceous.

Figure 2 – The figure caption has been updated – line 123:

Tracked changes: **Figure 2: Stratigraphic chart showing the major lithostratigraphic units of the Western Cape, South Africa.**

Figure 3 – We have updated the figure to help support the interpretation. We have also prepared some supplementary information so that the data can be viewed in table format.

Updated figure:



Section 4.2 – We have updated the text to reflect the comments regarding why we chose an erosion rate of 0.3m/myr and minimum ages:

Tracked changes: Assuming low erosion rates of 0.3 m My^{-1} (following Bierman et al. 2014) the pediment minimum exposure ages increase substantially for the older surfaces, with ~~minimum~~ ages ranging from 0.678 to 4.462 My (Table 3).

[Line 303-305]

Section 5.2 comment around deflation. The 0.6m/Myr relates to the whole profile, whereas the top depth profile sample has increased concentrations than expected. We interpret that deflation has removed material and there are missing data points, related to different geomorphic processes functioning over geological time. We will further elaborate the text on the concentration-depth profile following Brauchers' comments.

Section 5.3 – We have updated the text following the reviewers comments around the processes and occurrence of pediments and fluvial networks to improve the clarity of the text and to acknowledge the assumptions in our geomorphic interpretation.

Tracked changes: Based on the observed denudation of the sub-catchments within the CFB that back the pediments and the mean maximum denudation rates from Scharf et al. 2013 and Kounov et al. 2015 (Figs. 3 and 8, Table 5), we obtain indicative minimum ages of 9 - 14 My for the Laingsburg area pediment, 3 - 4 My for Floriskraal, 2 - 10 My for Leeuwgat and 2 – 28 My for Prince Albert. [Line 464 – 467]

Tracked changes: These age estimates correspond ~~to the timing of cessation of pediment formation and~~ start of dissection, and are based on the assumption that geomorphic process rates were steady over long timescales. [line 477-478]