Rates of surface lowering in Southern South Africa: a cosmogenic view

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Project and rationale

Southern South Africa is characterised by large scale erosion surfaces including extensive pediments and strath terraces within the Cape Fold Belt that document river evolution. However, the rates of landscape evolution within the Western Cape Province, South Africa remain poorly constrained. Previous dating attempts for the Western Cape are limited to 10 small Cape Fold Belt draining catchments (Scharf *et al.* 2013), pediment surfaces (Kouvnov *et al.* 2015) and one apatite fission track transect (Tinker *et al*. 2008). The Gouritz Catchment is one of three large antecedent catchments that drain the Western Cape. The rivers that drain south of the Great Escarpment are overlooked, with modern technological advancements in geomorphology not utilised in this region. The overall aim of this research is to constrain landscape evolution from the Cretaceous to the present day.

Methodology

Samples from quarzite boulders (Fig. 1) on four pediment surfaces within the Gouritz catchment and 5 samples from a depth profile (Fig. 1) from the thickest pediment were collected. Bedrock samples from strath terraces within the Cape Fold Belt were also collected (Fig. 1) to date using *in situ* produced ^{10}Be. The samples were crushed, sieved and the 0.25 - 0.5 mm grain size extracted. The ^{10}Be was extracted from purified sand using standard methods described in von Blanckenburg *et al.* (1996, 2004). The ^{10}Be/^{9} Be ratios were measured in BeO targets with accelerator mass spectrometry at ETH Zürich (Kubik and Christl, 2010), and the ^{10}Be concentration calculated based on the known concentration of the ^{9}Be carrier. All concentrations were normalised to the ETH in-house secondary standard S2007N. Uncertainties were propagated from AMS counting statistics and the uncertainty of the blank sample. The ^{10}Be concentration was then used in the CRONUS calculator (Balco *et al.* 2008) to calculate exposure ages and incision rates. For the depth profile data incision rates and exposure ages were solved numerically (Braucher *et al*. 2009). Optimal solutions for Eq. 1 were created using different exposure ages and incision rates, to find the closest match between observed and simulated ^{10}Be depth profiles (as shown by the chi squared value).

$$N(z,t) = \frac{P(z)}{\lambda+\frac{E}{z*}} e^{-(z_0-Et)/z*}\left(1-e^{-(\lambda+\frac{E}{z}*)t}\right)+N_{inh}e^{-\lambda t} \quad \text{Eq. 1.}$$

Where P(z) is the rate of production, λ is the decay constant (ln 2 /$t_{1/2}$), z_0 is the initial shielding depth, and E is the post-depositional erosion rate (cm/yr) of the top of the terrace.

Fig. 1 *– A) example boulder sample from pediment surfaces; B) depth profile; C) and D) arrows indicating location of bedrock samples from strath terraces within the Cape Fold Belt.*

Preliminary results and conclusions

The results indicate that the pediments are long-lived features with *minimum* exposure ages of 0.47 to 1.09 Ma (assuming no erosion). The surfaces of the pediments are eroding at rates of 0.44 to 1.24 mMa^{-1} (Fig 2), some of the lowest rates worldwide. The depth profile indicates an exposure age of 1Ma and erosion rates of 4mMa^{-1} (Fig. 3). The top of the depth profile shows evidence of deflation (Fig. 3), as it does not follow the expected trajectory, indicating that the lower samples would have been much lower in the depth profile than their present day position. The pediments are now deeply dissected, indicating a period of geomorphic activity after a long period of geomorphic stability forming the pediment surfaces, possibly due to climate change or isostatic adjustment.

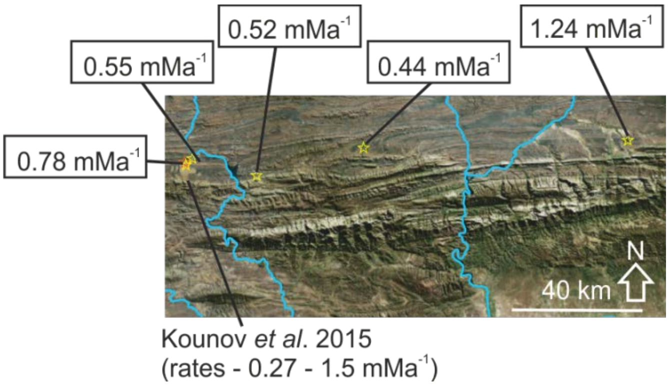

Fig. 2 *– Pediment surface lowering results. The blue lines represent major tributaries of the Gouritz catchment from West to East – Buffels R., Dwyka R. and Gamka. R.*

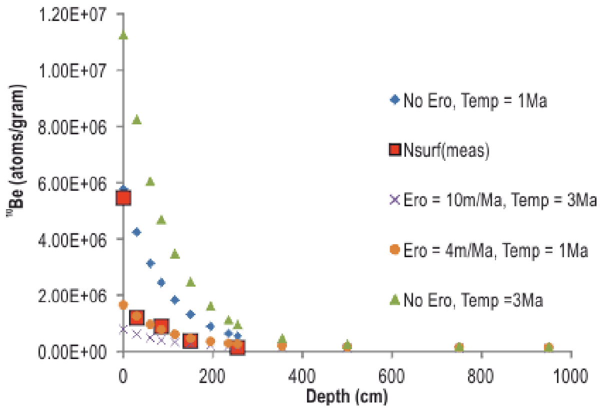

Fig. 3 *– Depth profile results of the measured concentrations (red squares) and simulated profiles.*

The strath terraces indicate rates of incision of 1.54 to 11.79 mMa^{-1} (4 samples), which are an order of magnitude higher than the surface lowering of the pediments but still some of the lowest within the world (Portenga and Bierman, 2011) (Fig. 4). Overall, the results indicate low geomorphic activity within the Western Cape despite the steep topography, which cannot be used to indicate high denudation rates (e.g. Scharf *et al*. 2013). The pediments are essentially fossilised surfaces due to resistant quartzite and silcrete formation. The rivers are eroding the Cape Fold Belt very slowly, with the gorges mainly a conduit of discharge rather than a zone of active incision.

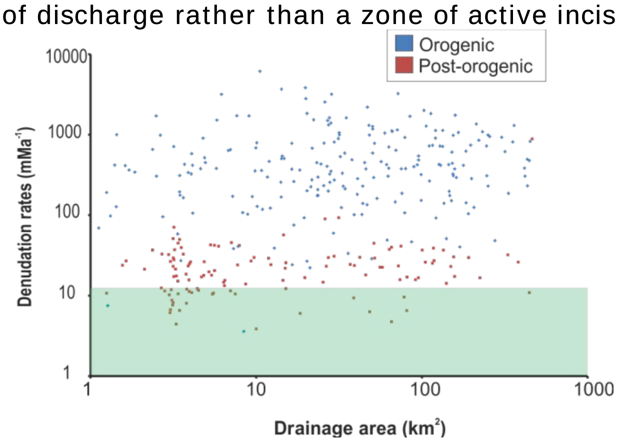

Fig. 4 *– Data from this study (green shaded box) compared to global incision values reported by Portenga and Bierman, 2011.*

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References

Balco et al. 2008, *Quat. Geol*., **3**, 174-195; Braucher et al. 2009, *Quat. Geochronol*., **4**, 56-67; Kounov et al. 2015, *SA J. Geol*., **118**, 129-144; Kubik & Christl, *Nucl. Instrum. Methods Phys. Res*., Sect. B 268, 880–883; Portenga & Bierman, 2011, *GSA Today*, **21**, 4-10; Scharf et al. 2013, *Geology*, **41**, 331-334; Tinker et al. 2015, *Tectonophysics*, **455**, 77-93; von Blanckenburg et al. 1996, *Chem. Geol*., **129**, 93-99; von Blanckenburg, *Geophys. Res. Earth Surf*., **109**, F3.