Insights on Denudation Controls of Volcanic Tropical Islands from Meteoric $^{10}Be/^{9}Be$ Ratios

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Highly energetic particles → Spallation

Supernovae* *or other cosmic event that would produce highly energetic particules

Motivations

Weathering of volcanic rocks accounts for approximately **one third of global CO_2 consumption** in the silicate weathering cycle [1]. However, how total denudation (D) divides into erosion (E) and weathering (W) fluxes, and **what controls their long-term rates on tropical islands remains unclear**. The recently developed meteoric $^{10}Be/^{9}Be$ ratio that uses **meteoric ^{10}Be together with stable ^{9}Be**, released during rock weathering, provides an **alternative to estimate D and weathering** intensity from soils to entire watersheds **independent of specific minerals**. We oriented our focus on testing **several hypotheses** :

- What is the influence and respective caracteristics of basalt vs andesite on weathering and erosion?
- Is weathering a function of **age of the underlying bedrock** [2] ?
- How are **climatic and geomorphologicals parameters** affecting both islands ? Is the effect comparable in terms of impact ?

Context in numbers

GUADELOUPE

- Up to 8000 mm precipitation
- 1450 m high relief
- 847 km^2
- Andesitic lithology

REUNION

- Up to 11000 mm precipitation
- 3070 m high relief
- 2512 km^2
- Basaltic lithology

Method [4]

Tool: $^{*}D_{met} = \frac{F_{met}}{\left(\frac{^{10}Be}{^{9}Be}\right)_{reac} \times [^{9}Be]_{parent}} \times \left(\frac{[^{9}Be]_{min}}{[^{9}Be]_{reac}} + 1\right)$

$^{*}D_{met}$: *Denudation rates in t/km²/yr*

Beryllium Weathering intensity $= 1 / \left(\frac{[^{9}Be]_{min}}{[^{9}Be]_{reac}} + 1\right)$

Requirements

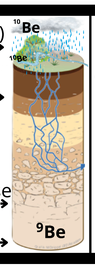
F_{met} — Depositional flux of ^{10}Be (atoms/cm²/year)

$\left(\frac{^{10}Be}{^{9}Be}\right)_{reac}$ — Ratio of both isotopes concentration in the reactive phase

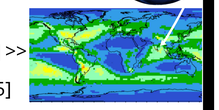
Reac = Beryllium retained in the secondary phase
Min = Beryllium still retained in the primary phase

$\left(\frac{[^{9}Be]_{min}}{[^{9}Be]_{reac}} + 1\right)$ — Ratio of ^{10}Be found in the mineral lattice and the reactive phase

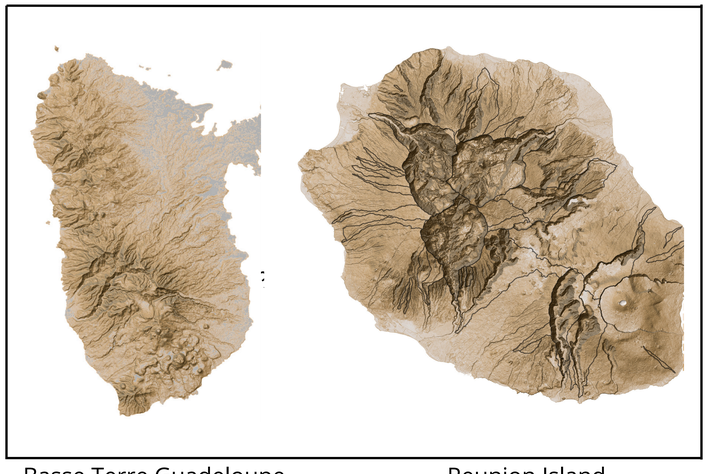
$[^{9}Be]_{parent}$ — Concentration of ^{9}Be in the parent bedrock



Challenges



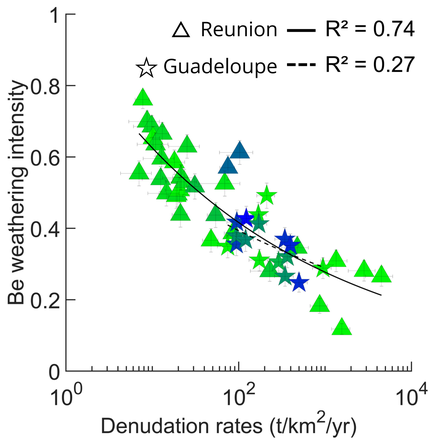
- Constraining ^{10}Be flux, from a model [3] >> or using precipitation based estimation [5]
- Assessing ^{10}Be flux bias in cyclonic climate context
- Assessing landslide bias in river sediment's ^{10}Be concentration



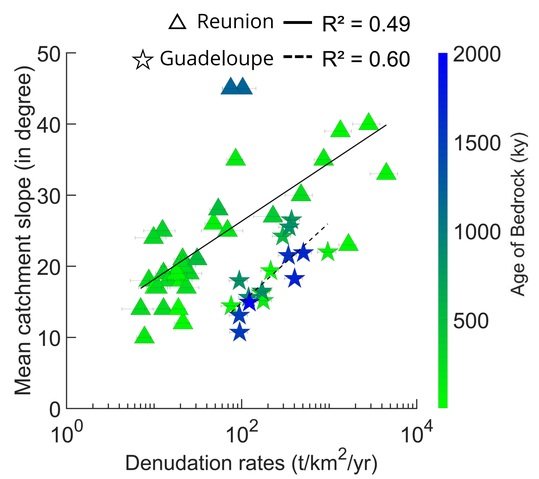
Basse Terre Guadeloupe — Reunion Island

What explains such differences in erosional dynamic?

Denudation rates' control

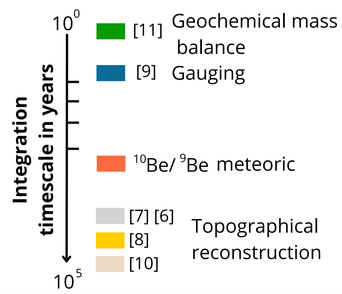


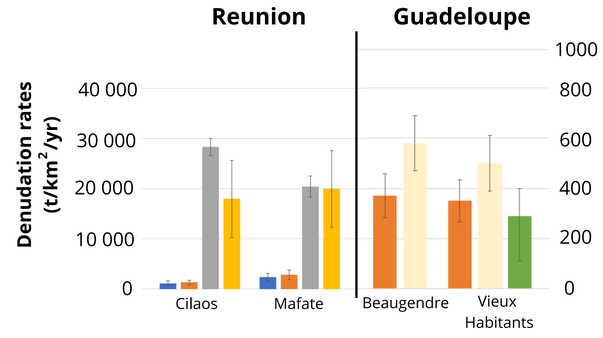
Lower Be weathering intensity seen in Reunion could be the result of landslides affected catchments



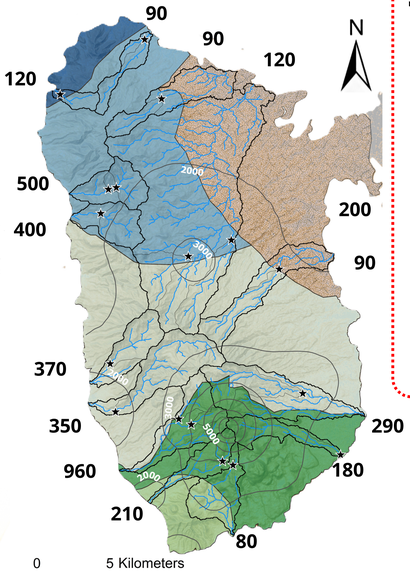
For comparable slopes angles Guadeloupe seems to show greater denudation rates

Method comparison





Results



Basse Terre, Guadeloupe

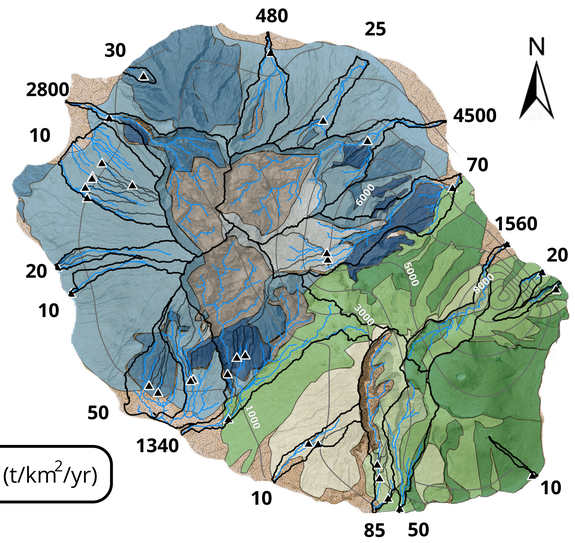
Summary

- Precipitation and denudation rates show no correlation

Range in denudation rates (t/km²/yr)

Guadeloupe	Reunion
80 - 960	**10 - 4500**

- Be weathering intensity show a good correlation with denudation for Reunion
- Slope appears to be an important controlling factor for denudation on both islands
- No relation was found between lava emplacement age and denudation rates



Reunion Island

Age of lava: Old — Young

100 Denudation rates (t/km²/yr)

Rivers — Rain isohyet — Sedimentary deposit — Sampling Positions — Catchment delineation

References

[1] Dessert et al., 2003
[2] Börker et al., 2019
[3] Heikkilä et al., 2015
[4] von Blanckenburg et al., 2012
[5] Graly et al., 2011
[6] Gayer et al., 2019
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[10] Ricci et al., 2015
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Abstract

Sharing is encouraged