Surface denudation and soil erosion over 300 ka at the Otago upland (New Zealand) using ^{10}Be and $^{239+240}Pu$

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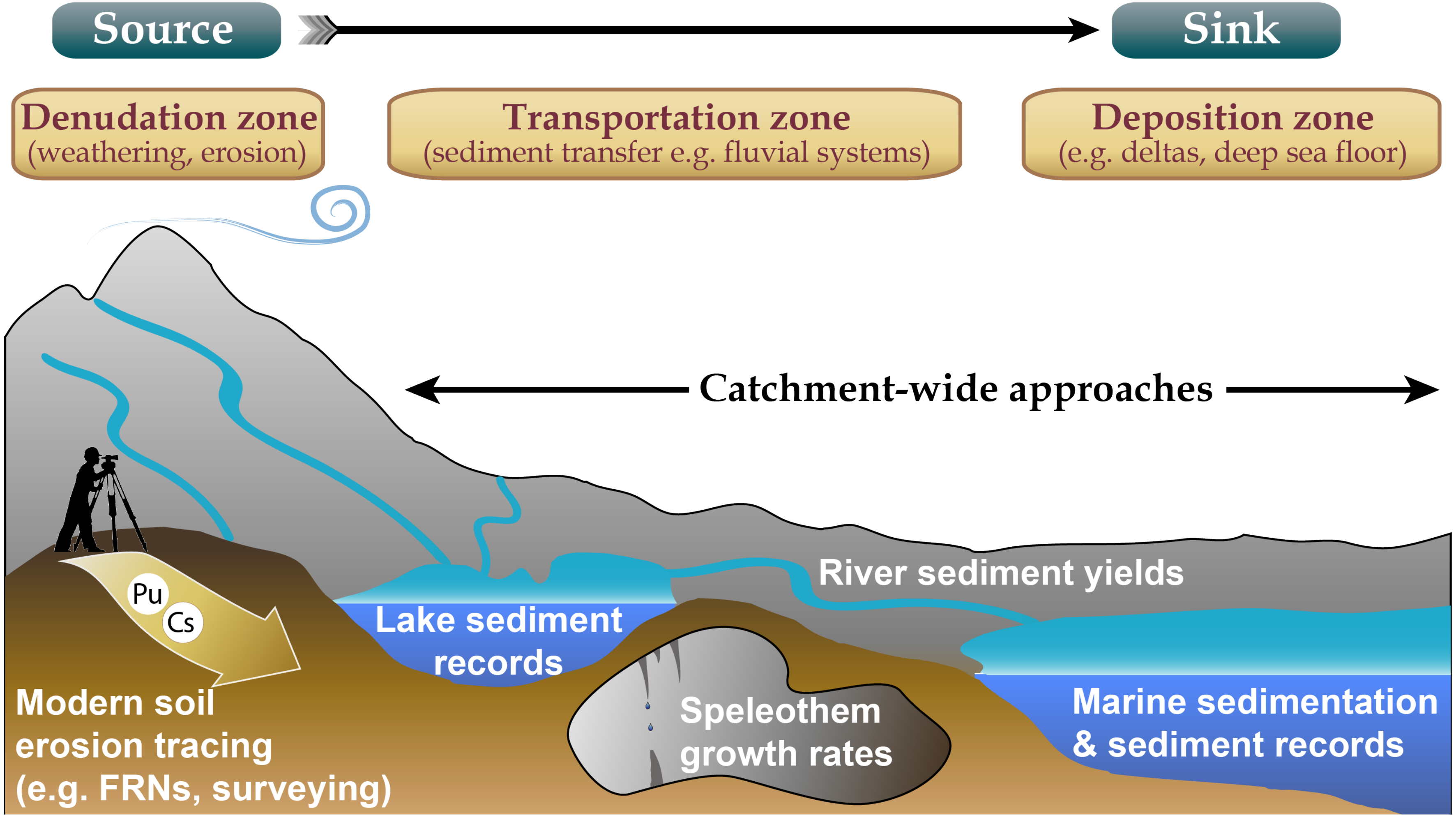
CONVENTIONAL ARCHIVES



(Raab, 2019)

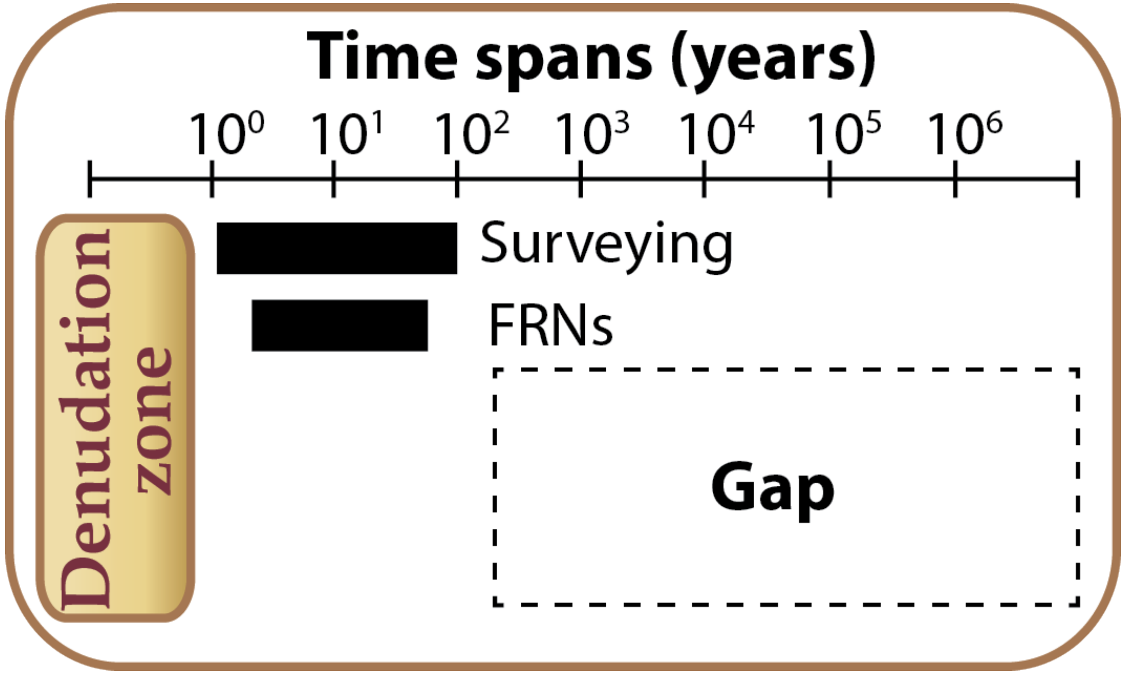
Surface denudation and soil erosion rates for source areas are mostly described by deciphered records of transportation and/or deposition zones.

We aim to quantify the continuous in-situ variations of denudation rates at the source area.

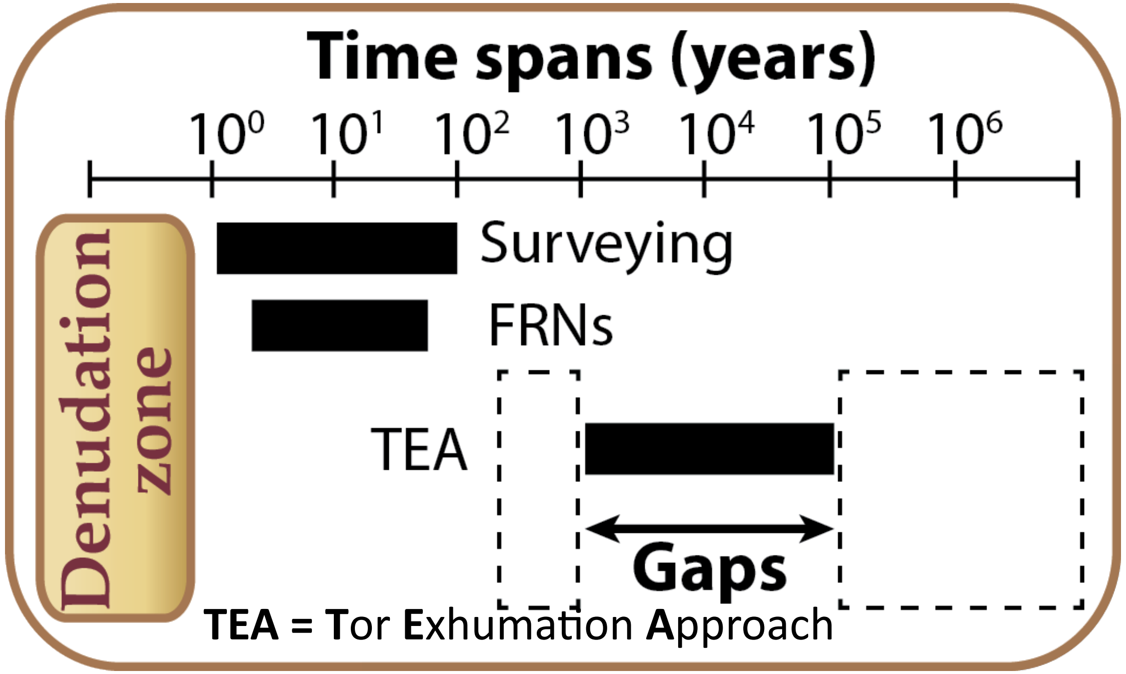
The Need for new Methods

There is still a need of adequate methods to capture soil erosion variations over a continuous time-frame within the denudation zone.

The tor exhumation approach (TEA), has shown early success in determining in-situ rates at the upland of the Sila Massif (Italy) (Raab et al., 2018, 2019).



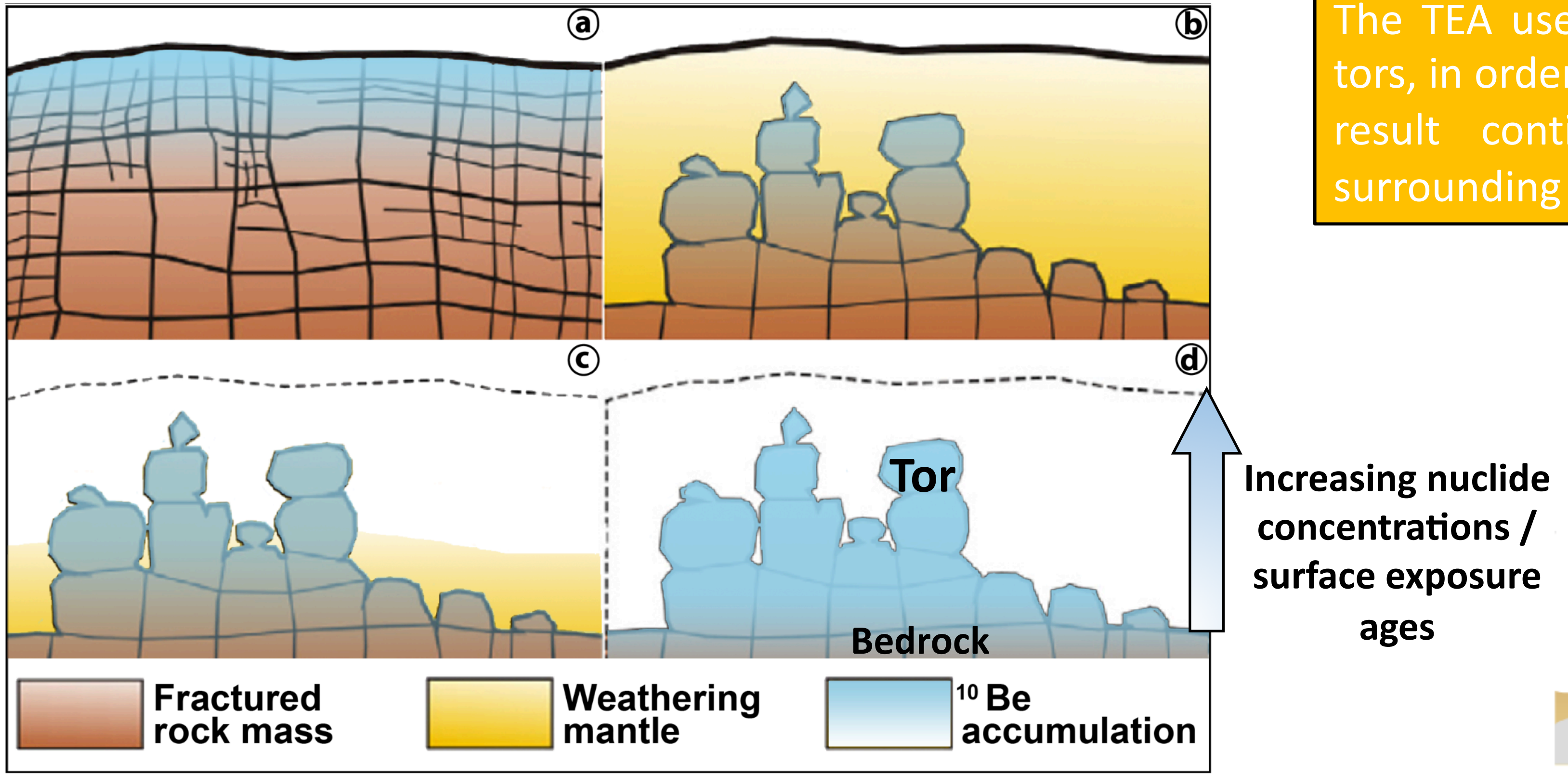
(Raab, 2019)



(Raab, 2019)

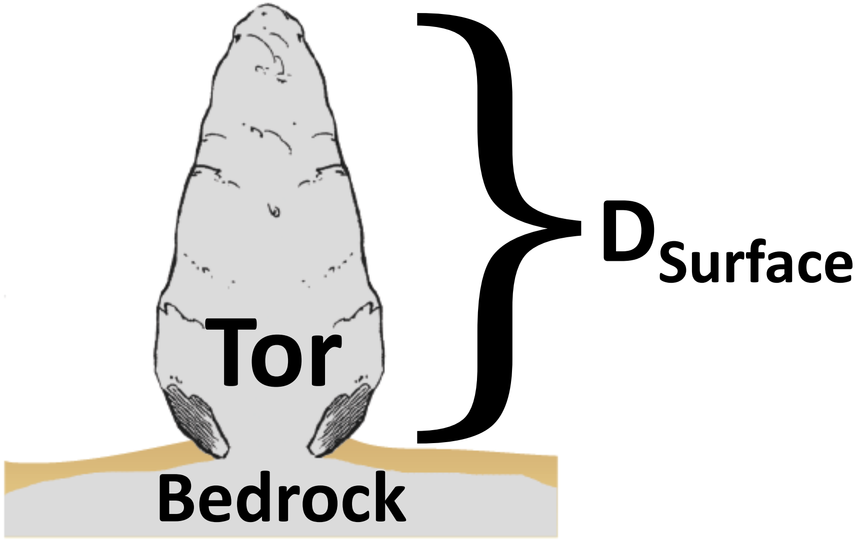
The Tor Exhumation Approach

Weathering starts with (a) rock fracturing, followed by (b) the formation of a deep weathering mantel and (c) erosion of the weathering mantel until (d) present-day surface has emerged.



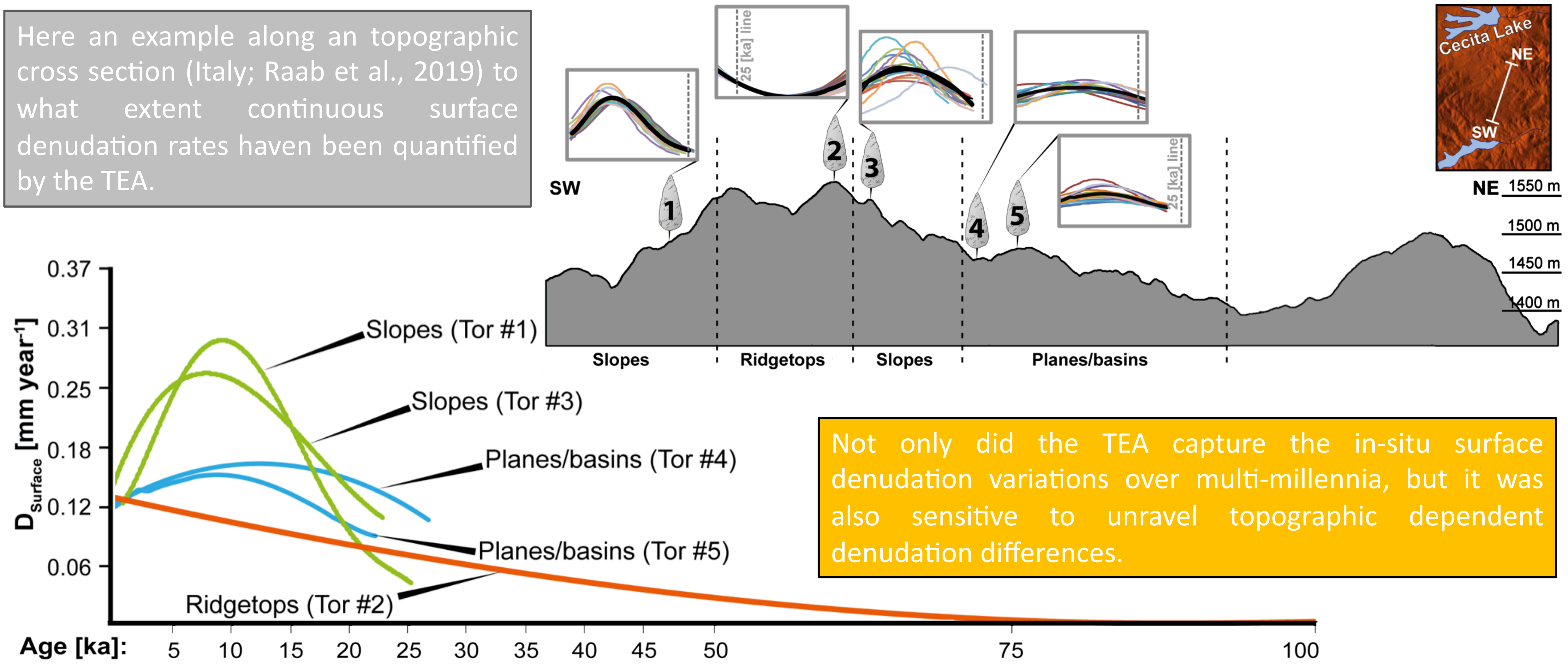
(Raab et al., 2018, after Migoń 2013)

The TEA uses vertical surface exposure dating along tors, in order to determine their exhumation speed. In result continuous denudation rates ($D_{Surface}$) of the surrounding surface can be modelled.



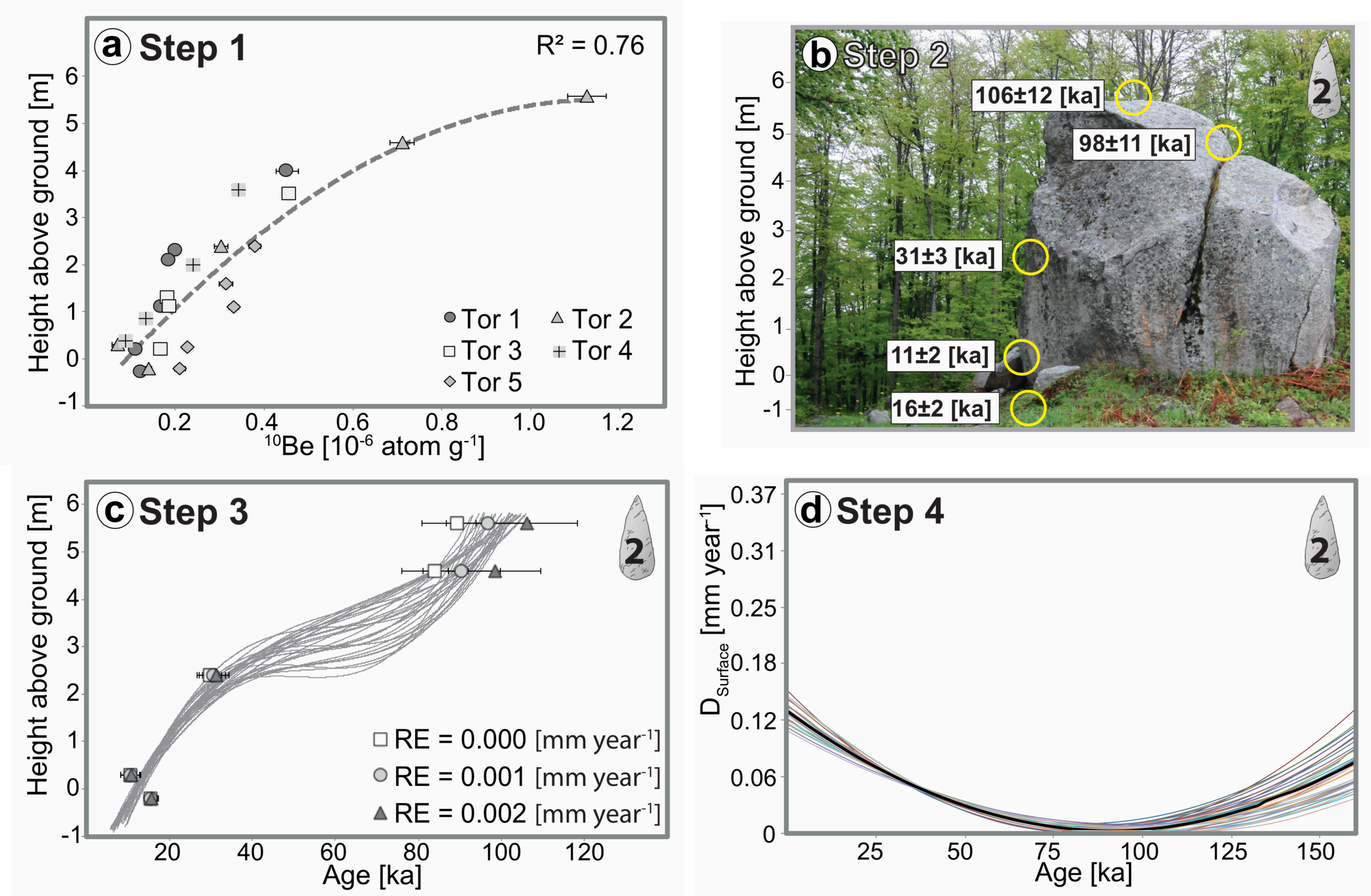
CURRENT CAPABILITY OF THE TEA

Here an example along an topographic cross section (Italy; Raab et al., 2019) to what extent continuous surface denudation rates haven been quantified by the TEA.



Not only did the TEA capture the in-situ surface denudation variations over multi-millennia, but it was also sensitive to unravel topographic dependent denudation differences.

The TEA Process

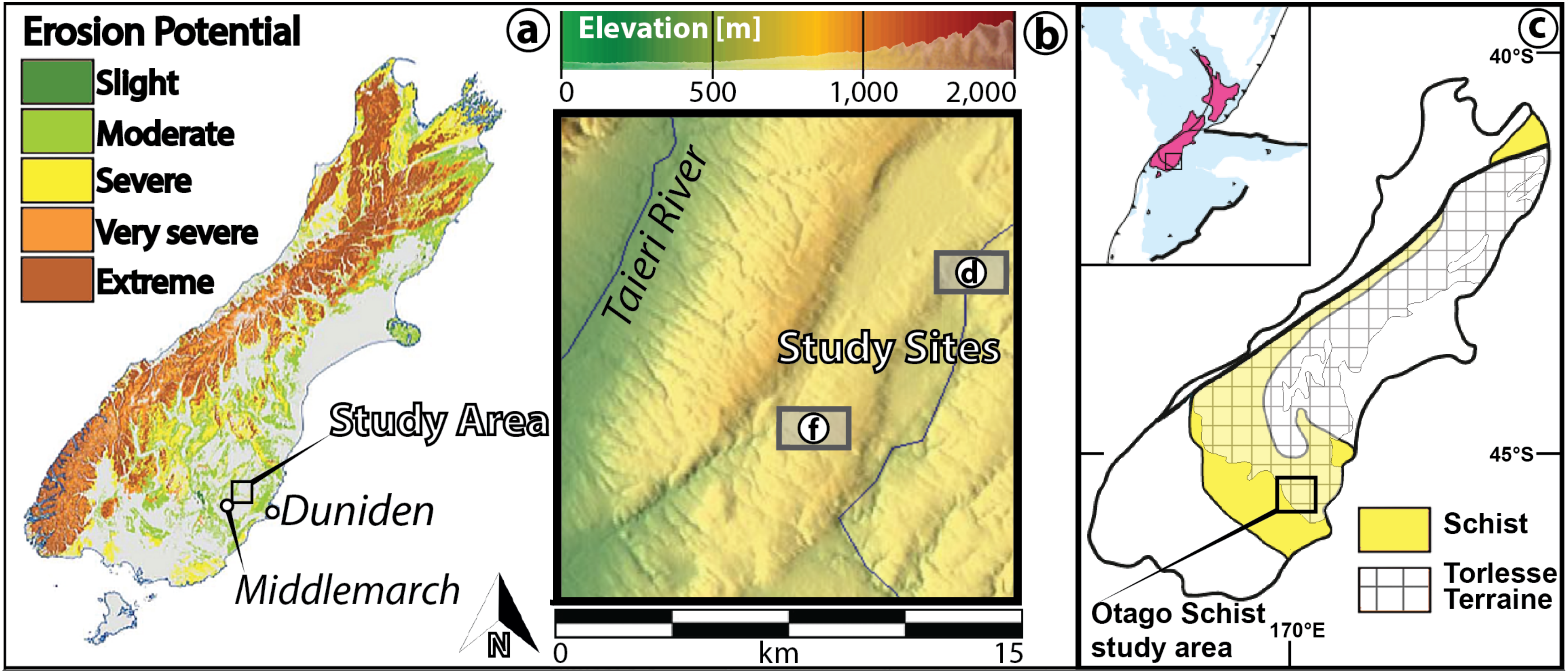


In order to obtain denudation models (a) corrected ^{10}Be concentrations are converted to (b) surface ages. Within the age variations, (c) various exhumation trends are modelled using Monte Carlo simulations. Mathematical derivations of these functions are used to model (d) surface denudation (Raab, 2019)

The TEA was so far just tested within a well-defined granitic area.

We challenged the approach now in an environment of schist-tors.

SCHIST TOR ENVIRONMENT



(a) Location of our study area at the Southern Island of New Zealand and overview of potential erosion (Basher, 2010). (b) Our detailed study sites are indicated with (d) and (f). (c) Overview of the tor terrain extent.

SCHIST (NZ) VS GRANITE (IT) TORS




General comparison of schist tors at the Otago upland on the Southern Island of New Zealand (on the left) and granite tors at the Sila upland in Calabria, Italy (right).

Schist-tors:

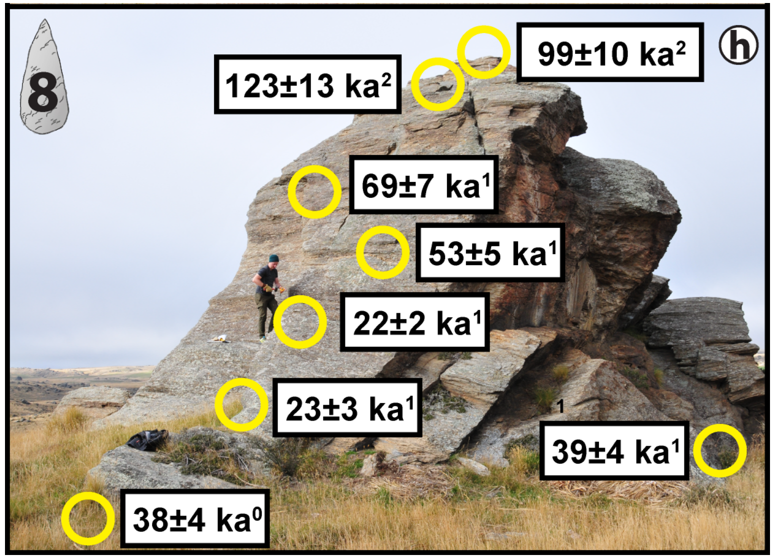
- Up to ~12 m
- Fractured /abraded by wind
- Semi-arid climate stripped of most vegetation;
- ~360–580 m a.s.l.

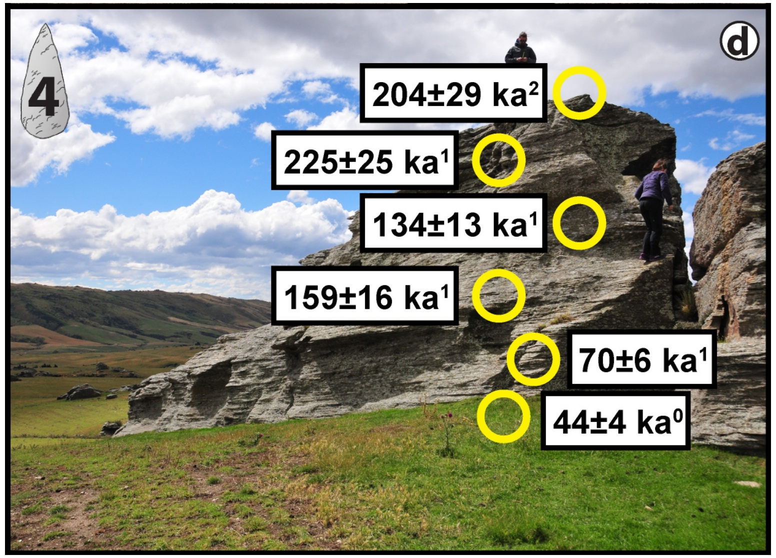
Granite-tors:

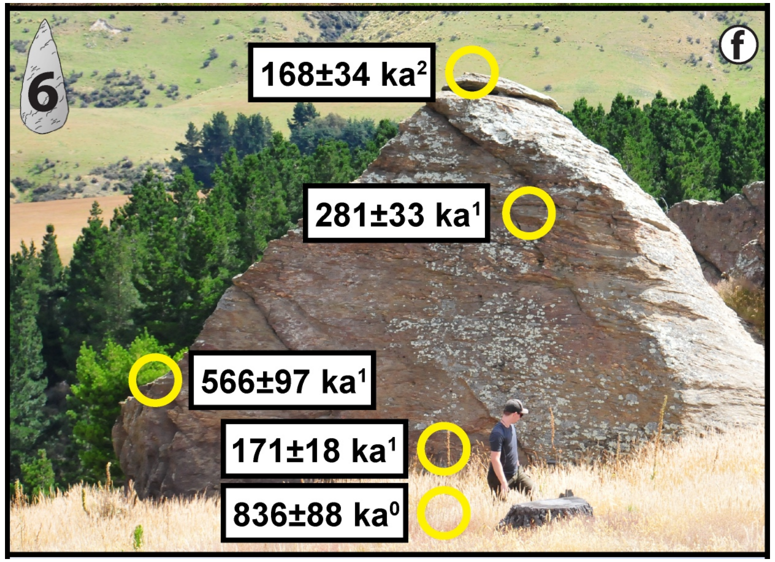
- Up to ~6 m high
- General polished, no exfoliation
- Temperate climate with denser vegetation
- ~1,400–1570 m a.s.l.

^{10}Be Results New Zealand

Here are some examples of our exposure age results.

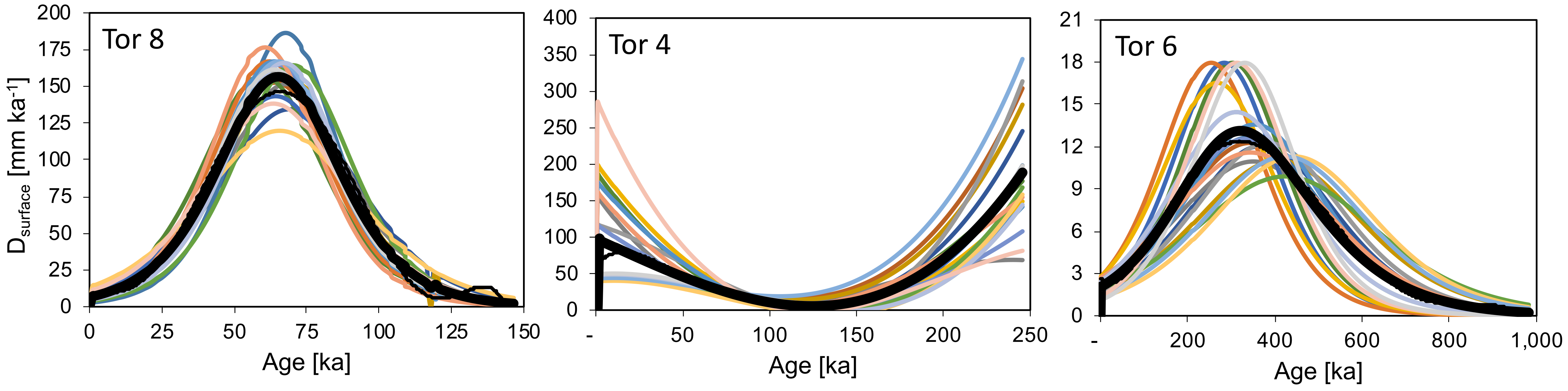






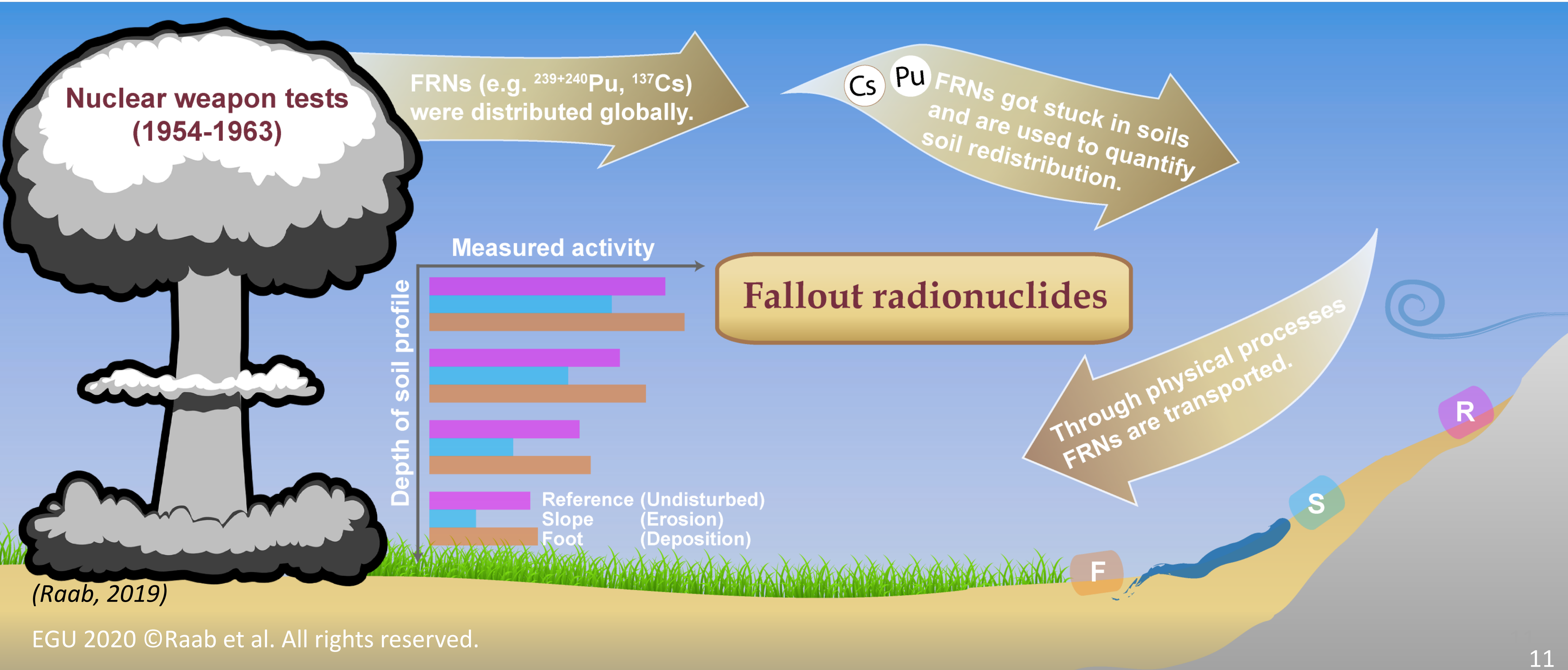
We have investigated 8 Tors, with a total of 38 successful cosmogenic nuclide measurements. Calculated surface ages span from as low as 22±2 [ka] to 836±88 [ka] (this includes questionable surface ages at certain positions). At our current status, we see reasonable exhumation trends to be found within an age span of 28±3 [ka] to 225±25 [ka].

PRELIMINARY MODELS



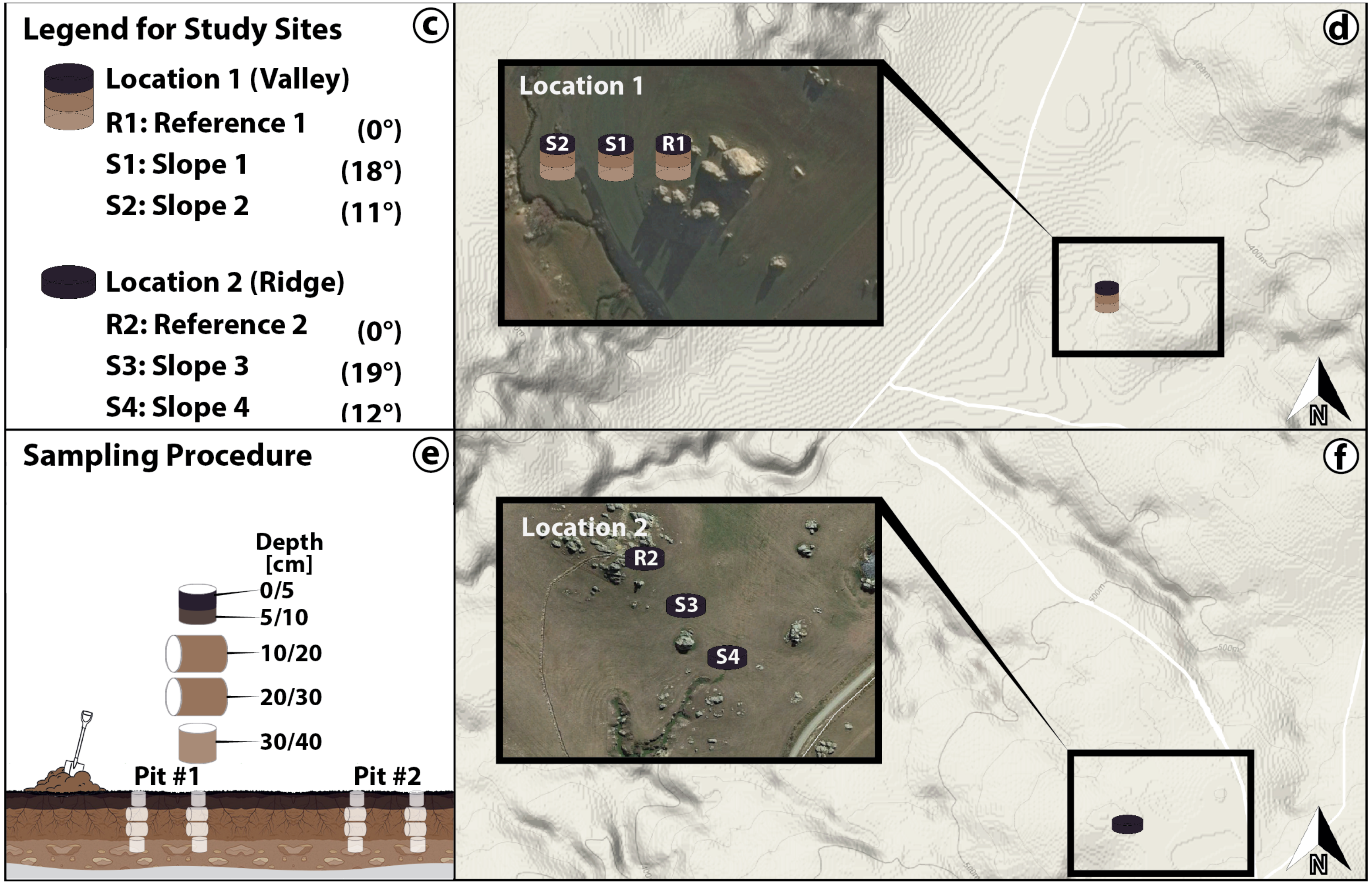
Some example model for the previous presented tors. The black lines indicate the average. Tor 8 and 4 are based on exhumation, while the Tor 6 model presents an experimental inversion model as result of potential undercutting or toppling (yet the tor was attached to the bedrock). Tor 8 and 4 have comparable $D_{Surface}$ rates. Tor 8 has very low $D_{Surface}$ due the relation of low heights above ground and high surface ages.

FALLOUT RADIONUCLIDES (FRNs)



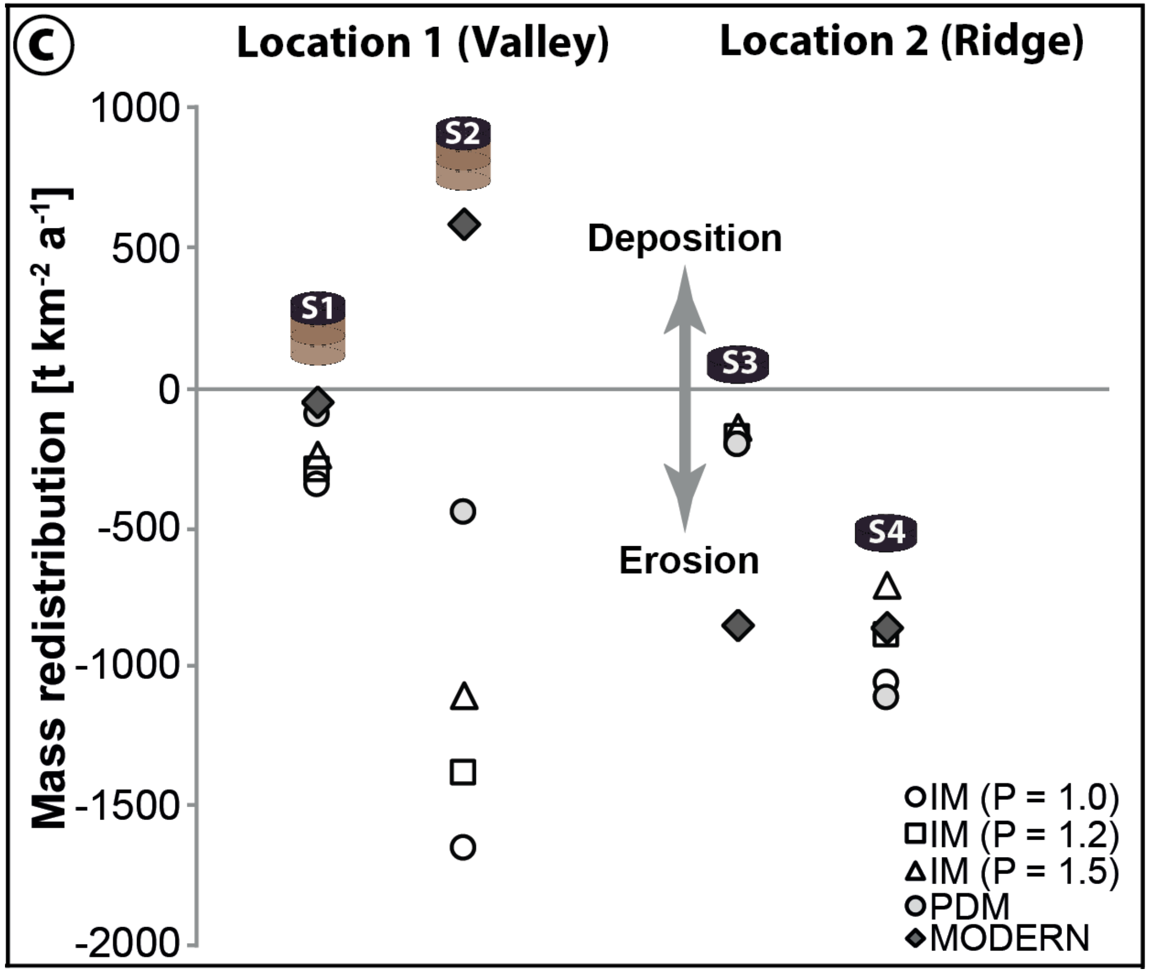
(Raab, 2019)

Sampling Procedure for FRNs



In addition we have investigated the short term erosion (~60 years) of the surrounding hill of two tors. Location 1 is positioned in the intertrain valley, Location 2 at the adjacent ridge. At each location a flat reference site and two slope positions where investigated. At each sampling spot 4 samples per sampling depth where taken out of 2 pits.

$^{239+240}$Pu Results



(c) We have evaluated our FRNs measurements with three models. The inventory model (Lal et al., 2013), the profile distribution model (Walling & He, 1999) and MODERN (Arata et al., 2016).

The PDM is considered to reflect the local distribution best. Rates at the foot slope (S2, S4) exceed maximum rats of Tor 8 and 4 by two to three-folds. Yet S1 and S3 are within the range of the TEA investigation.

SUMMARY

- ❖ Applying the TEA on schist tors can provide continuous surface denudation rates.
- ❖ The Otago tors covered usually double the time-span of the Sila tors which were half their size.
- ❖ Yet, Inversions and outliers due to irregular rock surface erosion remain challenging in this schist environment.
- ❖ FRNs determined rates partly align with TEA models, and indicate slightly higher rates today.
- ❖ There are still many new paths to take in regards of modelling an dealing with age inversions.

Thank You

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For more details about current projects:

www.geraldraab.com

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