Fluvial transport dynamics in the Rangitikei River (New Zealand) unravelled through single-grain feldspar luminescence

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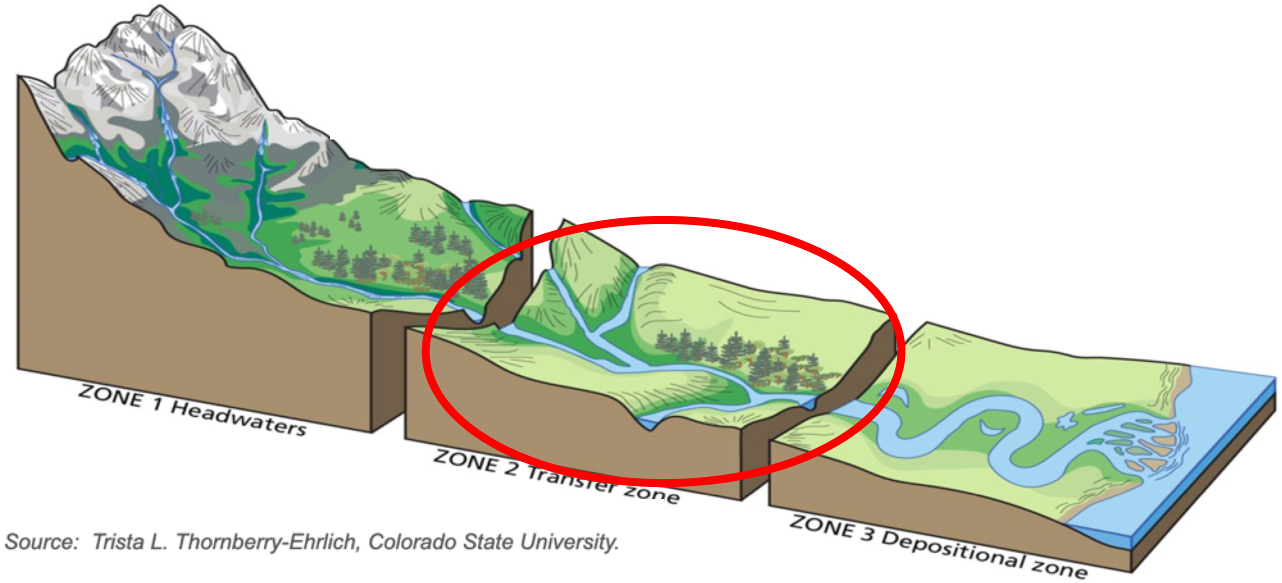
What information luminescence signals yield about past and present sediment dynamics ?

Recent studies show that luminescence signals of fluvial sediments can be used to unravell sediment transport in modern rivers (e.g. McGuire and Rhodes, 2015; Gray et al., 2017)

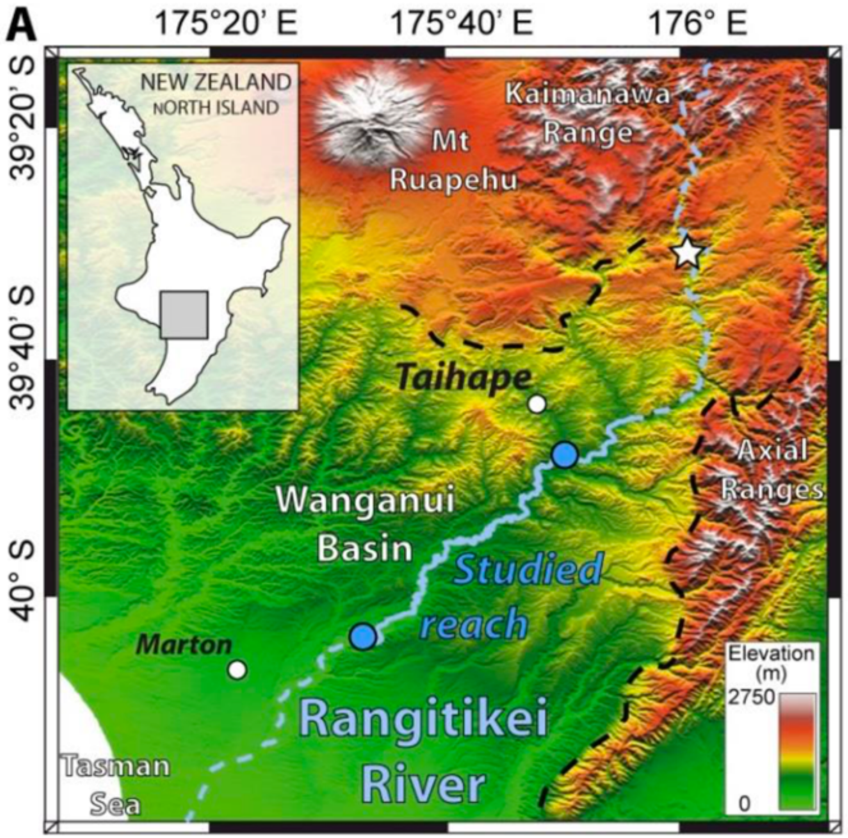


Source: Trista L. Thornberry-Ehrlich, Colorado State University.

→ **HERE we extent this approach to past settings by looking at luminescence signals in fluvial terraces**

Context

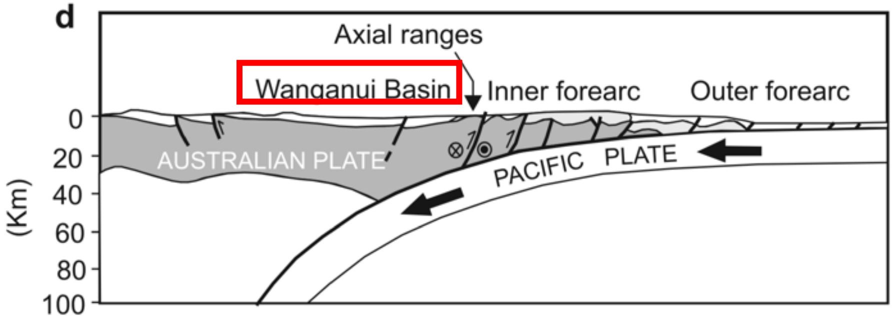
Rangitikei river, New Zealand



Bonnet et al., 2019

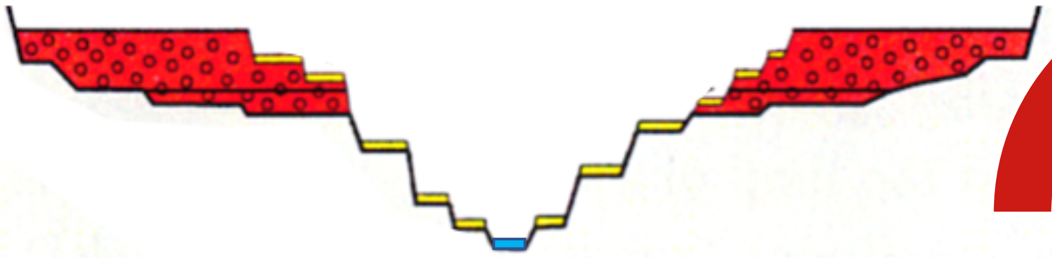
Rangitikei bedrock (Wanganui basin):

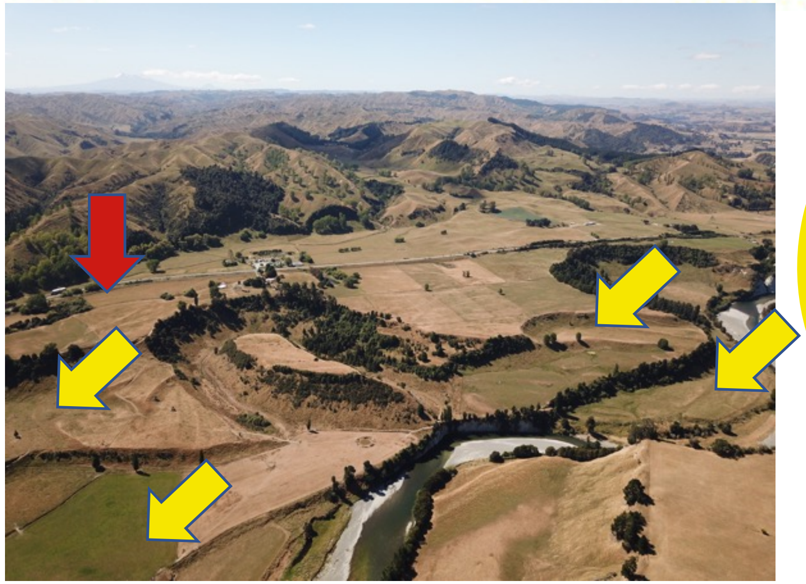
- Shallow marine mudstones and siltstones
- Formed 3.5-2.5 Ma
- gently sloping 2 à 6 ° SSE

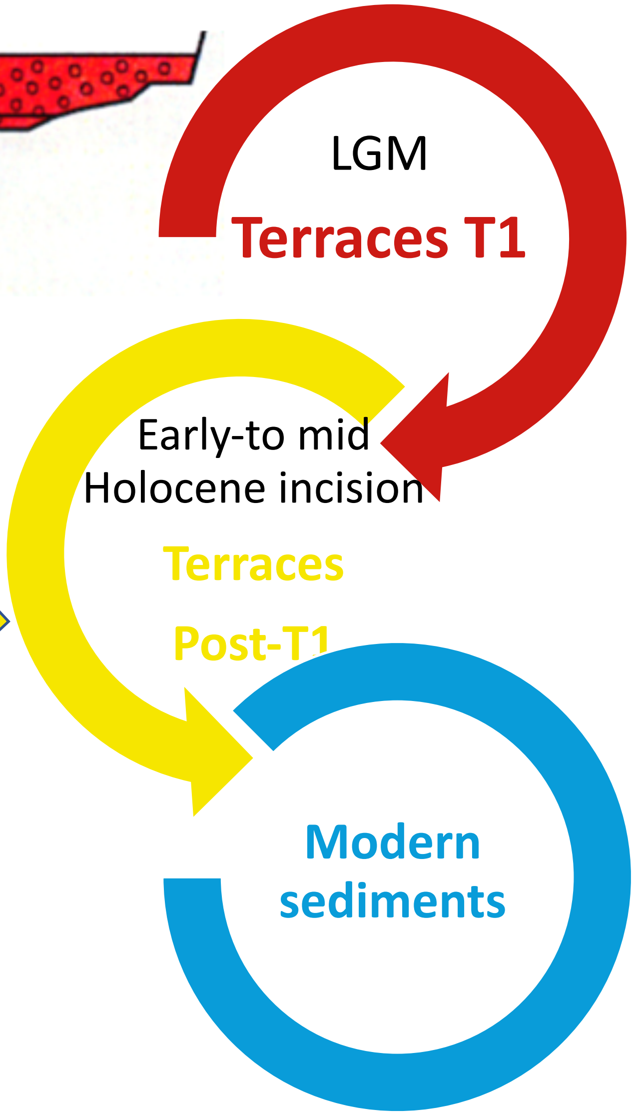


Litchfield et al., 2007

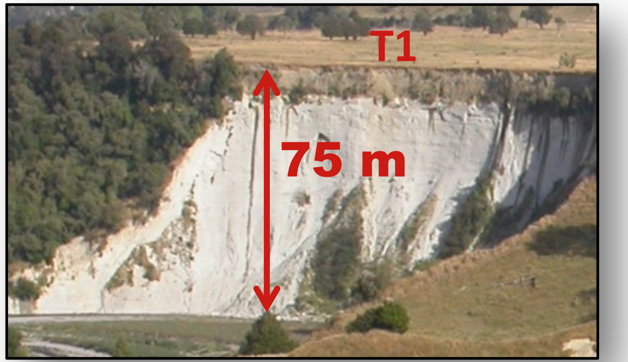
Three different features analysed

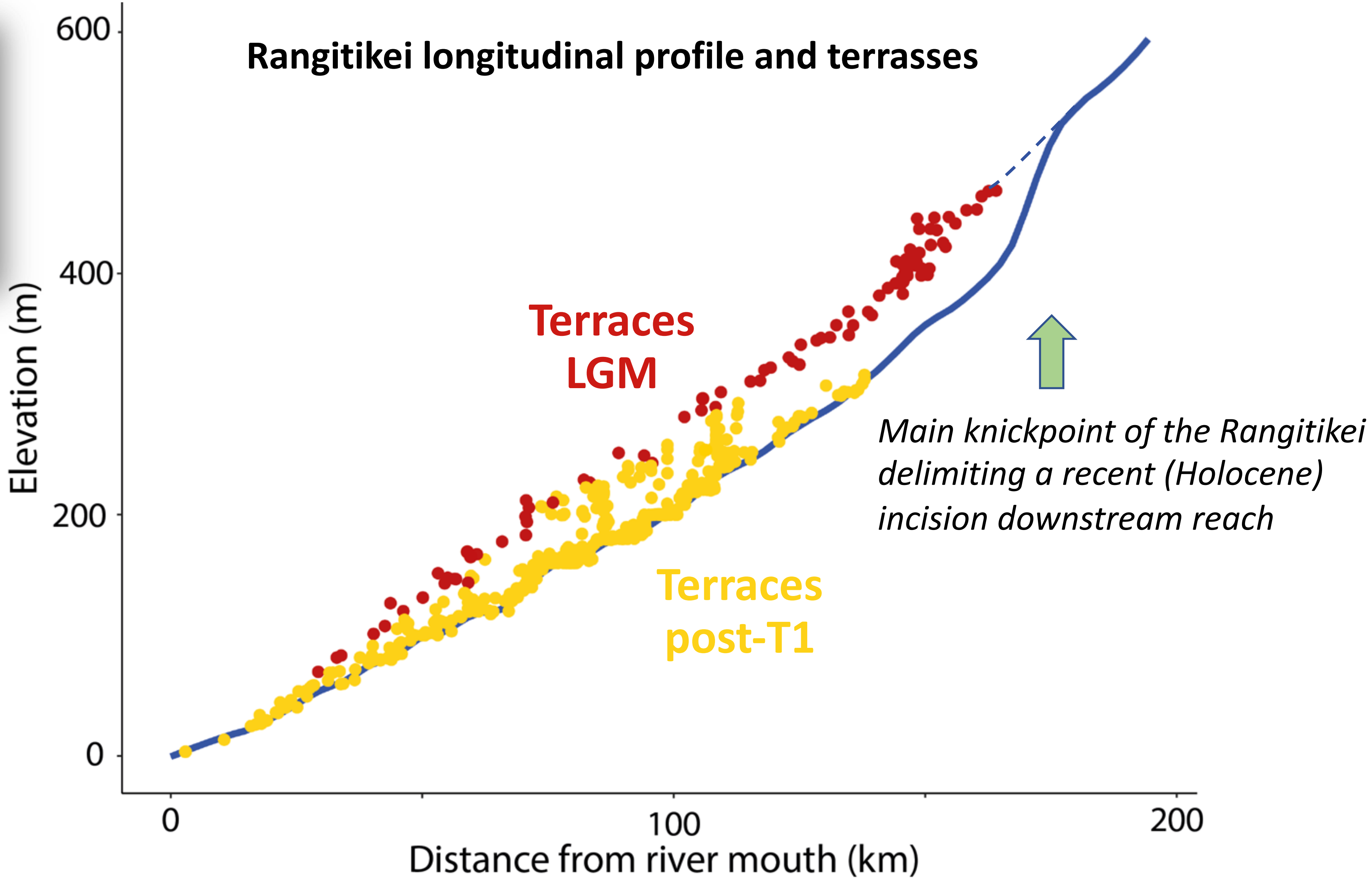




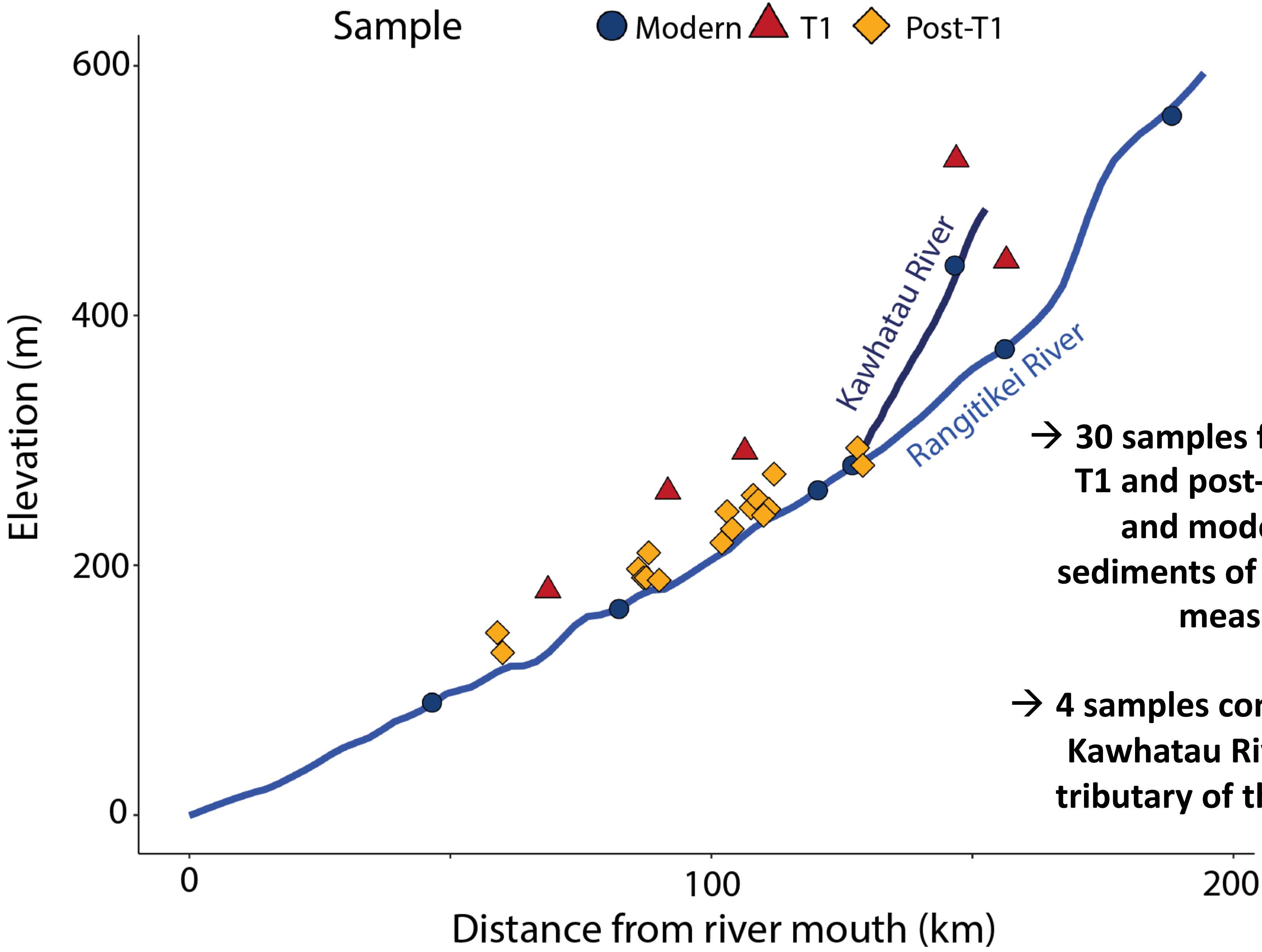


Context


T1
75 m


Rangitikei longitudinal profile and terrasses
600
400
200
0
Elevation (m)
0
100
200
Distance from river mouth (km)
Terraces LGM
Terraces post-T1
Main knickpoint of the Rangitikei delimiting a recent (Holocene) incision downstream reach

Samples for luminescence analysis



→ **30 samples from fluvial T1 and post-T1 terraces and modern river sediments of the RR were measured**

→ **4 samples come from the Kawhatau River, a major tributary of the Rangitikei**

Samples for luminescence analysis

Fieldtrip march 2019

Sampling : not always easy

Gathered from past deposit

Focus

SCIENTIFIC REPORTS

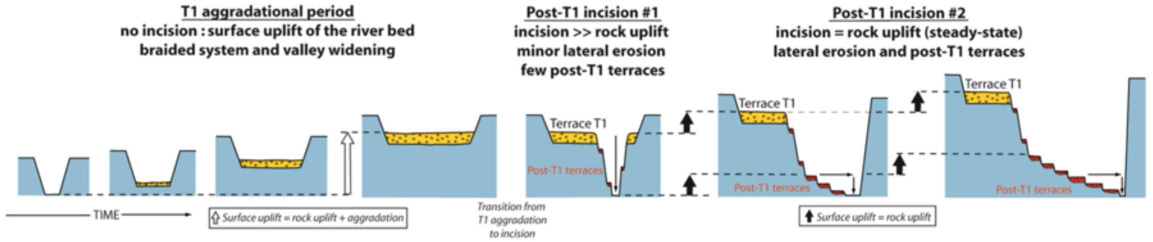
NOW

Landscape dynamics revealed by luminescence signals of feldspars from fluvial terraces

Stéphane Bonnet[1], Tony Reimann[2], Jakob Wallinga[2], Dimitri Lague[3], Philippe Davy[3] & Aurélien Lacoste[4]

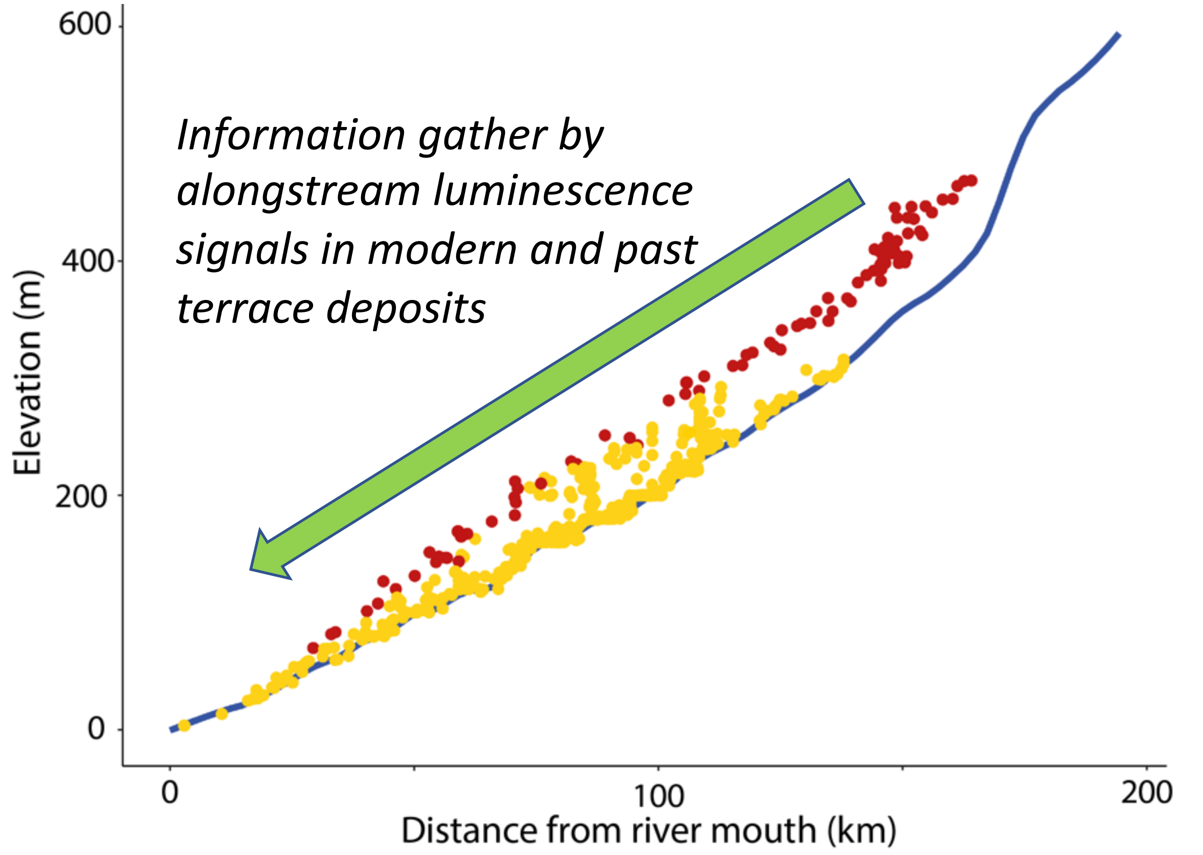
Bonnet et al., 2019:

- **Vertical processes of incision of the Rangitikei**



- **Behavior of the luminesence signals during incision**

→ This study : Longitudinal processes



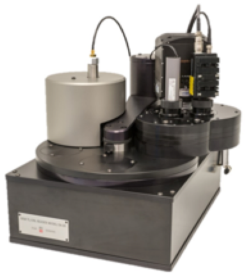
Method

single-grain luminescence measurements at WAGENINGEN UNIVERSITY & RESEARCH

- ➢ single-grain post-infrared infrared stimulation protocol (pIRIR)

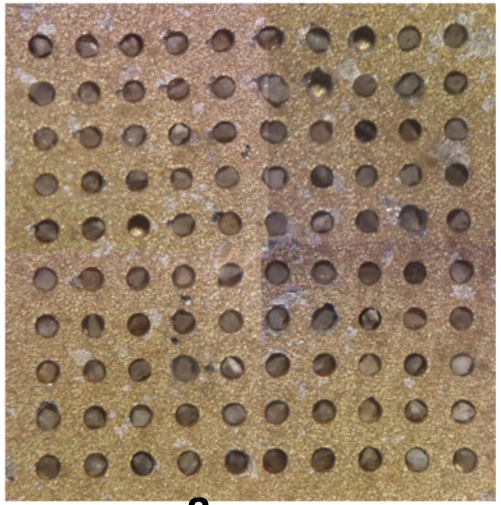
(see e.g. Thomsen et al., 2008; Reimann et al., 2012).

- ➢ automated Risø TL/OSL reader (DA 15) fitted with a dual (red and green) laser single-grain attachment and 90Sr/90Y beta source



- ➢ 30 samples
  - 5 T1, 18 post-T1 and 7 modern samples
  - 7 samples from Bonnet et al., 2019 and 23 new ones

A single grain disc



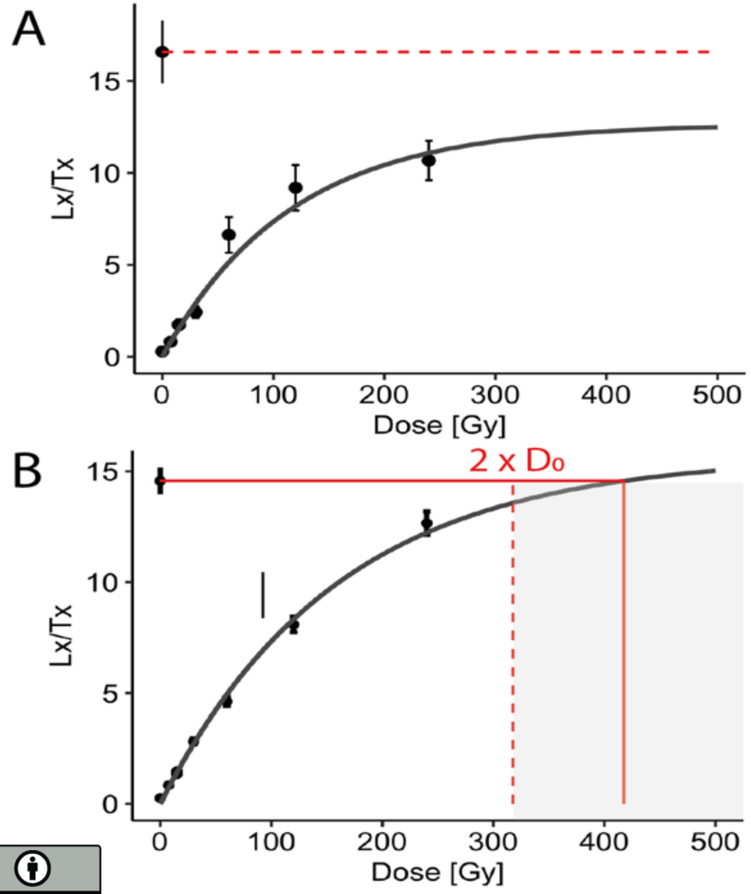
8 mm

- ➢ 300 individual grains of feldspars (212-250 µm) analysed /sample.

Method

Proxy used in this study

Dose response curves for two grains from sample RO_41.



Saturated grains emit a very strong luminescence signal relative to the total number of lights emitting grains:

- a grain is considered saturated when its natural signal is too elevated to be projected on the dose response curve : **case A**

or

- when the natural signal is above a $2*D_0$ criterion (Wintle, 2006) : **case B**

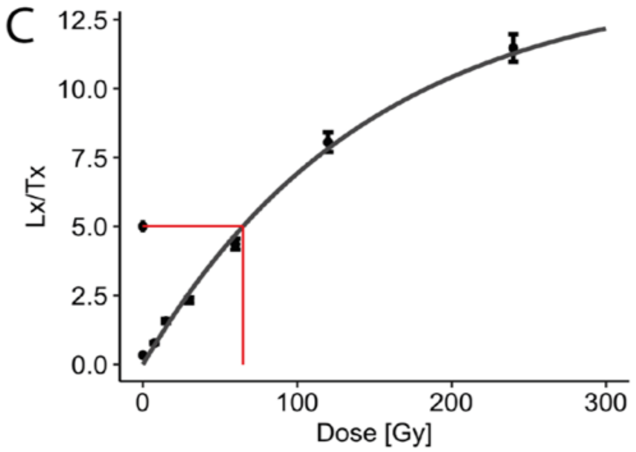
Saturated grains are grains eroded from bedrock and buried in the fluvial deposits with minimal light-exposure

→ Used here as a proxy for direct sediment supply from the bedrock to the river

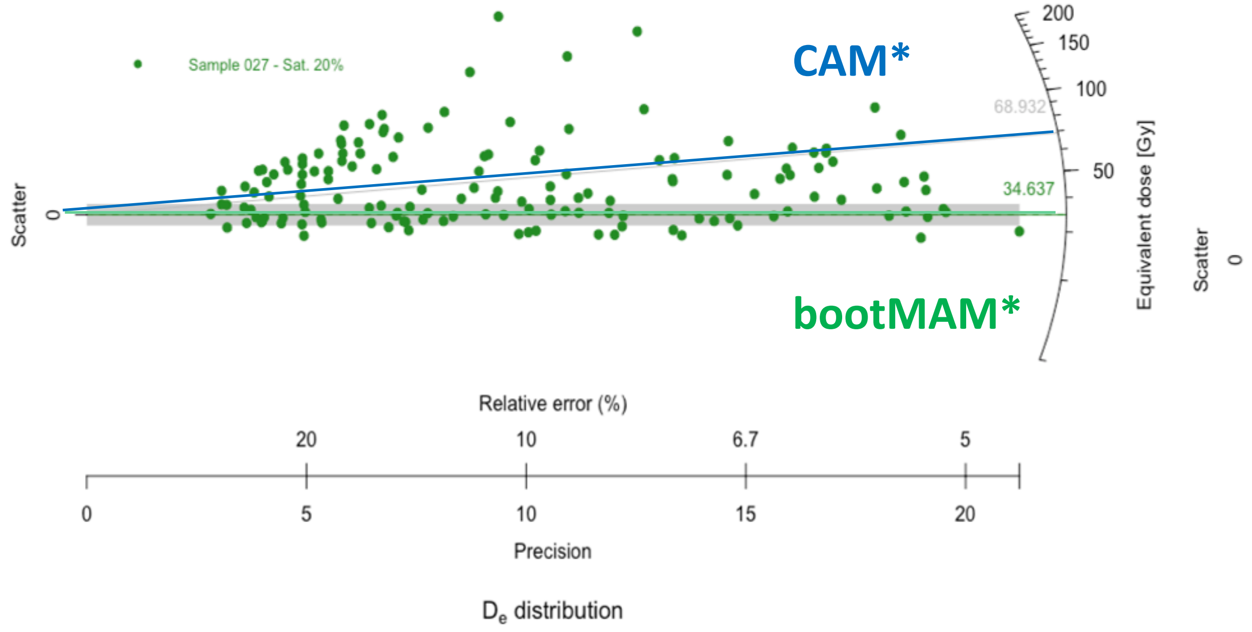
Method

Paleodose : proxy for the amount of natural irradiation since burial of the grains in deposits

Dose response curves for a single grain from sample RO_41.



Paleodose distribution of 147 unsaturated grains from sample RO_35



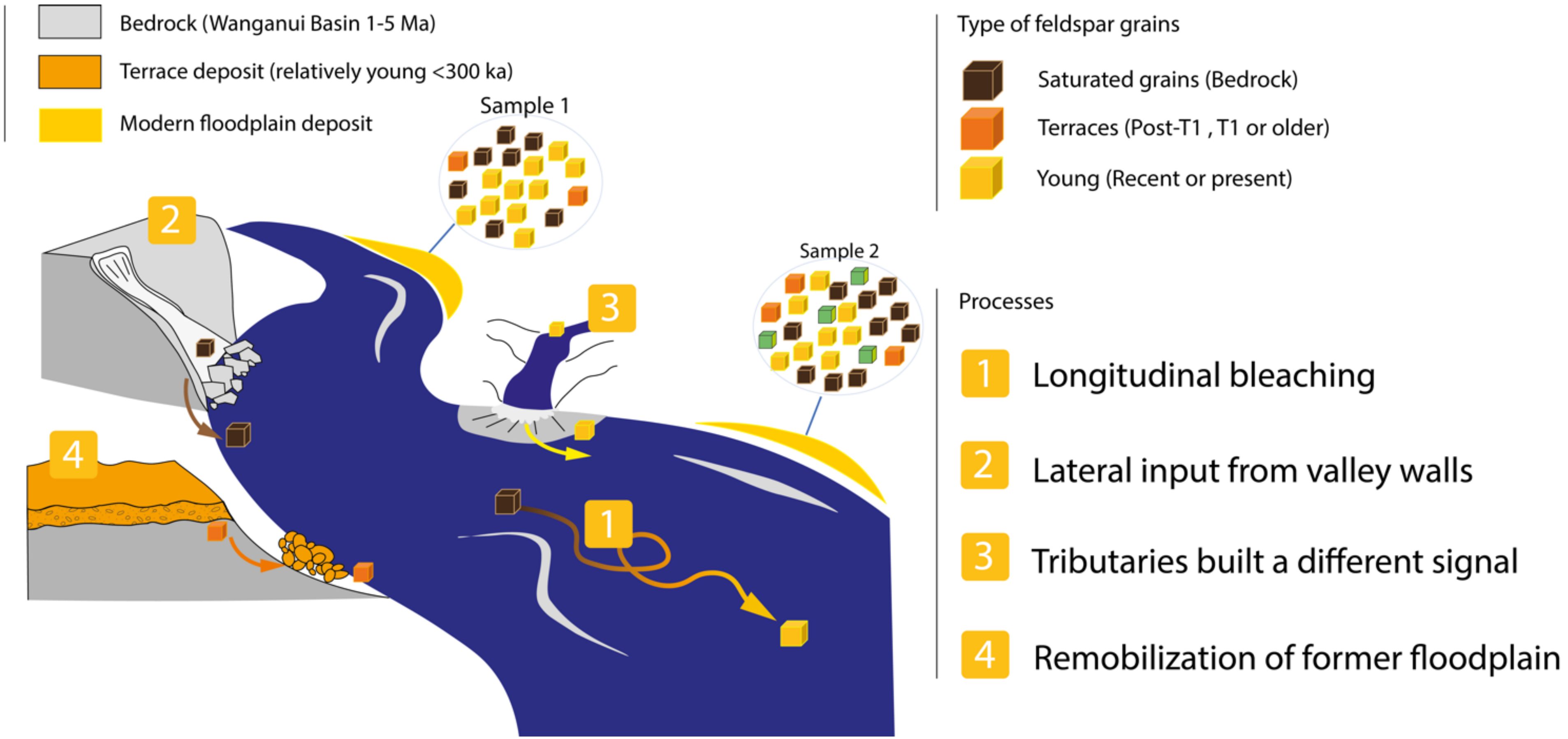
*Central Age Model : mean value providing information on light exposure (Galbraith et al., 1999)
*Bootstrapped Minimum Age Model providing estimate for burial age (Cunningham and Wallinga, 2012)

Paleodose can be used for studying along stream sediment transport, not shown here

Focus

Different processes may explain the variability in grains luminescence properties in a sample

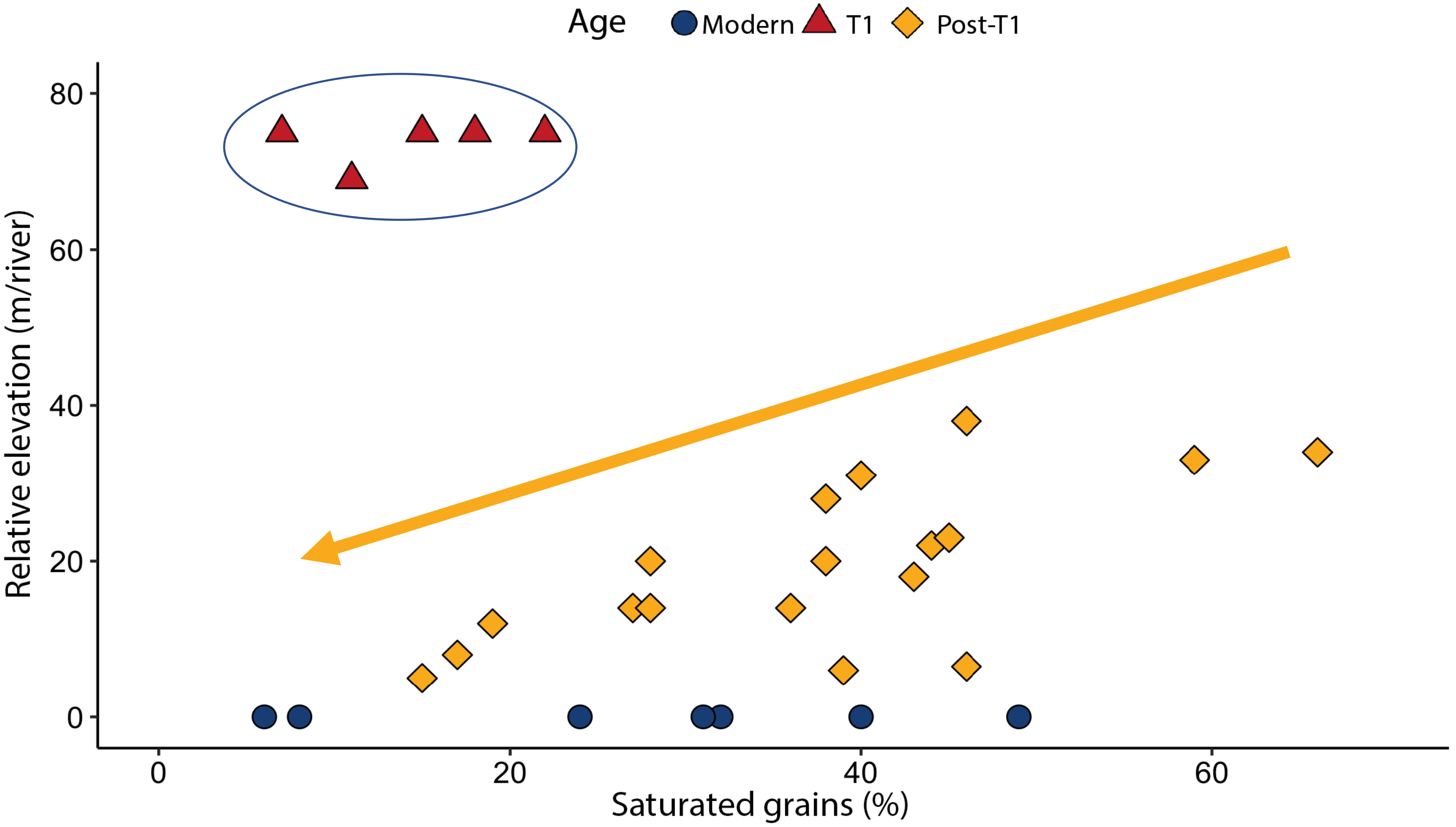
Then the variability can give information on transport and landscape dynamics



THIS STUDY : Focus on process #2

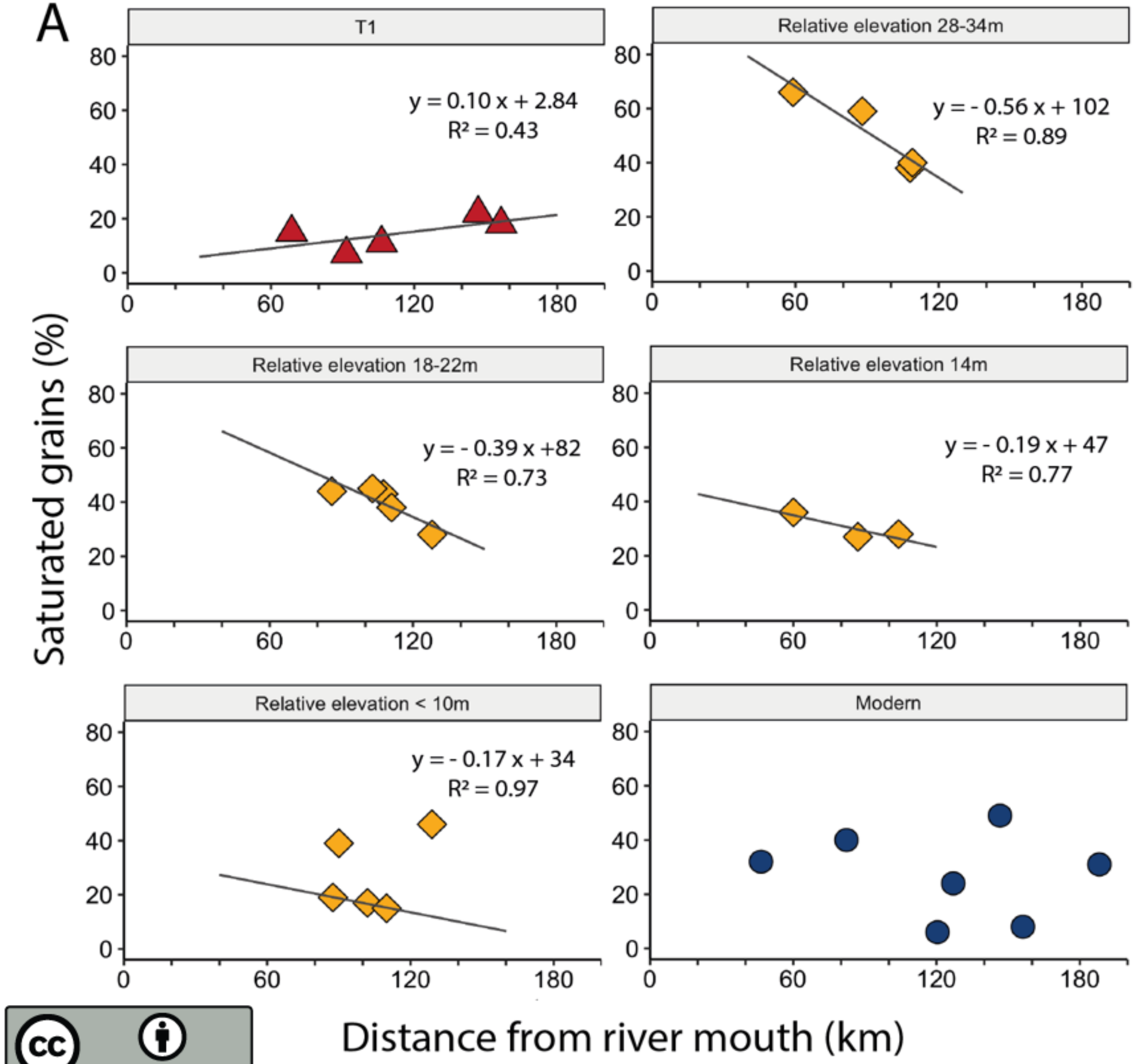
Results

T1 : few saturated grains
Post-T1 : Linear decrease of saturation with elevation



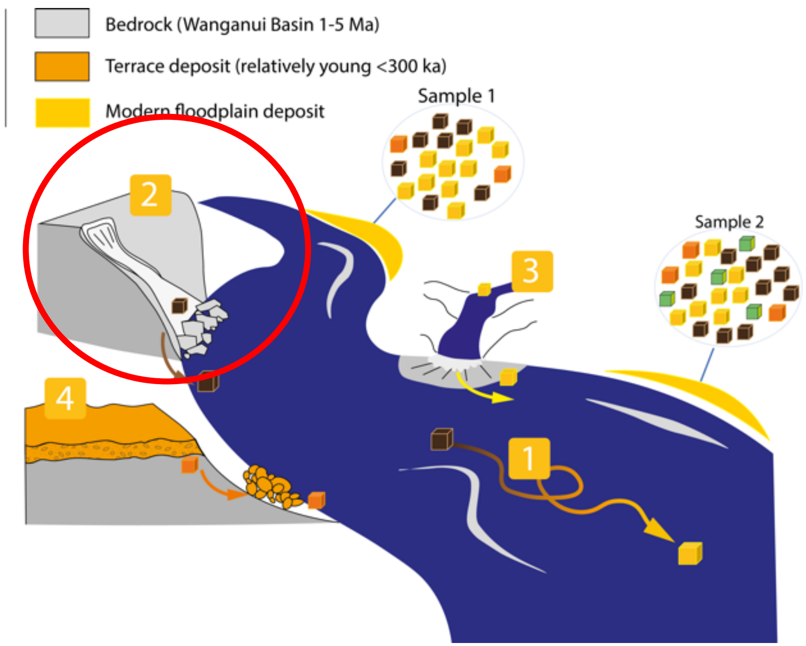
Results

Longitudinal trends of % of saturated grains in T1, post-T1 and modern deposits



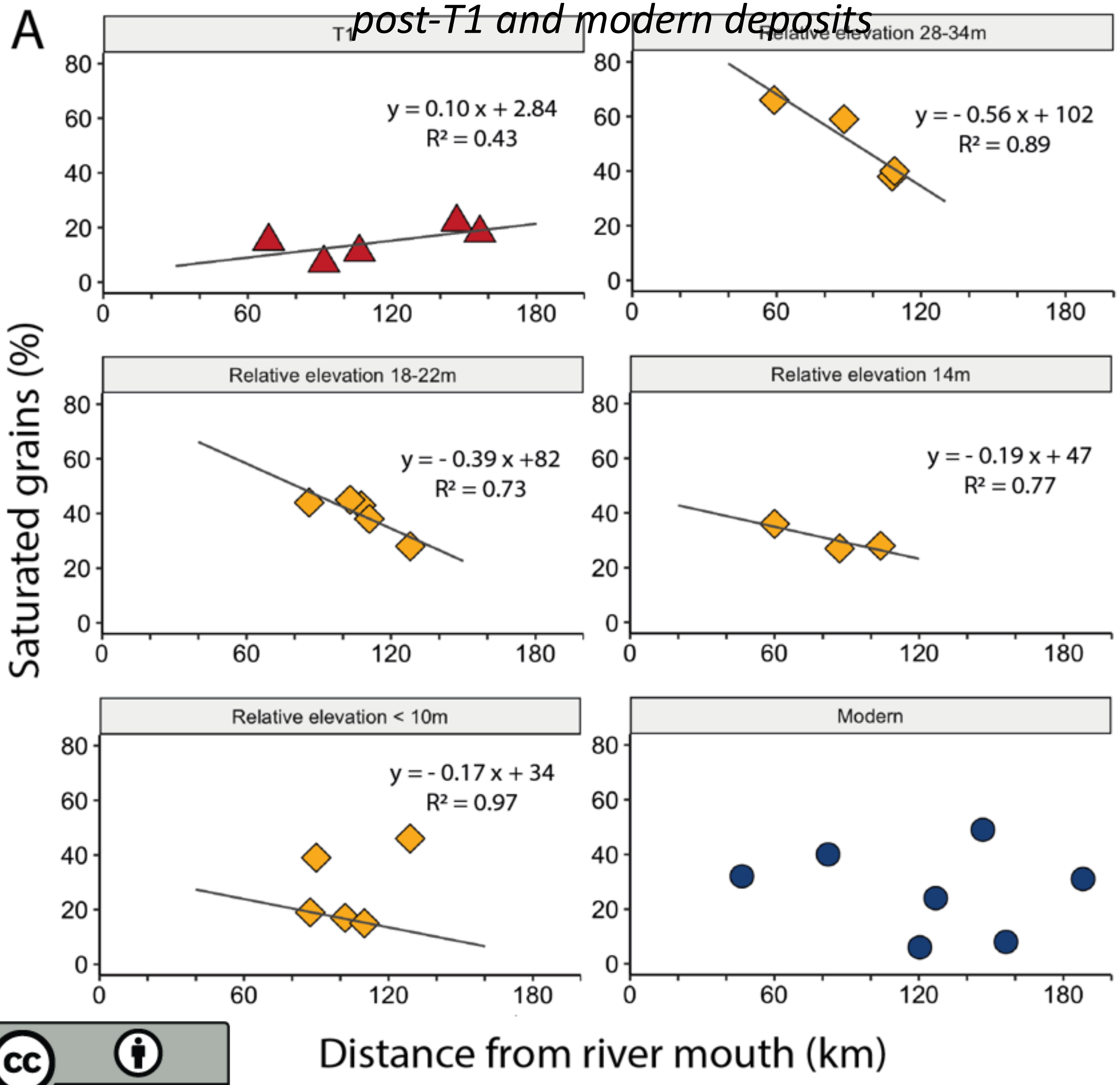
Post-T1 : downstream increase of % of saturated grains

→ **Implies longitudinal input of saturated grains from the bedrock to the river by processes which limit exposure of the particles to sunlight → mass wasting processes**



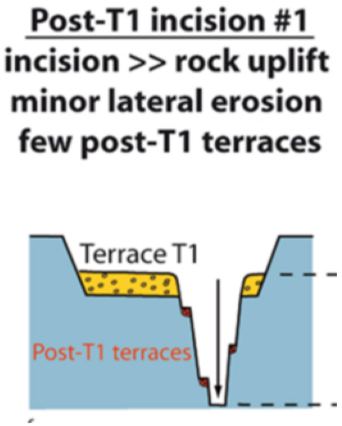
Results

Longitudinal trends of % of saturated grains in T1, post-T1 and modern deposits



Post-T1 : downstream increase of % of saturated grains

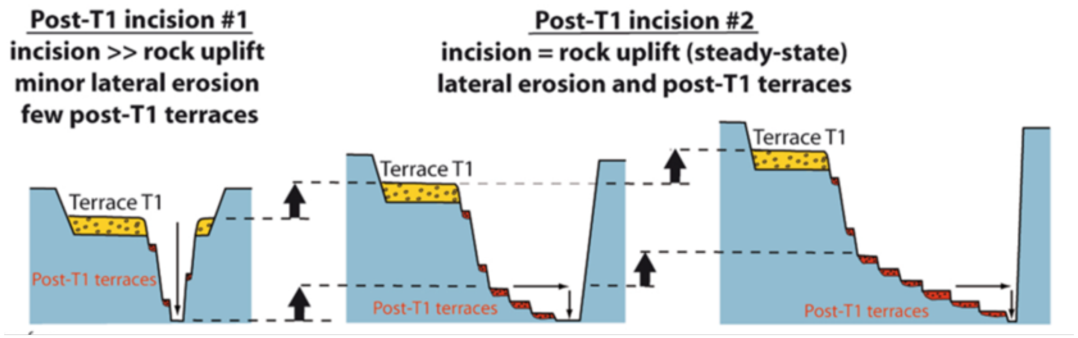
- **The downstream gain in saturated grains is maximum for post-T1 terraces in the interval of relative elevation +28 /+ 34 m**



→ very fast incision (Bonnet et al., 2019) and very strong supply of bedrock grains to the river

- **The downstream gain in saturated grains progressively decreases with relative elevation of post-T1 terraces**

-> progressive decrease of supply of bedrock grains to the river during the slowing down of the incision rate



Results

Along-stream variation of % saturation in modern deposits with two trends

- Upstream (between 120 and 200 km)

→ **downstream decrease of % of saturated grains in the Upstream Rangitikei and in the Kawhatau where the river is narrow.**

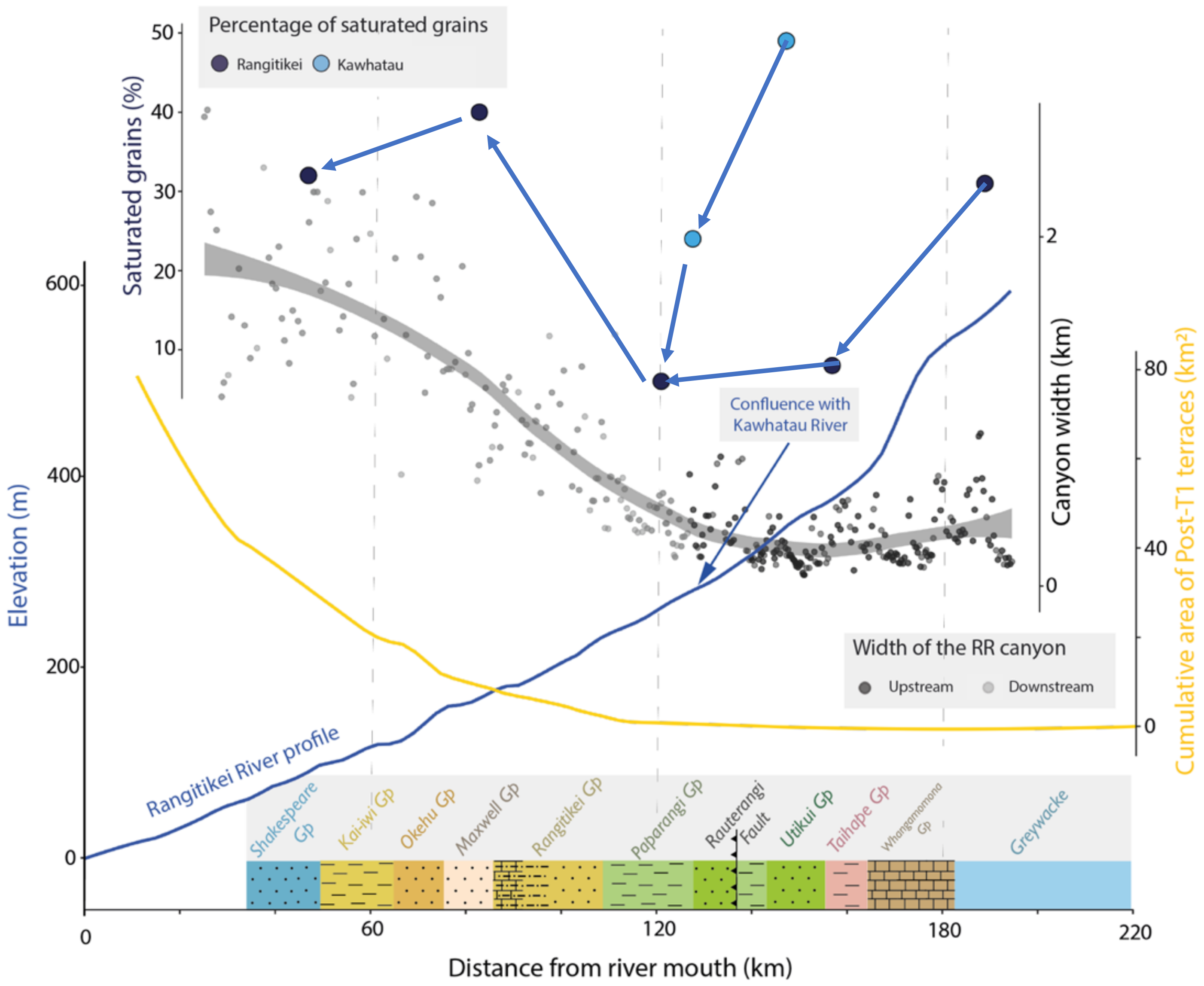
→ **Active process #1 : bleaching of the grain during transport**

-Downstream (between 120km and the sea)

→ **Increase of % of saturated grains in the Rangitikei**

→ **Correlated with : increase of canyon width and area of post-T1 terraces**

→ **Active process #2 : input of saturated grains related to lateral erosion and widening of the canyon**



THANKS

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