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Linking source to sink through sediment transport: The importance of spatially variable climate

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We test the general assumption that at geological timescales, sedimentary units provide a spatially and temporally integrated sample of upstream erosion.

Are sediment dynamics important in modulating sediment export at such timescales?

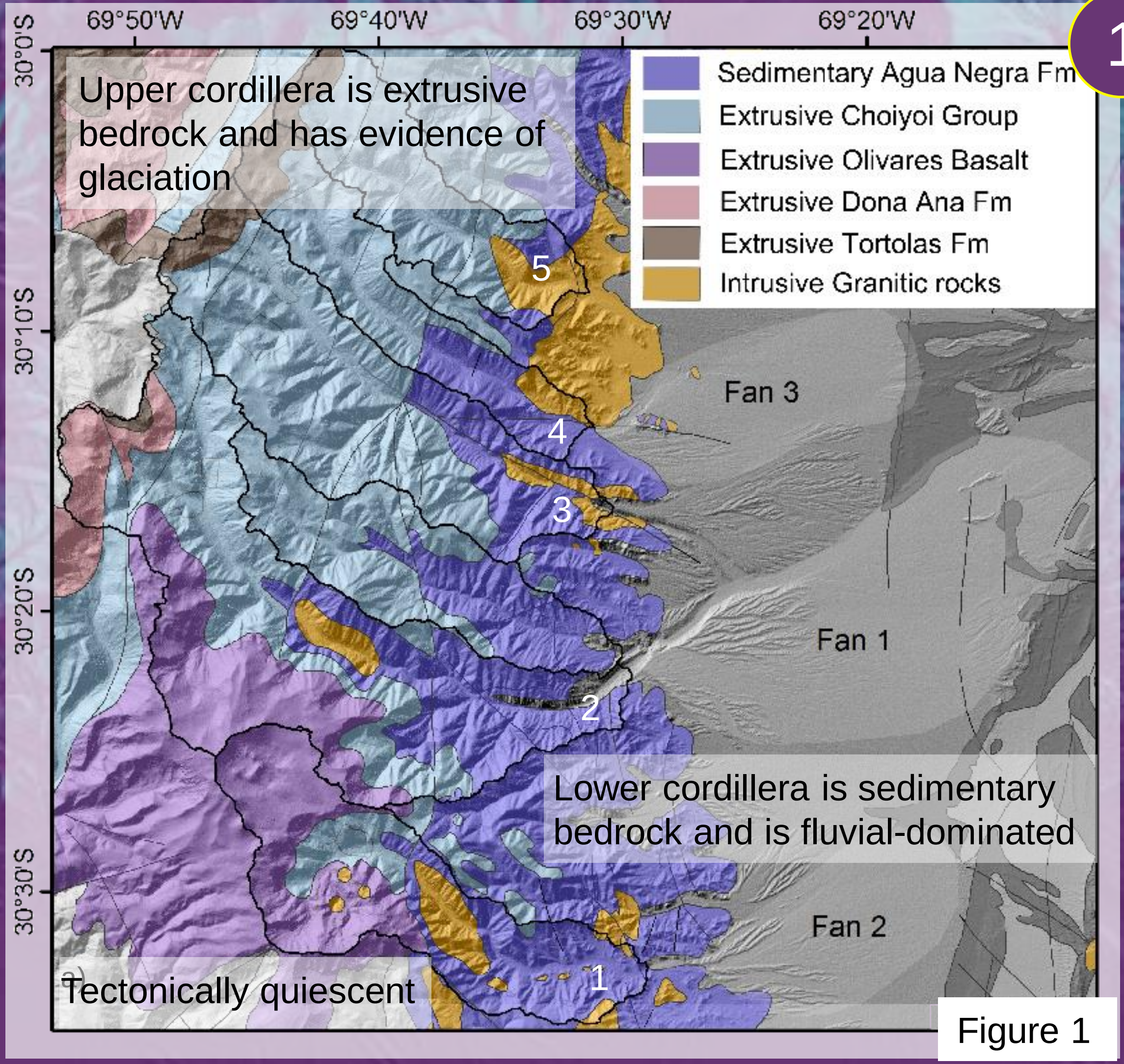


Figure 1

1 Study area: Argentine Frontal Cordillera 30-31^{o}S

2 Approach

We compare the lithological composition of gravels on three alluvial fans to the areal exposure of those lithologies in their catchments.

Where the composition of gravels does not have a one-to-one correlation with their bedrock areal exposure, we test whether sediment composition is modulated by:

a) spatial variability in bedrock erosion
b) abrasion
c) the storage of sediment within the Cordillera.

Harries et al. JGR 2018, Basin Res 2019

3

Methodology

Channel Steepness, k_{sn}

reference concavity

$$k_{sn} = Q_i^{\theta ref} S$$

effective discharge *slope*

Spatial variability in erosion rates is expected to be recorded in spatial variations in channel steepness, modulated by lithology and precipitation rates.

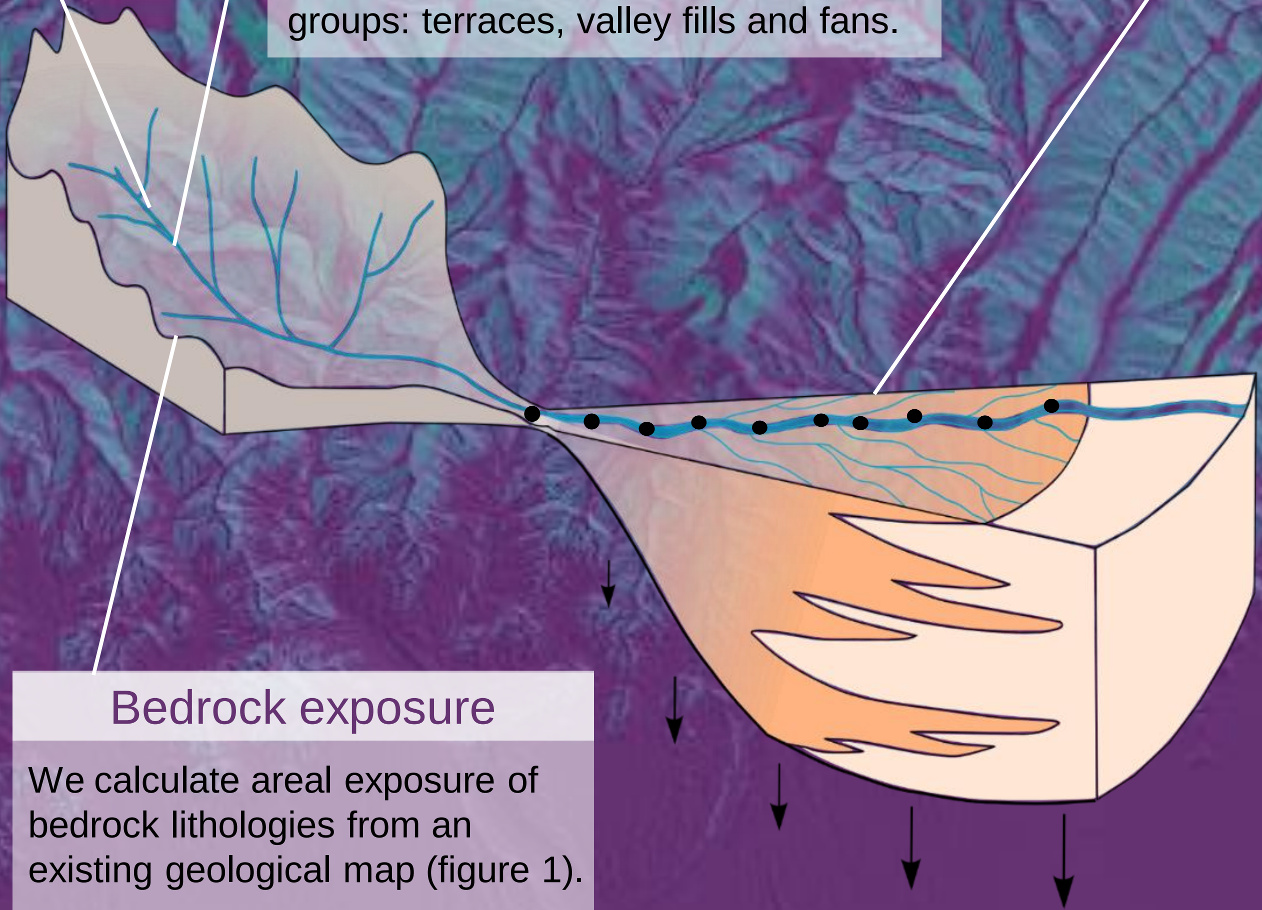
If erosion is the dominant control on channel steepness, we can use this metric to map out erosion trends in the cordillera.

We calculate k_{sn} using LSDTopoTools algorithms on a ~30 m resolution DEM.

We then analyse the influence of heterogeneous bedrock lithology, precipitation and glaciation on k_{sn}

Sediment storage

Using Google Earth we mapped sediment deposits within the cordillera, > 100 m wide, into three distinct groups: terraces, valley fills and fans.

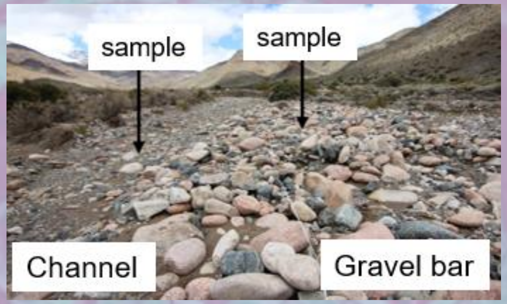


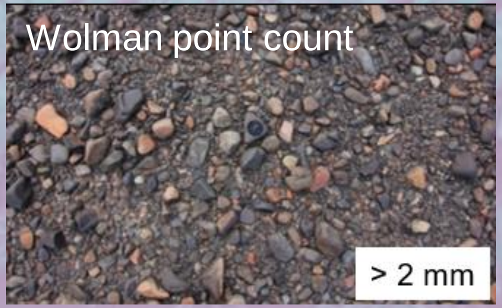
Bedrock exposure

We calculate areal exposure of bedrock lithologies from an existing geological map (figure 1).

Sediment composition

We measured the size and lithology of 200 clasts at each of 10-12 sites on each fan





Abrasion test: We analyse the relationship between gravel size and lithology along the length of each fan

4 Channel steepness, k_{sn}

k_{sn} is not spatially uniform

In the upper cordillera, main valleys have a low k_{sn} while their tributaries are steeper.

This fits a conceptual model for glacial erosion influencing the river profiles (Figure 2).

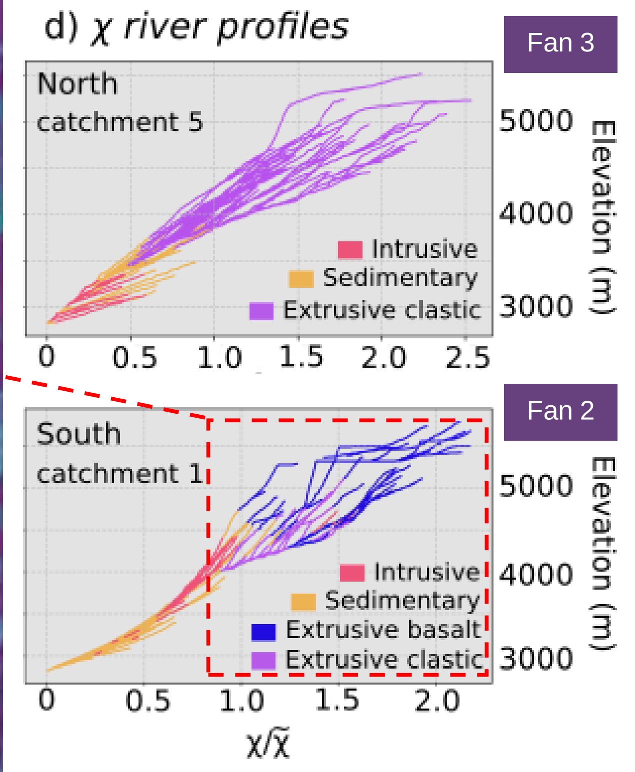
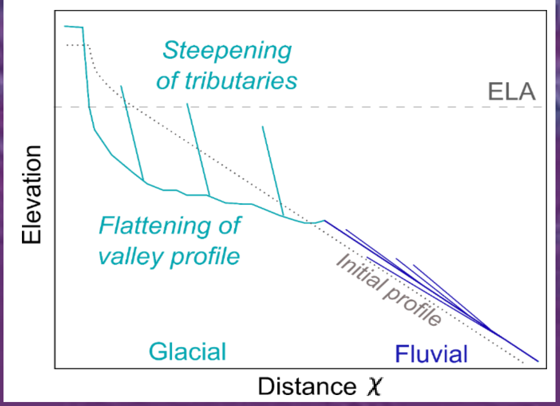


Figure 2

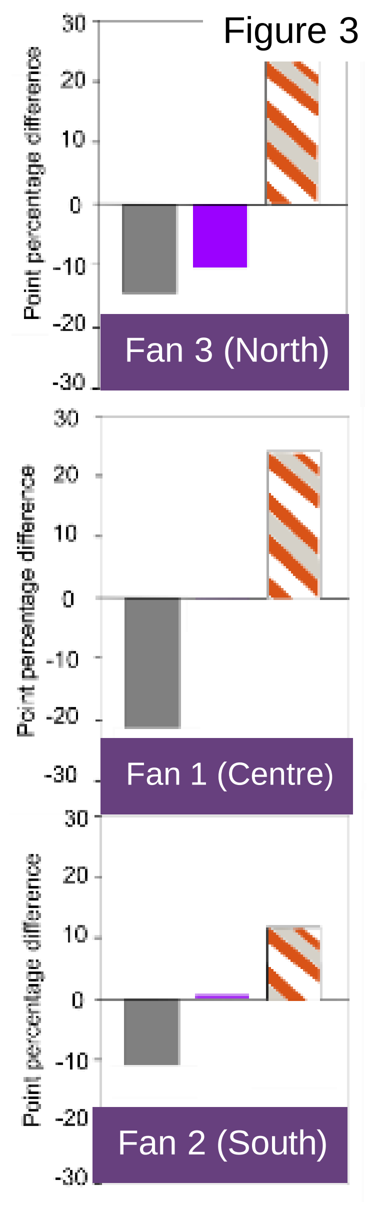


Erosion, and not lithology, is the dominant control on channel steepness.

We expect extrusive clasts sourced from the upper cordillera to be **over-represented** on the alluvial fans

Glacial influence decreases northward

5 Sediment composition



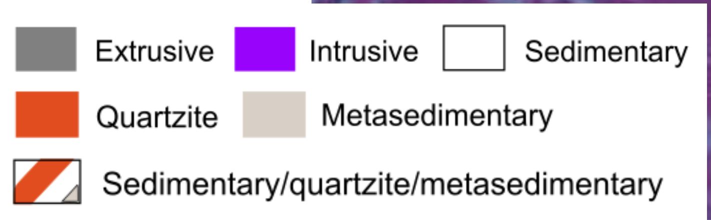


Figure 3: Lithological bias in the riverbed gravels of each fan with respect to their source regions. The proportions of gravel lithologies are averaged across the respective fan.

Extrusive gravels sourced from the upper cordillera are **under-represented** on all three fans

Fan 2 has the lowest under-representation of extrusive clasts.

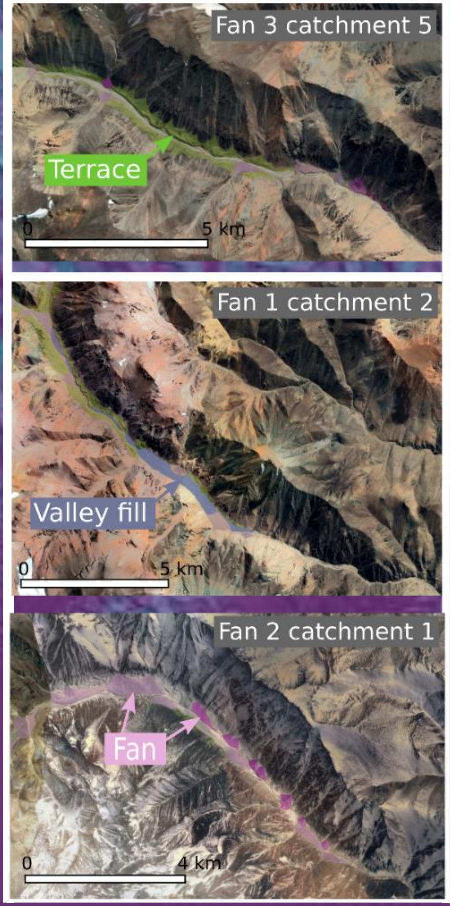
6 Abrasion

Weaker lithologies do not decrease in abundance and size with increased transport distance: This is not an abrasion-dominated system.

7 Sediment storage

1) Deposits are abundant in the upper cordillera and absent in lower cordillera

2) Fans 1 and 3 are dominated by terraced deposits whereas fan 2 is dominated by fans.



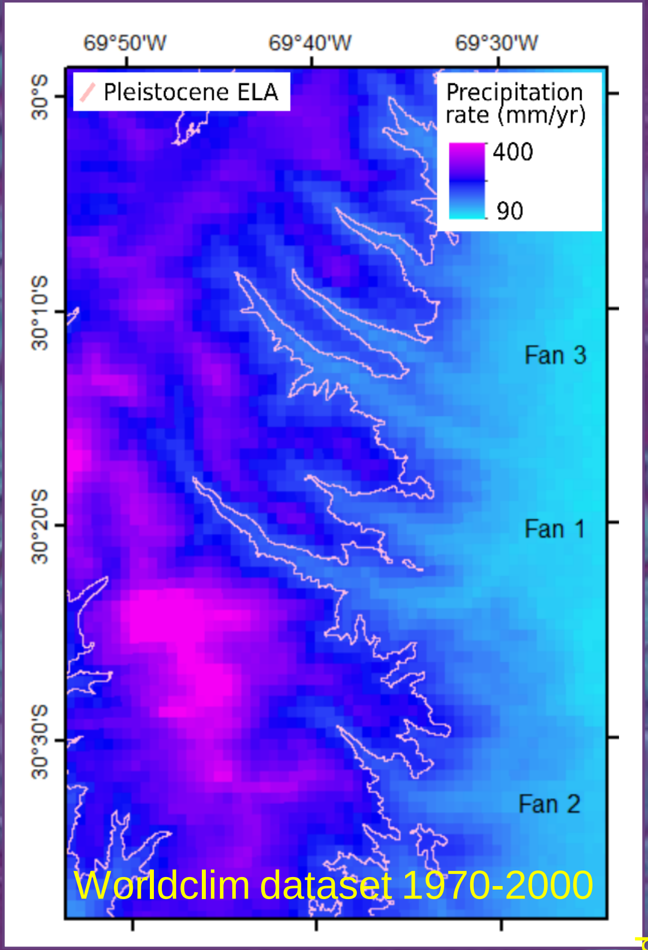
Sediment volumes are being stored upstream, in over-deepened and over-widened glacial valleys

The absence of terraces in fan 2's catchment suggests it has greater hillslope-channel connectivity.

8 Precipitation and sediment export

Despite glacial erosion having the greatest influence on lowering channel steepness in the south, fan 2 has exported a higher percentage of its sediment sourced from these glaciated reaches over the Holocene.

We attribute this to fan 2 having a greater hillslope-channel connectivity. We observe that greater hillslope connectivity is associated with higher precipitation rates, which vary as a function of elevation.



IMPORTANT IMPLICATION: The geomorphological evolution of source regions needs to be considered when reconstructing tectonic and climatic histories from stratigraphy