

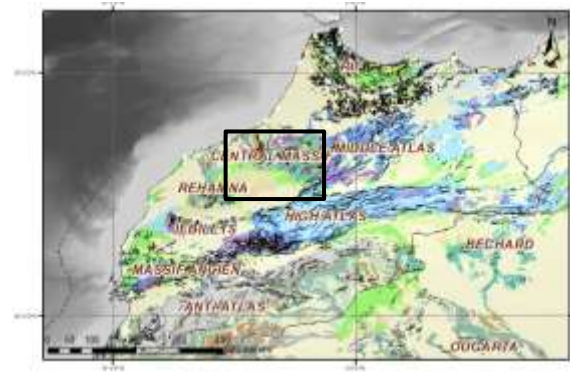
# Sedimentology and modelling of the Triassic fluvial system, Morocco

MSc Tess Oude Essink

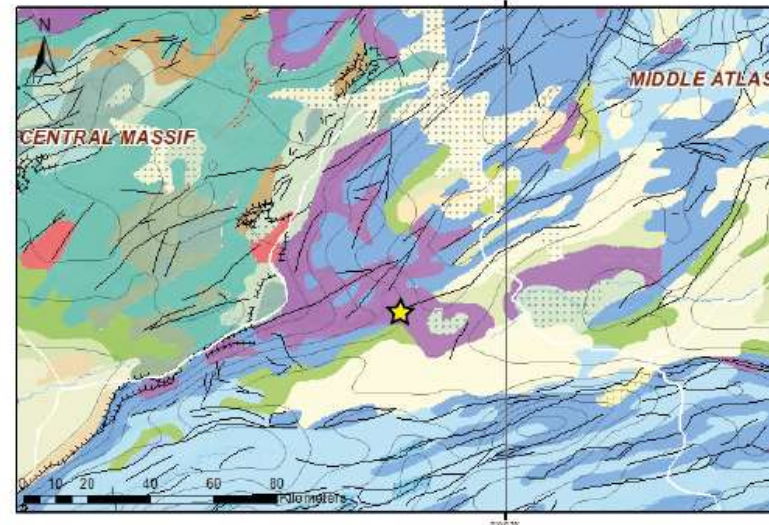


# Why Kerrouchen Basin?

1. The Kerrouchen basin was an active depositional system during the Triassic
2. Excellent analogue for understanding the northern Moroccan sandstone reservoirs
3. Little done on the Kerrouchen Basin, especially in regard to defining the stratigraphy and relationships to structure
4. Almost no work focusing on the sedimentology and conceptual deposition of the Kerrouchen Sandstone Formation



Kerrouchen Basin



# MSc research objectives

## 1. Sedimentology study

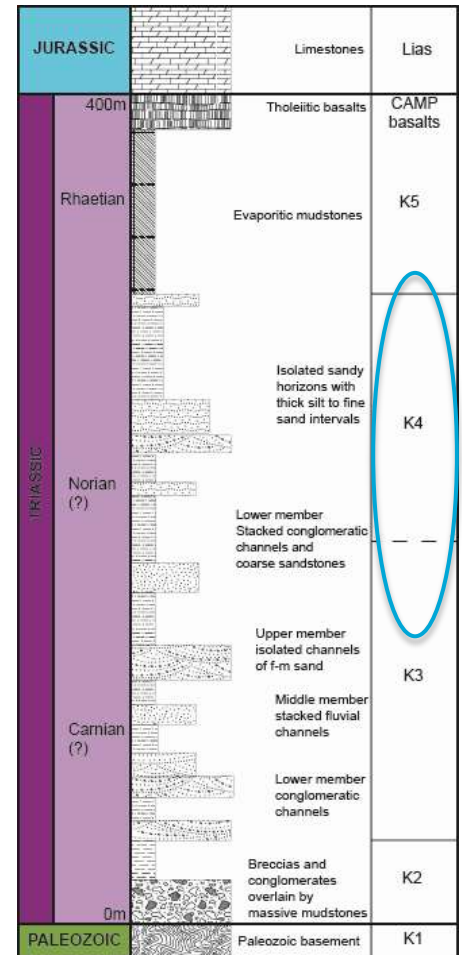
- Detailed sedimentology analysis of an understudied basin which will include a facies analysis of Kerrouchen Sandstone Fm, studying the architecture and stratigraphic stacking pattern of sandstone bodies.
- Identifying major sequence boundaries and real heterogeneities.
- Develop conceptual depositional and stratigraphic models.

## 2. 3D process-based modelling

- Quantifying stratigraphic information into a process-based models such as Karssenberg & Bridge 2008.
- Using process-based modelling to investigate the natural variability and associated uncertainties and primarily focusing on reservoir to non-reservoir rock distributions.
- Determine what consequences the above findings may have on a regional drainage network of the Moroccan continent.

# Triassic stratigraphy of Kerrouchen Basin

- Current stratigraphy
  - Palaeozoic basement
  - Basal 'stable' phase
  - Fluvial and alluvial-fan-fluvial
  - Uppermost red mudstones
  - Tholeiitic basalts
- Kerrouchen Sandstone formation is a prominent unit studied within the basin.
- Stratigraphic position unknown but likely to be within K4



# Sedimentology results

- Identified 3 major facies associations
  - The classification into facies associations (FA) has been implemented to interpret the sediments investigated
- Regional sequence boundaries
  - architectural elements and sedimentary geometries was also applied to define sequence boundaries to allows for correlations, to be made later, on a regional scale
- Identified heterogeneity scale
  - Understanding nature and scale of heterogeneities

# Kerrouchen Sandstone Formation\*

(\*stratigraphic interval K4)

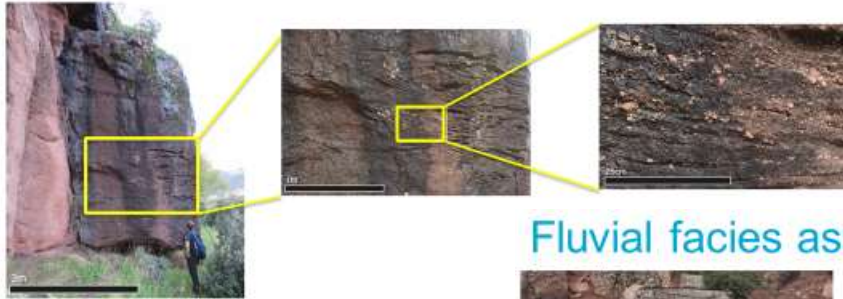
- Outcrop can be subdivided into 4 zones
- **Zone 1 & 2** - Migrating braided channel belt system, isolated sand packages in predominantly floodplain fine deposits (~30m thickness)
- **Zone 3** – (ephemeral) braided high energy fluvial system; massive amalgamated sands - isolated valley fill scenario, periods of high aggradation (25-30m thick)
- sediment influx > accommodation, observe channel incising, stacking of palaeo-channels, paleosol development, channel bars stacking, bar tops have desiccation cracks therefore periods of aerial exposure
- **Zone 4** – period of floodplain followed by short lived braided fluvial system stacked to 2m but thins out lateral along outcrop, not as continuous as zone 3 (5m thickness)

# Facies Associations

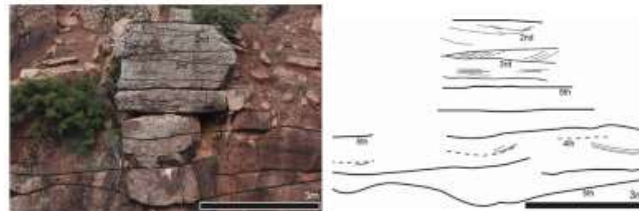


Alluvial-fan facies association- FA1

Overbank facies association- FA3



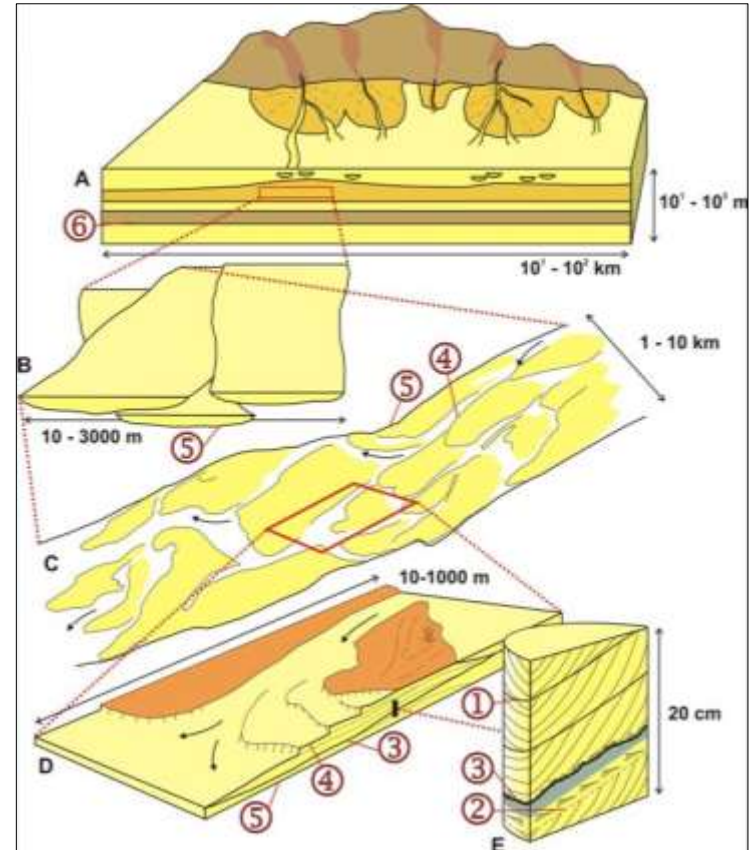
Fluvial facies association- FA2



# Sequence Boundaries

## Bounding surfaces

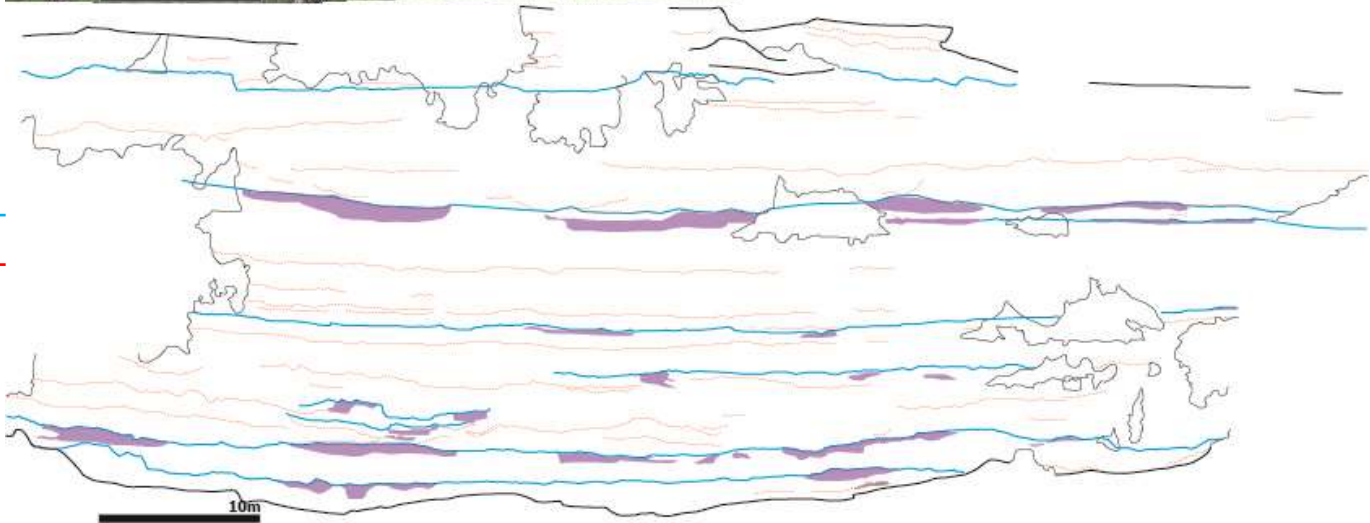
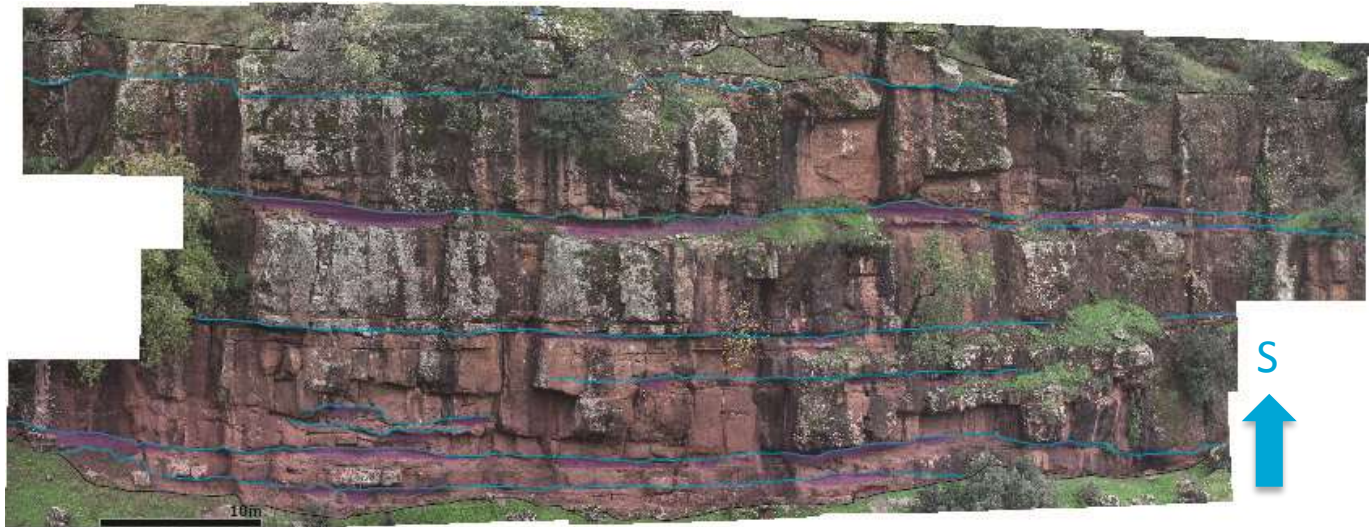
1. Migrating dunes
2. Change in hydraulic regime
3. Lag accumulation
4. Bar migration
5. Channel erosion
6. Major channel belt



# Major sequence boundaries

6<sup>th</sup> order bounding surfaces – channel belts





6<sup>th</sup> order ——— blue line  
5<sup>th</sup> order - - - - - purple line

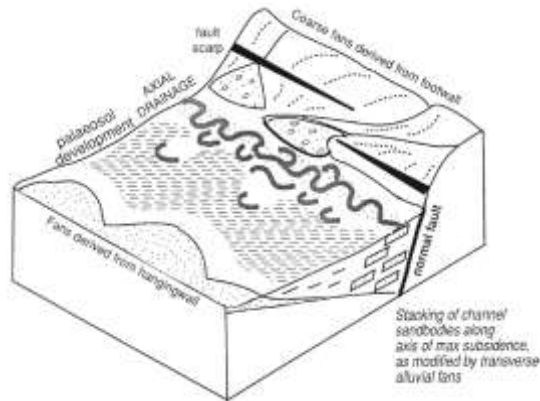


# Proposed depositional models

## Transverse-axial depositional system

### Axial braided river with transverse feeder alluvial fans

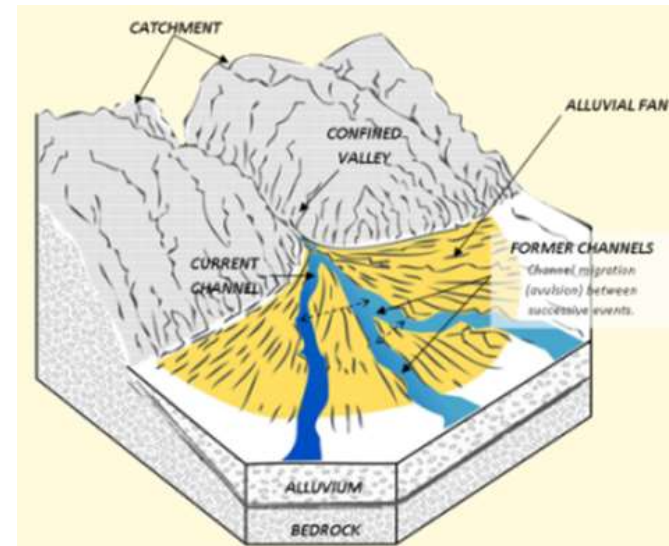
- Aggrading occurring in zone 3 – resulting in amalgamated channels
- Scattered palaeoflow indicators (braided system within the alluvial fan)
- High energy – gravel lag deposits, channel incising, erosional surfaces abundant
- Bars and bar tops present in outcrop, amalgamation of stacked bar
- Proximal to source
- Well developed palaeosols present which mark channel belts



## Transverse depositional system

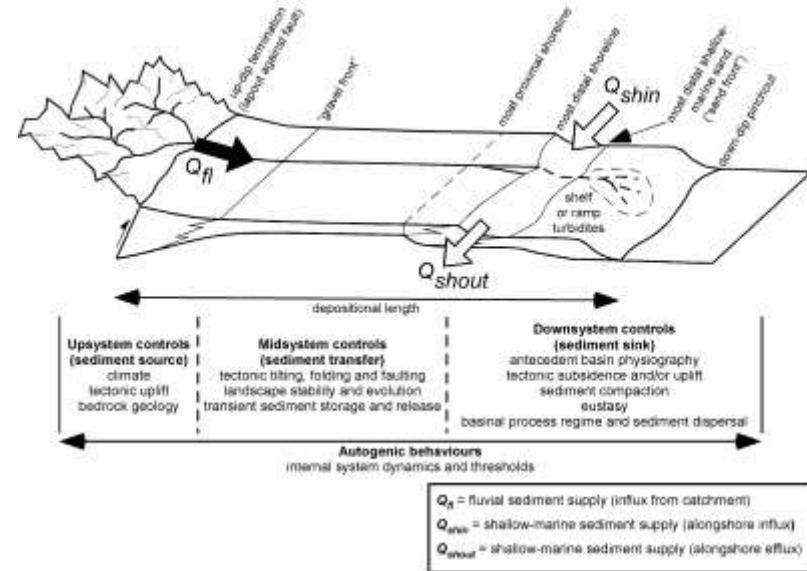
### Braided river in alluvial fan

- Arid fan with a main channel (braided river) and clear fan boundary
- High energy, poorly sorted material, large gravel lags



# Why use 3D process-based modelling?

- Inexpensive way to try and reduce basin uncertainties
- Because of the predictive power of coupling physical processes, process-based modelling can help us understand and explore processes that underline basin formation
- Controls on stratigraphic architecture of sedimentary basins can be realised relatively quickly
- Process-based modelling is a complete source to sink system. Sediments can be simplified by two domains, hinterlands (source) and basins (sinks) and input factors: tectonic, eustatic and climatic.



Hampson (2016)

# Numerical model inputs

Qs and Qw input

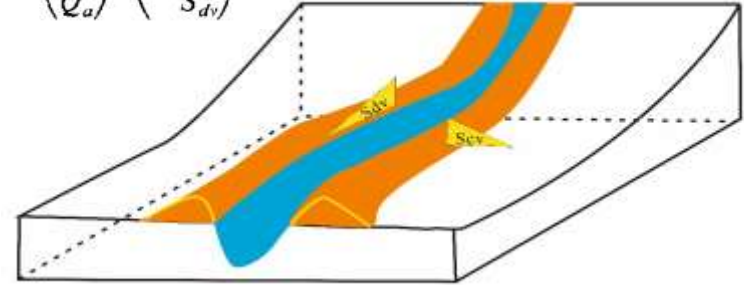


- **Dependent avulsion**

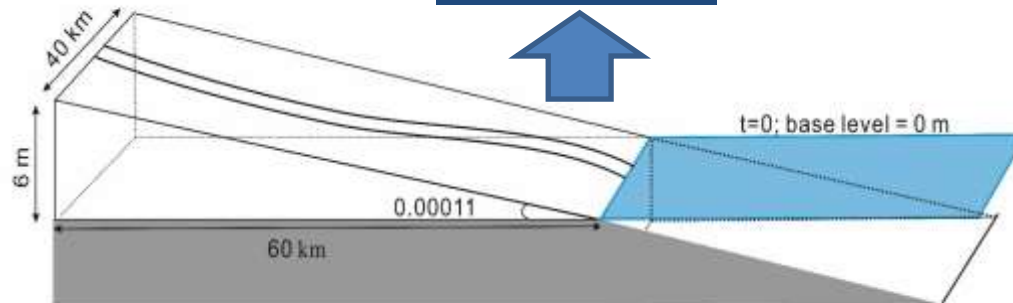
Slope advantage

Flood magnitude and frequency

$$P(a) = \left(\frac{Q_f}{Q_a}\right)^{e_Q} \left(k_s \frac{S_{cr}}{S_{dv}}\right)^{e_S}$$

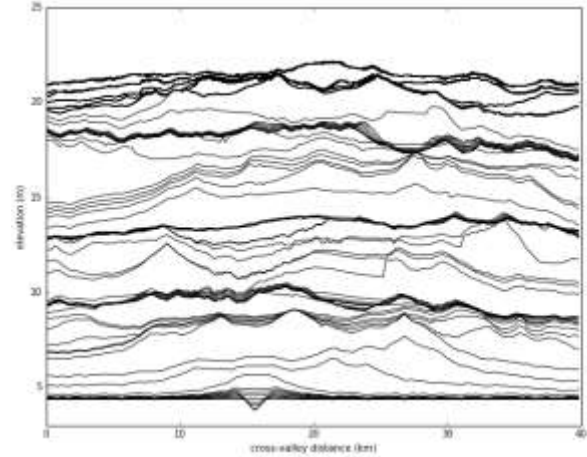
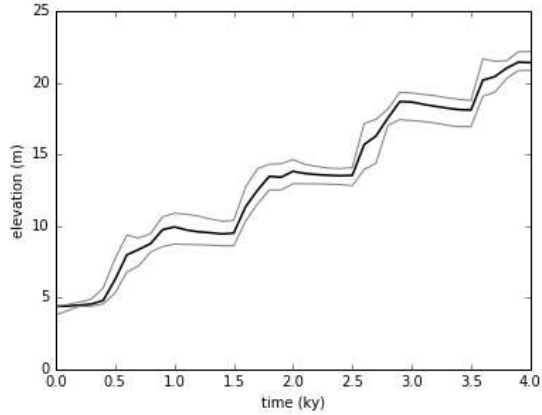


Rising base level

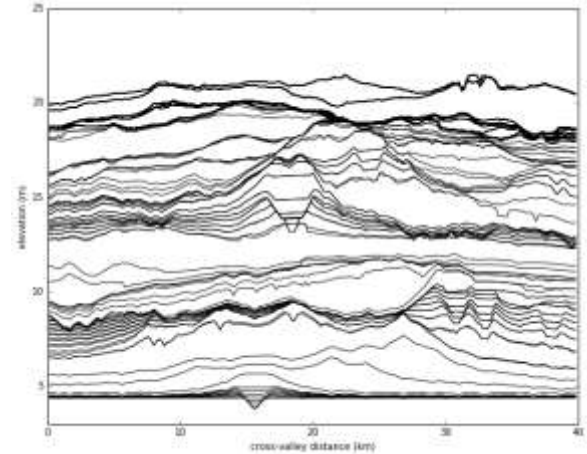
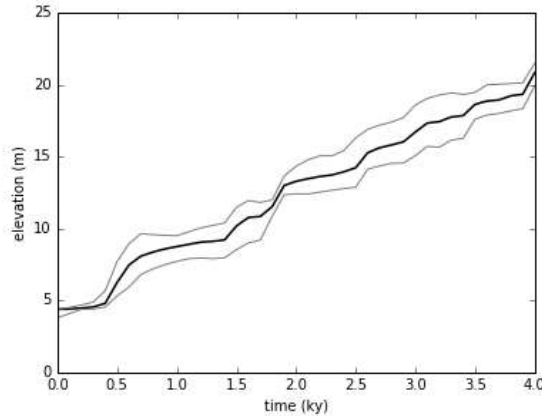


# Preliminary modelling results

5000 years

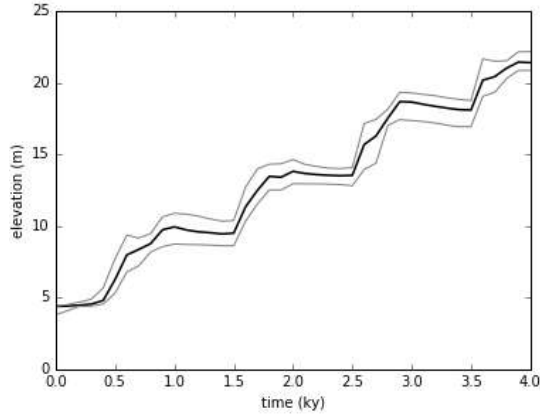


500 years

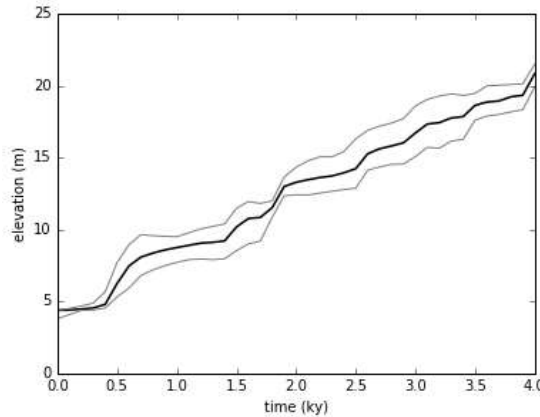


# Preliminary modelling results

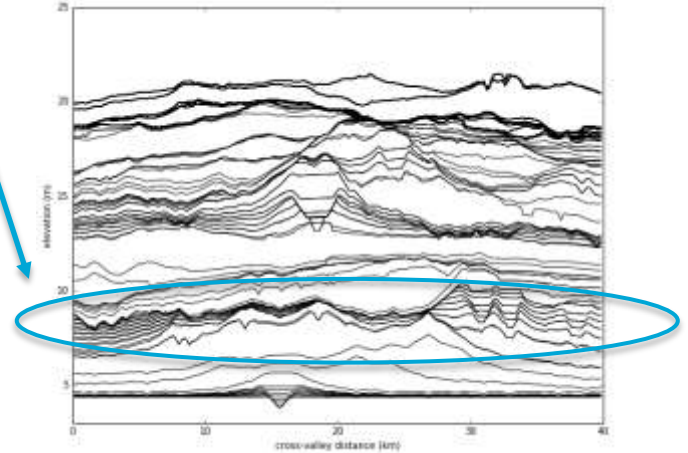
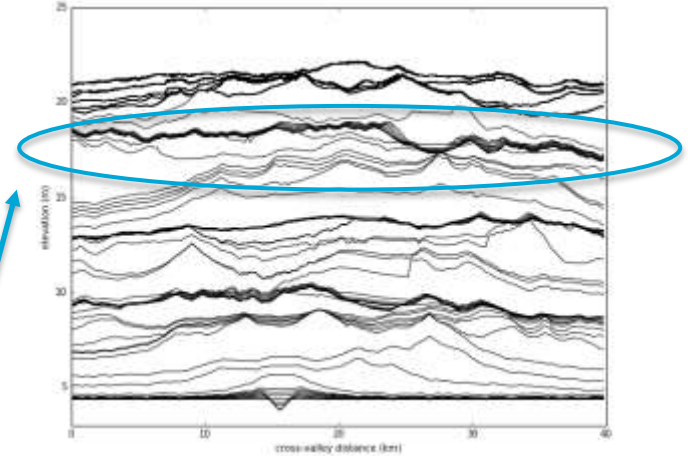
5000 years



500 years



6<sup>th</sup> order  
bounding  
surfaces



# Future numerical modelling work

1. Understanding the implications of  $Q_s/Q_w$  ratios
  - Model results exhibited that sediment input changes appeared to dominant the average elevation profile of the basin and number of channel bifurcations much more so than water input.
  - However this may just be due to large  $Q_s/Q_w$  ratios.
  - Applying varying  $Q_s/Q_w$  ratios to understand the link the model makes between these inputs and the corresponding output that is eventually recorded.
2. Including changing basin slope as a model input

An aerial photograph of a village built on a hillside. The buildings are made of reddish-brown earth. Below the village, a wide river valley is visible, with a riverbed that appears to be mostly dry or has very shallow water. The surrounding landscape is hilly and covered in sparse vegetation. The word "Question?" is overlaid in white text in the center of the image.

Question?

## References:

Hampson, G.J. (2016) Towards a sequence stratigraphic solution set for autogenic processes and allogenic controls: Upper Cretaceous strata, Book Cliffs, Utah, USA, *Journal of the Geological Society*, 173, 817-836. <https://doi.org/10.1144/jgs2015-136>

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NARG GIS data base (2019)