Can a Single Turbidite Flow Decouple and Become Separate High and Low Concentration Flows?*

Tim McHargue[1]

Search and Discovery Article #50708 (2012)**
Posted August 31, 2012

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012

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Abstract

The cross-sectional profile of some turbidite channel systems displays a small, sinuous channel element within a much larger container with low sinuosity. The sinuous channel element typically is 100-300m wide and 10-30m deep with a cross-sectional area of 1 to 9 KmSq, whereas the container, often confined by outer levees, is kilometers wide and hundreds of meters deep with a cross-sectional area that is 2 to 3 orders of magnitude larger than the area of the channel element. Well logs and 3D seismic data from numerous channel systems confirm that turbidite sands typically are concentrated within the element-scale channel unless the confinement relief is thin, on the order of 10m or less. Therefore, collectively, architecture and sediment distribution imply that the turbidity currents traveling through these channel systems were stratified, and the higher concentration portion of these flows were restricted to the element-scale channels. The dilute upper portion of these flows filled and overspilled a container that was several times wider and multiple orders of magnitude larger than the underlying channel element. Furthermore, the upper, dilute layer followed a low-sinuosity path and was in contact with the container floor, rather than the underlying high concentration layer, for 60% to 90% of its width.

Because the two layers of the turbidity flow have different concentrations, markedly different volumes, pathways with different sinuosities and limited vertical contact, it is reasonable to consider that the two layers may have traveled at different velocities and decoupled. The high concentration portion of the flow could have traveled at a higher velocity, albeit along a path of higher sinuosity, than the dilute portion of the flow. If decoupled, what are the flow parameters of the high density flow that allow it to sustain suspension of coarse grains across long distances?

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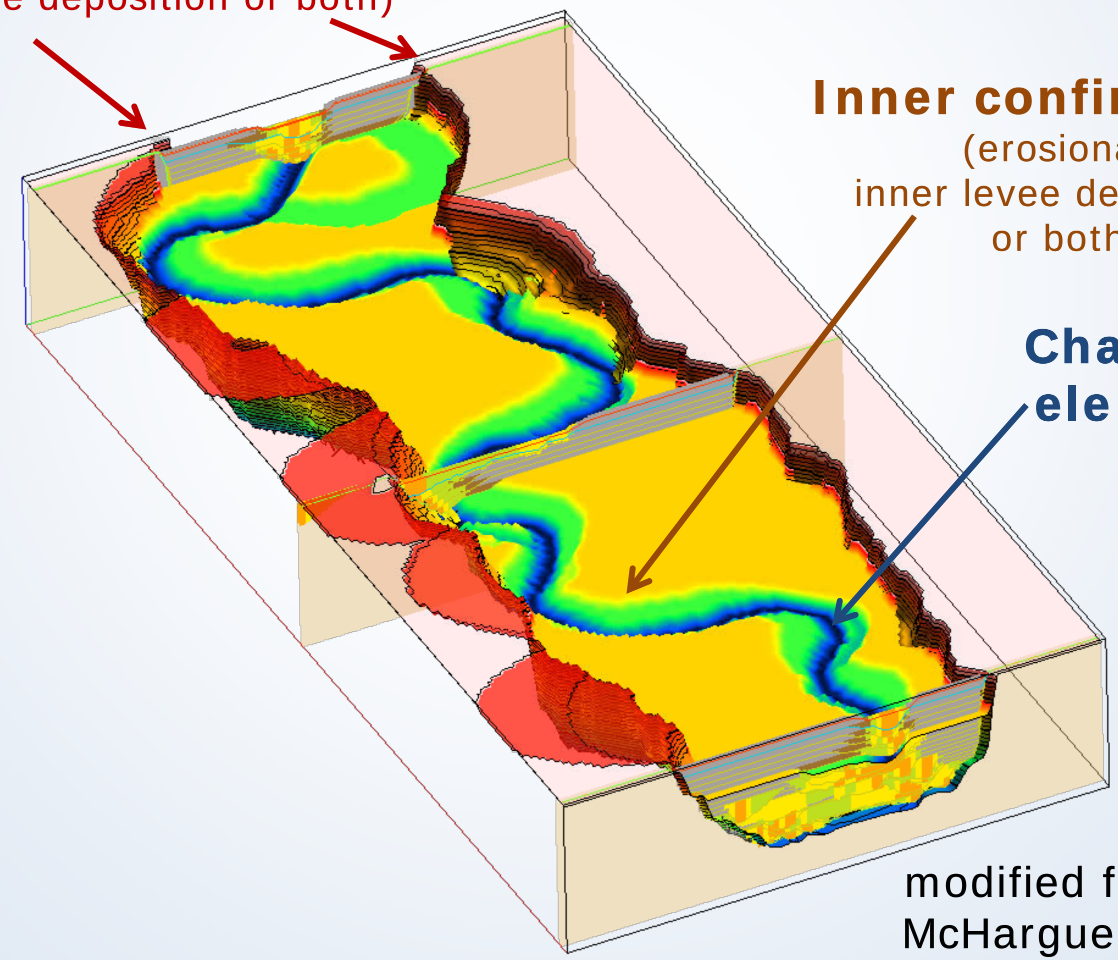
Tim McHargue

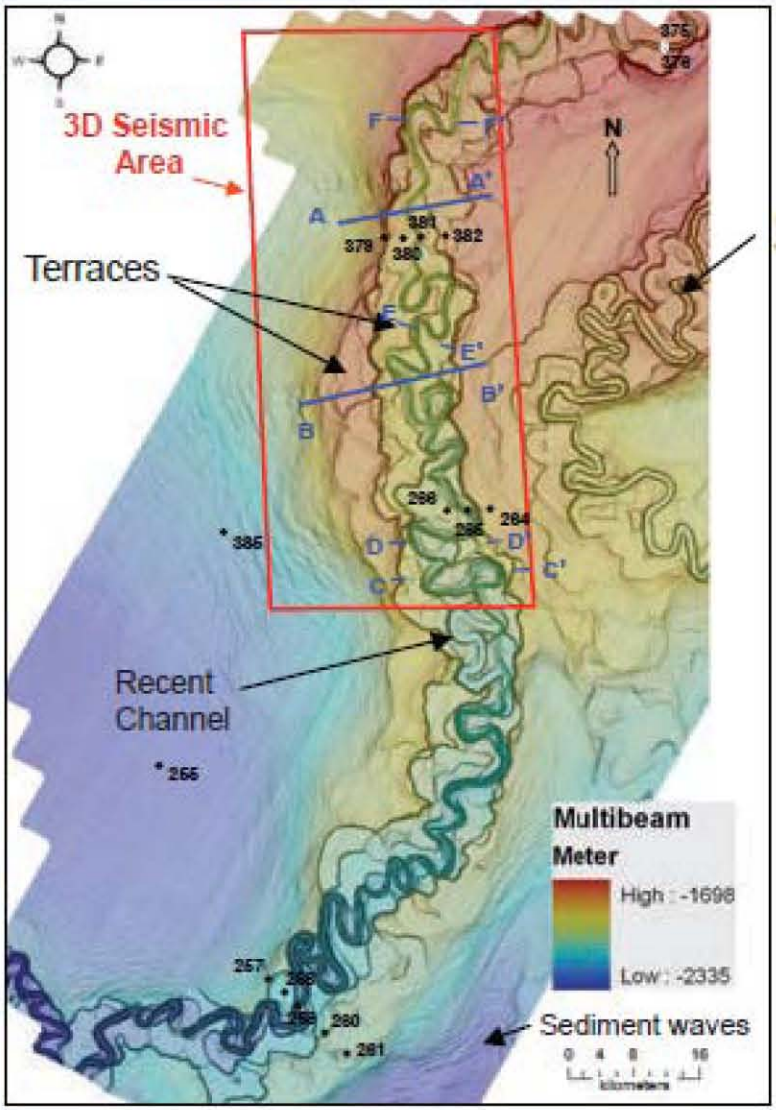
AAPG, Long Beach, April, 2012

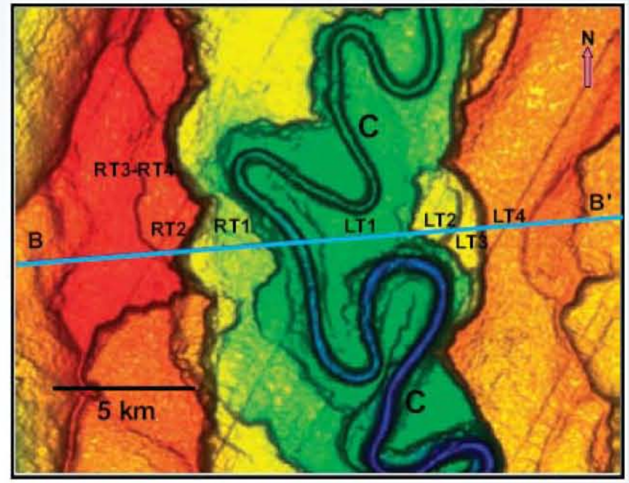
Many turbidite channel systems display a small, sinuous channel element within a much larger container with low sinuosity.

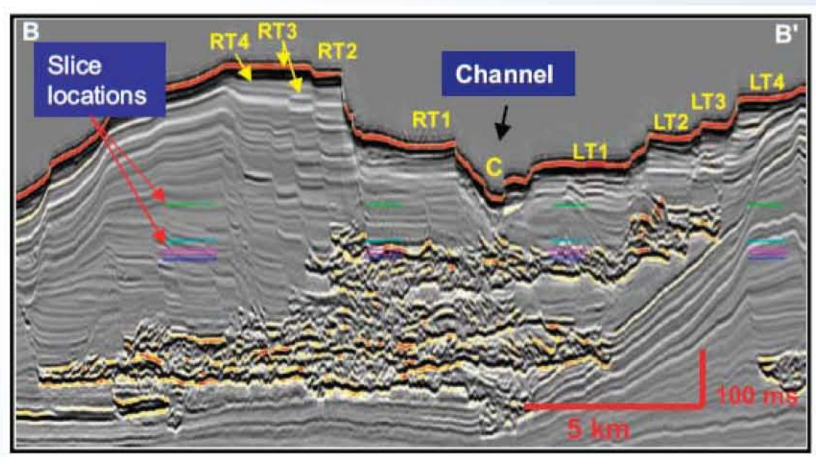


modified from McHargue et al., 2011

Proximal Bengal Fan Channel

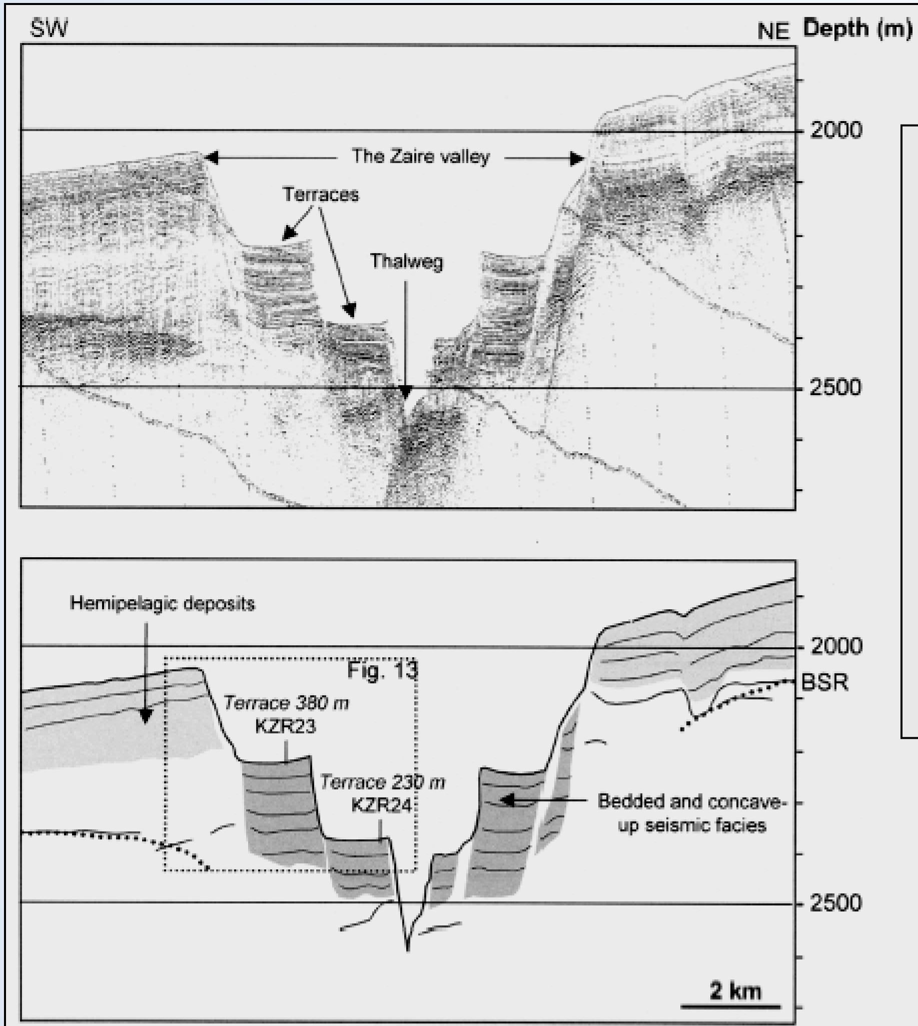


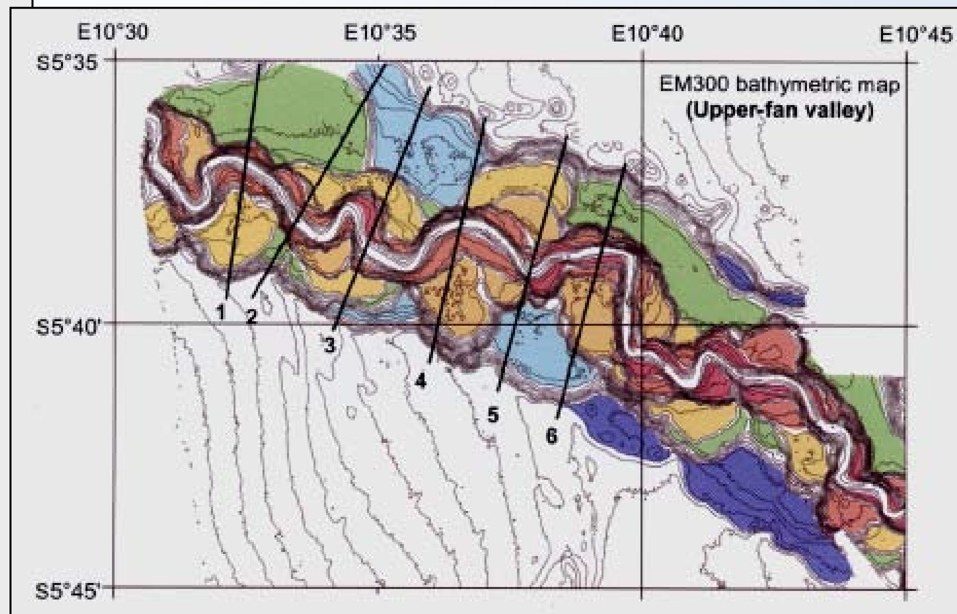




Kolla et al., 2012.

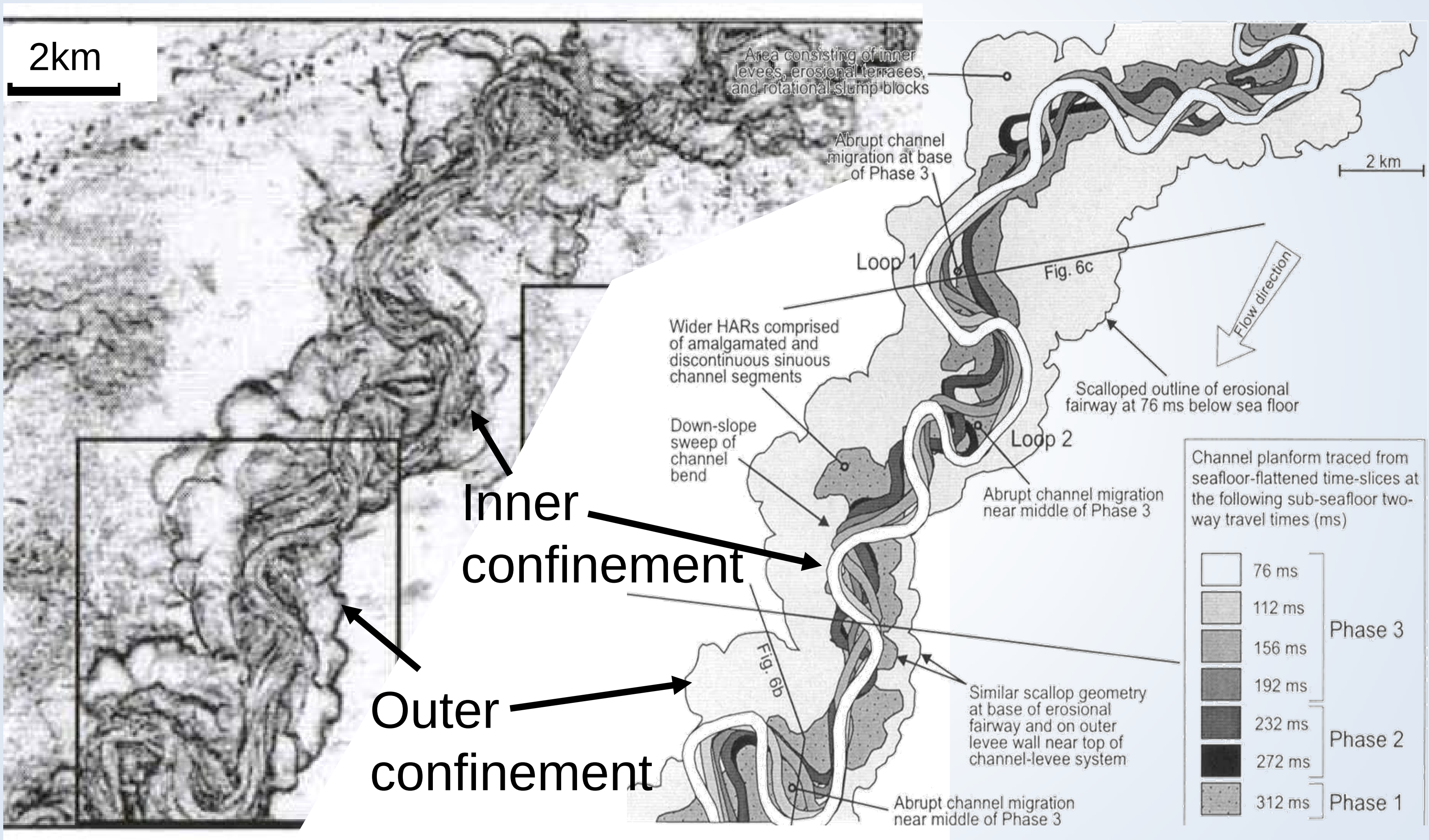
Zaire Upper Fan Valley





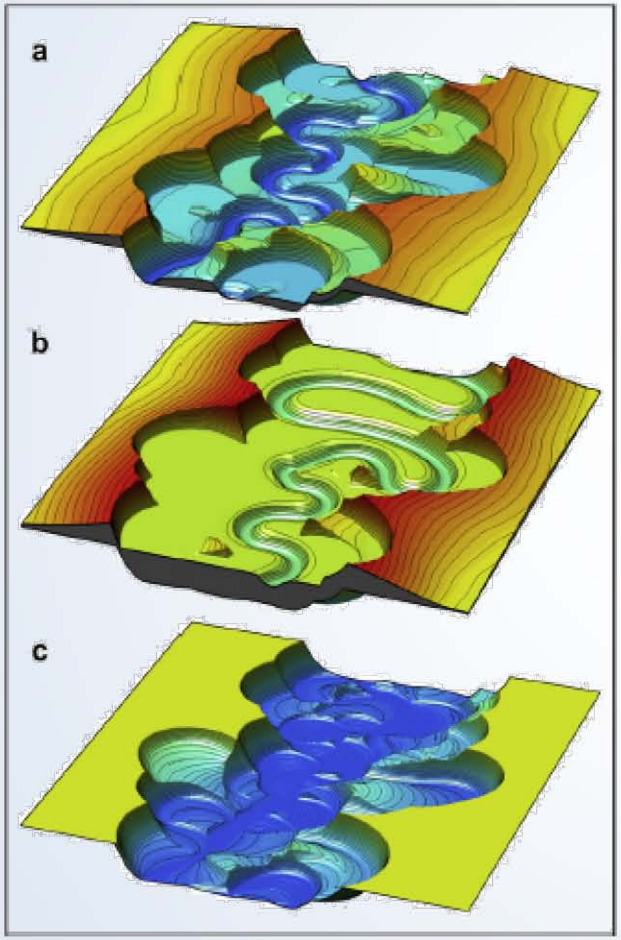
Babonneau et al., 2004.

Benin Major Channel System western Niger slope

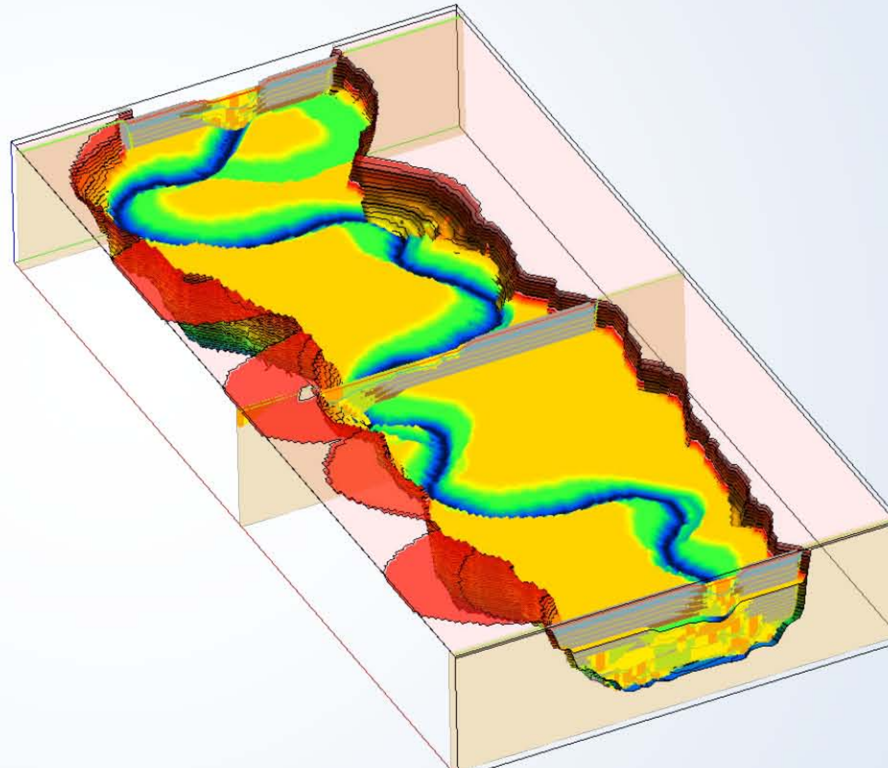


Deptuck, et al., 2003

This morphology for channel systems is modeled for petroleum reservoirs



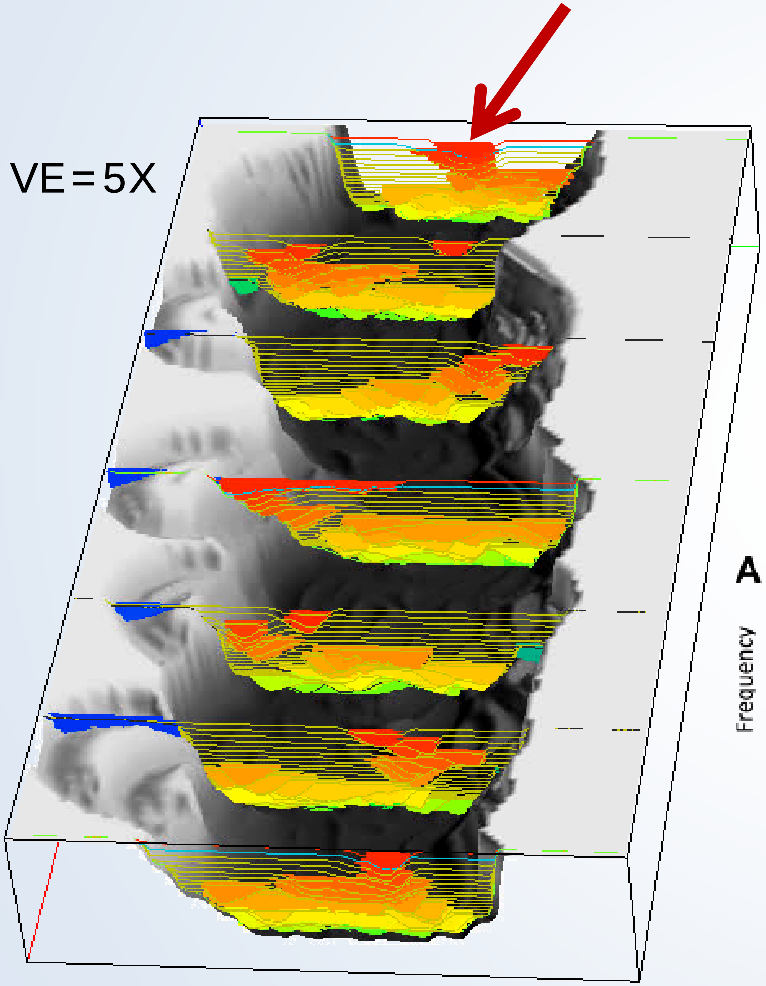
Sylvester et al., 2011



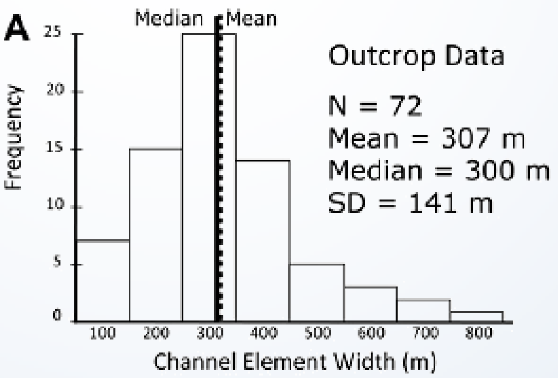
McHargue et al., 2011

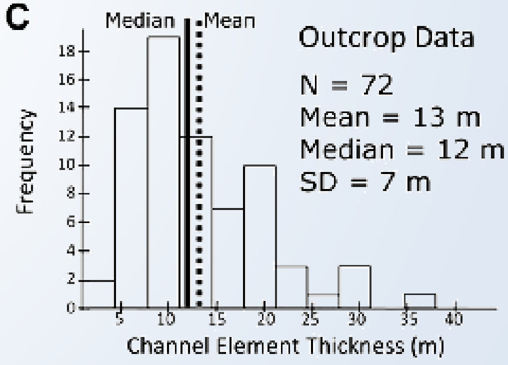
Channel Element Dimensions

VE=5X



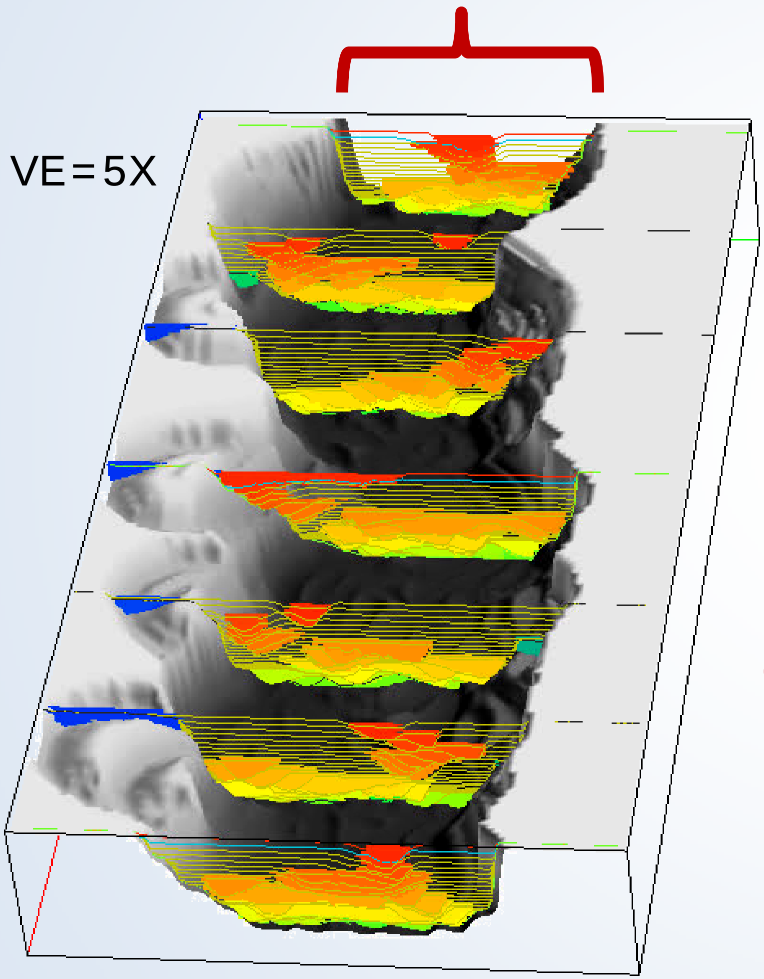
Average 13m X 307m
Cross-sectional area = 1- 9 km^2





McHargue et al., 2011

Valley Dimensions



McHargue et al., 2011

Range from 1km to 10km wide
by 100 to 500m deep

Cross-sectional area =
100 - 5000 km^2

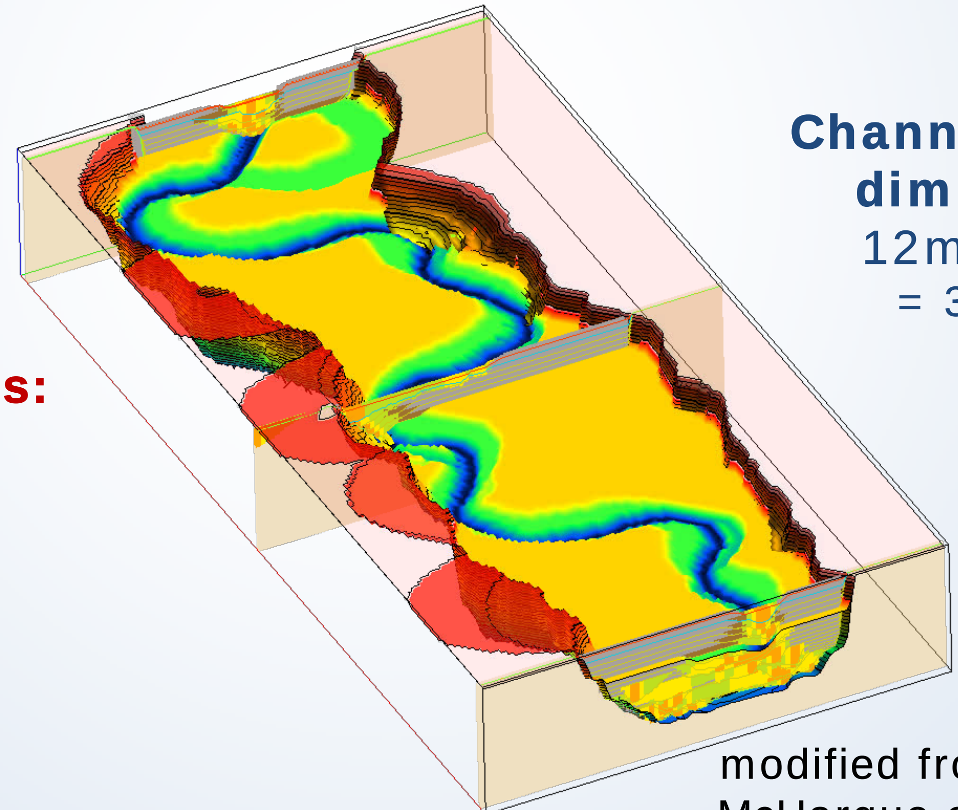
**Cross-sectional area =
1 to 3.5 orders of magnitude larger than the channel element.**

Flow Stratification Restricts Sand to Channel Elements

Tres Pasos Fm., Patagonia

Presenter's Notes: Well logs and 3D seismic data from numerous channel systems confirm that turbidite sands typically are concentrated within the element-scale channel unless the confinement relief is thin, on the order of 10m or less. Therefore, collectively, architecture and sediment distribution imply that the turbidity currents traveling through these channel systems were stratified, and the higher concentration portion of these flows were restricted to the element-scale channels.

By assuming that a single flow is responsible for constructing this morphology, we are assuming: The sandy, high density, portion of the flow is typically less than 10% of the flow height and Typically less than 1% of the flow volume.



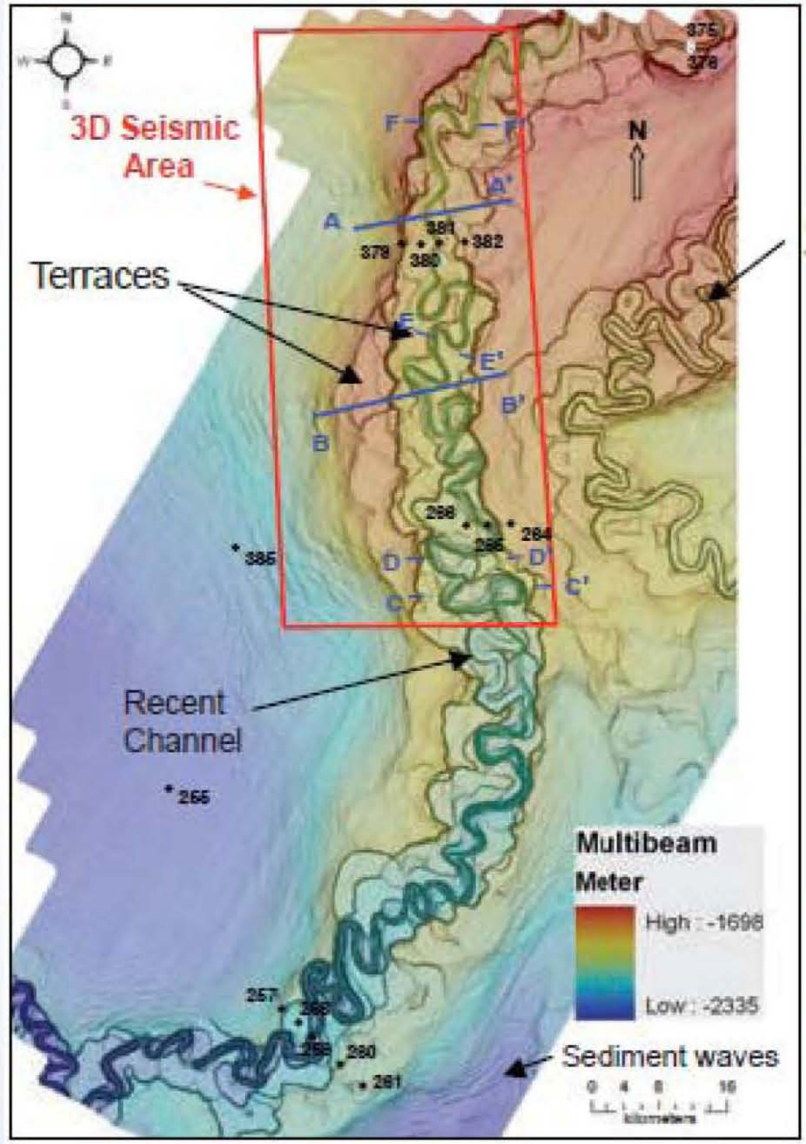
Channel element dimensions:
12m X 250m
= 3,000 m^2

Valley Dimensions:
3000m X 100m
= 300,000 m^2

modified from McHargue et al., 2011

We are also assuming:

- The upper, dilute layer, is confined by the valley walls and follows a low-sinuosity path.



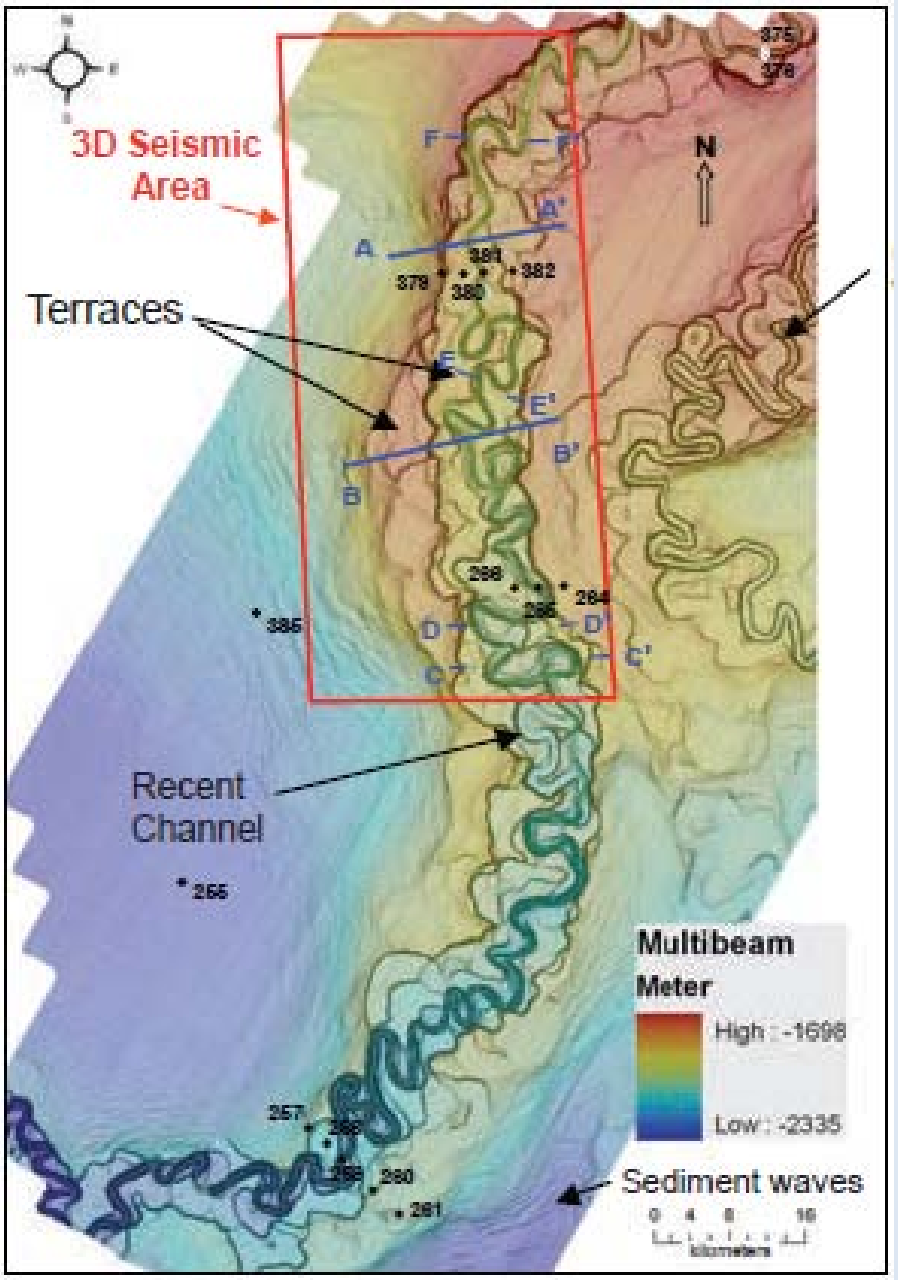
Proximal Bengal Fan, Kolla et al., 2012.

Presenter's Notes: The dilute upper portion of these flows filled and overspilled a container that was several times wider and multiple orders of magnitude larger than the underlying channel element. Furthermore, the upper, dilute layer followed a low-sinuosity path and was in contact with the container floor, rather than the underlying high concentration layer, for 60% to 90% of its width.

We are also assuming:

- The upper, dilute layer, is confined by the valley walls and follows a low-sinuosity path.

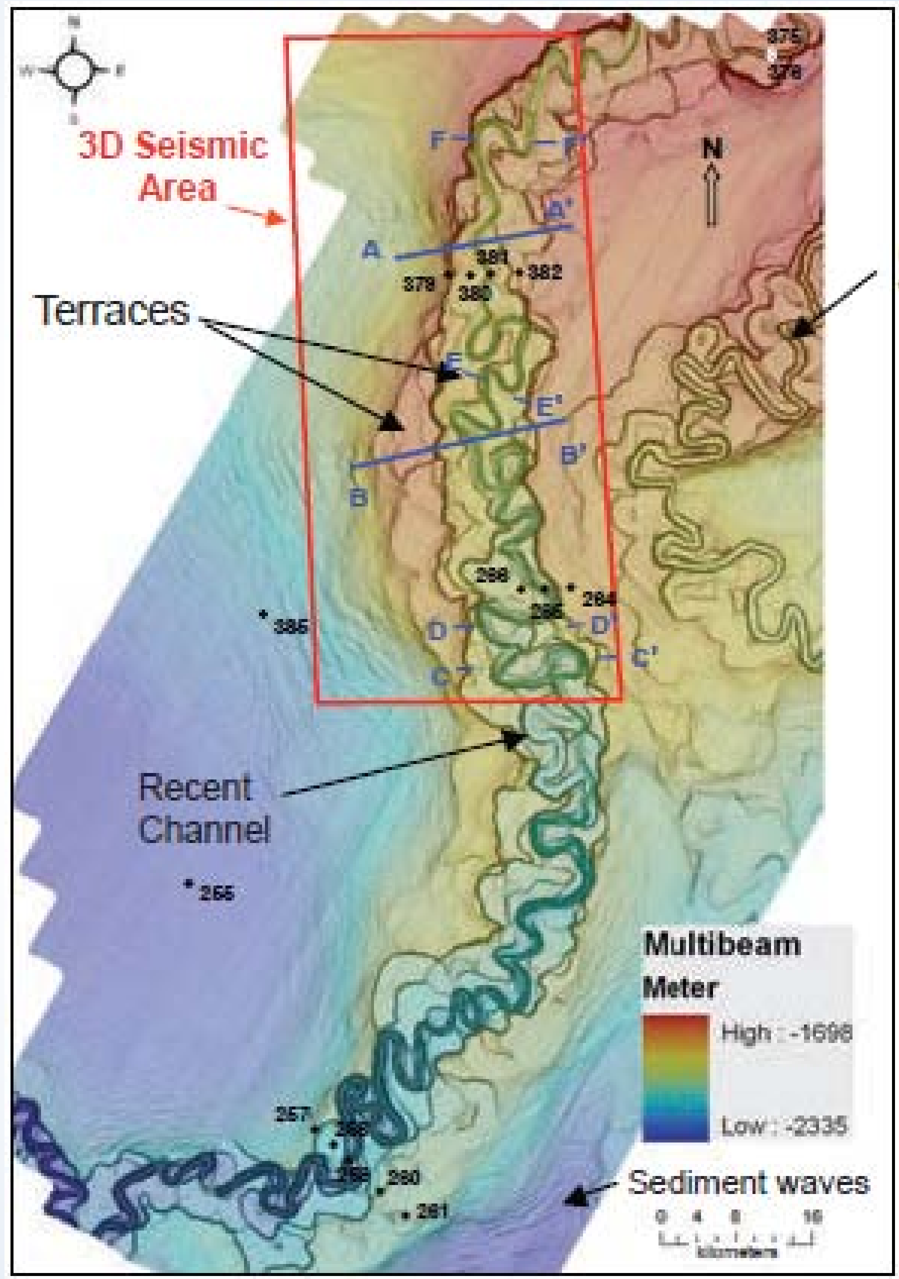
- It may overspill the valley walls and build outer levees.



Proximal Bengal Fan, Kolla et al., 2012.

We are also assuming:

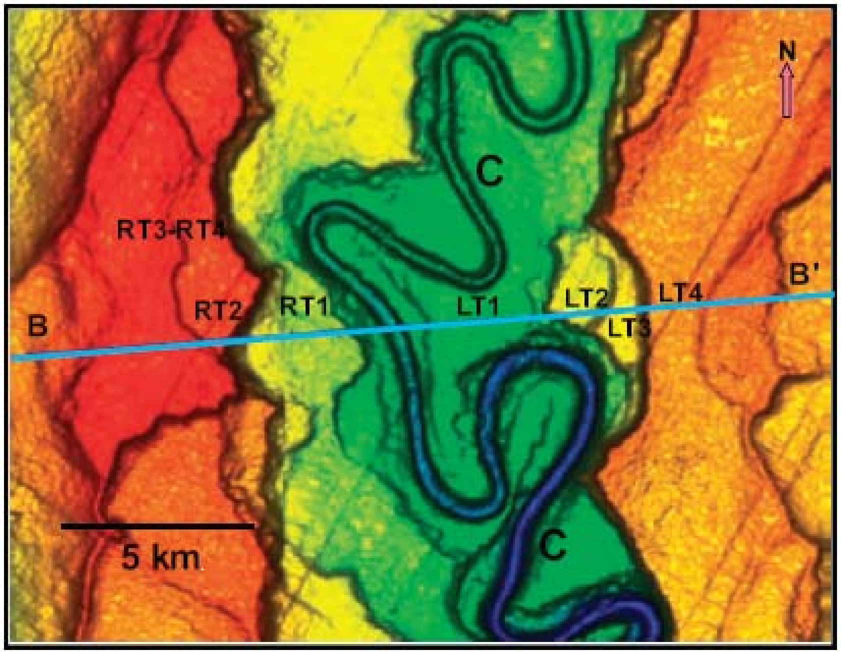
- The upper, dilute layer, is confined by the valley walls and follows a low-sinuosity path.
- It may overspill the valley walls and build outer levees.
- For 60% to >90% of its width the dilute layer is in contact with the valley floor, rather than the underlying sinuous channel.

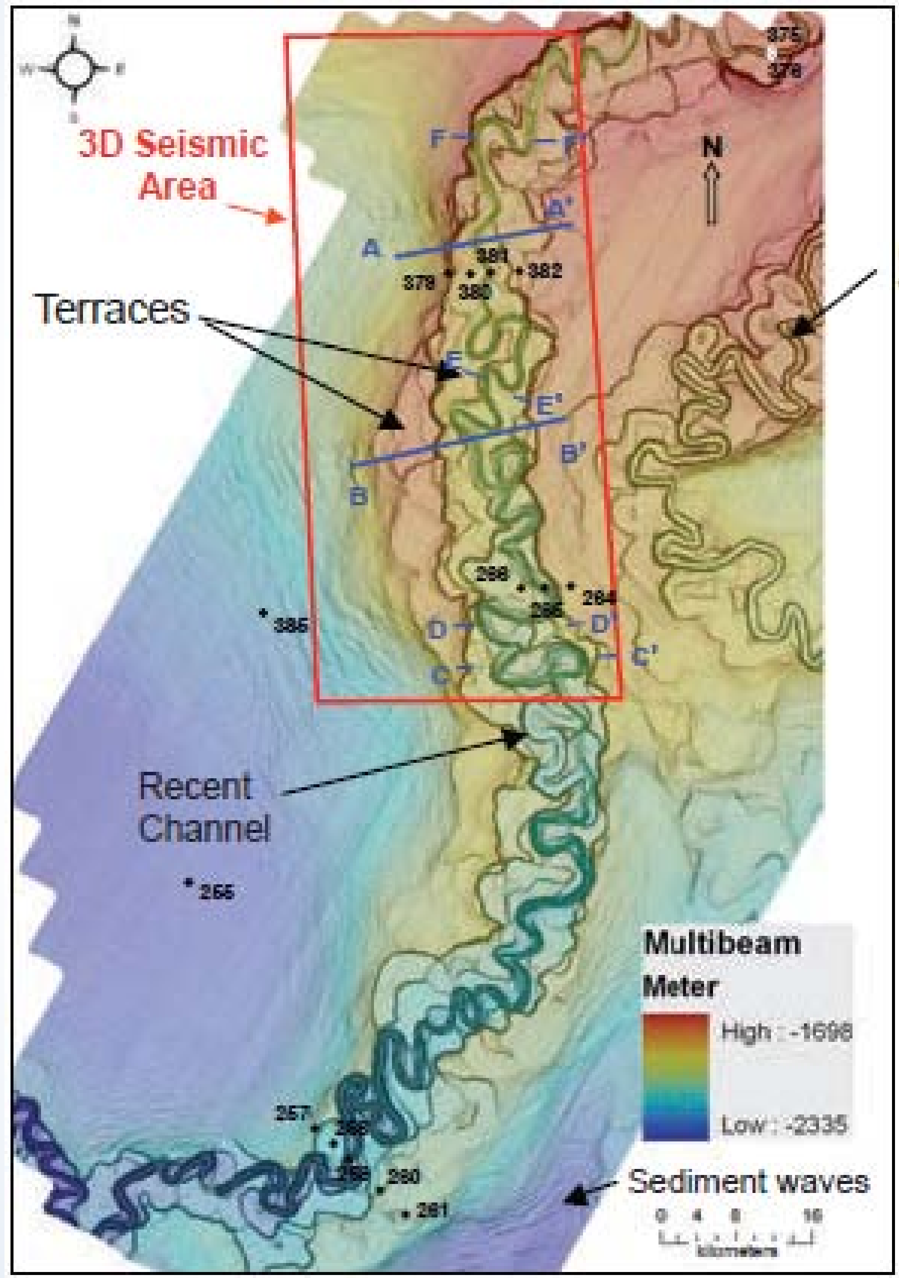


Proximal Bengal Fan, Kolla et al., 2012.

We are also assuming:

The underlying, high density layer, may erode a confining channel element that follows a high-sinuosity path.

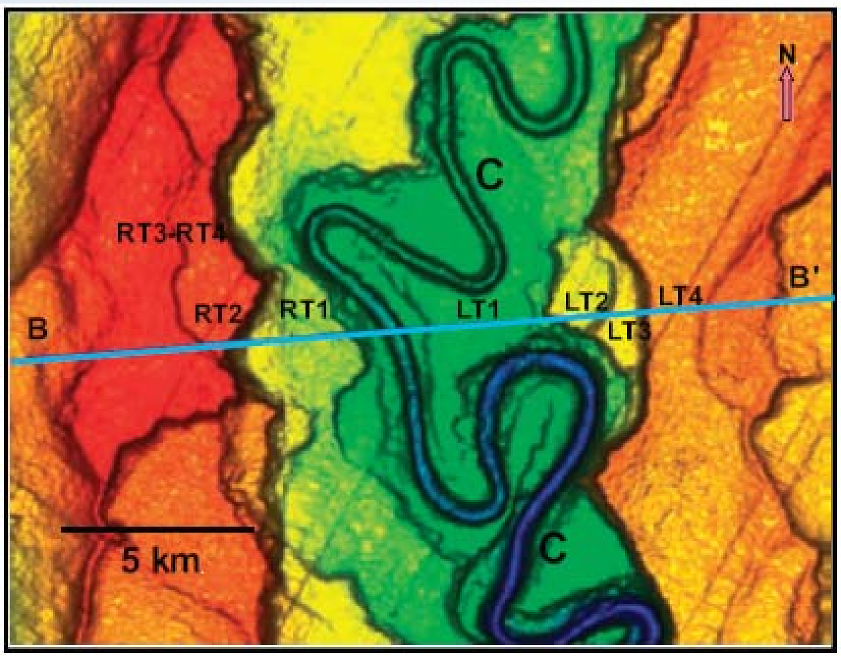


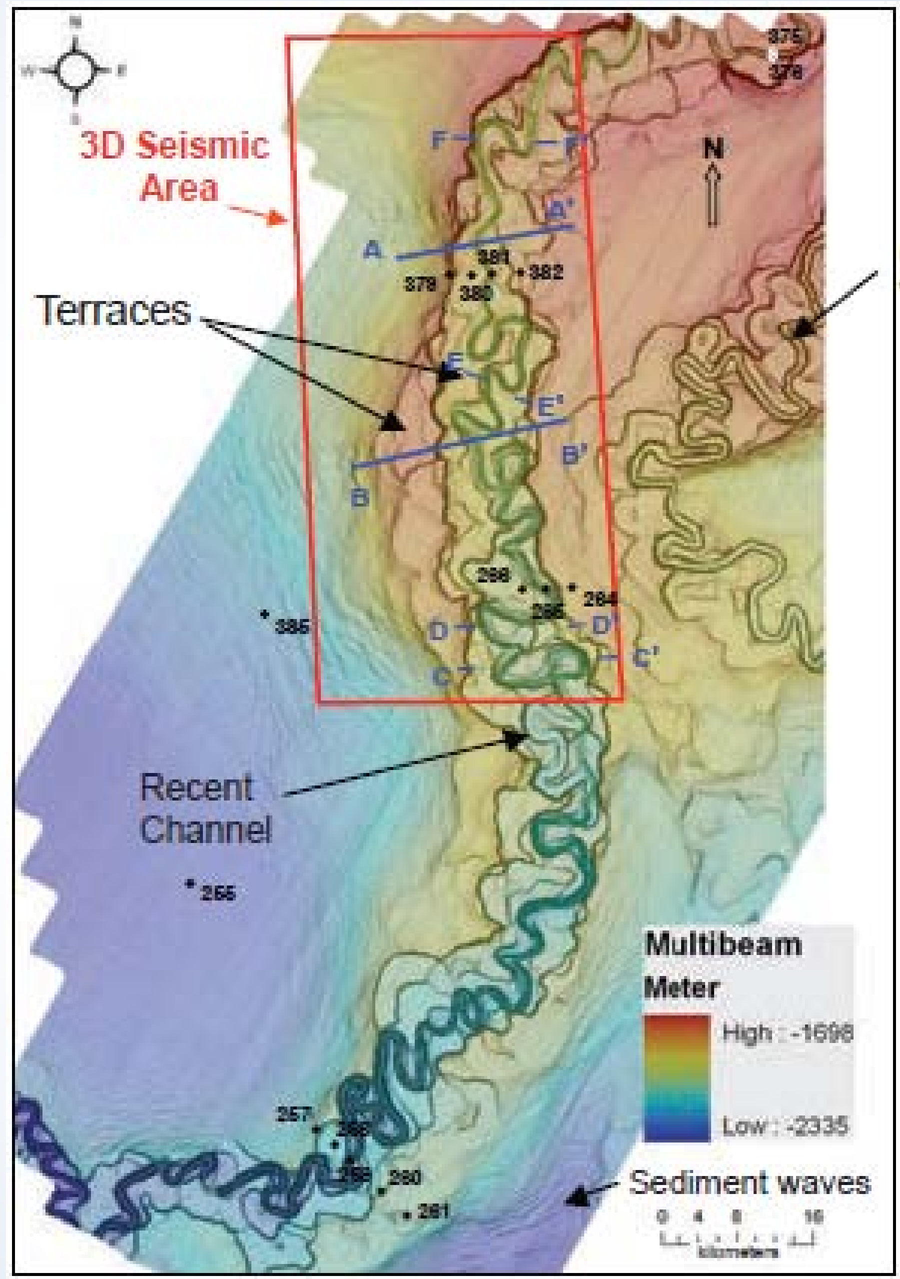


Proximal Bengal Fan, Kolla et al., 2012.

We are also assuming:

The underlying, high density layer, may build its own inner levees around the sinuous channel elements.

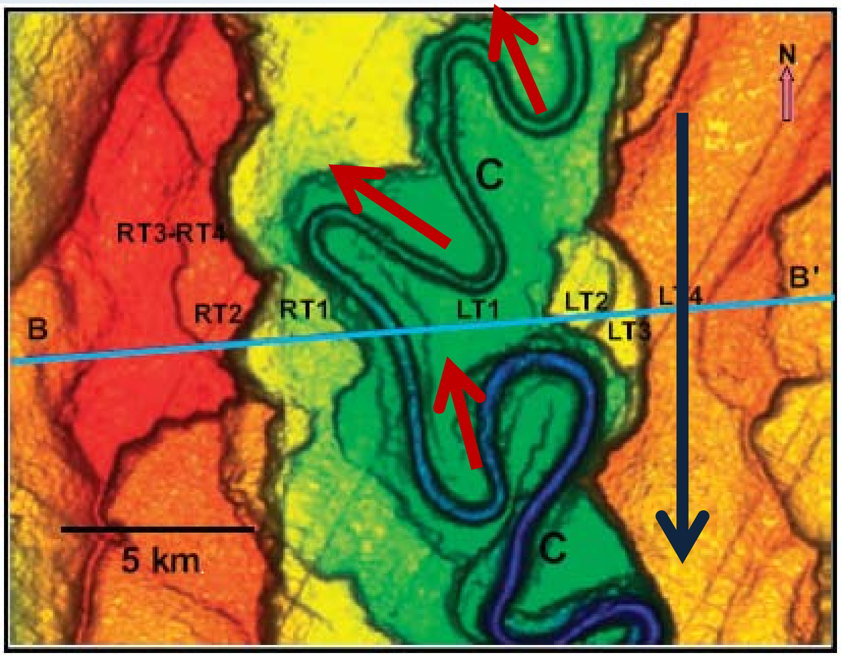


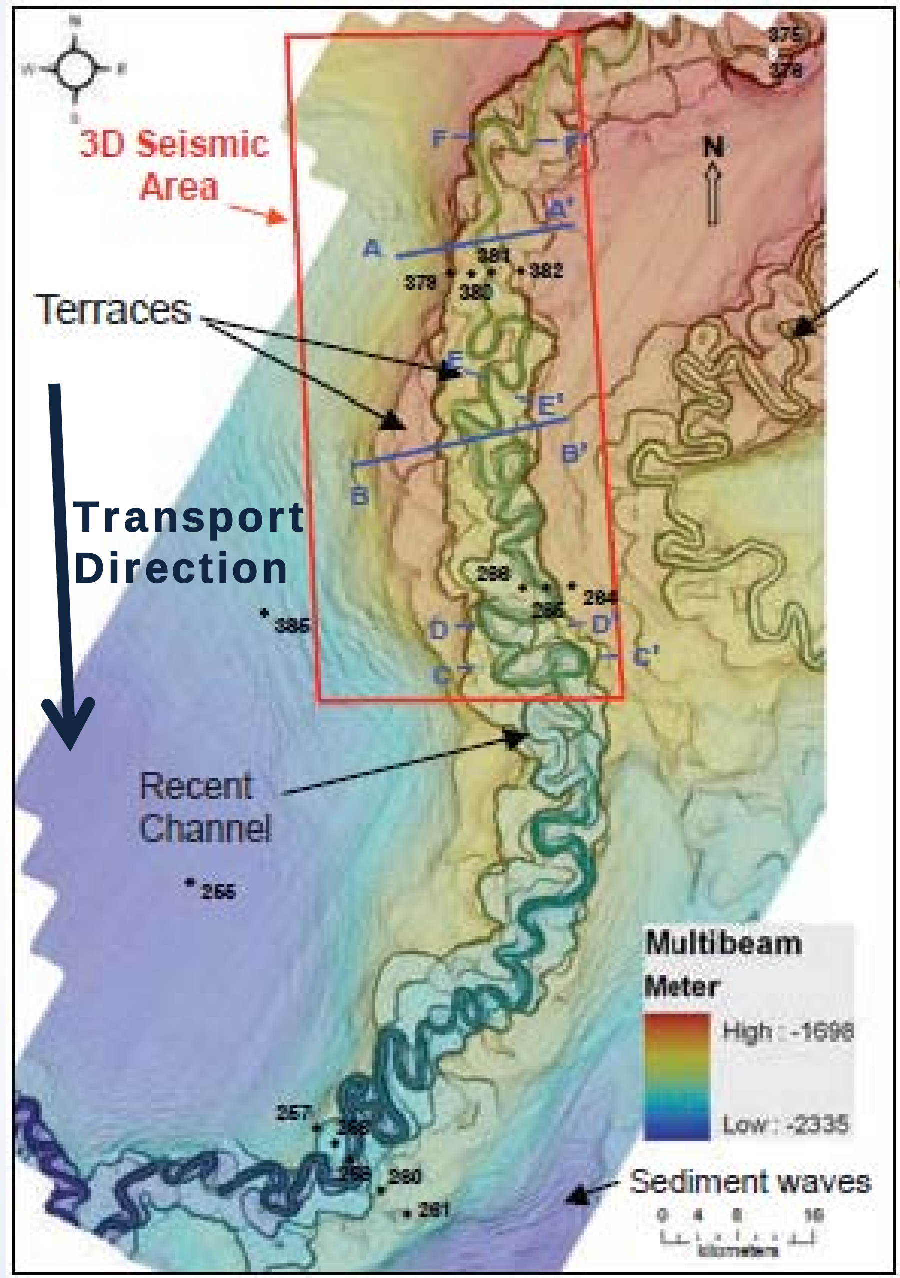


Proximal Bengal Fan,
Kolla et al., 2012.

We are also assuming:

The high density layer can even flow in the opposite direction to the dilute layer for kilometers at a time.





Proximal Bengal Fan, Kolla et al., 2012.

Single Flow Model Requires:

A single flow has two layers that can have

- ✓ different concentrations,
- ✓ markedly different volumes,
- ✓ limited vertical contact
- ✓ separate pathways with different sinuosities
- ✓ separate pathways with different patterns of erosion/deposition
- ✓ separate pathways that may be in opposite directions

Two Flow Model

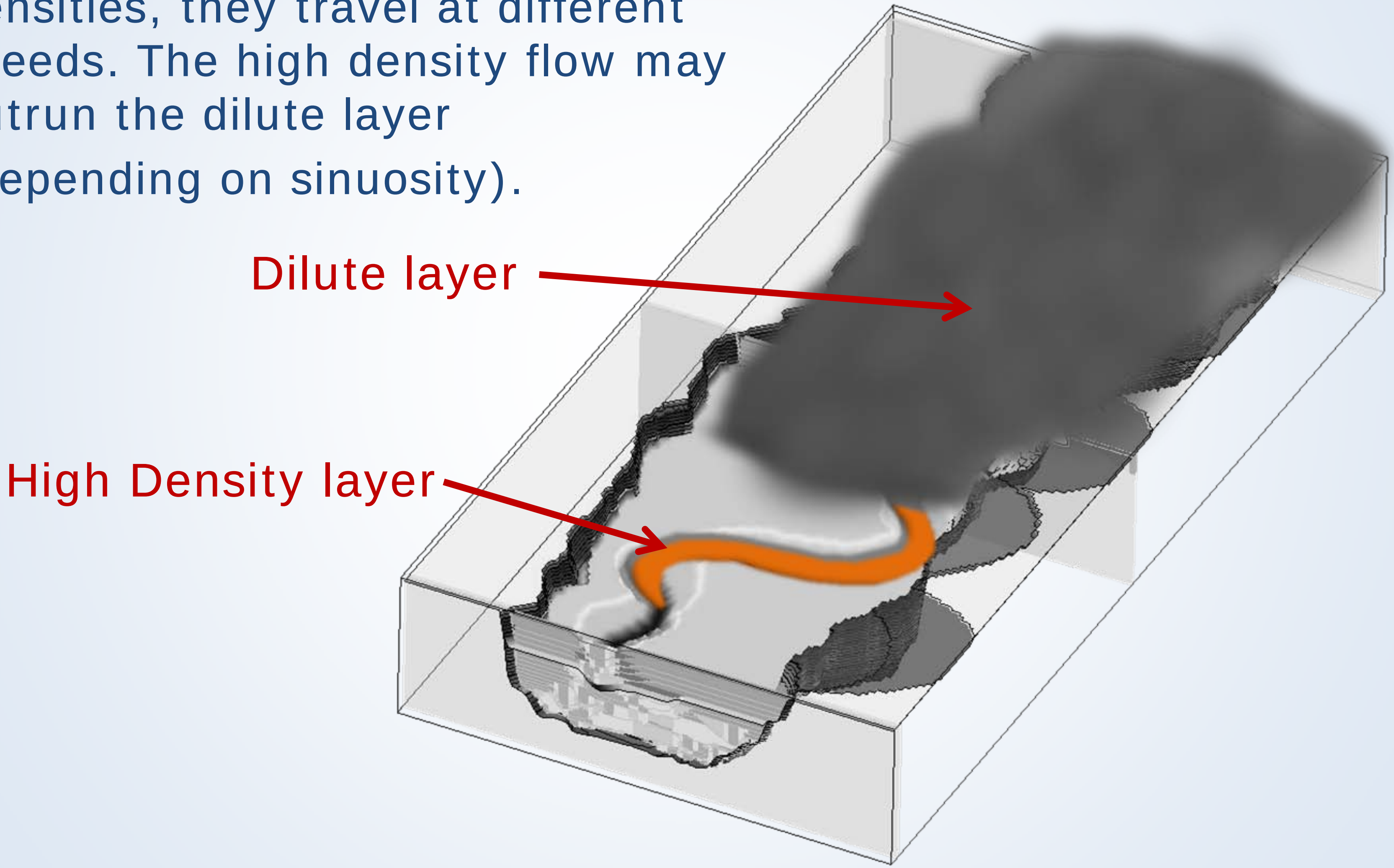
Alternatively, the two layers of the flow may decouple to behave as two separate flows; a low density flow and a high density flow.

It's not surprising if two separate flows have

- ✓ **different concentrations,**
- ✓ **markedly different volumes,**
- ✓ **limited vertical contact**
- ✓ **separate pathways with different sinuosities**
- ✓ **separate pathways with different patterns of erosion / deposition**
- ✓ **separate pathways that may be in opposite directions**

The two flows would have different velocities.

Because the two flows have different densities, they travel at different speeds. The high density flow may outrun the dilute layer (depending on sinuosity).



Hypothesis

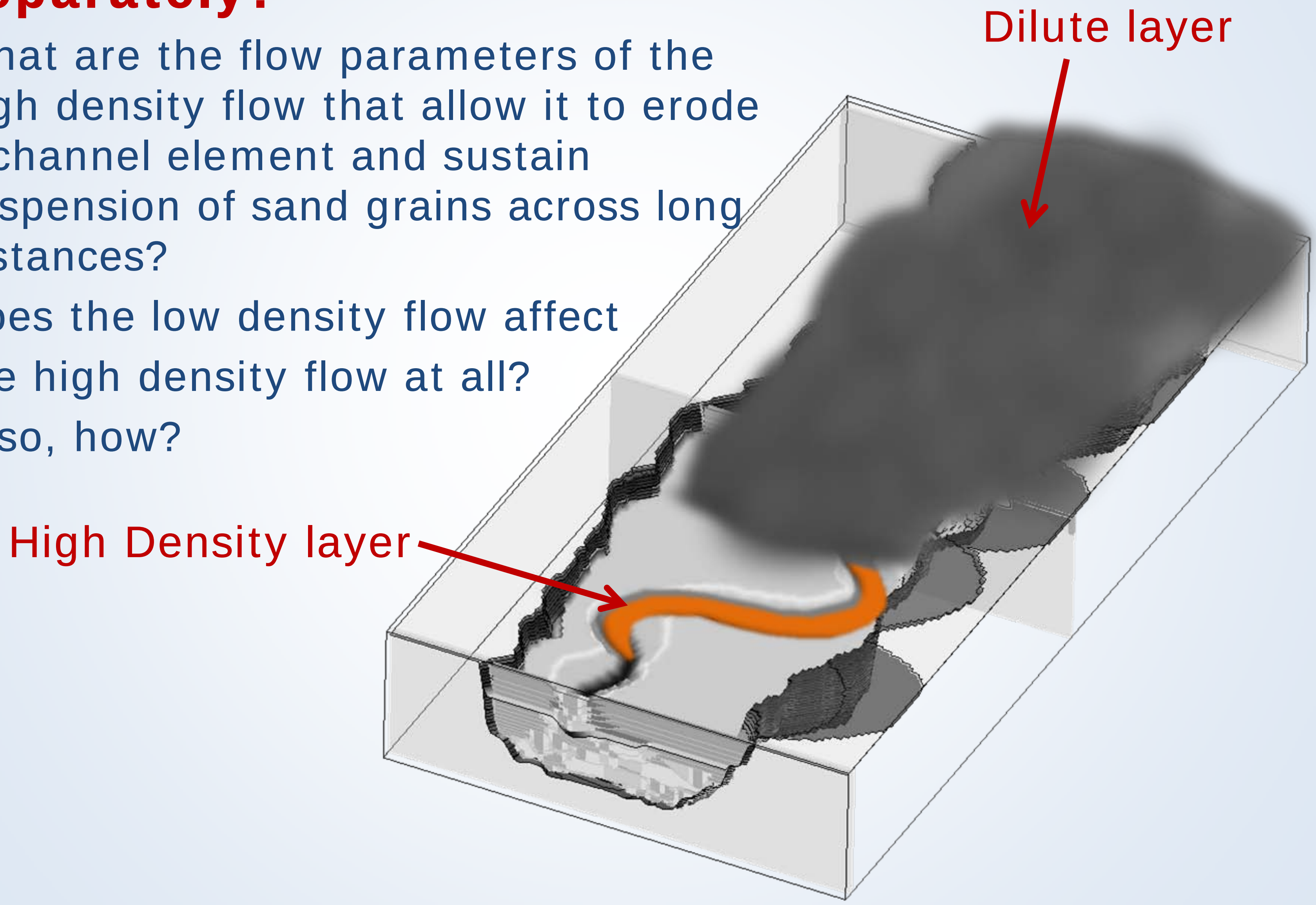
It is reasonable to consider that a large, thick, stratified gravity flow can decouple to become two distinct flows, one high density and one low density. Despite confinement by the same large valley, the two flows separate, travel at different velocities, and cause distinctly different depositional / erosional architectures.

Model the high-density flow separately?

What are the flow parameters of the high density flow that allow it to erode a channel element and sustain suspension of sand grains across long distances?

Does the low density flow affect the high density flow at all?

If so, how?



Thank You!