Facies Assemblages on Distributive Fluvial Systems*

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Abstract

Distributive fluvial systems (DFS) are likely to form a significant component of the continental rock record. Current facies models, however, as based on our understanding of tributary fluvial systems, are inadequate to interpret the downstream behaviour and signature of DFS. Analysis of DFS in aggradational continental sedimentary basins reveals that downstream channel and floodplain changes tend to behave in predictable ways to climate in the catchment and receiving basins. New generic models of facies assemblages derived from observations of remotely sensed imagery are presented. The distribution of sedimentary facies on modern DFS in a range of environmental settings and schematic predictions of downstream geomorphological response to external controlling variables were determined. Six generic models of facies assemblages were constructed based on the distribution and morphology of channels in plan-view on DFS, including; braided bifurcating; single braided; braided to sinuous; single major sinuous; single sinuous bifurcating, and multiple sinuous DFS types. Although there is great variation between and within the DFS planform types, with several exceptions behaving in a non-predictable fashion, our observations suggest that the vast majority conform to one of the generic models of facies assemblages. The facies associations are dependent on climate in the upstream catchment and downstream receiving sedimentary basin with the channel facies and architecture acting as distinguishing criteria for each major DFS planform type. DFS tend to terminate in a range of settings, such as eolian, playa, lacustrine, axial fluvial system, wetlands or marine environments. The termination types and floodplain facies, as represented in the facies assemblage models, are interchangeable depending on local conditions. Effectively, the new models suggest a novel way in which to view and interpret fluvial systems preserved in the rock record.

References

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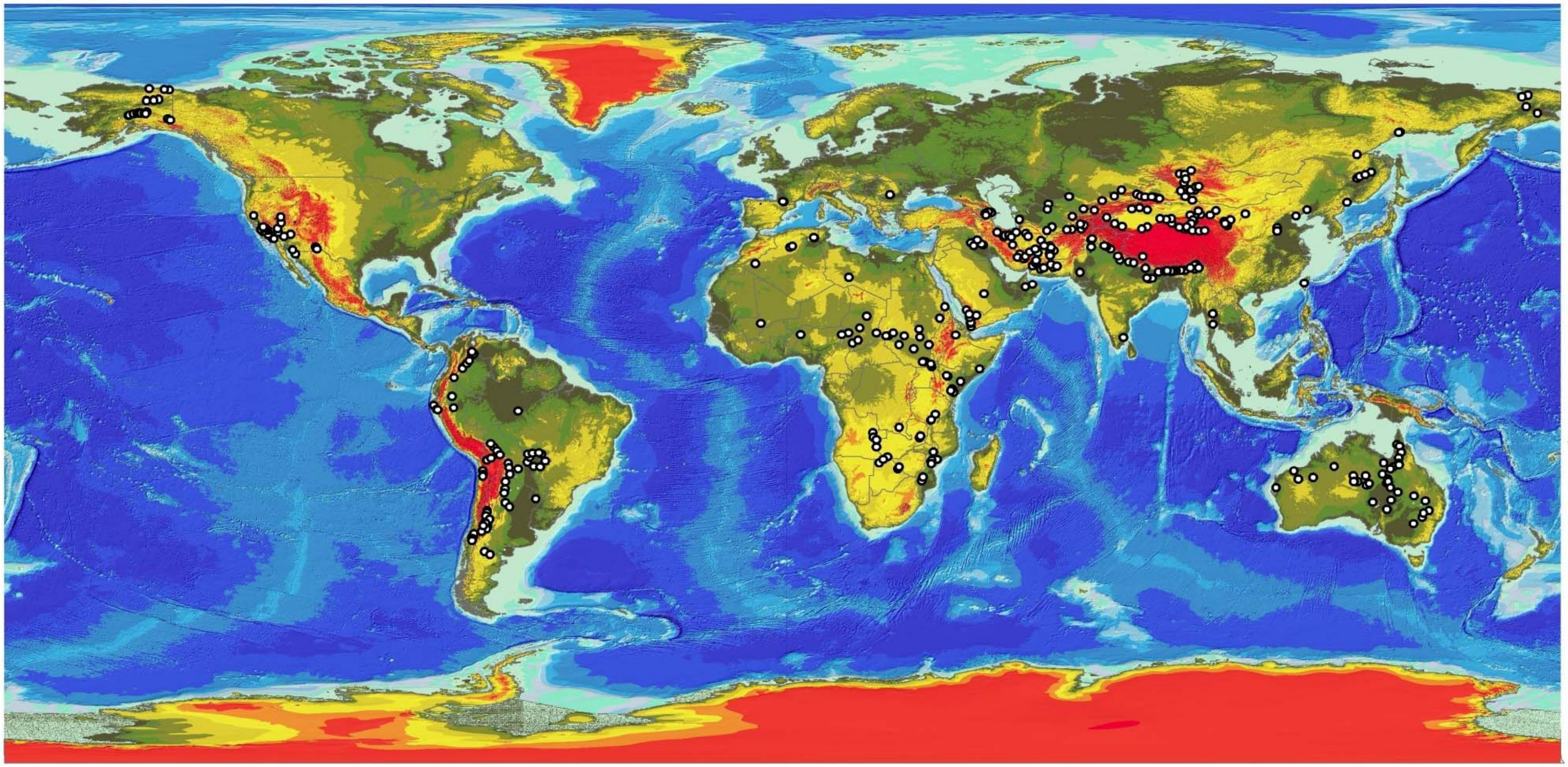
Objectives:

- Why are Distributive Fluvial Systems (DFS) important?
- What are the existing facies models for DFS?
  - Future directions
- Geomorphic elements or facies assemblages on DFS from modern observations
  - Facies model advances

Presenter's notes: In behaviour and resulting patterns of sedimentation, can we distinguish DFS from other fluvial systems?

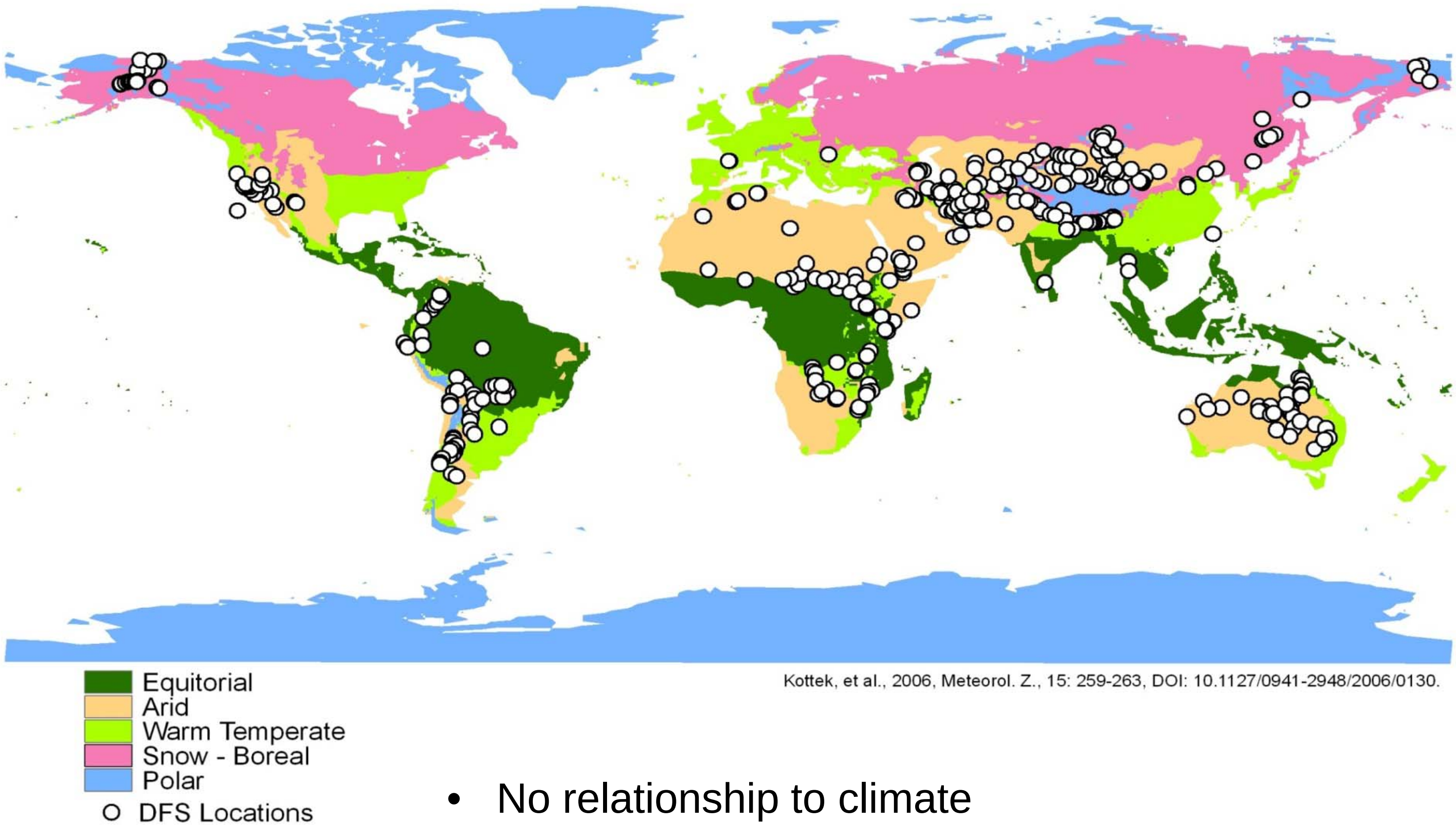
Distributive Fluvial System (DFS) database



- 400 large distributive systems greater than 30km in length
    - 1000s smaller systems, including alluvial fans

(After Hartley et al. 2010)

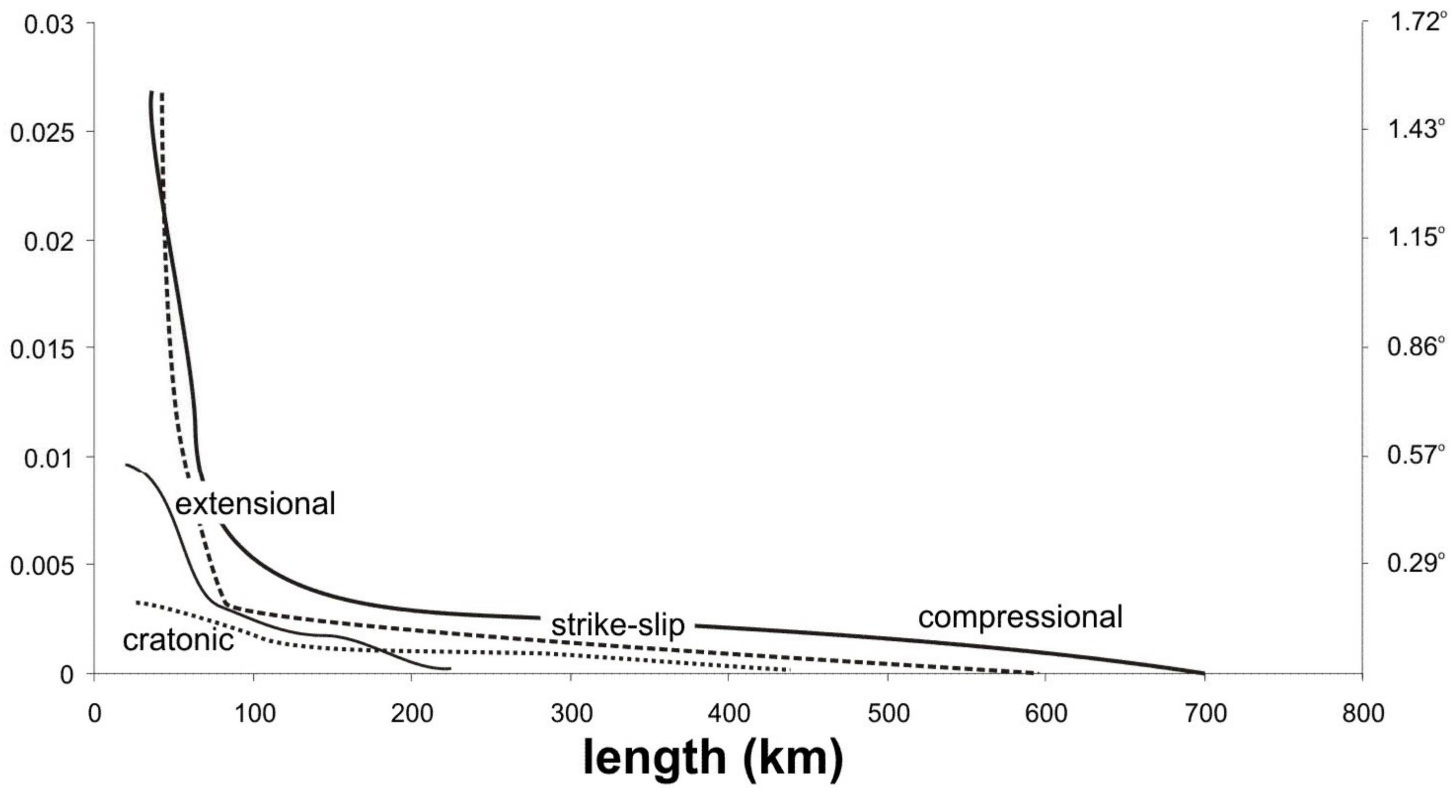
Climate classification (Köppen-Geiger) and DFS location



- No relationship to climate

(After Hartley et al. 2010)

DFS and tectonic setting

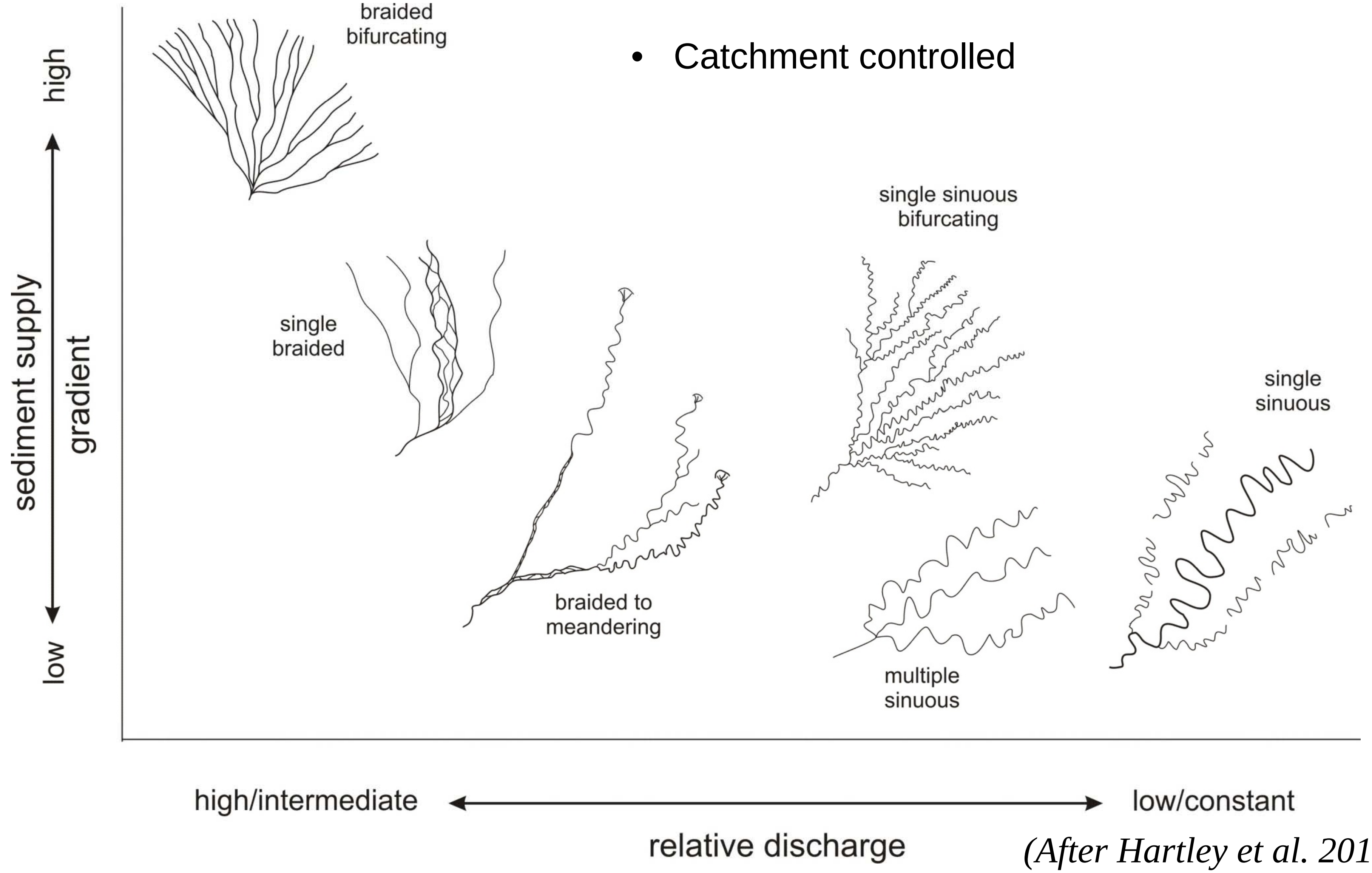


- Large range in length in all tectonic settings
- Length controlled by horizontal accommodation space
- Marked decrease in gradient after first 100km
- Cratonic only setting with consistently low gradients

(After Hartley et al. 2010)

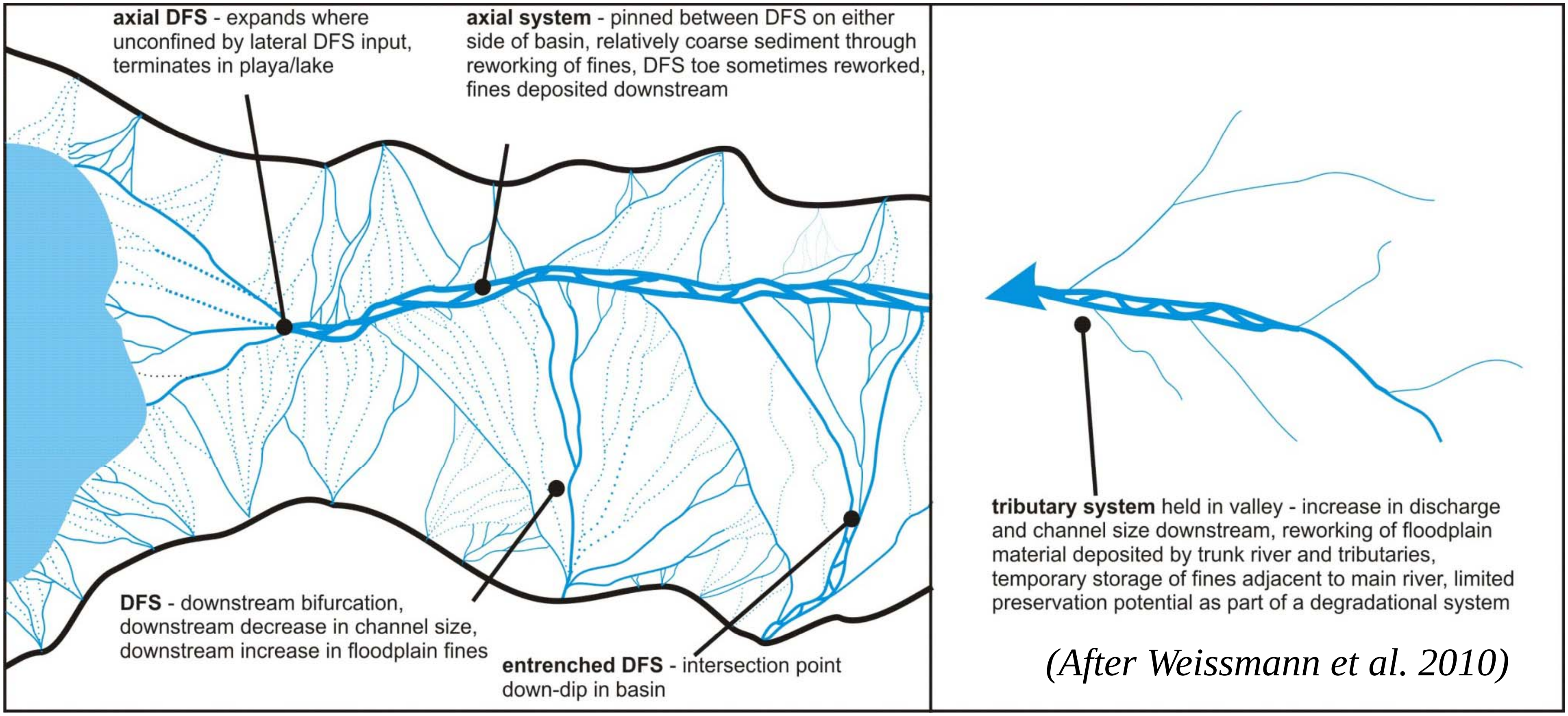
Relationship between planform types and controlling parameters

- Catchment controlled



(After Hartley et al. 2010)

Distributive Fluvial Systems



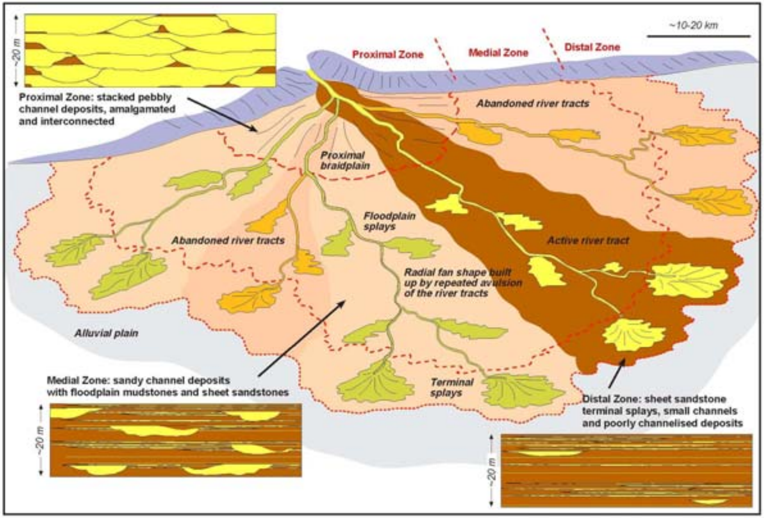
- Provides context for understanding lateral and down-dip facies in continental sedimentary basins
- A way forward from identifying stream types as braided or meandering

Important observations from aggradational fluvial systems

- Wide range of fluvial styles and facies relationships largely controlled by:
  - Discharge and sediment supply (catchment)
  - Tectonic regime (controls available horizontal and vertical accommodation space)

- Importantly there is no relationship between:
  - Climate and planform

Existing facies models:

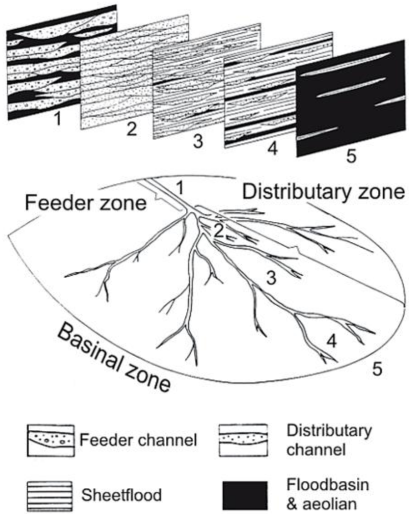


The development of a fan-shaped body of sediments by repeated avulsion (Nichols and Fisher, 2007)

- Semi-arid
- Terminal
- Rock record

Presenter's notes: Model derived for an arid, low accommodation system and from the rock record.

Existing facies models:



- Arid to semi-arid
- Terminal
- Rock record

Terminal fan facies model (Kelly and Olsen, 1993)

Presenter's notes: Another model derived from the rock record and not linked to modern observations or process geomorphology.

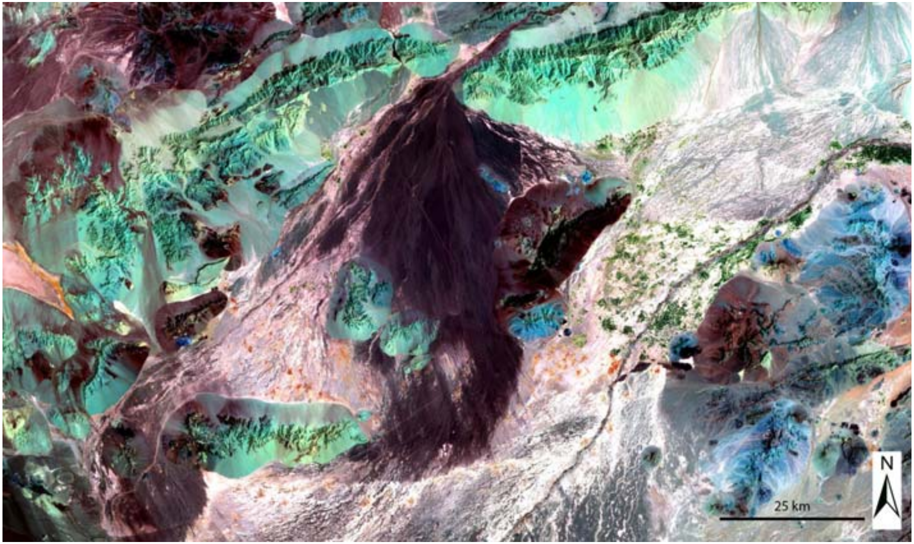
Facies models: Future directions

- Predictability
- Variability
- Full range of geomorphic elements
- Full range of facies and subsurface architecture

Presenter's notes: How can we improve on these types of models? By better linking modern and ancient.

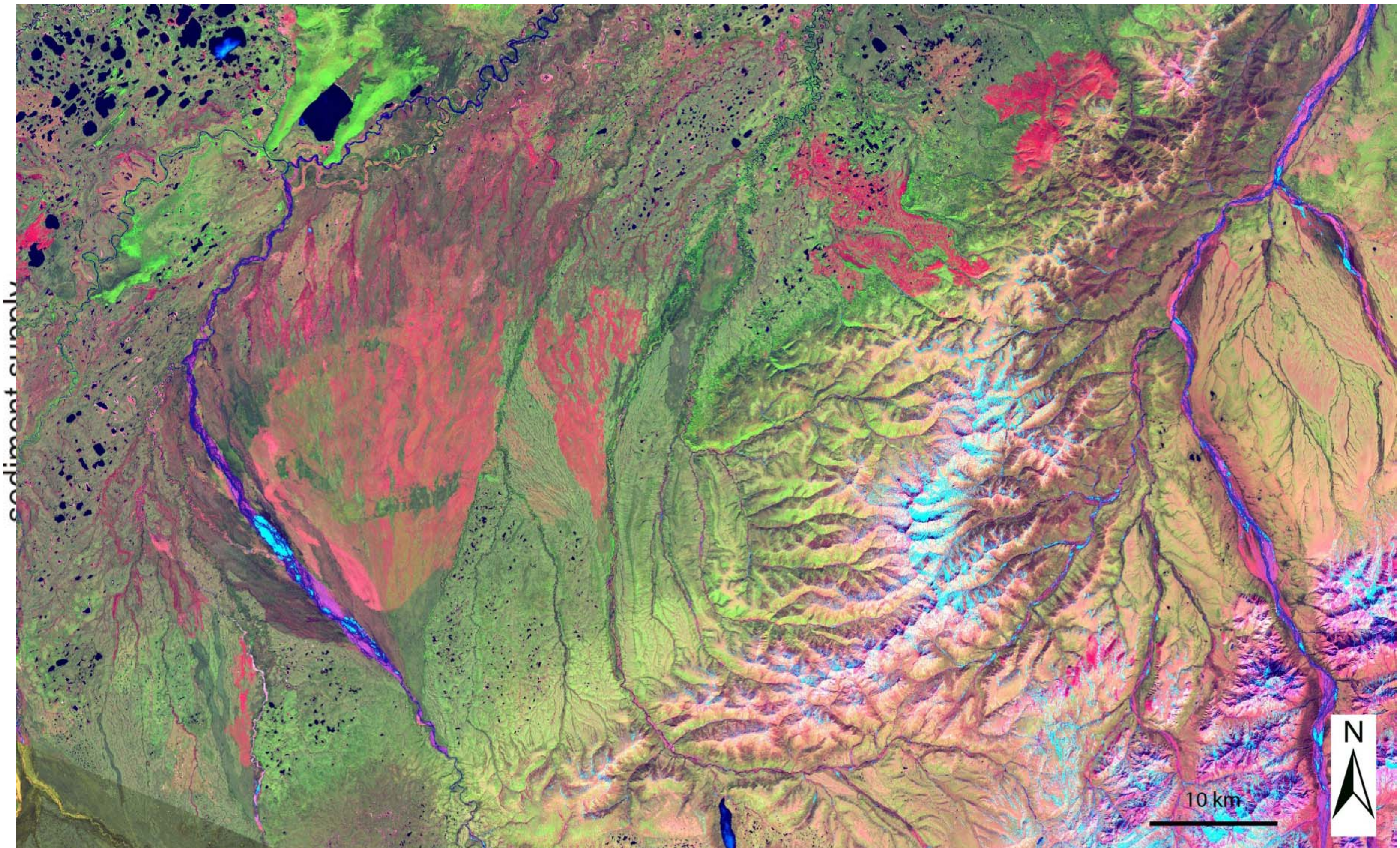
DFS planform types *(after Hartley et al. 2010)*

1. Braided bifurcating DFS: Harut River, Afghanistan



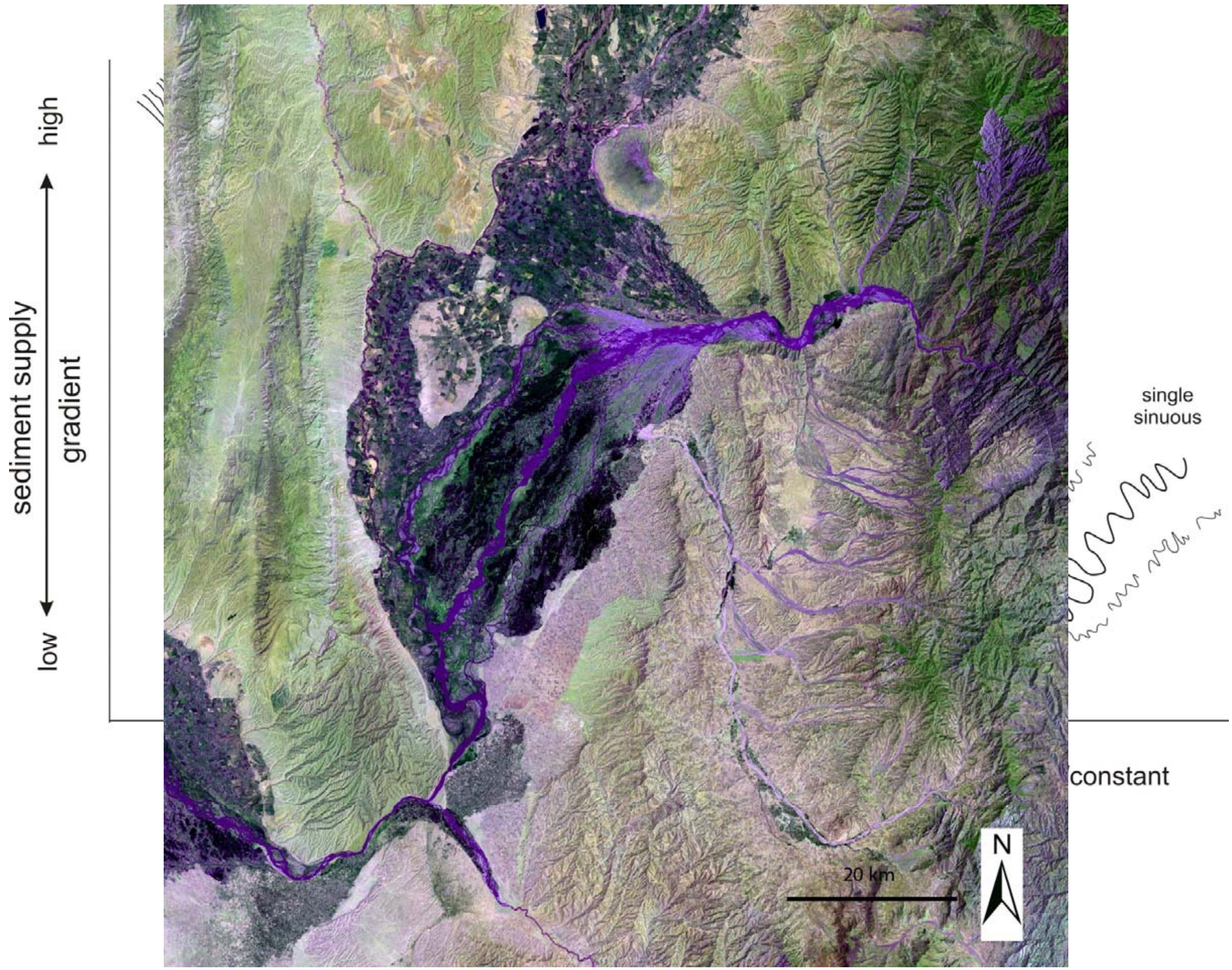
Presenter's notes: Advent of more widely available remotely sensed imagery, like Google Earth, has enabled us to capture the full scale and range of distributive fluvial systems.

2. Single braided DFS: Kongakut River, Alaska

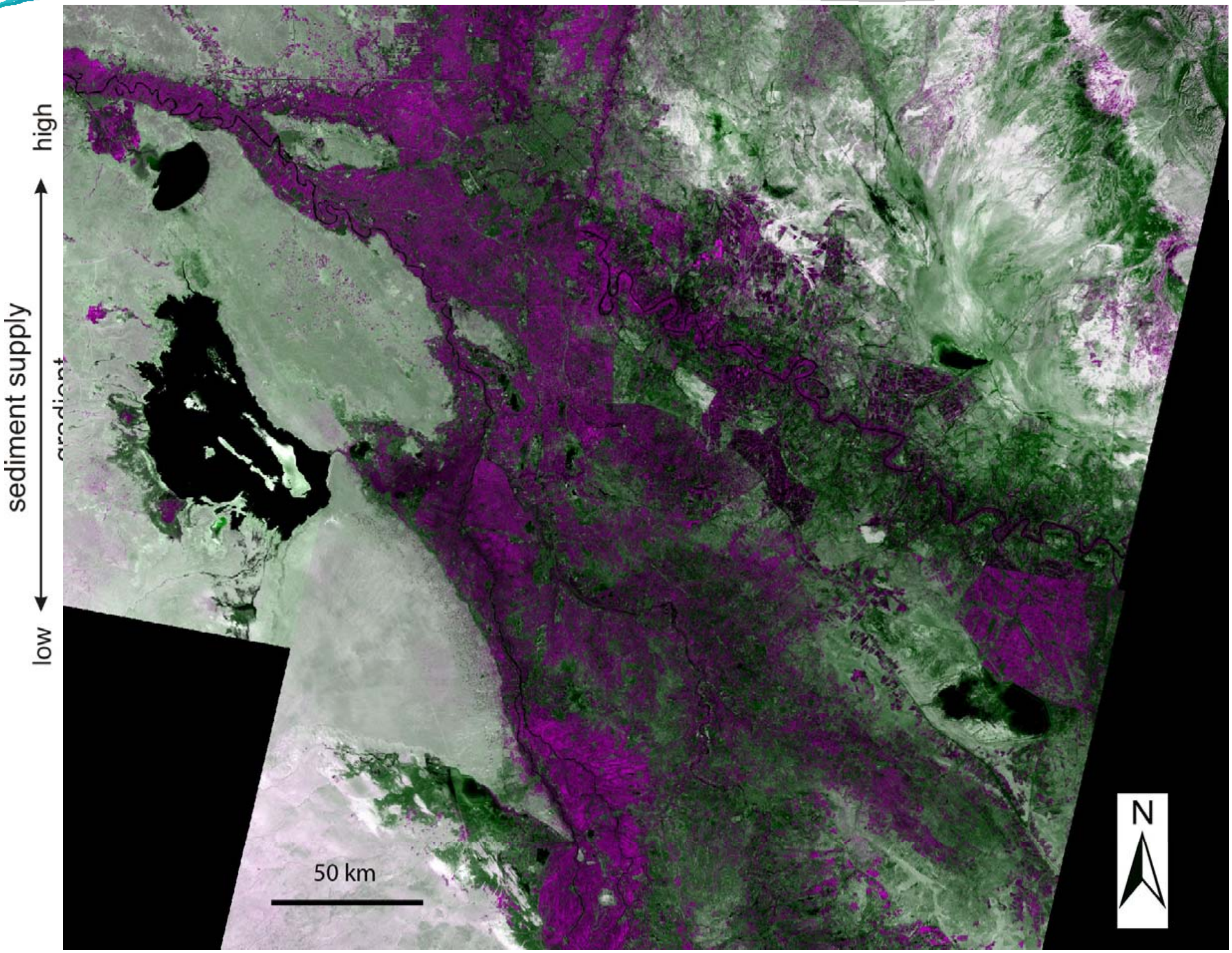


relative discharge

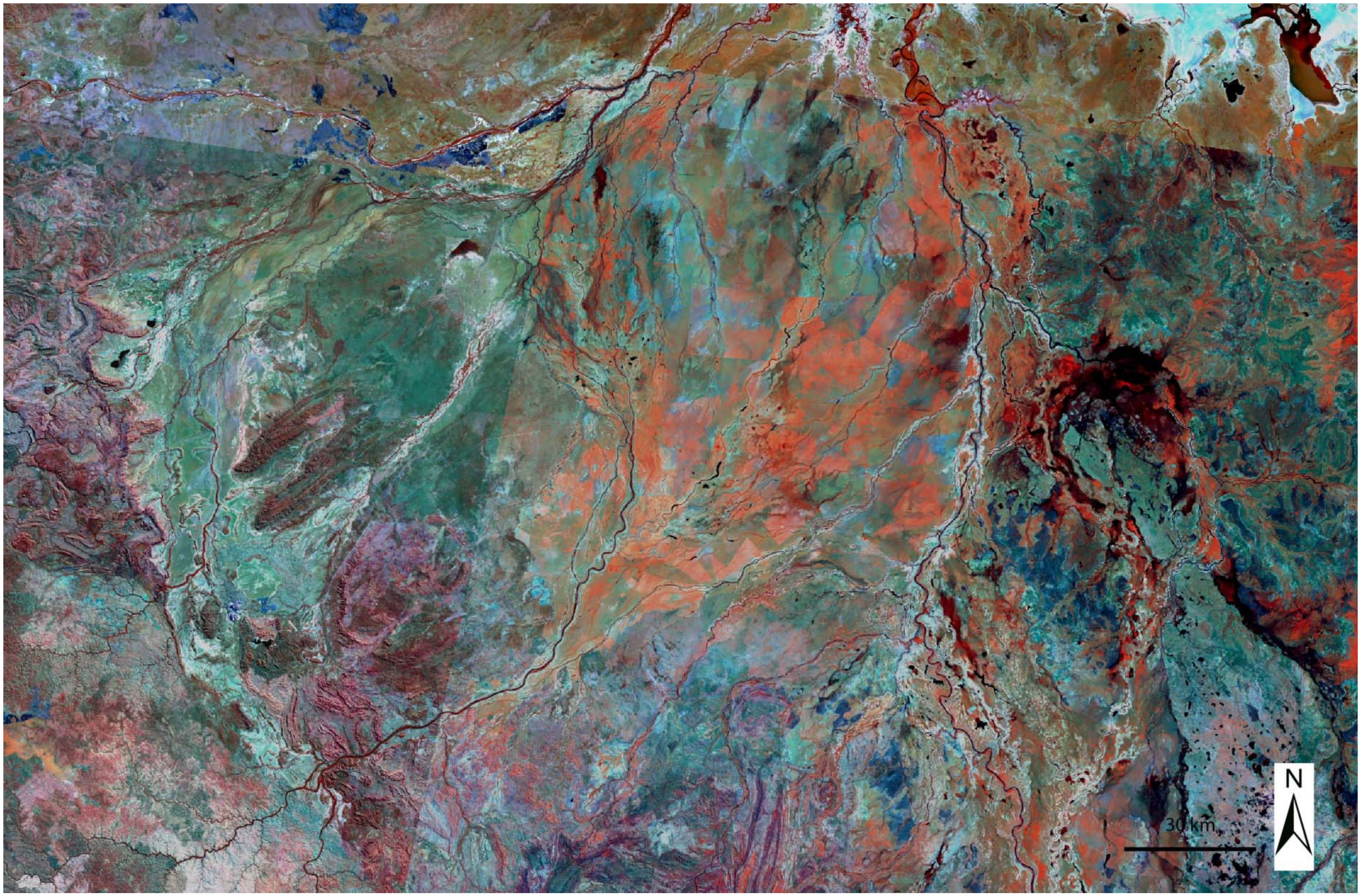
3. Braided to meandering DFS: Helmand River, Afghanistan



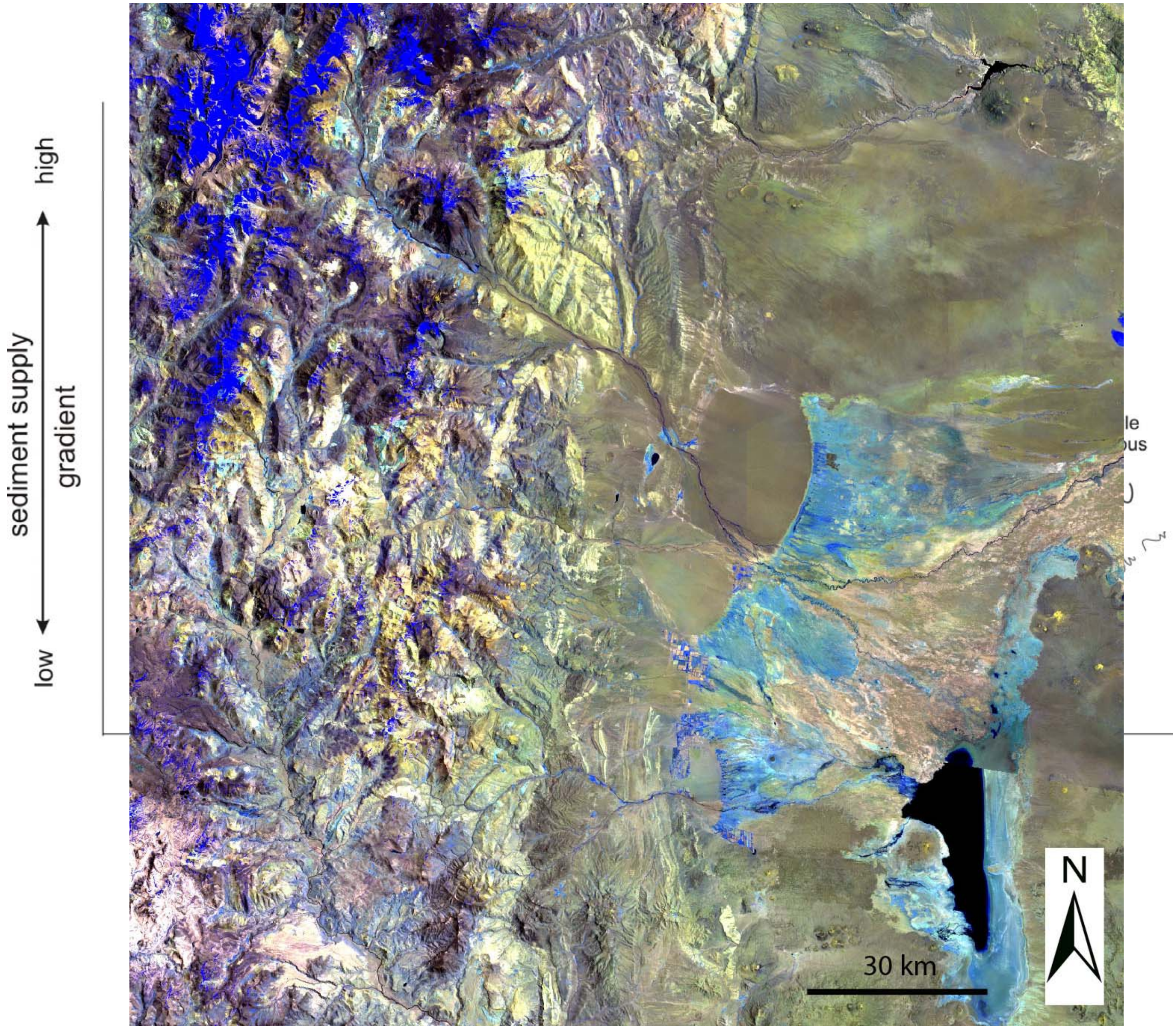
4. Single sinuous DFS: Euphrates River, Iraq



5. Single bifurcating sinuous DFS: Gregory River, Australia



6. Multiple sinuous DFS: Atuel River, Argentina



Geomorphic elements (or facies assemblages):

- River types:
  - Mountain-fed
  - Foothills-fed
  - Plains-fed
  - High sinuosity or low sinuosity
  - Multi-thread or single-thread
- Floodplain features:
  - Oxbows, scroll bars
  - Abandoned channels
  - Bars or islands
  - Aeolian dunes
  - Ponds, lakes or playas
  - Terraces
  - Soils
- Terminations:
  - Aeolian
  - Lacustrine
  - Axial fluvial system
  - Playa
  - Wetlands
  - Marine

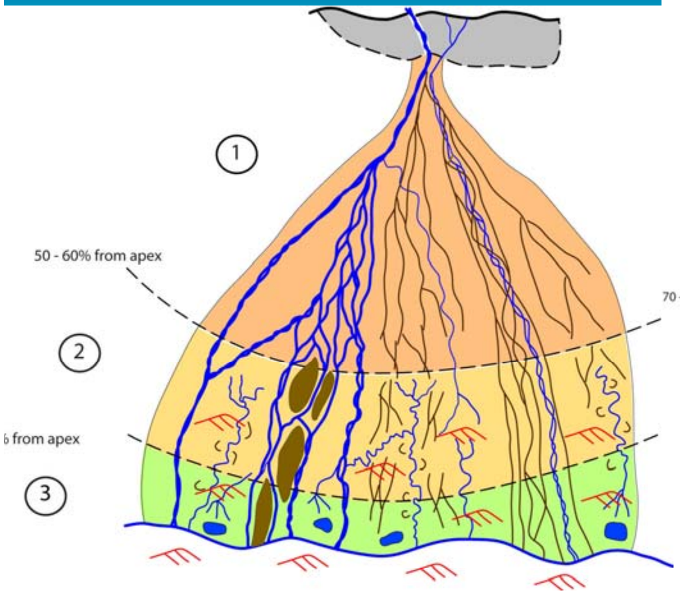
Presenter's notes: Modern observations show more complex assemblages of geomorphic elements than previously described in existing facies models. These are a response to catchment-controlled changes in discharge and sediment supply, and the influence of autogenic processes on downstream variability--variable rainfall and runoff in the upstream catchment, evapotranspiration, infiltration, diversion of flow away from the main channel, and decreased floodplain gradient.

More important observations from aggradational fluvial systems

- General recognizable changes in DFS downstream:
  - A decrease in bed material transport and calibre of sediment
  - Increasing proportion of floodplain area relative to channel area
  - An increase in avulsive behaviour and anabranching
  - Highly variable sinuosity
  - (An overall decrease in channel width and depth)

- Differing from downstream changes in tributive systems

Presenter's notes: The increase in avulsion tendency is important because it reflects threshold changes in the fluvial system's ability to transport water and sediment efficiently. The location and type of avulsion are variable with nodal avulsion prevalent in the apex and proximal areas becoming increasing dominated by channel reoccupation and crevasse splay progradation avulsion in the medial and distal regions. The dominance of each type of avulsion depends on climate, sediment supply, and aggradational setting. The overall planform of the DFS becomes more anabranching with any one of the branches displaying differing planform at any one time. In other words branches may be straight, meandering, or braided.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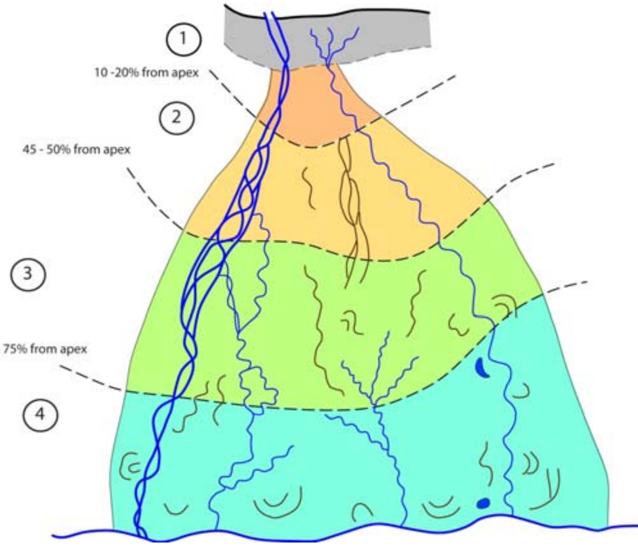
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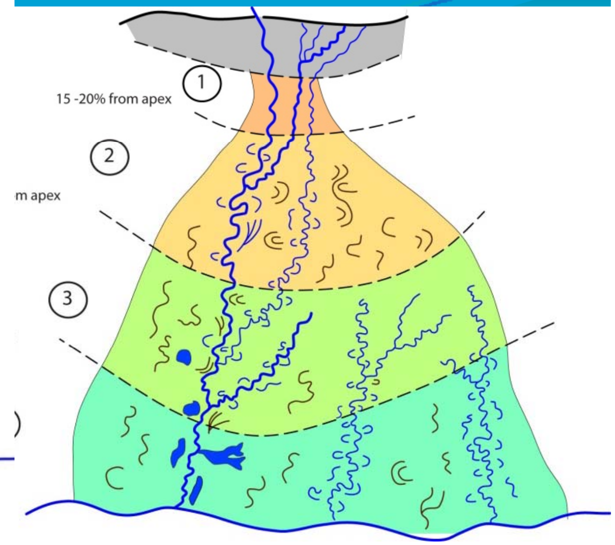
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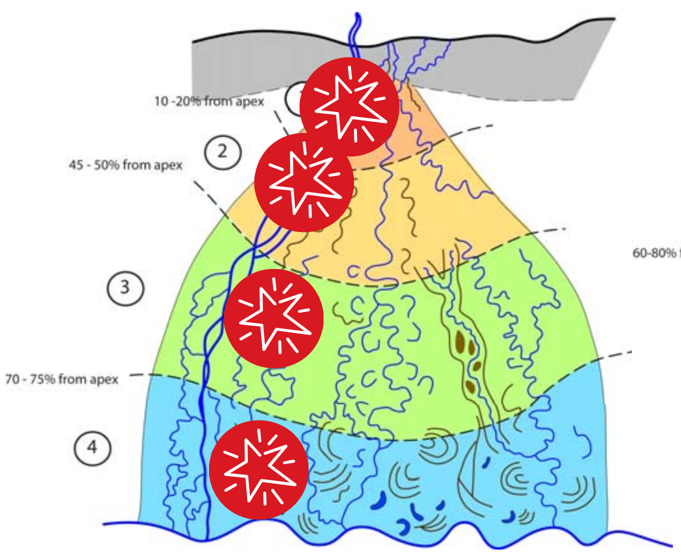
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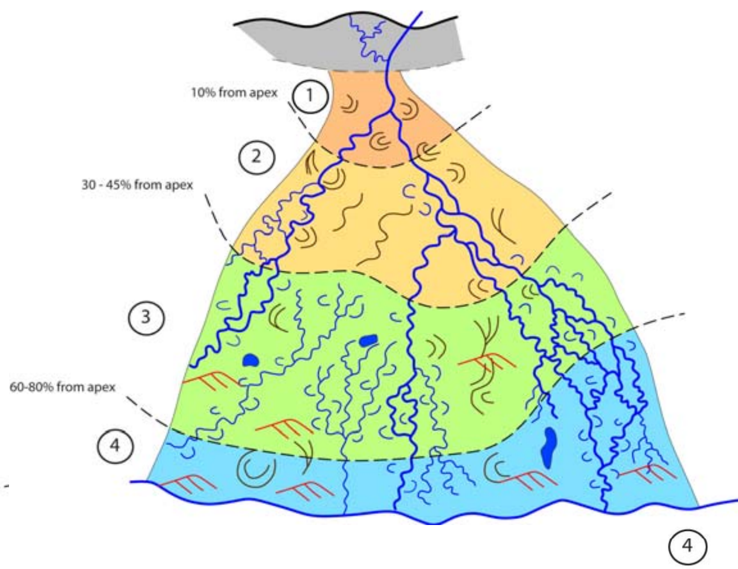
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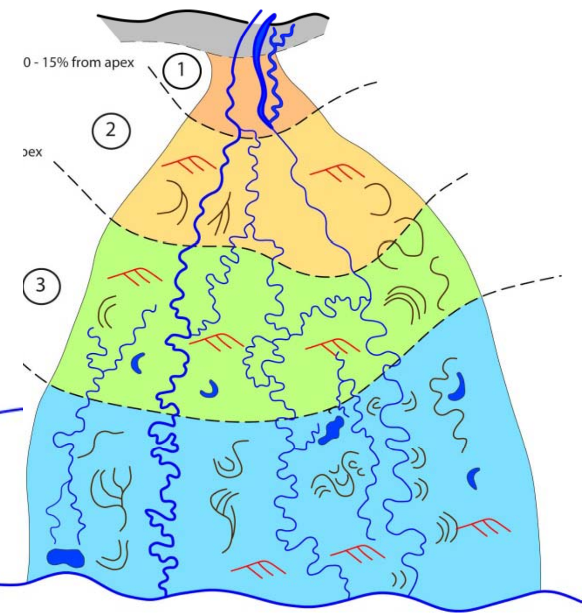
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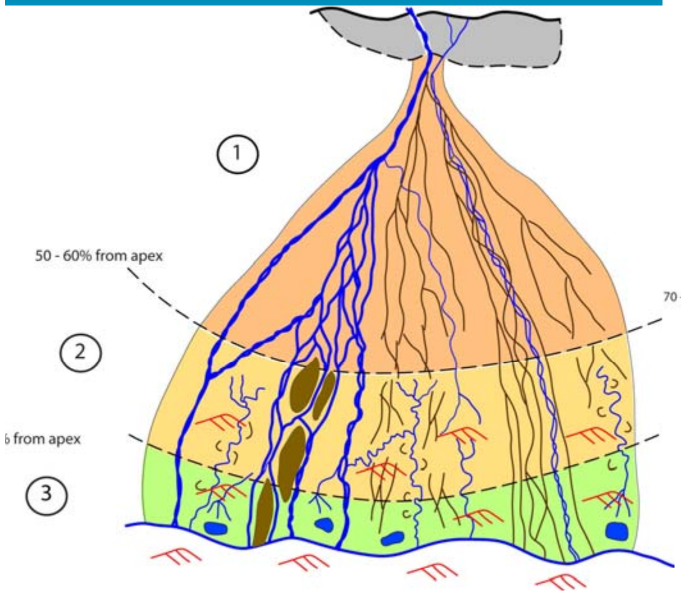
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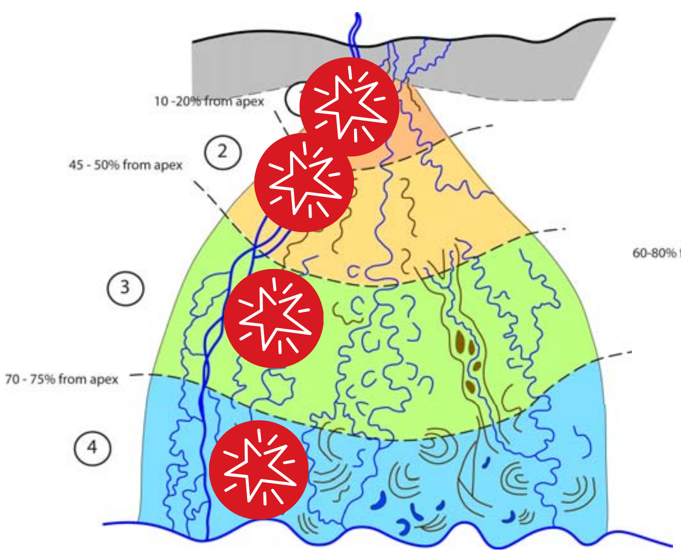
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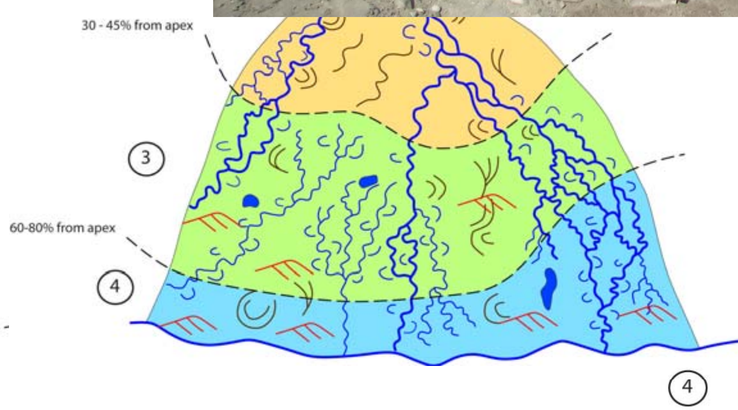
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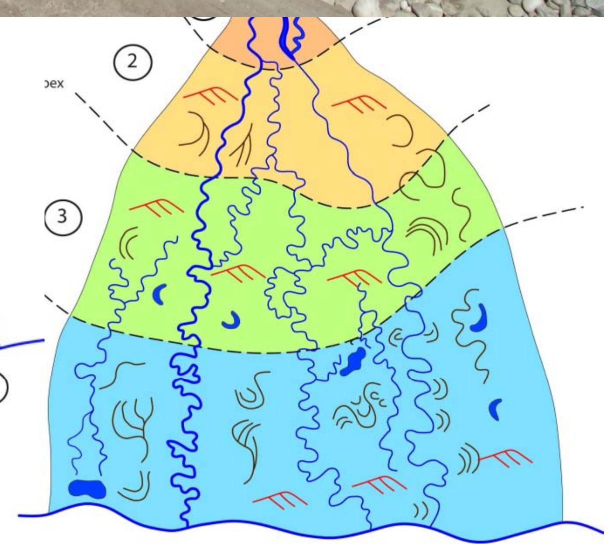
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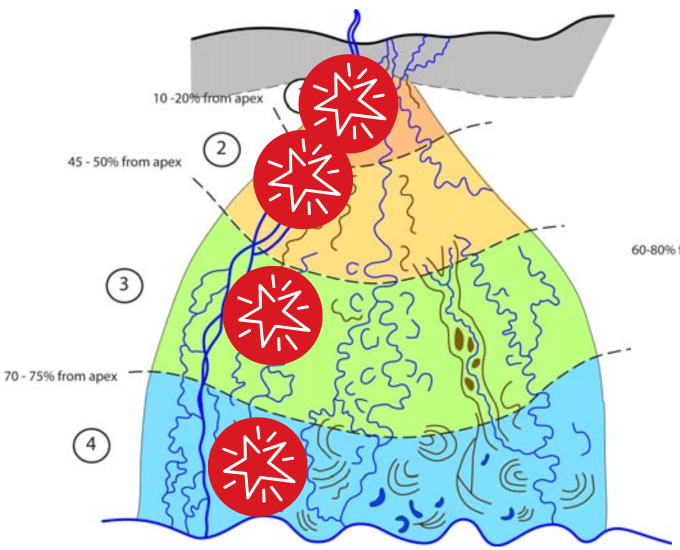
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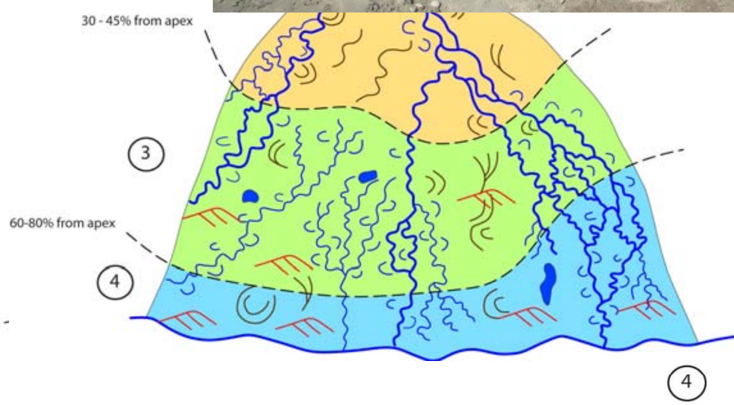
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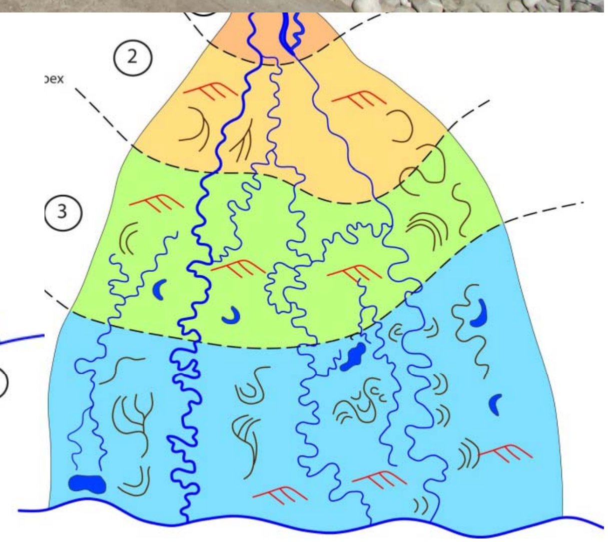
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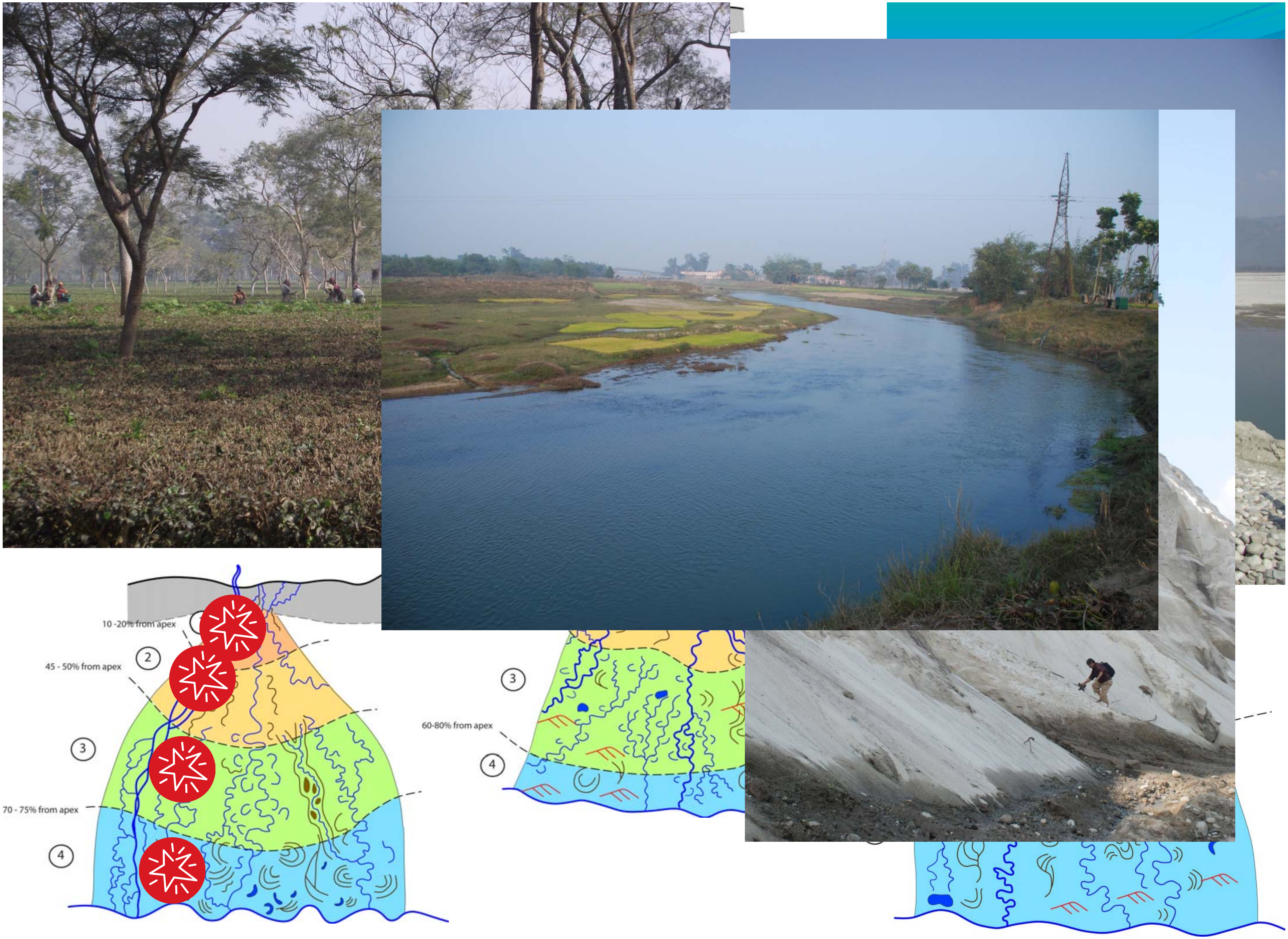
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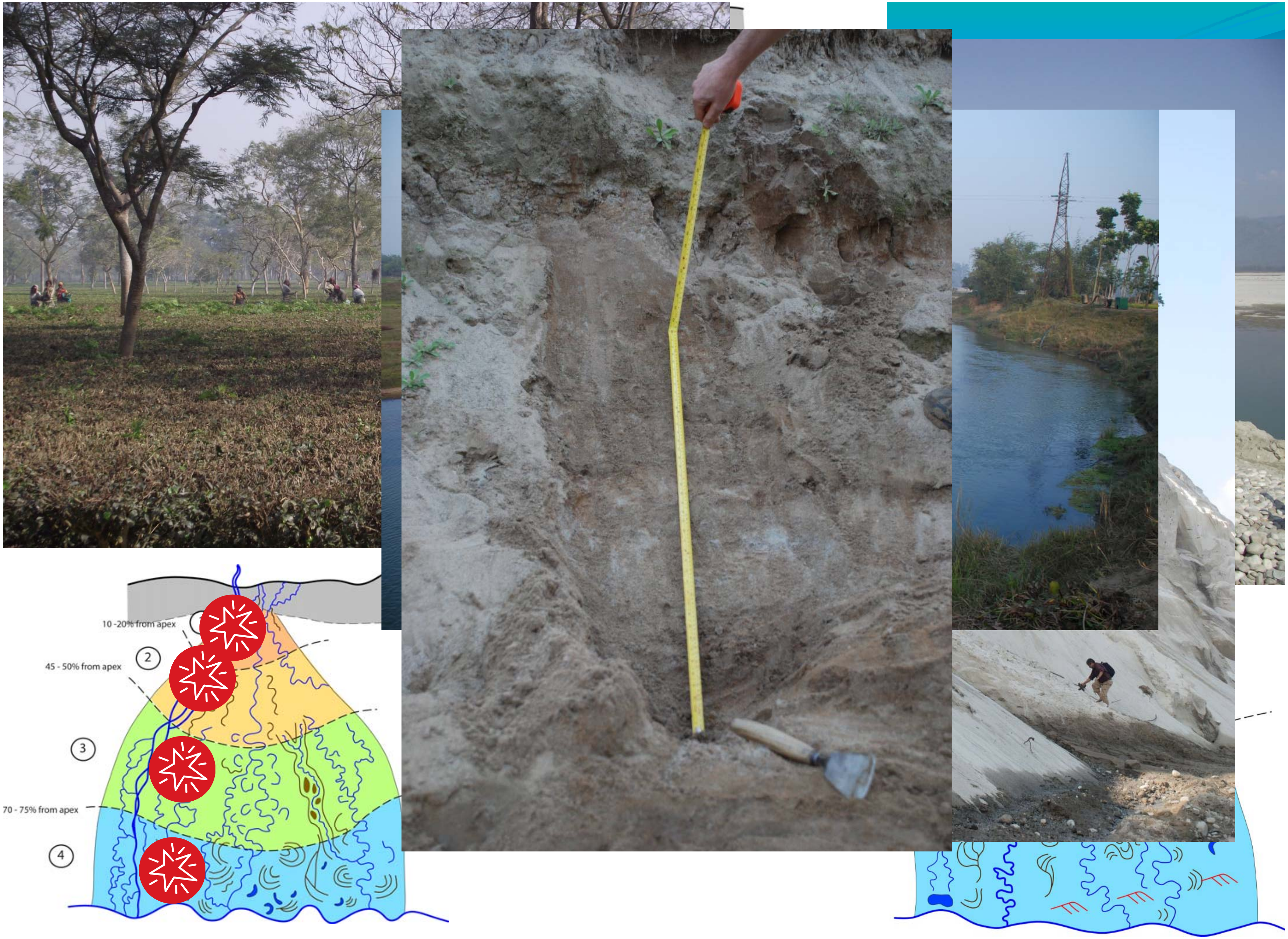
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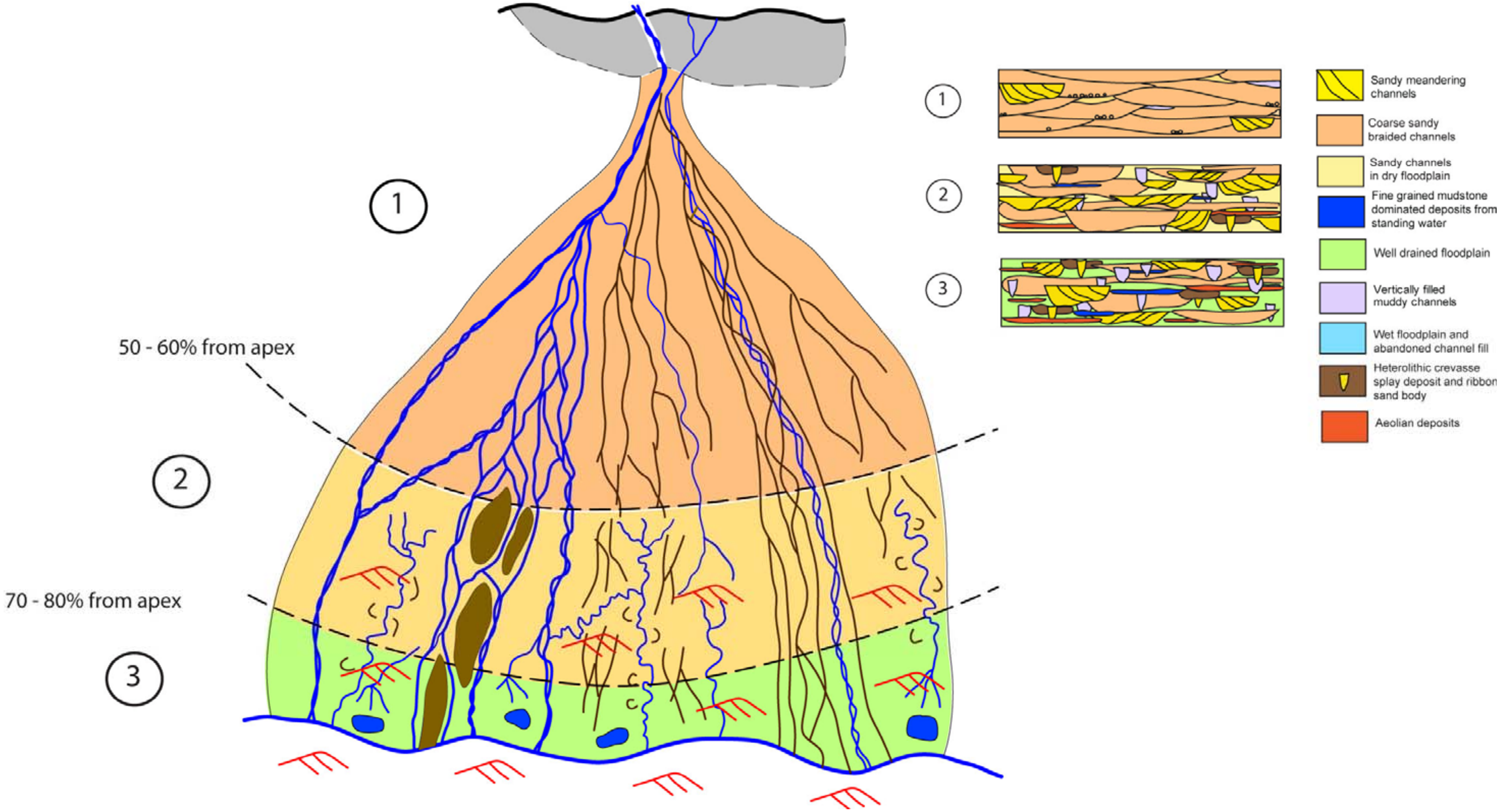
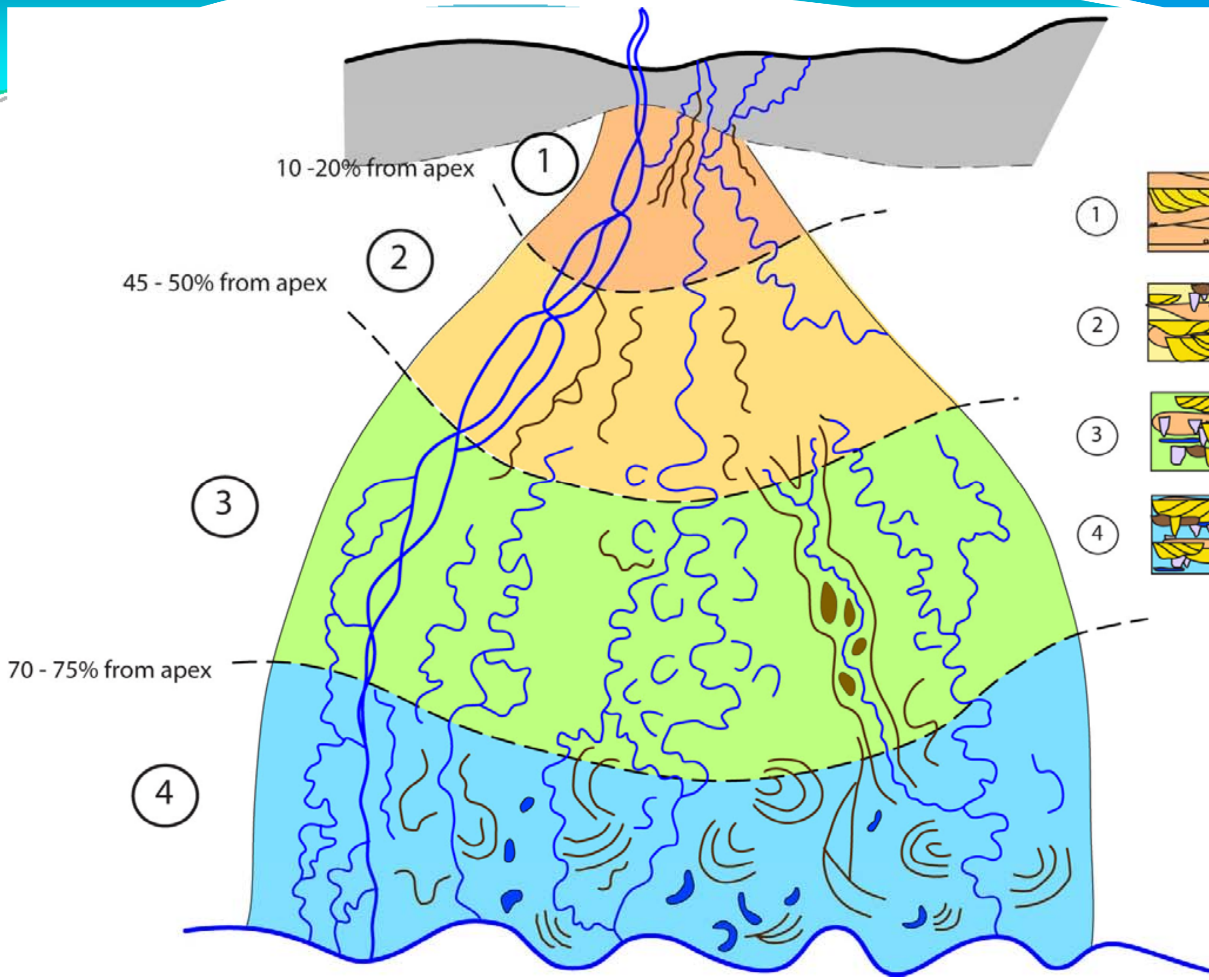
Presenter's notes: The observations of modern DFS geomorphology gives rise to a range of generic models describing the geomorphic elements or facies assemblages. The modern Tista River in India illustrates the types of geomorphic elements and sedimentary characteristics from apex to distal regions of a modern multithread anabranching DFS.

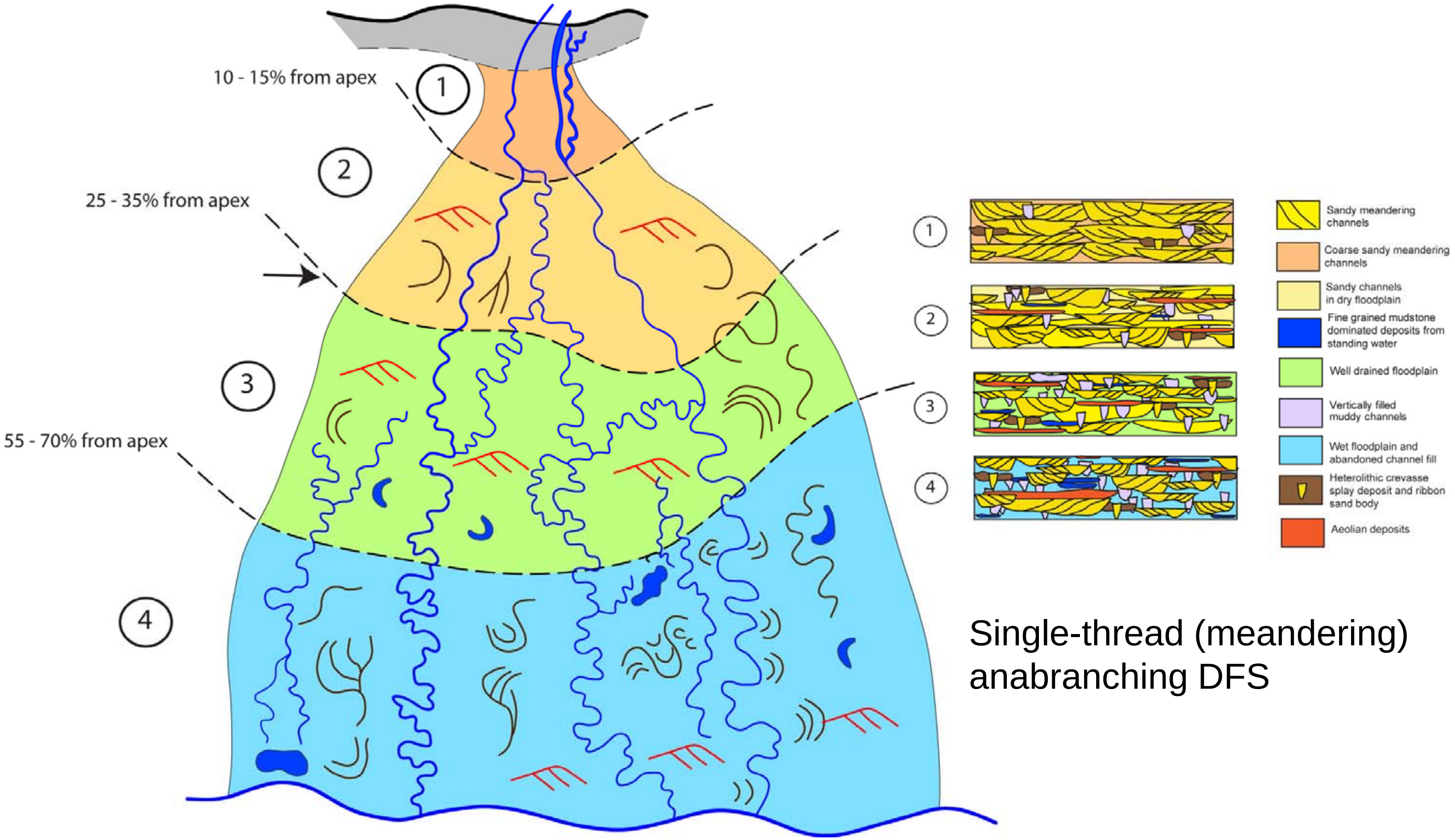
Generic DFS facies models:



Braided bifurcating DFS



Multi-thread (braided) anabranching DFS



Single-thread (meandering) anabranching DFS

- Schematic representation of the range of geomorphic elements observed on modern DFS.
- Preserved facies an amalgamation of geomorphic elements.
- Fluvial sand body architecture predominantly sheet-like.

Facies models: Advances

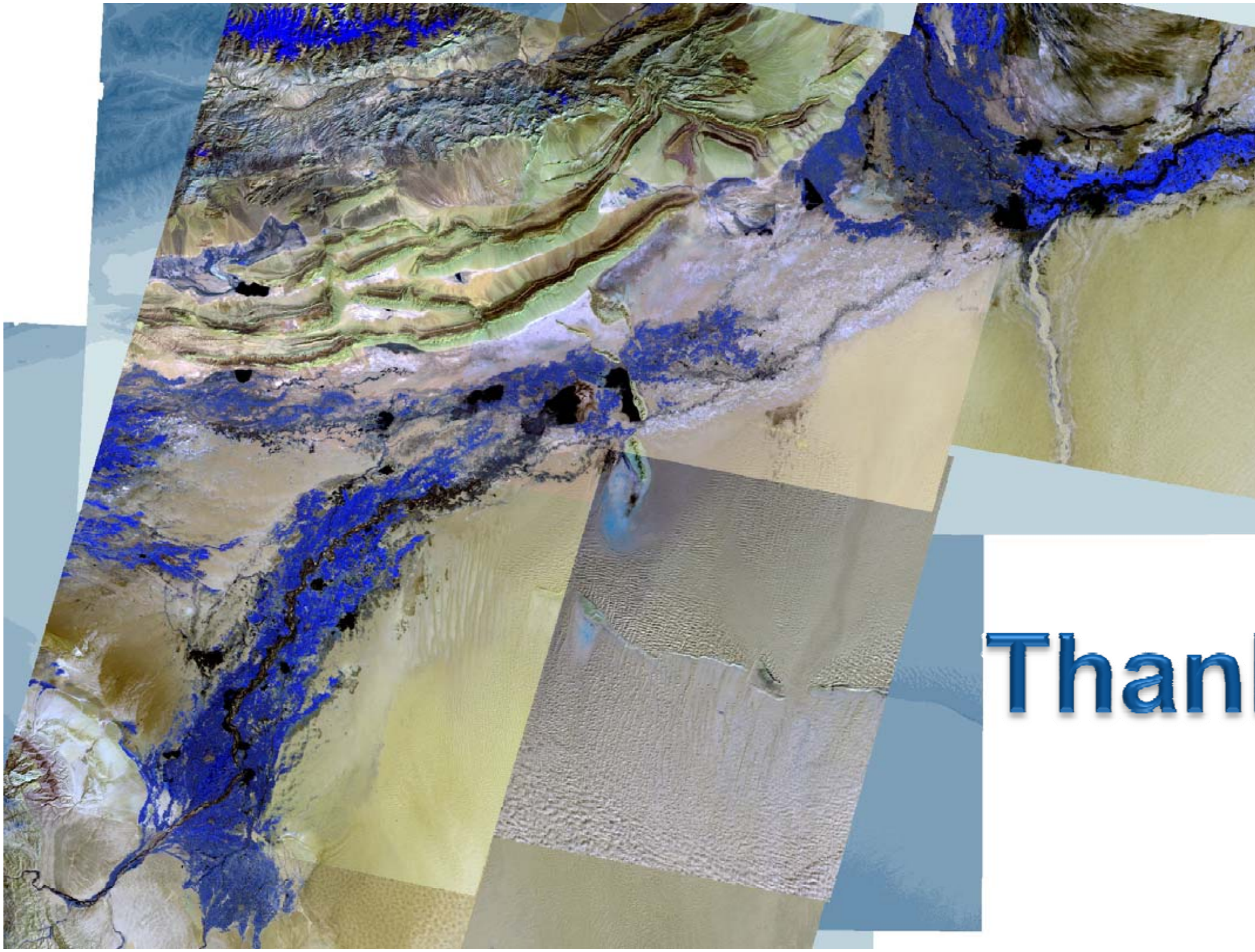
- Predictability
  - Discriminatory criteria - *downstream and lateral channel changes*
- Variability
  - Scale – *perennial channels, bifurcation, anabranching*
  - Terminations - *little effect on main DFS morphology*
- Full range of geomorphic elements
  - Amalgamation - *climate cyclicity, lobe switching, progradation*
  - Avulsion styles - *nodal, reoccupation or crevasse splay*
  - Continuum of channel form – *not just end-points*
- Full range of facies and subsurface architecture - *complex mosaic, degree of heterogeneity, sheet-like?*

Presenter's notes: Some axial systems transport relatively little of the discharge supplied at the apex; the DFS effectively are terminal. For those larger axial systems they effectively rework the distal sediments and have effect on the main DFS morphology.

Some minor, plains-fed channels are incised or misfit within larger paleochannels, reworking main DFS sediment input. They potentially leave a negligible impact in the rock record.

Next steps: To the rock record

- Dimensions
- Scale to system?
- Relative location in system



Thank you