Depositional Environments
Lec. 2 (part 1) Alluvial fans

DSRG

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What is an alluvial fans?

a fan-shaped deposit of alluvium found where a stream flows out of a mountain onto flatter terrain.

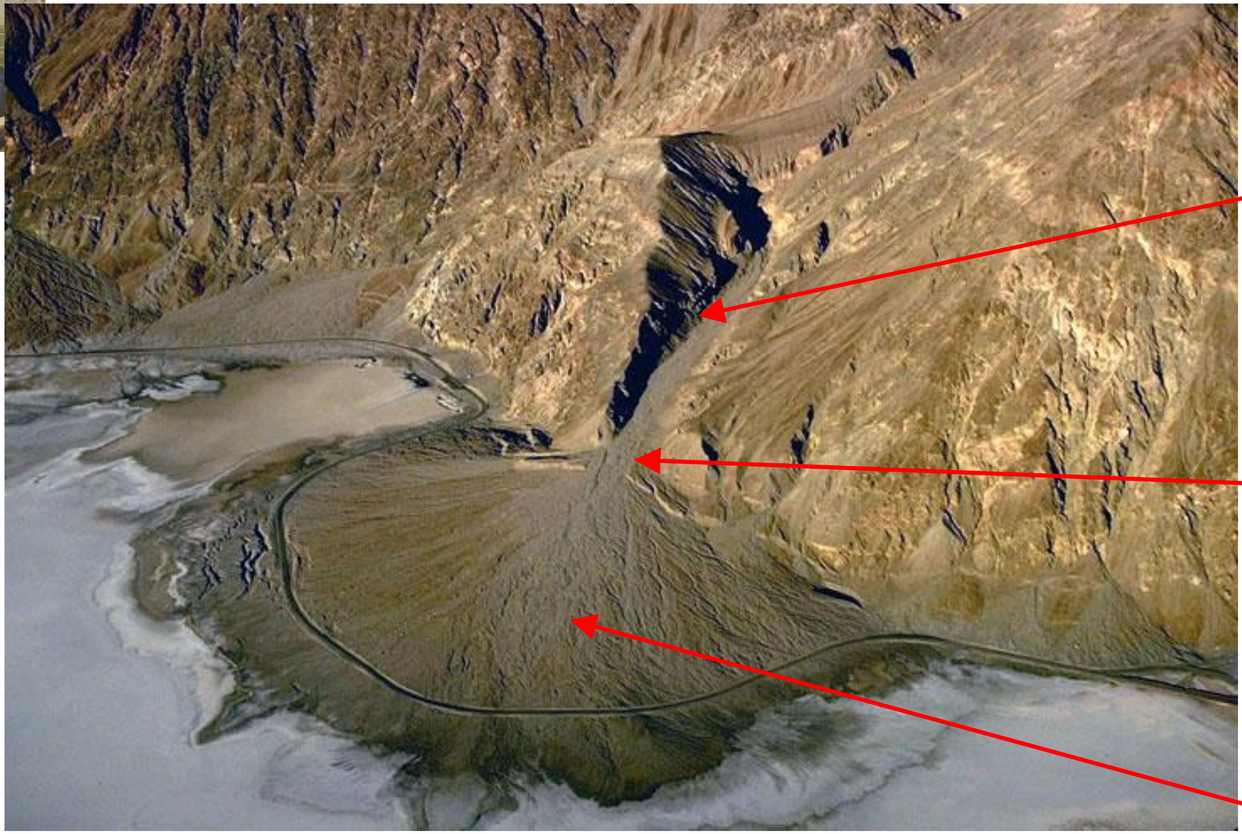
1. Alluvial Fan

Outline

1. Definitions
2. Morphology of alluvial fans
3. Processes of deposition in alluvial fans
4. Modifications of alluvial fan deposition
5. Controls on alluvial fan deposition

1. Definitions

An alluvial fan in Death Valley



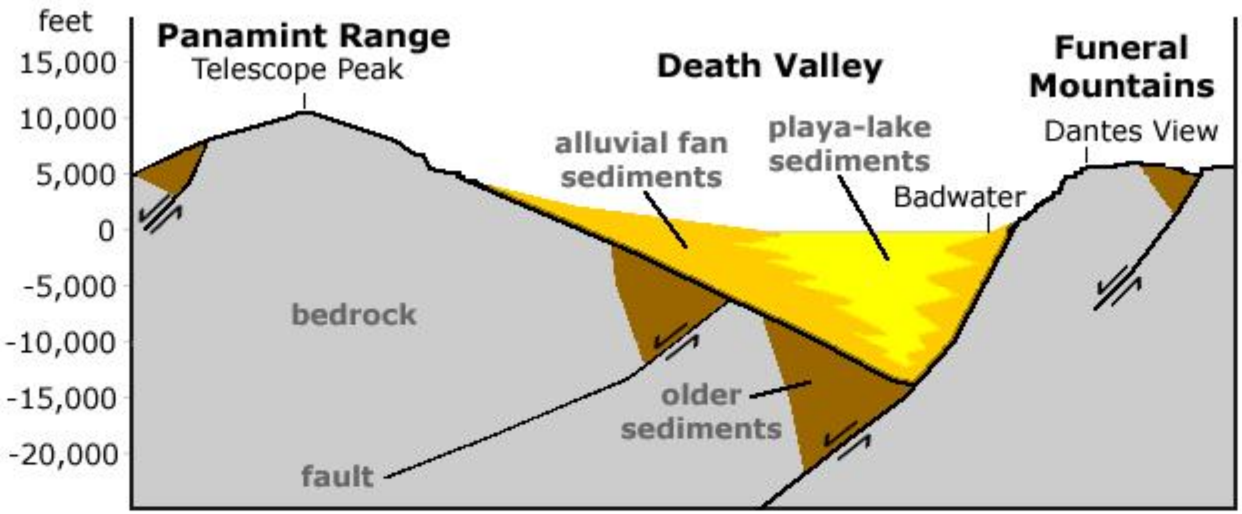
Narrow outlet (valley or gorge)

Fan apex

Radial spreading alluvial fan

1. Definitions

An alluvial fan in Death Valley



1. Definitions

Fan shape:

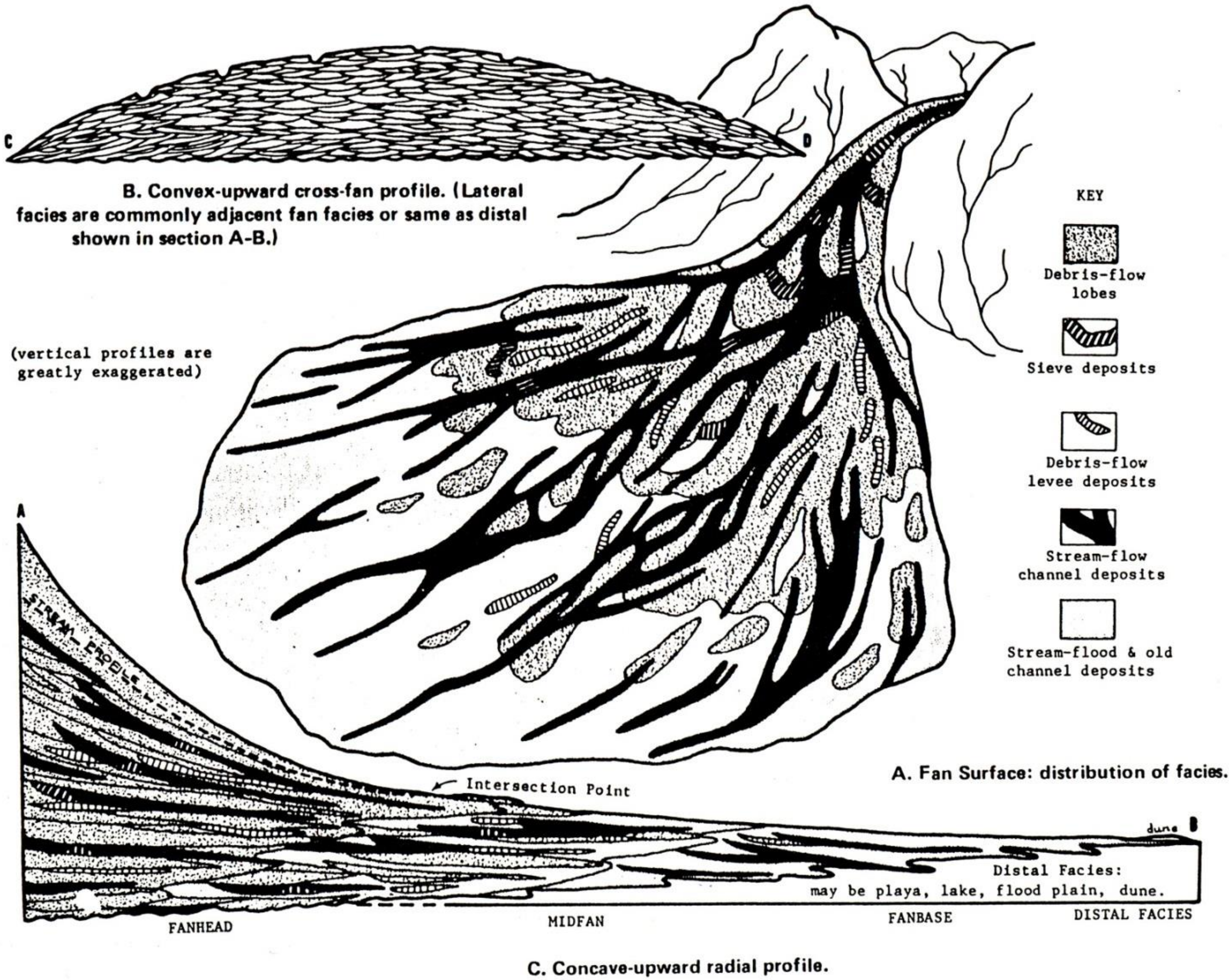


Figure 11.1 from Boggs, 2nd edition

2. Morphology of Alluvial Fan

Fan toe is a distinct break in slope at the fan toe, the limit of the deposition of coarse detritus at the edge of the alluvial fan.

feeder canyon funnels the drainage to the basin margin: at this point the valley opens out and there is a change in gradient allowing water and sediment to spread out.

The ***fan apex*** is the highest, most proximal point adjacent to the feeder canyon from which the fan form radiates.

A fan-head canyon may be incised into the fan surface near the apex.

2. Morphology of Alluvial Fan

Types of alluvial fans

Mixtures of all of these processes Can occur on a single fan

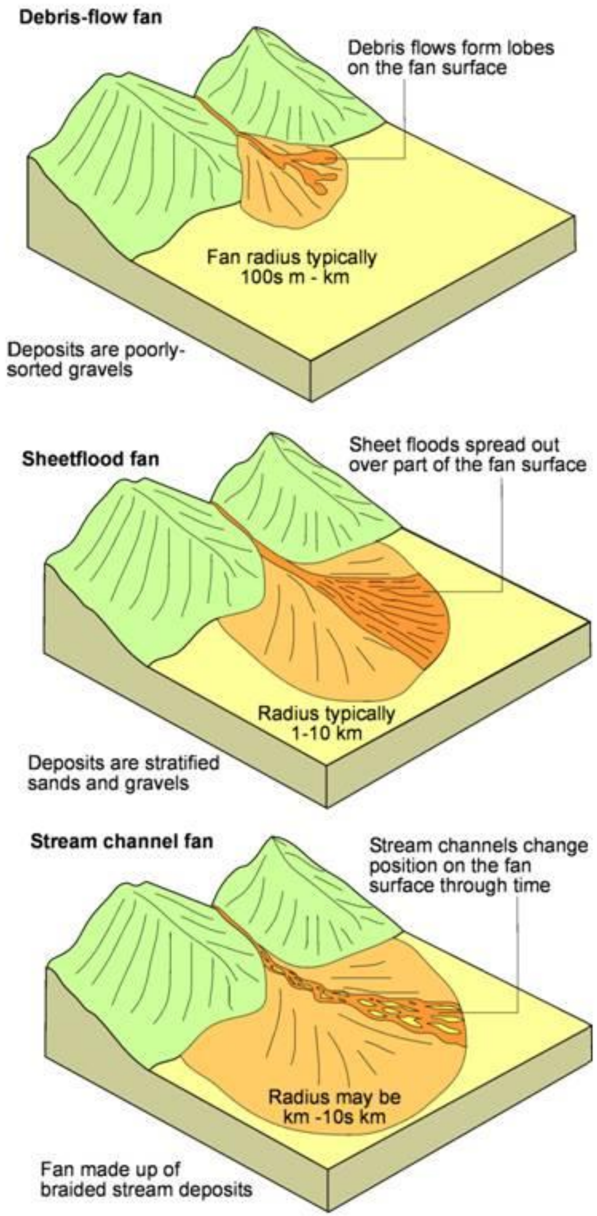


Fig. 9.20 Types of alluvial fan, Nicols (2010)

2. Morphology of Alluvial Fan

Intersection point:

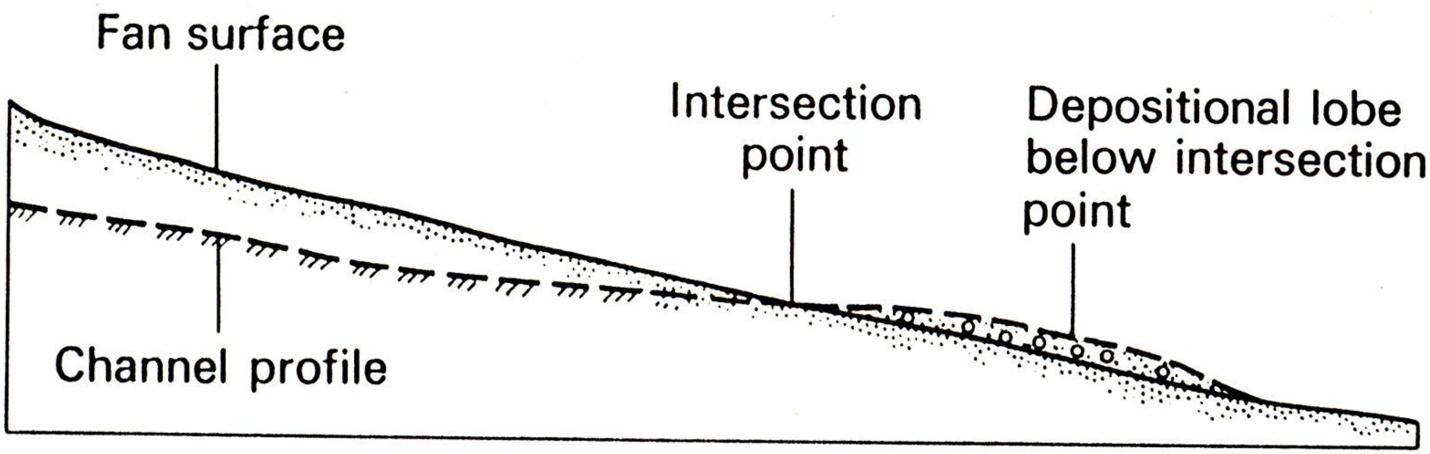


Fig. 3.14. Radial profile of an alluvial fan showing the position of the intersection point. This point will move up and down the fan surface in response to phases of incision and aggradation, probably related to tectonic activity (after Hooke, 1967).

Figure 3.14 from Reading, 1986

2. Morphology of Alluvial Fan

Fan parts:

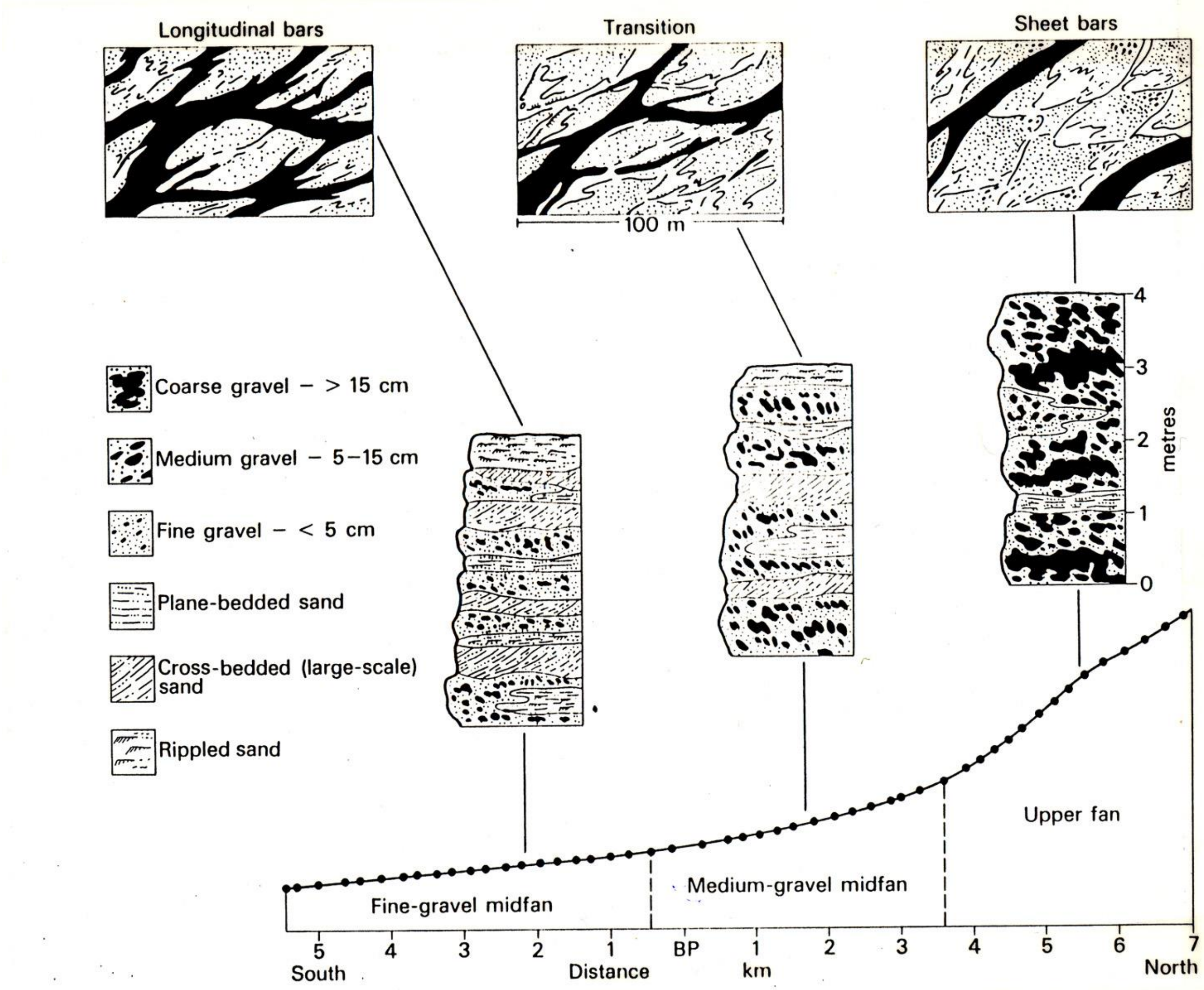


Figure 3.16 from Reading, 1986

2. Morphology of Alluvial Fan

Longitudinal change in grain size:

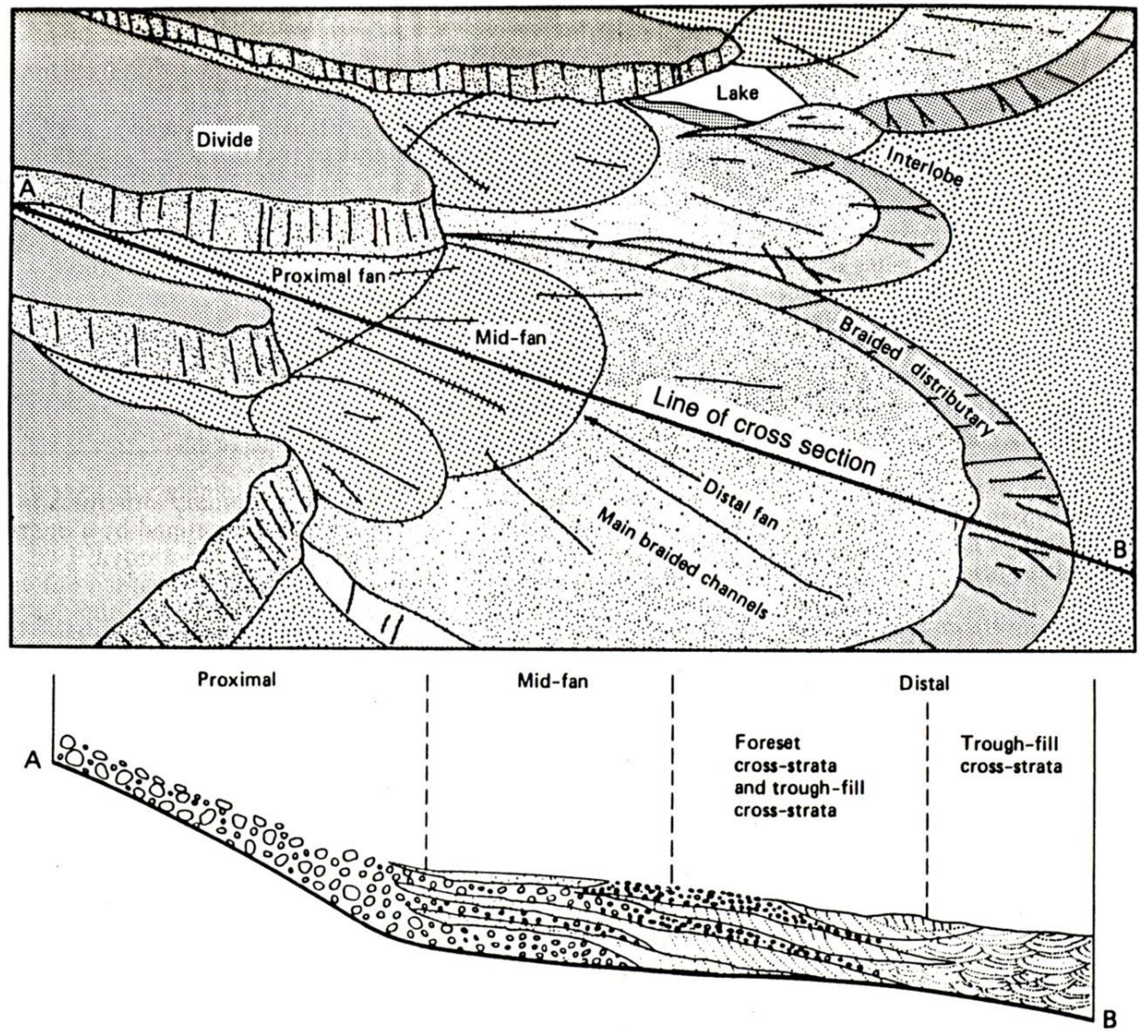


Figure 9.6 from Boggs, Princ

2. Morphology of Alluvial Fan

The evolutionary stages of alluvial fans

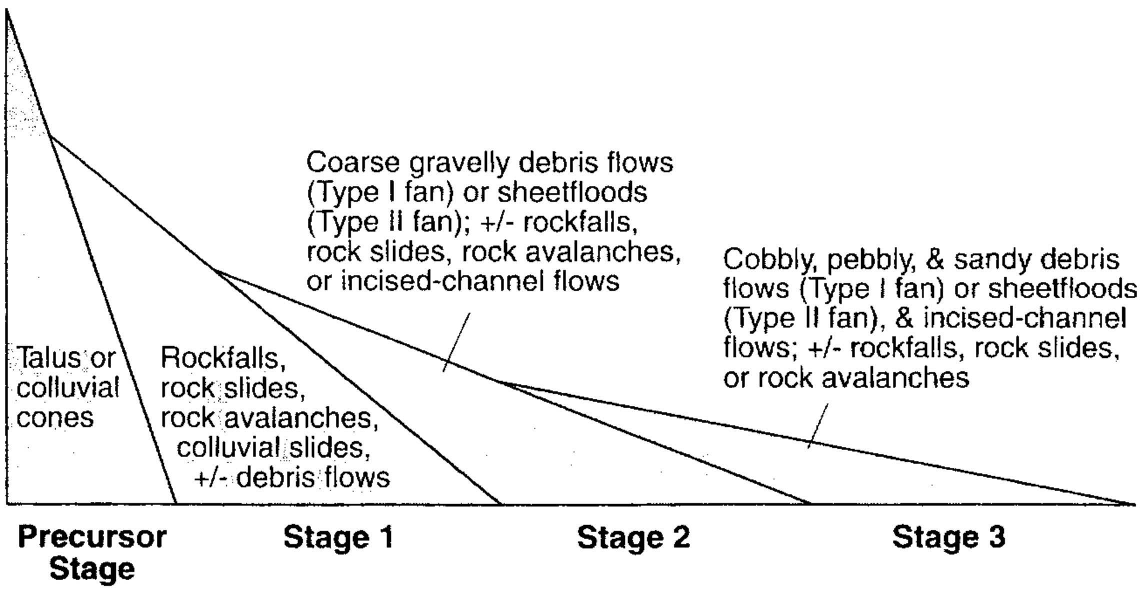


FIG. 20.—Schematic cross-sectional depiction of alluvial-fan evolutionary stages and their relationship to dominant sedimentary processes and facies assemblages (drawn with 2× vertical exaggeration). Depositional slopes increase towards the left, and fan radii increase toward the right. Stages refer to the common morphologic and sedimentologic evolutionary schemes that fans and their drainage basins ideally follow as they increase in size.

Intersection point

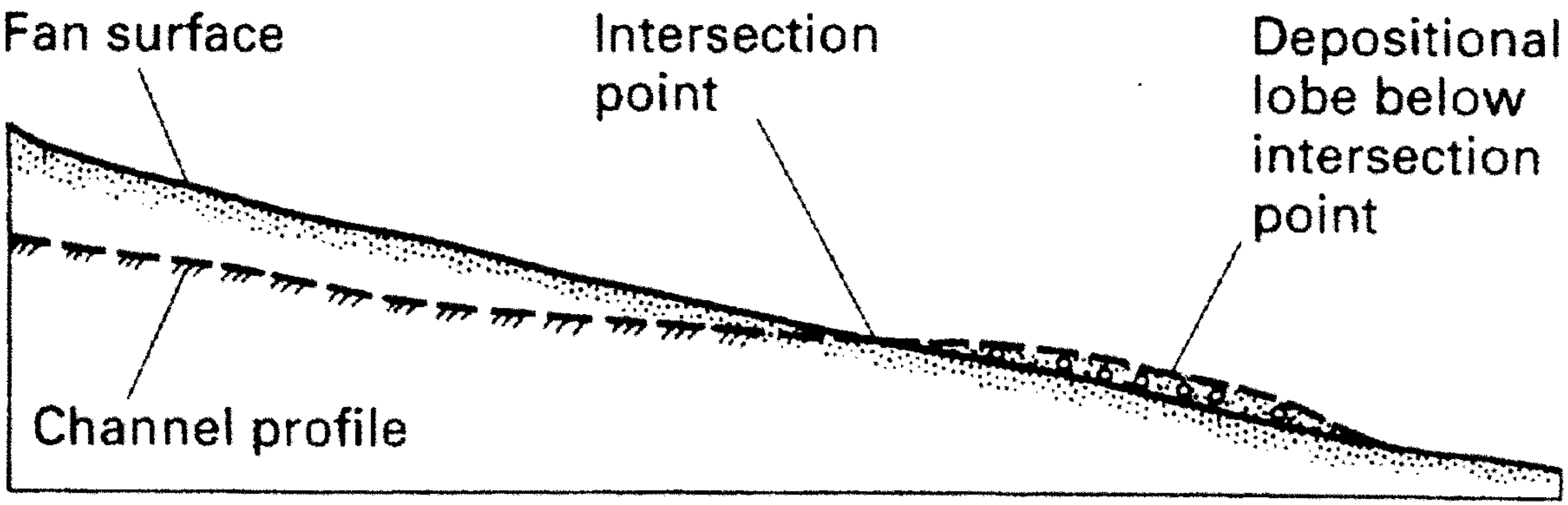


Figure 3.28 Radial profile of an alluvial fan showing the position of the intersection point (after Hooke, 1967).

2. Morphology of Alluvial Fan

The radial deposition of alluvial fan

Active depositional lobe

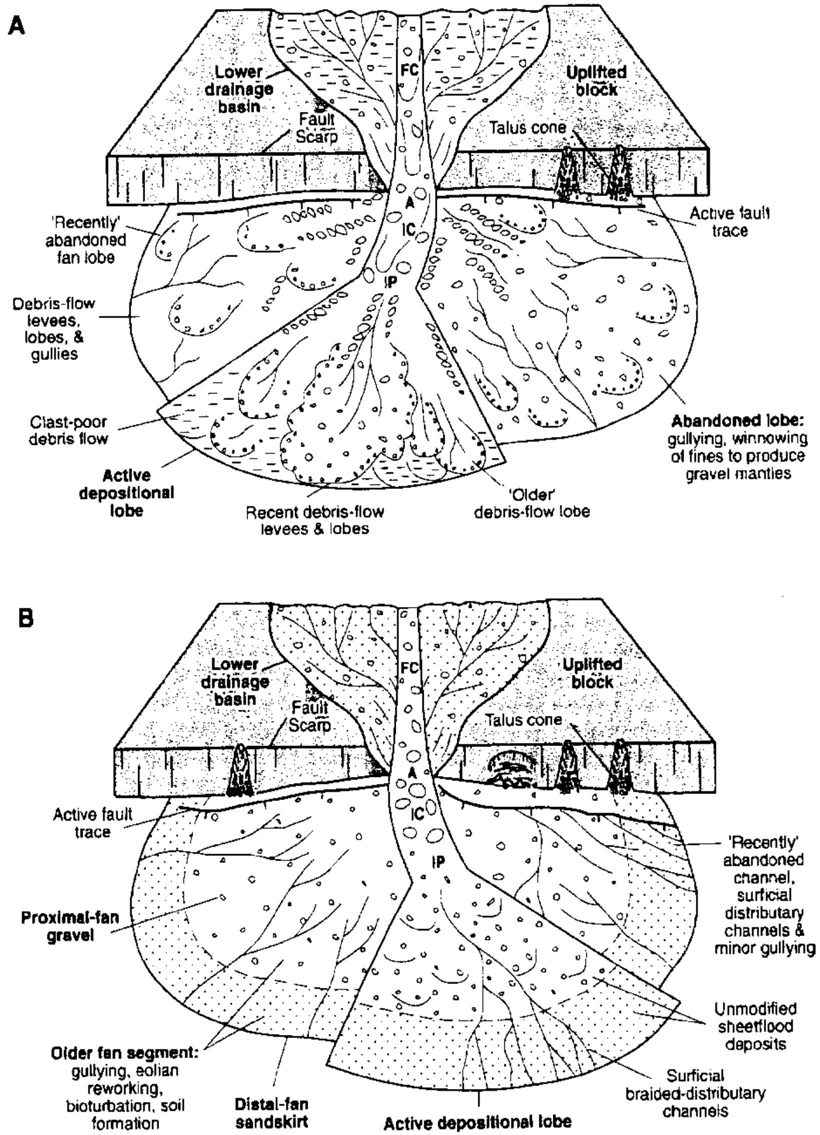


FIG. 1.—Schematic diagrams showing the lower drainage basin, and primary and secondary depositional features of alluvial fans, including those dominated by A) debris-flow processes and B) sheetflood processes. Abbreviations: A = fan apex; FC = drainage-basin feeder channel; IC = incised channel on fan; IP = fan intersection point.

2. Morphology of Alluvial Fan

And suspended load deposits on distal portions of the fan

3. Processes of deposition

- Availability of water
- The amount and type of sediment being carried out from the feeder canyon
- The gradient of the fan surface
- A dense mixture of water and sediment, transport and deposition by debris flow.
- With more water available, the mixture of sediment and water is more dilute; deposition will be either by
  - unconfined sheetfloods
  - channels on the surface

- **The river flows could be:**

Debris flow

- **The density of the fresh river water plus suspended sediment load may be less than that of the sea water, causing hypopycnal flow**

Sheetfloods

- **In fresh-water deltas greater degree of mixing between the river and standing body of water.**
- **In marine settings where the amount of bed load is high.**

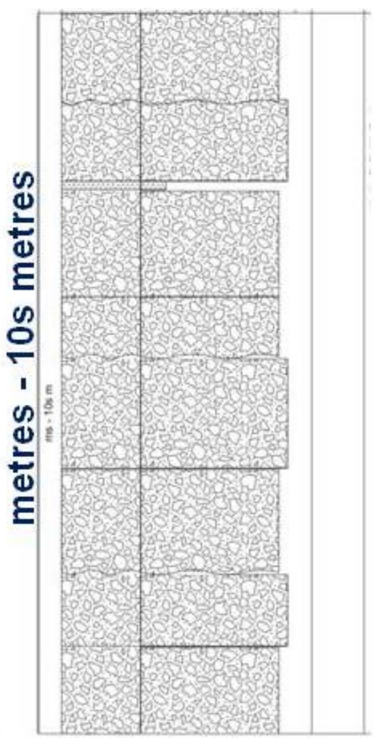
Streem Channels

- **In freshwater lakes, sediment concentrations <1 kg/m3 produce hyperpycnal conditions.**
- **Sediment concentrations >35 to 45 kg/m3) may be required to generate hyperpycnal flows in marine settings**

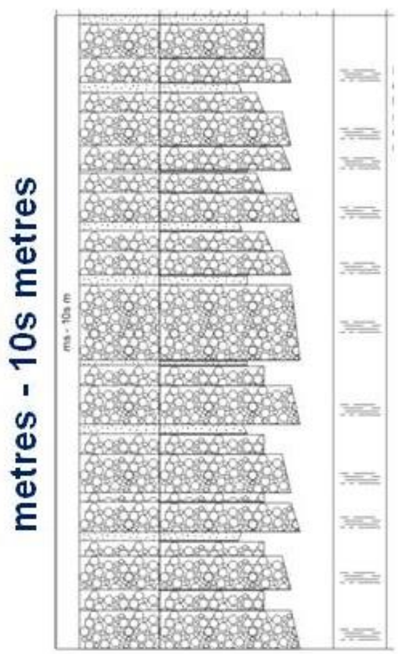
3. Processes of deposition

Sedimentary logs through alluvial fan deposits

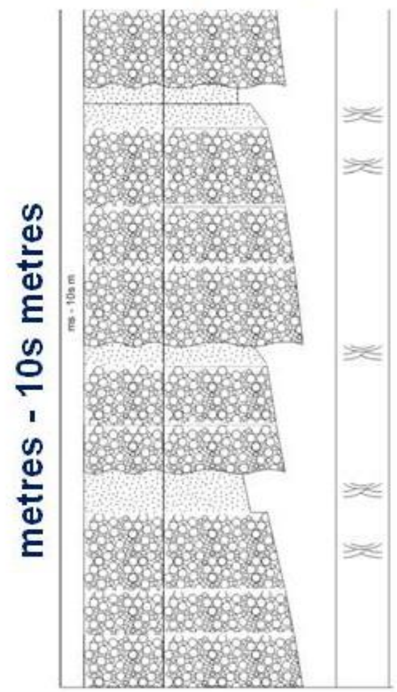
Debris flow dominated fan. Matrix-supported, poorly sorted conglomerate beds, no sedimentary structures



Sheetflood fan deposits. Horizontally stratified conglomerate and sandstone



Stream channel fans. Channel-fill units of conglomerates and sandstones in fining-up successions (braided river deposits)

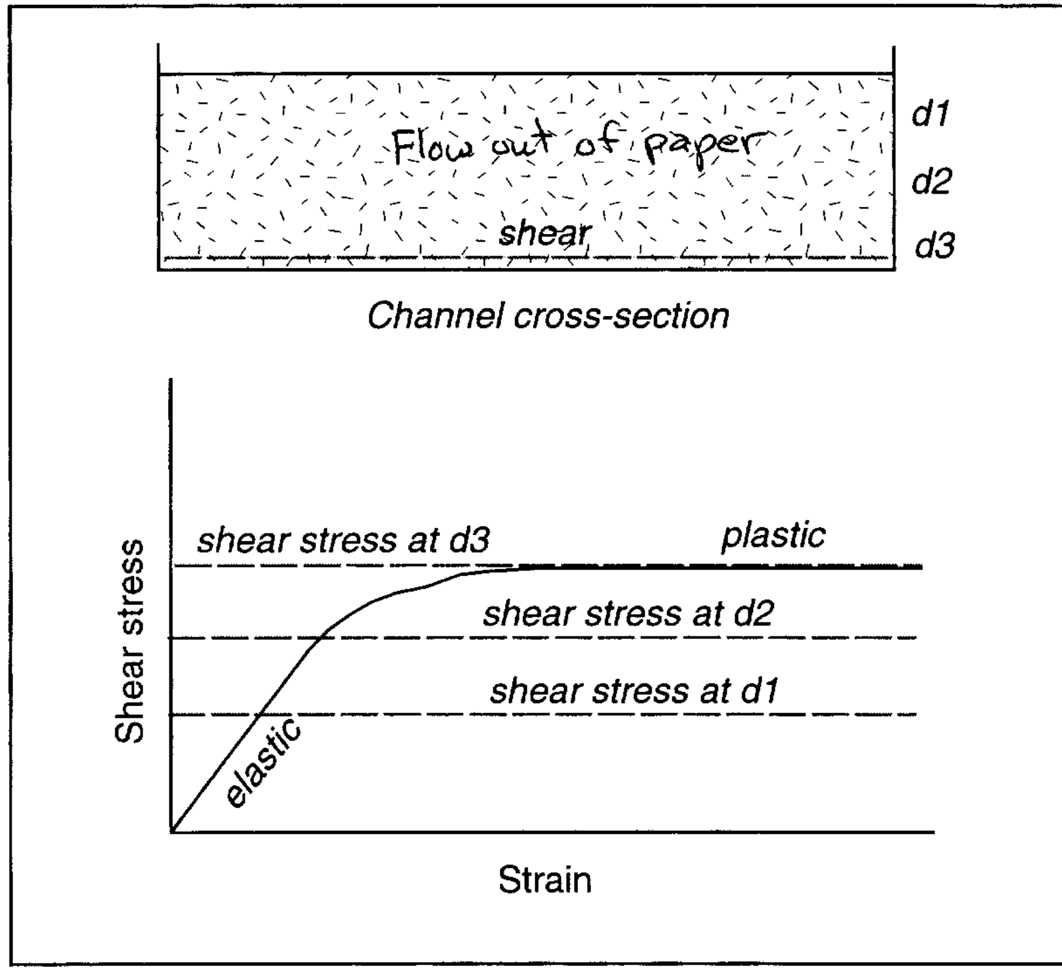


Debris flows

Shear stress vs. strain

So flow is plug like and ceases as it reaches shallower surface, hence the velocity diminishes

Flows also stop as they thin or lose water



SUBAERIAL DEBRIS FLOWS

Provided by: John Costa
(USGS Water Resources)

NOTES: First series shows mass wasting. The next clips are of relatively dry flows, followed by more fluid flows. Note levees deposited along channel margins.

Subaquous Debris Flow

3. Processes of deposition

The characteristics of a bed deposited by a debris flow are (Fig. 9.21):

1. the conglomerate normally has a matrix-supported fabric – the clasts are mainly not in contact with each other and are almost entirely separated by the finer matrix;

2. sorting of the conglomerate into different clast sizes within or between beds is usually very poor;

3. the clasts may show a crude alignment parallel to flow in the basal sheared layer but otherwise the beds are structureless with clasts randomly oriented;

4. outsize clasts that may be metres across may occur within a debris flow unit (Fig. 9.22);

5. beds deposited by debris flows are tens of centimetres to metres thick.

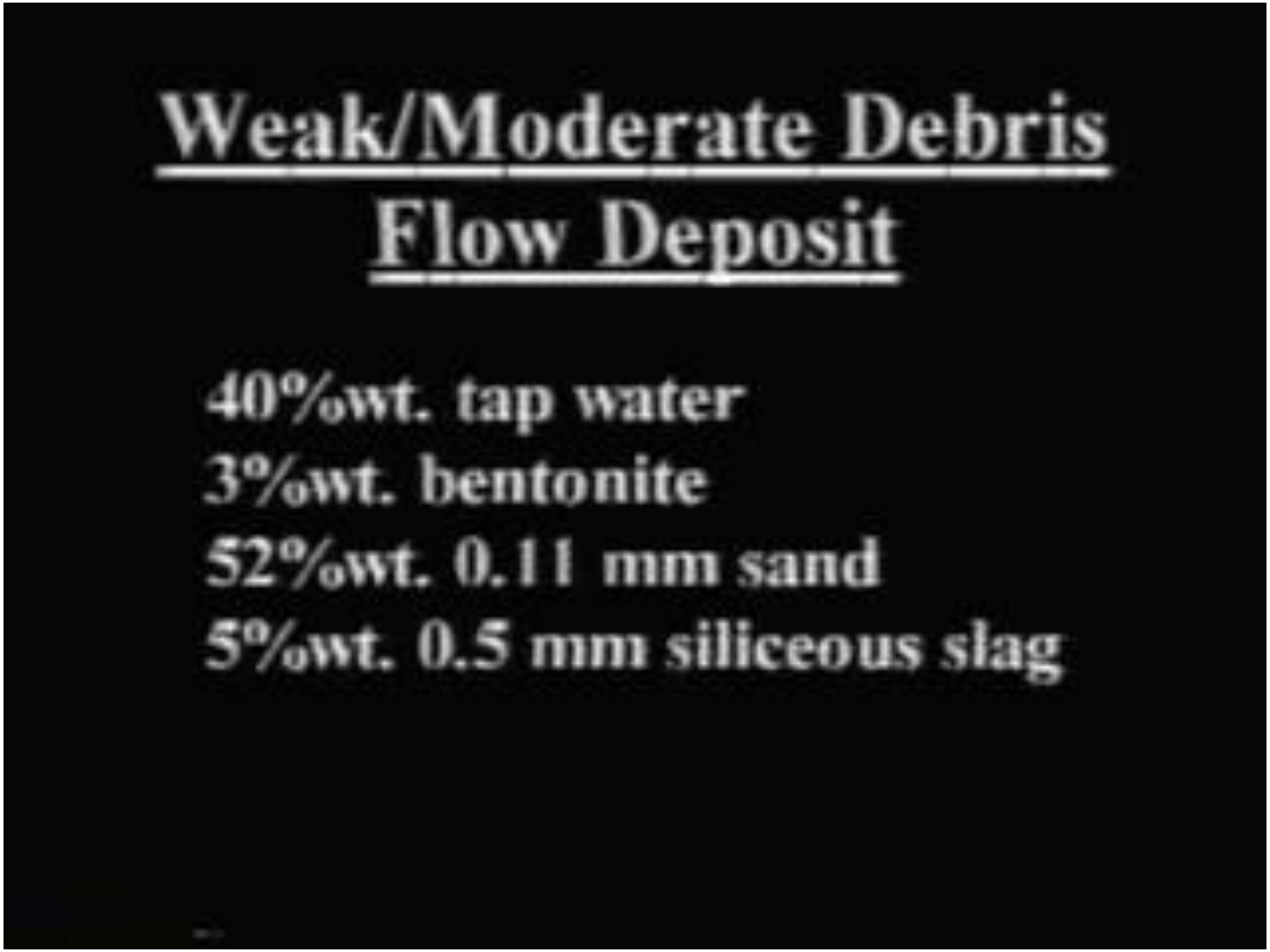
3. Processes of deposition

Debris flows

3. Processes of deposition

Debris flows

3. Processes of deposition



3. Processes of deposition

3. Processes of deposition

Younger sieve deposits in the distal part of alluvial fan

3. Processes of deposition

The characteristics of a sheetflood deposit on an alluvial fan are (Fig. 9.21):

1. sheet geometry of beds that are tens of centimetres to a couple of metres thick;

2. beds are very well stratified with distinct couplets of coarser gravel and sandy, finer gravel (Fig. 9.23);

3. imbrication of clasts is common, and up-stream cross-stratification formed by antidunes may also be preserved;

4. the sediment is poorly sorted, but silt and clay sized material is largely absent;

5. beds may show normal grading due to waning flow.

3. Processes of deposition

sheetflood deposits

Excellent exposure of Hanauphan fan, Death Valley. There are dozens of debris flow and sheet flood events recorded in this outcrop.

3. Processes of deposition

Debris flow "channel" on a talus in eastern Sierra Nevada

3. Processes of deposition

A closer view

Note the existence of the "levees"

3. Processes of deposition

Period of active deposition, massive floods and debris flows

3. Processes of deposition

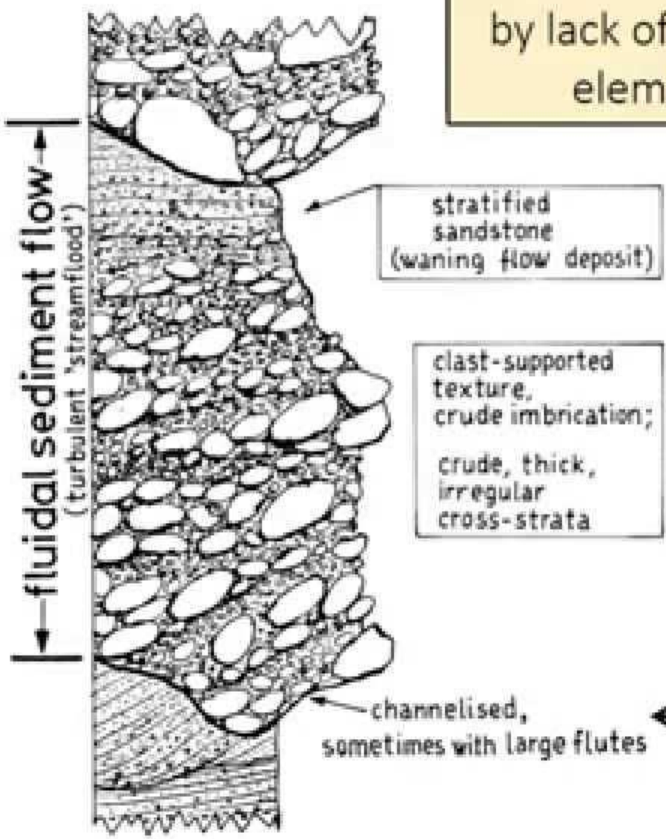
And afterwards…….

3. Processes of deposition

Debris flow fan caused by typhoon, southern Taiwan, 2005

Hyperconcentrated flow

Differs from braided fluvial system by lack of downstream accretion elements and bar forms

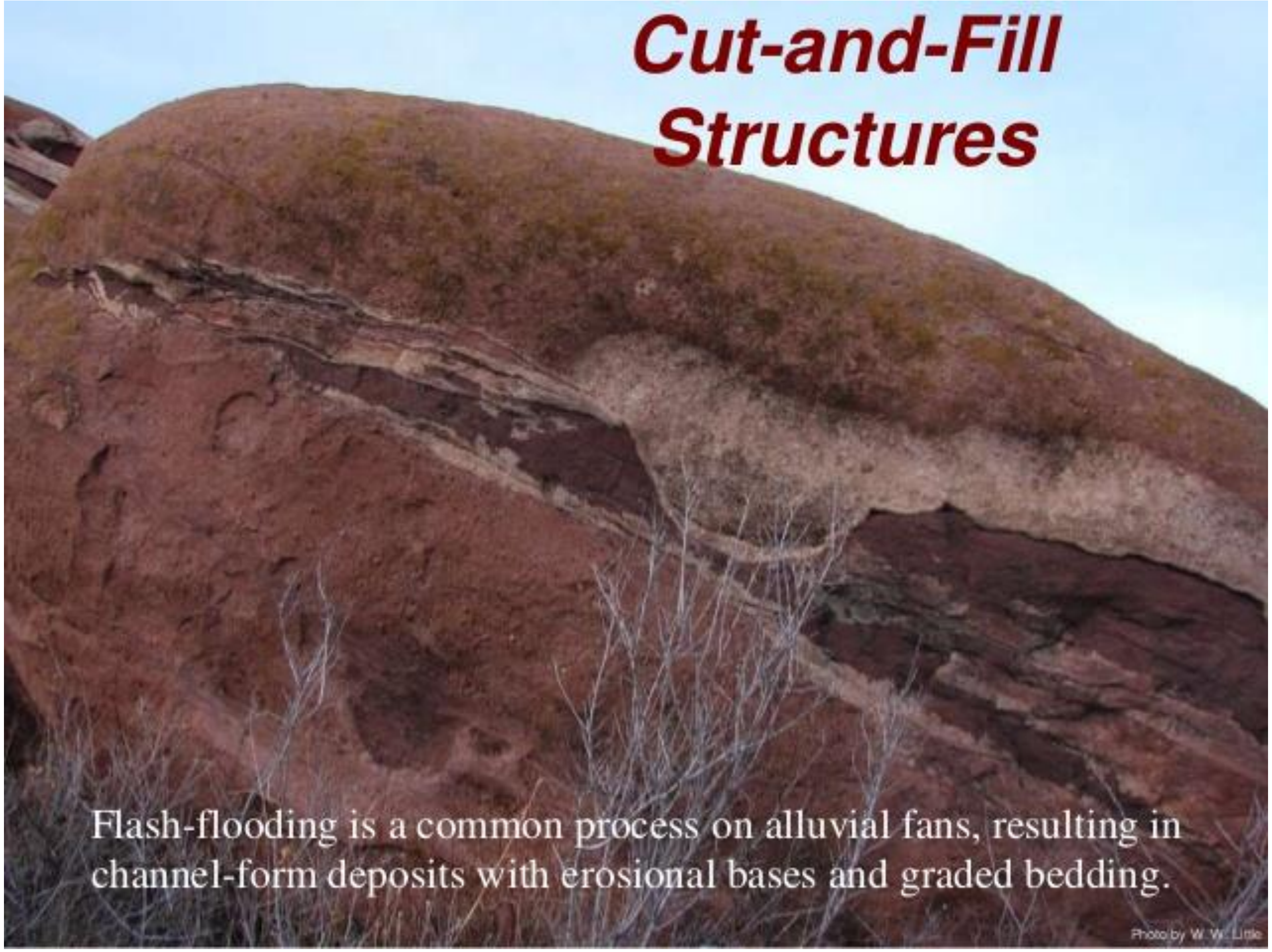


Usually clast-supported, imbricated

Crude normal grading from unhindered settling of grains in turbulent flow

Turbulence creates erosive base

Miocene sheetflood deposits, Fish Canyon, California

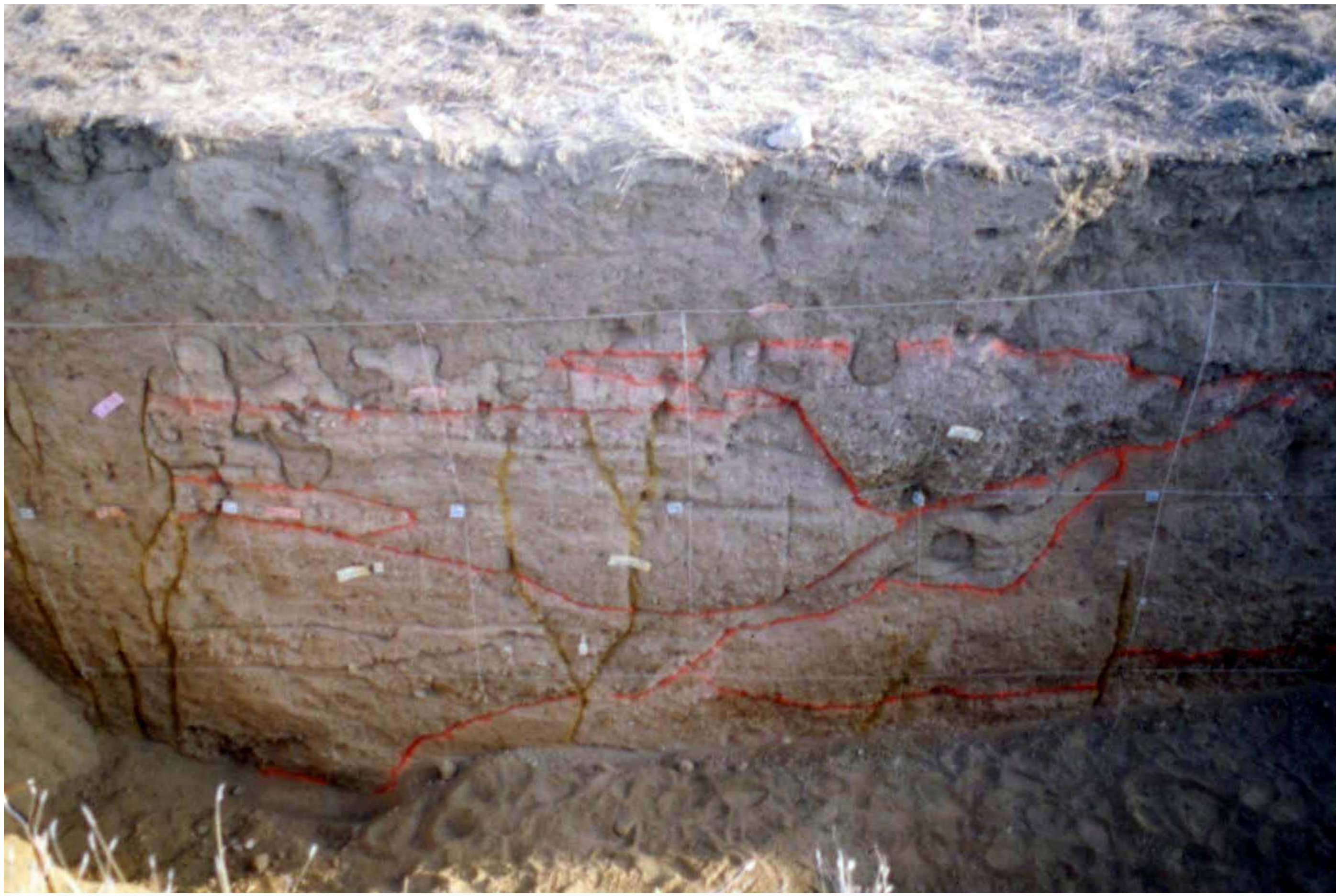

Cut-and-Fill
Structures
Flash-flooding is a common process on alluvial fans, resulting in
channel-form deposits with erosional bases and graded bedding.
Photo by W. W. Little

3. Processes of deposition

Losing water and velocity caused the debris flow to become more viscous and stop, creating a very steep front

3. Processes of deposition

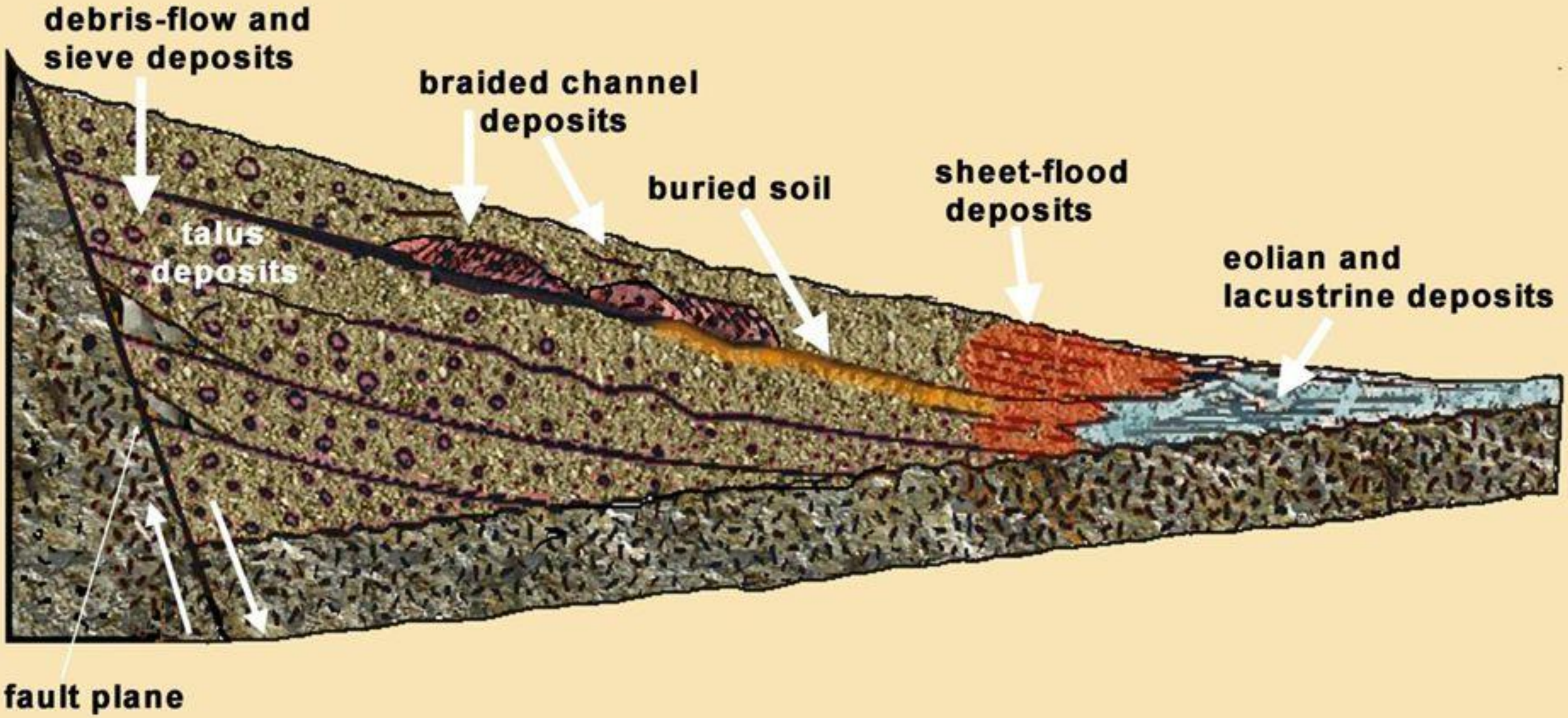
Channels near apex of fan



Channels gravels

3. Processes of deposition

Alluvial fan: general sedimentary facies model arid-climate coarse grained



5. Modification of Alluvial Fans

- Deposition on alluvial fans in arid regions occurs very infrequently (on a human time scale). The sheetfloods and debris flows that deposit sediment normally last only a matter of hours and these events are separated by tens or hundreds of years.

- Between depositional episodes, less intense rainfall events in the catchment will result in water flowing on the fan as superficial, non-depositing streams. These flows can locally winnow out sand and mud from between the gravel clasts, removing the matrix of the deposit, and if the spaces are not filled in later an open framework or matrix-free conglomerate may be preserved.

5. Modification of Alluvial Fans

- A more significant modification of the alluvial fan surface is by streams that become established on the fan surface between depositional episodes. These rework debris flow and sheetflood deposits, form a channel and remove some material from the fan surface and on many modern alluvial fans this is an important process (Blair & McPherson 1994).

- These steep channels have the form of a braided river with bars of gravel redeposited or left uneroded within the channel.

- Alluvial fan surfaces are also subject to modification by soil processes, and aeolian processes winnow the surface, removing fine-grained material from it.

6. Controls on Alluvial Fan Deposition

Tectonics:

- Alluvial fans develop at the margins of sedimentary basins and these can be sites of tectonic activity, with faults along the basin margin creating uplift of the catchment area and subsidence in the basin.

- It is therefore possible to see evidence of tectonic activity within an alluvial fan succession.

e.g. influx of coarse detritus onto the fan resulting from renewed tectonic uplift (Heward 1978; Nichols 1987).

- Analysis of the bed thicknesses and clast sizes within beds can therefore be used as a means of identifying periods of tectonic uplift in the high ground adjacent to the basin

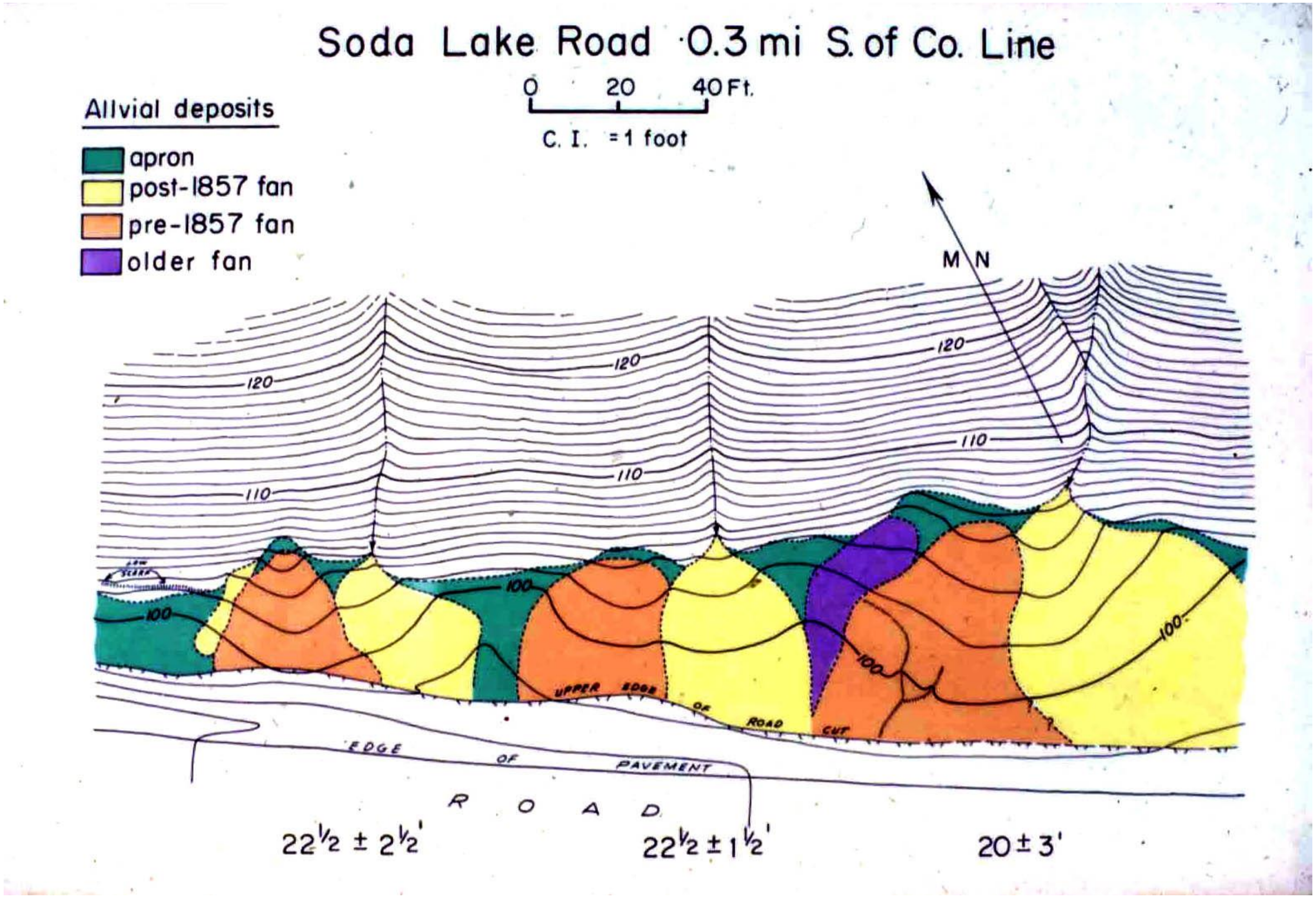
6. Controls on Alluvial Fan Deposition

Three small alluvial fans on Soda Lake Road

Is there anything strange of these fans?

6. Controls on Alluvial Fan Deposition

Yes! They are offset 6.5 m by the 1857 earthquake




6. Controls on Alluvial Fan Deposition

Climate

- A change in climate can also result in changes in the processes of deposition on a fan (Harvey et al. 2005):

e.g. an increase in rainfall more water is available and this may result in a predominance of sheetflood and stream-channel processes, with less debris-flow events occurring.

- The character of the conglomerates deposited on the fan will reflect this climatic change, with more clast-supported and fewer matrix-supported conglomerate beds.

6. Controls on Alluvial Fan Deposition

6. Controls on Alluvial Fan Deposition

6. Controls on Alluvial Fan Deposition

- **Nature of the bedrock in the catchment area.**

  e.g. lithologies that weather to form a lot of mud will tend to generate muddy debris flows, whereas more resistant rocks will break down to sand and gravel, which is transported and deposited by sheetflood and stream-channel processes (Blair 2000a, Nichols & Thompson 2005).

Fossils in Alluvial Fans

- *A poor potential for the preservation of fossil plants or animals*
- *Preservation occurs only if the organism has very resilient parts (teeth and bones of vertebrate or if the plant or animal is covered by sediment soon after the death*
- *Faunal remains are rare occurring as scattered bones or teeth of vertebrates but plant fossil are more common.*
- *fossilized tree; stumps may be preserved in situ in overbank deposits*
- *Pieces of branches an leaves occur within beds of both channel and overbank sediments pollen and seeds (palynomorphs) are very resistent to breakdown*
- *Footprints of animals in soft mud*
- *Trace fossils range from tracks of animals such as dinosaurs to the burrows and nests of insects such as bees and ants*

Fossils in Alluvial Fans

.....with bioturbation

Fossils in Alluvial Fans

Two scales of sea level change

1. Global ("eustatic") sea level rise:

(c) The role of glaciers

- Glacial melting increases sea level.
- Sea level has risen ~120 m since last glacial maximum (21,000 y BP).
- If remaining glaciers melt, sea level may rise another 60 m.

Sea Level Rise

Two scales of sea level change

1. Global ("eustatic") sea level rise:

(d) Global sea level also affected by formation or destruction of large, inland lakes.

(e) How is global sea level measured?

- Tidal gauges at various locations
- Satellite altimetry

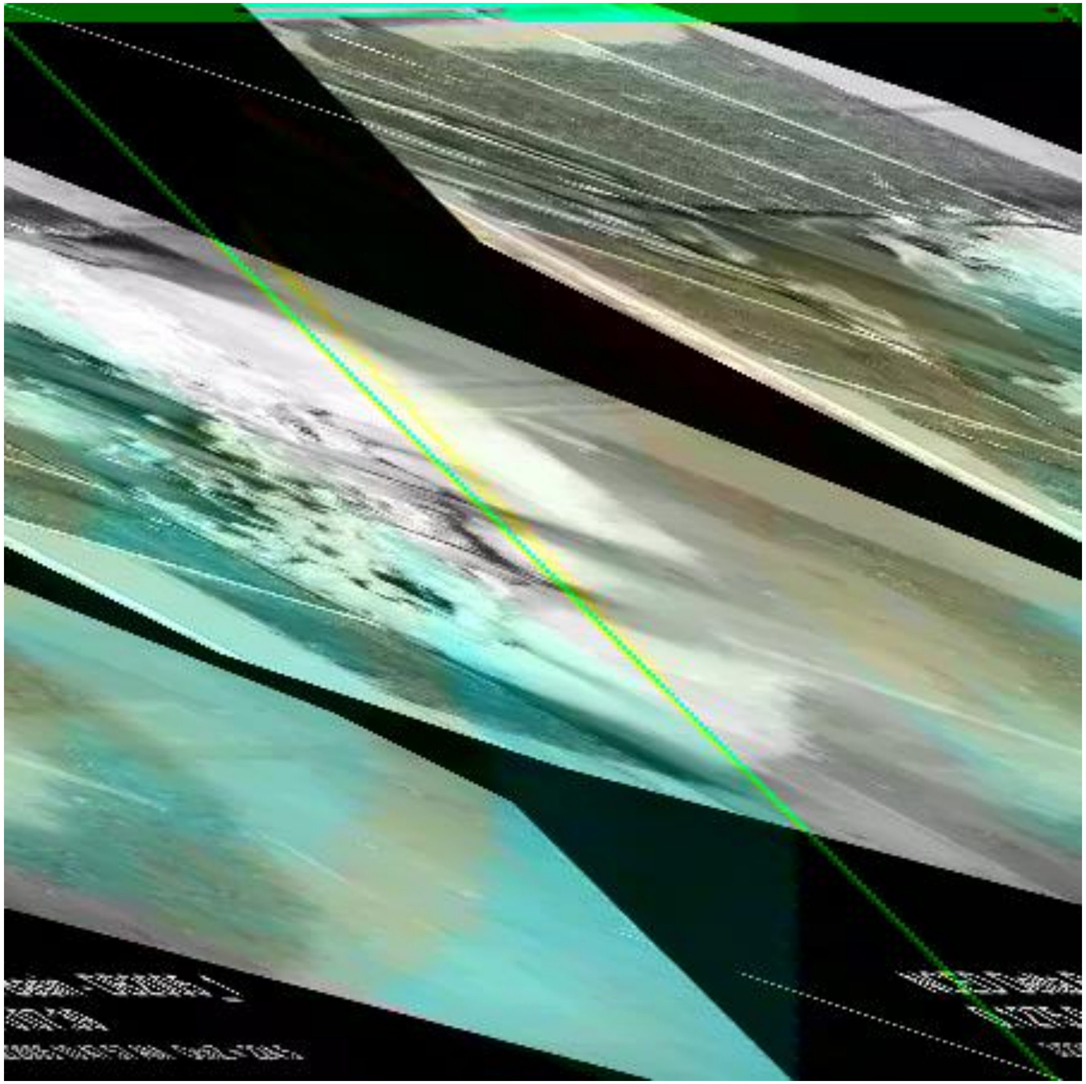
Two scales of sea level change

2. Local, or relative, sea level change

(a) Isostatic rebound

- Caused by the melting of glaciers
- Lithosphere rises to find equilibrium in absence of glacial load, results in observed drop in sea level
- Same process is causing New Orleans to subside

Alluvial Fans and Base -Level



Lecture Conclusions

- Wide spread sea level events have been identified
- The origin of the accommodation produced by them has been ascribed to
  - Eustasy
  - Tectonic events
  - Compaction
- This is used to interpret the sedimentary section and help find petroleum and model its reservoirs

5. Controls on Delta Morphology

Controls

- Tectonics
- Climate
- Sea-level changes

- Hinterland Characteristics
  - Slope
    - Relief
      - Discharge

Delta Regime | Delta Morphology | Delta Facies

- Basin Characteristics
  - Subsidence
    - Depth Control
      - Discharge

Thank You !

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