DOWNSTREAM SORTING OF SEDIMENT
(additional control on channel width, depth and slope)

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As the gravel gets finer, it is transported at lower slopes. The result is tendency to strengthen the upward concavity of a river profile.

The image shows a) the long profile of the Kinu River, Japan and b) the profile of median grain size in the same river. The river undergoes a sudden transition from gravel-bed to sand-bed before reaching the sea.

Fluvial gravels and conglomerates

Development of bedforms is suppressed by small values of flow depth/grain size.
(Toutle River, WA) [photo P. Heller]

Images Courtesy of Prof. Paul Heller, University of Wyomimg. Used with permission.

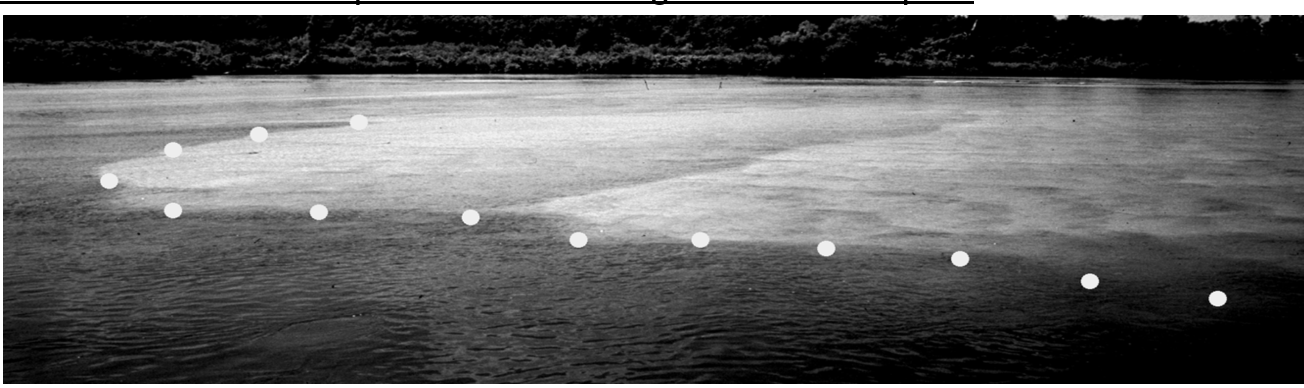
Stratification often defines bar topography.

The shingled arrangement of adjacent particles is called **imbrication** and is most easily seen in gravelly deposits. Studies of clast imbrication can be used to constrain paleocurrent directions.

Do not be fooled: Many contacts between adjacent particles may not be observed in a 2D cut through the grain framework.

Image Courtesy of Prof. Paul Heller, University of Wyomimg. Used with permission.

What is the relationship between bar height and flow depth?



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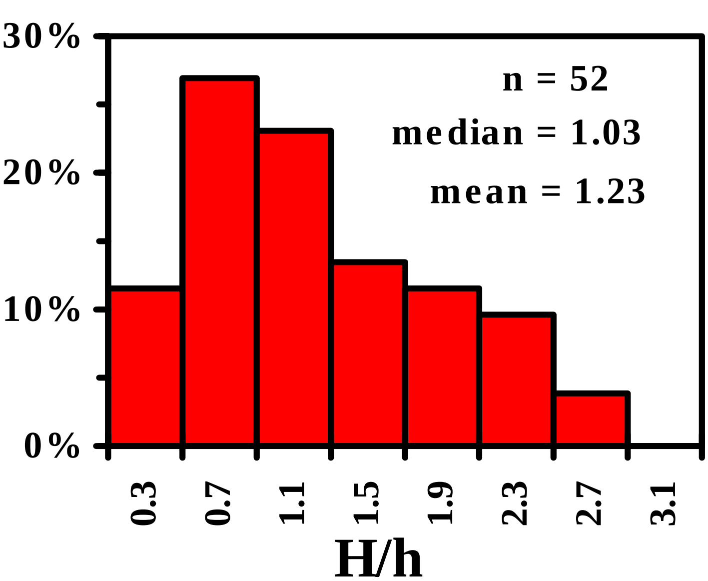


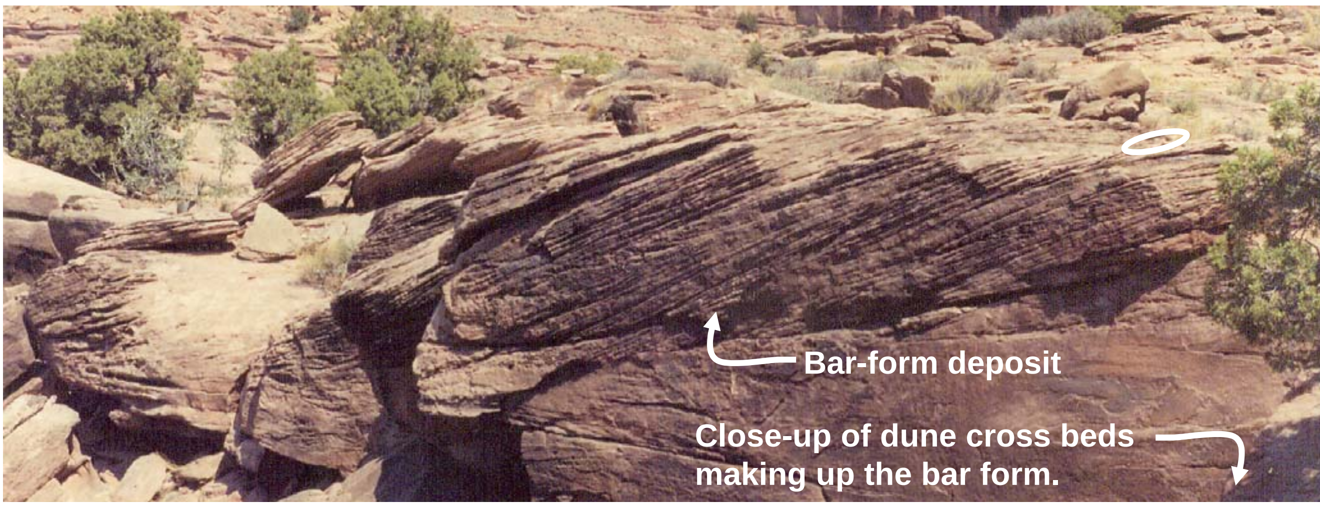
(upper) Mid-channel bar in the North Loup River, NE. White dots mark locations where bar height was measured

(left) Histogram of Local Bar Height (H) relative to Reach-Averaged Flow Depth (h) for Four Bars.

Values of H/h as high as 5 are commonly observed in river channels.

Examples of compound bedding: Bars built out of dune sediment.

Bar-form deposit (person for scale)

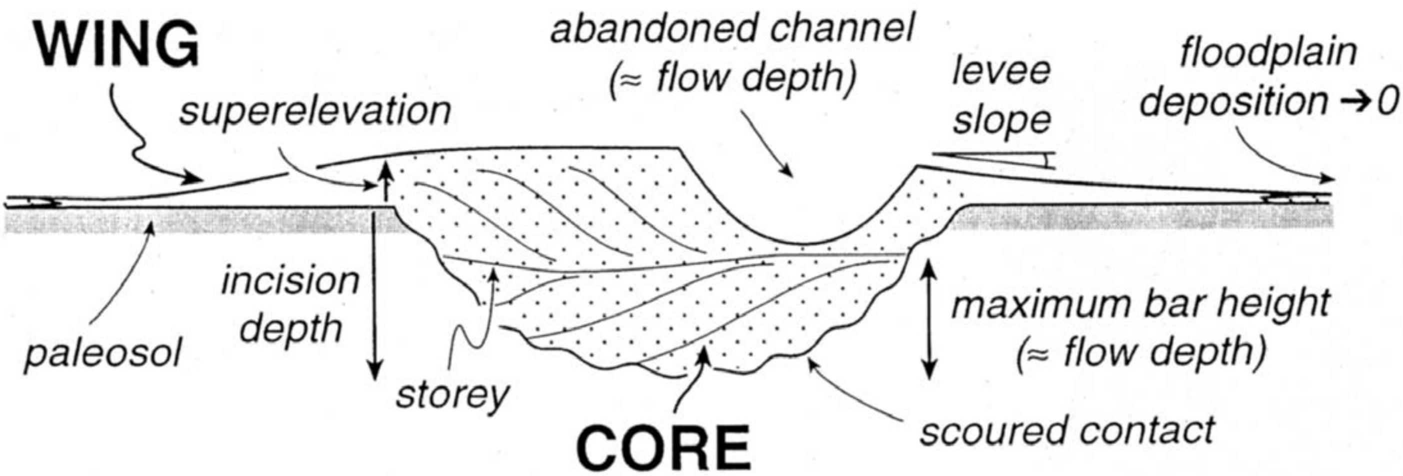


Overbank sedimentation

Rates of overbank sedimentation are greatest near channel margins, producing natural levees.

New overbank sand from the 1993 flood on upper Mississippi River, at Slim Island, MO, at mile 267. River flow is to the right. Photo by R.H. Meade, USGS.

Crevasse splay sand from levee break at Bryants Creek MO crossing floodplain of upper Mississippi River near mile 260. Photo by R.H. Meade, USGS



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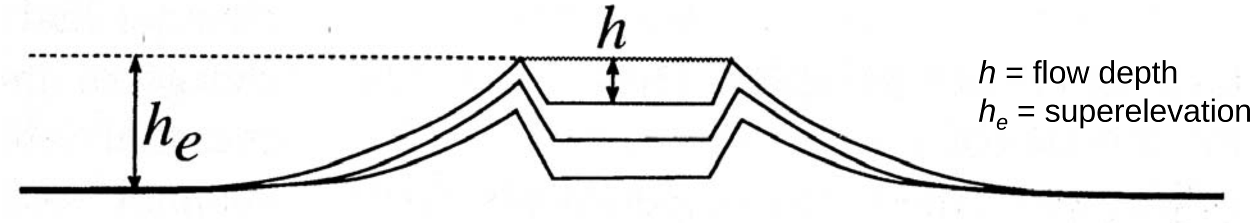
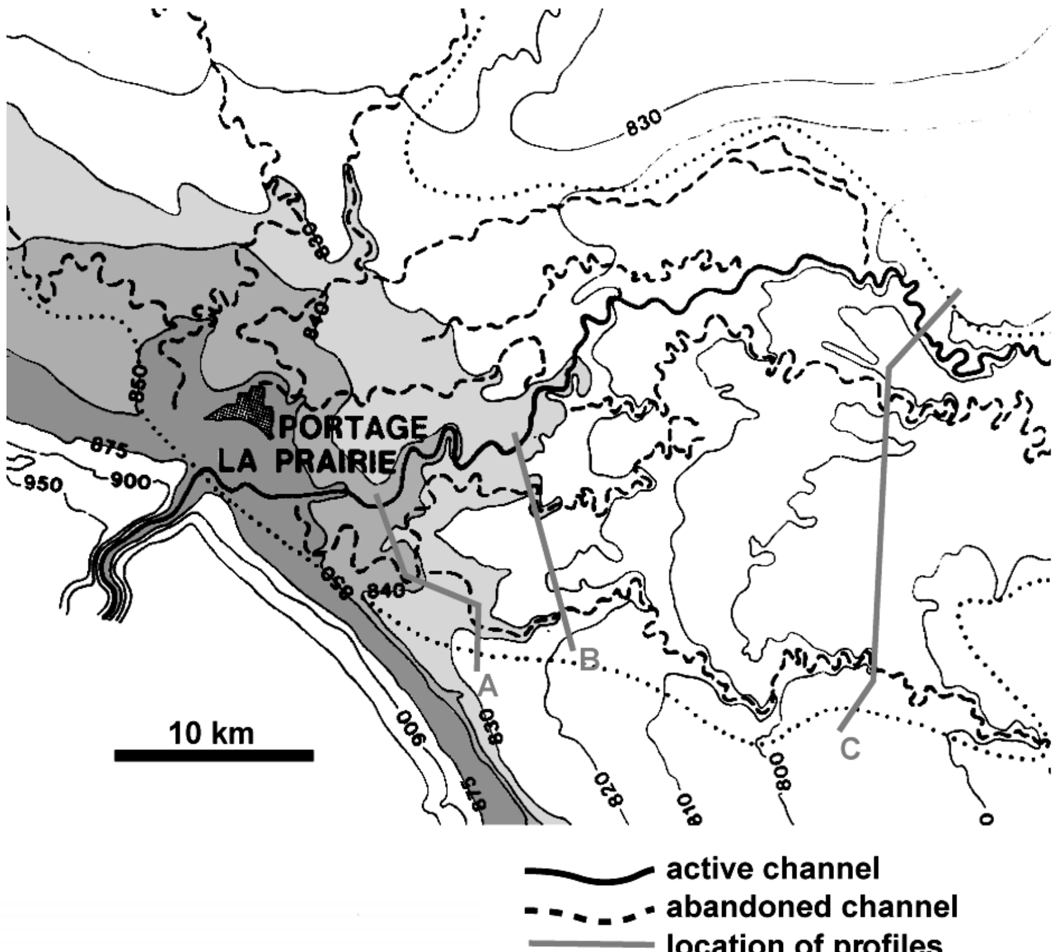
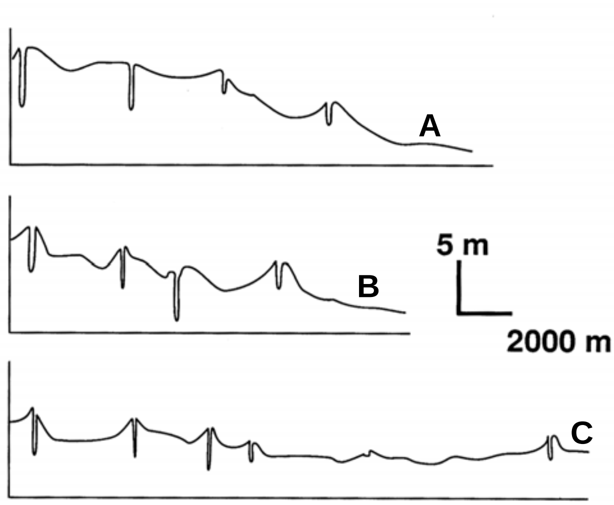
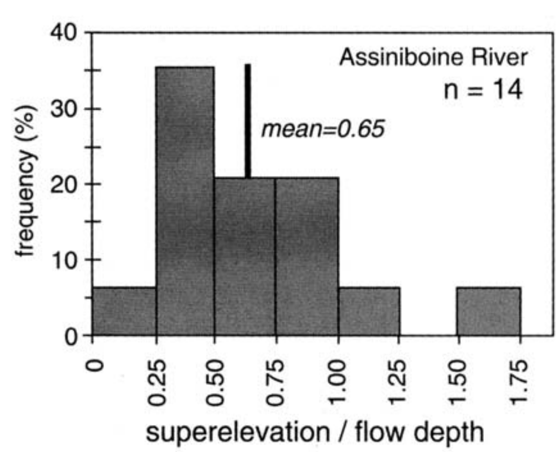
Focused sedimentation near channels results in their superelevation relative to the surrounding floodplain.

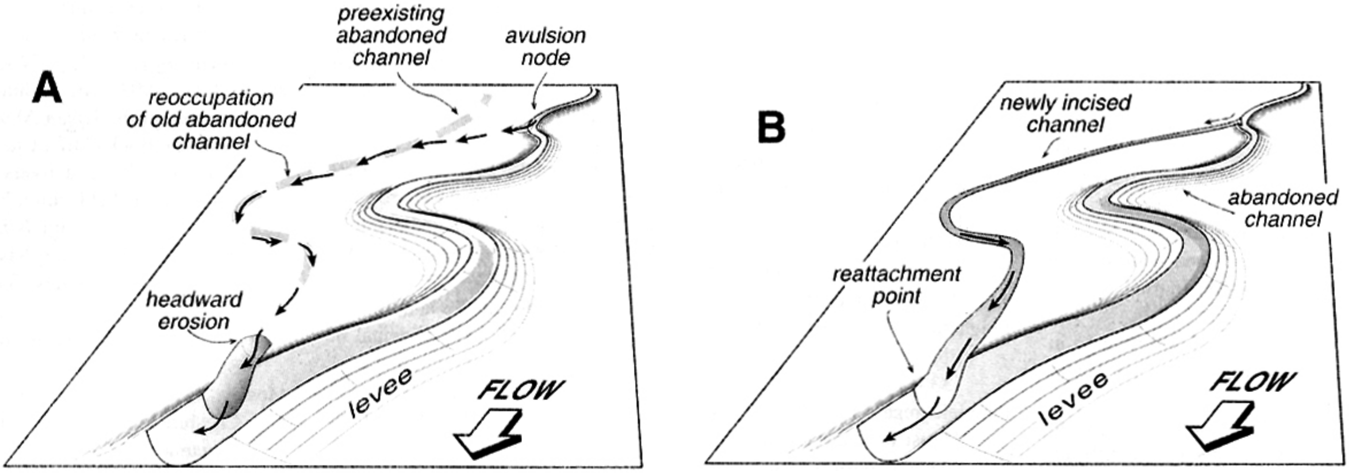


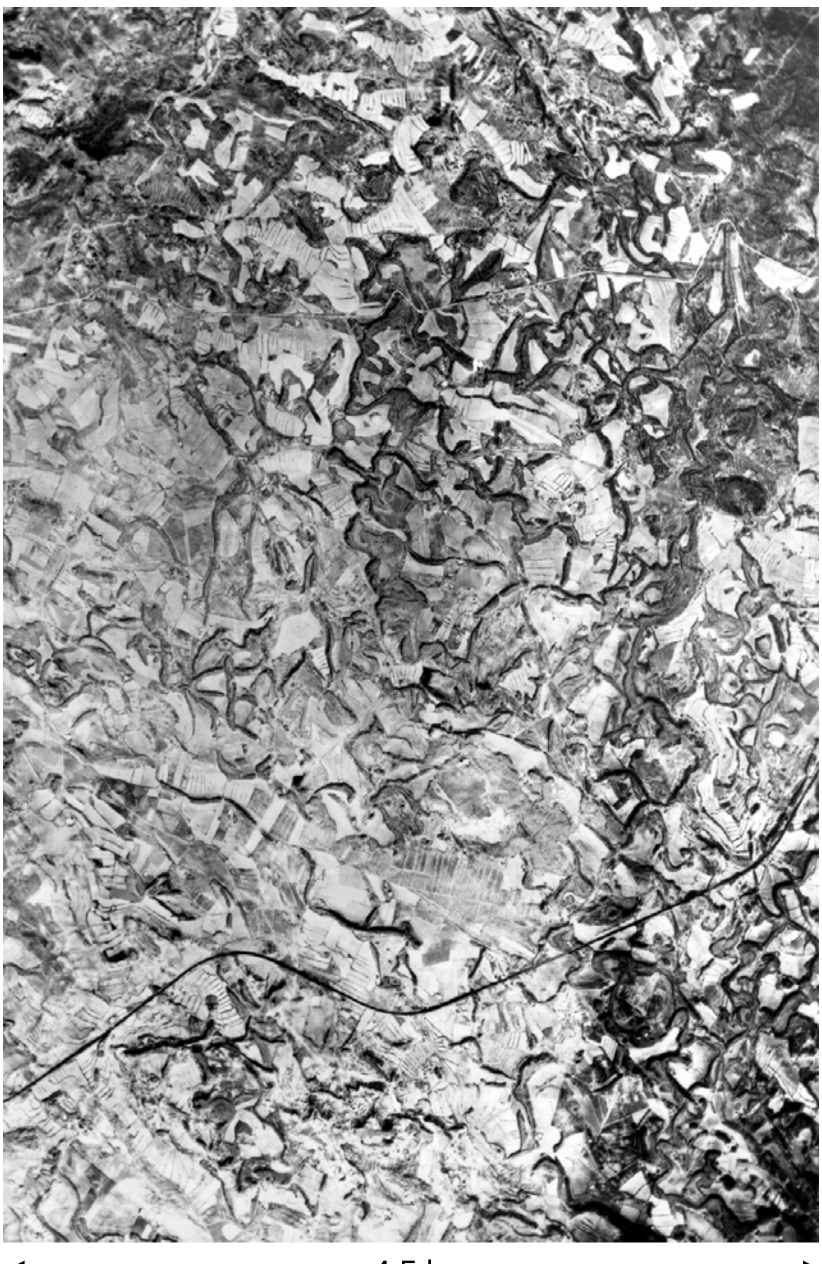




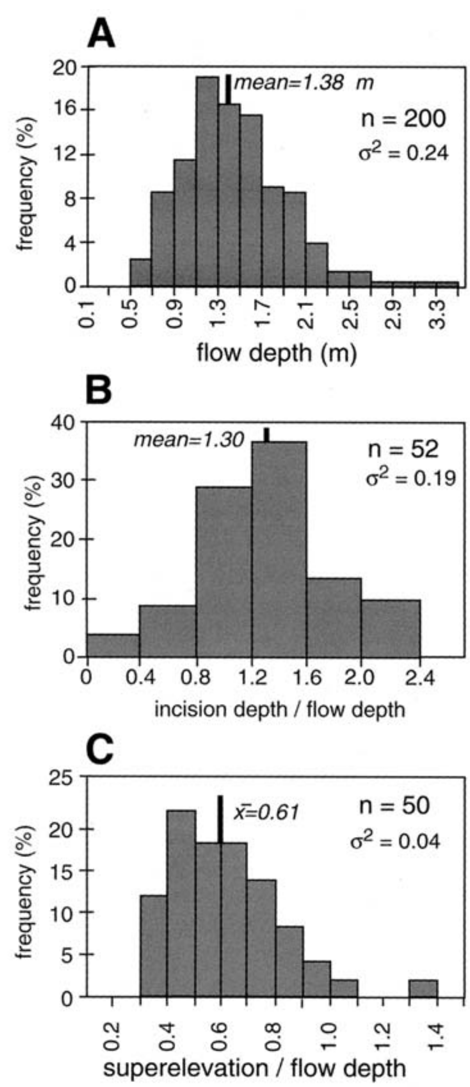


Influence of channel avulsion on stratigraphy





Aerial Photo of Ribbon Channel Sand Bodies Exposed near Caspe, Spain (Chattian)

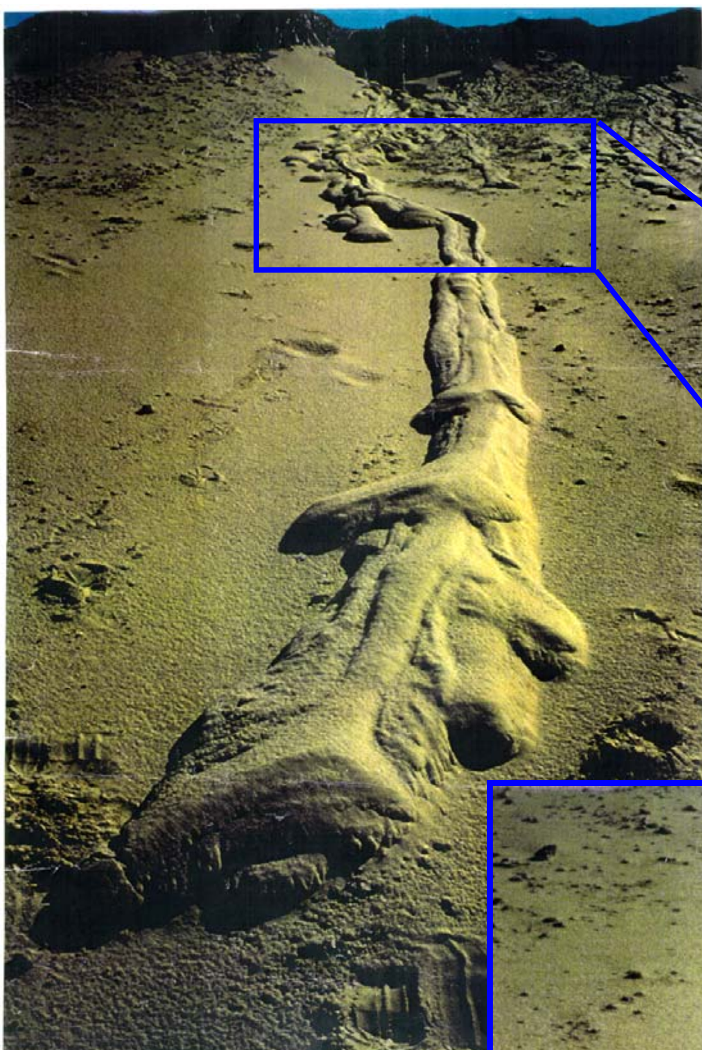


<u>Debris Flows:</u> A class of flows containing so much sediment that the particles are nearly touching. Their water component is interstitial and behaves as a pore fluid.

<u>Debris flow mobility can be facilitated by</u>:
1. Elastic collisions causing grains to vibrate enough for particles can move past each other. Inertial effect – typically associated with large surface slopes (i.e., grain flows)

2. Mixture of fine-grained sediment suspended in the water increases the viscosity of the fluid. Viscous effect – hinders motion of fluid around grains and effectively combines sediment +water so that for some period of time they move down slope as approximately a single phase.

3. Densification of the sediment framework by shear strain, transferring part of the vertical normal stress onto the pore fluid. High pore pressures – promote liquefaction of mixtures.



The Herschel-Bulkley constitutive equation is commonly used to describe the steady and uniform flow of debris flows.

$$\tau_{zx} = \tau_y + k\left(\frac{\partial u}{\partial z}\right)^n \qquad \tau_{zx} \geq \tau_y$$

$$\left(\frac{\partial u}{\partial z}\right) = 0 \qquad \tau_{zx} \leq \tau_y$$

where τ_{zx} is shear stress; *du/dz* is shear strain rate, and *k* and *n* are fluid index parameters. τ_y is the fluid yield stress.

Levees provide evidence of this flow possessing an effective yield strength.