

The Agents of Erosion

1. Erosion & Deposition
2. Water
3. Wind
4. Ice

1. Erosion and Deposition

Erosion is the physical removal and transport of material by mobile agents such as water, wind or ice.

The three common agents of erosion are:

- water
- wind
- Ice

These agents are mobile at the Earth's surface and are responsible for the transport of sediment.



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NWS

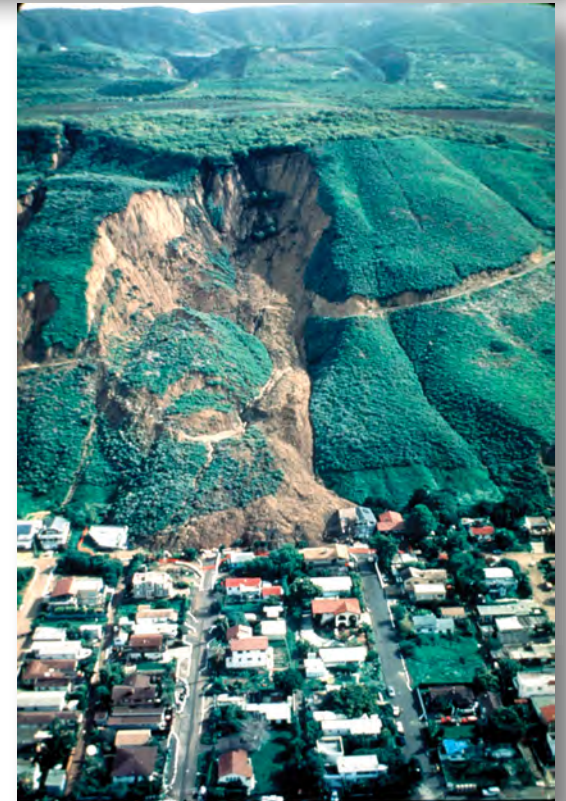


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Erosion and *mass wasting* appear to be similar processes but have distinctly different causes.

The movement of sediment by erosion *requires* mobile agents such as water, wind and ice. That is, the sediment is transported by the movement of the agents.

Mass wasting (commonly referred to as landslides) involves the transfer of rock and soil downslope under the influence of gravity. Gravity is the key factor in mass wasting and the movement of material does not require a mobile agent.



Weathering results in two types of products:

1. solid particles (sand grains, clay minerals, etc.)
2. dissolved constituents in water

These different types of sediment result in two fundamentally different types of sedimentary rocks:

1. ***detrital (clastic) sedimentary rocks*** - formed from transported solid particles (*detritus* or *clasts*).
2. ***chemical sedimentary rocks*** - formed by the precipitation of dissolved substances by either inorganic or biologic processes



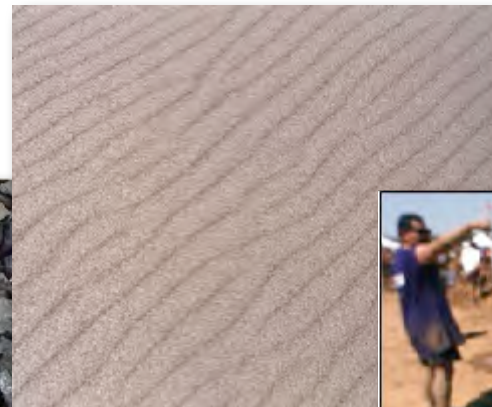
river rocks



salt flat

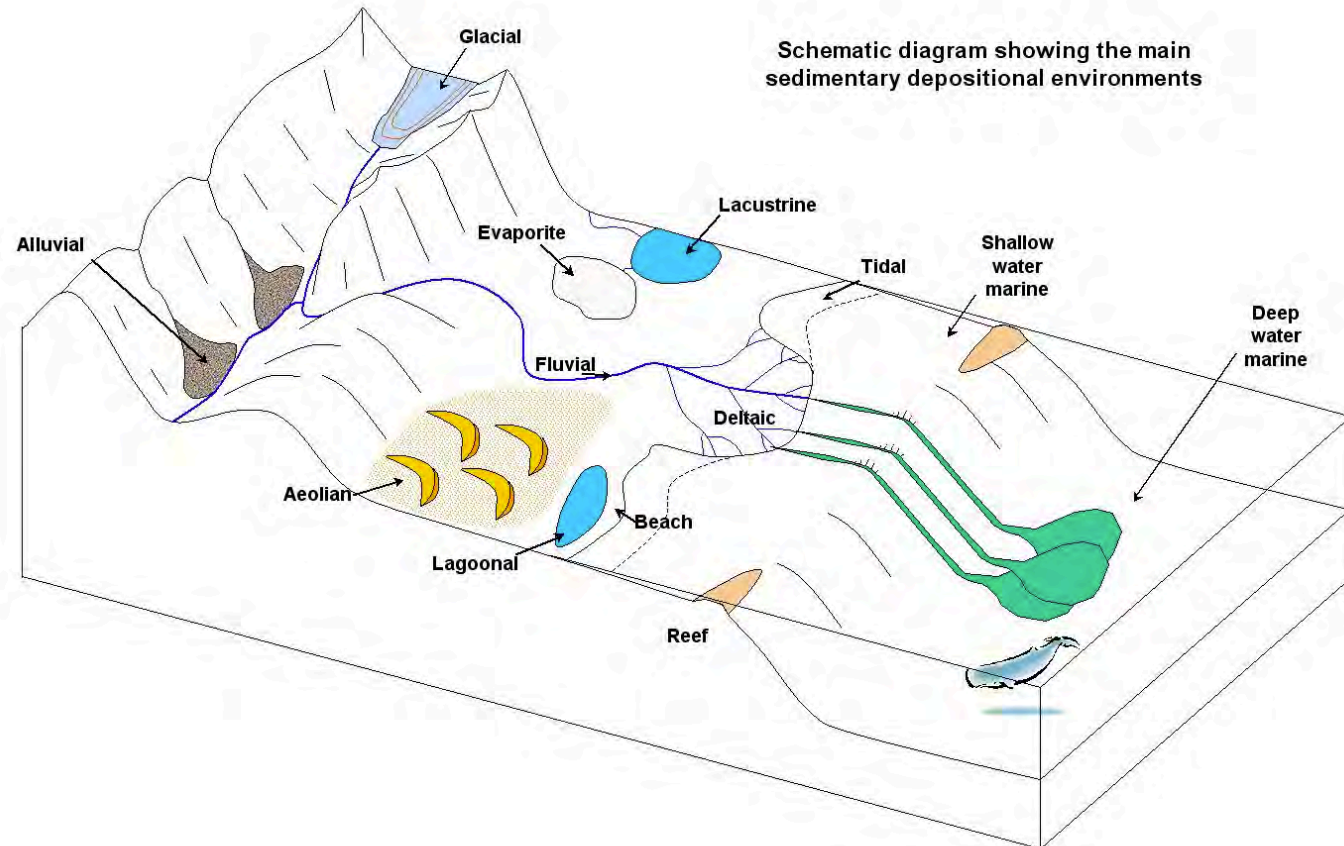
Particle Size Classification of Detrital Sedimentary Rocks

Size Range (mm)	Particle Name	Sediment Name	Rock Name
>256	Boulder	Gravel	Conglomerate or Breccia
64 - 256	Cobble		
4 - 64	Pebble		
2 - 4	Granule		
1/16 - 2	Sand	Sand	Sandstone
1/256 - 1/16	Silt	Mud	Shale or Mudstone
<1/256	Clay		



Erosion (transport of sediment) usually ends with the deposition of sediments (and soil). Deposition occurs when the forces responsible for erosion are no longer sufficient to transport the sediment.

There are a wide variety of environments on the Earth's surface where the deposition of sediments occur as the result of fluvial (rivers), aeolian (wind) and glacial (ice) erosion.



The particle shape may indicate information about origin and transport (rounded v. angular).

Sizes of particles can provide useful information about the environment of deposition:

- **Gravels** are found in high energy environments such as mountain streams and some beaches.
- **Sands** are found in intermediate energy environments such as beaches and river deposits.
- **Clays** are found in quiet environments such as lakes and the deep ocean.



2. Erosion by Water

Water is the most efficient and effective agent for erosion.

Erosion by water commonly occurs in two different geologic settings:

1. Coastlines – erosion that occurs on coastlines is due to the action of ocean currents, waves, and tides.
2. Streams and Rivers – erosion commonly occurs along the bank of the stream. A *stream* is any size channelized body of running water (small creeks to giant rivers).



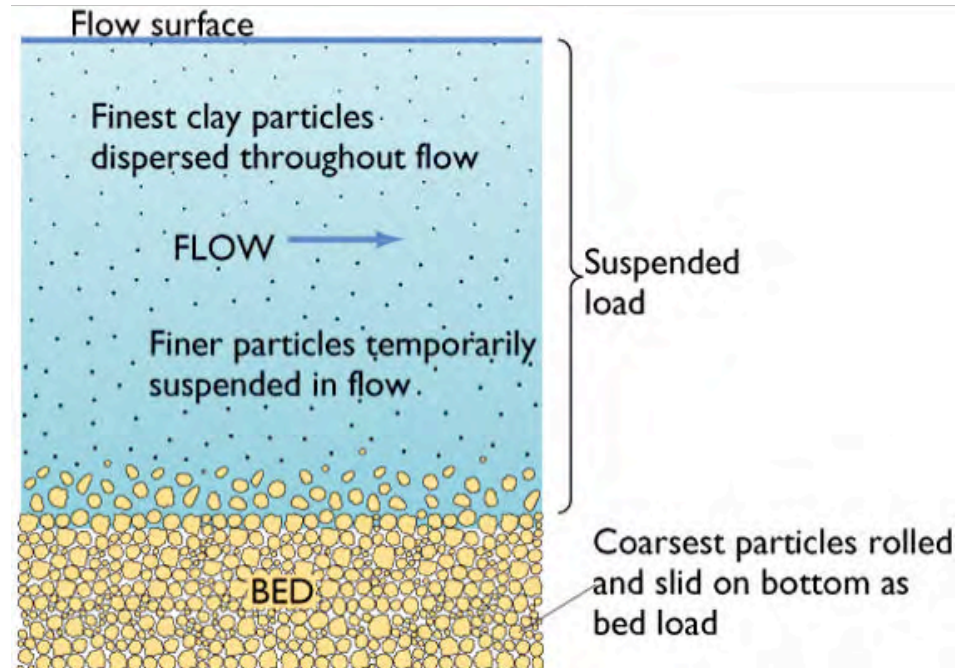
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Streams are able to transport sediment very long distances. There are different types of material carried by a stream depending on the size and chemical properties.

- 1) **Dissolved load** - transport of ions and chemicals in solution - responsible for the saltiness of the sea.
- 2) **Suspended Load** - typically the largest load - clays, silt and fine sand. This material settles out when the river slows (settling velocity) usually in an ocean or lake.
- 3) **Bed Load** - the material that is transported along the river bed - rolling, sliding and *saltation* - where the particles bounce or skip along the river bed.



The sediment found in a river bed is evidence of the type of sediment that is being transported.

The sediments found in a river bed are indicative of the energy of the river.

The *stream gradient* is the grade or the drop in elevation of a stream (as a ratio) and is usually expressed as feet/mile or m/km. The higher the gradient, the greater the energy in the stream.

Very high energy mountain streams can transport large particles, boulders and gravel whereas lower energy streams can only transport more fine sediment such as silt and clay.



Streams will erode the surface by cutting downward and tend to form V-shape valleys. Rivers with steep gradients tend to form steep walls. Rivers with shallower gradients tend to form broader valleys.



[Geographer Online](#)



[NPS](#)

When a stream has a very shallow gradient (nearly flat), most of the erosion is lateral (side to side) and sediment is deposited forming flood plains. The stream valley can be very broad and gentle.



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Streams form a wide variety of landforms due to erosion and the deposition of sediments.

Alluvial fans and deltas are landforms that result from the deposition of sediments. They are similar structures, and differ mainly by being deposited either above or below water. They are formed from the deposition of the sediment carried by the river it flows into a canyon or flatter plain (fan) or an ocean or a lake (delta).



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3. Erosion by Wind

Compared to running water and glaciers, wind erosion is relatively insignificant as an agent of erosion. It is more effective in dry lands compared to humid environments.

The photo to the right (NASA) shows a small dust storm blowing from Sudan onto the Red Sea.



NASA



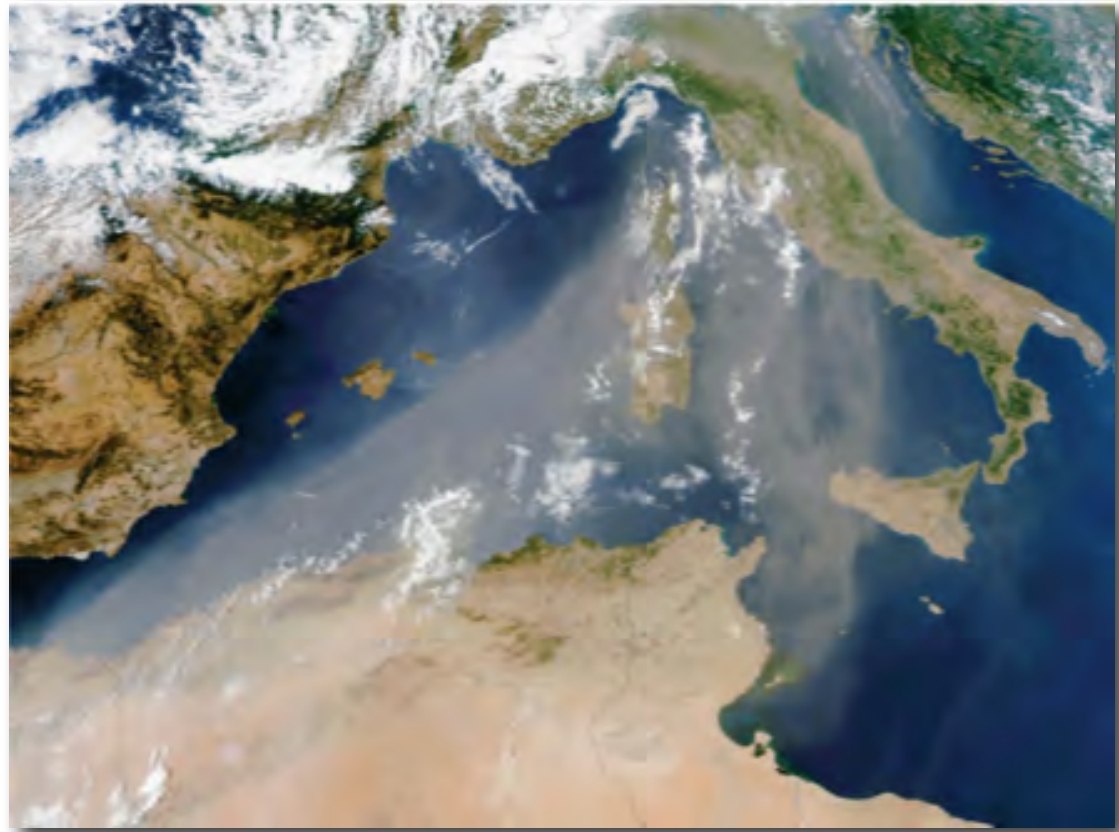
In the 1930's, large dust storms occurred in the midwest of the U.S. - "Dust Bowl." This occurred because of poor soil practices (elimination of vegetation) and a severe drought.

NOAA

The transport of sediment by wind differs from running water in two important ways:

1. Wind's lower density compared to water makes it less capable of picking up and depositing coarse material
2. Wind is not confined to channels - it can spread over large areas.

The suspended load of wind consists of silt and clay particles - small and platy grains may take days to settle down.



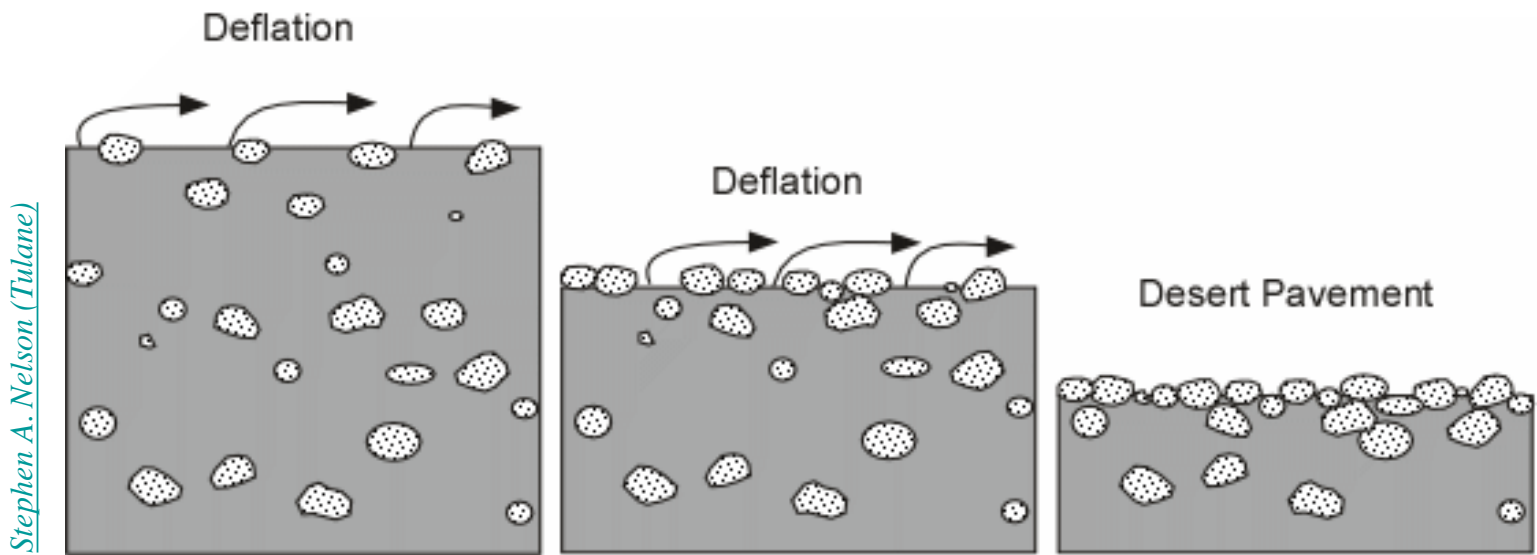
NASA satellite image of dust storm blowing off the Sahara Desert across the Mediterranean Sea toward Italy.

In arid regions, wind erodes the surface through a process called **deflation**. *Deflation* lowers the surface by removing the finer grain material (sand, silt, clay) and leaving the coarser material.



Mark A. Wilson

Desert pavement develops as a result of *deflation* leaving the surface covered with pebbles and cobbles. Other processes may also lead to the development of desert pavement.



Wind erodes by *abrasion* which can cause interesting shapes. The figure to the right shows the erosion (abrasion) of the lower softer limestone forming these shapes in the Libyan desert. Abrasion can be thought of as a type of mechanical weathering.



Thomas Wilken

Wind carrying sand particles can *abrade* surfaces, creating strange shapes and giving them a smooth polished appearance.



NSF

The wind sculpted rock to the left in the Dry Valleys, Antarctica.

Sand Dunes

Wind commonly deposits sand in mounds or ridges called *dunes*.



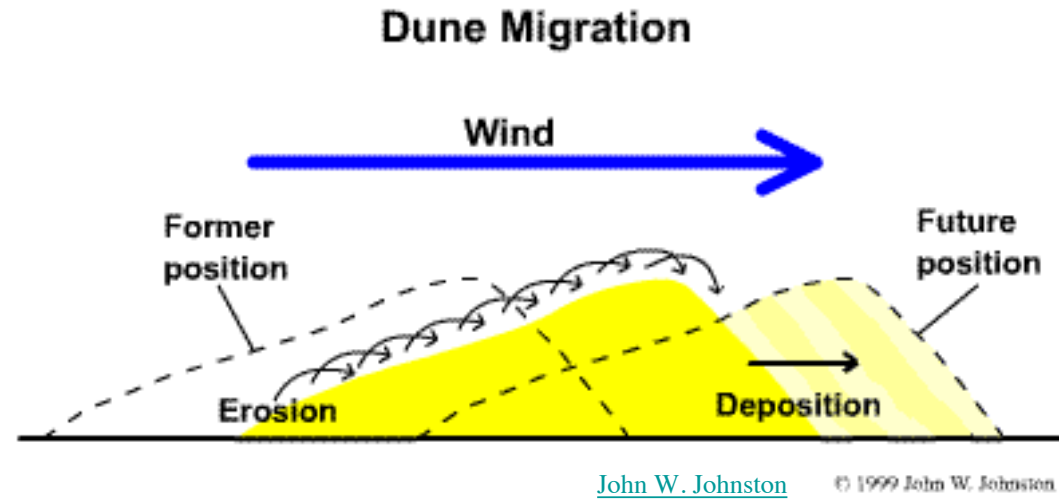
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Dunes commonly form around a clump of vegetation or a rock - where the wind velocity is decreased (wind shadow). The wind drops its sediment load making the obstacle even larger - self-propagating process.

Many dunes have an asymmetrical profile:

- steep leeward (downwind) slope
- gentle windward slope

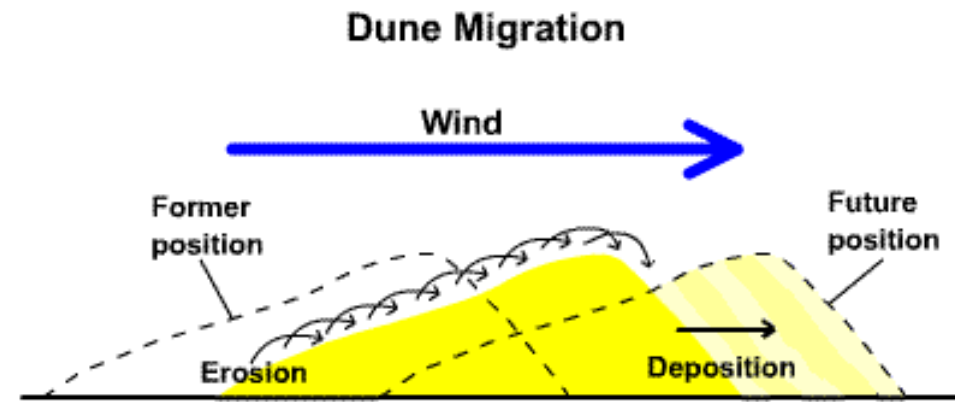


Sands move up the gentle slope by the force of the wind. At the crest, the wind velocity decreases and sand grains fall out and accumulate on the leeward side.

The leeward slope is about 34° - the angle of repose for dry sand.

This process of dune development results in the dunes migrating in the direction of the wind.

As the sand is deposited on the leeward side, the sand is inclined in the direction that the wind is blowing. These sloping layers are called *cross beds*.



[John W. Johnston](#) © 1999 John W. Johnston



The photo depicts a sandstone in Zion National Park that shows preserved sand dunes. Note the well-preserved *cross beds*.

4. Erosion by Ice

Glaciers cover nearly 10 % of the Earth (decreasing steadily), but in the past, about 30% was covered.

They are responsible for the basic character of:

- European and Southern Alps (NZ).
- Cape Cod & Long Island.
- Yosemite Valley, Glacier National Park, Grand Tetons
- Hudson Bay, Great Lakes, Fiords of Norway & Alaska



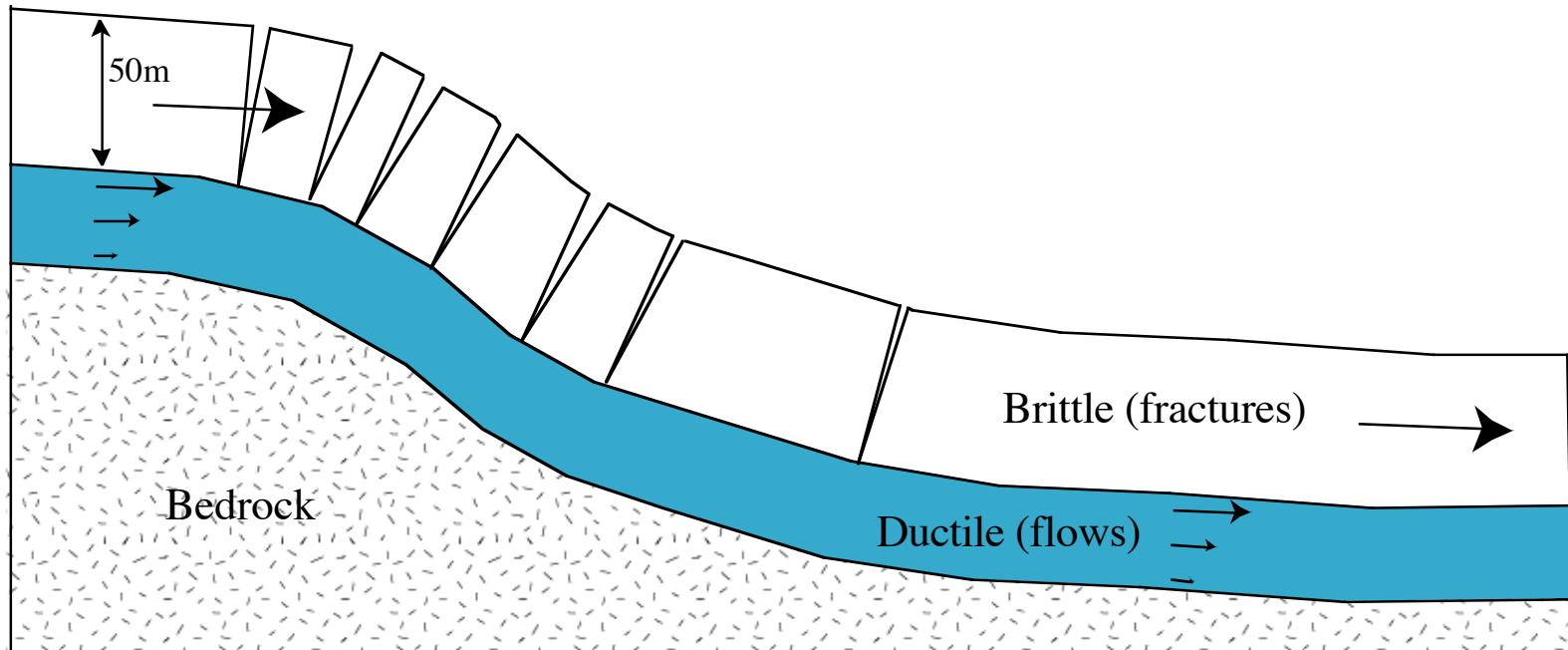
[Frank Paul, University of Zurich](#)



[NASA](#)

A *glacier* is a thick ice mass that originates on land by the accumulation, compaction and recrystallization of snow.

- Glaciers are capable of flow, and therefore move downhill under the force of gravity.
- When ice accumulates to greater than 50 m thick, the ice below 50m can flow. The ice above 50 m remains brittle, below it is ductile.



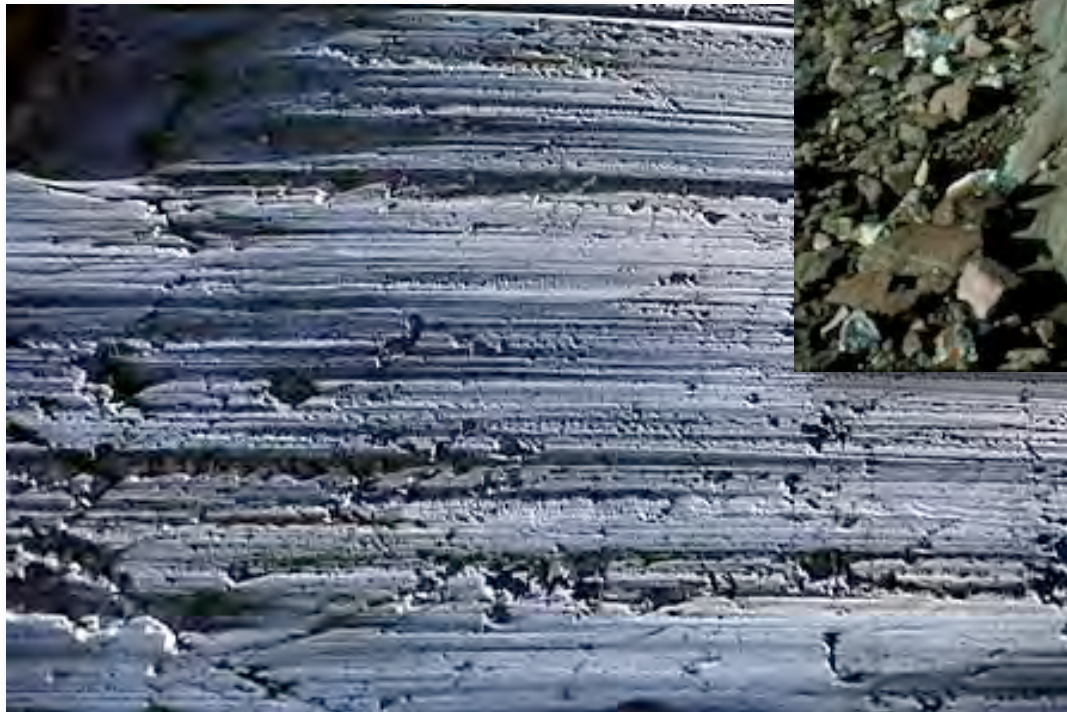
Glacial Erosion

As sediment-laden ice moves over rocks, it *abrades* (polishes) them and may leave grooves or *glacial striations* on the rock surface.

Glacial abrasion can be thought of as a type of mechanical weathering.



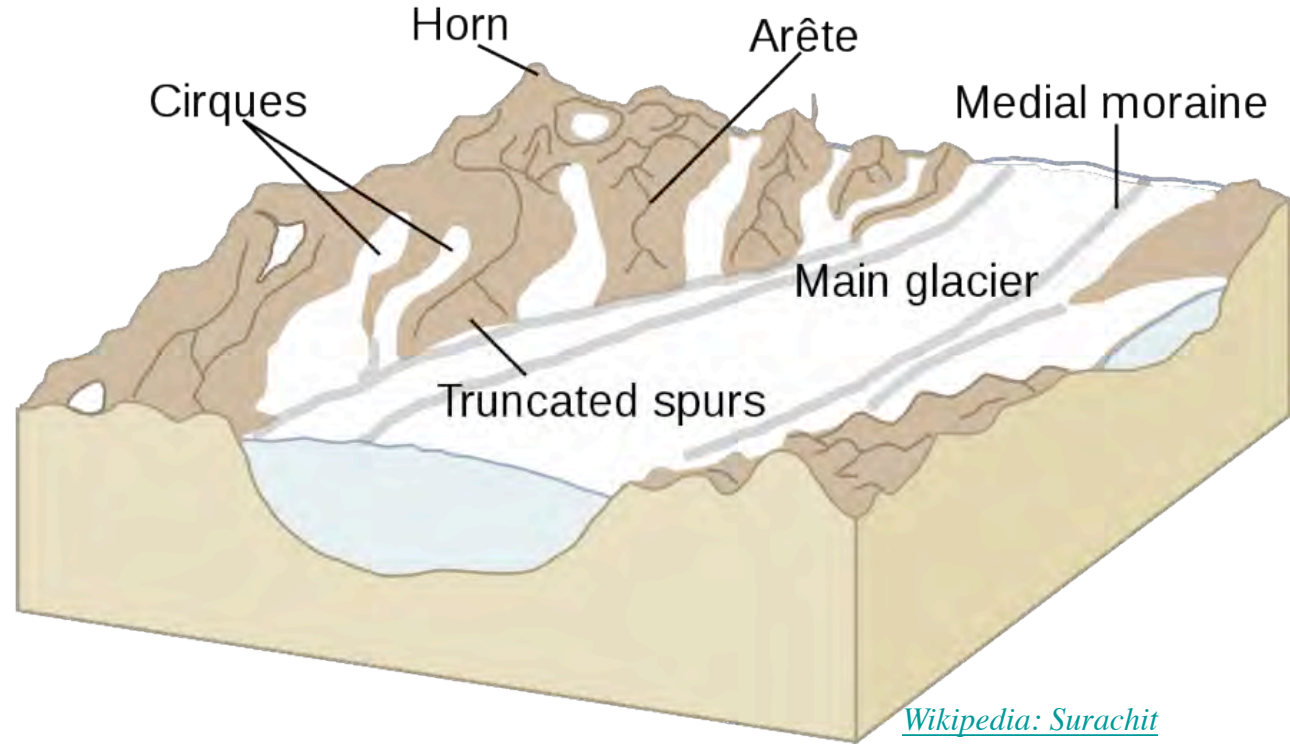
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Tom Lowell NSIDC

Glacial Landforms

Ice as an agent of erosion can move large quantities of rock and sculpt the surface with landforms that are distinctive to glacial erosion.



[Wikipedia: Surachit](#)

Glaciated Valleys

Prior to glaciation, mountain valleys are typically V-shaped from stream erosion.

During glaciation they are deepened and widen - creating a U-shaped valley.

After a glacier melts or retreats, it may be further modified by a stream and form a V-shaped valley

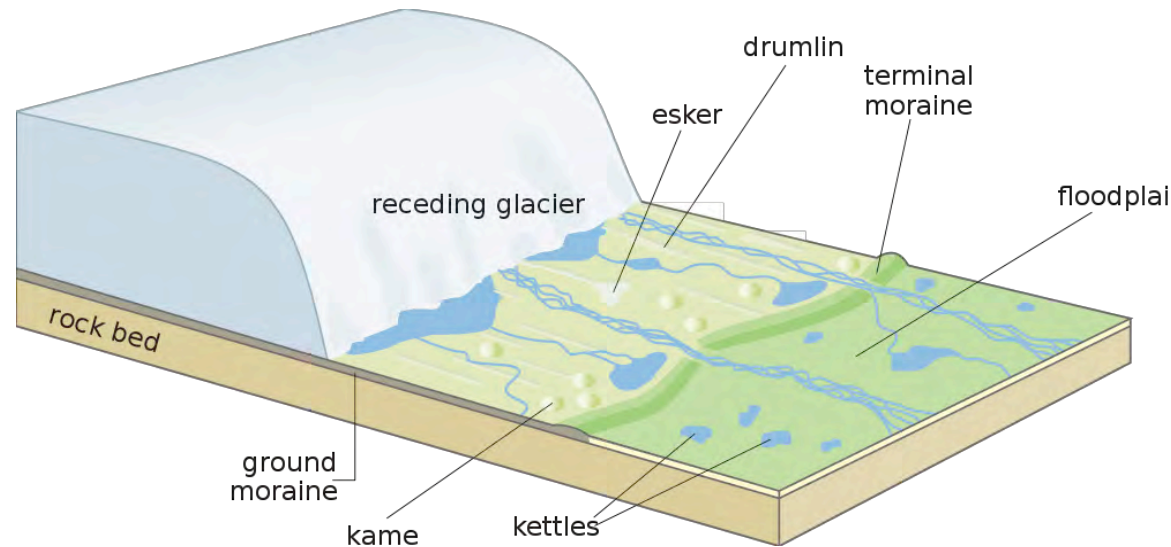


Glacial Deposits

The general term for all types of glacial materials is *glacial drift*.

Drift can be broken into 2 groups:

- 1) *Glacial Till* - material that is *deposited directly* by a glacier and is not sorted by size , and;
- 2) *Stratified Drift* or *Outwash* - deposited by *meltwater* from the glacier and the sediment is sorted according to size.



Glacial drift is deposited in a wide variety of landforms

Moraines are a deposit of sediment that forms from the direct action of a glacier.

The figure on the right shows the different types of moraines that can be formed.

The image below shows lateral moraines exposed after the retreat of the glacier.

