8.1.1: Glacial Environments

Glacial environments are defined as those where ice is a major transport process. Liquid water and wind can also transport sediment in these environments. Wind transport is common when there is little vegetation. Liquid water transport occurs when the ice melts.

As you all remember, the high viscosity of ice makes all ice transport of sediment laminar. Thus, grain sizes are not sorted. All of the sediment is transported together, with the ice, and it is deposited when the ice melts. There are several features that are characteristic of glacial environments, including the process of erosion.

Erosion

Erosion in glacial environments is dominated by physical processes:

1. ice freezing in cracks in rocks, breaking them up
2. flow of glaciers “plucking” rocks up from the base of the flow
3. grinding of rocks against each other and against the floor of the glacial valley as the ice flows

These processes produce some distinctive sedimentary features including:

1. faceted clasts, e.g. rocks with smoothed off faces from dragging against other rocks
2. striations and grooves in rocks from dragging against other rocks
3. flat valley floors called glacial pavements that are smoothed off due to glacial flow
4. rock flour, which is clay size lithic grains formed from the bits of rock that are abraded off as facets, striations, grooves, and glacial pavements form.

There is often little chemical weathering in glacial environments because temperatures are cold.

Deposition

Ice flows are laminar because they have very high viscosity. This can be seen in the ice cliffs along the edges of glaciers in Taylor Valley, Antarctica. The ice is particularly cold and is so viscous that it does not flatten out on the time scale of at least dozens of years. Because the flow is laminar, when the ice melts or sublimates, it dumps all grain sizes into one deposit, forming a diamictite. If one knows that the diamictite was deposited by ice, it is then called till or tillite. If the glacier melts on land, it leaves piles of till in moraines. If it melts over water, the debris is deposited into the water, commonly forming a till sheet. If only a few large clasts are deposited in the water, they are called “drop stones”. These commonly are deposited by melting ice bergs that carry large grains out over lakes or the ocean, where they are deposited in (nearly) standing water.

As glaciers melt over land, melt water commonly reworks glacial till into braided river deposits. In arid environments, much less reworking of the sediment takes place.

Glacial Facies Assemblage

For illustrative purposes, I am describing the glacial facies as an assemblage of other facies.

Morraine Facies

1. Composed of diamictite; no sedimentary structures.
2. Diamictite in mounds.
3. Clast composition mostly lithic fragments, including silt and clay-sized rock flour.
4. Clasts mostly angular, some with facets and striations.

Till Sheet Facies

1. Composed of diamictite; sedimentary structures suggestive of turbidites in rare sandstone interbeds.
2. Diamictite in sheets with rare shale and sandstone interbeds.
3. Clast composition mostly lithic fragments, including silt and clay-sized rock flour.
4. Clasts mostly angular, some with facets and striations.

Distal Glacial-Lacustrine/Marine Facies

1. Shale with isolated large clasts and sandstone interbeds with sedimentary structures suggestive of turbidites.
2. Clast composition mostly lithic fragments.
3. Clasts mostly angular.
4. Frequency of large clasts decreases away from the glacier.
Braided River Facies
We will describe these later.

The parts of the glacial facies assemblage that are observed depends on whether the glacier ends on land or in standing water. Thus, the way I have described the facies here are particularly good for studying the environment for the glacier. If one wanted to determine how ice sheets around Antarctica have advanced and retreated through time, one would want to subdivide the Till Sheet Facies and Distal Glacial-Marine Facies into smaller groupings that would help locate the edge of the ice sheet. In contrast, if one wanted to distinguish between alluvial fan deposits and glacial deposits in Owens Valley, CA, one would want to pay particular attention to the geometry of the diamictites because they form in both environments, but the geometry of the deposition are different.