Background Reading: Glaciers on Mars

Like great rivers of ice, glaciers have sculpted mountains and carved out valleys. Even today they continue to flow and shape the landscape in many places. Glacier ice is the largest reservoir of fresh water on Earth, and second only to oceans as the largest reservoir of total water.

Like on Mars, most of the Earth’s glaciers are found near the Poles. However, unlike Mars, terrestrial glaciers can also be found in high mountains in the temperate zone and very high mountains in the tropics – places where snow remains throughout the year and is buried by the next year's snow. Glaciers exist on six of seven of the world’s continents, even Africa. Australia is the only continent to not have a glacier. However, Oceania, a geographical region consisting of numerous lands in the Pacific Ocean that includes Australia, Papua New Guinea and New Zealand, does have glaciers as both Papua New Guinea and New Zealand have glaciers.

Geologic features created by glaciers include end, lateral, ground and medial moraines that form from glacially transported rocks and debris, U-shaped valleys and cirques at their heads.

The upper part of a glacier that receives most of the snowfall is called the accumulation zone. In general, the accumulation zone accounts for 60-70% of the glacier's surface area. When enough mass has accumulated the ice slowly deforms and flows in response to gravity. After the glacier is gone, this often leaves a bowl or amphitheater-shaped depression called a cirque.

At the opposite end of the glacier is the ablation zone, ablation is the depletion of ice or snow from the glacier. Here more snow is lost through melting, evaporation, iceberg calving and sublimation exceeds annual gain of snow and ice on the surface. Ablation may result from wind erosion, melting, and evaporation. The zone of ablation is the part of the glacier where ice melts faster than it can be replaced by snowfall. The base of the glacier is called the terminus, snout or toe. This is where the glacier deposits all manner of debris.

The ablation zone, zone of ablation or zone of wastage is the area in which annual loss of snow through melting. Of these, melting is most important in most glaciers, but the others, especially iceberg calving, can be significant.

Crevasses. Crevasses. An acceleration in glacier speed can cause the formation of a crevasse—a crack or fissure sometimes running hundreds of feet deep. Crevasses are one of the phenomena that make the navigation of glaciers deadly. Once a crevasse has occurred, subsequent heavy snow may create a perilous bridge from one side to the other. The snow bridge may hide the crevasse from the eyes of skiers, hikers and climbers, who have been forced to develop special tools and techniques to protect and extricate themselves.

In between the accumulation zone and ablation zones, U-shape valleys medial moraines.
The altitude where the two zones meet is called the equilibrium line, also called the snow line. At this altitude, the amount of new snow gained by accumulation is equal to the amount of ice lost through ablation. Due to erosive forces at the edges of the moving ice, glaciers turn V-shaped river-carved valleys into U-shaped glacial valleys.

The "health" of a glacier is defined by the area of the accumulation zone compared to the ablation zone. When directly measured this is glacier mass balance. Healthy glaciers have large accumulation zones. Several non-linear relationships define the relation between accumulation and ablation.

Evidence suggests that even Mauna Kea has had glaciers. Research has found four glacier episodes occurred over the last 300,000 years. The youngest glacial episode reached its maximum sometime after 30,000 years ago and disappeared from Mauna Kea summit before about 9,100 years ago. Glacier may also have existed on Mauna Loa, but if so all evidence of hem has been buried by more recent lava flows. None of the other Hawaiian mountains are as high as the low point reached by the glacier on Mauna Kea, and consequently they were not cold enough to have had ice caps.

There are two main types of glaciers: valley glaciers and continental glaciers (also known as ice sheets).

Glaciers require very specific climatic conditions. Most are found in regions of high snowfall in winter and cool temperatures in summer. These conditions ensure that the snow that accumulates in the winter isn't lost (by melt, evaporation, or calving) during the summer. Such conditions typically prevail in polar and high alpine regions. Under such conditions it accumulates to greater and greater thickness, and beneath the surface the delicate and beautifully-shaped snowflakes are gradually transformed; first to granular snow consisting of little lumps of ice, and finally into ice. When the accumulating ice reaches a sufficient thickness it starts to flow outwards and downwards under the pressure if its own weight, and becomes a glacier. We do not ordinarily think of a solid as being capable of flow, but actually all solids can flow under certain conditions, and ice flows more easily than most.

*Glaciers continually move, transporting mass from higher to lower elevations, somewhat like a conveyer belt. If the combination of climate and ice dynamics determines that the glacier is also advancing, the effect of the advance of the terminus is to increase the overall glacier area; however, because glaciers move slowly, a significant time lag occurs between the climatic conditions that caused the advance or retreat, and the actual advance or retreat. This time lag may last several years or longer, and is determined by the complicated and sometimes uncertain processes that control how fast the glacier moves.*

The amount of precipitation as snowfall is important to glacier survival. In areas such as Antarctica, where the low temperatures are ideal for glacier growth, very low annual precipitation causes the glaciers to grow very slowly.
In polar and high-altitude alpine regions, glaciers generally accumulate more snow in the winter than they lose in the summer from melting, ablation, or calving. If the accumulated snow survives one melt season, it is considered to be firn. The snow and firn are compressed by the overlying snow, and the buried layers slowly grow together to form a thickened mass of ice.

The pressure created from the overlying snow compacts the underlying layers, and the snow grains become larger ice crystals randomly oriented in connected air spaces. These ice crystals can eventually grow to become several centimeters in diameter.

As compression continues and the ice crystals grow, the air spaces in the layers decrease, becoming small and isolated. This dense glacial ice usually looks somewhat blue.

Glaciers move by internal deformation and/or by sliding at the base. Internal deformation occurs when the weight and mass of a glacier causes it to spread out due to gravity.

Sliding occurs when the glacier slides on a thin layer of water at the bottom of the glacier. This water may come from glacial melting due to the pressure of the overlying ice, or from water that has worked its way through cracks in the glacier. Glaciers can also readily slide on a soft sediment bed that has some water in it. Basal slip may account for most of the movement of thin, cold glaciers on steep slopes, or only 10 to 20 percent of the movement of warm, thick glaciers lying on gentle slopes.

When a glacier moves rapidly, internal stresses build up in the ice that cannot be relieved by deformation alone, and cracks (called crevasses) form at the surface of the glacier.

Glaciers dramatically impact their surrounding environment by reshaping the underlying and surrounding landscape as they move, through both erosion and deposition.

Glaciers erode the rock underneath them. A glacier can carve a valley, wearing away rocks and soil through abrasion and plucking up and moving large pieces of rock and debris. The glacier pushes this earth and rock forward as it advances, almost like a conveyor belt, and dumps it to the side along the way or at the end of the glacier (deposition). Depositional features include moraines, drumlins, and eskers.

As large glaciers retreat, the underlying ground surface is typically scoured of most materials, leaving only scars on the underlying surface.

Glacier retreat, melt, and ablation, result from increasing temperature, evaporation, and wind scouring. Ablation is a natural and seasonal part of glacier life. As long as snow accumulation equals or is greater than melt and ablation, glacier health is maintained.
Over the past 60 to 100 years, glaciers worldwide have tended toward retreat. Alpine glaciers, which are typically smaller and less stable to begin with, seem particularly susceptible to glacial retreat. Whether this is due to a predictable climate trend or because of increased human impacts on global climate remains to be determined.

In the aftermath of the Little Ice Age, around 1850, the glaciers of the Earth have retreated substantially. Glacier retreat has increased since the 1980s, the coldest decade since 1900.

http://nsidc.org/data/atlas/index.html (National Snow & Ice Data Center)