Formation of glacial ice

The primary source of ice in a glacier is snowfall. The transformation of snow into ice is not simple and involves a complex sequence of compression, partial melting and re-freezing. The process begins when snow at the base of a thick snow pack (5-10m) (Photo) is compressed by the weight of the overlying snow into a mass of granular ice crystals called firn, a change that may occur over one winter-summer cycle. The transformation of firn into ice occurs as summer meltwater from the snowpack above percolates down into firn and re-freezes, which causes the voids between the ice crystals to freeze up and close. The final conversion into true glacier ice only occurs when the weight of the overlying ice squeezes any remaining air bubbles out of the ice mass. The transformation of firn into ice may occur within 5 years in temperate environments as snowfall is high and the relatively high summer air temperatures frequently melts the surface snowpack. In contrast, the transformation in polar areas may take 10's or even 100's of years since there is little or no surface melting and limited snowfall.

Material	Structure	Density
Snow	feathery hexagonal ice crystals and trapped air bubbles	0.02-0.05 g/cm^3
Firn	a mass of granular ice crystals separated by air voids	0.5 g/cm^3
Impure glacial ice	solid ice containing trapped air bubbles	0.8 g/cm^3
True glacial ice	solid ice with no air bubbles	0.9 g/cm^3

Table: The density of materials associated with the transformation of snow into ice (note: the density of water is 1.0 g/cm3, which being heavier than ice explains why ice floats in water).

Snowline

Snowbanks on the mountain slope in Kazakhstan

Since glacial ice only forms in areas where snow can lie throughout the year, the accumulation zone (i.e. the region where glaciers gain mass) of glaciers must lie above the snowline, the lowest altitude of snow that has survived summer melting. (Photo) The height of the snowline declines with latitude in response to decreasing temperatures (Table 4) and more locally varies across valleys because of the effect of aspect. For instance, in the Northern Hemisphere the snowline is lower on north facing slopes as these receive less solar insolation.

Region	Latitude	Altitude of Snowline
Kilimanjaro	0°	5500 m
European Alps	44-47°N	3500 m
Southern Norway	60-63°N	1500 m
Greenland	80-83°N	Sea Level

Table: The relationship between latitude and the altitude of snowlines in the Northern Hemisphere

Photo: Snowbanks on the mountain slope in Kazakhstan