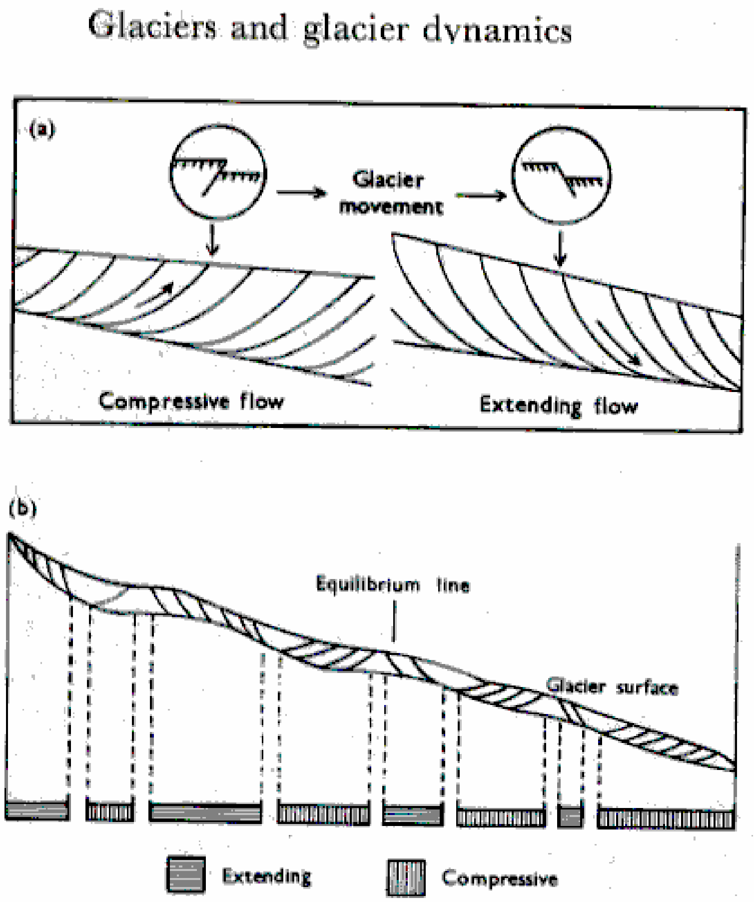
How and Why Glaciers Move.

1. **Creep** – This is the gradual deformation of the ice of a cold (polar) glacier owing to internal pressure and accompanying intergranular motion.
2. **Fracture** – Internal compression or tension in glacial ice can cause it to fracture along fracture planes. The most obvious fractures occur close to the surface as crevasses.
3. **Basal Sliding/Slippage** – the sliding movement of a warm (temperate) glacier over its rock floor. Plastic deformation takes place, resulting from the gradient of the slope and the weight of the ice.In a warm (temperate) glacier, the process of creep can be enhanced at the base of a glacier due to **pressure melting**. Meltwater at the base of the glacier can act as a lubricant and reduces friction.



Intergranular yielding or plastic deformation: the glacial ice can flow within individual crystals as a result of internal gliding along the crystallographic planes. This process does not destroy the coherence of the solid ice and it does not disrupt or alter the crystal's internal atomic arrangements. It is thought to be a principle mechanism in *glacial flow*. Not to be confused with *intergranular adjustment.*

Intergranular adjustment: individual ice crystals reposition themselves under stress assisted by localised pressure melting and vapour transfer (sublimation). This process is thought to be of minimal importance in *glacial flow*, but a significant factor in the deformation of *névé*.

Pressure melting point: the pressure at which ice can be induced to melt as a result of increased pressure. At the surface of a *glacier* the melting point is about 0^{o}C, but at depth within a *glacier* this temperature declines because of the increased pressure of the overlying ice.

Regelation: The process of refreezing of ice subsequent to melting caused by pressure. Ice that melts under pressure may flow within, or below the *glacier* to a place where pressure is lower and then refreeze.

Extending Flow: the extension and related thinning of ice in a glacier when the surface velocity increases. In the zone of extending flow, the slip-lines within the *glacier* descend to the ice rock interface. The slip-lines, caused by shear stress, curve down towards the glacier bed and are always located over the crests and rises in the rock floor. They are also found in the steeper gradients within the *accumulation zone* where velocities are at their greatest.

Compressing flow: a term used to describe the flow of a glacier whereby a reduction in the surface velocity leads to an increase in the thickness of a glacier. The phenomenon is characterised by the appearance of shear planes along which the ice rides obliquely upwards due to compressive stresses. The compression may be caused by the narrowing of the valley, a decrease in velocity at the bottom of an icefall or by the termination of the glacial flow at the

snout. Zones of *extending flow* alternate with zones of compressing flow and both are responsible for the formation of transverse *crevasses*.
Crevasses: deep fissures of variable width within the surface of a glacier. Differential movements within the ice resulting from shear stress cause them. Crevasses can be transverse (usually when the glacier move down a steep gradient) or longitudinal (pointing up the glacier) partly because the glacial sides move more slowly than the centre, and partly because the glacier spreads laterally when its valley broadens. When both types of crevasse intersect, **ice pinnacles** will form. Crevasses allow *meltwater* and rock debris to penetrate the glacier.

The Difference between Cold and Warm Glaciers

Cold (polar) glaciers: The ice temperature may be as low as -30^{O}C throughout the year so there is no appreciable surface melting. The lack of *meltwater* means there is no *basal slippage*, as the glacier remains frozen to the underlying rock. Movement only takes place, very slowly, under great shear stress.

Warm (temperate) glaciers: These are characterised by having all but the surface 10-20m of ice at its pressure melting point. The surface layer will have temperatures below 0^{O}C for at least part of the year but this cold layer will disappear before the end of the summer. The large quantities of *meltwater* at all levels in the ice, especially at its base, leads to high rates of *basal slippage* and considerable glacial erosion by plucking and abrasion as the ice slides with relative ease over the underlying rock. Warm glaciers are usually faster flowing than *cold* or *polar glaciers*.

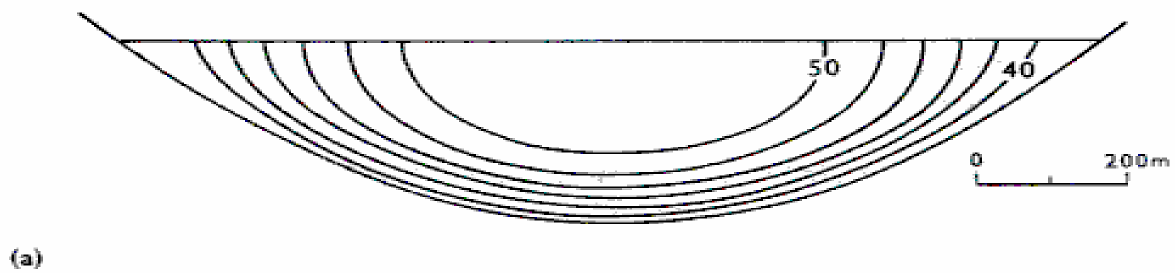
Velocity increases with distance from the bedrock as frictional drag is lower. In a valley glacier, maximum velocity is achieved in the central and upper layers.

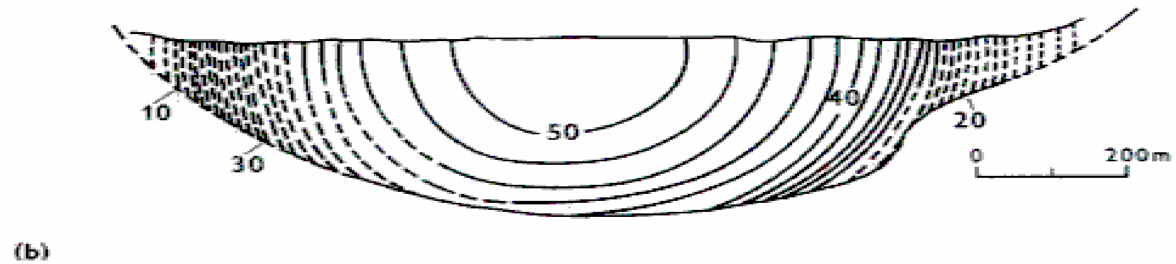
The distribution of velocity in glacial channels.

(a) A glacier with no basal slip - a cold (polar) glacier

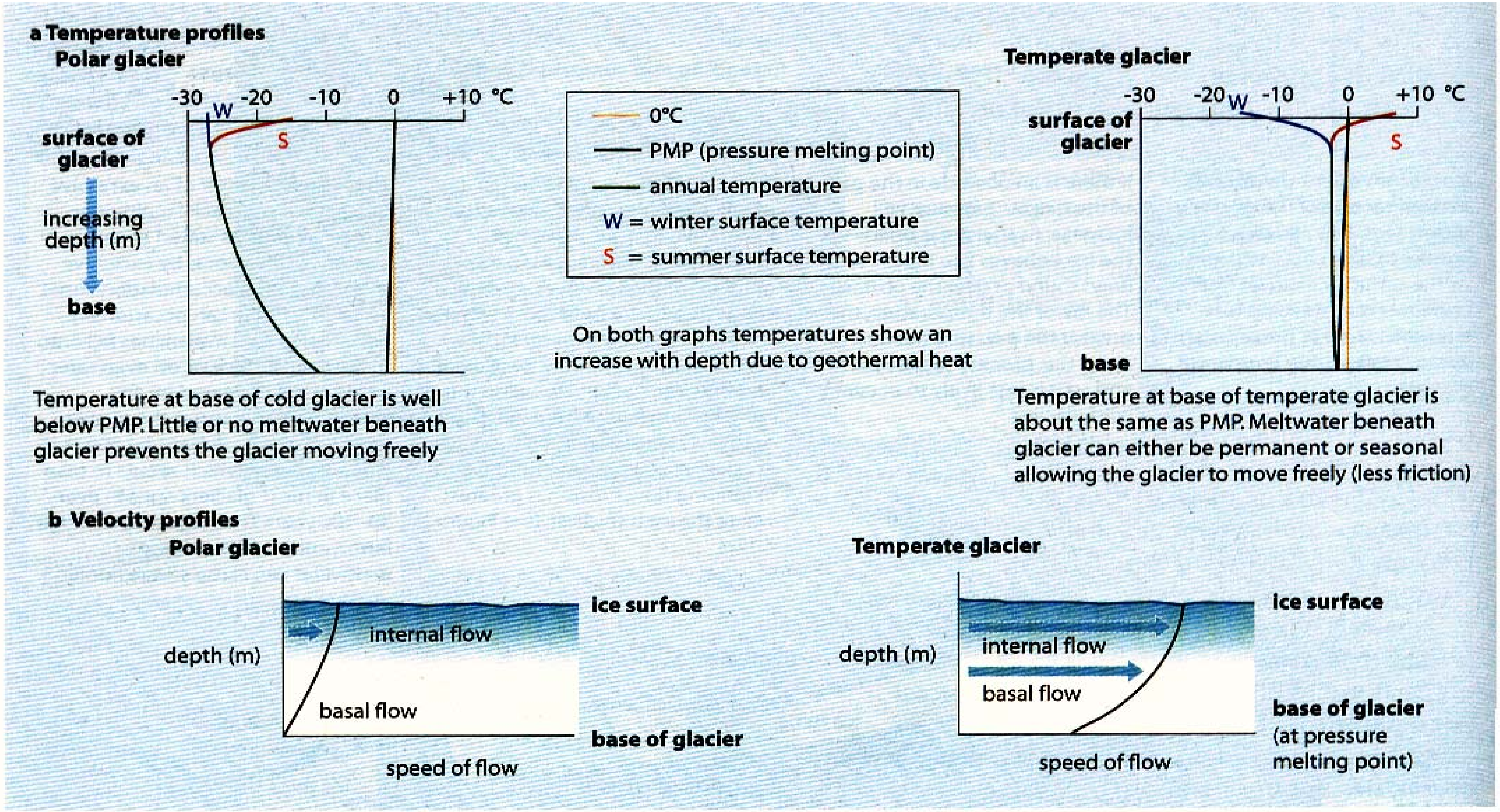
(b) The Athabasca glacier (with basal slip) – a warm (temperate) glacier.

"isovels" are in metres per year.





You need to be familiar with the temperature profiles of cold and warm glaciers and how these relate to the processes of movement and rates of movement (SEE DIAGRAM ON NEXT PAGE).



Temperature and Velocity Profiles of Polar (Cold) and Temperate (Warm) Glacier – see Waugh p108 for colour version)