

GLACIAL GEOLOGY LECTURE #3.

ICE FLOW

DEFORMATION

Flow by gravity
Single x-tal vs. large ice masses
Stress and Strain Rate (Fig. #1)

$$\tau = \rho gh \sin a, \text{ Basal shear stress - yield stress - 100 kPa}$$

Temperature dependence

SLIDING

Simple translocation slips
Pressure melting
Enhanced basal creep
Cavities (Fig. #2)

INTERLAYER

Deforming beds
Slippage

TYPICAL VELOCITY PROFILES. (Fig #3)

TEMPERATURE PROFILES

CONTROLLING FACTORS (Fig. #4, 5)

Gradient
Surface Temperature
Basal Temperature
Ice Thickness

PRESSURE MELTING POINT

CONTROLS ON EROSION

Flow lines down
Flow lines up

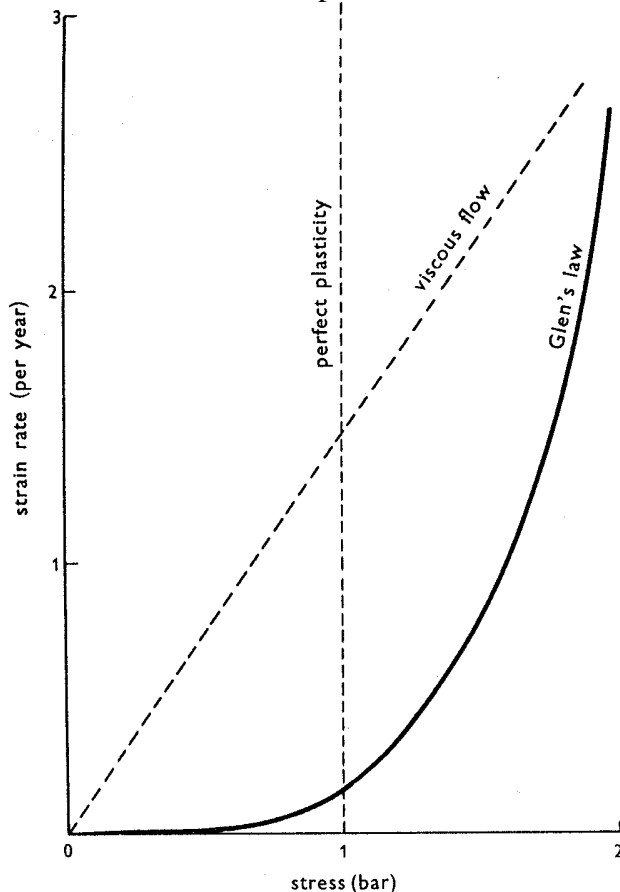


Figure 1. Various models of the relationship between stress and strain rate. Glen's law is contrasted with perfect plastic flow and viscous flow (Paterson, 1969).

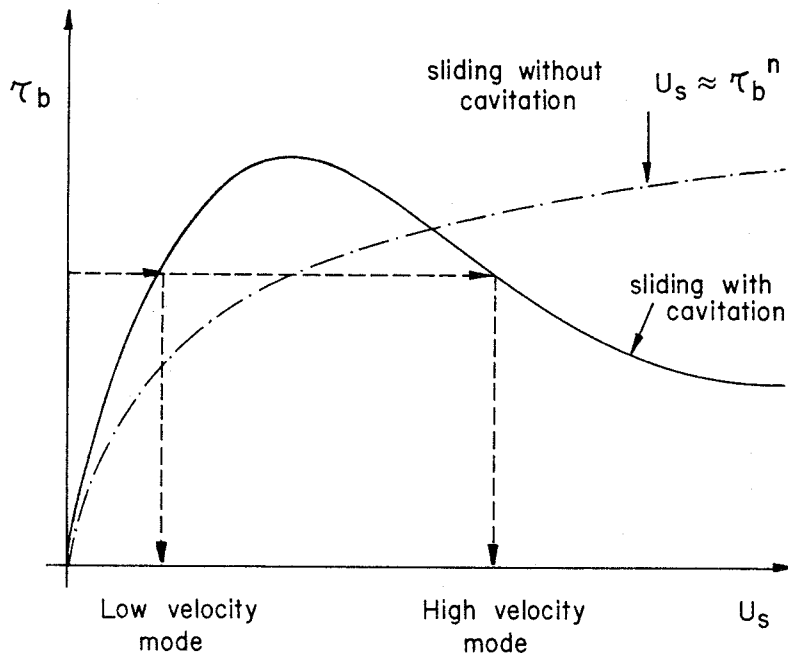


Figure 2. Relationship between sliding velocity and basal shear stress for sliding without cavitation. The possible double-valued characteristic of the sliding law giving a high and a low velocity mode for a single value of τ_b where there is cavitation (modified from Hutter, 1982)

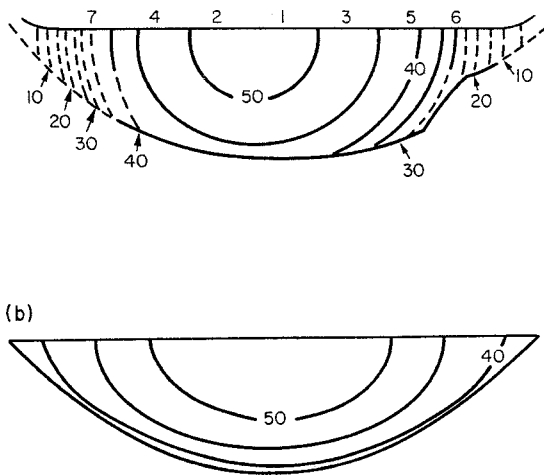


Figure 3. a) Distribution of longitudinal velocity in cross-section of Athabasca Glacier measured by Raymond (1971). Points 1 to 5 are positions of boreholes. Surface measurements at points 6 and 7. b) Computed velocity distribution from Nye(1965). Units in m/yr.

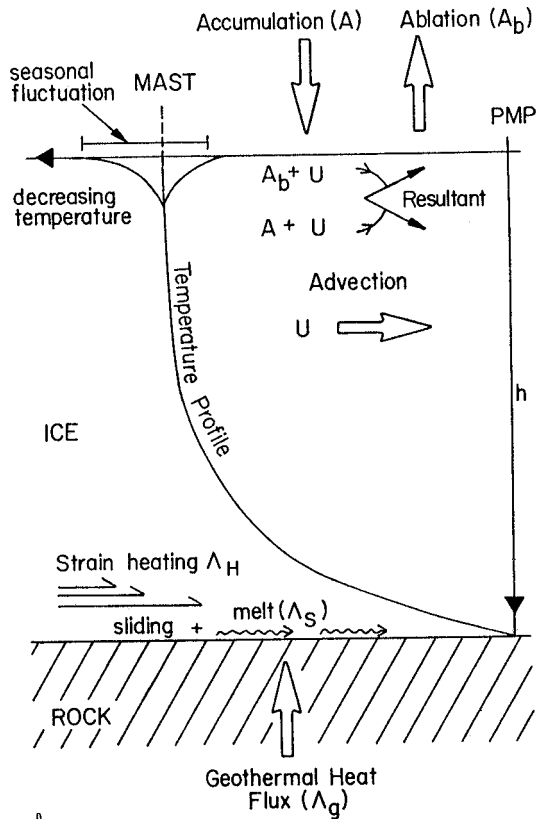


Figure 4. Factors affecting the vertical temperature profile in an ice mass. Seasonal variations and mean annual surface temperatures (MAST) are shown. PMP= pressure melting point. The effects of surface snow accumulation (A) and ablation (A_b), and ice motion (U) are also included. The resultant direction of ice movement and thus heat transport is shown.

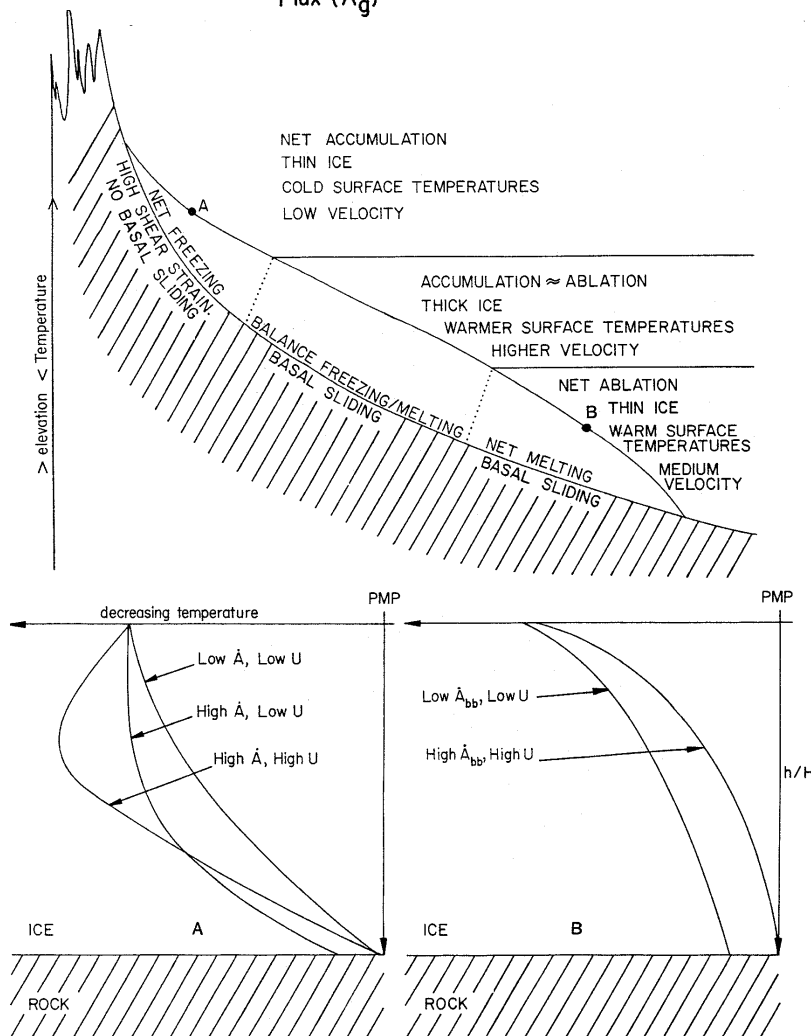


Figure 5. Composite model of the thermal regimes of a valley glacier showing the variety of conditions that are possible and controlling parameters. Typical vertical profiles for points A and B are shown beneath. A) Temperature profiles in the accumulation zone of an ice mass for specified rates of accumulation (\dot{A}) and horizontal ice velocity (U). The depth scale has been normalized. B) Temperature profiles in the ablation zone of an ice mass for specified rates of ablation (\dot{A}_b) and horizontal ice velocity (U).