

Name _____

10 Points

Glacial Shear Stress

LEARNING OUTCOMES

By the end of this assignment you should be able to:

- Calculate shear stress for glaciers;
- Describe the impact of shear stress and strain rates on glacial flow rates; and,
- Describe variations in glacier flow velocity with depth and explain why that variation exists.

INTRODUCTION

Researchers dug a 35 m deep pit in Panda Glacier. They embedded a set of pins in the wall of the pit in a perfectly straight vertical line (★ in the figure below). One year later they returned to find that the pins had all moved to new positions (⊗ in the figure below). The depth of the first pin is 15 m below the glacier surface and the depth of the last stake is 35 m below the surface. The base of the glacier is 400 m below the surface (i.e. the ice is 400 m thick).

Ice flow through plastic deformation involves a strain response to shear stress. Shear stress, τ , is defined by the equation:

$$\tau = \rho \times g \times h \times \sin\theta$$

where:

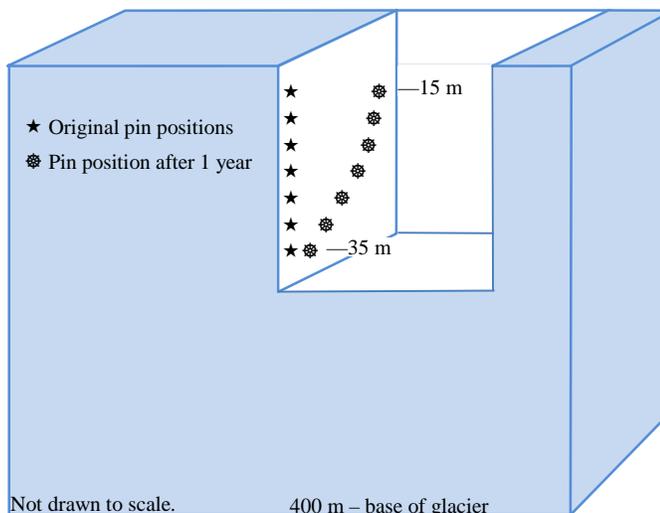
- ρ = density of ice = 900 kg/m³
- g = acceleration of gravity (9.8 m/s/s)
- h = thickness (height) of glacier above a point
- θ = slope of underlying surface = 3° in this case

Glen's Flow law says the strain rate (i.e. the flow rate) equals a constant times the shear stress cubed:

$$\epsilon = A\tau^3$$

where:

- ϵ = is the strain rate
- A = constant related to ice temperature
- τ = shear stress at a point



QUESTIONS

1. What is the shear stress at 15 meters, the top of the pit? [1]

2. What is the shear stress at 35 meters, the bottom of the pit? [1]

3. What is the shear stress at the base of the glacier? [1]
4. Assuming the constant in Glen's flow law equals one ($A = 1$), what is the strain rate at: [3]
- a. 15 m?
 - b. 35 m?
 - c. 400 m?
5. How much greater is the strain rate at 35 m than at 15 m? [1]
6. a. Based on your calculated shear stress values and strain rates, where should the flow rate be fastest, 15 m or 35 m? Why? [1]
- b. Based on the pin positions, where the was flow rate actually fastest, 15 m or 35 m? [0.5]
- c. Explain. [1.5]