ESS 431 Principles of Glaciology
Homework Assignment #7
November 06, 2007

Due: November 15.

Glacial Erosion

A spherical rock (radius R) at the base of a glacier is in contact with a planar bedrock surface. The sliding velocity of the ice (along the plane) is U, and the rate of ice convergence with the bed (velocity normal to the plane) is ($fU+m$), where f is a small dimensionless constant (f=0.01), and m is the melt rate of basal ice due to geothermal heat flow, typically m~0.5 cm/year.

Assume that the significant forces on the particle are viscous and frictional, and take a representative coefficient of friction of around μ ~0.7. When a fluid flows around a sphere, Stokes Law says that the viscous force F on the sphere is

$$F = 6\pi\eta RV ,$$

where V is the velocity of the fluid relative to the sphere, and η is the fluid viscosity.

(a) Write an equation relating the Stokes force acting in the vertical direction (by ice flowing down around the rock) to a contact force (exerted by the bed on the rock to resist penetration of the rock into the bed).

(b) Write an equation relating the Stokes force acting in the horizontal direction (by ice flow parallel to the bed and dragging the rock along the bed) to a frictional force from the bedrock that resists the motion of the rock.

(c) Write an equation based on a simple friction law, relating the contact force to the frictional force.

(d) Find the sliding velocity of the rock in terms of the basal melting rate and the ice sliding velocity.

(e) Under what conditions does the particle tend to stop moving?

(f) The particles that stop moving will form a deposit known as glacial till or diamicton, which is composed of particles of all sizes. Based on your work above, how could you account for this size distribution in tills?