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Summer School in Glaciology, Fairbanks/McCarthy, 2010

Lecture outline: Water and glaciers

Part I.

Motivations

Hydrograph from glacial catchments. Spring event is characteristic
Sliding is related to water system evolution… and erosion depends on sliding
Alters temperature structure of a glacier
    Which in turn sets i) viscosity structure, ii) possibility of sliding
Outburst floods from blockage of drainage
Depositional forms: eskers in particular
Chemistry of runoff…where does weathering occur?

Sources: snow and ice melt (see Regine's course contributions)
    [Source from basal melt, scales of melting by geothermal
    Depends on the thermal state of the glacier – polar or temperate
    Maximum melting if temperate – why? Lesson on thermal state at base]
    [Role of surface melt in the thermal state of a glacier
    Warming of firn…Scale heat balance] topics likely already covered
Paths into the glacier: motion over the surface in supraglacial channels
    How does it melt ice if 0°C?
    Heat source in turbulent dissipation. Strain heating = product of stress*strain rate
    The channel meander problem
    Channel morphology – meandering coolness
Sinks: the outlet channel or channels
    How do we measure this?
    What do you expect a rating curve to look like?
    Law of the wall, Mannings, Darcy-Weisbach formulations
    What if a braided river? – Larry Smith method from satellites
Glacier-wide water balance
    dS/dt = I-O
    lag between I and O results in storage history in the glacier, S(t)
    Spring flood events
        Examples from Bench and from Kennicott
Inside the glacier, where is the water and how much is there?
    Englacial: Veins, fracture fillings, moulins
        Evidence from boreholes
    Subglacial: cavities and tunnels and a thin film in the temperate case
        Evidence for a thin film: subglacial precipitates in carbonate terrain
        How do we study it? Boreholes, glacier-wide water balance, tracers
        Subglacial spelunking, deglaciated beds
Equipotentials

Relevance to eskers: how water goes over ridges on the bed

Pathways of water at base of the glacier

Dynamics of subglacial system – key is that this is reborn each year

(view the bed as a fault, so attach to fault hydrology)

Rothlisberger tunnels opening and closing – fast system

Pipe flow but the pipes are dynamic

Closure timescales – which pipes stay open? And under how much ice?

Opening and closure of cavities – slow system

A major source of opening is sliding

How do we see this? Bench and Kennicott results, bed separation

Generates macro-porosity at the bed, and anisotropic permeability

Relevance to sliding motion: the linked systems. Kessler model

Tunnel system serves as a drain, but must extend upglacier

Evidence for this in onset and demise of sliding: the rug-flap

Tunnel system must be at least nearby before an outburst flood can occur

The chemistry of water and what it can tell us. Constraints on significant contact with the bed, weathering

Part II.

Outburst floods. How they arise and a few key examples

Some of the largest floods in the geologic record

Damming of water is required

Dams can repair themselves, setting us up for repeated floods (e.g. Missoula)

Kennicott's Hidden Creek Lake floods

Annual event, makes it amenable for study

Advance in time through the century

Water balance and close observation of one event.

Donoho Falls Lake, supraglacial lakes, glacial geysers

Hint of glacial response

Kessler model

Missoula Floods (and the importance of Grimsvotn as a model)

English Channel

8.2 ka Lake Agassiz

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