ESS 203 - Glaciers and Global Change

Class 02 Wednesday January 6, 2021

- Please turn in assignments on Canvas
  - HW 01 under **Assignments**
  - Day 1 Questionnaire under **Quizzes**.

- Questions about class outline and objectives?

- Reporting highlights from the previous class is one way of participating in the class.
  - Sign-up sheet is linked on Canvas home page

ESS 203 A

Winter 2021

- **Home**
- Assignments
- Discussions
- Grades
- People
- Pages
- Files
- Syllabus
- Quizzes
- UW Libraries
- Panopto Recordings
- Zoom
- UW Resources

ESS 203 A Wi 21: Glaciers And Global Change

We will post assignments and use the Grade Book here on Canvas. Materials for this class will also be available through the class web page at:

http://http://courses.washington.edu/ess203/

Please sign up to report class highlights from a future class:

Class-highlights sign-up

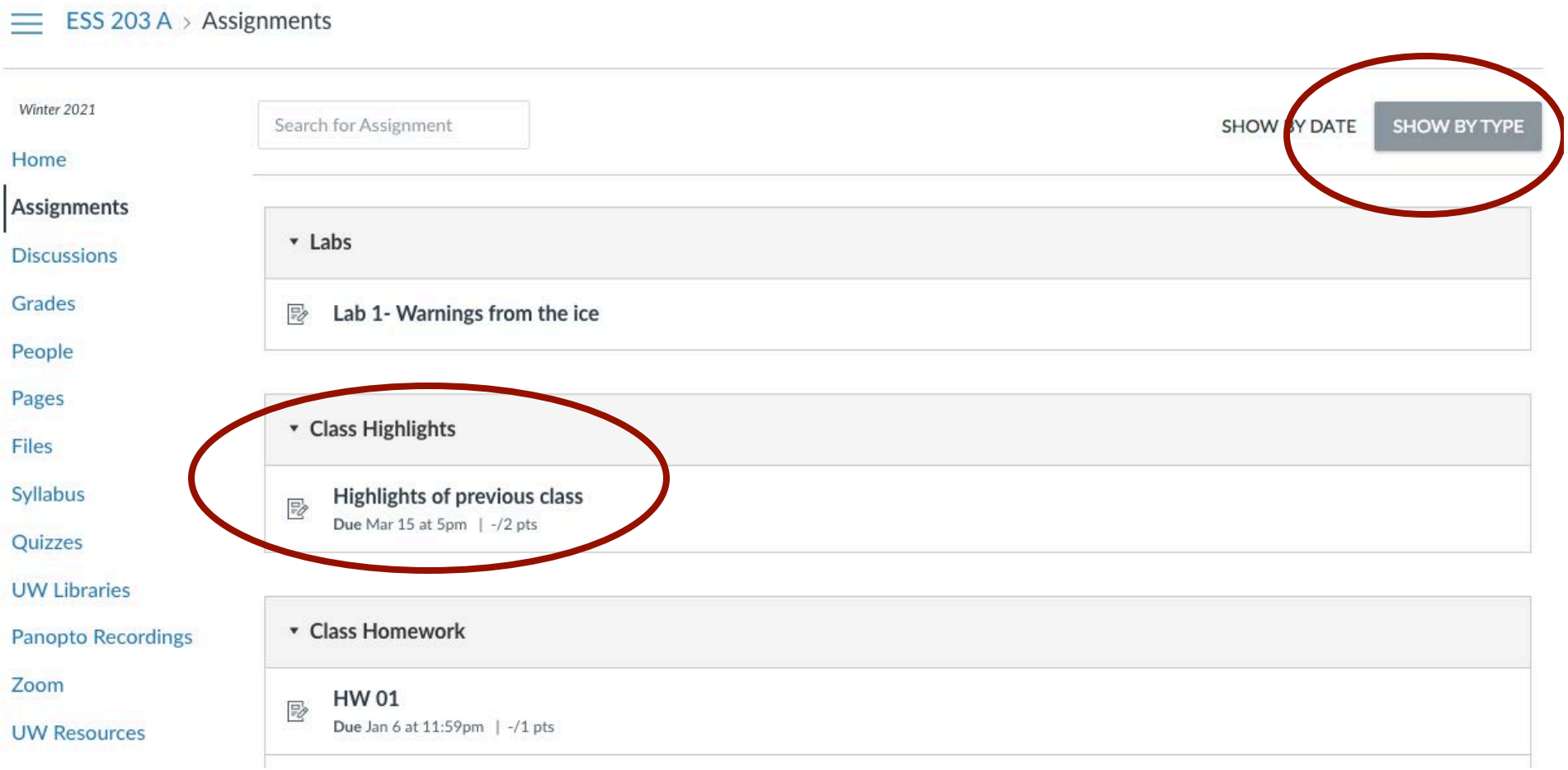
Fossil discovered on field trip to Discovery Park!

Upload your report to Assignments/Class Highlights

The "Class Highlights" Assignment is open until the end of the Quarter

- But please upload *your* written report on the day you deliver your oral report in class. ☺
- It may be hard to find the Class Highlights Assignment if you display Assignments by "SHOW BY DATE" in the upper right – I think you see only the coming week.
- If you "SHOW BY TYPE", "Class Highlights" will appear for you and will be accessible.

Assignments SHOW BY TYPE



Highlights sign-up sheet

- Today's highlights report on Friday
  – Alexander MacKinnon

- 60-second highlights of Monday class
  – Berrit Stow

How to do well in ESS 203

I am posting lecture materials on-line.

- This is ***not*** so that you can skip class. ☺
- Slides alone make a poor substitute for integrated learning opportunities that occur in class.
- Your participation in discussions in class will be a key part of learning (and your participation grade).

History shows that:

- Students who attend class and Labs, join in discussions, and turn in homework and Lab reports generally get between 3.0 and 4.0
- Students who do not attend class have generally done poorly.

Assignments HW 02

Writing assignment for Friday

In about half a page, summarize what you think is one key idea in each of the four sections labeled *Types*, *Structure*, *Formation*, and *Motion* in wikipedia ***Glacier*** entry.
(This is also your reading assignment for Friday.)

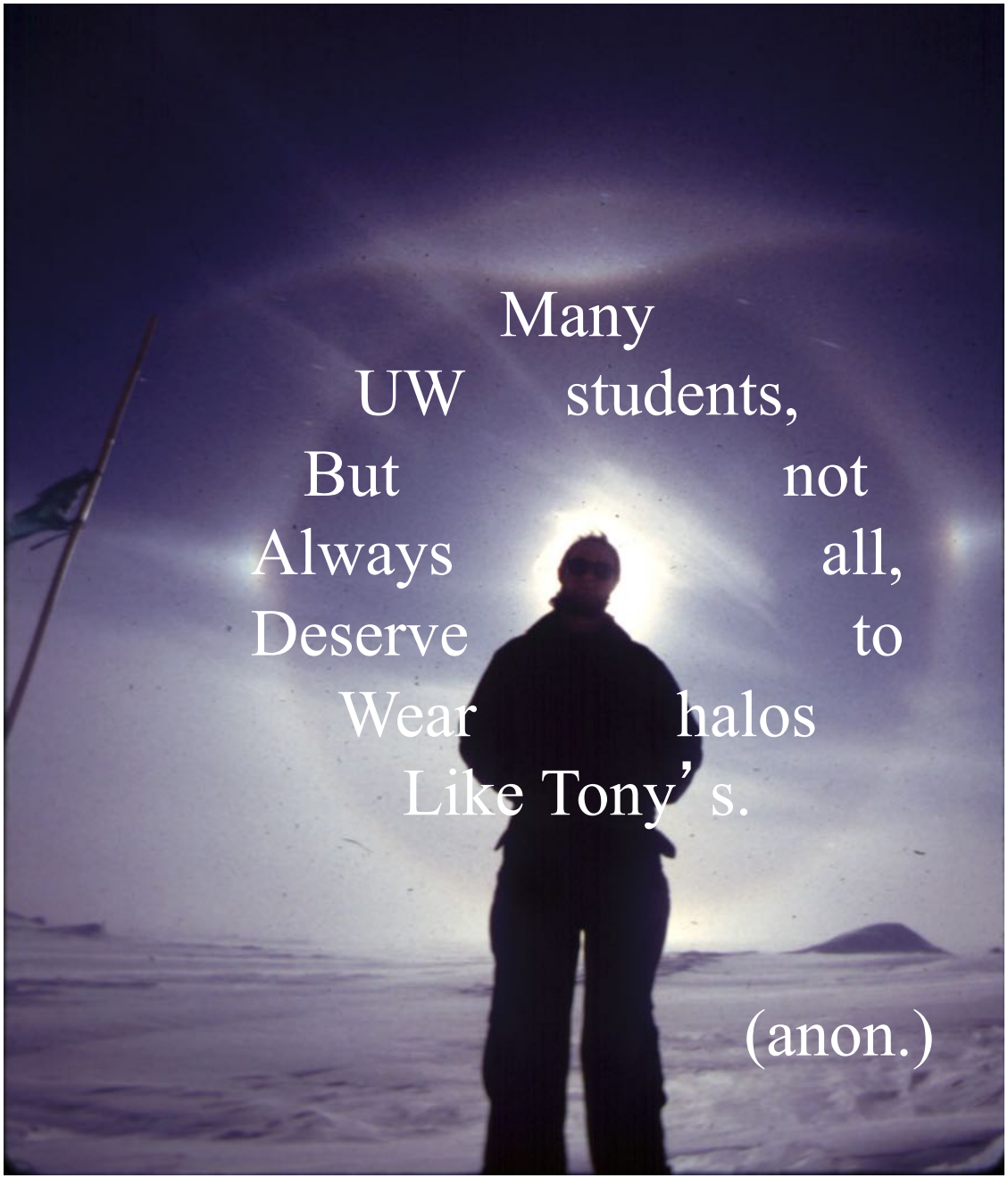
Learning Objectives for Today

- What conditions are needed for a glacier to form?
- How to describe the mass budget of a glacier.
  - Accumulation and Ablation Areas, Equilibrium Line.
- What is a "steady-state" glacier?
- How might glaciers respond to climate changes?

Sun Dogs and Halos

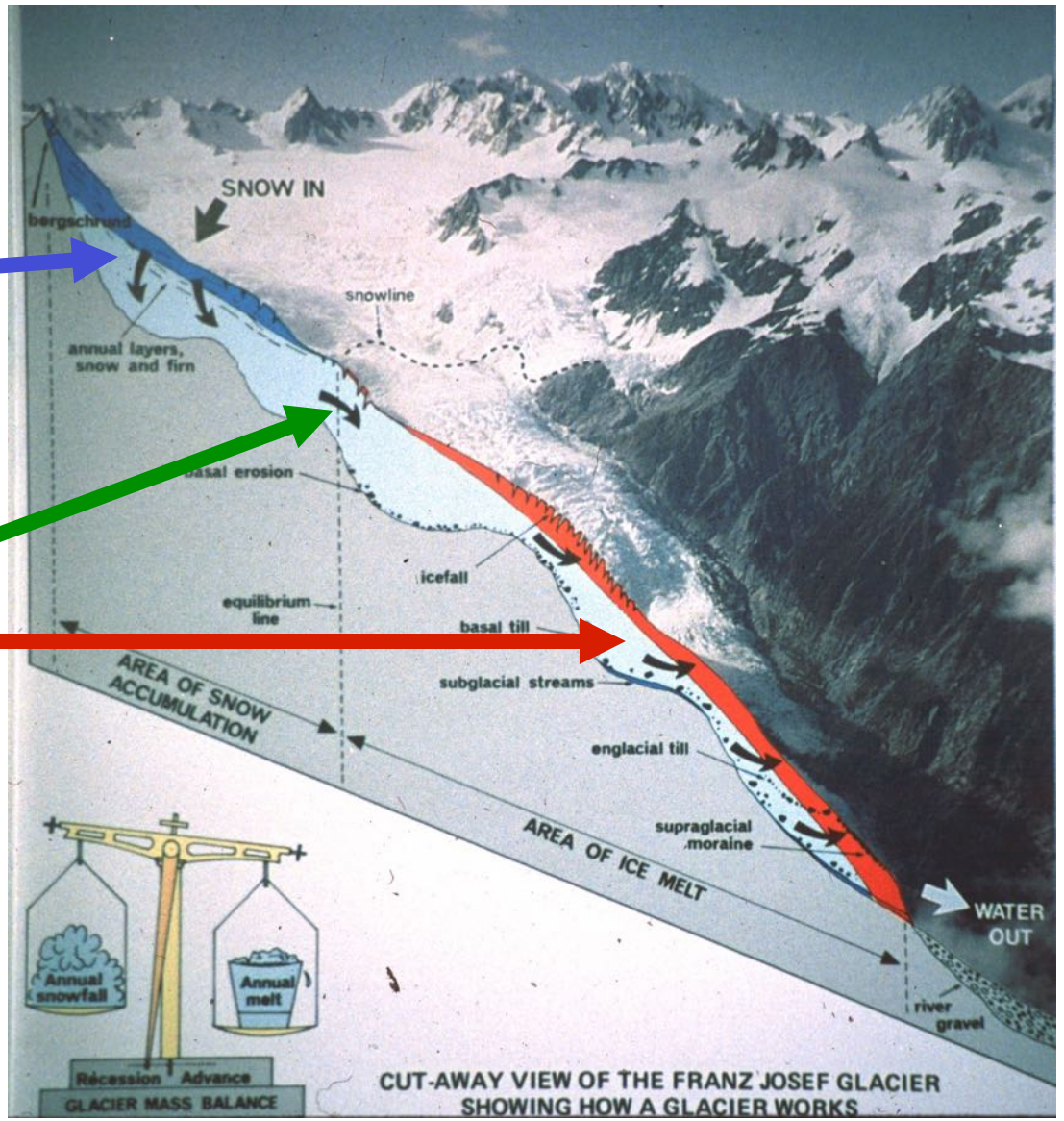
Ice crystals floating in the air can reflect and refract sunlight (like a rainbow).

However, the non-spherical shapes of ice crystals cause some very different optical effects.



Glacier Mass Budget

- Net accumulation of snow on upper glacier, where annual snowfall exceeds annual melting.
- Snowfall equals melting on "equilibrium line".
- Net melting ("ablation") on lower glacier.
- Ice flow continually carries excess ice and snow from ***accumulation area*** to ***ablation area*** to maintain a rough balance.



Late-summer snow line on Blue Glacier, Mt. Olympus

Some Facts from Ed

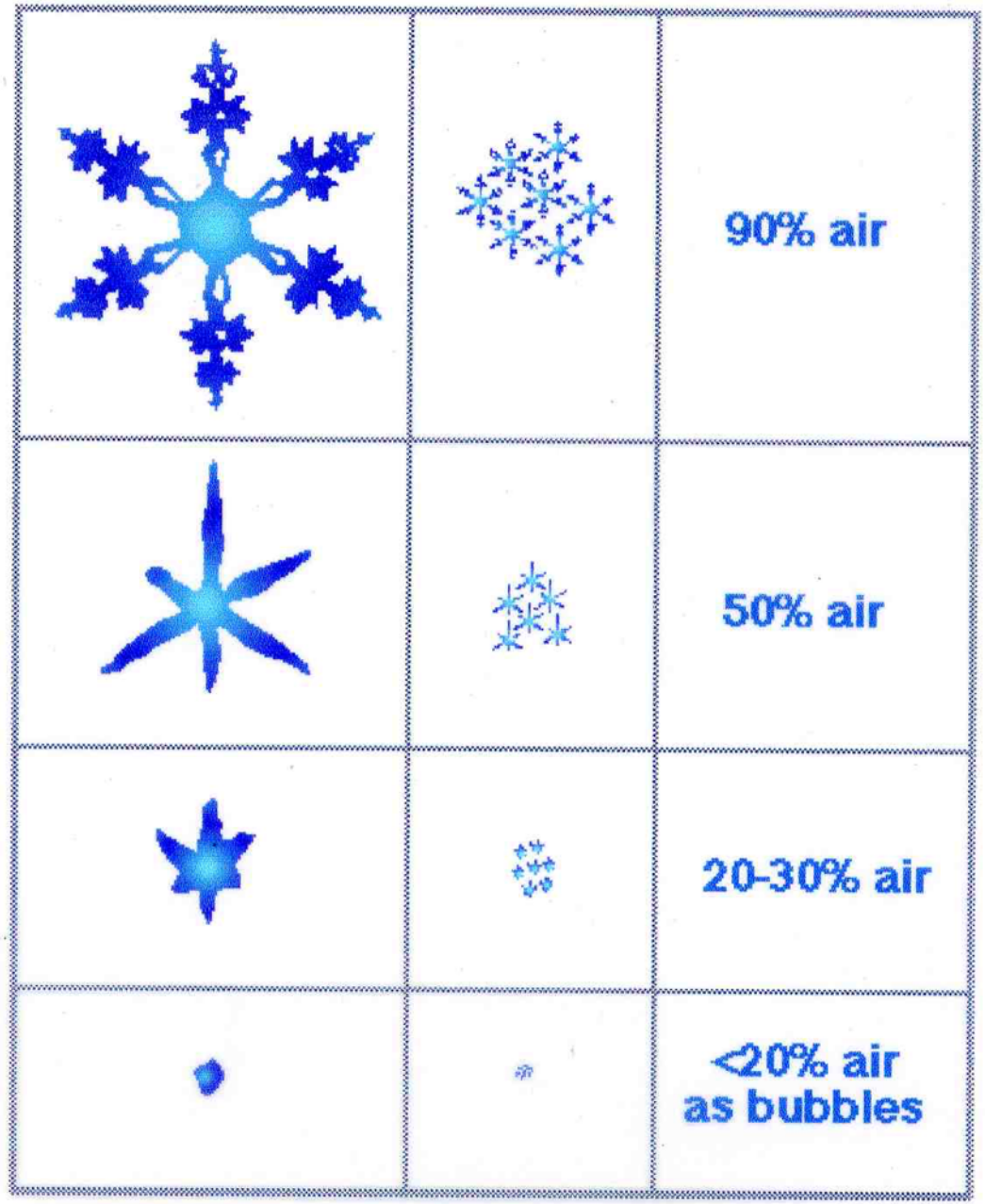
- Glaciers are composed of ice formed from snow (mainly); they can also contain dirt, rocks, water, air bubbles.
- Glaciers flow downhill
- Glaciers have an accumulation area and an ablation area
- Glaciers can be tens of meters to a few km thick. (What's a km?)
- Many glaciers have water in, on or under them.

Some questions from Curious Scientists

- How can a glacier persist if it is always flowing down hill?
- How can a glacier persist if it is always melting at the terminus?
- Does a glacier terminus always stay at about the same place?
- Ice is solid - does it really "flow"?
- How fast does a glacier move?
- How old is the ice in a glacier?
- How cold are glaciers?
- What is under a glacier?

Formation of Glacier Ice

- Formed from snow
- Crystals become rounded over time

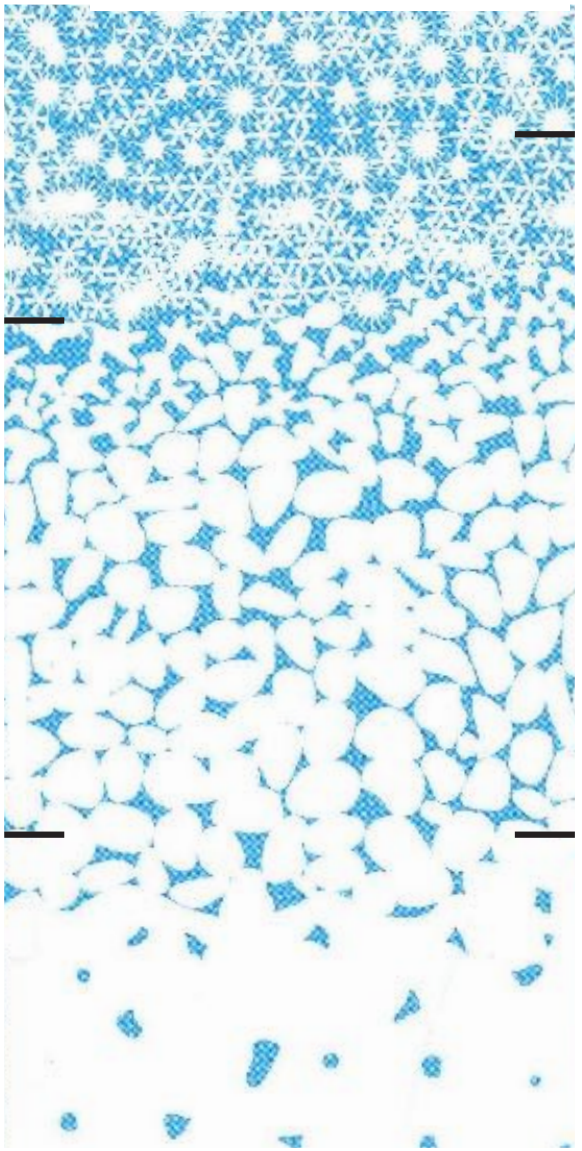


Turning snow into glacier ice

- Snow layers are compacted under the weight of snow above.
- Snow that has survived through a summer is called ***firn.***
- Conversion into solid ice can take years to centuries, or even millennia ...

- Snow crystals (white) in air (blue)
- Air is progressively squeezed out by weight above
- Air bubbles trapped in solid ice

Glacier surface



Bubbly glacier ice

Adapted from D. Raynaud, "The Ice Core Record of the Atmospheric Composition: A Summary, Chiefly of CO_2, CH_4, and O_2," in *Trace Gases in the Biosphere*, ed. B. Moore and D. Schimel [Boulder, CO,: UCAR Office for Interdisciplinary Studies, 1992].

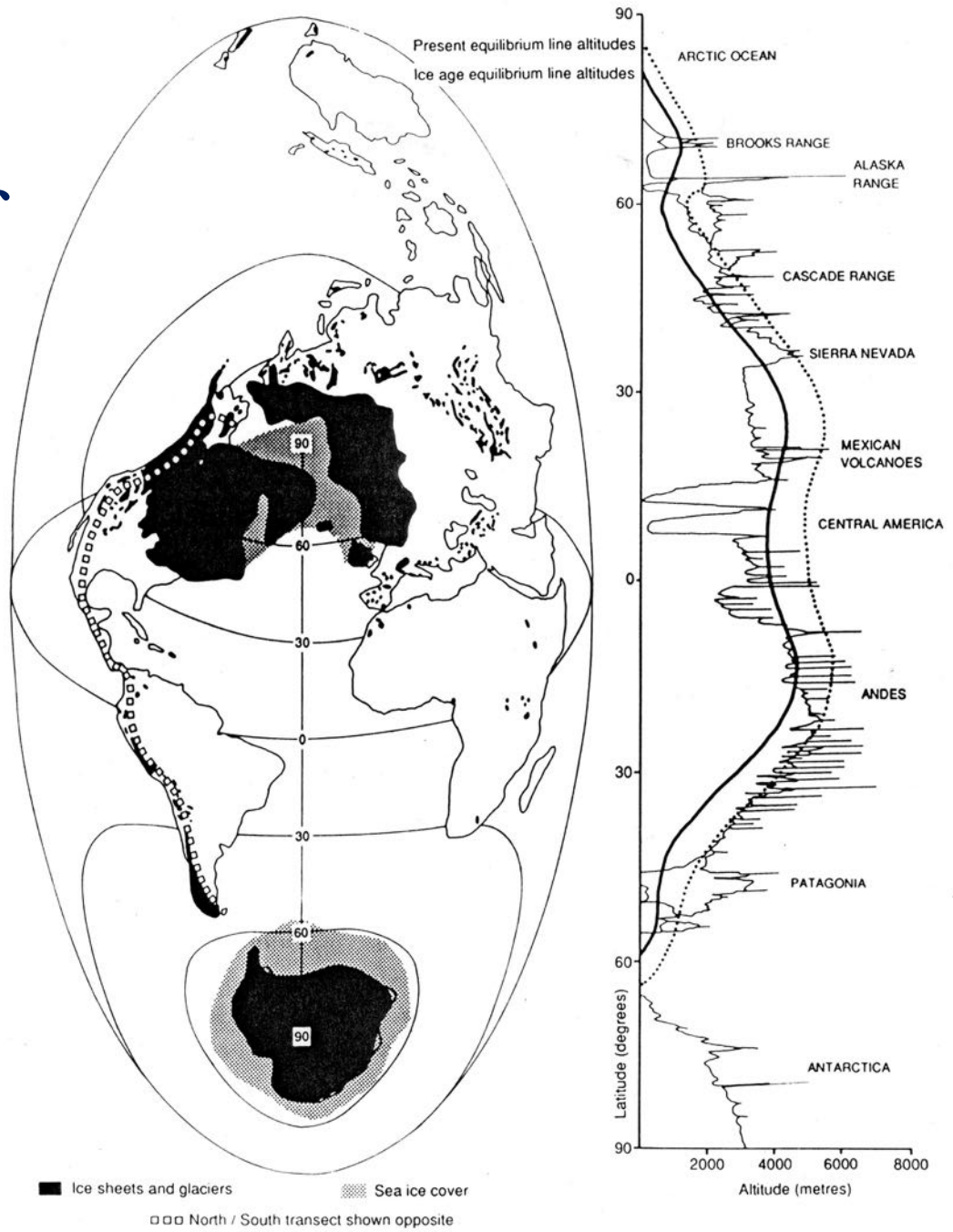
Formation of a Glacier

- Some snow must ***survive through summer*** in most years, before a glacier can form or be sustained.

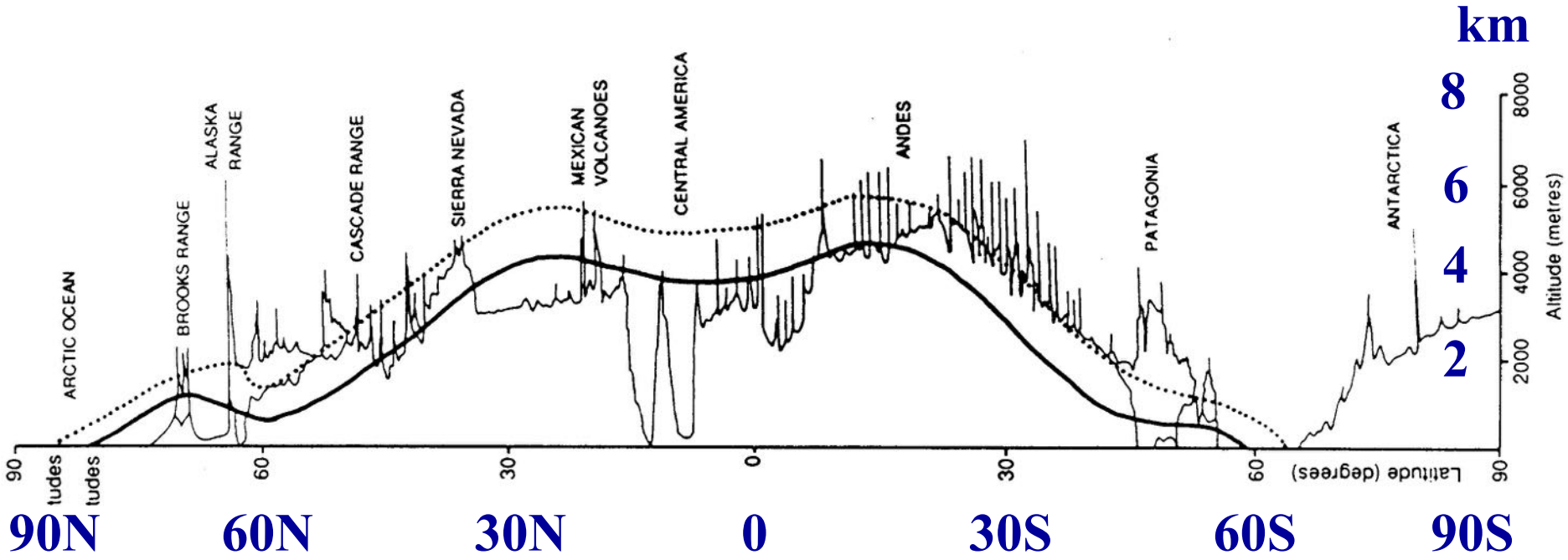
(***Remember this! This is key to understanding glaciers!***)

- ***Equilibrium Line Altitude*** (ELA) at any point on a map is the lowest elevation at which winter snow could survive through the following summer (if the ground surface was at that height).

Transect along the west coast of the Americas



ELA along the Americas



..... ELA today

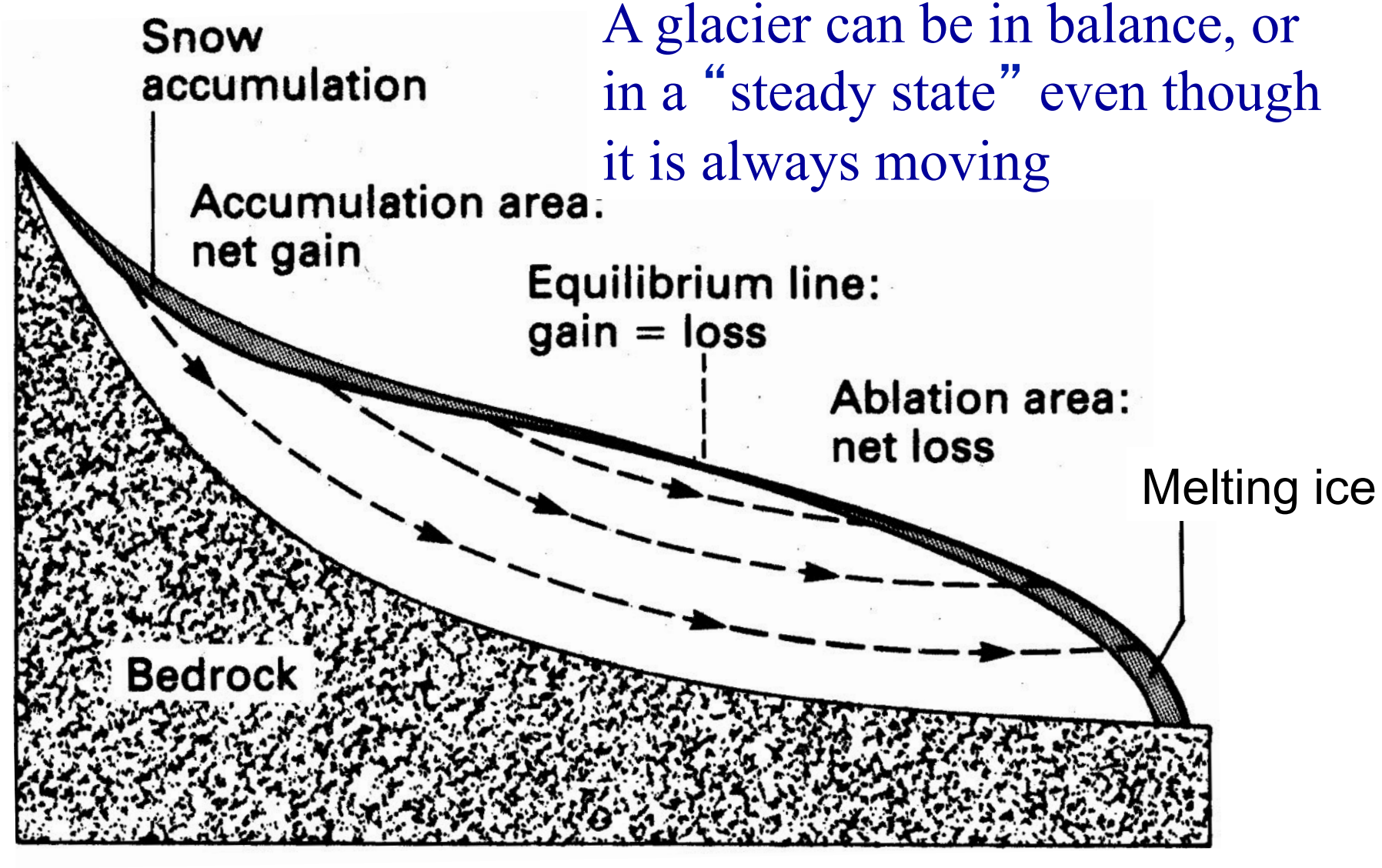
——— ELA at Last Glacial Maximum (20 ka BP)

We will explore this further in a few days to understand why it has this shape.

- ka means “kilo-annum” or thousands of years
- BP means “before present” which is before 1950 CE
- CE or Common Era started in 1950 (by definition)

How does a Glacier Work?

A glacier can be in balance, or in a "steady state" even though it is always moving



Steady State

A Glacier	Your Bank Account
• Accumulation area	• Deposits into savings
• Flow from Accumulation Area to Ablation Area	• Transfers to checking account or debit card
• Equilibrium Line	
• Ablation area	• Withdrawals with checks or debit card
• Amount of ice passing by in a year is roughly equal to the total amount of ice collected upstream in a year.	• Amount that you spend in a year should be roughly equal to the amount that you deposit in a year.

Questions for Group Discussion …

To use class time efficiently, we want focused discussion groups. Here are some roles that should be filled by in each group:

- Facilitator - who makes sure the group stays on task.
- Recorder - who keeps track of the ideas by making notes, and turns in group summary on Canvas.
- Reporter - who reports results orally to the class.

ESS 203 Glaciers and Global Change

Date: _____

Group members: Facilitator _____ _____

Recorder _____ _____

Reporter _____ _____

Our Question: _____

_____

_____

Our Answer: (add pictures or text as necessary.)

_____

_____

_____

What's a group report look like?

The recorder writes down:

- Date
- Names of group members
- Question addressed. (if it is long, citing just the Question number is fine.)
- The group's answer. Bullet points are fine (there isn't time for polished prose ☺).

Rotate through the roles as you take part in different discussions, i.e. if you were the Recorder in the last discussion, volunteer to be Facilitator or Reporter in the next discussion.

Questions for Group Discussion …

In every group discussion, the order of business should be:

- Introductions - Do you all know one another's names?
- Roles - Who will be Facilitator, Recorder, Reporter?
- Discussions - Facilitator keeps discussions moving to completion in allotted time.
- Summary - Recorder summarizes ideas. Does group agree?
- Report - Reporter presents conclusions to class, with help from other Group members if needed.
- Wrap-up - Recorder submits notes from your group in Canvas at end of class, under

Assignments/Class Discussions/Day xx Group Reports

Group Discussions – break-out rooms

Here are the 2 questions.

- You can find them on the slides for today

On Canvas:

- Files > Lecture Slides > ESS203_day_02.pdf

On Class web page:

- http://courses.washington.edu/ess203/LECTURES/ESS203_day_02.pdf

1. Glaciers in the Cascades

- Why is Seattle ice-free? (where is the ELA at Seattle?)

Now we look at a glacier on a mountain side, e.g. on Mt Rainier:
A glacier extends from 4,500 m (~14,000') to 1,500 m (~4,600')

- What might be the approximate elevation of the equilibrium line?

- Why do you think so?

http://www.nps.gov/mora/

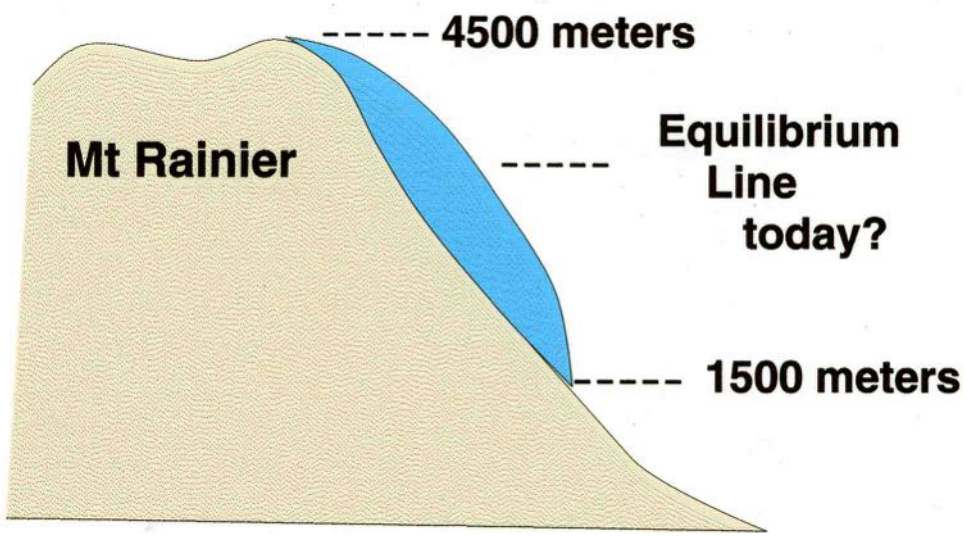
1(b). Glaciers in the Cascades (cont'd)

Suppose climate warms and ELA rises 100 m.

- What will happen (eventually) to the size of the glacier?
- What will happen (eventually) if the climate then cools back to today's temperature?

Suppose climate warms and ELA rises above the summit.

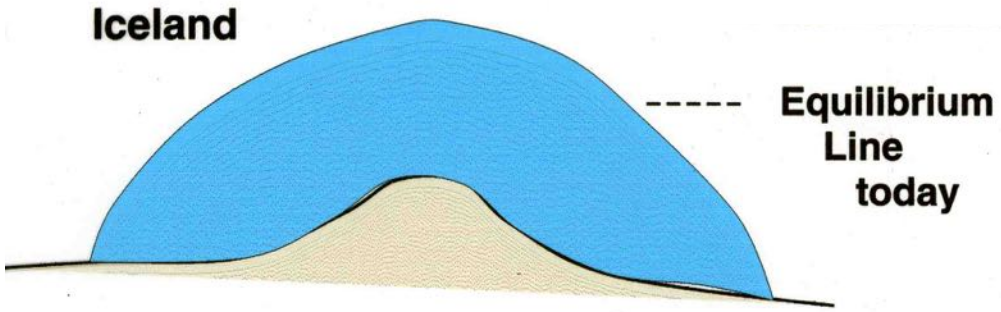
- What will (eventually) happen to the glacier?
- What will happen if the climate returns to today's temperature?



2. Glaciers in Iceland

We assume that the ice caps in Iceland are in steady state today. (We may question this assumption another day.)

- On some ice caps, the ELA is higher than the highest point on the glacier bed.



Map:
http://worldatlas.com/webimage/countrys/europe/lgcolor/iscolor.htm

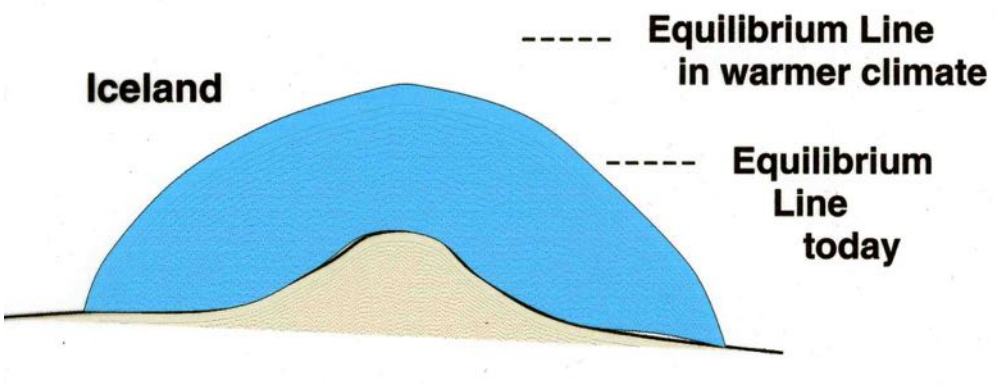
2(b). Glaciers in Iceland (cont'd)

Suppose climate warms and ELA rises 100 m, so that the ablation area gets a little bigger, and accumulation area gets a little smaller.

- What will happen to the size of the ice cap?
- What will happen if the climate then cools back to today's temperature?

Suppose climate warms and ELA rises above the summit.

- What will (eventually) happen to the ice cap?
- What will happen if the climate returns to today's temperature?



Group Discussions – break-out rooms

Here we go!

Nepal – Glaciers and people

Manang Glacier and Manang village, Annapurna Himal

- Note the lake dammed by a ***glacial moraine***.

Lowell Glacier

Yukon Territory

- Note ***medial moraines.***

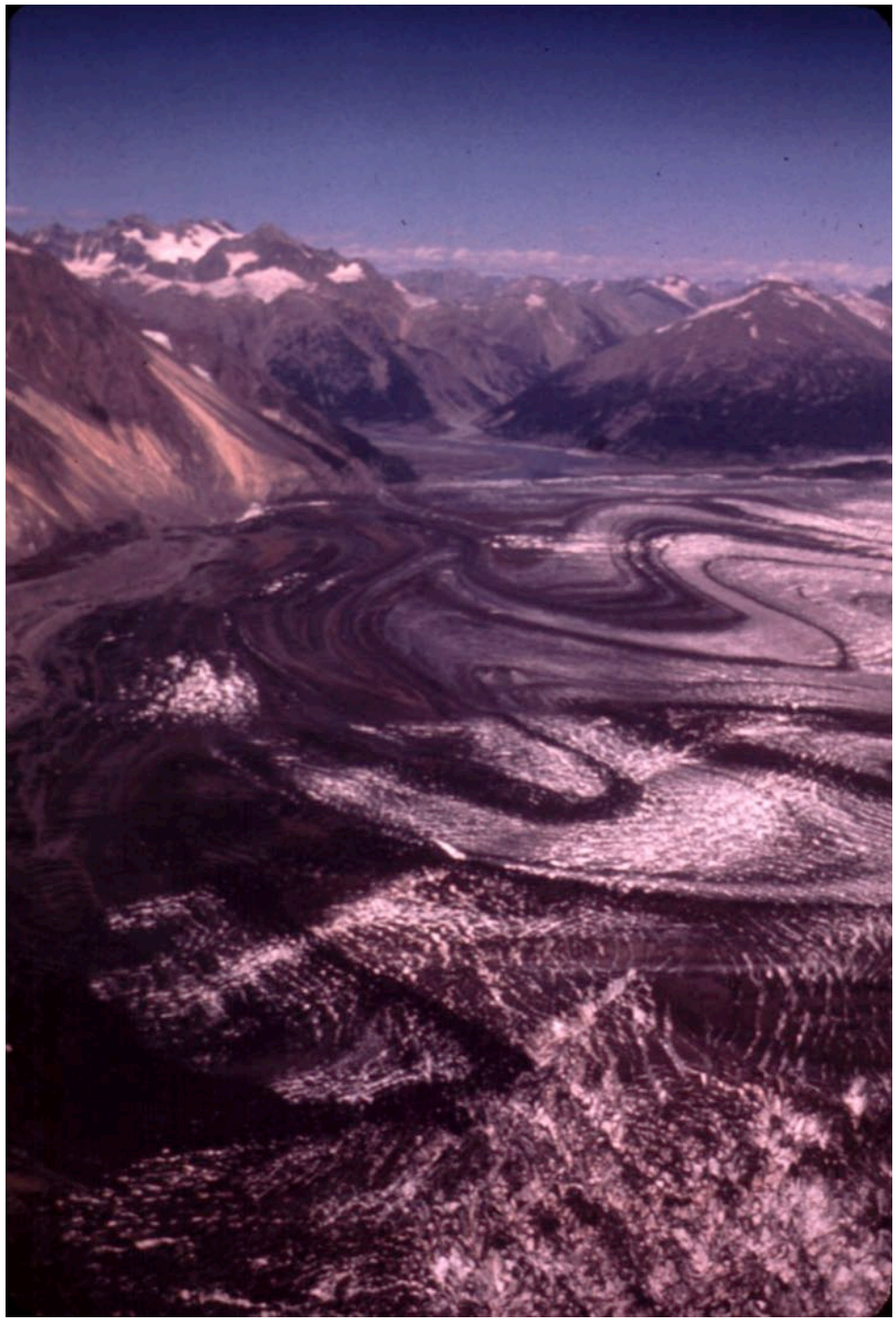
Whenever 2 tributary glaciers join, dirt and rock from their margins becomes part of the combined glacier downstream.

The glacier is ~2 miles across near its terminus in Lowell Lake.

Tweedsmuir Glacier

in northern British Columbia

- Note the looped medial moraines.
  This glacier ***"surges"*** every few decades.



Surging Glacier

Tweedsmuir Glacier surges into Alsek River.

- Note helicopter for scale.
- What might happen to the river when the glacier surges?

South Cascade Glacier, WA

1960-2006