# **Today**

- 1) Quiz- Vocabulary Chapter 17 and Review Chapter 8
- 2) iclicker review of last week
- 3) Glaciers and Ice Ages Lecture
- 4) Inconvenient Truth excerpt/ Chasing Ice Video

Nov. 27	THANKSGIVING BREAK BEGINS
Dec. 4.	QUIZ: Chapter 8 Review - Chapters 17 Vocabulary Chapter 17: Glaciers and Ice Ages
Dec. 11	QUIZ: Chapter 17 Review – Chapter 19 Vocabulary Chapter 19: Shores and Coastal Processes
Dec. 18 6:00-8:00 pm	Exam III **VERY IMPORTANT** Final exam start ON THE HOUR, not 10 minutes after. You may have the full 2hrs ONLY if you show up on time. If you show up late, you must be done by the time the last person who showed up on time is.

# Current State of the Syllabus

Nov. 27	THANKSGIVING BREAK BEGINS
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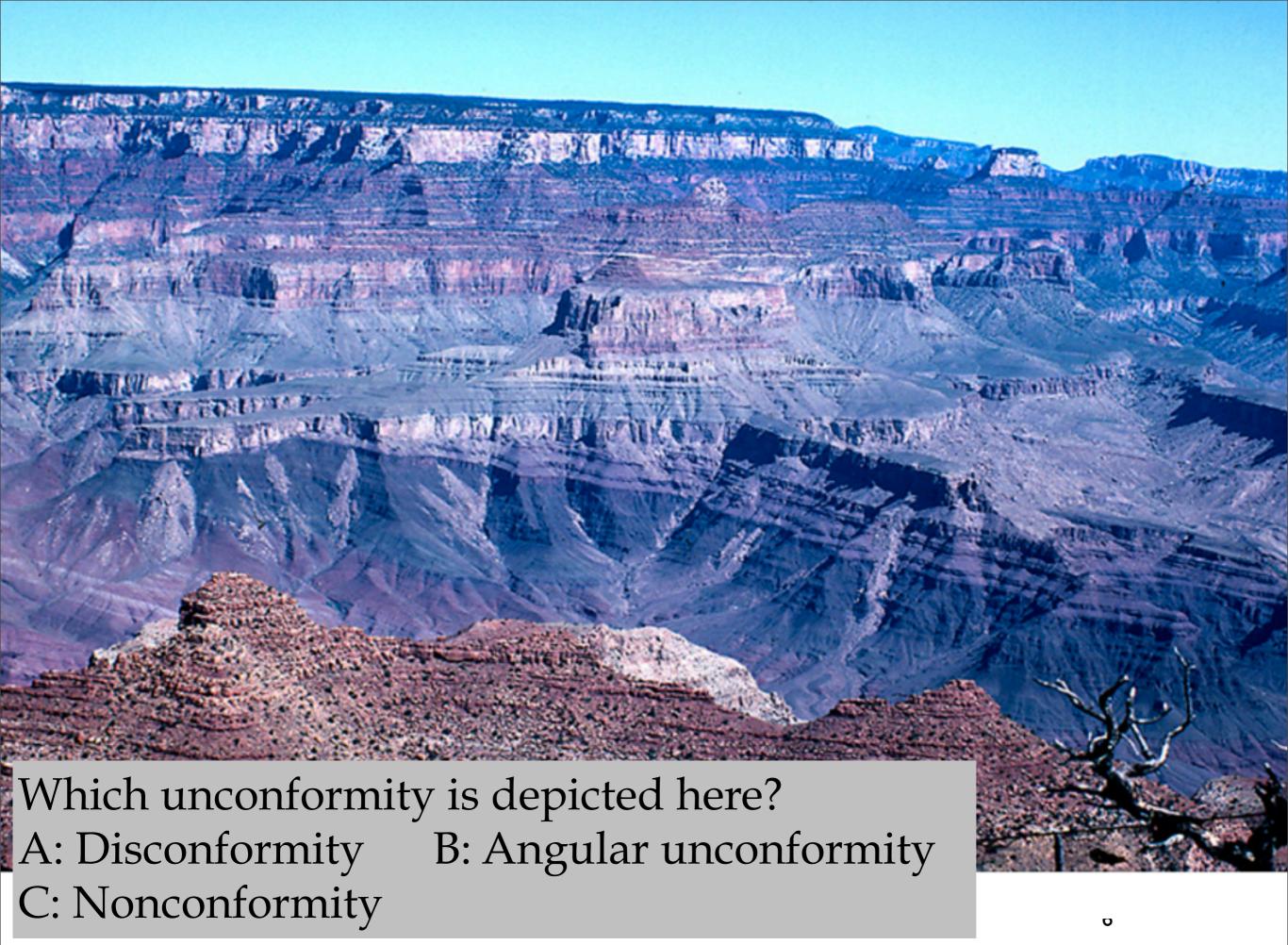
- a) Costal erosion New Material
- b) Summary Video +Final Review

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# Current State of the Syllabus

- a) Costal erosion New Material
- b) Summary Video +Final Review

Extra Credit Due Next Wednesday
No Partial Credit-Must Be Correct
Worth 10% bump to second Mid-term score





Which unconformity is depicted here?

A: Disconformity B: Angular unconformity

C: Nonconformity



Vishnu Schist

Which unconformity is depicted here?

A: Disconformity B: Angular unconformity

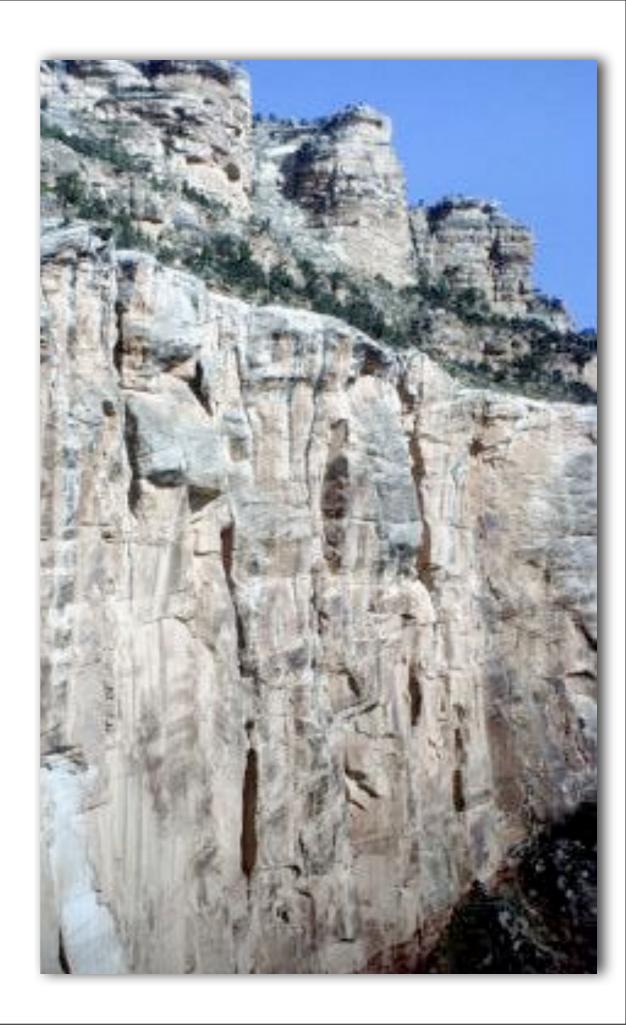
C: Nonconformity



Vishnu Schist

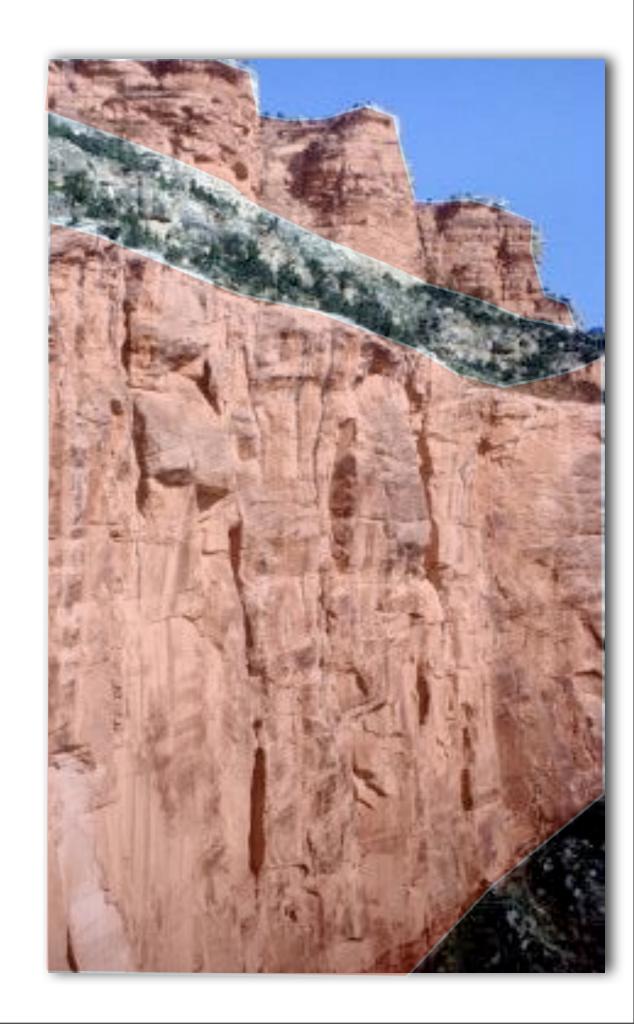
The photograph below shows a section of the Grand Canyon stratigraphy discussed last week. How many distinct compositional layers (e.g., sandstone, limestone, shale, conglomerate) of sedimentary rock overlie the prominent cliff that composes most of this photograph?

- (A) 1
- (B) 2
- (C) 3
- (D) 4
- (E) Can't be determined from this photograph



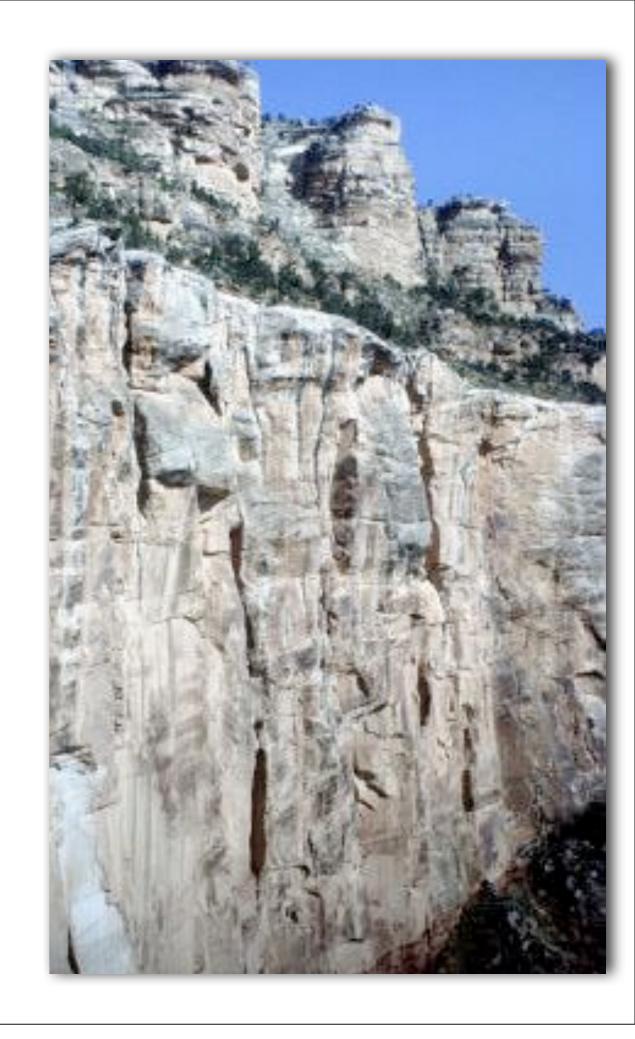
The photograph below shows a section of the Grand Canyon stratigraphy discussed last week. How many distinct compositional layers (e.g., sandstone, limestone, shale, conglomerate) of sedimentary rock overlie the prominent cliff that composes most of this photograph?

- (A) 1
- (B) 2
- (C) 3
- (D) 4
- (E) Can't be determined from this photograph



This photograph shows the upper three sedimentary formations of the Grand Canyon. Which of the following is <u>not true</u>.

- (A)The lower prominent cliff at the base is likely composed of Sandstone or limestone.
- (B)The middle formation is likely composed of Sandstone or limestone.
- (C) The upper formation is likely composed of Sandstone or limestone.
- (D) Both A and B
- (E) Both B and C



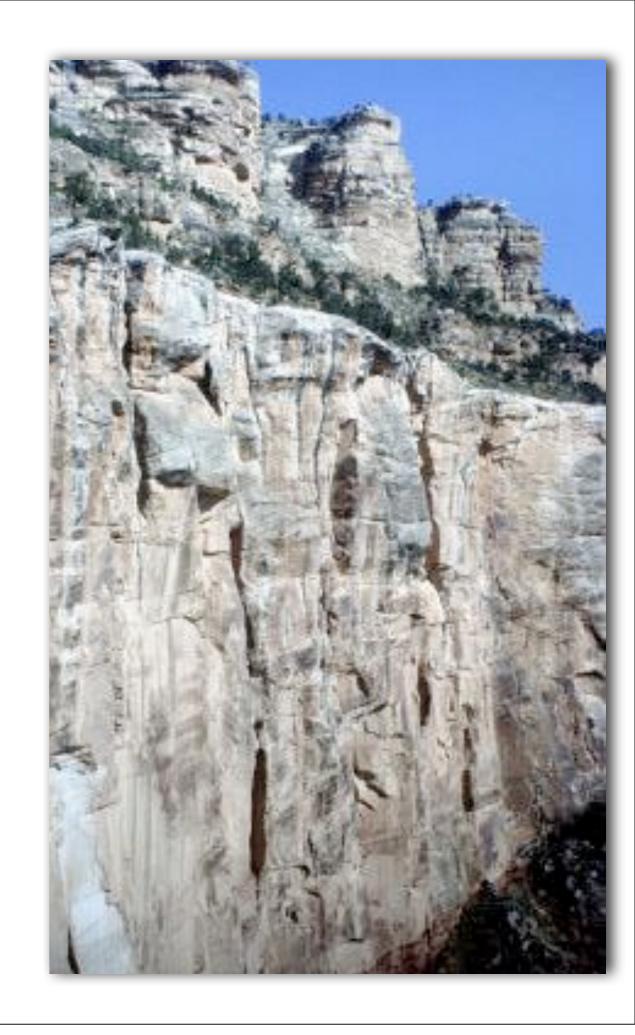
This photograph shows the upper three sedimentary formations of the Grand Canyon. Which of the following is <u>not true</u>.

(A)The lower prominent cliff at the base is likely composed of Sandstone or limestone.

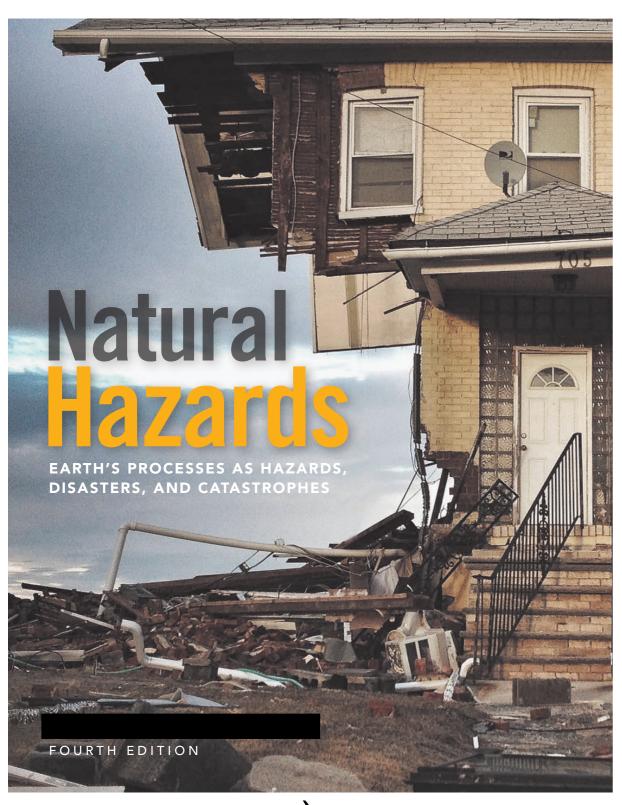
(B)The middle formation is likely composed of Sandstone or limestone.

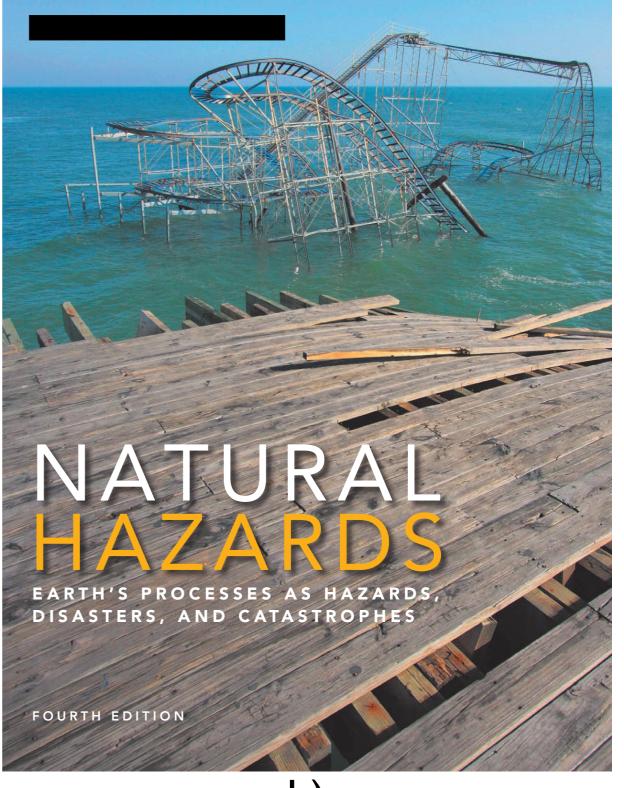
(C) The upper formation is likely composed of Sandstone or limestone.

- (D) Both A and B
- (E) Both B and C



# Which textbook cover draws you in more? In other words, which might make you want to enroll in a Natural Hazards course?





a)

b

Ice Ages are protracted intervals of time lasting millions of years where global temperature is cool enough to sustain ice at the poles.

Glacial intervals are relative short intervals lasting thousands of years during Ice Ages when glaciers are advancing.

Interglacial intervals are relative short intervals last thousands of years during Ice Ages when glaciers are in retreat.

#### Glacier Classification

#### Two main types:

Alpine Glaciers - ice is confined within local topography. Subdivided into two types.

- —Cirque glaciers
- Valley glaciers
- Ice caps

Continental ice sheets unrestricted by local bedrock topography and typically expand from the poles during glacial intervals.



# Cirque Glaciers

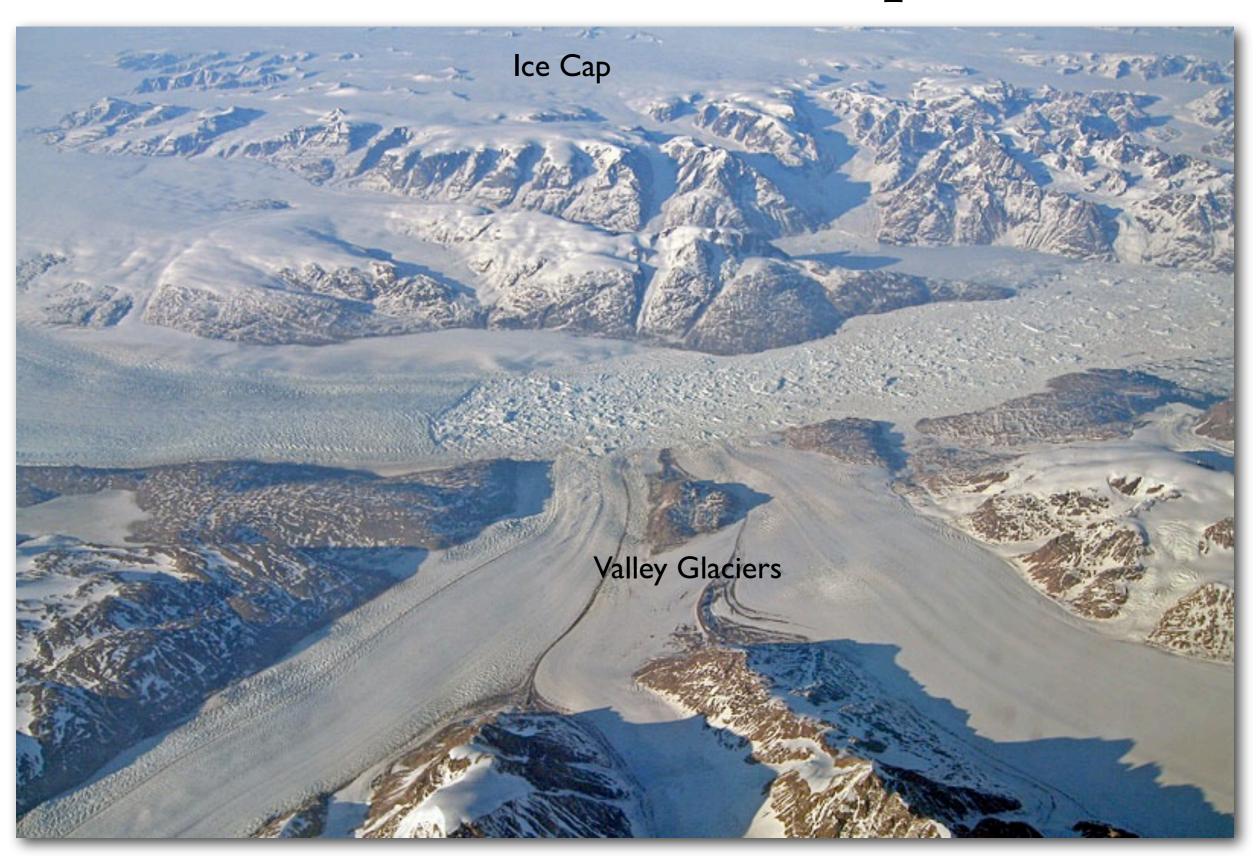




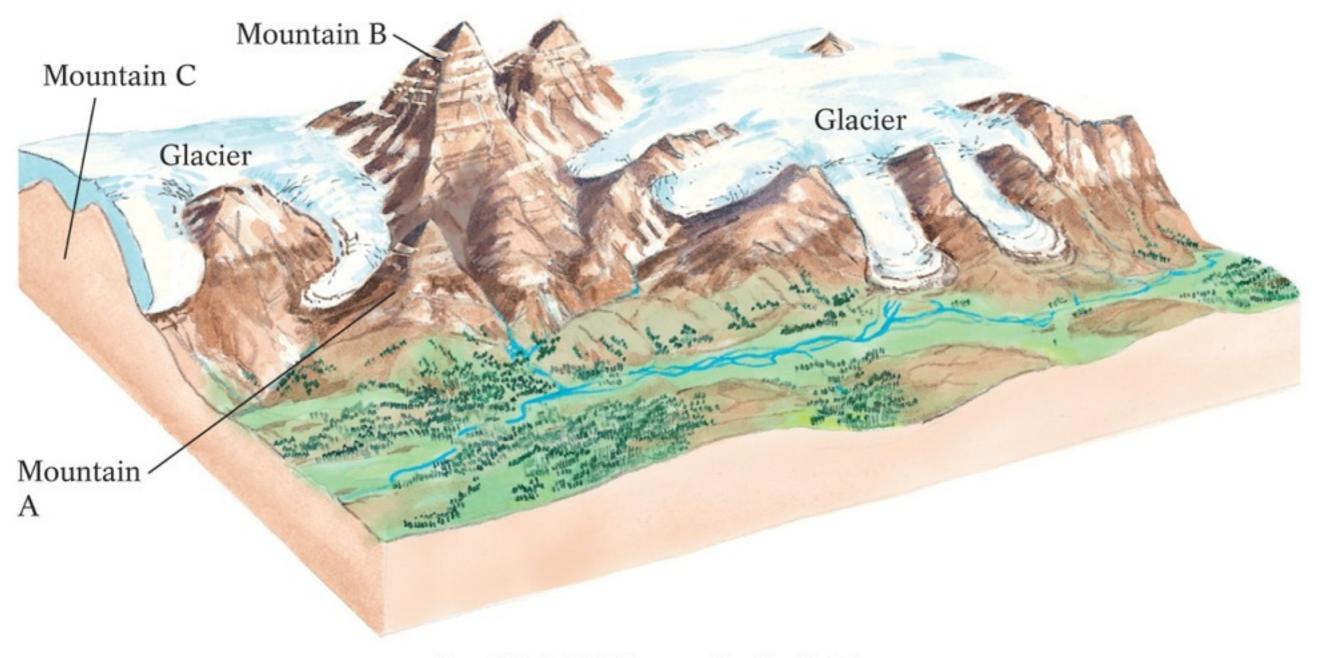
# Valley Glaciers



# Ice Cap

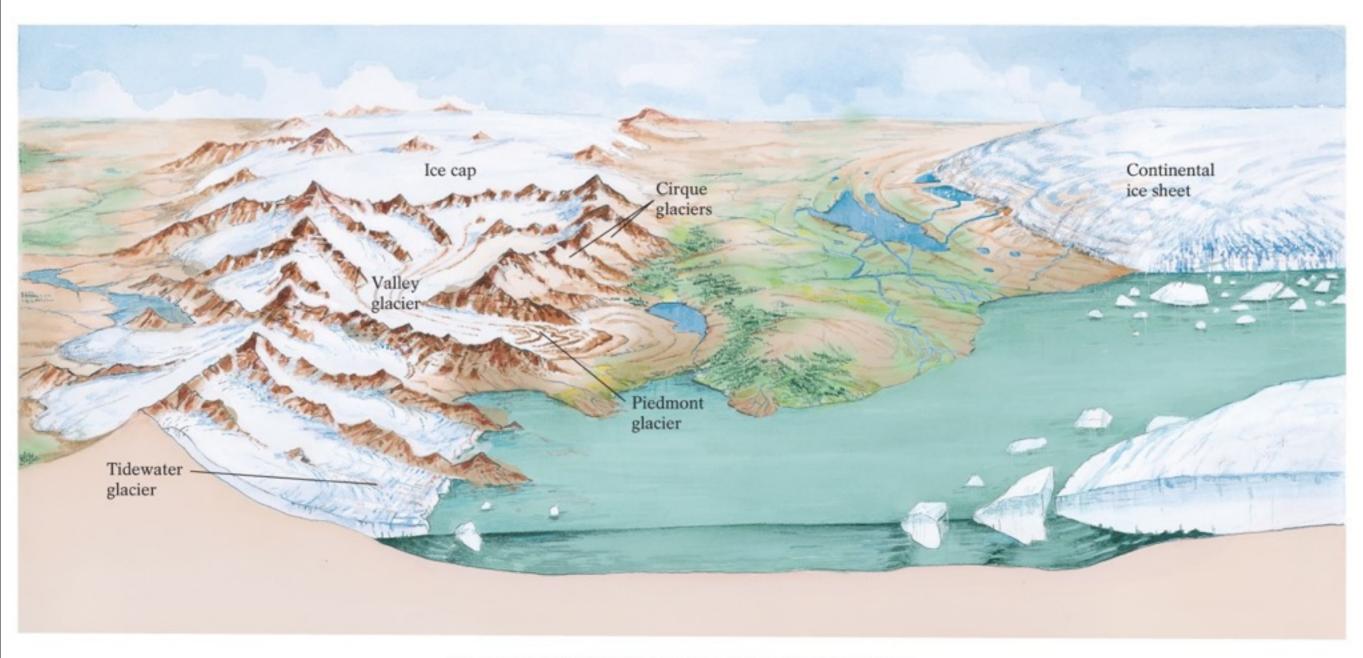


# Ice Caps and Glaciers



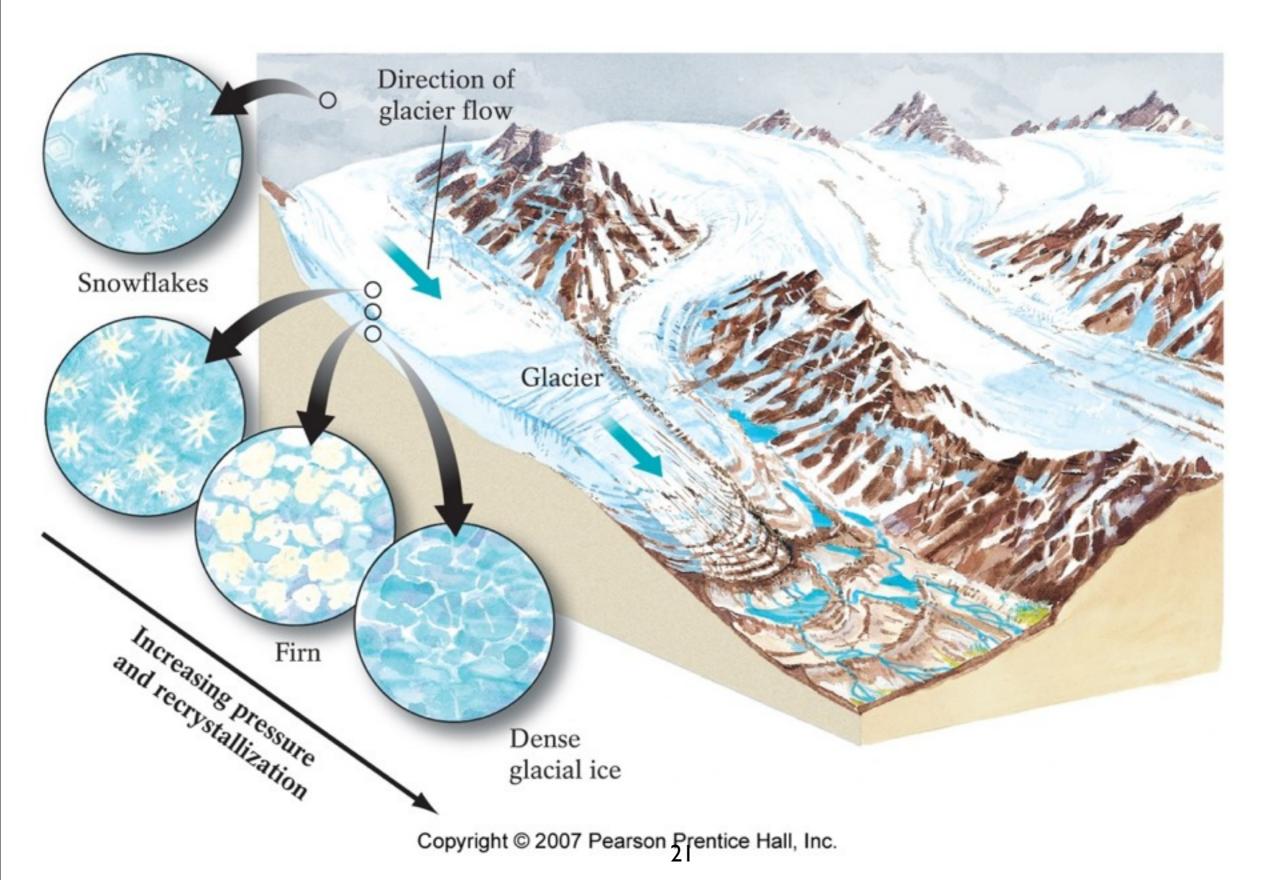
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### The Ice Team

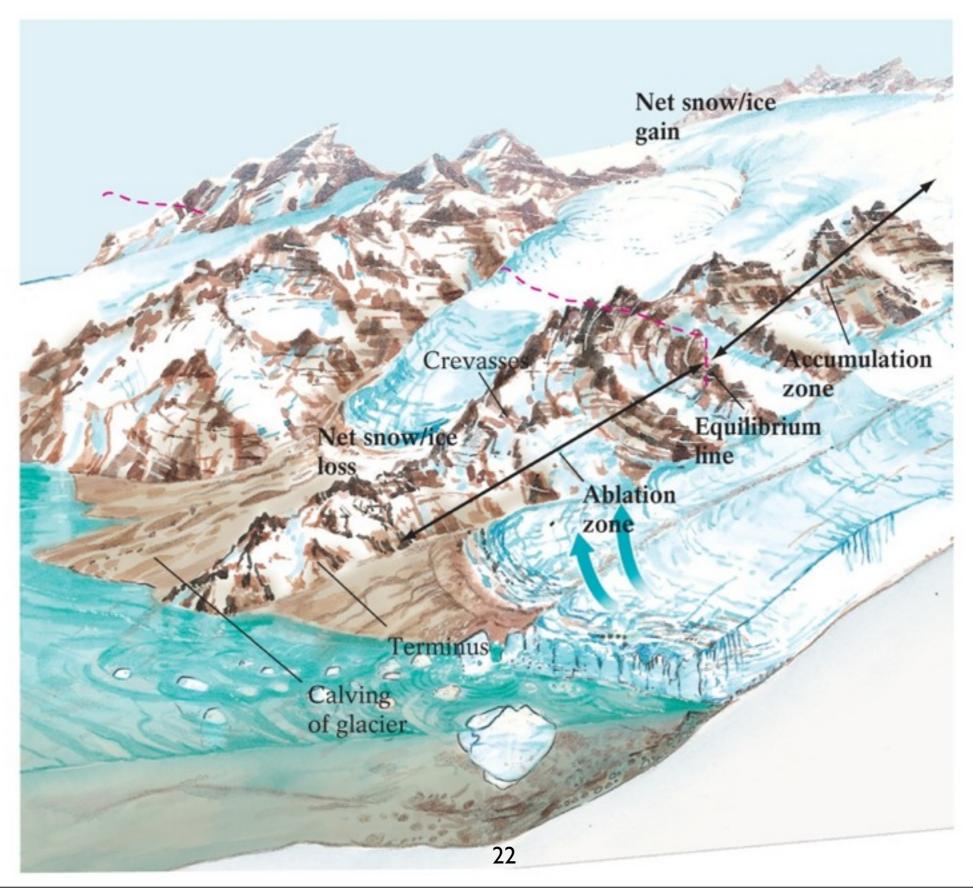


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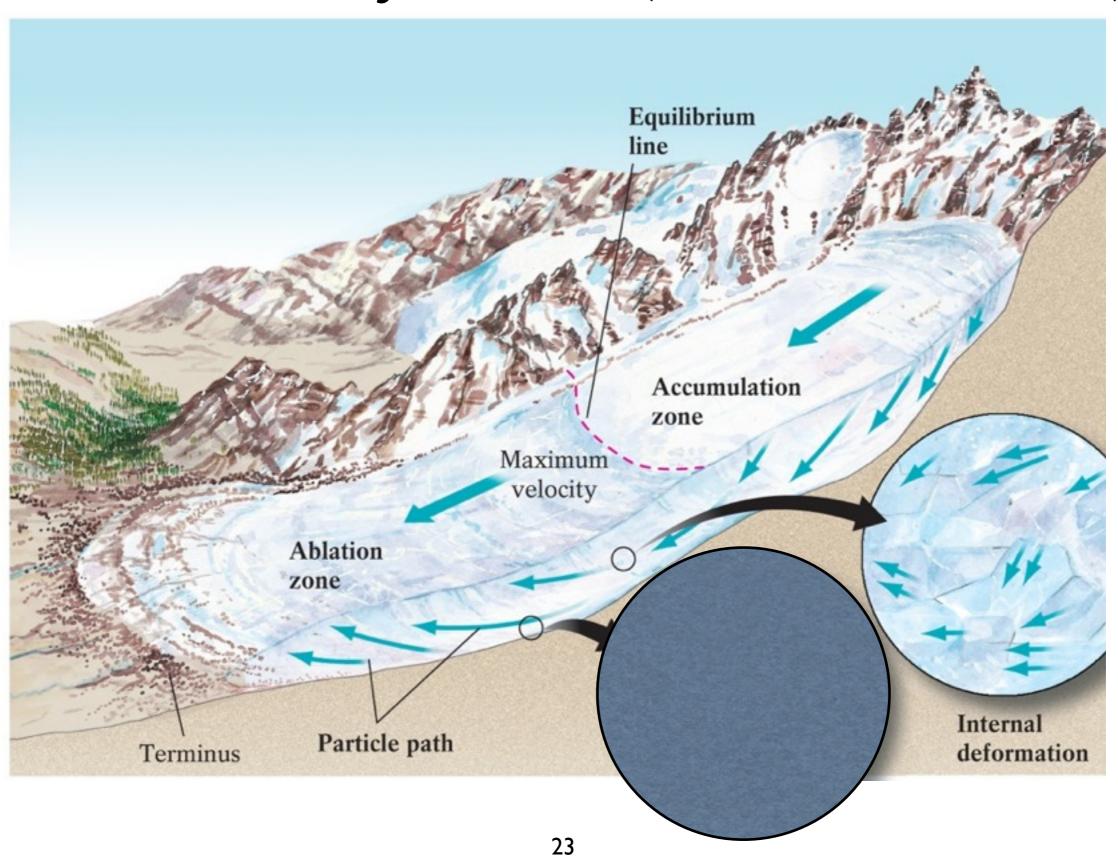
#### **Glacial Ice Formation**

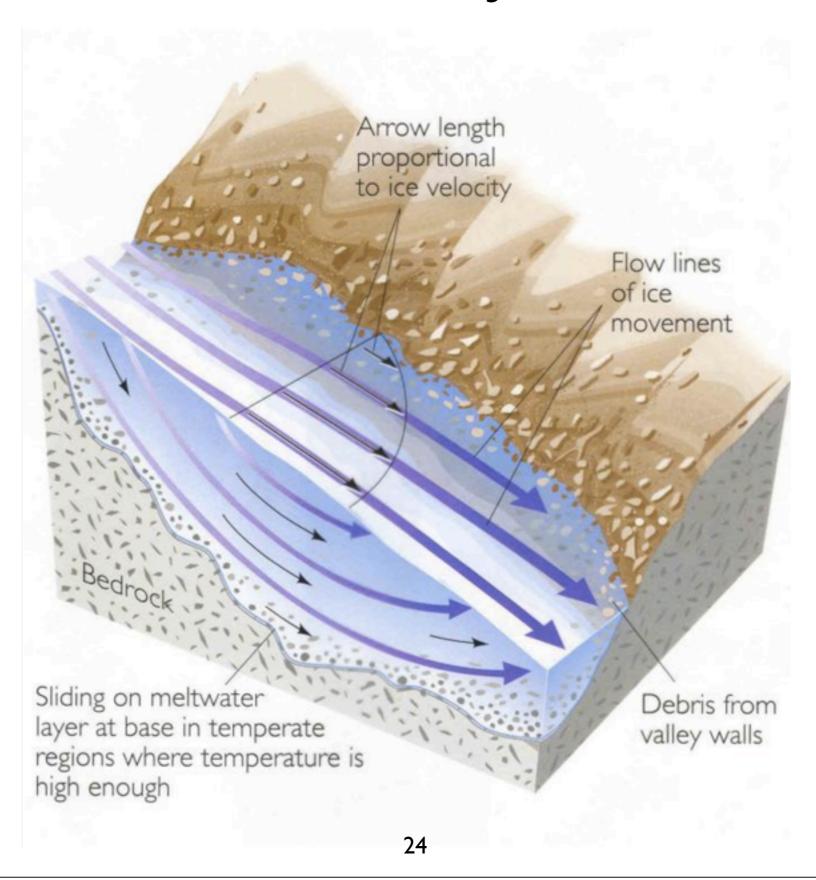


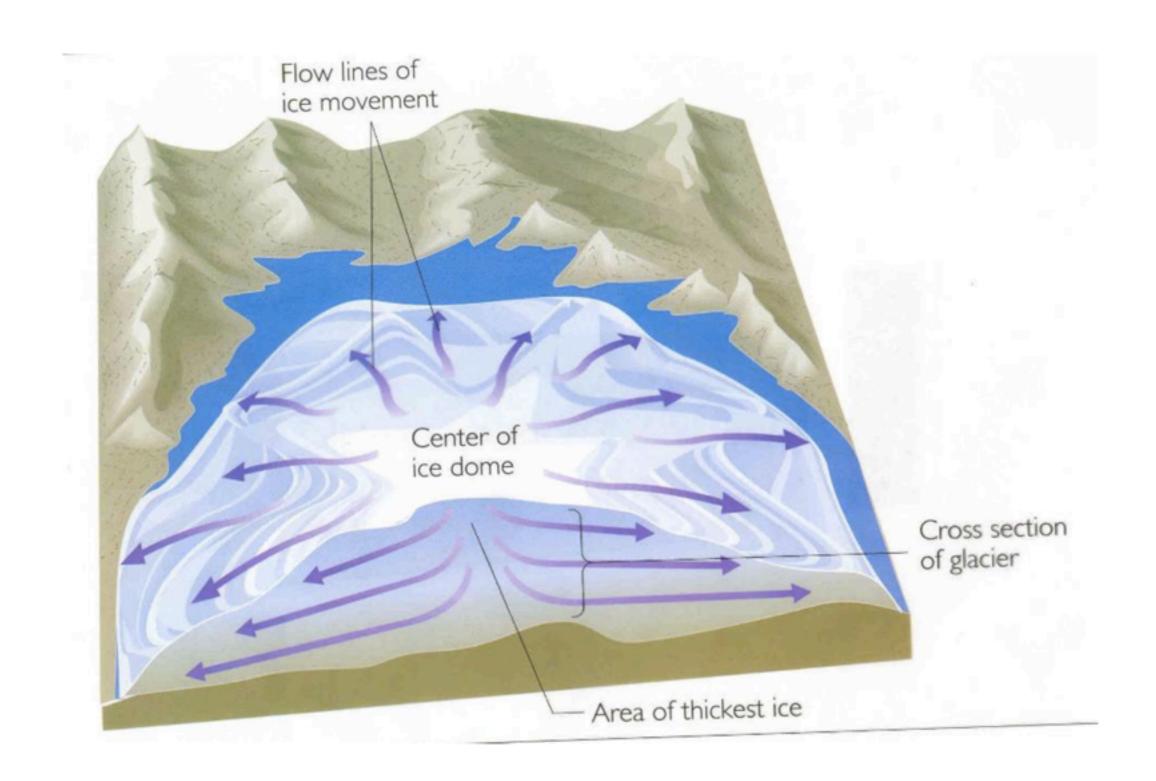
#### **Glacial Ice Formation**

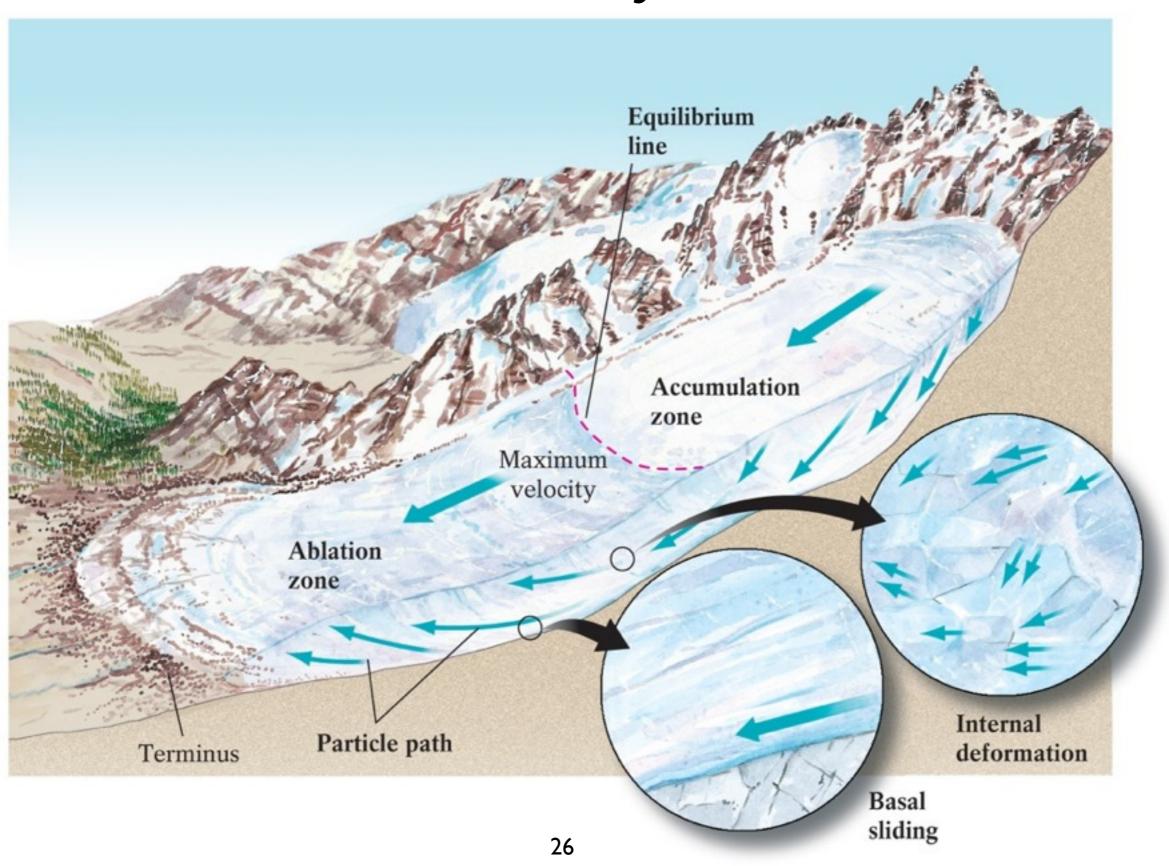


# Glacial Ice Dynamics (ice on the move)









Glacier V2 Animation

The <u>average speed</u> of *cold-based, nonsliding ice* sheets movement is only a few meters a year.

The <u>average speed</u> of *warm-based*, *sliding* alpine glaciers on steep slopes is 300 meters or more a year (just less than 1 m/day).

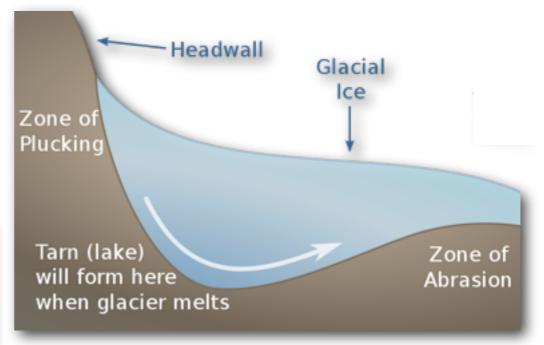
Surging glaciers, however, can move 100x faster than normal for several months to a few years.

Most rapid surge known was in 1953 in northern Pakistan – 100 meters per day! (~12.5 m/hour or ½ meter a minute!)



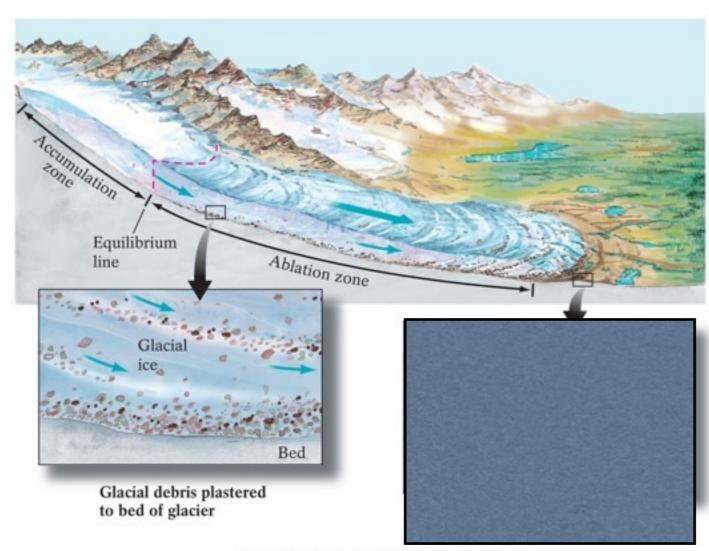
# Glacial Ice Erosion From Top (cirque) to bottom



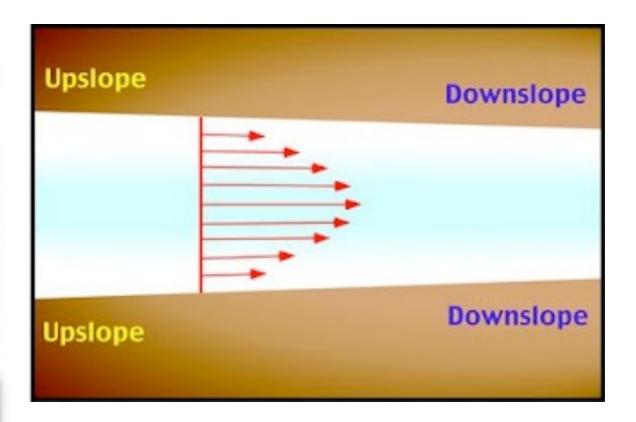


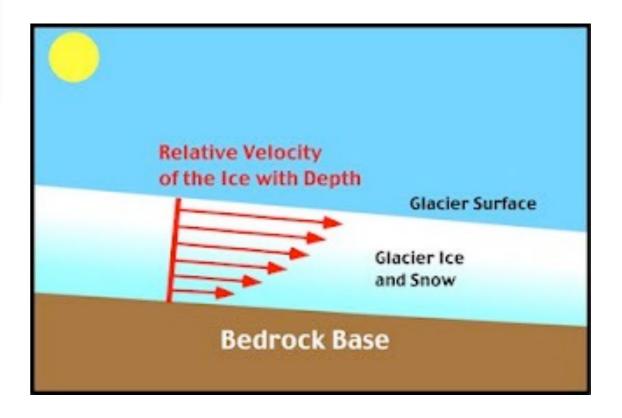


#### Glacial Ice Erosion



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# Glacial Erosion vs. River Erosion

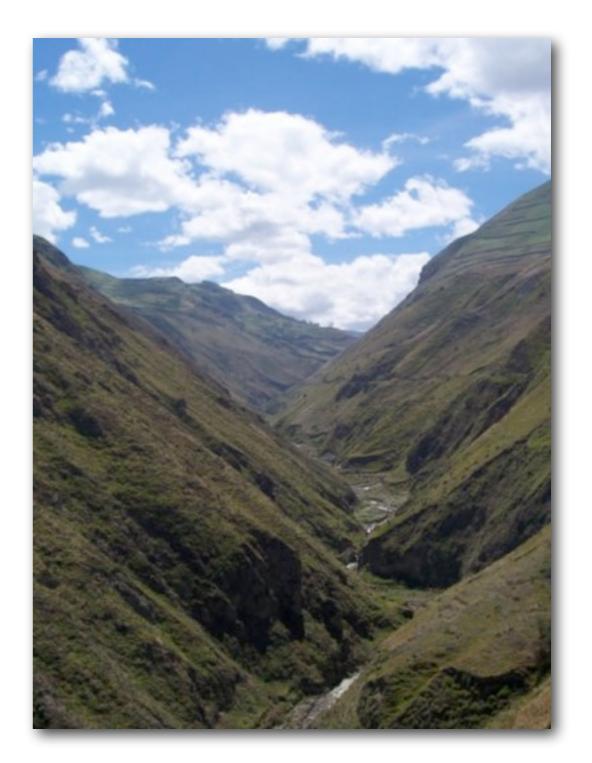




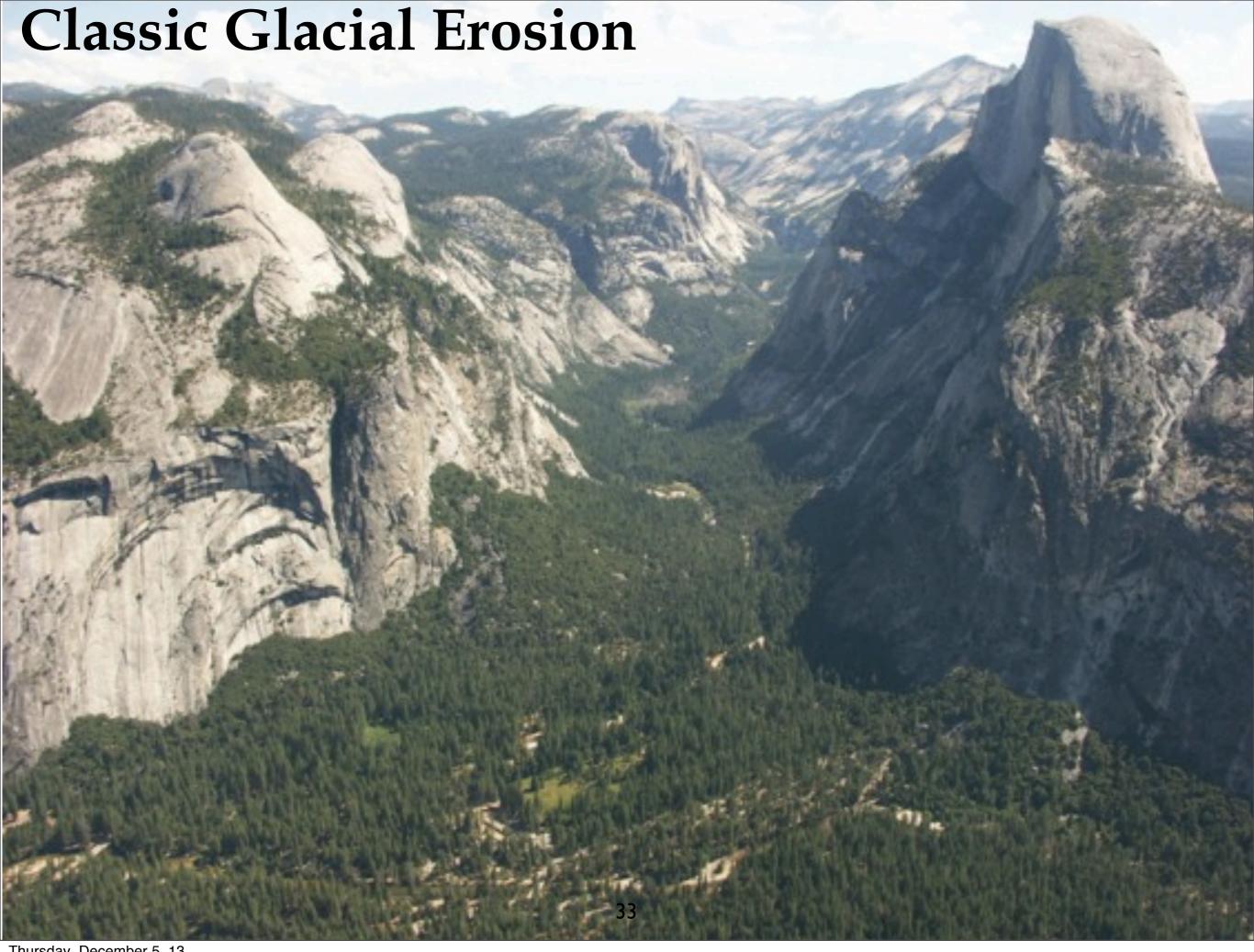
#### Glacial Erosion vs. River Erosion

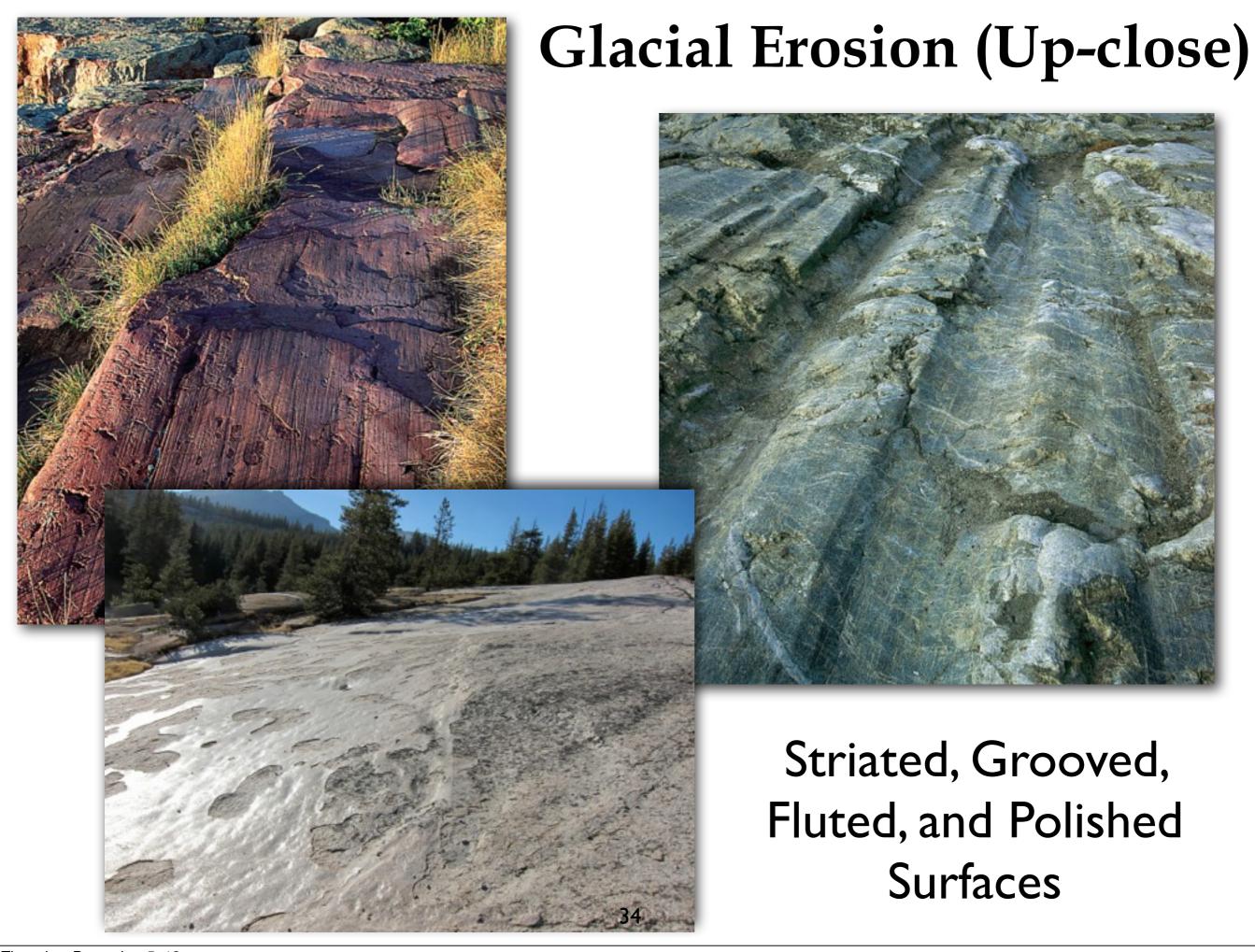


U-Shaped Glacial Valley



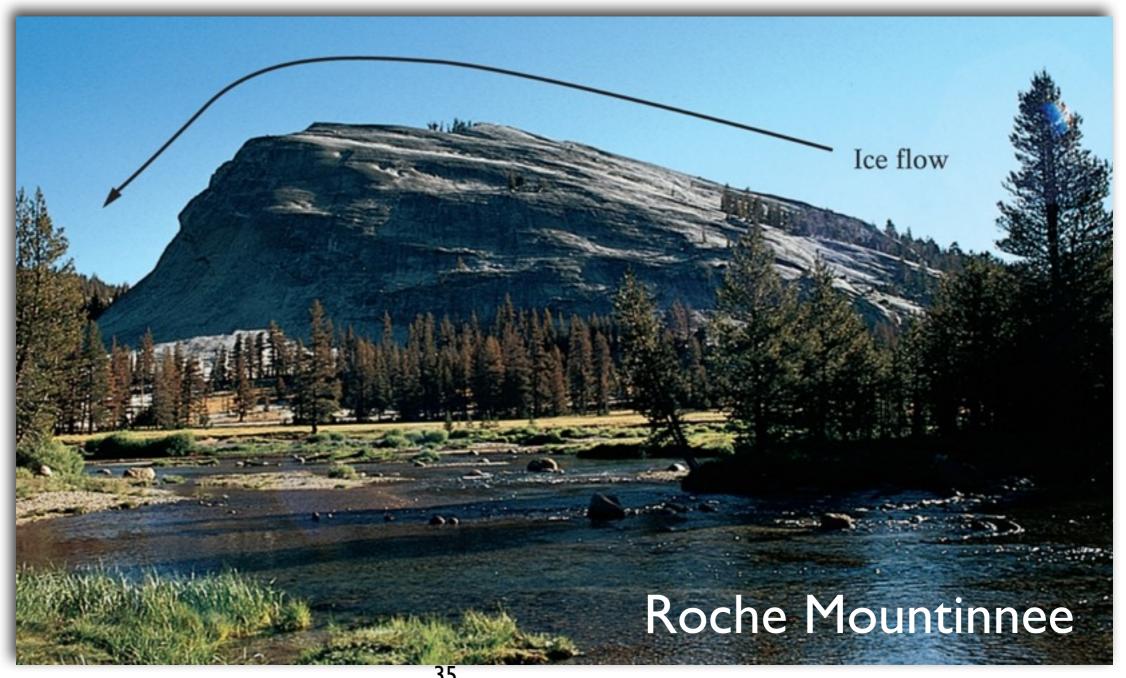
V-Shaped River Valley







# Glacial Erosion (Landforms)



Glacier with embedded rock fragments slides over bedrock

# Glacial Quarying (Roche Mountinnee)

Roche moutonnée

Open space where subglacial water refreezes in

Glacial quarrying Bedrock masses removed

Glacial quarrying bedrock

by glacier

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Ice flow

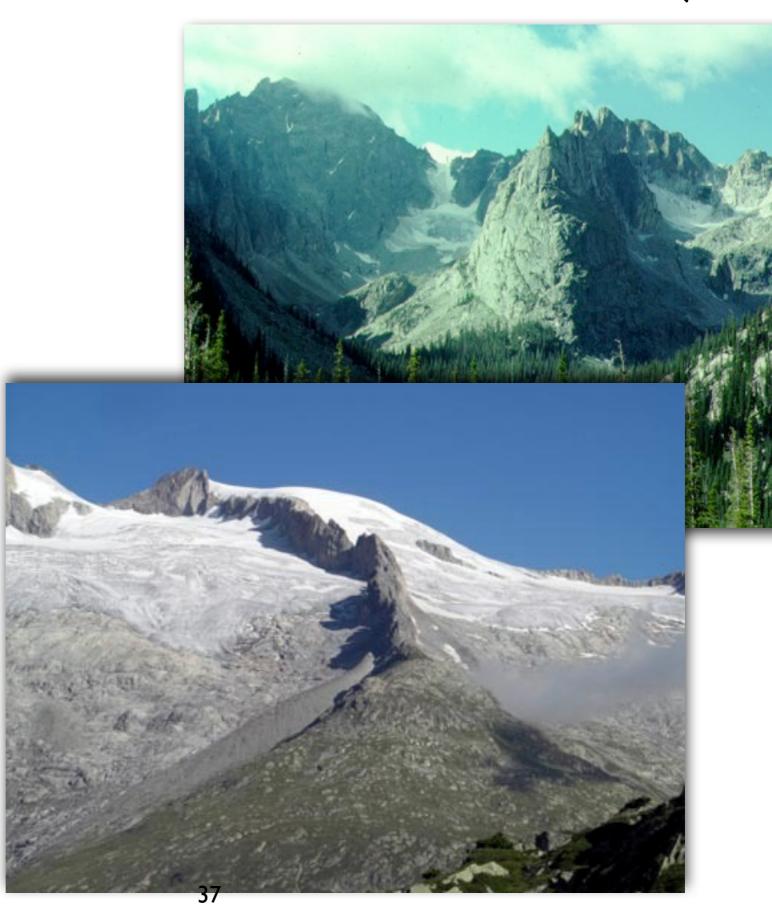
rock fractures

## Ice flow

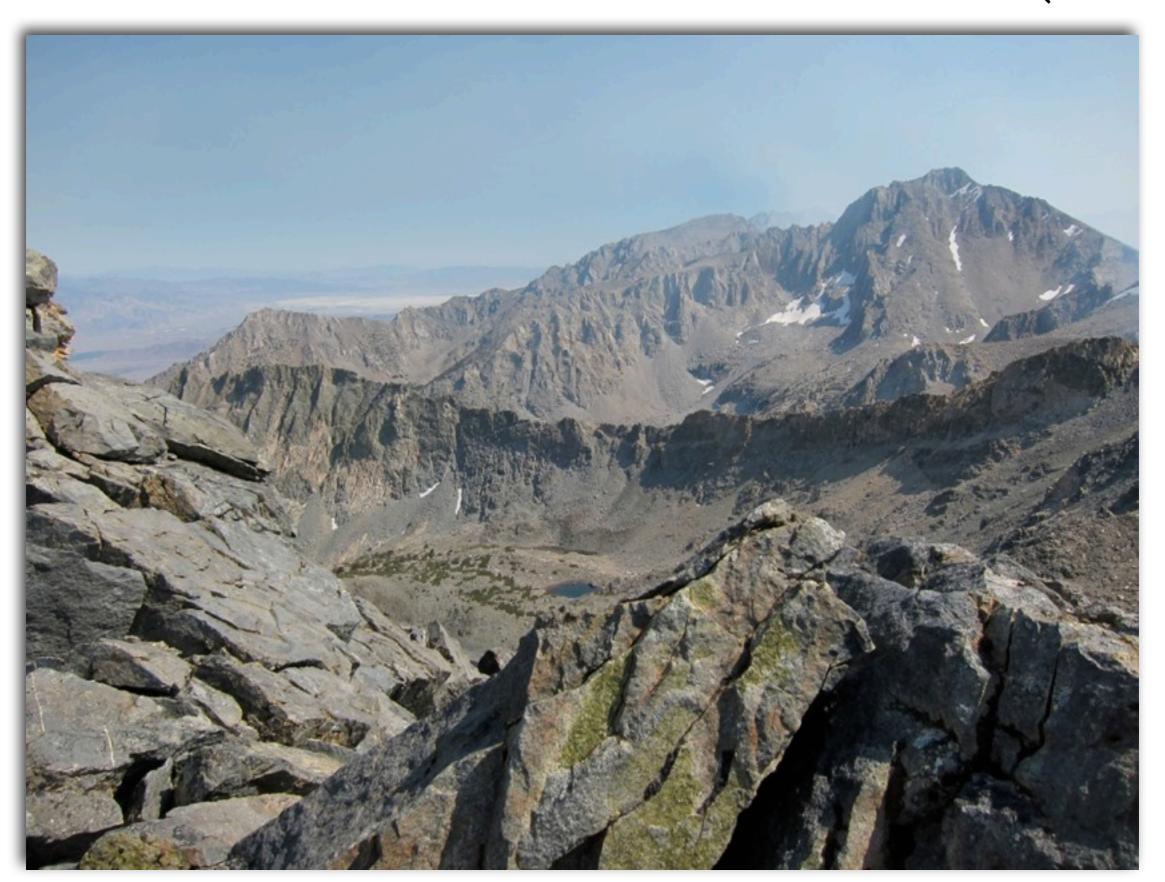


Carved by 2
Glaciers

### Glacial Erosion (Arete)



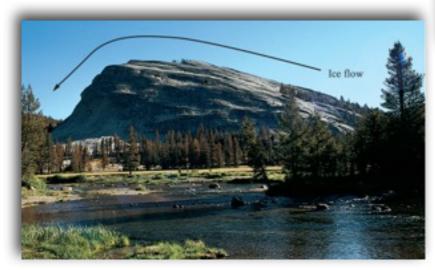
### Glacial Erosion (Arete)



### Glacial Erosion (Horn)

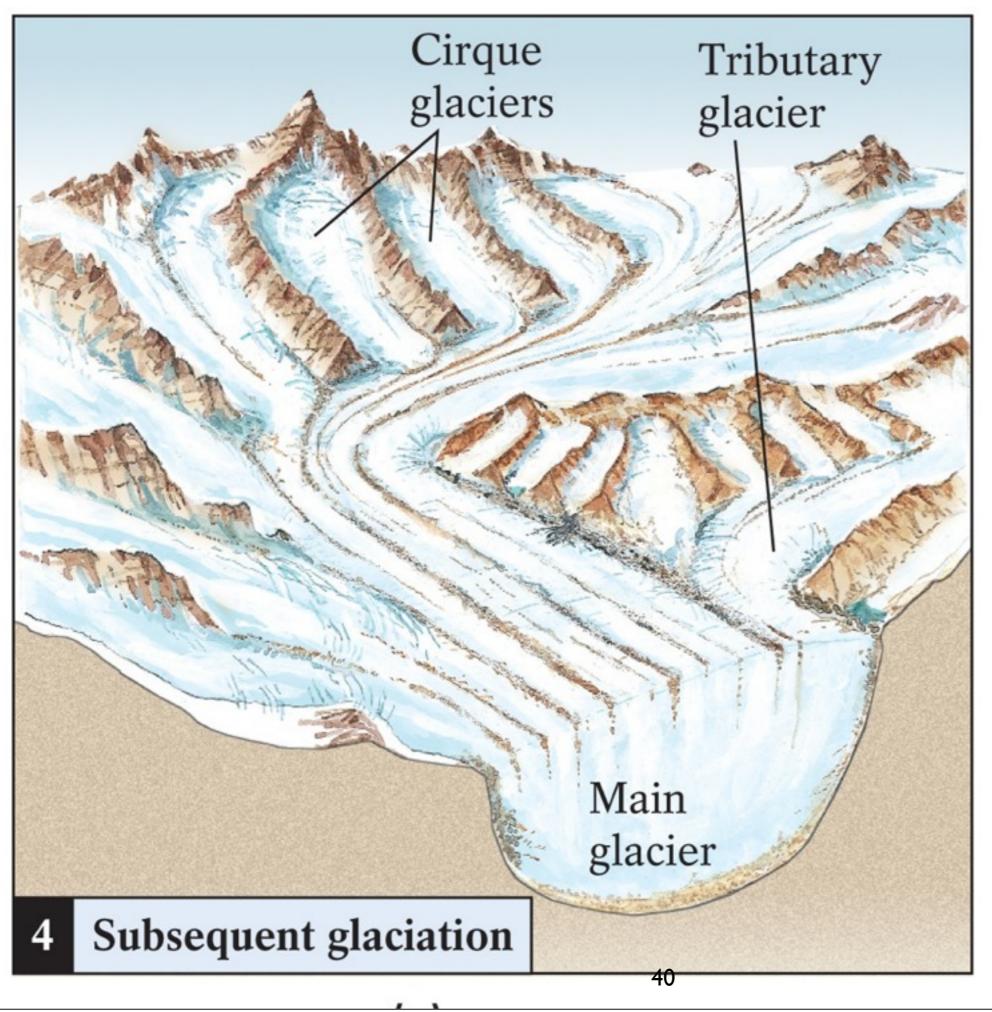




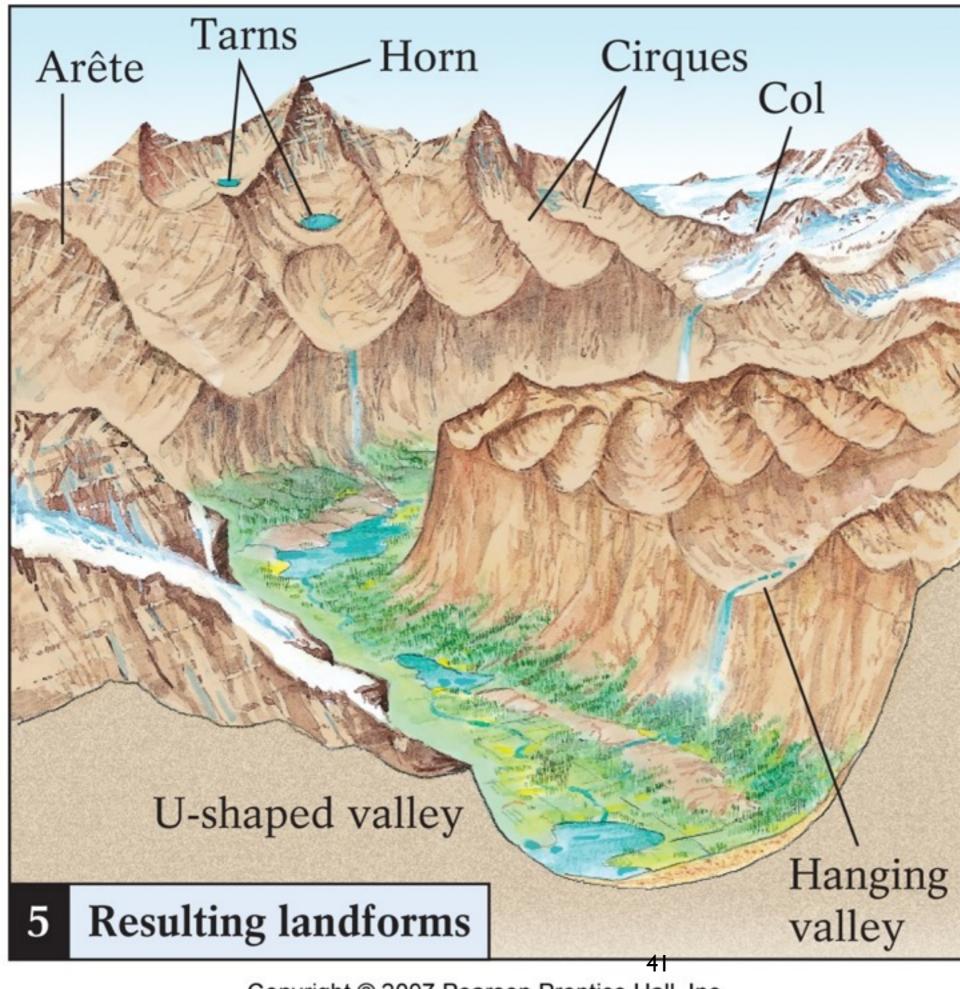




Carved by 3 Glaciers



### **Glacial Erosion**

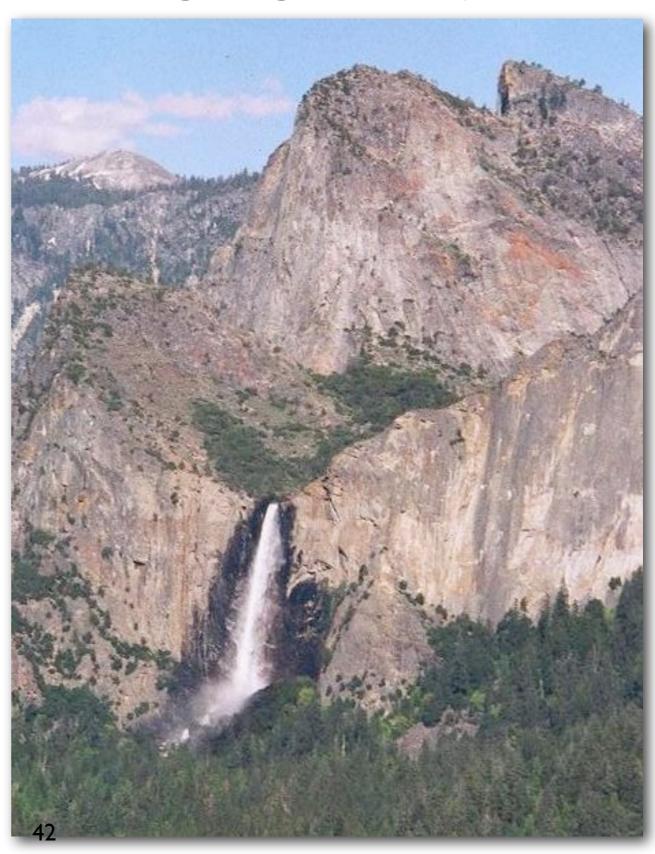


### Glacial **Erosion**

### Tarns Horn Cirques Arête Col U-shaped valley Hanging **Resulting landforms** valley

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### Glacial Erosion (hanging valley)



## Arête Horn Cirques Col U-shaped valley 5 Resulting landforms

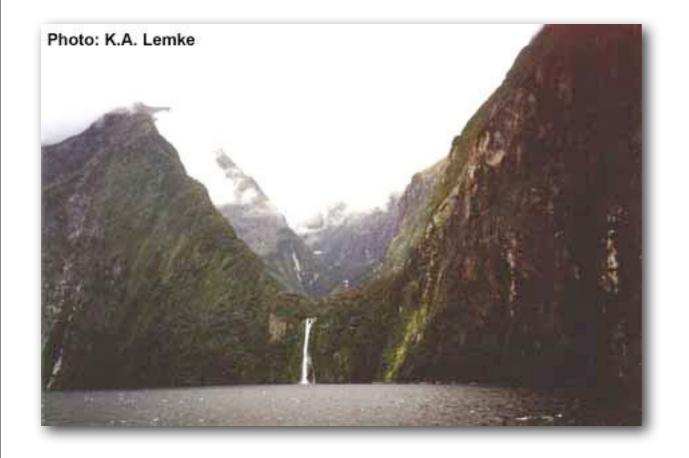
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### Glacial Erosion (hanging valley)



# Arête Tarns Horn Cirques Col U-shaped valley Hanging valley

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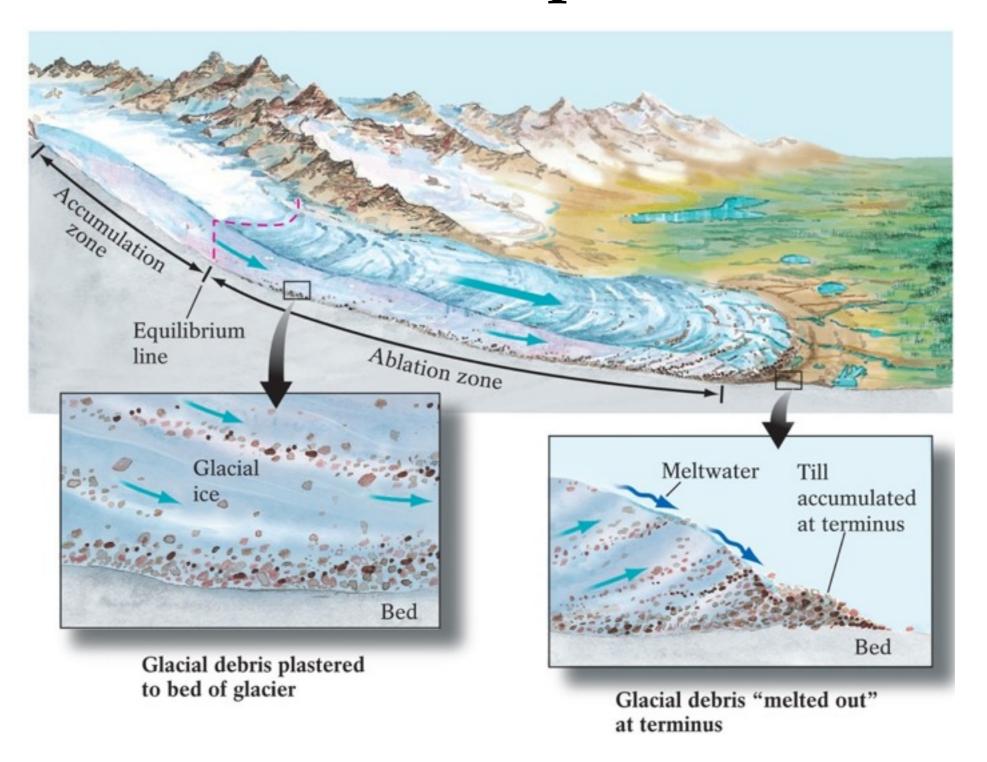


### Glacial Erosion (hanging valley)





### Glacial Deposition



Glacier V3 Animation



Thursday, December 5, 13

### Glacial Deposition

Till - Sediment, clay- to boulder-sized particles deposited directly by glacial ice.

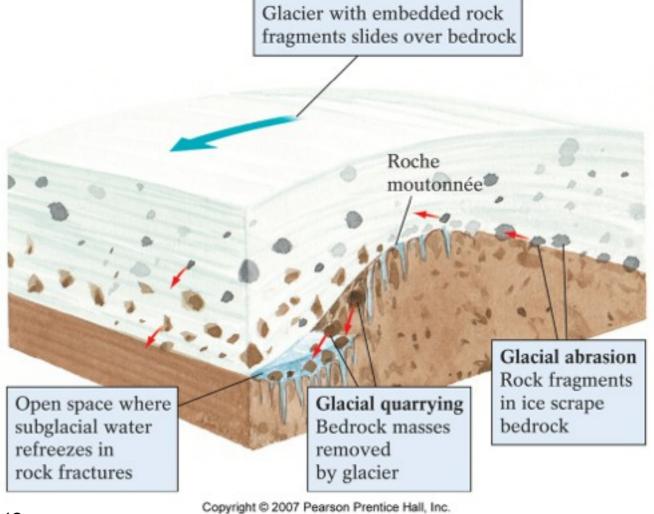
Outwash - Sediment, clay- to boulder-sized particles deposited by water sourced from melting glacial ice.

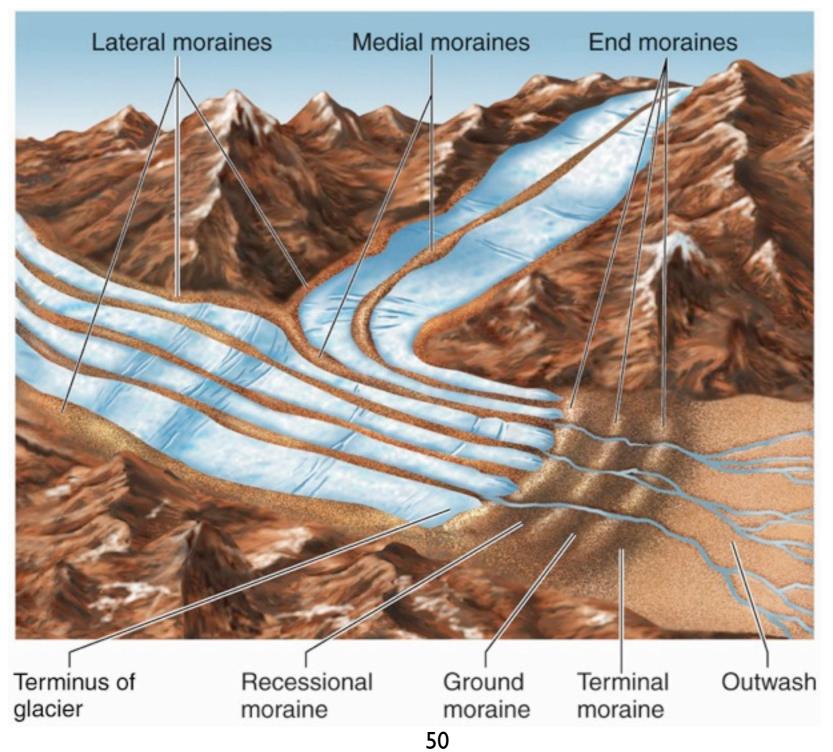




### Glacial Deposition







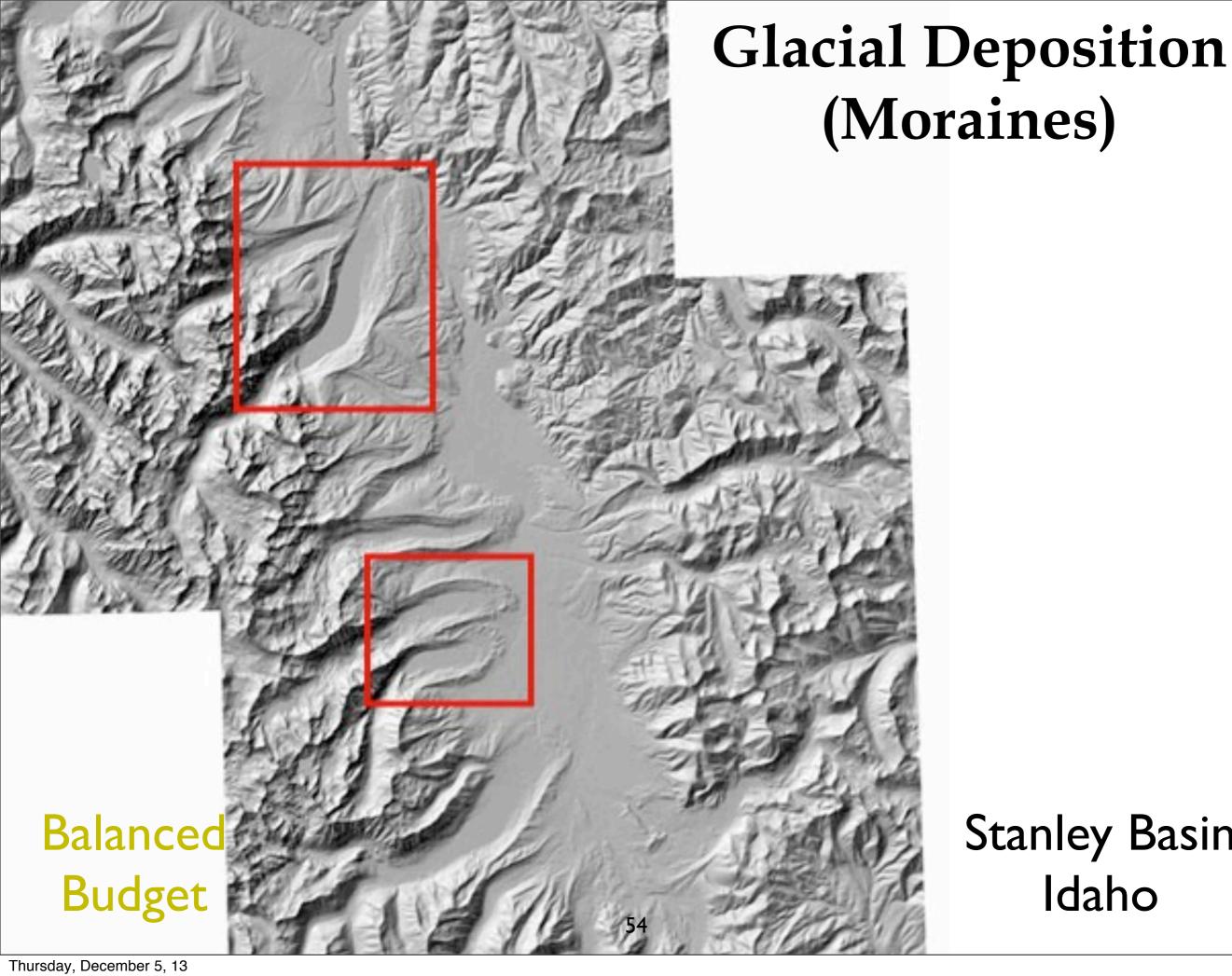
### Glacial Ice Dynamics

Glacier V2 Animation

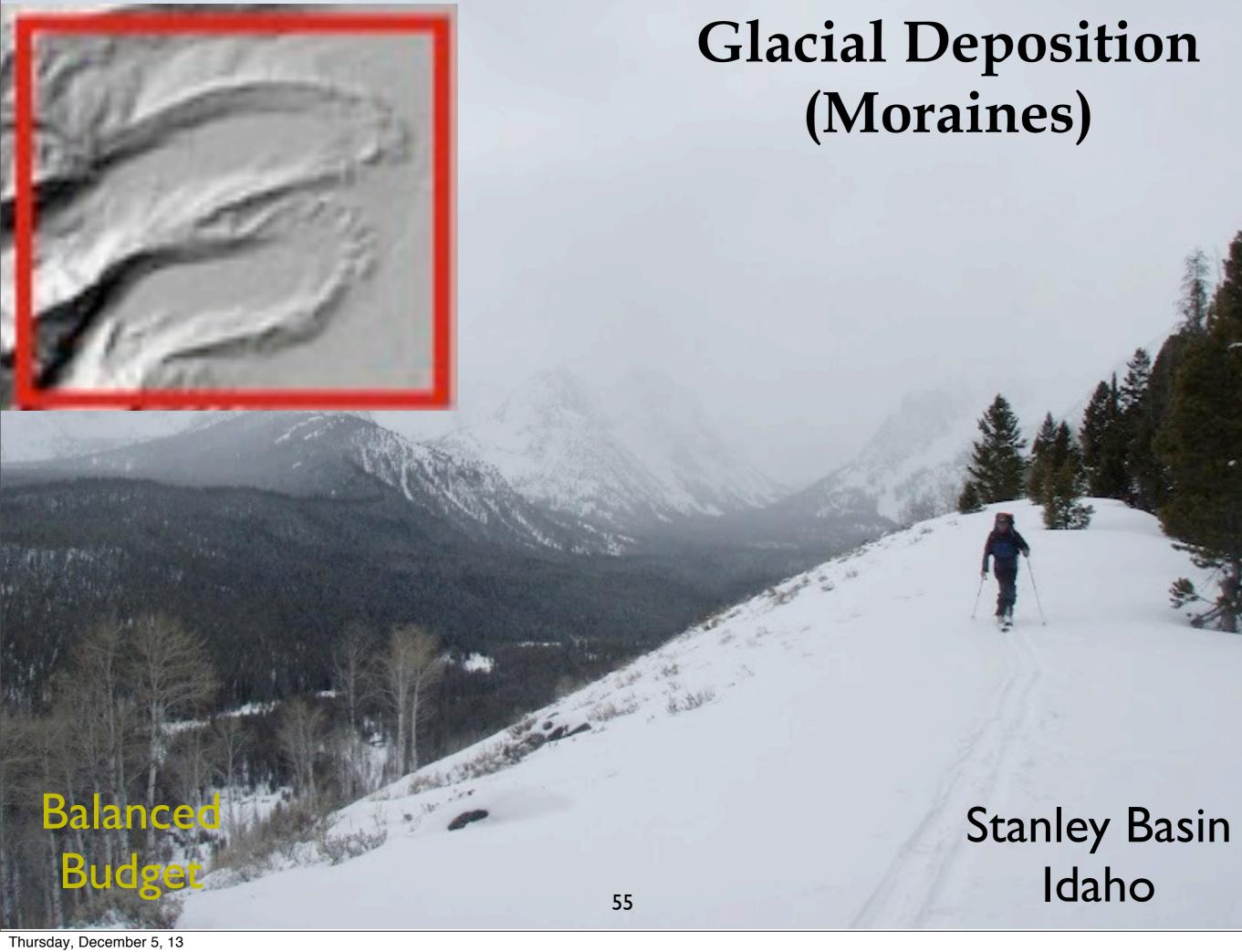




**Balanced Budget** 



Stanley Basin Idaho





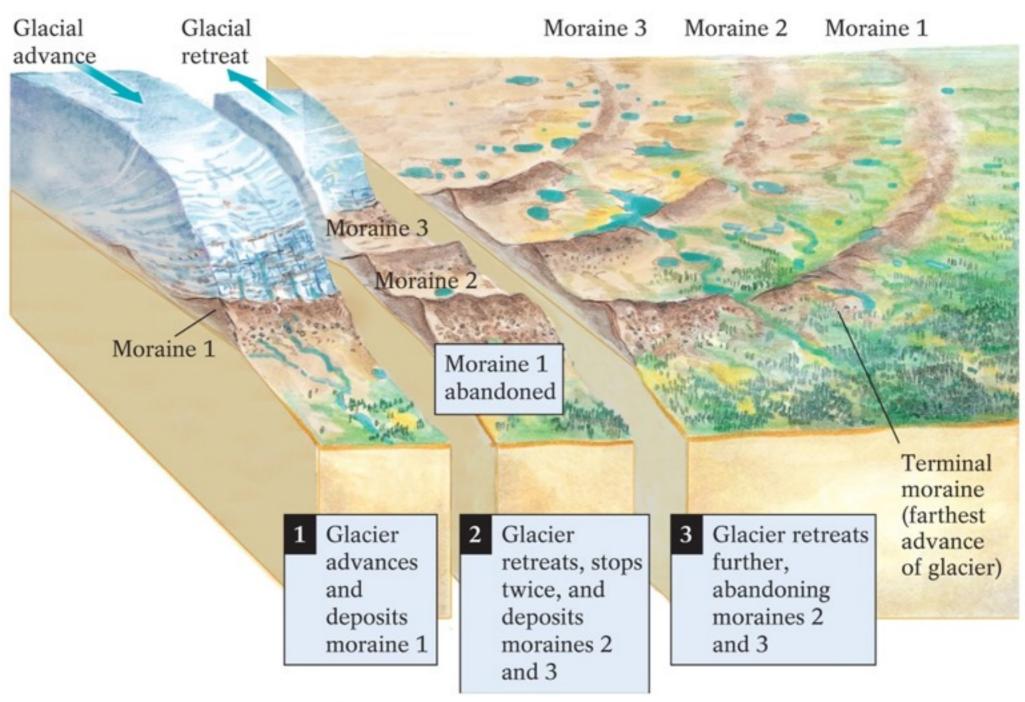


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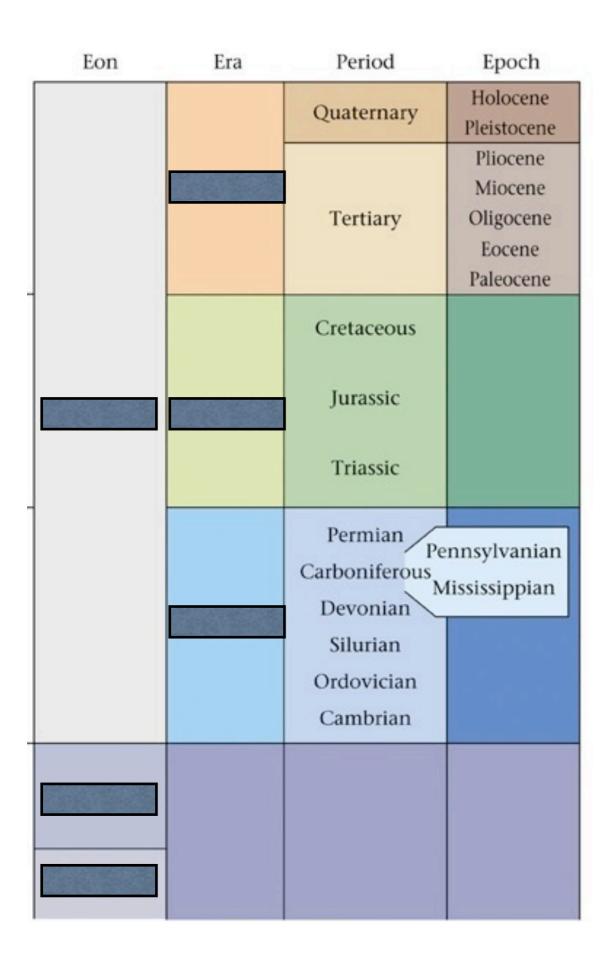
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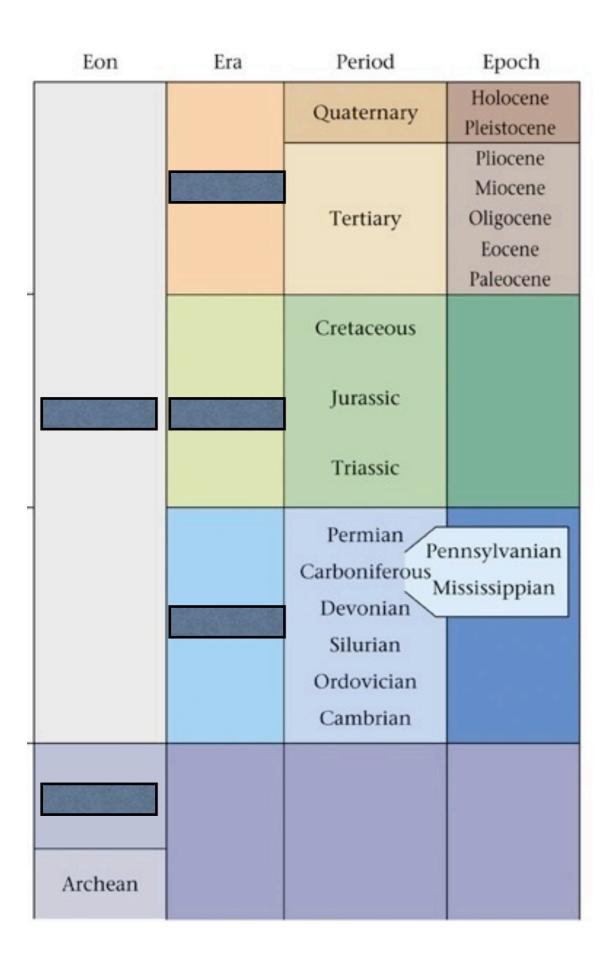
Terminal — Lateral — Medial — Recessional



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Eon	Era	Period	Epoch
		Quaternary	Holocene Pleistocene
		Tertiary	Pliocene Miocene Oligocene Eocene Paleocene
		Cretaceous	
		Jurassic	
		Triassic	
		Permian Pennsylvania Carboniferous Mississippia	
		Silurian	100
		Ordovician Cambrian	
Proterozoic	Pre	cambri	an
Archean		James	

Eon	Era	Period	Epoch
		Quaternary	Holocene Pleistocene
		Tertiary	Pliocene Miocene Oligocene Eocene Paleocene
		Cretaceous	
Phanerozoic		Jurassic	
		Triassic	
		Permian Pe Carboniferous M Devonian	nnsylvanian fississippian
		Silurian	11 7 7 7 7 8
		Ordovician	1 2.2
		Cambrian	
Proterozoic	Pre	cambri	an
Archean		Carriori	an

Eon	Era	Period	Epoch
		Quaternary	Holocene Pleistocene
		Tertiary	Pliocene Miocene Oligocene Eocene Paleocene
		Cretaceous	
Phanerozoic		Jurassic	
		Triassic	
	Paleozoic	Carboniferous	nnsylvanian Iississippian
		Ordovician Cambrian	
Proterozoic	Pre	cambri	an
Archean		Carriori	an

Eon	Era	Period	Epoch
		Quaternary	Holocene Pleistocene
		Tertiary	Pliocene Miocene Oligocene Eocene Paleocene
		Cretaceous	
Phanerozoic	Mesozoic	Jurassic	
		Triassic	
	Paleozoic	Permian Permian Permian November Novemb	nnsylvanian fississippian
Proterozoic	Pre	cambri	an
Archean		Carriori	

Eon Era		Period	Epoch	
		Quaternary	Holocene Pleistocene	
	Cenozoic	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	
		Cretaceous		
Phanerozoic	Mesozoic	Jurassic		
		Triassic		
	Paleozoic	Devonian  Silurian  Ordovician	nnsylvanian fississippian	
		Cambrian		
Proterozoic	Pre	cambri	an	
Archean		Carriori		

Eon	Era	Period	Epoch
	Cenozoic	Quaternary	Holocene Pleistocene
		Tertiary	Pliocene Miocene Oligocene Eocene Paleocene
		Cretaceous	
Phanerozoic	Mesozoic	Jurassic	
		Triassic	
	Paleozoic	Permian Permia	nnsylvanian fississippian
Proterozoic	Pre	cambri	an
Archean			

4.6 Ga

Eon Era		Period	Epoch
		Quaternary	Holocene Pleistocene
	Cenozoic	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene
		Cretaceous	
Phanerozoic	Mesozoic	Jurassic	
		Triassic	
	Paleozoic	Permian Permia	nnsylvanian fississippian
Proterozoic	Pre	cambri	an
Archean		Carriori	an

~545 Ma

4.6 Ga

Eon Era		Period	Epoch
		Quaternary	Holocene Pleistocene
	Cenozoic	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene
		Cretaceous	
Phanerozoic	Mesozoic	Jurassic	
		Triassic	
	Paleozoic	Carboniferous	nnsylvanian fississippian
Proterozoic	Pre	cambri	an
Archean		Carriori	an

~245 Ma

~545 Ma

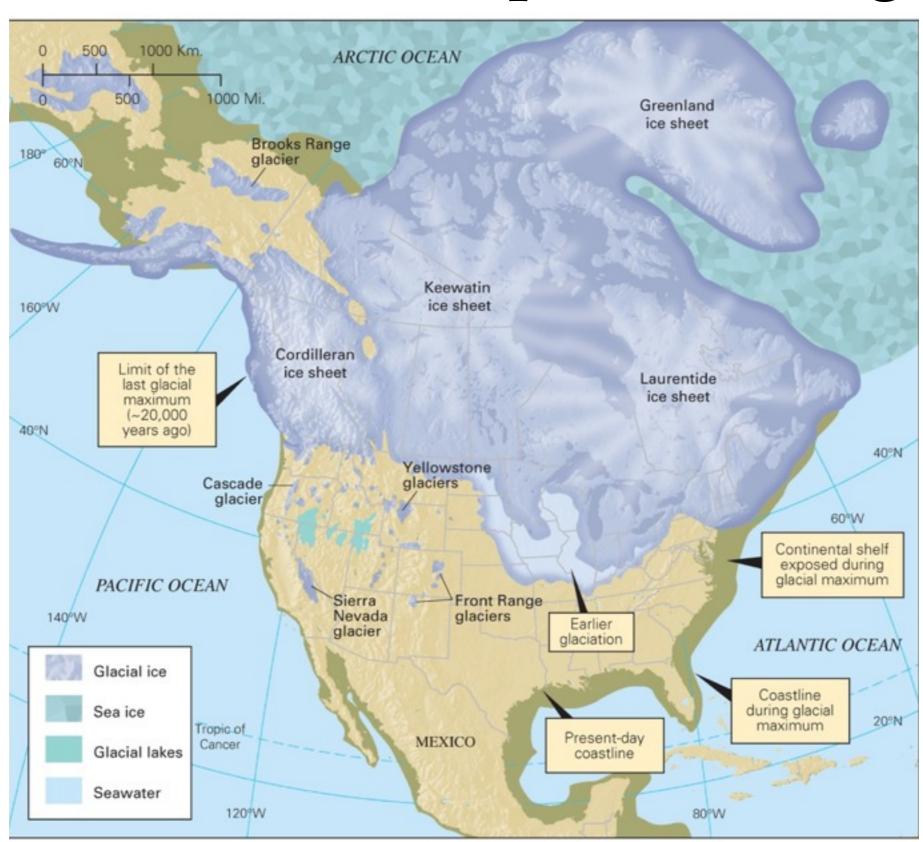
4.6 Ga

Eon	Era	Period	Epoch	1/
		Quaternary	Holocene Pleistocene	V
	Cenozoic	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	~65 Ma
		Cretaceous		~65 Ma
Phanerozoic	Mesozoic	Jurassic		
		Triassic		
	Paleozoic	Permian Permian Permian Devonian Silurian Ordovician	nnsylvanian fississippian	~245 M
		Cambrian		~545 M
Proterozoic	Pre	cambri	an	3131
Archean		Carriori	an	4.6 Ga

**1**a

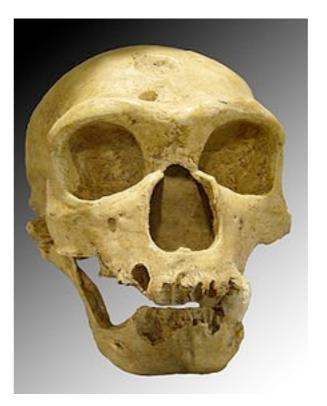
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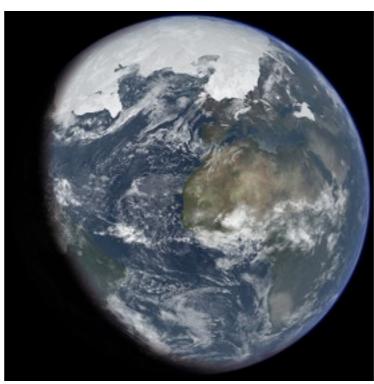




20 kyr (-5-7 C)

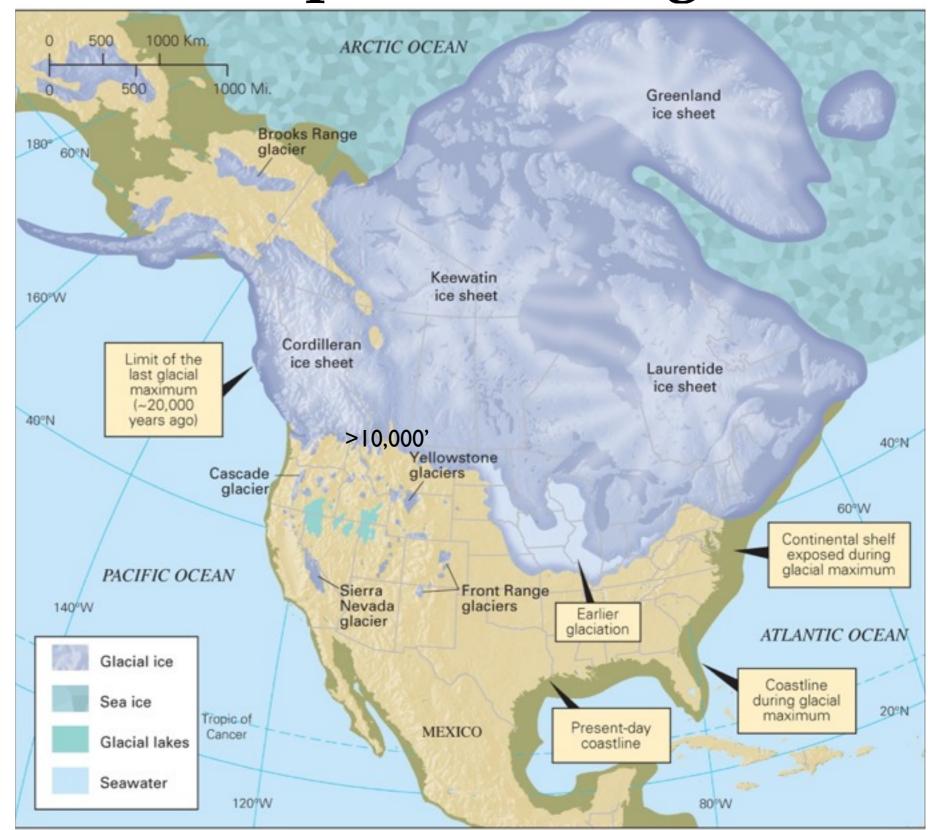


Neanderthal

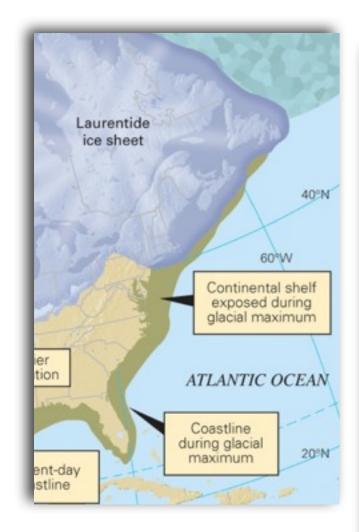




- 1) -20 k.y.
- 2) ~-10 F cooler
- 3) 30% of Earth

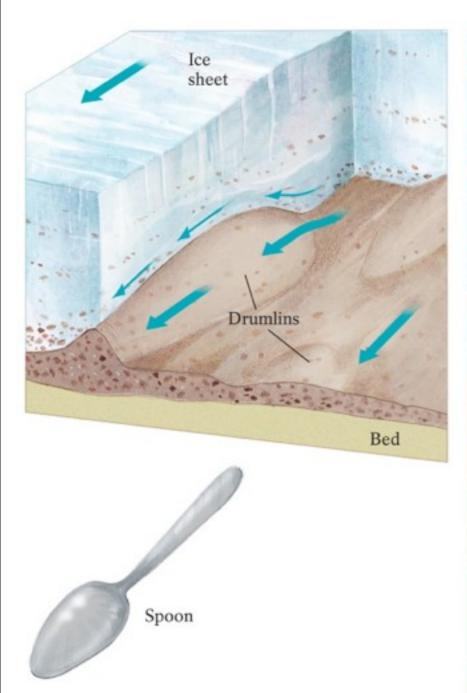


#### Continental Ice Caps and Ice Ages Depositional feature: Ground Moraine





## Continental Ice Caps and Ice Ages Drumlins



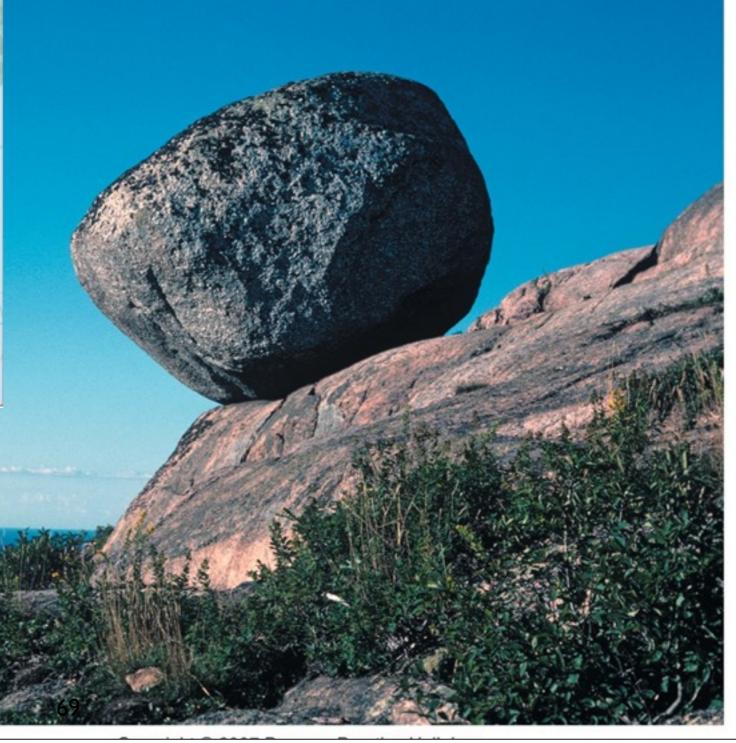


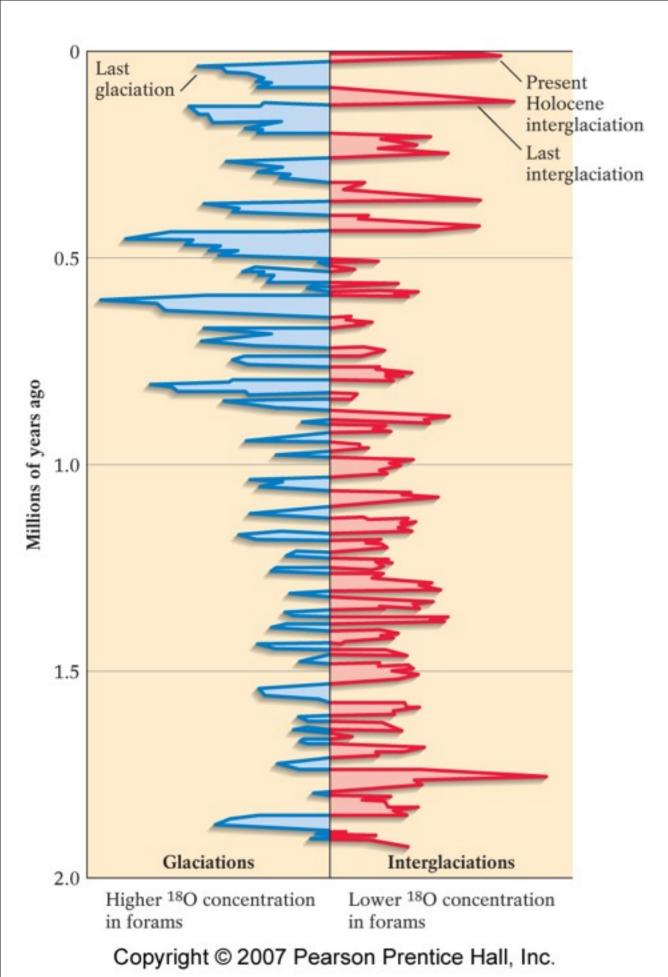
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(How do we know?) Laurentide ice sheet 60°W Continental shelf exposed during glacial maximum ATLANTIC OCEAN Coastline during glacial ent-day Springfield

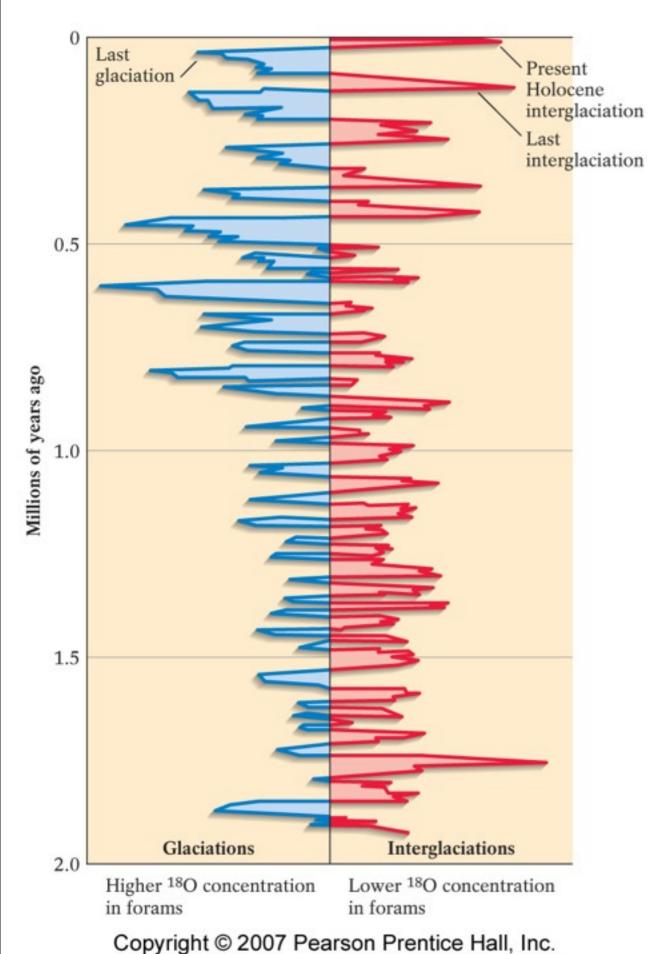


Glacial Erratic





### Glacial and Interglacial cycles



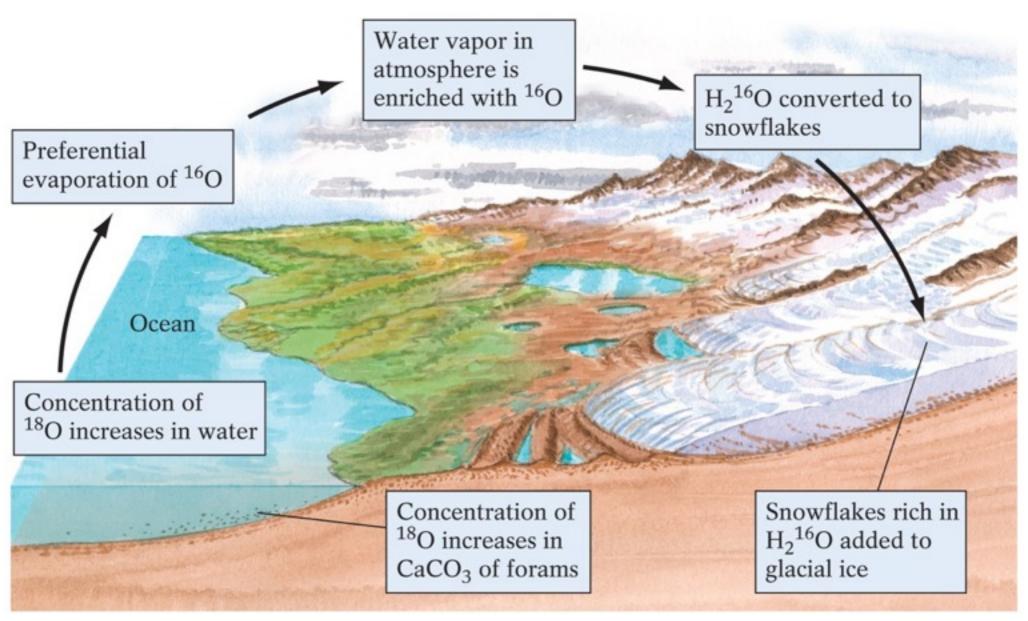
#### Glacial and Interglacial cycles

(How do we know?)

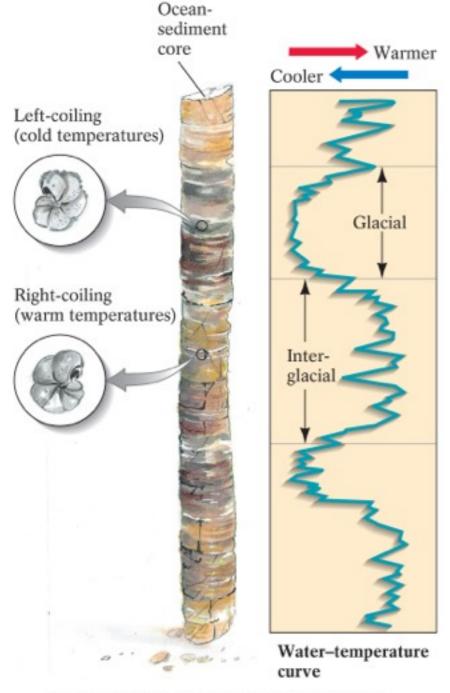
70

## Continental Ice Caps and Ice Ages (How do we know?)

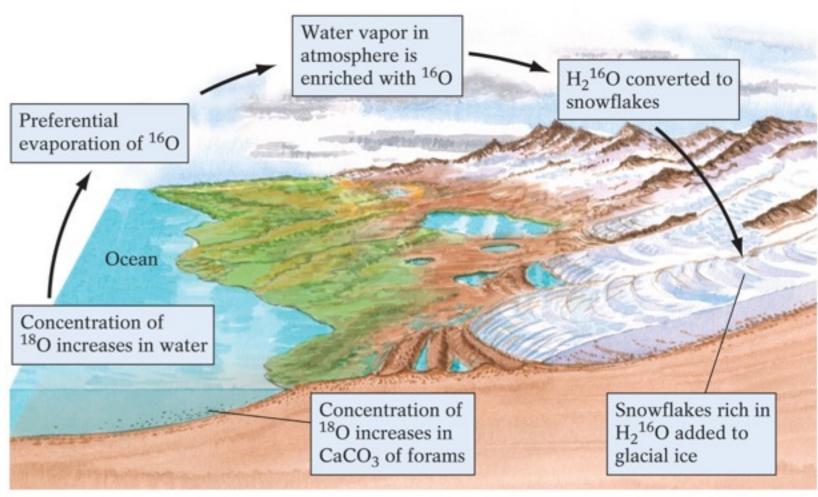
### Stable Isotopes of Oxygen 16 and Oxygen 18



## Continental Ice Caps and Ice Ages (How do we know?)



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#### Last Present glaciation Holocene interglaciation Last interglaciation 0.5 Millions of years ago 1.5 Glaciations Interglaciations 2.0 Higher <sup>18</sup>O concentration Lower <sup>18</sup>O concentration in forams in forams

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### Glacial and Interglacial cycles

~100,000 year cyclicity separated by brief intervals (10,000yr)

## Continental Ice Caps and Ice Ages (What are the Driving forces?)

There is consensus among scientists that three main factors must be present in order for an Ice Age to occur

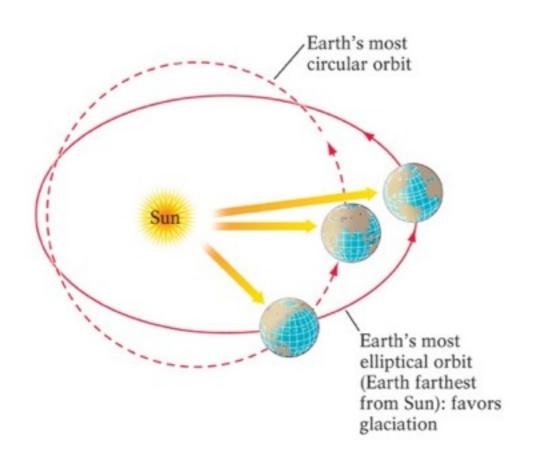
1) Sizable landmass at or near the poles; 2) land surfaces with relatively high elevations; 3) and nearby oceans to provide moisture

## Continental Ice Caps and Ice Ages (What are the Driving forces?)

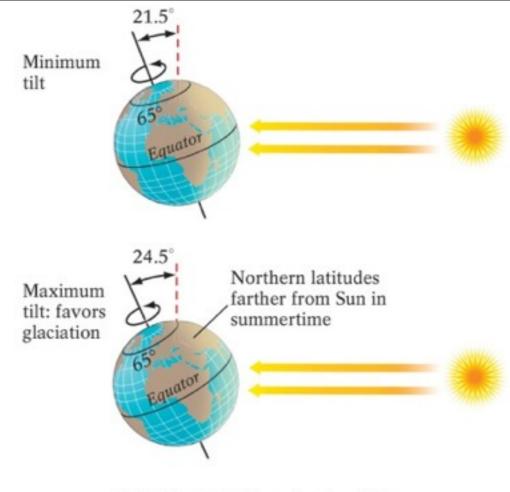
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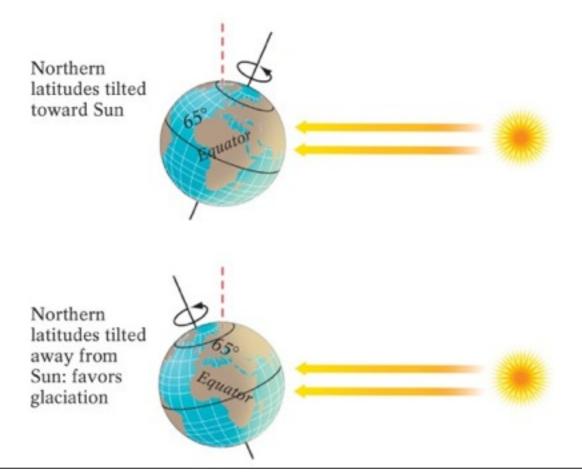
Why cannot plate tectonics be the driving force?







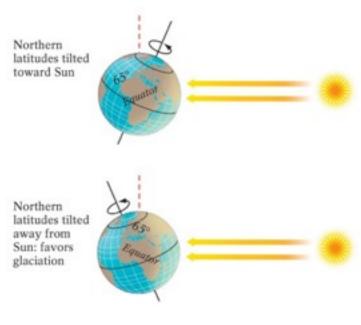
(b) Tilt of Earth's axis of rotation



# Milutin Milankovitch suggested Orbital forcing was the dominate mechanism

# Earth's most circular orbit Earth's most elliptical orbit (Earth farthest from Sun): favors glaciation

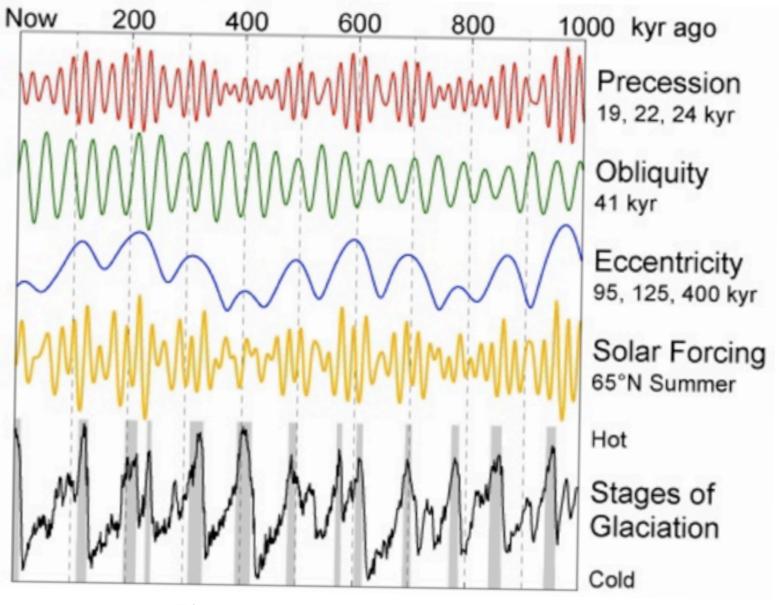
#### (a) Orbital effects



(c) Wobble of Earth's axis of rotation (precession)

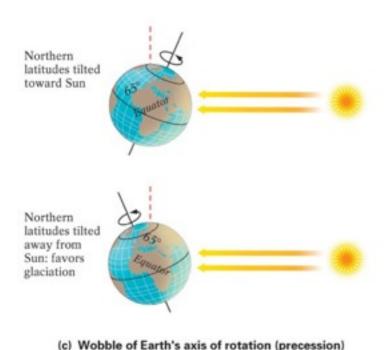


(b) Tilt of Farth's axis of rotation

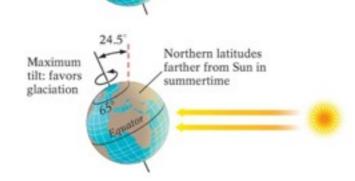


# Earth's most circular orbit Earth's most elliptical orbit (Earth farthest from Sun): favors glaciation

#### (a) Orbital effects



### Milonkovitch Cycles



(b) Tilt of Farth's axis of rotation

