GLACIAL LANDFORMS AND PROCESSES

A. Erosional Processes- The movement of ice and the pressure exerted on the underlying earth surface result in capability of glaciers to perform great amounts of erosion and earth sculpturing.

1. **Abrasion-** ice as a belt sander- ice incorporates rock fragments at its base and operates as a rasp on underlying rock strata

a. Direct Evidence of Abrasion

(I) May produce Rock Flour or

(II) Glacial striations: on polished bedrock surfaces linear scratches on bedrock surface that preserve clues as to the direction of glacial motion

b. Controlling Factors of Abrasion Rates

(1) Concentration of basal rock debris

(2) Supply of rock debris to glacier base (ice flow path mechanisms)

(3) Hardness of debris vs. hardness of bedrock

(4) Basal meltwater wash-out mechanism

(5) Glacial flow velocity

(6) Thickness of ice: pressure of overburden

(7) Basal hydrostatic pressure

(8) Grain shape of basal rock debris

2. Plucking/Quarrying

a. *Plucking Process*- as ice flows over fractured bedrock surface, the ice/movement loosens and lifts blocks of rock/debris and incorporates them into the ice via a freeze/thaw process. Meltwater from ice generated via friction and temperature, water fills cracks of rock, frost wedging breaks and pulverizes rock.

b. Friction Cracks-stick-slip motion/freeze action produces small-scale fractures in underlying bedrock

(1) *Chatter Marks*: small-scale concentric fractures of gouges (mm to cm in scale)

(a) Paleoflow Indicator:

i) "smooth polished" direction = ice flow direction

ii) "rough" direction = up flow direction

3. Subglacial Fluvial Erosion

a. Glacial Meltwater: subglacial flow and channelization

(1) "englacial" flow: within body of ice

(2) "subglacial" flow: at base of ice

(3) Channel patterns parallel to topographic gradient and ice flow directions

b. Seasonally fluctuates according to temperature/melting

(I) glacial conduits expand and contract seasonally

B. Transportation and Depositional Processes: Deposition of eroded debris occurs when glacial ice melts, sediment may be deposited directly by the glacial ice or by melt waters flowing away from the glacial ice.

1. Transportation Process: massive amounts of debris generated, debris deposited directly from glacial ice or from glacio-fluvial meltwater

2. Debris Terminology

a. Glacial Drift: all deposits derived from glacial process (either directly or from meltwater)

(I) Till: debris deposited directly from glacial ice (a) poorly sorted admixtures from flour to boulders

(II) Outwash: sorted and stratified debris deposited by meltwaters

3. Deposition

a. Non-stratified, Poorly Sorted Sediments

(I) Diamictons: deposits of poorly sorted glacial clasts

(II) Till- sediment deposited directly by glacial ice

(a) Process:

i) Deposited by ice when it melts

ii) Unsorted mixture of sediment of many sizes (clay to boulder)

a) Polished and striated clasts iii) Highly compacted from weight of ice

(b) Lodgment Till: till derived from melt of basal ice, debris subsequently compacted and plastered to ground surface by over-riding ice

(c) Ablation Till: debris released from melting ice as the glacier undergoes ablation (not overridden by ice sheet directly, later ice advances notwithstanding)

EROSIONAL GLACIAL LANDFORMS:

(Massive sculpturing of landscape, extremely high rates of erosion compared to "normal" weathering and mass wasting processes)

A. Cirques- a bowl shaped depression located at the head of a glacial valley, steep walls on three sides of cirque, with open end leading down valley

1. cirque- represents the cradle of the glacier where snow accumulated most with ice formation, glaciers flowing away from cirque.

2. Bowl shaped depression results from plucking rock from sides, and scooping out at base of glacier.

3. Headwall Erosion: intense freeze-thaw (frost shattering) and plucking action along headwall of cirque a. Bergschrund-crevasse formed between head of glacier and headwall of cirque

4. Tarn Lakes: lake-filled cirque basins

5. Compound Cirques: coalesced cirque basins, scalloped surface topography

6. Nivation Cirques: development of cirques on non-glacial topography, depression-hollows found commonly on north slope areas (northern hemisphere)

a. Aspect Control: North slope areas: decreased influx of solar radiation, extended periods of snow cover prior to melting

B. Aretes, Cols and Horns

1. Aretes- saw-toothed ridge which separates two glacial valleys (a glacial valley divide)

2. Cols- A sharped-edge pass or saddle between two adjacent cirques. Occurs when two adjacent cirques cut back to remove part of arete between them resulting in col.

3. Horns- 3 to 4-sided pyramid shaped mountain peaks, produced by the adjoinment of 3-4 cirques on each side of the peak.

a. Process: result as erosional remnant from the plucking and frost wedging action at the head of glacial tributary valleys.

b. Effectively produced by glacial "headward" erosion

C. Glacial Valleys: U-shaped Cross Section

1. U-shaped Valleys- flat valley bottoms and steep valley walls, result of shear stress and glacial erosion along valley walls

a. Valley glaciers tend to conform to original fluvial topography

b. Through Glacial erosion they tend to: (1) Widen a valley (2) Deepen a valley (3) Straighten valleys

c. Depth of valley modification dependent upon thickness of glacial ice

d. Massive amounts of rock eroded during valley glaciation

2. Hanging Valleys- tributary valleys left hanging high above the main glacial trough upon melting of glacial ice.

a. Process: result from glaciers cutting main valleys deeper than tributary valleys due to greater accumulations of icen in main valleys, upon melting, tributary valleys were not cut as deep as main valley, thus leaving them hanging.

3. Fjords- glacial valleys which have been inundated by the sea (i.e. a drowned U-shaped valley).

4. Paternoster Lakes- a string of glacial lakes in line along a glaciated valley

5. Finger Lakes (Upstate NY)

a. Glacial scouring and deepening of pre-glacial valleys by continental ice sheets

b. Scoured to 1000's of ft depth, partially filled with unconsolidated sediment

c. Lakes 600-700 Ft deep

D. Glacial Scour and Streamlined Forms

1. Whale Backs: streamlined erosionally abraded rock outcrops

2. Roches Moutonnees- phenomena in which pre-existing bedrock hills are sheared off and rounded by moving ice, with plucking dominant on lee side forming a smooth sloping stoss side and more steeply inclined irregular lee side.

3. Striated Glacial Pavements: on bedrock via the abrasion process. a. Striations: abrasion scratches on underlying bedrock pavement, evident upon removal of glacial ice (

1) Scale: fractions of mm to 100's of m's

(a) Depends on size of abrading fragments

(2) Groove orientation provides paleo-flow indicator

b. By-product: striated/polished clasts in till deposits.

DEPOSITIONAL LANDFORMS

A. Moraines- layers or ridges of till (unsorted glacial deposits) deposited from glacial ice (commonly curvilinear in shape conforming to lobate form of ice front)

1. End Moraines- may be applied to both continental and valley glaciers- till deposited at the terminus of a glacier at any given time (thus may be later bull dozed by the glacier)

a. Terminal Moraine- deposited at the point of furthest advance of a glacier

b. Recessional Moraine- deposited at the terminus of a glacial as it recedes back up the valley., accumulated during stillstands of retreat process

2. Lateral Moraines- associated only with alpine glaciers, moraine/till deposited along valley walls.

a. Debris derived from direct glacial scour and from freezethaw frost shattering along valley walls

b. Eventually grade into terminal moraines

3. Medial Moraines- till deposited at the juncture of two alpine glaciers which coalesce as tributaries (i.e. lateral moraines which come together as medial moraines)

a. Eventually grade into terminal moraines

4. Interlobate Moraines-accumulates between two adjacent lobes of ice

5. Ground Moraine- applied to continental glaciers: till deposited irregulary as the glacier recedes forming a gently undulating surface, fills in low spots

a. comprised of lodgment and ablation till

b. forms irregular hummocky blanket of till over land surface

B. Drumlins- (continental glaciers)- streamlined, tear-drop shaped, asymetrical hills composed of till, the tail of the drumlin points in direction of ice movement, round/wide steep side points in opposite direction of flow. Steep and wide stoss side, narrow tail on lee side a. Avg. 1 mi long, 150 Ft high, 1500 Ft wide. Drumlins often found in clusters, possibly related to re-advance 152 of a glacier over end moraine, resulting in bulldozing and shaping drumlins into the forms.

C. Flutes: amalgamated, elongate drumlins forming parallel ridges as opposed to well defined drumlin hills.

GLACIAL STAGNATION: MELTWATER LANDFORMS

A. Eskers- (continental glaciers)- sinuous ridges composed of sorted sand and gravel, deposited by sub-glacial streams flowing in tunnels beneath the ice, near the terminus of the glacier. These area composed of coarse, stratified, sorted sand and gravel

B. Kames- (continental glaciers) irregular steep-sided hills that are composed of sand and gravel, thought to represent sediment deposited in hollows within glacial ice.

C. Outwash Plains- (continental and/or alpine glaciers)- melt water from the glacier flows over end moraines, eroding them and carrying sediment further downslope, sediment becomes sorted and deposited downslope of most end moraines.

D. Kettle Holes (term applied to continental glaciers)- depressions found in deposits- represents situation where an isolated block of ice became buried in drift, subsequently melted, leaving a pit in the glacial sediment.