

**GLG101: Physical Geology Lecture Review Series**

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# **GLG101: Physical Geology Lecture Outlines for Exam#4:**

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References to Tarbuck, Lutgens & Tasa (or T & L) refer to the 10<sup>th</sup> or custom GCC edition.

18 pages including this cover

## GLG101: Mass Wasting Lectures- Reviews

**Mass Wasting Dfn:** Soil, rock debris, and/or bedrock moving in bulk at the Earth's surface is Mass Wasting. Movement is downhill and the main driving force is gravity. Mass Wasting is a form of erosion/transportation. Mass wasting is an important geologic process for us as consumers to be aware of.

### Gravity- the driving force

Weight of material- mass acted upon by gravity is weight

Normal force- component of gravitational force perpendicular to slope

Shear force- component of gravitational force parallel to slope

Shear Strength- Cohesive force of material- resistance to deformation (breaking or flowing)

Different materials have different shear strengths (different angle of repose)

Friction- force resisting movement between two bodies

### Water- a critical factor

Water content of material strongly influences the potential for mass wasting to occur.

- Small amount is OK- surface tension actually helps hold loose materials together
- Too much saturates material and pushes loose grains apart- reduces shear strength
- Reduced shear strength allows for faster movement of material
- Water also adds weight to the material
- Freezing and thawing of water allows for additional break-up of material and freezing contributes to lifting force to separate particles from underlying material.

### Factors for the Classification of Mass Wasting

#### *Rate of Movement*

**Creep** (<1 cm/year)

**Flows and Slides** (1 mm/day to around 5 km/hr)

**Falls and Avalanches** (>5 km/hr)

Flows, slides, falls and avalanches are collectively known as **landslides**

#### *Type of Material*

**Debris**- any unconsolidated material at the Earth's surface. Debris includes soil and masses of rock fragments or sediments

**Bedrock**- a coherent, consolidated mass of rock

### *Type of Movement*

**Flow**- mass is moving downhill as a viscous liquid- particles are moving as an incoherent mass

**Slip**- mass moves downhill as a relatively intact coherent block. Movement occurs along one or a few fairly well-defined planes. (form **slides** and **slumps**)

**Fall**- movement occurs as a free-fall off a more-or less vertical cliff

### **Types of Mass Wasting**

#### **Flows**

**Creep**- slow continuous movement of soil or debris downhill. Can take place in any climates but are enhanced by climates with lots of freeze-thaw cycles. Solifluction and permafrost heating also cause creep. Evidence of creep: bent trees, tilted man-made structures like power poles, fences, walls, etc.

**Debris Flows**- mass wasting in which motion is taking place throughout the mass- the material is flowing as a viscous fluid

#### Earthflows

**Mudflows**- flowing mixture of debris and water typical in arid environments during flash floods. Other environments are melting of glaciers by volcanic heat such as at Mt St Helens during pyroclastic eruption.

**Debris Avalanches** (material starts as debris

**Rock Avalanches** (material starts as bedrock)- breaks up into mass of rock debris

#### **Slips and Slides**

**Debris slides**- coherent mass of debris moving along plane of weakness

**Debris slumps**- coherent mass of debris moving along plane of weakness but motion is a rotating one- weakness is spoon-shaped.

**Rockslides**- sliding mass of rock along plane of weakness (foliation etc.) Rockslides may break up into rock avalanches.

**Rock slumps**- Toreva blocks

#### **Falls**

**Rock Falls**- Rocks freely fall from cliffs. Undercutting by wave action, human activity (bulldozers); or from frost heaving along steep cliffs.

**Talus**- apron of debris of broken rocks at base of large cliffs.

**Debris Falls**- Debris falls from cliff as coherent mass initially. May degrade into debris avalanches with continued movement.

**\*\*Key Controlling Factors in Mass Wasting**

- Slope Angle- the steeper the slope the higher the shear force
- Local Relief- local relief is the difference between the highest and lowest elevations in the vicinity of interest. The greater the relief, the higher the potential for moving masses to build up momentum and speed
- Thickness of debris over bedrock- the thicker the debris the more it weighs and the more susceptible it is to holding large quantities of water
  
- Orientation of planes of weakness (foliation, bedding) in bedrock
  - Foliations- metamorphic rocks
  - Bedding - in sedimentary rocks particularly in shales or weak bedding planes between coarser rocks
  - Sheet joints and other fractures such as cooling joints or faults- any fractures along which water can infiltrate can be susceptible
  - General rule-* if planes are oriented perpendicular to slope, system is stablest. Planes oriented parallel to shear force (i.e. parallel to the slope) is most hazardous
- Climate
  - Freeze/thaw cycles- expansion and contraction during freezing and thawing contributes to break-up of material (physical weathering) and lifts materials so that gravity can act on them during melting- moving them downslope.
  - Precipitation- frequent but light precipitation can inhibit mass wasting by keeping materials together with surface tension of water. Heavy or very intermittent precipitation enhances mass wasting potential. Less vegetation and quick saturation.
- Vegetation- roots of vegetation can hold material together- more vegetation, stabler the system. Less vegetation- less cohesion
- Addition of weight to upper slope- extra force applied on slope- a push
- Frequency of Earthquakes, volcanism- Earthquakes can trigger mass wasting by the emanation of shock waves moving the material; or by liquefaction, jostling water saturated sand to break grain contacts and allow flow of water around grains- quicksand. Magmas rising beneath volcanoes can increase slope angles (Mt. St. Helens) and cause mass wasting.

## **Recognizing and preventing mass wasting situations**

### **Recognition**

- Look for signs of creep or any other mass wasting (scarps, hummocky toes)
- Look for planes of weakness (foliation in meta rx in Phx)
- Consider consequences of steepening slope as in making road or landscape cuts
- Beware of removal of vegetation
- Consider addition of weight
- Systems such as sprinklers that add water

### **Prevention**

- Retaining walls with adequate drainage so water does not build up
- Planting vegetation to enhance cohesion
- Bolting material to bedrock
- Removing unstable slopes imparted by planes of weakness in bad directions.
- Minimizing extra weight due to construction.

- Summary diagrams- none
- Summary films - Earth Revealed- Mass Wasting; available in media center library

## GLG101: Streams Lectures- Reviews

**Dfn: Stream-** a body of running water that is confined in a channel and moves downhill under the influence of gravity. Streams do not have size in the definition. Rivers are large streams; brooks, or creeks are also streams.

### *Stream Dynamics*

#### Basic overview & concepts (features of streams):

- **Headwaters** = origin of stream flow
- **Mouth** = end of stream flow
- **Base Level**
  - lake or playa lake (closed basin) **Local**
  - resistant layer of rock **Local**
  - the ocean **Ultimate**
- **Tributaries and stream order**
  - Drainage Basin**= area in which all water flows into a particular stream of interest
  - Drainage Divide** = higher areas separating adjacent drainage basins. Point out significance of Continental Divide.

*Predominant danger of streams for consumers is flooding, the act of a stream breaching it's channel boundaries or increasing beyond its usual depth.*

*Flooding dependent on climate UPstream.*

*THE MANNER IN WHICH A STREAM BEHAVES (THE STREAM'S DYNAMIC) IS PRIMARILY CONTROLLED BY ITS VELOCITY AND THE DISCHARGE.*

- **Stream velocity**- rate of flow in feet / second
  - Factors affecting stream velocity
  - Stream gradient** = stream slope = longitudinal profile = (topographic profile parallel to stream flow)
  - Channel geometry** = Cross profile (topographic profile perpendicular to stream flow)
    - Narrow channels- less drag, faster velocities
    - Wide channels - more drag, decreased velocities
    - Rough channels choked with debris- more drag decreased velocities
- Stream Competence**- increases with **velocity**- the size of the material a stream is capable of moving- *Can tell what stream is/was capable of moving by looking a particles in channel.*

- **Discharge** = cross sectional area of channel (square feet) multiplied by velocity = cubic feet per second. Affects stream's ability to carry sediment- high discharge = higher stream capacity (greater volume of sediment transport). Dependent on size and climate of drainage basin.
  - **Perennial streams** = streams which discharge year round
  - **Intermittent streams** = streams which discharge only intermittently
- Stream Capacity**- increases with **discharge**- the amount of sediment a stream is capable of moving
- **The stream's velocity & discharge regulate stream erosion and deposition**
  - **Higher velocities and discharges = erosion**
  - **Lower velocities and discharges = deposition**

### Types of streams

- **High-Gradient Streams** = stream competence high. Stream cuts into channel deepening it. Cuts down to base level = **Downcutting**. Forms V-shaped channel or narrow V slot canyon depending on rock types. Increase in discharge results in deeper water
- **Low-Gradient Streams** = stream channel near base level. stream velocity and competence decreases.
  - **Types of Low-Gradient Streams**
    - **Meandering Streams** = stream capacity sufficient for supply of sediment
    - **Braided Streams** = stream capacity is lower than supply of sediment. Stream braids into multiple channels
  - **Low-Gradient Stream Evolution through time\*\***
    - Most streams do not flow in a straight line.** This curvature causes an interesting phenomenon- streams will move through time. Consumer's and river runners beware
    - Outside bend of stream** = fastest velocity, most erosion, deepest channel
    - Inside bend of stream** = slowest velocity, deposition, shallow channel
    - Migration of meanders, Cutoff meanders, and Oxbow Lakes**
    - CONSEQUENCE: STREAM ENERGY GOES FROM SIDE TO SIDE (= LATERAL EROSION) CUTTING A FLOOD PLAIN,** relatively flat area area over which flooding occurs in low gradient streams- **otherwise, floodplains are deceptively dry. Danger to consumers: Stream flooding in flood plain**

## Landscape Development

### Basic concepts (Review)

- **Changes in Base Level** - local or ultimate, cause changes in stream velocity which can change action of stream from **depositional to erosional** or vice versa
- **Downcutting**- effort of a high gradient stream to reach base level. **Incised Meanders & landscape rejuvenation**
- **Lateral Erosion**- erosion perpendicular to longitudinal profile- valley widening in low gradient stream
- **Headward Erosion**- erosion parallel to longitudinal profile in direction of headwaters

**Stream Piracy (aargh)** - headward erosion and capture of one stream by another..

**Stream Terraces: caused by small abrupt changes in base level: [OH + Laserdisc]**

- **Base Level drops erratically (not steadily)**- stream becomes erosional and downcuts to new base
- **Lateral Erosion**- cuts new flood plain leaving old one high & dry
- **Terraces** are Oldest surface on top, youngest on bottom.

### Landforms developed by streams

**Factors influencing landscape development: Rock type**- resistance to erosion; **Climate**- how much water is available and how much chemical weathering is taking place; **Stream competence and capacity** - size of drainage basin, stream gradient.

**Cycle of Landscape Evolution- Hypothesis 1: Change of slope angle**

- **Initial incision of slot canyon** (youthful)
- **Mass wasting on sides decreasing gradient of slopes**-(mature-old age)
- **Streams stay in more or less same place until peneplanation**

**Cycle of Landscape Evolution- Hypothesis 2: Parallel Retreat of Slopes**

- **Initial incision of slot canyon** (youthful)
- **Lateral Erosion**- widens valley maintaining slope angle (mature-old age)
- **Streams move throughout history**

**Drainage Patterns - indicate something about the geologic features underlying the landscape**

- Dendritic**- uniformly eroding rock types- drainage pattern looks like tree branches
- Radial**- erosion of area surrounding a conical mountain- typically a volcano; drainage pattern looks like spokes emanating from a central hub.
- Rectangular** - stream channels favor faulted or cracked surfaces. Sharp corners in stream patterns
- Trellis** - main streams flow down valleys in folded rock units

•Summary diagrams- none; Summary films - Earth Revealed- Running Water I & II

## GLG101: Groundwater Lectures Reviews

### Hydrologic Cycle

Water precipitating on the surface. Most- over 50% simply **evaporates** back into the atmosphere. Another huge component is taken in and eventually **transpires** (effectively evaporates) from water bearing vegetation (leaves & such). **Streams** are part of the hydro cycle = **runoff**. But not all of the water that hits the surface of the Earth goes back to the ocean as surface runoff in streams. Much of the water- perhaps 15-20%- in fact soaks into the ground, or **infiltrates**, to become **groundwater**-- "Water flowing underground". **Source of groundwater is generally precipitation. It is important to note that groundwater is usually not in underground lakes and rivers. It simply occupies the empty space between individual clasts and crystals.**

### Factors influencing how much water gets into ground

Steepness of slope

Amount of rain/snow

Vegetation

\*\*\*what kind of material is present at surface\*\*\* must be both **porous** and **permeable**

**Porosity**- The amount of empty space in a rock measured in percent. (see Table 11.1 in book)

- Unconsolidated material= sediment or soil (gravel, sand and clay) are usually fairly porous 25-80%
- Clastic rocks = generally less porous than the sediments of which they are made because of compaction and cementation in the process of becoming rock. Porosity typically ranges from 10-30% for conglomerates & sandstones to 0-30% in mudstones
- Crystalline materials (Igneous intrusives and extrusives, chemical sedimentary rocks and metamorphic rocks)- porosity generally very poor in crystalline rocks. However, fractures increase the overall porosity of the rock body

**Permeability**- the capacity of a rock to transmit, or allow the flow of water within it. Pores are connected with each other. A rock must not only be porous but also permeable to allow the infiltration and flow of water.

Unconsolidated sands and gravels are very permeable;

Clastic sandstones and conglomerates are permeable to moderately permeable

whereas clay, mudstones, and unfractured crystalline rocks are not very permeable.

Fractured rocks of any type may be permeable if the fracture systems are connected.

**Basic Groundwater**= water filling in pore spaces and cracks beneath the surface. Materials in which groundwater is stored are classified on the basis of whether water can be economically extracted from them

**Aquifer**- a body of rock or unconsolidated sediment which is both porous enough and permeable enough to allow for the storage, flow and extraction of water (e.g. sand & gravel, sandstones and conglomerates are usually good aquifers. Heavily fractured crystalline rocks are also sometimes useful).

**Aquiclude**- a body of rock or unconsolidated sediment which is either not porous or not permeable and prohibits the passage of groundwater (e.g. unfractured crystalline rocks).

**Aquitard**- a body of rock or unconsolidated sediment which is either not porous or not permeable enough to allow for the commercial extraction of groundwater. Aquitards may contain water though (e.g. clay and shale/mudstone).

**Zone of saturation**- volume of rock or unconsolidated material in which all open space is occupied by groundwater

**Zone of aeration** or undersaturated or vadose zone- volume of rock or material above the zone of saturation in which open space is partly occupied by water

**Water Table**= the upper surface of the zone of saturation

**Recharge** = the addition of water to the ground; where water enters the groundwater

**Discharge** = a place where groundwater is lost to the surface

**Groundwater flow** = Flows from high pressure to low (usually from recharge to discharge areas)

#### **A simple unconfined or open aquifer groundwater system- the basics**

Open aquifers recharge over their entire area- they are open to receiving infiltration above them everywhere

Open aquifers are dependent on climate- water table may rise and fall seasonally.

**Springs**- points of natural discharge where the water table intersects the Earth's surface.

**Gaining (effluent) Streams**= Streams fed from beneath by discharge of groundwater- common in wet or humid climates

**Losing (influent) Streams** = Streams = streams in which the surface water is lost to the ground. Common in arid (dry) climates

#### **More Complicated Systems- confined and artesian systems**

**Confined aquifers**- aquifers bounded above and below by aquicludes or aquitards. Water under pressure from overlying rock and hydraulic pressure from recharge

**Artesian systems-** Tilted or folded confined aquifers in which the recharge area is at a higher elevation than much of the aquifer. In these aquifers, wells drilled such that the top is lower than the recharge area will flow freely from the weight of the water above.

**Artificial Artesian systems-** supplying pressure for your water supply

**Groundwater pollution-** Infiltration of chemical or biological pollutants into the saturated zone. Pollutants flow with groundwater into discharge areas (wells or gaining streams). Pollution is basically the result of:

Leaking underground storage tanks (**gas stations**) or **un-lined landfills may travel considerable distances to pumping wells or discharge into gaining streams.**

**Overpumping** of wells under certain conditions

**Wells- pumps.** A cylindrical hole drilled into the zone of saturation allowing water to be pumped out of the ground.

**Cone of depression** = drawdown cone- a conical area surrounding a pumping well caused by pumping the groundwater out faster than it can flow through the saturated zone

**If drawdown cone causes reversal of groundwater flow or impacts saltwater, pollution can result.**

**Weathering, erosion and landscape features produced by groundwater**

**Groundwater dissolution** and erosion- because groundwater is infiltration of rainwater, it is, like rainwater, slightly acidic. Can dissolve some materials- particularly limestone, gypsum, and rock salt.

**Cave formation-** "holes" or empty space underground- often in limestone caused by the dissolution and transportation of calcite by groundwater. Ex. Carlsbad, Mammoth Caves.

**Sinkholes:** If enough material is removed, cave roofs may become unstable and collapse creating **sinkholes.**

**Karst topography-** an area underlain by limestone or other soluble rock in which numerous sinkholes have developed by the passage of groundwater.

**Effects of groundwater overdraft**

**Groundwater overdraft** occurs in areas in which groundwater has been withdrawn faster than it can be recharged. Compaction of formerly saturated zone may cause **subsidence** of the overlying area

**Earth cracks-** Uneven subsidence may cause Earth cracks (typically in arid climates like Phx for example).

**Geothermal energy-** Hot rock in areas of recent volcanism may be used to heat water into steam which can be used to drive turbine generators to produce electricity.

**In really active areas, natural hot springs and geysers may result**

•Summary films - Earth Revealed- Groundwater; available in media center library

## GLG101: Glaciers Lectures- Reviews

**Glacier Dfn:** A long-lasting body of ice that moves under the influence of gravity.

### *Glacial Dynamics*

#### Basic Concepts:

- **Formation of glacial ice:**
  - snow- granular snow- firn (clasts of ice)-- glacial ice (xln)
  - requires burial of snow by overlying snow- **thus prolonged cold periods.**
- **Zone of accumulation** (similar to headwaters of stream)
- **Zone of wastage or ablation** (similar to mouth of stream)
  - melting, evaporating (sublimation), calving
- **Glacial budget**
  - Advancing** (or expanding) glaciers = accumulation exceeds wastage
  - Retreating** or receding (or shrinking) glaciers = wastage exceeds accumulation
- **Glacial movement** Ice flows- example snow on car windshield
  - zones of flow: **basal sliding**
  - zone of **plastic flow**,
  - **rigid zone- crevasses potential hazard to extreme skiers.**

#### *Types and distribution of glaciation*

##### Alpine-

- Area: confined to mountainous areas; valley glaciers, glaciers confined by valleys.
- Cause: cold climates usually because of altitude but can occur in low polar climates
- Motion: downhill under influence of gravity.

#### **Glacial Erosion & features of alpine glacial landscapes**

- **Glacial Striations:** grooved surfaces, polished and scratched surfaces.
- **Erosional features of valley glaciers-**
  - cirques, aretes, horns, U-shaped valleys, hanging valleys.

#### **Glacial Deposition**

- **Glacial till-** extremely poorly sorted material dropped by melting ice (clay through boulders).
- **Moraines** (lateral, medial, terminal, recessional, ground): landforms of till deposits.
- **Braided stream deposits** (improves sorting of glacial material)
- **Lake deposits** from stranded ice stands (kettles).
- **Varves and dropstones**

**Continental-**

- Area: cover vast areas of continents; ice sheets and ice caps- Antarctic
- Cause: global climate changes- Ice Ages

**-Motion: from area of higher thickness to lower thickness**

**Erosional Features of continental glacial landscapes (similar to alpine glaciers)**

- **Glacial Striations:** grooved surfaces, polished and scratched surfaces; often the only erosional feature left by advancing continental ice sheets.
- **Kettles**

**Glacial Deposition- same as Alpine glaciers but also include**

- **Kames-** little hills of glacial till
- **Drumlins** (bullet shaped landforms of till deposits).
- **Eskers** - probably sub glacial stream deposits

**Global Climate Change****Why study global climate change?**

- **Global Sea Level Drops-** during ice ages, sea level drops allowing advance of glaciers from Greenland across shelf; Bering land bridge.
- **Global Sea Level Rises-** between ice ages, sea level rises Flooding of coastal cities and agriculture belts
- **Global Weather Patterns-** affects crops, water supplies, etc.

**Global Cooling and Warming: Milankovich Theory- Earth's orbital parameters.**

- **Changes in rotation axis tilt (precession)** Explain cause of seasons using drawing on board of Earth orbiting in solar ecliptic
- **Changes in orbital distance** Explain cause of seasons using drawing on board of Earth orbiting in solar ecliptic, sometimes circular, sometimes more elliptical.

**Global Warming: CO<sub>2</sub>/O<sub>2</sub> ratio and the "greenhouse effect"**

- **Increase of CO<sub>2</sub> traps solar radiation. Examples**
  - Rain forest changes CO<sub>2</sub> ratio.
  - Air pollution increases CO<sub>2</sub> concentration.

**Global Cooling: Nuclear Winter/ Volcanically induced "mini- ice ages"**

- **Atmospheric dust blocks sunlight Examples**
  - Use Mt. Tambora eruption.
  - Demise of the dinosaurs at K/T boundary

Supplemental Attachments: none

Supplemental films: Britannica: Evidence for the Ice Ages

## GLG101: Deserts Lectures- Reviews

**Dfn: Desert-** An area characterized by low rainfall (<10" or 25 cm/year) possessing a dry or arid climate. Under this definition, our usual image of desert of a barren place full of sand dunes as represented in Lawrence of Arabia falls quite nicely. However, many other types of regions fall into the definition as well. Antarctica actually doesn't get that much precipitation- also a desert. In some other desert areas (Phoenix, for example) the landscape is not all that barren- plants have adapted to the arid climate to yield a rich flora and fauna.

### Distribution of deserts-

**Main mechanism-** similar to pot of beans example- thermal convection

- Air heated allowing greater dissolved water content from evaporation
- Warm moist air rises due to less density
- As it rises it enters the cooler area where Earth's heat lost to radiation into space
- As air cools to a certain temperature- water condenses out and rain falls
- Air is now dry but continues to rise until enough heat is lost so that air now has the same density as surrounding air.
- Like in pot o beans- air now begins to be displaced laterally by continually heated air below.
- Continued cooling until air is dense enough to fall back down to Earth
- As air falls back to Earth it becomes compressed from weight of air pushing it down from above
- Falling air gains heats up from compression and renewed solar heating. Flows to areas of lower pressure complete circuit. Falling air is quite dry- so if it falls on land it can rapidly evaporate whatever ground moisture is around and transport it to a lower pressure area somewhere else.

### Major factors contributing to arid climates

- Global Circulation- Air heated at equator where solar radiation is a maximum and descending in convection cells that dive near the "horse" latitudes- at the Tropic of Cancer (30°N) and the Tropic of Capricorn (30°S).
- The position of the land masses- Deserts occur on land. For global circulation pattern to work- must have land mass at horse latitudes AND have land mass immediately windward because of Coriolis Effect due to spinning of Earth
- Rain shadow deserts- Position of mountain ranges in air circulation pattern. Sierra Nevada rain shadow on Great Basin, Nevada. Coast Ranges shadow on Arizona.

- Cold ocean currents (water also has circulation pattern due to climate and tectonic activity- inhibit evaporation and cool air immediately above cold current. If current flows near continent, cool dry air evaporates moisture as it goes overland causing arid climate- responsible for Peruvian Desert, Baja Desert, and South African Desert.
- Deserts far inland in large continents- More chance of losing moisture from sea as air travels great distances inland on large continents.

**Work of Water in Deserts-** water, although scarce, is actually the **dominant agent of landscape development** in arid climates

### **Weathering in deserts**

- Mechanical weathering prominent
  - Chemical weathering slowed greatly by lack of water- but it nonetheless occurs
- Desert Varnish-** buildup of Manganese and iron oxides OR calcite encrusting on outside of basalt- on the outside of rocks- mechanism is somewhat unclear as some rocks which apparently contain neither manganese nor iron can have desert varnish.

### **Erosion & Transportation**

Braided, Intermittent (= ephemeral), Losing Streams  
 Arroyos (Washes, wadis, etc.)  
 Flash Floods

### **Deposition**

- Alluvial Fans           •Playas
- Bajadas               •Pediments

**Work of Wind in deserts-** Wind is a fluid like water but less viscous

- Weathering and Erosion
  - Abrasion   Ventifacts
  - Blow outs
- Transportation- Suspended and bed loads
  - Deflation   Desert pavement
- Deposition
  - Dunes- deposits of fine grained sand by wind
  - Leeward Slip face = deposition
  - Windward- Stoss side = erosion
  - Dune migration (from shallow side toward steep side of dune)
  - Loess- forms major agricultural belts in the continents where it is most prevalent

## GLG101: Coastal Processes Reviews

### MAJOR FORCES AT COASTAL AREAS

**-Wind-driven waves-** waves formed by wind induced by global air circulation or storms

As air masses collide, storms occur. Wind on water causes waves (analogy to blowing on hot soup) Waves travel over ocean in same manner **ALTHOUGH MUCH SLOWER** as seismic Rayleigh Waves

Wave Geometries

Crests and Troughs, Wavelength, Wave Height- Note that motion of water is effectively negligible beneath a depth equivalent to about a half wavelength.

Ocean Wave speed is typically 20-60 mph.

Heights are typically within 7-18 feet but can reach 100 feet

Wavelengths typically 40-600 meters (thus calm below 20-300 meters)

**-Seismic sea waves= tsunamis-** Earthquakes and/or near-shore or undersea volcanic eruptions

**-Tides-** waves driven by the twice-daily tidal bulge in the sea caused by the gravitational attraction of the moon in concert with the centrifugal force of the Earth/Moon center of mass

**Spring Tides-** Solar and lunar tides parallel

**Neap Tides-** solar and lunar tides perpendicular

### INTERACTION OF WAVE ENERGY AT SHORELINE

**Surf zone-** Waves break- back (**backwash**) & fourth (**swash**) motion

**Rip currents**

**Wave refraction**

**Longshore currents & Longshore transport**

Formation of beaches (Summary films - The Beach: A river of sand)

Beach geometry

Berms

Sand sources- Coastal erosion from waves; Material brought into ocean by streams and redistributed along beaches by longshore drift

Beach deposition- Sandstones with low-angle seaward dipping cross-bedding often containing marine fossils

**Spits and bay mouth bars**

**Effects of jetties/groins and Breakwaters**

## **TYPES OF COASTLINES**

**Erosional Coasts-** coasts eroding from intense wave energy

Wave cut Terraces

Coastal erosion- Coastal straightening

**Depositional Coasts-** material at coast deposited, lower wave energy

Barrier Bars

**Drowned (submergent) Coasts-** tectonics or rise in sea level causes sea to bury former inland areas. Example: Norwegian fjords, Maine, British Columbia

**Uplifted (emergent) Coasts-** tectonics or fall in sea level causes formerly underwater areas to be exposed above sea level. Example: most of northern California