- forms lateral moraines built along the sides of valley glaciers; end moraines (curved ridges)
at the glacier terminus where it piles debris by dumping and bulldozing (ground moraine is
plastered beneath glaciers)
- drumlins are mounds streamlined under the glacier (blunt ends point up-glacier)
- stratified drift: (comprises sand and gravel deposited by glacial melt-water)
- provides an excellent source of aggregate for building cities;
associated landforms
include:
- kettle: (rounded pit from a melted ice block) a depression in the ground left by an ice block
that melted there
- kame: (mound lowered from glaciers surface on melting) a debris mound lowered to the
ground from the glacier surface as ice melted
- esker: (winding ridge from subglacial tunnel) a winding gravel ridge commonly formed in a
subglacial tunnel
Causes
- plate tectonics and continental drift bring a major continent over a pole, allowing glaciation to
start (by inducing global cooling)
- minimum contrast in seasons in mid to high latitudes
- glaciations are controlled by three cycles related to Earth's orbit around the Sun
- when conditions combine for minimum contrast in seasons at mid to high latitudes, more snow

falls during mild winters and less snow melts during cooler summers (then a major glaciation
happens)
Chapter 18 (November 17th): Deserts and Winds
- deserts are dry places where there is low precipitation and little vegetation
Geologic Processes
- in spite of lack of water and vegetation, processes still occur, such as:
- weathering: almost entirely mechanical and very slow due to low precipitation (however, clays
and thin soils form by oxidation of ferromagnesian silicate minerals)
- mainly mechanical with some oxidation
- water: ephemeral streams and flash floods from short, intense rainstorms do most of the
erosion of desert surfaces, especially sediment not anchored by vegetation
- mainly ephemeral streams and “flash” floods
Transportation of Sediment by Wind
- main sediment movement in deserts is from saltation (grain collision, bouncing and skipping)
- wind can move faster than water and carries sediment farther and higher than streams because
flow is not confined to channels
- bedload: sand moves by saltation (grain collisions) and by rolling over the ground
- mainly by saltation (bouncing and skipping); depends on grain collisions

- suspended load: dust particles are pushed into the air by saltating sand grains, then swept up
by the wind in dense clouds and carried high into the air
- dust swept into the air and carried far away
Wind Erosion
- occurs by deflation and abrasion
- deflation: blowing away fine sediment to create blowouts, while leaving coarser particles
behind that cover the desert floor as desert pavements
- wind removes fines, leaving blowouts, and coarse particles as desert pavements
- abrasion: mainly by saltation as particles sandblast things; wind polishes, pits, and facets stones
(ventifacts) sitting on desert floor, and streamlines ridges (yardangs)
- saltation sandblasts rock and stones, crating ventifacts and yardangs
Wind Deposits
- deposition occurs when the wind slows down and is no longer able to carry its sediment load
(produces landforms made of sand and silt)
- sand dunes: commonly form in wind shadows around obstacles where the sand builds small
mounds that induce more deposition (self-perpetuating)
- form downwind of obstacles where a steeper slip face develops opposite the shallower
upwind side (dunes migrate downhill)
- an unstable slip face forms on the leeward (downwind) side which is always steeper (~34°)
than the windward (upwind) side; the dune gradually migrates in the direction of the slip face
on which primary cross-beds are deposited
Types of Dunes:
- barchan: - crescent-shaped with tips pointing downwind; form where supplies of sand are

limited and the ground surface is flat and lacking vegetation
- traverse: series of ridges and troughs elongated perpendicular to wind direction,
commonly along coasts where wind is steady, sand abundant, and little vegetation
- ridges and troughs at right angles to the wind
- longitudinal: elongated parallel to wind in large deserts where sand is moderate
- long ridges parallel to the wind
- parabolic: crescent-shaped with tips pointing upwind and commonly anchored by
vegetation (form where lots of sand occurs along coasts and wind blows onshore)
- loess: from deflation of dust carried far from deserts or glacial deposits of outwash or till
- carried far then eventually deposited as a blanket over landscape (makes fertile
farmland)

Chapter 19 (November 22nd): Shorelines
Waves
- from wind blowing over the ocean; a surface waveform of energy moves through the water whose
molecules move side to side and up and down

- as a wave approaches the shore it "feels bottom" and breaks into surf that moves up a beach as
swash then water flows back down as backwash; storm waves erode headlands by wave impact
compressing air in fractures, by abrasion, undercutting

- wind-generated energy forms that move through water
- “feel bottom” as approach the chore then break into surf
- swash and backwash
- erosion: mainly by abrasion of headlands

Sand Movement on the Beach

- waves bend as they approach an irregular shoreline (wave refraction) so that erosion focuses on headlands, deposition occurs in bays
- most waves hit the shore at an angle and move sediment along beaches by the zigzag pattern of swash and backwash called beach drift; also, oblique waves in the surf zone produce longshore currents that flow parallel to the shore
- move most of the sediment in transport that is supplied mainly by rivers
- wave refraction: waves bend toward irregular shoreline to erode headlands, and deposit in bays
- sawtooth pattern of swash and back was results in beach drift, longshore current that transport sediment along the shore

Shoreline Features:

- erosional include, depending on geology and wave activity…

• wave-cut cliffs: by cutting action of surf against the base of cliffs, causing them to collapse and retreat, leaving a wave-cut platform as debris is swept out to sea

- by surf erosion, leaves a wave-cut platform

• arches: where waves cut caves into the sides of headlands until the caves join; eventually arch collapses and leaves a stack sitting alone on the wave-cut platform

depositional features depend on sediment supply and current activity

- where surf cuts through caves in a headland; may collapse to form sea stacks

• spits: elongated sand ridges that form where beach drift, longshore currents move sand into the
mouths of bays; where a ridge crosses the bay it is a bay-mouth bar
- beach drift forms sand ridges into mouths of bays; may become a bay-mouth bar
• tombolo: a sand ridge that connects an island to the mainland or another island
- many coastlines start out with an irregular shape as a series of headlands and bays
but continued cliff retreat and sand deposition tend to straighten out the shoreline
- eventually shorelines will straighten out over time
Stabilizing the Shoreline:
- erosion can be fast, damaging during storms

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• engineers build jetties to keep sand out of river mouths, and groins perpendicular to the shore to
trap sand and widen beaches, but this causes erosion on the down-drift side of the jetties and
groins and forces neighbours to build more structures
• offshore breakwaters are built parallel to the shore to protect marinas and beaches from storm
waves but they tend to widen the beach and fill in marinas; seawalls along shores protect from
storm waves but walls must be maintained at high cost
• beach nourishment: can be attempted but requires a lot of sand, very expensive, only lasts
several years and requires continual maintenance and more sand and money
- requires a lot of sand, and is very expensive

• relocation of buildings: is best along shorelines that get the worst storms; let nature reclaim the
beach (costs too much in money, materials, and safety)
- best to move away from worst storm erosion areas
- jetties: extend river channel beyond its mouth to inhibit beach drift
- groins: at right angle to the shore; sand deposited on up-drift side, erosion on down-drift side
- breakwaters and seawalls: parallel the shore to protect from storms
Chapter 20 (November 24th):Metallic Mineral Deposits:
- called ore if mined for profit; non-metallic are industrial minerals
• magmatic process: heavy crystals like chromite and magnetite can settle in cooling pluton
- lightest minerals with rare elements crystallize in pegmatite dykes (huge crystals)
- early crystal settling of chromite, magnetite, platinum (late crystallization of lightest mineral in
pegmatites)
• hydrothermal process: metals in hot solutions from magma precipitated as vein deposits of gold,
silver in rock fractures
- disseminated deposits of copper, molybdenum ore are spread throughout porphyritic host
rock; volcanogenic massive sulphide deposits resulted from fresh seafloor reacting with hot
water at ancient oceanic ridges
- hot fluids with metals precipitate ore in vein deposits (gold and silver)
- disseminated deposits spread throughout host rock;
- volcanogenic massive sulphide deposits in ancient seafloor at oceanic ridges
• sedimentary process: banded iron formation including magnetite, hematite, chert formed by
bacteria in Precambrian seas when the atmosphere lacked oxygen; placer deposits

- formed by running water concentrating heavy minerals (gold, diamonds)
- placer deposits of gold and diamonds by running water
• metamorphism: contact metamorphism and associated igneous activity cooked rocks including
limestone that became skarns rich in zinc, lead, copper, and gold
- skarns by plutons cooking limestone

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• weathering: by hydrolysis of silicate minerals in the tropics; concentrated insoluble aluminum as an
oxide (bauxite) that is shipped to Canada to extract the aluminum
- bauxite forms in tropics, provides aluminum ore
Non-metallic Resources
- (industrial minerals) important to construction, food, and chemical industries:
- diamonds for abrasives, gemstones; form deep in mountain belts but mined from kimberlite
pipes;
- clay for bricks, drainage pipes, pottery; weathering silicates;
- calcite for cement, asphalt
• aggregate and stone: crushed stone, sand, gravel used for concrete, asphalt; cut stone used in
building facings, walkways, countertops – e.g. granite, gneiss, slate
• industrial minerals: diamonds mined in Canada for abrasives and gems, form in deepest roots of
old mountain belts then picked up by rising bodies of kimberlite magma from asthenosphere;
clays from silicate weathering used for bricks, sewer pipes, pottery, and chemical industry; calcite

(limestone) quarried for cement, asphalt, chemical industry; evaporite salts include gypsum for
plaster (drywall), salt for chemical and food industries, and potash for fertilizer; phosphate for
agriculture is mined from marine sedimentary rocks and sulphur is extracted from coal, oil, gas
• evaporite slats: gypsum for plaster, salt for food etc, potash for fertilizer
- phosphate and sulphur for agriculture
Non-renewable Energy Resources:
- fossil fuels whose use is hard on environment
• petroleum – used mainly for fuel and plastics:
- formed in ancient seas from remains of plankton that were buried, then progressively heated to
kerogen, oil, natural gas
- because oil, gas are lighter than water, migrate up into permeable reservoir rocks until they hit a
petroleum trap where reservoir rocks meet impermeable cap rock
- oil, gas migrate up into reservoir rocks, get trapped in petroleum traps where they hit cap rock
• coal – mainly used for fuel, formed from decayed land plants in ancient swamps that
were buried, compressed, then cooked to form coal; Canada is a major exporter
heavy oil sands of Alberta are huge but viscous, must be heated to extract the oil
• nuclear – energy released by splitting uranium atoms (fission), uraninite is main ore
• heavy oil sands - highly viscous, hard to extract oil from sand
Renewable Fuel Sources:
- a couple of geologically-related alternatives to fossil fuels:
• hydroelectric – damming streams gives clean energy, supplies most of Canada’s

electricity but dams do not last forever, reservoirs fill with sediment, lose capacity
- dams on streams provide clean energy but reservoirs fill with sediments
• geothermal – where heated groundwater and steam in volcanic area is tapped and piped to
turbines that convert energy to electricity; not developed much in Canada
- steam in volcanic areas is piped to tribunes to generate electricity