The Earth

I. Introduction

A. Metric System

B. Geology

1. James Hutton .1790…..first geologist
2. Uniformitariansim = events occur at same rate….
   ex. quakes, erosion, volc., floods

II. Study of Science

A. Scientific Method – in Social and Natural Sciences
rational study with no bias

1. Observation…
2. Hypothesis (ideas)…..many?
3. Research /experiment / testing
4. Accept or Reject Hypothesis

"Theory" = set of accepted facts, concepts,explanation…..

III. Origins

A. Origins of the Universe

1. Big Bang =13 ½ B.Y. ago
2. Stars And Galaxies…….

B. Origin of Solar System

P.

1. Rotating cloud of dust & gas…
2. "Eddies" –-> Planets (8)
3. Sun ignites……..
4. Inner Planets – 4 small, rocky (=craters)
5. Outer Planets – 4 huge, gaseous (+ many moons)

C. Origin of Earth = *4.5 Billion years

1.Planetesimals (rocks) collide

2. Melting

a. Gravitational Separation -into 3 layers

P. b. Core= iron sinks

c. Crust = lighter elements float

d. Mantle

ex: E. like egg or avocado

D. Origin of Ocean + Atmosphere

Volcanoes – out gassing = H20 (rain) + C02 (carb diox)

P. first ocean =4 B.Y. ago

E. Origin of Moon

-formed by collision of large object with Earth

-debris ……..together to create moon 4.5 B.Y.

P. 1.Craters -happened after solidified.

High speed impact, eroded on E.

IV. Interior of Earth

A. Seismic Studies

-seismic waves travel away from quake

-use arrows ……

P.

1. Refraction – waves bend

P. 2. **Reflection** –waves reflect (echo) layers

3. S-Wave Shadow Zone

P. -s waves stopped by liquid outer core.

B. Core = ½ diameter of E.

1. Iron-Nickel (+ Uranium =heat in E.)

P. a. inner core =solid

b. outer core =liquid,

currents create magnetic field:

1) mag. compass 2)protect life

C. Mantle = solid, 5/6 (82%) of E. vol.

1. Convection

P. - hottest part rise & coolest sinks.

- heat from core (radioactive)

– goes horizontal on top= drags cont.s

2. Asthenosphere = part melted layer >60 miles deep

P. slipper surface that plates slide on

3. Lithosphere

- crust and uppermost mantle = Solid.
- creates plates
- like cracked eggshell

D. Crust = thin, solid, two types:

P. 1. Continental = covers 1/3 of E. surface

a. Lighter (wt. + color) = “granite” rock

b. Thicker ~40 mls. thick

c. Older… billions yrs. old

2. Oceanic = covers 2/3 of E…. covered by deep oc.

a. heavier = “basalt” rock

b. thinner ~4 mls. thick

c. younger… millions yrs. (aver. 60 M.Y.)

3. Isostacy "floating" crust at equilibrium

a. thicker = higher above & deeper below

P. - co.crust mostly dry

- oc.cr. thin=lower=under ocean

b. add or subtract wt. = crust sags or rises.

Ex. volcano, ice cap

V. Ocean Floor

A. Continental Shelf = 1/7 of all cont. cr.

-flat, shallow (100's feet deep)

P. -outer edge of cont. crust…flooded

-beneath shelf = ½ of all oil !

B. Continental Slope

-steeper

-edge of cont. crust

C. Abyssal Plains = flat, huge area

P. -deep sea ~3 mls. deep (…km)

-old oceanic crust …….mud

D. Trench

P. -long, deep ditches ~6 mls. deep

-around edge of ocean basins (esp. Pacific)

E. Oceanic Ridges all under water

"Mega-mountain range"

P. - goes 1½ times around E. = 40,000 miles long

-rises 1½ miles high….. 1,000 miles wide

-new oc crust = basalt.

1. Rift Valley = deep, on top

I. Continents

A. Plains = large flat areas

-low elevation, geolog. Interactive

P. -no earthquakes, no volcanoes.

- ex:……..

B. Plateaus

-"flat," large area that's **high**, but w/ canyons

- ex: …….

C. Mountain Ranges

P. - high, long…, geol. active

- most on edge of conts.

- thicker crust

-ex: ……..

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PLATE TECTONICS

I. Plate Tectonics

A. Plates = 12 pieces of lithosphere move continuously
- seven major plates
- six named after continents:

P. N. Am., S. Am., Afr., Eurasia, India – Australia, Antarct. =
= half cont. cr. & half oc. cr.!

Pacific Plate= biggest, 99.9% oc. Cr. (.1%=So.Calif)

P. "Pangaea" = all conts. were together (200 mya.)
-cont.s moving apart ~1"/yr.

B. Wegener's "Continental Drift"
early theory of plate tectonics (pangea)

P.

1. Evidence =1912…..

a. Continents Fit Together

P. -esp. if matching cont. shelf edges

b. Geology matches up

P. -mtn ranges, types + ages of rock match up between cont.s that *were* together

C. Fossils match up. –types and ages

P. ex. dinos., plants

D. "Paleo" Climates match up " " "

P. ex. deserts, ice caps, tropical

2. Problem he had no way to explain motion.
-technology (testing) wasn't available for 50 years

C. Mantle Convection = why it happens?
see p.9 in notes.

D. Plate Boundaries (edges)

1. Seismic Belts

P. - most (90%) quakes occur at edges of plates
and =where plates move ……. each other.
P.

2. Volcanoes

P. -same=most (90%) on plate boundaries
- needed for water = life……

E. Paleo Magnetism – proved pl. tect. in 1960s
= ancient rock magnetism (in basalt)

1. Magnetic Orientation

P. -in "magma", magnetite crystals point to magn. pole
-when magma cools, crystals freeze in position
-both direction (N,S) and "inclination"
= can tell where mag. Pole was when rock cooled.

II. Divergent Plate Boundaries =separating = rifting
=pulling apart due to M.C…

A. Sea Floor Spreading
-plates pulled apart at ~1"/yr.
P. -basalt "magma" oozes out "lava",
creating new oceanic crust *ex. Iceland*

B. Oceanic Ridge + Rift Valley = huge straight valley
Ridge= ultra-huge "mtn. Range"
P. *oc. cr. youngest near R.V.
oc. cr. highest " "

C. Paleomagnetism on seafloor

1. Magnetic pole reversal (N. or S.)

-they switch every ~1mil. Yrs.

P. =rock from diff. periods have opposite orient.

* Normal (to N.) and Reversed (to S.) "polarities"

2. Magnetic Stripes on seafloor

-1960s – magnetometers

P. - invisible pattern of normal + rev.magn. stripes

* due to mag. xtals lining up w/ N. or S. poles when basalt cooled….R.V…..

a. Symmetric (mirror image) ….rift valley

P. =oc. cr. pulled apart at same rate on both sides

b. Glomar Challenger (1968) drilling ship

P. got samples to date

Calculated rate = $\frac{\text{distance}}{\text{Age of rock}} = \frac{\text{1 inch}}{\text{year}}$

D. Continental Rifting = forms oc. basins

1. Stages

P. a. Mantle Conv.makes bulge in co.cr.
=pulled apart *ex: Nevada (faults)*

P. b. Contin. Crust Stretched –forms Rift Valley
=deep long lakes *ex: E. Africa Rift Zone*

P. c. Gap filled by basalt magma =new oc.crust
=long narrow straight sea *ex: Red Sea*
ex: Gulf of Calif.

P. d. New oc. crust widens
-ocean floor *ex: Atl. Oc. & Indian Oc*

P. 1) Cont. Crust Margins =stretched
=thin =low elev.=cont. shelf (flooded)
P. * Pangea fits well using slope (shelf edge)

2) Rifting of Pangaea
P. a) started ~200 m.y. ago

b) N. Atlantic opened 1st
-"unzipped to S. (later to N. Atl.)

c) Indian Oc. =Started when India rifted

d). Pacific oc…… getting smaller!
=oc.cr. destroyed around edge.
="Ring of Fire"

IV. "Convergent" Plate Boundaries
(come together) = due to mantle convection.

A. "Subduction" Zone ="going under"
P. -thinner, *heavier* oc.cr. subducts into mantle
- forms trench…..
(co. crust can't subduct……)
P. 1. subducting Oc. Cr. causes quakes
=deeper =farther from trench (2nd proof of Pl.Tect.)
-most tsunamis (…….) caused here

2. subducting oc.cr. melts ~100 mls deep
- magma rises to form volcano chain
(~100mls. fr. trench)

B. Island Arc Volcanism

P. -oc.crust collides with another oc. crust
- result = volc. island chains parallel to trenches
- always = ocean-trench-island-sea-cont……,
- on map= makes an arc

P. * *ex: Japan, Philippines, Aleutian Is*.=***western Pacific***
also Caribbean (Atl. Oc), Indonesia (Ind. Oc.)

C. Oceanic-Continental Collision

P. -granite magma…….
-volcano chain on cont. edge =volc. mtn. range (arc….)
-largest quakes caused! (ex: Alaska…9.2)
* *ex: Alaska, Cascades, Mexico, Andes* ***= eastern Pacific***

D. Continental-Continental Collision

P. - cont. cr. cannot subduct = folds
- thick crust =highest mountain ranges
?
- quakes, but no volcanos

P. - *ex. Himalayas (India into Eurasia*)… 40 my

* cause of most ancient mtn. ranges
- *ex: Applachians, Eurasian mtn.s (Alps….)*

C. Terranes

P. =smaller co.cr pieces collide with cont.
- island arc or other islands “weld” onto co.cr at subd. Zone
- result= cont.s grow larger
- *ex. Alaska & western N. Am.*

IV. Transform Plate Boundaries (rarest….)
=plates go past each other.

A. Transform Faults

P. - they offset (shift) R.V. and ridge
- caused by plate (near R.V.) going past another pl. in opposite direction
?
- Quakes =plates jerk past each, but no volcanoes or tsunamis

P. – on map = plate boundary…zigzags…..ridge

B. San Andreas Fault

- large transform fault slicing cont. cr. (Calif…….)
- we are on PacificPlate =moving n.w.
- Gulf of Calif. gets larger

VI. California Plate Tectonics

A. Originally Subduction Zone

1. Granitic magma = new cont. crust
P. 2. Compressed sediment=made rocks (coastal mtns.)
3. Subd. Zn still happening in N. Cal (Cascades)

B. San Andreas Fault = stopped subduction ~ 15 my ago

C. Erosion – since
- granite now on surface *ex. Sierras*

VII. Hot Spots = stationary "plume" in mantle (like lava lamp)
–often in middle of plates (they are not subd. zones!!)

P. - As plates move, H.S forms straight chain of volcanoes
- *ex. Hawaiian Islands*, *Yellowstone*
- each volcano is older……more eroded
-can tell plate direction
ex. Hawaii to NW…..Kilaeua active ….Loihi next

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Earth Deformation

I. Rock "Deformation" –original shape changed
(originally = flat + youngest layer on top)

A. Stress – the cause (why?) of deformation

P. =results from force on rock

1. Compression stress = pulled apart
-causes folds + mtns. (faults) ex: Converg…

2. Tension stress =pulled apart ex: Rift V….
-causes stretching+faults

3. Shear stress = opposite direct.
-causes faults ex. Transform…

B. Deformation = "strain" in text = result

P. 1. Elastic strain – rk can return to orig. shape
-during Quakes, rk block returns " "

2. Fracture strain –rk breaks (during quakes) on fault
(upper 10 mls. of crust)

P. 3. Plastic strain –rk bends+flows (under pressure)
(below 10 miles deep in cr.)

C. Strike and Dip – see text and lab

P. Dip= angle + direction rk. layers tilt

D. Folds = formed by compression mils. deep (plastic….)

P. 1. Anticline arched fold…

vs.

P. Syncline down-bent fold

= form stripes on surface (maps) when

* * visible on surface after erosion removes mls. of rk !

2. Limb –"side" of fold.

P. 3. Assymetrical Folds = tilted to one side, common

a. Overturned folds - rare

formed really deep underground……

4. Plunging Folds = not horizontal

=most folds "dive" into the earth

-erosion = obvious "V" pattern on surface (map)

5. Basins + Domes =look "round" on map

P. Basin = layers dip toward ctr. (like round syncline)

Ex: L.A.Basin

Dome = layers dip toward edge (" " anticline)

ex: Palos Verdes Penn.

E. Joints –fractures with no movement, very common

P. - set of joints = many parallel joints…

- most rx = 1-3 sets

P. - formation: compress. or extension cracks

P. -weak zones…causes rk. erosion easily

F. Faults = fractures w/ movement….opposite direction

1. Definitions

P. a. fault “plane”= fracture…straight…movement...

P. b. hanging wall =upper block

c. footwall =lower block

2. Dip-Slip Faults = cr. blocks move up+down (dip direction)

P. a. Normal Fault –upper (hanging) block goes down.

- due to tension *ex: R.V.s*

P. 1) Horst + Graben = up+down-dropped blocks.

ex: Basin + Range (Nevada)

2) Tilting = uplifted on one side

ex: Sierras (Cal.)

b. Reverse Fault = lower (footwall) block goes up

P. -due to compression ex: L.A County

P. 1). Thrust Fault = low angle…

P. -extreme pressure. ex: Rocky mtns.

3. Strike - Slip Fault

-horizontal motion of blocks… pass each other

P.

a. Left - Lateral = other side moves to left

b. Right-Lateral =other side moves to right

ex: San Andreas Flt. + most Calif. Flts.

4. Oblique Faults (=diagonal) common=most So. Cal. flts.
-both vertical and horiz. motion combo

a. Southern California Faults + Mtn.s
= most are a combo of rt.lat & rev.
-Why? S.Andreas Flt has double bend.

P.

1) co.cr. colliding = creates mtn.s
ex: S. Gabriel Mtn.s …tallest mtns. in So.Cal.

2)several faults parallel to S.A.Flt. =
- cr. blocks ~20 mls. across
- form most mtn. ranges + islands
ex: P.V. and Catalina

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EarthQuakes **(Ch.)**

I. **Seismology**

Earthquake=vibration…sudden release of energy along a
P. Fault (fracture caused by crust movement).

A. **Epicenter** =pt. on surface above Q's "focus"
P. 1. **Focus** = pt. In crust where rupture starts
a. **Shallow focus** = most quakes (0 –10 ml. deep)
-greatest destruction…… *ex. Calif.*
b. **Deep focus** = 40-400m deep =subd. zones
ex. Japan

B. **Seismograph** –detects+measures Q.s
P. - heavy weight stays still during Q…….
1. **Seismogram** –paper drawn on
P. -measures: when, how long, how strong

C. **Elastic Rebound**…rock…
-blocks bend until rupture during Q.
P. = snap back into original shape
1. **Offset** both sides move, displaces features
P. ex. canyons, roads
2. **Fault Creep** =both sides move continuously
CD-ROM -no Q, rare ex: Mid. S.Andreas Flt.

D. Quakes = temblors, tremors, seismicity, jolt, shocks
1. Foreshocks -only 3%……rare

2. Main Shocks -biggest (1/2 energy released)

3. Aftershocks -"always" smaller (all = other ½ energy)

E. **Seismic Waves** –started by Q

1. **Types** –travel different ways + speeds

P. a. **P-waves** -primary, arrives 1st
-move like slinky or sound (weak)

b. **S-waves** -secondary, arrives 2nd
- move like rope (also weak)

c. **Surface waves** – arrive last…we feel !
-move like ocean waves =most destructive!

all 3 seen on seismogram = both time + intensity

2. **Locating Quake Epicenters**
-P waves go ~ twice speed of s-waves

P. a. P-S time interval –difference between arrival times

P. b. Travel/Time graph = get distance to quake

P. c. Draw circles on map = " " " "
from 3 locations ……find epicenter

F. **Intensity+ Magnitude**

1. **Mercalli Scale**

P. -damage measured in Roman numbers (ex. XII)
-put on map =see extent

P. -depends on ?:
1. Magnitude, 2. Distance, 3. Ground material

- Trinet.org = So. Cal. only, internet….. known in minutes

2. **Richter Magnitude Scale**
-measures total energy of Q…strength
-based on max. amplitude of s-gram
-logarithmic scale=
* * each 1.0 on scale = 10x shaking (=30x energy)

Mag.	**Damage near epicenter**	**Example**	**no. per yr.**	**Length**	**Potential nearby** fault
4.0	rattling	Many	6,000	5-15 sec.	any active fault
5.0	bricks fall	Whittier '87			
6.0	some bldgs. damaged				
7.0	most bldg.s damaged				
8.0	most bldg.s destroyed				
9.0	total destruction				

II. Destruction by quakes
A. Ground shaking –most damage, by surface waves
1. Bedrock –the least amt. of damage
2. Sediment –more amt. of damage
P. 3. Water saturated sediment –worst damage, greatest shaking…like jello

B. Ground failure –most danger to us
P. 1. Liquification = water-saturated sed. flows during Q.
-bldgs. sink or tilt…as if on quicksand

P. 2. Landslides –destabilizes slopes
-esp. if wet, too.

Figure 1

C. Tsunamis (misnamed Tidal Waves)

P. - due to vertical motion of the seafloor
- arrive as series of surges every 20 min.= floods…..

P. - damage…….
ex: 2004 Indonesia = 250,000 dead

P. -also landslides…

1) Seiche = sloshing back + forth in lake or harbor
ex: L.A harbor? S.F. Bay?

D. Fire + Destruction
- shaking breaks gas lines, water, sewer (regional, too…)
- closed stores, power off, no phones

E. Damage Prevention
- avoid low coastal area housing
- have emergency water, food, first aid kits (home + car!)
- don't run out during Q.!…….

P. - Retrofitting = quake-proofing freeways, bridge, bldgs.

III. **Earthquake Prediction** – can't predict when, just where…..

A. Seismic Risk Maps

P. -"probability" (based on past Q.s + active flts.)
and "intensity" (size of flt.s and ground….)
- ex. 3/4 of all US damage in Calif. (1/3……..in L.A. Cnty)!

A. PreCursors =clues before quake
-after much research ($), not reliable
-don't occur before most Q's
1. Elevation change-use satellites (GPS…in ECC yard)
2. Tilting – use tilt meters
3. Water and radon levels in wells change
4. Animals = often can detect p + s waves

C. Quake Warning System = possible
- Problems: $, false alarms, panic

D. Seismic Gaps…useful…

P. =parts of flt. that haven't moved recently = "overdue"

1. S.F. and Mex. City in '90s

P. 2. "The Big One"= S. Bernadino area of S.A.Flt.

3. Oreg./Wash. = predicted 9.0, based on:

a. mud layers (every 500 yrs.) \

b. Japanese….. …..tsunamis } last in 1700 AD

c. Native American oral……. /

IV. Identifying Faults on surface

P. A. Epicenter Maps (fault maps)

B. Rocks along faults:

1. Fault "gouge" = Q.s grinds rock into clay (impermeable)

P. 2. Folded + offset rock layers

3. Slickensides…….

P. 4. Different Rocks on both sides = most common way

C. Land Features…seen when driving or flying

P. 1. Straight valleys …… ex. S. Andreas Flt.\

2. Sag ponds (marsh) *ex. Lake Elsinore* }fault gouge

3. Springs…water rises ex. Palm Springs /

P.

4. Straight fault "scarps" (super cliffs)

P. 5. Offset streams, etc.

V. Distribution of Earthquakes

A. Plate boundaries = 95% of Q's

P. 1. Conv…subd…Pacific Rim

2. Diverg…R.V…Mid oc.

3. Transf…SAF

B. Inside Plates ("intraplate" = inside plates)

P. ex. Missouri 1812 ……. ancient Rift V.

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Geologic Time (ch.)

I. Relative Dating –1800's…….
- compare rocks…..put rocks and fossils in order…old to young

A. Geology Rules –1790's = J. Hutton

P. 1. Law of superposition
-lower sediment rock beds =older

P. 2. Original horizontality
- sediment was horizontal when deposited
- any tilting or folding occurred later

P. 3. Cross cutting
- magma intrusion cut through older rock.
- faults cut through older rock.

B. Unconformities –interruptions in rock layers
=long time when these occurred:
1. Uplift…folding….
2. Erosion
3. Drop …. deposition again

P. 1. (Disconformity) - common
=beds stacked parallel.….uncomf.

P. 2. Angular Unconformity *
=horizontal layers over tilted layers
- due to uplift **+ *tilt*** + erosion + drop (depos….)

P. 3. Non-Conformity
- layers over nonlayered rock like "granite"
ex: granite in Calif.

P. C. Solving geologic puzzles

D. Correlation = match rk layers over big areas
1. Similar rock types – (rare) unique rk. (like fingerprint)
P. 2. Sequence of beds - pattern of rk. layers (“ DNA)
3. Fossils -1800’s geology

E. Paleontology –study of ancient life….

1. Fossils –parts (or trace) “ “ “
P. a. Replacement of orig. part by minerals
Over m.y.s by groundwater
1. Petrification – cells filled by silica mineral
2. Mold of leaf or feather….

b. Trace Fossils – tracks, burrows, or “coprolites”…..
c. Hard parts = teeth, bone, shells.
d. Rapid burial –no scavengers + no bacteria (low oxygen)
-swamps and mudflows *ex: La Brea Tar Pits (L.A.)*

2. Correlation by Fossils –best……to match rx……
P.
a. Faunal Succession –ancient animal species
evolved + lived in certain order…
- most went extinct…, some evolved….

P. b. Index Fossils = very accurate dating, but need:
1. Short time span they existed, but now extinct
2. Widespread…worldwide….? *ex. seashells*
3. Easy to identify
4. Use many fossils……

F. Geologic Time Scale

=E's history in units (not equal periods…)

P. 1. Era –major life form changes (last 100s m.y.s)

a. PreCambrian (before 550 m.y. ago)
=7/8 of E.'s history, but little rk. on surface
- only fossils were microscopic
-"shield" areas of conts. + S. Gabriel Mtns.

b. Paleozoic =(550 - 250 m.y. ago)
-1st visible fossils shells
- early Paleoz. = shelled animals in sea
- late Paleoz. =land plants(coal), fish (…bones)
- ended with greatest extinction……..

P. c. Mesozoic (250-65m.y.)
-dinosaur fossils, "conifer" frees
- meteor collision ….mass extinction….
…..dust cloud = …. Cold for few yr.s…….

d. Cenozoic (also "Tertiary") (65-0 m.y.)
-mammals, birds, flowering plants (big leaf trees)…

P. 1. Pleistocene (also "quaternary")
-ice ages…*ex. La Brea Tar Pits*
-humans

2. Periods –smaller periods of time (10's of m.y.'s)

P. *ex: Jurassic*

3. Epochs – smallest (m.y.s)
ex: Miocene -most of LA County rocks, faults, oil…
= S. Andreas Flt. started…basins (sed.)

II. Radiometric Dating =1900's study
- absolute dating (exact ages = m.y.'s in previous notes)
- dates almost any rk…without fossils *ex. basalt*

A. Radioactivity –in some elements (rare)
-unstable variations (isotopes) of "nucleus" break up

P.

1. Parent/Daughter elements
-orig. "parent" element "decays" into another ('daughter")
2. Half Life =time for ½ of parent material to decay

P. into daughter material. (ex. Uranium → Lead)
* we can date any rock by measuring the ratio
(¼ = one H.L., 1/8 = two H.L.s, etc)

P. a. Commonly Used isotopes – exact H.L.s known

Parent	Daughter	Half Life
Uranium	Lead	700 m.y.
Potassium	Argon	1.3 b.y.s
Carbon 14	Nitrogen	5700 yrs.

b. Potassium → Argon -most used
-detects ages from 100,000 to 4.5 b.y.old
-potas. common in rk.= easy to age of ***any*** rk.

P. c. Carbon → Nitrogen
-detects ages from 500 to 500,000 yrs. old
-common in organic remains…wood, bones, teeth
- archeology, history….???
-dates quakes, landslides, ice age, mudflows, fires

B. Difficulties in Dating
1. Volcanic Rocks – accurate, but must use "fresh" rock
2. Sedimentary Rocks - grains from elsewhere (many dates)
3. Solution -cross check AND use several types

C. Why dating rocks is important in California?

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MINERALS (Ch.)

P. Minerals = natural solid with specific chemical formula, make up "rocks"

I. Chemistry

-Minerals are "molecules" = 2 or more atoms (= elements =one type of atom)

P. A. Atoms = smallest normal unit of matter

-Most are "ions" (= atoms with positive or negative charge)

-Symbols from Periodic Chart

P. 1. Eight Common elements of crust (= 98% of crust):

O = oxygen, makes up 47% of crust	Ca = calcium, 3%
Si = silicon, makes up 28% of crust	Na = sodium, 3%
Al = aluminum, 8% of crust	K = potassium, 2%
Fe = iron, 5% of crust	Mg = magnesium, 2%

Others:

C = carbon, Cl = chlorine, H = hydrogen, N = nitrogen, S=sulfur

A. Molecules = combinations of atoms held together by bonds

1. Covalent Bond = strongest bond (like "super glue")

P. Silica = one Si plus four O = SiO4= most common

Carbonate = one C plus three O = CO3

2. Ionic Bond = weaker bond (like magnets), dissolvable

ex. salt

II. Physical Properties of Minerals – used to identify them

A. Crystal Form =determined by chem. Formula

P. -distinct for each mineral, but rarely perfect in nature

ex: quartz (6 sided), salt (cubes)

P.

B. Color = not reliable for most

P. some distinct (ex. olivine, garnet, pyrite)

C. Luster = the "look" of the surface

Glassy, pearly, metallic, dull

D. Hardness = relative =compare to each other, useful in identifying min.

No.	Mineral	Use
1.	Talc – softest	Baby powder
P. 2.	Gypsum –soft	Drywall (sheetrock)
	Fingernail =2.5	
3.	Calcite	Cement
4.	Fluorite	
5.	Apatite	
	Glass=5.5	
6.	Feldspar	
7.	Quartz - hard	glass making
8.	Topaz	gem
9.	Corundum	ruby (red), sapphires
10.	Diamond - hardest	gem, rock saws

E. Streak

F. Specific Gravity – "weight" compared to water

Very heavy = 10-20 times wt. of water	ex: gold, lead
Heavy (dark minerals) = about 3.0 – 4.0	ex. magnetite, ferromag.s
Lighter (lighter color) = about 2.5 – 3.0	ex: quartz, feldspars

G. Mineral Cleavage – how a mineral breaks along a plane

- distinct for each mineral= helps identify them
- "Cleavage plane" = natural smooth, flat shiny surface

P.	1 plane – like potato chips	ex: micas
P.	2 planes – like french fries	ex: feldspars
P.	3 planes – like cubes	ex: calcite, salt

H. Fracture – how mineral breaks irregularly (not on a plane)

Ex: quartz – breaks like glass

P.

I . Others:

Taste (ex: salt), Feel (ex: graphite), Magnetism (ex: magnetite), Fizzes with HCl acid (only calcite)

III. Mineral Groups = 4000 minerals, but only 20 common ones

A. Silicates - most common, makes up most rock!

P. - **S - O "tetrahedron**" = SiO4 "pyramid" (4 Ox. and 1 Silica atoms)
- These are "glued" together by positive atoms (ex. Fe, Ca, Na…)
- Combine in diff. ways:

1. Individual Tetrahedra

P. -"glued" together randomly = weak ex. olivine,

P. 2. Single Chain \
} forms long crystal ex: ferromags.
P. 3. Double Chain / (most dark min.)

4. One Plane = chains of tetrahedra form sheets ex: micas

P. a. Biotite – black mica
b. Muscovite – white mica

5. 3-D Network - sheets form solid crystal = strongest silicate min.

P. a. Feldspars – most common mineral ….50% of all rocks
P. 1. Orthoclase – tan or pink, gives color to granite
" 2. Plagioclase – white, in volcanic rocks

P. b. Quartz – all silica tetra. with no ions
- milky qtz = white, in veins…..
P. - colors from impurities

A. Non-Silicates – less common, but more important economically!

	Group	Example	Use
	1. Carbonate – has CO3 attached	Calcite	Cement
	2. Oxides – metal ion and oxygen (O)	Hematite	Iron

"ore" = rock or min. mined for a metal

P.	3. Sulfides – metal ions and sulfur (S)	Galena	Lead
		Copper Sulfide	Copper
	4. (Sulfates) – ions plus SO4	Gypsum	Drywall
	5. (Hydroxides) – ions plus OH	Bauxite	Aluminum
P.	6. (Halides) - ion plus Chlorine (Cl)	Halite	Salt, Chlorine
P.	7. Native Elements – pure elements	Diamonds	Jewelry, saws
		Gold	" , electronics

IV. Gemstones – have to be rare, hard, beautiful
diamonds, emeralds, ruby, opals, topaz
P. ex. L.A. County Museum of Natural History – free 1st Tu./mo.

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Volcanic Activity (ch.)

I. Magma -molten rock underground

A. Origin -melting cr. or mantle…caused by high or low pressure

1. Distribution

P. a. Rift Valleys -up. mantle melts →basalt magma

b. Hot Spots - lwr. mantle melts→basalt magma

P. c. Subd. Zones -basalt oc.cr melts →granite magma

B. Viscosity =ability to flow (=stickiness = thick = gooey)

P. 1. Temperature hotter= less viscous

* 2. Composition - more silica = more viscous

P. a. Basaltic Magma ~50% low silica
= very fluid = flows farthest…fastest

b. Andestic Magma ~60% silica
= medium silica = flows med. distance at med. speed

P. c. Granite Magma (or rhyolitic) ~70% sil.
= high silica = slow, thick = doesn't flow

P. 3. Dissolved Gas – mostly steam, propels lava out
-near to surface (low pressure) = bubbles = jets out

a. Quantity
-more gas = more propel

b. Ease of Escape =viscosity

P. 1. Basalt magma – "soupy"
gases escape = creates lava fountains (like soda)

P. 2. Andesitic + rhyolitic magma
= stick = gasses trapped

P. -pressure builds….. explosions + shattered rk.

II. Ejected Material

P. A. Lava = molten (~2000 F)….on surface

P. 1. Basaltic –fluid (soupy)…flows fast
P. - lava tubes (caves)….cools on the top first……empties…
a. Pahoehoe -river of lava …smooth wrinkled surface…
P. b. Aa -slower, cooler (end of flow)
= sharp chunks of lava fall down as lava moves

2. Andestic - medium speed + distance
P. 3. Rhyolitic = pasty → domes pile up

B. Gases = dissolved in magma until eruption
P. - ~5% of magma =1000's tons/day
- 70% H2O, 15% C02, sulfur oxides (smells "bad")

1. Fumeroles =-vent w/ only gas
ex: Mt. Lassen (No. Cal.)

C. Pyroclastics = "fire + particles"
P. -released gas explodes lava …shattered…..thrown up through air

1. Ash - lava shattered into tiny shards of glass (rhyolitic)
P. -settles down ….hot or cold

2. Pumice -gas trapped in cooling rhyolitic lava

P. 3. Cinders - " " " " basalt lava
vesicular (=bubbly), nut-sized, from lava fountains

P. 4. Bombs – larger, streamlined during flight

III. Volcanoes = pile of ejected material, 6 types
vs. crater =steep walled hole over vent

P.

A. Shield Volcano = low side mound

P. - Lava flows – like river…10's miles to sea…….black sand

P. *ex. Kilauea (Hawaii hot spot)* = 1983-now, largest eruption…..
largest volc…….100 mls. across, 6 mls. high

B. Cinder Cones

P. - from lava fountains = only 1 eruption (~1 week long)
- steep pile of cinders (and bombs)…basalt

P. <1/2 mile across, <1000 ft. high
- 2nd stage: lava flows out of base

P. - *ex: Paricutin, Cal. desert…..*

C. Dome –viscous lave (rhyloit), wart-like *ex. Mammoth, CA*

P. D. "Composite" Volcanoes = mix of lava and ash
- found at subd. zone ……

P. - beautiful… miles high (over 1 mil. yrs.)
ex: Cascades (Mt. Shasta, Rainier), Japan (Mt. Fuji),

P. *Philipines (Mt. Pinatubo), Italy (Mt. Vesuvius)*
- but most dangerous:

P.

1. Lahar -volcano mudflow of **ash** & water (rain or meted ice)
- go far and fast = on to valleys
- biggest killer! *ex. Colombia …1985….20,000 killed*

P. 2. Glowing Avalanche = pyroclastic flow (Nuee Ardente in text)

P. - avalanche of hot ashes and gas (~2000 F)

P. - fast (100 mph) and dense
ex: Mt. Pelee ….1902….30,000 dead

P. 3. Parasitic Cones -new volc.mtn on side of volcano
ex. Mt. Shasta

P. 5. Caldera =huge "crater" due to collapsed volcano
after huge ash eruption (=rare)
P. *ex. Crater Lake = 6 miles wide, rain….deepest lake….*
ex. Long Valley caldera (Mammoth, CA), Yellowstone
P. *ex: Krakatoa, Santorini (Greek island)*
6. Andesite lava

E. "Fissure" Eruption -rarest, largest vol.
P. 1. Rift Valley -basaltic lava *ex. Iceland*
2. Flood Basalts -huge areas, only in ancient ….. very rare
- 100's of fissures - basalt ……flows 100's miles….
P. *ex. Columbia River Basalt = 150' thick….2 states*

F. Volcanic Pipes - fast eruption from mantle
-happened b.y.a.= ancient rock only
= tube w/ diamonds *ex: So. Africa*

IV. Intrusion Features =magma cools underground (= rock)
P. - exposed by erosion over m.y.s

P. A. Dike - magma cuts across rock layers (= vertical)
-from magma through fissures (common)
P. -when eroded = reveals a wall

P. Columnar Jointing- in basalt…..cooling joints as shrinking
P. - 6-sided "honeycomb" *ex. Devils Postpile and Devil's Tower*

P. B. Sill -magma between layers (= horizontal)

P. C. Batholith =huge body of granite (="pluton")
-sub zn… granite magma…..viscous…
P. -formed deep underground (slow cooling), erosion exposes it
ex: Sierras (Yosemite) and most tall mntns. in Calif.
P.
E. Volcanic Necks -magma in vent → hard rock
P. *ex: Morro Rock (Bay)*

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Igneous Rocks (Ch.)

A. Textures = appearance (size of crystals = "xtl.s")
=how rock formed. *deeper = slower = larger

P.

1. Coarse Grained (phaneritic in text) = visible xtl.s (speckled)
-cools underground slowly

P. *ex. granite*

2. Fine Grained (aphanitic in text) = invisible xtl.s (one color)

P. *cools on the surface fast

ex. basalt

P.

3. Mixed (porphyritic in text) = big crystals in fine background

P. - magma started to cool underground and then moved up to surface

P. 4. Vesicular =bubbles in rk. (volc.) = gas trapped as lava cooled

5. Glassy = natural glass (no xtl.s) -due to fast cooling of rhyolitic lava

P. -solid (*obsidian*) or bubbly (*pumice*)

6. Pyroclastic

-rhyol. Glass shattered by gas =ash (+ pumice)

P. a. Tuff -rock made from loose ash

b. Welded tuff –hot = melts together

P. -rk from glowing avalanche

ex. Bishop Tuff

B. Composition- chemistry (= silica %)

1. Balsaltic Rocks ="mafic"
-low silica (50%) =dark (black), heavy rock

a. Gabbro-coarse grain, intrusive (underground)
P. b. Basalt -fine grain (volc.)
…vesicular, cools on surface
[c. Peridotite -`ultramafic`= super-low silica, mantle rk.]

2. Andesitic (medium) = med. color + compos.
P. a. Diorite
b. Andesite -fine grain = volcanic, gray
P. -subd. zn. composite volc.
ex. Andes, Cascades

3. Granite =felsic, light(gray or pink)
P. a. Granite -coarse grain, light gray
b. Rhyolite -fine grain = lava rk. (domes)
c. Obsidian -glassy volcanic rock
d. Pumice
e. tuff
f. welded tuff

C. Magma Crystalization
= solidification = silica & ions bond together to form "crystals"=minerals…grow in arrangement…chains,sheets…
-form & interlock

1. Crystal Size
pg 46 a. Extrusive – volc…surface, fast cooling= small xtls
in notes b. Intrusive – underground, slow cooling = big xtls

D. Mineral Composition

1. Bowen's Reaction Series – important concept,
   = shows order that minerals xtlize
   - low silica min (dark) xtlize 1st (hotter temp.)
   - higher " " (light) " later (cooler temp)

Temp.	Melt	Xtlize	Minerals in order		Mineral trends
Hot	Last	first	Olivine	Ca-Plag.	Soft=less complex,
2000 F			Ferro mags		less silica= darker
			Biotite	Na-Plag.	
			Ortho. Feldsar		
			Muscovite		
Cool					Hard=more complex
1000 F	First	last	Quartz		more silica= lighter

2. Partial Melting
   - higher silica min. (qtz, feld.) melt first (low silica min. melt later)
   - resulting magma is different (more silica, lighter) than original rock

3. Magmatic Differentation
   a. If magma moves up before whole rk. melts
      = lighter magma (higher silica) results
      ex. granite from basalt

P. b. Crystal Settling (like soup)
   =1st min. to xtlize =heavy =can sink
   = bottom rock is more basaltic (heavy) *ex; gabbro*
   and top is more granitic

III. Economic Deposits of Igneous rocks

A. Diamond Pipes…So. Africa

B. Magmatic Differentiation = xtl settling

- heavy min. found together…settled…at the bottom.

P. - Chromium (…….), Platinum (……), Nickel (…..)

ex. So. Africa – ore mines

C. Pegmatites -last pocket of granitic magma to xtlize

P. -huge xtls= qtz, mica, gems (emerald, topaz)

D. "Hydrothermal" Deposits – hot groundwater from magma

P. -Si & metals dissolve into water →through rk →solidify (cool)

P. a. Veins – gold + silver in milky quartz "veins"

ex. California "mother lode" (underground "shaft" mining)

b. Disseminated - ~1% copper throughout rock

P. ex. Ariz. & Chile mines ("open pit" mines)

E. Cinders = make red roads

F. Fertile Soils =best

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Weathering and Soil (Ch.)

I. Weathering =breakup and decomposition

P. A. Mechanical Weathering = physical breakup, visable

1. Ice wedging - freezing H2O expands 9%

P. (like bottle in freezer)

"Talus" = pile of rk at base of cliff

P. 2. Sheeting (Unloading in text) =pressure release ……erosion.

-rk. splits in "joints"……. parallel to surface (like onion).

P. "Exfoliation" = granite sheets peel off *ex: domes in Sierras*

P. 3. Organic -roots split rx along joints.

B. Chemical Weathering -decomposition (rot) of min. + rk by water (invisable).

1. Hydrolysis =feldspar decomposition

P. ions (in water) change……form clay (washed away as mud)

2. Solution =CaCO3 (calcite) dissolves in

P. carbonic acid (rain + CO2) … forms caves, etc…

3. Oxidation = iron rusting

P. -red color on rk surface or soil = hematite

*all 3 need water!

C. Rate of Weathering (chemical)

1. Jointing -more joints = faster w….

P.

2. Spherical Weathering = rk erodes into round shapes
   - corners eroded more ……..under wet soil (in past)
   - common in granite with joints *ex: Joshua Tree Ntl. Park*

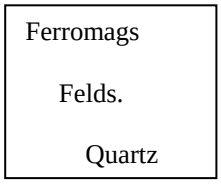
P.

3. "climate" (aver. weather) = most important
   a. moisture – rainy = more weathering *ex: N&E USA*
   b. temperature- hot = " " *ex. tropics*

4. Parent Rock –depends on how stable min. are

P.

Bowen's R.S.



Unstable (decays into mud)

P.

Stable (left behind as sand)
ex: beach sand from granite

II. Soils – needed for crops…

P. A. Formation – amount & "fertility"…soil (affect on hmans…)

1. Parent Rock + minerals

P. Ex: granite & sand vs. volcanic basalt & andesite
=bad fertility = good fertility
ex. Nevada *ex. Hawaii*

2. Time – longer = deeper soil *ex. Hawaii*

3. Slope

P. a. steepness - flatter = more H20 → more soil.

b. orientation =direction it faces
-to south = sunny = less H20, soil
-to north = shade = more H20,soil

c. Rainy side = more chem. W… *ex. west side in Calif.*

4. Climate Effect on Soils …most important

a. Dry (desert) climates = mechanical weathering (wind, floods)

P. 1. Pedocal soils =tan *ex. SW USA*

2. Caliche = calcite layer on surface formed by evap. grndwtr

b. Moist Climate

= chem. weathering = good soil (farming areas)

P. 1. Pedalfer =dark soil *ex. No. USA*

c. Hot Moist Climate "leaching"= infertile soil

P.

1. Laterite = red clay soil *ex. Tropics*
(Bauxite -aluminum ore…)

P. 2. Bad rainforest destruction → farms with infertile soil
= abandoned after years →erosion → red soil into rivers

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Sedimentary Rocks (Ch. 7)

I. Sedimentary Rocks

Common =3/4 of surface rk. on cont.s (+L.A. county)

P. * Two categories…based on how they are formed

A. Detrital Sed Rocks

- made by rock particles that are buried, then lithified deep down

* visible to us = were uplifted and eroded

1. Characteristics

P. a. Size of particle = classify rocks

coarse

Particle	Wtr.Speed	Where (ex)	Sediment	Sed. Rocks
Cobble	Very Fast	Canyon		
Pebble	Fast	River….	Pebbles	Conglomerate
Sand	Medium	Beach	Sand	Sandstone
Silt	Slow	Lake, Bay	Mud	Shale
Clay	Calm	Deep sea	”	”

fine

- tells where sed. deposited & water speeds

* slower = finer sed.

B. Sorting -how many sizes

- good(1 size) - one speed
- poor(all sizes) - many speeds

C. Rounding – due to how much rolled around

ex: beach vs. mountains

*most sand is from mtn.s, not crushed up by waves on beach

D. Composition -tells source + distance it came

ex: granite (……..) vs. basalt pebbles (……)

3.Detrital Sedimentary Rocks:
-common…1/2 of sed. rk. 1/3 or cont's surface rocks.

a. Shale (mudstone) – half of all sed. rx.

P. 1. fine grain rk. (silt + clay)
2. deposited in sea + lakes = calm….
P. 3. "impermeable" = barrier to water….
4. easily eroded (= slopes + valleys) *ex. Cal. freeways…*
P. 5. Fossils + thin layers = crumbly

b. Sandstone

1. Visible grains (medium)
P. 2. deposited in beach, dunes, rivers
3. "permeable"……..water & oil wells
P. 4. harder to erode (forms cliffs+hills) *ex. Cal. coast cliffs*

c. Conglomerate

P. 1. rounded pebbles (+ sand)…like concrete
2. dep. in rivers…
ex; eastern L.A. Cnty hills

d. Breccia - angular pebbles

P. - fast formed…??
- landslide, volcano neck, fault.

e. Turbidites

P. -repeated layers of shale + sandstone
-formed in deep oc. by "turbidity currents" (undersea mudflow)
ex: L.A. Cnty hills = P.V. cliffs (rx. depos. 15 m.y…)

B. Chemical Sedimentary Rocks = rk. originally dissolved in water

1. BioChemical sed. Rocks -organisms make shells

P. plankton die → shells sink to seafloor

a. Limestone - most common = 10% of sed. rx.

P. - $CaCO_3$ shells (microscopic) = calcium carbonate
- buried → compressed into calcite xtl.s
- test: acid fizzes

P. 1. Chalk -pure microsc. shells… white, light weight
- **use**: chalk *ex. Dover*

b. Chert =flint

-silica (SiO_2) shells…buried…….used for arrowheads…

1. Diatomite… white, very light weight
- **use**: filters, **flat** paint *ex: S.Barbara Cnty... mines…*

2. Diatomaceous Shale…. used for cat litter

P. c. Coal -land plants→ buried in low O_2 swamp →coal (m.y.s.)
causes air & water pollution *ex. China, Applachians*

---

2. Inorganic Chemical Sed. Rocks -minerals crystalize directly from water

A. Evaporites -forms when water evaporates from sea or lake .

P. 1. $CaCO_3$ (limestone) - 1st to xtlize **use**: cement

2. Gypsum – 2nd to xtlize **use**: wall board

P. 3. Salt … -last " " **use**: food, roads

B. Travertine -$CaCO_3$ xtlizes from grnd. wtr.
- on surface from springs
- Tufa = $CaCO_3$ towers formed in lake *ex: Mono Lake*

P. C. Agate = layers of quartz
- deposited in empty spaces by groundwater
- geode = hollow with xtls.

C. Features of Sed. Rocks (buried = preserved in rx)

P. 1. Beds =layers (= strata) all sed rx : = originally horizontal
P. 2. Cross Bedding -dune sands *ex. Red Rock Canyon Park…*
P. 3. Ripple marks -waves in sand (=sandstone)
P. 4. Mud Cracks -mud dried (=shale)
P. 5. Fossils - organisms in calm water (=limestone + shale)

D. Lithification = sed.→ rk.

1. Compaction -weight of overlying rk. = weak (shale)
2. Cementation -main method
   -minerals in groundwater (silica, CaCO3) glue particles

E. Sedimentary Environments - different conditions = diff. rx.

P. Turb. Curr→ turbidites
Lake & Bay → shale
Beach & Dunes → sandstone
Rivers, mudflows → conglomerate
Coral reef, shells → limestone
Dry lake → evaporites
Swamp→ coal

F. Oil

P. 1. ocean plankton →die → sink to cont. shelf
2. buried in low O2 = no decomposition
3. in pores in sandstone (m.y.s buried)
4. Geologic traps = oil fields
5. drill miles deep and pump oil out….
6. refine….. **uses**: gasoline, fuel, tires, plastics
   ex. L.A. Basin …., Persian Gulf

G. Natural gas (methane) – formed in same way
Deeper = 2 – 5 miles deep
ex. Sacramento area

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Metamorphic Rocks (Ch.)

I. Metamorphism - any rock can "change form"… deep underground

A. Causes of Met.

1. Heat

-Geothermal Gradient= 75 F per mile deep

-minerals change -stable at high temp

ex. clay → feldspars

2. Pressure

P. a. due to wt of overlying rk. (deeper = higher P.)

b. mainly compression (pl. tect) …from sides

B. Metamorphic Changes in minerals

= xtl.s get larger, aligned, + change composition

P. 1. Texture =appearance

a. Foliation = striped or sheets

P. -xtl.s grow 90 to compression

- fol. is NOT original sed. layers!

P.

b. Non-Foliated = no stripes or sheets. One color

C. Metamorphic Rocks

1. Foliated Rocks = met. rx from **shale**

P. a. Slate -dark, slatey cleavage *Use: shingles*

P. I

\I/

P. b. Schist –scales (or sequins), parallel mica xls. big

I

P. \I/

c. Gneiss -stripes of wh + blk, "zebra rock"

P. * ***ex: So. Cal. mtns***.

2. Non-Foliated Rocks = from 1-mineral sed.rock

P. a. Marble -coarse-grained calcite
- from **limestone** (CaC03) = HCl acid ….fizz
- soft = carving ***ex: Italy sculptures***
- colors from impurities *Use: floors*

b. Quartzite -coarse gr. quartz xtl.s

P. -from **sandstone**, hardness 7….hardest rock!

c. Asbestos -fibrous, carcinogenic, fireproof insulation…..

d. Serpentine – slipper, soft, green

-use: jade and soapstone carvings ***ex: central Cal. coast***

D. Metamorphic Occurrences

P. 1. Contact Metamorphism = next to magma (heat)

a. Hornfels -fine grain, unfoliated, black rock

p.49 in notes b. Hydrothermal Solution

3. Regional Metamorphism=

P. = most important cause
- converging cont. crust →huge mtn. ranges (now = under Himalayas)

a. Grade – level of heat + pressure

P. - highest in center
- low (slate), med.(schist), high (gneiss)

ex: Appalachians

b. Index Minerals –related to grade

P.	- low grade: micas	*Use:*
	- med. grade: garnet	*sandpaper*
P.	graphite	*pencil leads*
	- high grade: talc	*baby powder*

c. Continental Shields – huge meta. rk. areas = many collisions

P. d. Rock Cycle –rocks “turn into” other types by geol. processes

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Mass Wasting (Ch)

I. Mass Wasting ="landslides and mudflows"
P. -movement of rock and/or soil downhill due to gravity

A. Factors

1. Water – "groundwater" most important..…rainy season
P. a. water in pores = lubricates soil…moves
b. added weight = heavier (8 lbs/gal.)…"
c. wet clays = slippery "

2. Steepness
-steeper = easier to slip

3. Soil –more likely to move than rock
- desert soil easily moved

4. Vegetation
-stablize slope (roots…….)
P. –cheapest = grass seed after fire…roots hold soil during rain

5. Geology of bedrock
P. 1. Dip of layers *ex: P.V. dome = all layers dip down to sea*
2. Sed. Rock = clay/shale layers slide more

P. 6. Stability – man-made roads undermine base
P. *ex: Malibu & P.V. roads*

7. Triggers = immediate causes
-rainiest weeks (rarely quakes)

P. D. Types

P. 1. Rock Falls –single **rock** breaks + falls → talus
-common, melting ice, quakes
ex: N. Hampshire rock…on 2003 quarter

2. Slump = "landslide" in media
-large **rock** block slips down (together)
-rotates down on concave surface
-slow (takes days…) *ex. Sunken City, San Pedro*
?? - most $ destructive in Cal, but no deaths

Visible scarp (on top) & bumpy landform (base) = Common in So. Calif…..rainy…..

3. Earth Flow = takes hours
P. -**soil** and water flow part way down slope
-lava-like flow
-common here in grassy areas……..…

4. Creep –very slow = takes decades
P. -gradual motion of **soil** downhill
-trees & walls tilt.

P. 5. Mudflow –fast (10-mph)…takes minutes
- **soil** + water flows (far…down canyon & on to valley)
P. - carries boulders, cars…. destruction
* common in deserts (flash floods) …loose soil.....
?? - biggest killers in Calif.!

6. Mixture –large, whole mtn. slopes….several combined
ex: Portugese Bend (P.V.) …started 1956…..roads
-lawsuits……..

E. Reducing Mass Movement

1. Mapping –locate old slides
   -slope stability maps
   Ex: www.consrv.ca.gov/dmg/shezp/maps = LA area maps
   -city planners ….. control development.

2. Geologic Engineering

a. Drain pipes – horizontal, remove water no mvmt.
b. benching – man-made slopes w/ steps
c. Retaining Walls – anchored to rock
d. Plants…cheapest
P. e. Storm Drains – pipe water away

II. Permafrost

P. - permanent frozen groundwater
- *ex. Alaska, Russia*
- ancient mammoths buried

A. Top Soil Thaws – in summer, global warming…

P. - mushy….structures collapse….

B. Solution
- build on stilts (piling)
- insulation…..

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Running Water (Ch)

I. Hydrologic Cycle –sun powered

P. A. Stored Water - ocean 97%, ice 2%, rivers and lakes = only 0.1%
B. Evaporation - most over ocean (=71% of E. surface)
C. Precipitation - on land too (average 3 ft. rain….)
D. Infiltration - groundwater (1% of total)
E. Runoff (river)- flowing on surface downhill
* most erosion by it, energy from gravity….

II. Running water

A. Streamflow = rivers

1. Speed -bicycle speed (slow…. fast)

a. Gradient – steeper = faster

P. b. Size – deeper = faster (less friction)

c. Bends –outer edge = faster = erodes!

P. *ex: Californians buying property…..*

P. 2. Discharge –amount of water flowing by per second

B. Changes Downstream

P. 1. Longitudinal Profile (C-S along length of river)
= flatter downstream…. horizontal near end.

2. Base Level –lowest level eroded to (usually sea level)

C. Stream Transport –most important erosion force on earth

1. Erosion –particles carried away by water (sand and mud)
2. Sediment "load"

a. Dissolved material = CaCO3

P. b. Suspended Load = mud….. carried to sea

c. Bed Load -on bottom –[faster = bigger grains]

P. 1. Saltation = sand bounces along bottom

2. Rolling = pebbles & cobbles

P. 3. Potholes = holes in rock
pebbles swirl around & dig holes in waterfalls

D. Drainage

P. 1. Drainage Basin –area drained by river
ex: Mississippi R.= 1/3 of USA

P. 2. Drainage Divide = "ridge" between basins
-"Continental Divide"……

3. Tributary –feeder rivers

P. 4. Drainage Patterns

a. Dendritic (branching) –most common,
- large rivers *ex: Miss. R, Amazon*

b. Radial – (spokes) - volcano or dome *ex: Mt. Shasta*

c. Rectangular –joints (granite) *ex: Sierras*

d. Trellis –folds or faults *ex: coastal Calif.*

E. Stream Valley Stages

P. 1. Young –steep v-shaped canyons = "straight"
fast, waterfalls & rapids

2. Mature –flat "flood plain"(……), formed over m.y.s

a. Meanders – bends w/ side cutting (outside)

P. b. Sand Bars – deposited on inside bend

c. Placers – gold in point bars ….nuggets and dust
ex: Sacramento, Cal. 1849

P. 3. Old Age = wide flood plains, flat , formed over 10s m.y.s
a. Oxbow Lakes = abandoned meander
- river makes "cut-off"= creates a horseshoe lake

P. b. Levee –sand ridge deposited on R. edge
= natural dike…flood
- artificial levees protect people ex: New Orleans

4. Rejuvenation –common in CA
-after land uplifted = R. faster = cuts down into rock

P. a. Entrenched Meanders
- orig: meandering R. cuts down → canyon
ex: Grand Canyon (only 5 m.y. old)

1. **Natural Bridge** = arch left by cutoff canyon
ex: Natural Bridge National Mon, Death Valley

F. Delta –sediment deposited at mouth of river.
-when water slows down …sand + mud depos….new (flat) land
- flat = high flood danger

P. 1. Distributary = -river branches into smaller rivers

2. Types:

P. a. Calm –River sed. depos. in calm sea or lake
ex: Miss. R. "birdfoot" delta

P. b. Wavey -waves spread sed., "common", / \ shape
ex: Nile R. (Egyptian history)

P. G. Floods

P. a. Slow – seasonal, most damage to property, few deaths

P. b. Flash Floods – rainy days, mountain areas, most deaths

c. solution – flood control dams *ex: four in L.A. area*

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Ground Water (Ch.)

I. Water Table –top of water saturated zone (not horiz…follows surface)

A. Zone of Saturation - 100% pores filled w/ water

P.

B. Definitions:

1. Aquifer –rk or sed. layer that water goes through
2. Porosity –open space between grains (25% in sandst.)
3. Permeability –ability for water to go through it.

P. C. Springs =water flows out of ground

P. - water table touches surface

P. D. Wells –open hole down into w. table

P. - mostly for irrigation (farms)…, some city, most pumped

E. Ground Water Movement

–ground water flows downhill .....gravity

II. Man-Made Problems

A. Contamination (if so = close wells)

P. 1. Sewage-purified over distance

Problem septic tanks near wells

2. Oil – on top of water table

ex. L.A. area = 15 refineries, 50 fields, 1000s gas stations

Environmental geologist clean it up = good career

3. Chemicals –urban area

-worst = PCBs, *ex. TCEs in east LA Cnty.*

P. 4. Landfills = garbage dumps, ...toxics

-new = have clay liner = no pollution?

B. Subsidence –permanent, sinking land

P. 1. Water Removal –pump water out = "shrink + sink"....

ex. Mexico City (old lake); Venice, Italy (delta)

2. Oil Fields –pumped.....

ex: Long Beach Port....30 ft....1950's

Solution: pump water in.....

III. Geothermal

A. Hot Springs -flowing hot water out of ground

P. - 100 in U.S… west (faults and volcanoes)

- hot water from: 1. very deep faults

2. above magma *ex: Mammoth Mtn. area*

P. 1. Travertine –CaC03 depos. by springs

= limestone in layers

P. 2. Geyser –fountain of steams + water, very rare

P. – from complex chambers…400 F water....erupts often....

a. Geyserite – silica rock *ex: Yellowstone*

B. Geothermal Energy = earth heat energy

P. -making electricity ..... pump cold down .....hot water out....

= Steam turns turbines --> electricity

P. *Ex: Calif., Phillipines, Iceland (steam.....)*

IV. Groundwater Erosion

A. Carbonic Acid = C02 in water… dissolves limestone

B. Caverns –dissolve **below** water table
w. t. drops = air = caves

1. Dripstone = CaC03 travertine
- formed in air-filled caves
P. - dripping water deposits CaCO3 slowly

a. Stalactites = hanging
b. Stalagmites = on cave floor…drips
c. Columns –grow together

ex: Carlsbad Caverns (New Mex.)
ex: Mitchell Caverns (Mojave I-40), Sequioa N.Park

C. Karst "Topography" = "landform" from collapsed caves
- in humid climates..…m.y.'s .... limestone eroded "

P. 1. Sinkholes collapsed of ground step 1 = 1000s yrs.
P. *ex: Florida (round lakes), Yucatan....*

P. 2. Karst Drainage –rivers appear + disappear
-due to going in + out of caves step 2 = m.y.s

P. 3. Tower Karst –humid tropics m.y.'s
-very steep limestone mtns. step 3 = 10's m.y.s
ex: S.E. Asia + China

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Deserts (Ch)

I. Desert Locations = dry (less than 10 in. rain)
¼ of all the land:

A. Global Desert Belts
P. -atmosphere sinks = dry & hot *ex: Sahara & No. Mexico*

B. Rain Shadow -rain falls on windward side of mtns
P. ** -dry air on back side (desert) *ex: Calif. & Nevada*

C. Desertification = expansion of a desert
P. 1. Natural (since ice age) = all deserts
P. 2. Man made = overgrazing by farm animals.... *ex: Africa*

II. Desert Erosion
A. Sediment lack of water & plants (roots)
P. pedocal = tan, mech. weathering

1. Iron Oxide –rust color
P. 2. Desert Varnish = manganese oxide... only desert
black coating…100's years

B. Water Erosion **Most desert erosion
P. - heavy rain (few/yr) = a lot of water \ very erosive
- lack of plant (roots) w/ a lot of sed /

1. Arroyo –wash = "wadi"
P. -steep walled "canyon" w/ flat bottom (filled w/ sed.)

P. 2. Flash Floods -much water suddenly flows
-mud flows are common.....carry boulders!

C. Wind Erosion = not major in desert
- wind less dense than water AND not in channels
- but depostion of sand important

P. 1. Saltation = sand bounces along
-less than 2 ft high = low erosion level

2. Suspended Load -clay & silt removed
P. a. Dust storm –silt blown from soil
- causes desertification *ex: Dust Bowl.....1930's*

P. 3. Desert Pavement = when sand blows away,
pebbles left behind on the surface = protects soil from erosion

4. Abrasion = sand-blasting
P. a. Ventifact = polished rock (on a side)

III. Wind Deposition
A. Sand Dunes = 1/10 of the desert *ex: Kelso Dunes, Death Valley*

1. Formation where wind slows down (calm)
P. a. Movement -sand removed from windward side
- sand deposition on back side = steep
P. - dunes "move" downwind ... 10s ft/yr

P. b. Cross Beds -layers of angled beds, seen in sandstone

2. Types of Dunes = due to amount of sand (+plants)
P. a. Barchan – common in deserts
–crescents on map w/"tails" pointing downwind

P. b. Transverse = sand ridge 90 to wind
- common along coasts *ex: our beach cities*

IV. Desert Landscape (= "topography")

A. Interior Drainage -separate drain basins..... not to ocean
- rivers flow only few times a year

P. 1. Great Basin = E.Cal, Nev., Utah
-rivers...…into dry lakes

2. Exotic River = flow through desert from distant mtns.
ex: Nile R.& 3 other cradles of civilization, Colorado R.

P. 3. Oasis : water table (grnd wtr) is close to the surface

B. Cap Rock –hard layer protects rock underneath
ex: basalt, limestone, sandstone

P. 1. Mesa = flat top mtn. ex: Monument Valley
2. Butte = pointy rock on Colorado "Plateau"

P. C. Alluvial Fan = pile of sed. deposited at mouth of canyon
- flat valley = mudflows slow down (boulders near canyon)
- flashflood danger *ex: Pasadena-San Bernardino (I-210)*

P. 1. Bajada -combined fans =wedge.

D. Playa –dry lake bed, flood rarely, evaporites common

P. *ex: salt flats along I-15*

E. Stages of Desert Erosion

P. 1. Early = rk. mtn.s uplifted, canyons....alluvial fans
ex: Owens Valley

2. Middle big canyons w/ bajadas,
-basins filled w/ sediment (½ sed & ½ rk) *ex: Death Valley*

3. Late –mtn.s eroded…mostly sediment (no mtn. ranges)

P. a. Inselberg = small bedrock island in sea of sediment
ex: western Mojave desert (Victorville)

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Shorelines (Ch.)

I. Erosion

A. Waves

P. 1. Cliff –eroded by storm waves

P. 2. Marine Terraces *ex: Palos Verdes*

a. Wave Cut Platform eroded by waves below sea level

P. b. marine terrace uplifted by tectonic (quakes)

ex: Palos Verdes – 13, each 100,000 yrs older ....

3. Other –formed as cliff erodes

a. Cave -soft rock eroded

P. b. Arch -2 caves meet = tunnel *ex: Abalone Cove Park*

P. c. Stack -mini island of rock not yet eroded by waves

B. Mountainous Coasts…any…caused by uplift

P. 1. Tectonic Uplift =mtns. on coast, cliffs, mar terr.

2. Tectonic Drop = bay if under water *ex: S.F. Bay*

P. -basin or plain if filled with sed. *ex: L.A Basin*

II. Deposition –beaches on all coasts

A. Long Shore Drift = movement of sand along coast

P. - zig zag motion of waves going up and down beach
- moves sand along beach
- to south along U.S. coasts
- beach sand from rivers (not broken rocks on beach)
- bigger waves = bigger grains (rocks) *ex: Alaska*

B. Submarine Canyons –on shelf, huge

P. -gravity take LSD sand out to basins *ex. Redondo Canyon*

C. Coastal Dunes –transverse dunes
= blown onto land by wind from beach
ex: Manhattan Bch. & Redondo Beach

D. Features from LSD

P. 1. Spit dry sand bar partly across bay *ex: San Diego's Coronado*

2. Bay Mouth Bar –dry sand totally across bay…LSD
-only during dry season *ex. So. Calif. lagoons*

P. 3. Tombolo –sand bridge to rock island *ex: Morro Bay*

E. Coastal Plains –no uplift

P. = flat, mostly deposition (no erosion= no mtns.) ex: East Coast

1. Barrier Islands -dry sand ridge parallel to shore

P. *ex: East + Gulf coast…2000 miles long...longest....*

- urbanized =prone to destruction by hurricane.

P. - *ex: Miami Bch, Atl. City*

- Destruction: storm surges & huge waves

P. *ex: Galveston, TX in 1900....8000 killed !*
ex: New Orleans in 2005.....1000 killed

- Solution: build bldgs. on stilts, evacuations of millions.....

F. Seasonal Change
- beaches wider in summer = smaller waves
- narrower in winter (& more pebbles) = bigger waves

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Glaciers

I. Glacier =moving river of ice on land
-snow →compact →ice →gravity…down

A. Continental –huge ice caps (land)

P. 1. Modern: Greenland & Antarctica.= …2 miles thick

P. 2. Ice Age: Canada/N.E. USA and N. Europe covered w/ ice

B. Alpine Glacier: rivers of ice flow down valleys in mtn. ranges

P. 1. Today's: 1000's… ex: Cascades, N. Rockies

2. Ice Age: Sierras

C. Movement = feet/day

P. 1. Crevasses = -cracks near surface, -don't go very deep

2. Plastic Flow =slow river-like, under its own weight

D. Erosion

P. 1. Abrasion –ice w/ rock in it = best erosional agent in solar system

a. Glacial Striations –parallel scratches on bedrock

P. b. Rock Flour –ground up rk =clay formed by rocks under glacier

P. 2. Cirque =amphitheater…steep, rk sides, -at head of gl. valley

a. Arete –knife ridge between 2 cirques

P. b. Horn –pyramid peaks between 3 cirques

*steepest mtns =high cliffs + bare rk.

P. 3. U-Shaped Valley = vertical cliffs…only glaciers create
ex: Yosemite Valley

P. a. Fjord – long deep bays, popular with cruises
-form by: 1. glacier valley erosion
AND 2. flooded by sea *ex: Alaska*

E. Deposits

P. 1. Icebergs –if glacier goes to sea…only 4 places in world
a. "calving"-drop off w/ splash (bang, splash)

P. 2. Moraine –ridge of sed. left behind by glacier
a. Terminal Moraine –at bottom (end of glacier).
P. Like a "conveyor belt" that builds up ridge at end

F. Ice Age –many
1. Evidence:
P. a. Glacial Valleys –high mtn ranges on earth
b. Sea Level Change ~ 400 ft. lower during ice age
P. *Ex: Bering Straight ...Native Americans walked here*

P. c. Moraines –huge *ex: Long Island, NY*
d. Pluvial Lakes –were in "today's deserts"
P. = more rain and snow (no deserts then) *ex: Death Valley*