***Geog 317 Study Guide** – Whole Semester (exam breaks provided in class)*

I. What is Soil?

Soil Definition, etc.

perspectives on soil study; edaphology, pedology

Soil Properties:

texture: sand-silt-clay-loam; USDA size separate categories (2/.05/.002mm)
structure: platy, blocky, columnar, prismatic, crumb, massive, single-grained
consistence: (related to cohesion & adhesion): "sticky" "plastic" "friable" "soft" "firm"
cementation: carbonate, oxide: weakly cemented to indurated
density: particle density vs. bulk density
porosity: % pore space, can be derived from bulk density & particle density: (1 - BD/PD) * 100%
color: causes (iron oxides, etc.) Munsell System, hue/value/saturation; For example, what does 10YR 5/2 mean?
chemistry: Cation Exchange Capacity, base saturation, pH
fabric: microscopic characteristics -- mineralogy of "plasma", nature of porosity
aeration
temperature: permafrost; site effects; Soil Temperature Regimes
soil moisture: infiltration capacity (and what determines it), permeability, hydraulic conductivity, evapotranspiration, runoff, throughflow, tension (due to H bonding/cohesion and adhesion): effect of evaporation, plant roots, gravity; significance of macropores, mesopores, micropores, adhesion water; field capacity; available water; capillarity; pore pressure & tension (negative); Permanent Wilting Point; Measures of Soil Moisture: gravimetric, resistance, TDR, neutron scattering, tensiometers. Soil Moisture Regimes: aquic, aridic, udic, ustic, xeric

Soil Development Processes & Horizons

additions, losses, translocation, transformation, horizons (A, Bw (cambic), Bt (argillic), E (albic), C) and horizonation, 5 soil-forming factors (parent material, climate, organisms, relief, time).

Soil Taxonomy

descriptive, not genetic. Organization: order, suborder, great group, subgroup, family, series
Lower-level Classification: for soil surveys: series, type, phase. Soil mapping unit: associations and complexes. pedons and polypedons
Higher level Classification, using Diagnostic Horizons:
Epipedons: mollic, umbric, melanic, anthropic, plaggen, histic, ochric

Horizons: albic (E), cambic (Bw), argillic (Bt), natric (Btn), spodic (Bh Bs Bhs), oxic (Bo), fragipan, duripan (Bqm), calcic (Bk), petrocalcic (K), gypsic (By), petrogypsic, salic (Bz).

All orders: typical properties/horizons, factors (where significant), significant distribution patterns.

The most important requirements and characteristics of each order. Know these:

	essential requirements	other facts
Entisols	no B horizon	young
Inceptisols	cambic (Bw) horizon	young
Histosols	histic epi	relief: wetlands
Andisols	andic properties -- glass-derived	PM: volcanic ash, high OM, melanic
Vertisols	>30% clay (smectite) to 50 cm	PM: smectite clay
Aridisols	aridic, ochric epi, some subhorizon	suborders by subhorizon
Mollisols	mollic epi, >50% BS	grass
Alfisols	argillic, >35% BS	forest
Ultisols	argillic, <35% BS	humid subtropical to tropical, 1:1 clays
Oxisols	oxic, low CEC	tropical
Spodosols	spodic	pine forest, typically on sands
Gelisols	permafrost	

II. Factors of Soil Formation.

Parent Material

physical and chemical properties; chemical and mineralogical composition of the earth's crust; common elements in the earth's crust (O, Si, Al, Fe, Ca, Na, K, Mg -- 98%) vs. elements essential for plant growth (CHOPKNSCaFeMgBMnCuZnMoCl); spatial variation as related to plate tectonics;

Important Geologic Mineral Groups, common ions, where they occur. Know the major sources of cations. For instance, calcium should be common in sedimentary rocks that contain calcite (like limestone).

mineral group	common cations	Where	example
carbonates CO_3^{--}	Ca^{++} Mg^{++}	sedimentary rocks	calcite $CaCO_3$
sulfateSO_4^{--}	Ca^{++} Mg^{++}	evaporites, muds, coals, wetlands, shales	gypsum Ca sulfate
oxides O_3 etc	Fe^{3+} Cu Mn	some major deposits, primarily a coating on sediments	hematite Fe_2O_3
silicates		92% of crust minerals vary in resistance to weathering by sharing of O atoms among SiO4 tetrahedra, since Si-O bond is very strong	

Know the following cation and anion valences common in parent material: H^{+} K^{+} Na^{+} Ca^{++} Mg^{++} Fe^{++} (ferrous) Fe^{3+} (ferric) Al^{3+} Si^{4+} O^{--} OH^{-} CO_3^{++}

Weathering and Secondary Mineral Formation

Mechanical Weathering Processes: unloading/exfoliation, thermal expansion/contraction, freeze-thaw & frost action in general, crystal growth in voids (ice & salts), hydration shattering, root growth.

Chemical Weathering Processes: Understand the following processes, and know one important example for each, including chemical formulae (except for chelation): solution, hydration, hydrolysis, carbonation (understand weathering of calcite), oxidation, chelation (significance of spodosol translocation, lichen).

Silicates and formation of secondary clay minerals from primary minerals

Know the major sources of Mg Fe ions (more oceanic crustal sources like basalt, etc.) vs. K (more continental); Know how increasing sharing of oxygen atoms in the basic building block of tetrahedral SiO_4 makes more resistant minerals; Know that sheet silicates (phyllosilicates) include the clay minerals, and others weather directly to clays.

Tetrahedral sharing	Common ions	Source	Minerals
Independent tetrahedra	Mg Fe "mafic"	oceanic crust, basalt lava	olivine Fe_2SiO_4 to Mg_2SiO_4
Chains single : pyroxene double : amphibole	Mg Fe "mafic" Ca	oceanic crust, CA coast range, basalt lava, dark minerals in continental rocks	hornblende
Sheets (phyllosilicates)	K Mg Fe	micas common in many rocks common in many rocks; K especially on continents secondary clay minerals, common in sediments and soils	mica, smectite, kaolinite
Framework (tectosilicates)	K Na Ca "felsic"	common in many rocks; K especially on continents	feldspars K-spar, Na-spar or Ca-spar; quartz SiO_2

Clay Minerals

Tetrahedral sheets - Silicate; Octahedral sheets - oxides/hydroxides, with Al, Mg, Fe.

Silicate phyllosilicates & clay minerals -- mica, smectite & kaolinite. Know basic structure, process of formation, effect of weathering environment, properties, etc. as shown in lecture figures , discussed in class, and covered in text.

Oxide and Hydroxide clays: gibbsite $Al(OH)_3$, hematite Fe_2O_3, Goethite $Fe_2O_3*2H_2O$. How might goethite be formed?

Rock Weathering Examples: limestone, sandstone, shale, quartzite, schist, serpentinite, granite, volcanics.

Sediments as PM: colluvium, alluvium, loess, glacial till, marine deposits, dune sands, cumulic soil profiles.

Organisms Factor

Soil Ecology

Skip: Autotrophs vs. Heterotrophs; Phototypes vs. Chemotypes; examples of Photoautotrophs, Chemautotrophs, Chemheterotrophs; Primary Producers, Consumers, Decomposers

Significance of the following organisms in soils, soil development, and soil ecology: bacteria, fungi (including mycorrhizae), actinomycetes, protozoa, springtails, ants, grubs, mites, sowbugs, millipedes, nematodes, earthworms, gophers (etc.), centipedes.

Organic Matter Decomposition

Composition of plant residues & soil OM; rates of decomposition of cellulose, hemicellulose, lignin, sugar, amino acids, minerals; decomposition reactions; Formation of Humus; Clay-Humus complex; Characteristics of Humus; Mineralization Process;

Nutrient Cycling & Important Soil Elements

: plant requirements, sources, and cycles of the following:

Carbon : aerobic/anaerobic; soil, air, rock, water, organism; CO2; CH4; CaCO3, hydrocarbons;

Nitrogen : fixation (with plant examples), mineralization, nitrification, immobilization, denitrification; roles of bacteria, actinomycetes; inorganic forms: ammonia, ammonium, nitrate. Nitrification - fixation balance. Potential for groundwater pollution.

Sulfur : sulfates, sulfides, significance with N, renewed need for fertilization.

Phosphorus: needs by plants (ATP, DNA); weathering, immobilization, mineralization, leaching, fixation, dissolution, leaching; H2PO4, Ca-phosphates, Fe-phosphates; significance of pH; fertilizer.

Potassium (common in fertilizer), Calcium, Magnesium -- similarities, significance for plants.

Vegetational influences on Nutrient Cycling -- general considerations: temperature and moisture controls; grasslands vs. forests; needleleaf conifers vs. broadleaf deciduous

Relief

Soils & Landforms: effects of slope angle and aspect; types of deposits, especially alluvium and colluvium; slope position and oxidation vs. reduction

Significant slope processes: rainsplash erosion, slopewash vs throughflow & piping, soil creep, gullies

2D & 3D soil-landscape systems: the 9-unit slope model where does creep occur most, where does colluvium collect, where would the "oldest" soils occur; where would cumulic soils develop?; catena; spurs & hollows, water-spreading vs. water-collecting slopes; meaning of "drainage"

Time

time required: PM + horizons; argillic horizon; hasteners (warm, humid, forest, drainage, low lime) vs. retarders (cold, dry, grass, poor drainage, high lime, steep); OM accum. vs. decomp.; primary vs. secondary minerals; relation to horizons (e.g. cambic, argillic, spodic). Weathering Stage -- If presented with lists of soil minerals for different soils, can you assign relative ages, assuming climate and parent material are constant? Think of the major primary and secondary mineral indicators: gypsum & calcite, smectite, kaolinite (kandite), oxide clays.

Climate

Role of Climate: precipitation effects; temperature effects ..on weathering processes, soil development, etc.

Humans

Humans as a factor: influence on each of the 5 factors.

III. Soil Distribution

Soil Taxonomy: The most common suborders. This one's easy -- just know the meaning of the prefix – the moisture and temperature regimes:

	aqu-	per-	ud-	ust-	xer-	torr-	cry-
entisols	**aquents**						
inceptisols	**aquepts**		**udepts**	**ustepts**	**xerepts**		**cryepts**
andisols	**aquands**		**udands**	**ustands**	**xerands**	**torrands**	**cryands**
vertisols	**aquerts**		**uderts**	**usterts**	**xererts**	**torrerts**	**cryerts**
aridisols							**cryids**
mollisols	**aquolls**		**udolls**	**ustolls**	**xerolls**		**cryolls**
alfisols	**aqualfs**		**udalfs**	**ustalfs**	**xeralfs**		**cryalfs**
ultisols	**aquults**		**udults**	**ustults**	**xerults**		
oxisols	**aquox**	**perox**	**udox**	**ustox**		**torrox**	
spodosols	**aquods**						**cryods**
gelisols							

Other suborders not included above:
aridisols: salids, gypsids, calcids, durids, argids, cambids
mollisols: albolls, rendolls
ultisols: humults
spodosols: humods, orthods
gelisols: histels, turbels, orthels
entisols: arents, fluvents, psamments, orthents
inceptisols: anthrepts
histosols: fibrists, hemists, saprists, folists
andisols: vitrands

If I give you a suborder name, you should be able to tell me about it:

e.g. a Xerept is an Inceptisol with a xeric moisture regime. (And what's a xeric moisture regime? And what's an inceptisol?)