## <u>GEOL 1301 - 002 (87128); Earth Systems</u> <u>Fall 2015, 08/27/2015 - 12/09/2015</u>

Instructor: Andrew Hunt, PhD

Office Number: Room 245 Geosciences Building

Office Telephone Number: 817-272-0437

Email Address: hunt@uta.edu

Faculty Profile: https://www.uta.edu/profiles/dr-andrew-hunt

Office Hours: Tuesday 2.00 - 4.00 pm

Section Information: GEOL 1302-002 (87128) (Texas Common Course Number GEOL 1303)

**Time and Place of Class Meetings:** Geosciences Building (GS), Room 100 Monday and Wednesday – 11.00 am - 10:50 am

**Description of Course Content:** Fundamentals of Geology using a "systems approach." Students will learn geological concepts, principles, and related scientific terms. Students will learn about active geologic processes and the driving force of plate tectonics. Students will be exposed to the principles behind the formation of different rock types, and the nature of the earth's interior.

**Student Learning Outcomes:** On completion of the course it is expected that: (I) The students will be able to describe the structure of the earth. (II) The students will be able to identify the characteristics of different rock types, how they are formed, and what minerals they are composed of. (II) The students will be able to explain plate tectonics and how associated processes lead to the cycling of rock. (IV) The students will be able to understand the concept of the geosphere as a set of distinct systems. (V) The students should be able to synthesize what the learn in the lectures and apply this knowledge to thr problems they will be presented with in the Laboratory section of the course.

**Required Textbook:** Understanding Earth, J. Grotzinger & T Jordan, 7e W.H. Freeman and Company, NY, The print version or the Launch pad version is acceptable. To register for the course go to: <a href="http://www.macmillanhighered.com/launchpad/understandingearth7e/1408080">http://www.macmillanhighered.com/launchpad/understandingearth7e/1408080</a>

**Descriptions of major assignments and examinations:** There will be 5 exams during the course (as marked on the syllabus), the results from the four exams with the highest grades will be used to calculate the student's final grade. There will be additional extra credit exercises online through Launchpad. The results from the class exams will make up 75% of the final grade (25% will be determined from effort in the Labs)

**Attendance:** As the instructor of for this section I allow students to attend class at their own discretion. However, I have established the following attendance policy: attendance will be taken and if a student attends all lectures they will be eligible for a half letter grade extra credit.

**Other Requirements:** Lab attendance is expected. Please remember 25% of the final grade comes from your efforts in the lab class.

**Grading**: A final letter grade will be assigned to each student in the following manner based on the cumulative percentage score from the class exams plus the score from the Lab exercises. A Grade => 90%, B Grade 80-89%, C Grade 70-79%, D Grade 60-69%, F grade <60%. Students are expected to keep track of their performance throughout the semester and seek guidance from available sources (including the instructor) if their performance drops below satisfactory levels. Students are expected to keep track of their performance throughout the semester and seek guidance from available sources (including the instructor) if their performance drops below satisfactory levels. Students are expected to keep track of their performance throughout the semester and seek guidance from available sources (including the instructor) if their performance drops below satisfactory levels; see "Student Support Services," below.

**Expectations for Out-of-Class Study**: Beyond the time required to attend each class meeting, students enrolled in this course (which is highly condensed) should expect to spend at least an additional nine

hours per week of their own time in course related activities, including reading required materials, completing assignments, preparing for exams, and preparing for lab.

Make-up Exams: There will be NO make-up exams unless the need is critical.

**Grade Grievances**: Any appeal of a grade in this course must follow the procedures and deadlines for grade-related grievances as published in the current undergraduate catalog. See: <a href="http://wweb.uta.edu/catalog/content/general/academic\_regulations.aspx#10">http://wweb.uta.edu/catalog/content/general/academic\_regulations.aspx#10</a>;

**Drop Policy:** Students may drop or swap (adding and dropping a class concurrently) classes through self-service in MyMav from the beginning of the registration period through the late registration period. After the late registration period, students must see their academic advisor to drop a class or withdraw. Undeclared students must see an advisor in the University Advising Center. Drops can continue through a point two-thirds of the way through the term or session. It is the student's responsibility to officially withdraw if they do not plan to attend after registering. **Students will not be automatically dropped for non-attendance**. Repayment of certain types of financial aid administered through the University may be required as the result of dropping classes or withdrawing. For more information, contact the Office of Financial Aid and Scholarships (http://wweb.uta.edu/ses/fao).

**Disability Accommodations:** The University of Texas at Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including the *Americans with Disabilities Act ADAAA*), and Section 504 of the Rehabilitation Act. All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of that disability. Any student requiring an accommodation for this course must provide the instructor with official documentation in the form of a letter certified by the staff in the Office for Students with Disabilities, University Hall 102. Students experiencing a range of conditions (Physical, Learning, Chronic Health, Mental Health, and Sensory) that may cause diminished academic performance or other barriers to learning may seek services and/or accommodations by contacting: The Office for Students with Disabilities, (OSD) www.uta.edu/disability or calling 817-272-3364 Counseling and Psychological Services, (CAPS) www.uta.edu/caps/ or calling 817-272-3671

Only those students who have officially documented a need for an accommodation will have their request honored. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.uta.edu/disability or by calling the Office for Students with Disabilities at (817) 272-3364.

**Title IX**: The University of Texas at Arlington does not discriminate on the basis of race, color, national origin, religion, age, gender, sexual orientation, disabilities, genetic information, and/or veteran status in its educational programs or activities it operates. For more information, visit uta.edu/eos. For information regarding Title IX, visit <u>www.uta.edu/titleIX</u>.

Academic Integrity: All students enrolled in this course are expected to adhere to the UT Arlington Honor Code:

I pledge, on my honor, to uphold UT Arlington's tradition of academic integrity, a tradition that values hard work and honest effort in the pursuit of academic excellence.

I promise that I will submit only work that I personally create or contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code.

Instructors may employ the Honor Code as they see fit in their courses, including (but not limited to) having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System *Regents' Rule* 50101, §2.2, suspected violations of university's standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student's suspension or expulsion from the University.

Lab Safety Training: <u>Students registered for this course must complete all required lab safety</u> training prior to entering the lab and undertaking any activities. Once completed, Lab Safety Training is valid for the remainder of the same academic year (i.e., through the following August) and must be completed anew in subsequent years. There are <u>no</u> exceptions to this University policy. Failure to complete the required training will preclude participation in any lab activities, including those for which a grade is assigned.

**Electronic Communication:** UT Arlington has adopted MavMail as its official means to communicate with students about important deadlines and events, as well as to transact university-related business regarding financial aid, tuition, grades, graduation, etc. All students are assigned a MavMail account and are responsible for checking the inbox regularly. There is no additional charge to students for using this account, which remains active even after graduation. Information about activating and using MavMail is available at <a href="http://www.uta.edu/oit/cs/email/mavmail.php">http://www.uta.edu/oit/cs/email/mavmail.php</a>.

**Student Feedback Survey:** At the end of each term, students enrolled in classes categorized as lecture, seminar, or laboratory shall be directed to complete a Student Feedback Survey (SFS). Instructions on how to access the SFS for this course will be sent directly to each student through MavMail approximately 10 days before the end of the term. Each student's feedback enters the SFS database anonymously and is aggregated with that of other students enrolled in the course. UT Arlington's effort to solicit, gather, tabulate, and publish student feedback is required by state law; students are strongly urged to participate. For more information, visit <u>http://www.uta.edu/sfs</u>.

**Final Review Week:** A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week unless specified in the class syllabus. During Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. During this week, classes are held as scheduled. In addition, instructors are not required to limit content to topics that have been previously covered; they may introduce new concepts as appropriate.

**Emergency Exit Procedures:** Should we experience an emergency event that requires us to vacate the building, students should exit the room and move toward the nearest exit. There are three immediate exits. One is located in the lecture hall itself. The other two are immediately to the left and right of the lecture hall main entrance. When exiting the building during an emergency, one should never take an elevator but should use the stairwells. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist individuals with disabilities.

**Student Support Services**: UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. Resources include tutoring, major-based learning centers, developmental education, advising and mentoring, personal counseling, and federally funded programs. For individualized referrals, students may visit the reception desk at University College (Ransom Hall), call the Maverick Resource Hotline at 817-272-6107, send a message to resources@uta.edu, or view the information at <a href="http://www.uta.edu/resources">www.uta.edu/resources</a>.

## START STRONG Freshman Tutoring Program:

All first time freshmen can receive six FREE hours of tutoring for this course and other selected subjects for this semester. Students must register for and complete their first hour of tutoring by October 2, 2015. To register, visit University Tutorial and Supplemental Instruction in Ransom Hall, Suite 205. Upon completion of your first tutoring appointment you will receive five (5) hours of additional free tutoring to be used during the Fall 2015 semester.

**The English Writing Center** (411LIBR): [Optional.] Hours are 9 am to 8 pm Mondays-Thursdays, 9 am to 3 pm Fridays and Noon to 5 pm Saturdays and Sundays. Walk In Quick Hits sessions during all open hours Mon-Thurs. Register and make appointments online at http://uta.mywconline.com. Classroom Visits, Workshops, and advanced services for graduate students and faculty are also available. Please see www.uta.edu/owl for detailed information.

**Course Schedule:** As the instructor of record for this course, I reserve the right to adjust this schedule in any way that serves the educational needs of the students enrolled in this course. – Andrew Hunt, PhD.

DAY	DATE	Week	SESSION	ΤΟΡΙϹ	BOOK CHAPTER
Monday	8/31/15		1	Earth System I	1
Wednesday	9/02/15		2	Earth System II	1
Monday	9/07/15	2	3	Plate Tectonics I	2
Wednesday	9/09/15	2	4	Plate Tectonics II	2
Monday	9/14/15	2	5	Plate Tectonics III	2
Wednesday	9/16/15	5	6	(EXAM 1 Covering Sessions 1-5)	
Monday	9/21/15	4	7	Igneous Rocks I	4
Wednesday	9/23/15	4	8	Igneous Rocks II	4
Monday	9/28/15	5	9	Sedimentary Rocks I	5
Wednesday	9/30/15	5	10	Sedimentary Rocks II	5
Monday	10/05/15	6	11	Metamorphic Rocks I	6
Wednesday	10/07/15	0	12	Metamorphic Rocks II	6
Monday	10/12/15	7	13	(EXAM 2 Covering Sessions 7-12)	
Wednesday	10/14/15	/	14	Clocks in Rocks I - Relative Age	8
Monday	10/19/15	•	15	Clocks in Rocks II – Absolute Age	8
Wednesday	10/26/15	0	16	History of the Continents	
Monday	10/28/15	0	17	Volcanoes	12
Wednesday	11/02/15	5	18	Earthquakes	13
Monday	11/04/15	10	19	(EXAM 3 Covering Sessions 14-18)	
Wednesday	11/09/15	10	20	The Climate System	15
Monday	11/11/15	11	21	The Hydrologic Cycle	17
Wednesday	11/18/15		22	Stream Transport I	18
Monday	11/23/15	10	23	Stream Transport II	20
Wednesday	11/25/15	12	24	(EXAM 4 Covering Sessions 20-23)	
Monday	11/30/15	12	25	Winds and Deserts I	19
Wednesday	12/02/15	13	26	Winds and Deserts II	20
Monday	12/07/15		27	Glaciers I	22
Wednesday	12/09/15	14	28	Glaciers II	23
TBD	TBD	17		FINALS WEEK starts December 12 <sup>th</sup> Possibly Wed. December 16 11.00-1.30* (Final exam Covering Sessions 25-28)	

\*Actual timing in finals week may quiet possibly change

**Emergency Phone Numbers:** In case of an on-campus emergency, call the UT Arlington Police Department at 817-272-3003 (non-campus phone), 2-3003 (campus phone). You may also dial 911.

SESSION	Session Content			
1	Earth System I         • GEODESY – study of Earth's shape and surface         • The GEOLOGICAL RECORD         • James Hutton's principle uniformitarianism         • Speed of geological processes         • Discovery of a layered Earth         • Differences in elemental compositions         • Differences in mechanical properties         • Earth as a system of interacting components         • The Geo-System         • The plate tectonic system			
2	Earth System II         • The Climate System         • Hydrosphere         • Cryosphere         • Biosphere         • Lithosphere         • Lithosphere         • The Plate Tectonic System         • Ridged Lithospheric Plates         • Plastic Asthenosphere         • Convective processes in the Mantle         • The Geodynamo System         • The Earth's Magnetic Field         • History of the Earth's Magnetic field and the Geological record         • Overview of Geologic Time			
3	Plate Tectonics I         • The Theory of Plate Tectonics         • Evolution of the Theory         • Jigsaw fit of Continents         • Continental Drift         • Seafloor Spreading         • Plate Boundaries         • Convergent Plate Boundaries         • Divergent Plate Boundaries         • Transform Fault Boundaries			
4	Plate Tectonics II         • Rates and History of Plate Motion         • Tectonic Driving Forces         • Divergent / Extensional Tectonics         • Rift to Drift Sequence         • Mantle Hot Spots         • Oceanic Crust         • Formation         • Magnetic Time Scale			

	Plate Tectonics III			
	Grand Reconstruction			
	Reconstructing the history of plate motions			
	Transform Faults			
	Seafloor Isochrons			
5	Pangaea			
	Supercontinents before Pangaea			
	Cratons – Stable interiors of Continents			
	Assembly of Pangaea			
	Breakup of Pangaea			
	Suprtcontinent Cycles			
6	(EXAM 1 Covering Sessions 1-5 )			
	Igneous Rocks I			
	Classification of Rocks			
	Igneous, Sedimentary, and Metamorphic Rocks			
	Common Minerals in Igneous, Sedimentary, and Metamorphic Rocks			
7	About Igneous Rocks			
	<ul> <li>How do igneous rocks differ from one another</li> </ul>			
	Where do igneous rocks form			
	How do rocks solidify from a melt			
	Where do melts form			
	Igneous Rocks II			
	Magmatic Differentiation			
	Fractional Crystallization			
	Bowen's Reaction Series			
	Granite and Basalt Magmatic Differentiation			
8	Forms of Igneous Intrusions			
	Igneous Processes and Plate Tectonics			
	Magma factories			
	<ul> <li>Spreading centers</li> <li>Subduction concerning</li> </ul>			
	Subduction zones     Mantle plumes			
	Origin of magma in magma factories			
	Sedimentary Bocks I			
	Processes forming sedimentary rock			
	Weathering			
	• Erosion			
	Transportation			
	Deposition (sedimentation)			
	Burial and compaction			
9	Diagenesis			
	Sedimentary environments			
	• Glacier			
	• River			
	• Delta			
	• Desert			
	Lakes and playas			
	Marine shelf			

	Classification of codiments
	Classification of sediments
	Chemical sediments
	Biological sediments
	Current strength and distance of transport
	Size of clastic particles
	Sorting of clastic particles
	Rounding of clastic particles
	Sedimentary basins
	Sedimentary Rocks II
	Sedimentary environments – location
	1. Continental
	• Lake
	• River (alluvial)
	Desert
	Glacier
	2. Shoreline
	• Delta
	Tidal flat
	• Beach
	3. Marine
	Continental shelf
	Organic reef
10	Continental margin
	Continental slope
	Deep sea
	Sedimentary structures
	Bedding (stratification)
	Cross-bedding
	Graded bedding
	Ripples
	Bioturbation structures
	Burial and diagenesis
	Classification of Siliciclastic Sediments and Sedimentary Rocks
	<ul> <li>Coarse: gravel and conglomerate</li> </ul>
	Medium: sand and sandstone
	• Fine: silt and siltstone; mud, mudstone, and shale; clay and claystone
	Classification of Chemical & Biological Sediments and Sedimentary Rocks
	Metamorphic Rocks I
	Metamorphism and the Earth system
	<ul> <li>Driven by Earth's internal heat</li> </ul>
	Closely related to plate tectonics
	Releases gasses into atmosphere
11	Grades of metamorphism
	• Low
	Intermediate
	• High
	The Role of Temperature

	The Role of Pressure
	Confining Pressure
	Directed Pressure
	Role of Fluids
	Metasomatism
	Accelerated chemical reactions
	Types of metamorphism
	Shock metamorphism
	Regional metamorphism
	Contact metamorphism
	Burial metamorphism
	Sea-floor metamorphism
	Metamorphic Rocks II
	Metamorphic textures
	Foliated rocks
	<ul> <li>Slate</li> </ul>
	<ul> <li>Phyllite</li> </ul>
	<ul> <li>Schist</li> </ul>
	<ul> <li>Gneiss</li> </ul>
12	<ul> <li>Migmatite</li> </ul>
	Granoblastic (non-foliated) metamorphic rocks
	<ul> <li>Hornteis</li> <li>Ouerteite</li> </ul>
	<ul> <li>Iviarbie</li> <li>Groonstone</li> </ul>
	Greenstone     Amphibalita
	Oranunic     Oranunic     Degional Metamornhic Grade
12	
13	(EXAIN 2 Covering Sessions 7-12) Clocks in Pocks L. Polative Age
	Drinciples of stratigraphy
	Original horizontality
	Superposition
	Eaunal succession
	Index fossils
	<ul> <li>Unconformities – gans in the record</li> </ul>
14	Disconformity
	Angular unconformity
	Cross-cutting relationships
	Divisions of geologic time
	• Fras
	Periods
	• Epochs
	Clocks in Rocks II – Absolute Age
	Measuring Absolute Time - Farly Calculations
15	By the salinity of the oceans
	<ul> <li>By the Cooling of the planet</li> </ul>
	Radioactive decay

	Isotopic dating methods
	Uranium-lead
	Potassium-argon
	Rubidium-strontium
	Carbon-nitrogen
	Geologic Time Scale: Absolute Ages
	• Four Eons of geologic time
	■ Hadean
	<ul> <li>Archean</li> </ul>
	<ul> <li>Proterozoic</li> </ul>
	<ul> <li>Phanerozoic</li> </ul>
	Advances in Timing the Earth System
	Sequence stratigraphy
	Chemical stratigraphy
	Paleomagnetic stratigraphy
	Clocking the climate system
	History of the Continents
	The Tectonics of North America
	The Stable Interior
	The Appalachian Fold Belt
	The North American Cordillera
16	Tectonic Provinces Around the World
	Tectonic Age
	How Continents Grow
	Continental Accretion
	Orogeny
	Volcanoes
	Volcances As Geosystems
	Parts of the geosystem
	<ul> <li>Rocks</li> </ul>
17	<ul> <li>Magmas and lavas</li> </ul>
	<ul> <li>Processes of melting and eruption</li> </ul>
	Volcanoes As Chemical Factories
	Lavas And Other Volcanic Deposits
	Flood Basalts
	Earthquakes
	WHAT IS AN EARTHQUAKE?
	Stress
	Strain
	Strtength
	Why earthquakes occur
18	Elastic rebound theory
	• Fault rupture
	• Enicenter
	• Focus
	Aftershocks
	Foreshocks
	Seismographs

	Vertical ground Movements
	Horizontal ground movements
	Seismic wave types
	P waves (primary waves)
	• S waves (secondary waves)
	Surface waves
	The size of an earthquake
	Richter magnitude
	Moment magnitude
	Shaking (Mercalli) intensity
19	(EXAM 3 Covering lectures 14-18)
	The Climate System
	Atmospheric zones
	Troposphere
	Stratosphere
	Mesosphere
	Thermosphere
	Atmosphere composition
	Components of the climate system
	Hydrosphere
	Ocean circulation
	Cryosphere
20	<ul> <li>Ice caps</li> </ul>
	<ul> <li>Mountain glaciers</li> </ul>
	Lithosphere
	<ul> <li>Orographic rainfall</li> </ul>
	<ul> <li>Sea floor spreading</li> </ul>
	<ul> <li>Volcanism</li> </ul>
	Biosphere
	Global distribution of plant life
	Greenhouse gas regulation
	Greenhouse effect
	Climate variability
	Ice ages
	The Hydrologic Cycle
	Flows and reservoirs
	Hydrological cycle
	Precipitation
	Infiltration and runoff
24	<ul> <li>Evaporation, transpiration, and sublimation</li> </ul>
	Groundwater flow
21	Key climatic factors
	Relative humidity
	Rainfall
	Landscape
	Key tectonic factors
	Ocean-land relationships
	Mountain rain shadows

	The man off and sinitation melationship
	• The runoff-precipitation relationship
	Surface storage of water runoff
	Lakes and reservoirs
	Wetlands and swamps
	Groundwater
	<ul> <li>Groundwater flow through soil and rock</li> </ul>
	Porosity and permeability
	<ul> <li>Groundwater table</li> </ul>
	Water table
	<ul> <li>Water table</li> <li>Vadose zone</li> </ul>
	<ul> <li>Aquiters</li> <li>Unconfined equifers</li> </ul>
	- Oncommed aquiers
	Aquiciddes
	Artesian flow
	Stream Transport I
	Stream valleys, Channels, & Floodplains
	Basic parts of a stream
	Valley
	Channel
22	Floodplain
22	Channel patterns
	Meanders
	<ul> <li>Braids</li> </ul>
	Floodplains
	Drainage networks
	Stream erosion
	Stream Transport II
	Stream Transport II
	• Laminar
	• lurbulent
	Factors affecting laminar/turbulent
	<ul> <li>Velocity, depth, and viscosity</li> </ul>
	Erosion and sediment transport
	Suspended load
	Bed load
22	Competence and capacity
25	Velocity
	Volume of flow
	River bed-forms
	Dunes
	Rinnles
	Deltas
	Dolta hodding structure
	Deita beuung structure     Tonsot hade
	- Topset beds
	Porteset beds
	Bottomset beds
24	(EXAM 4 Covering Sessions 20-23)

	Winds and Deserts I
	Wind as a flow of air
	Turbulence
	Wind belts
	<ul> <li>Trade winds</li> </ul>
	<ul> <li>Westerlies</li> </ul>
	Wind transport
25	Wind strength
	Particle size
	Surface material
	Wind as an agent of erosion
	Ventifacts
	Yardangs
	Deflation hollows
	Desert pavement
	Winds and Deserts II
	Wind as an agent of deposition
	How sand dunes form and move
	Types of dune
	Dust fails and Loess
	Where deserts are found
26	Location
26	Role of plate tectonics
	Role of climate change
	Desert weathering
	Color of deserts
	Desert varnisn     Streame as exercise
	Streams as agents of erosion
	Desert sediments     Evanevite denosite
	Claciers I
	• Valley glaciers
	<ul> <li>Ice cans</li> </ul>
	How glaciers form
	Accumulation
	Ablation
27	• Snow line
	Sublimation
	Wind erosion
	Glacial budgets
	How glaciers move
	Plastic flow
	Basal slip
	Formation of crevasses
	Glacial landscapes
	Erosion
	<ul> <li>Grinding</li> </ul>
	<ul> <li>Plucking</li> </ul>

	<ul> <li>Striations</li> </ul>		
	Landforms		
	<ul> <li>Roche Moutonees</li> </ul>		
	Circues		
	<ul> <li>Aretes</li> </ul>		
	<ul> <li>Horns</li> </ul>		
	<ul> <li>U-sahped valleys</li> </ul>		
	<ul> <li>Hanging valleys</li> </ul>		
	Glaciers II		
	<ul> <li>Glacial landscapes</li> </ul>		
	Sedimentation (ice deposits)		
	<ul> <li>Drift</li> </ul>		
	• Till		
	<ul> <li>Morraines</li> </ul>		
	<ul> <li>Erratics</li> </ul>		
	Landforms (Ice deposited)		
	<ul> <li>End Morraines</li> </ul>		
	<ul> <li>Ground Morraines</li> </ul>		
	<ul> <li>Lateral Morraines</li> </ul>		
	<ul> <li>Drumlins</li> </ul>		
28	Landforms (water formed)		
	<ul> <li>Kames</li> </ul>		
	<ul> <li>Kettles</li> </ul>		
	<ul> <li>Eskers</li> </ul>		
	<ul> <li>Varves</li> </ul>		
	<ul> <li>Permafrost</li> </ul>		
	Extent and landforms		
	<ul> <li>Pingos</li> </ul>		
	<ul> <li>Glaciations and climate</li> </ul>		
	Orbital forcing of ice ages		
	Greenhouse gas controls		
	Tectonic controls		
	<ul> <li>Snowball earth</li> </ul>		