

GEOLOGY 404C (#27440-27465)

PLATE TECTONICS AND EARTH HISTORY

INSTRUCTOR - Dr. James Sprinkle Office - JGB 4.106 Lecture – JGB 2.218
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Office Hours - Tu, Th 12-12:30 PM; F 12-1 PM, M, W 1-2 PM; other times by appointment

TAs – Adam Smith <adam_smith@mail.utexas.edu> and Clint Boyd <cab@mail.utexas.edu>;
Office hours in Lab Room JGB 3.202; hours to be selected

PREREQUISITES - A grade of C or better in GEO 401 or 303 or 312K or the equivalent.

COURSE TOPICS - The geologic time scale, new 2004 version (1st lecture)
- Structure and composition of the earth (4 lectures)
- Plate tectonics and its implications to earth history (6 lectures)
- Sedimentary rocks and depositional environments (5 lectures)
- Setting up and measuring “deep” geologic time (4 lectures)
- Fossils, history of life, and evolution (3 lectures)
- History of the Southern African & North American continents (6 lectures)
- Origin and evolution of invertebrates, plants, and vertebrates (8 lectures)
- Human evolution and place in nature (2 lecture)

Lecture Outlines (plus the Syllabus, Lecture Schedule, and other useful information) will be posted on the GEO 404C Blackboard site.

TEXTBOOKS - D. R. Prothero and R. H. Dott, Jr. (2004), *Evolution of the Earth* (7th ed.), McGraw-Hill (Paper), and T. McCarthy and B. Rubidge (2005), *The Story of Earth & Life*, Struik Publishers (Paper). Both books are on reserve in the Geology Library (4th floor).

COURSE READING - Other reading assignments are in the Geology Library (4th floor) either on reserve (books), or in my file cabinet drawer (separates) at the back of the Reading Room.

EXAMS AND COURSE GRADES - Grades will be determined in the following manner:

<u>Lecture</u> - 2-week Friday quizzes (6 total, count top 5)	- 15%
- 1st Hour Exam - Friday, Feb. 18th	- 15%
- 2nd Hour Exam - Friday, Apr. 1st	- 15%
- Final Exam – Fri., May 13th, 9-12 Noon, 2 hrs.	- 30%

<u>Discussion Section</u> - Exams, exercises, and participation	- 25%
Total	- 100%

Lecture quizzes, exams, and the final may include any of the following types of questions: true-false, multiple choice, matching, complete-the-answer, lists, definitions, problems, drawings or charts, and short to intermediate-length essays. All exams are closed-book and are usually intermediate in difficulty. Hour exams and the final are cumulative, covering all previous work up to the time of that exam; quizzes will cover the previous 2-weeks' work (usually 6 lectures). Marks will be carried

through as numbers, added up at the end of the course, and then curved to get a final grade. Last spring's average mark for this course was a 67.4 (top mark 87, lowest mark 32), and there were 11 A's, 33 B's, 35 C's, 11 D's, 4 F's, 2 Q's, and 1 W in a large class of 97, giving a overall class GPA of 2.38. Some plus and minus grades will be given to students near a major grade boundary.

ACADEMIC POLICIES - No special policy on drops, incompletes, or time extensions; see General Information Catalog, Part V. A make-up exam for a missed hour exam may be given at the instructor's discretion up to the time of the next lecture period (usually a Monday) when the corrected exams are returned. Last day to drop this course without academic penalty is Monday, Feb. 14th; last day to drop this course or withdraw (need Dean's approval) is Monday, March 28th.

STUDENTS WITH DISABILITIES may request appropriate academic accommodations from the Division of Diversity and Community Engagement, Services for Students with Disabilities, 471-6259.

GEOLOGY 404C - PLATE TECTONICS AND EARTH HISTORY

LECTURE SCHEDULE AND READING - SPRING, 2011

- Wed., Jan. 19 - Introduction + the new 2004 geologic time scale
Memorize time scale handout
Bjornerud, p. 53-63
McCarthy & Rubidge, p. 71
- Fri., Jan. 21 - The Earth's interior and surface features
Prothero & Dott, p. 102-114
McCarthy & Rubidge, p. 28-32, p. 51
- Mon., Jan. 24 - Continents and oceans
Prothero & Dott, p. 122-125, p. 130-131
McCarthy & Rubidge, p. 25-27
- Wed., Jan. 26 - Geosynclines and mountain belts
Prothero & Dott, p. 125-130, p. 245-252
- *Fri., Jan. 28 - 1st QUIZ + Continental drift and the plate tectonics "revolution"
Stanley, p. 129-141
Prothero & Dott, p. 321-332
- Mon., Jan. 31 - Plates, plate boundaries, & plate movement
Dietz, Sci. Amer. #899 (Wilson book)
McCarthy & Rubidge, p. 22-25, p. 32-50, p. 52-57
- Wed., Feb. 2 - Plate tectonics and Phanerozoic Earth history
Dietz & Holden, Sci. Amer. #892 (Wilson book)
Bambach et. al., p. 86-98 (Skinner book)
- Fri., Feb. 4 - Plates, terranes, and the history of life
Jones et. al., p. 70-84
Dalziel, 1995, p. 58-63 (Jan. Sci. Amer.)
Hallam, Sci. Amer. #903 (Wilson book)
- Mon., Feb. 7 - Precambrian plates and supercontinent cycles
Prothero & Dott, p. 159-162
Kerr, 1989, p. 529-530
Kerr, 1997, p. 613-615
Rogers and Santosh, 2002, p. 5-19
McCarthy & Rubidge, p. 148-162, p. 186-195, p. 244-251
- Wed., Feb. 9 - Sediments and sedimentary environments
Eicher, p. 20-32
McCarthy & Rubidge, p. 64-65, 72-73, 82, 98-100, 162-163
- *Fri., Feb. 11 - 2nd QUIZ + Sedimentary structures and diagenesis
Eicher, p. 32-35
Newton & Laporte, p. 21-26
McCarthy & Rubidge, p. 86-87
- Mon., Feb. 14 - Sedimentary facies
Prothero & Dott, p. 73-78
- Wed., Feb. 16 - Unconformities
Eicher, p. 45-51
Prothero & Dott, p. 80-81
- *Fri., Feb. 18 - 1st HOUR EXAM (15%)

- Mon., Feb. 21 - Discuss corrected exams and catch up
- Wed., Feb. 23 - Geologic maps and cross sections
Eicher, p. 35-41
Prothero & Dott, p. 18-22
McCarthy & Rubidge, p. 77
- Fri., Feb. 25 - Relative age dating
Stokes, p. 72-82
- Mon., Feb. 28 - History of the geologic time scale
Prothero & Dott, p. 22-30, p. 70-73
McCarthy & Rubidge, p. 71
- Wed., Mar. 2 - Geologic clocks and absolute age dating I
Prothero & Dott, p. 88-92
McCarthy & Rubidge, p. 68-69
- *Fri., Mar. 4 - 3rd QUIZ + Absolute age dating II
Prothero & Dott, p. 92-98
- Mon., Mar. 7 - Fossils - preservation, usefulness, and classification
Ausich & Lane, p. 19-20, p. 33-47
McCarthy & Rubidge, p. 204
- Wed., Mar. 9 - Darwin and evolutionary theory
Prothero & Dott, p. 40-50, p. 53-62, p. 238-240
- Fri., Mar. 11 - Patterns from the fossil record
Freeman & Herron, 2001, p. 521-536

SPRING VACATION

- Mon., Mar. 21 - Origin of the Earth's crust, oceans, and atmosphere
Prothero & Dott, p. 114-119
Hammond, p. 245
Tyson, 1999, p. 92-95
McCarthy & Rubidge, p. 61-63, p. 66-70, p. 74-75
- Wed., Mar. 23 - Precambrian orogenic & cratonic history of N. America & southern Africa
Prothero & Dott, p. 153-159, p. 165-177
McCarthy & Rubidge, p. 60, 75-76, 78-81, 83-85, 89-91, 94-99,
101-112, 118, 121-145,
- *Fri., Mar. 25 - 4th QUIZ + Phanerozoic orogenic history of North America
Prothero & Dott, p. 252-256, p. 289-295, p. 315-320, p. 352-355,
p. 361-376, p. 414-432
- Mon., Mar. 28 - Phanerozoic cratonic history of North America
Prothero & Dott, p. 210-219, p. 271-282, p. 284-289, p. 300-304,
p. 355-361, p. 376-378, p. 440-442
- Wed., Mar. 30 - Coal and cyclothem
Prothero & Dott, p. 304-310, p. 336-340, p. 414-416
McCarthy & Rubidge, p. 199-202
- *Fri., Apr. 1 - 2nd HOUR EXAM (15%)
- Mon., Apr. 4 - Discuss corrected exams and catch up

- Wed., Apr. 6 - Evaporites, salt domes, coastal plains, fault basins
Prothero & Dott, p. 279-283, p. 440-442
Martinez, 1991, p. 420-431
- Fri., Apr. 8 - Pleistocene glaciation and Greenhouse-Icehouse cycles
Prothero & Dott, p. 466-485
Broecker and Denton, p. 49-56
McCarthy & Rubidge, p. 119, p. 195-199, p. 270-273
- Mon., Apr. 11 - Origin and Precambrian evolution of life
Cowen, 2004, p. 6-14, p. 22-36, p. 42-46
McCarthy & Rubidge, p. 112, p. 114-116, p. 166-176
- Wed., Apr. 13 - Precambrian-Cambrian boundary & origin of metazoans
Prothero & Dott, p. 187-203
Freeman & Herron, 2001, p. 511, p. 516-520
McCarthy & Rubidge, p. 176-183
- *Fri., Apr. 15 - 5th QUIZ + Patterns of invertebrate evolution
Stokes, p. 278-285, p. 309-314, p. 348-353, p. 388-390
- Mon., Apr. 18 - Extinctions and "living fossils"
Newell, Sci. Amer. #867 (Laporte book)
Stokes, p. 500-511
McCarthy & Rubidge, p. 298-300
- Wed., Apr. 20 - Evolution of higher plants and origin of vertebrates
McAlester, p. 89-107
Bone, p. 1-16
McCarthy & Rubidge, p. 216-222
- Fri., Apr. 22 - Fish evolution
McAlester, p. 78-85
- Mon., Apr. 25 - Amphibians and early reptiles
McAlester, p. 85-88, p. 108-117
McCarthy & Rubidge, p. 223-234
- Wed., Apr. 27 - Dinosaurs vs. early mammals
McAlester, p. 117-131
McCarthy & Rubidge, p. 234-239
- *Fri., Apr. 29 - 6th QUIZ + Cenozoic mammals and birds
Prothero & Dott, p. 446-459
Padian & Chiappe, 1998, p. 38-47
McCarthy & Rubidge, p. 240-241, p. 277
- Mon., May 2 - Evolution of humans and Pleistocene mammal extinctions
McAlester, p. 137-154
Prothero & Dott, p. 489-496
McCarthy & Rubidge, p. 276, p. 277-295
- Wed., May 4 - Resources & the environment, + Should you become a geology major?
Prothero & Dott, p. 506-523
Kerr, 1998, p. 1128-1131
McCarthy & Rubidge, p. 309-317
- Fri., May 6 - Review for Final Exam on Fri., May 13th (30%) + Course evaluation

GEOLOGY 404C - Reading and Reference List

Course Texts: *Prothero, D. R. and Dott, R. H., Jr. 2003 (2004). *Evolution of the Earth* (7th Ed.). McGraw-Hill Higher Education, New York, 553 p. (PB)

*McCarthy, T. and Rubidge, B. 2005. *The Story of Earth & Life*. Struik Publishers, Cape Town, South Africa, 333 p. (PB)

Other References (* = books or articles containing assigned reading; in Geology Library):

*Ausich, W. I. and Lane, N. G. 1999. *Life of the Past* (4th Ed.). MacMillan Publishing Co., New York, 334 p. (PB)

*Bambach, R. K., Scotese, C. R., and Ziegler, A. M. 1980. Before Pangaea: the geographies of the Paleozoic world. *American Scientist*, v. 68, 13 p. (in Skinner book).

*Bjornerud, M. 2005. *Reading the Rocks. The Autobiography of the Earth*. Westview Press, New York, 237 p.

*Bone, Q. 1979. The origin of chordates (2nd Ed.). *Carolina Biology Readers* (Carolina Biological Supply Co.), no. 18, 16 p. (PB)

*Broecker, W. S. and Denton, G. H. 1990. What drives glacial cycles? *Scientific American*, v. 262, no. 1, p. 49-56 (January).

*Cowen, R. 2004 (2005). *History of Life* (4th Ed.). Blackwell Publishing, Cambridge, Mass., 324p. (PB)

*Dalziel, I. W. D. 1995. Earth before Pangea. *Scientific American*, v. 272, no. 1, p. 58-63 (January).

*Dietz, R. S. 1972. Geocynclines, mountains, and continent building. *Scientific American*, offprint 899, 9 p.

*Dietz, R. S. and Holden, J. C. 1970. The breakup of Pangaea. *Scientific American*, offprint 892, 12 p.

*Eicher, D. L. 1976. *Geologic Time* (2nd Ed.). Prentice-Hall, Inc., Englewood Cliffs, N.J., 150 p. (PB)

*Freeman, S. and Herron, J. C. 2001. *Evolutionary Analysis* (2nd ed.). Prentice-Hall, Inc., Upper Saddle River, N.J., 704 p.

*Hallam, A. 1972. Continental drift and the fossil record. *Scientific American*, offprint 903, 11 p.

*Hammond, A. L. 1975. The uniqueness of the Earth's climate. *Science*, v. 187, p. 245.

*Jones, D. L., Cox, A., Coney, P., and Beck, M. 1982. The growth of western North America. *Scientific American*, v. 247, no. 5, p. 70-84 (November).

*Kerr, R. A. 1989. Another movement in the dance of the plates. *Science*, v. 244, p. 529-530 (May 5th).

Kerr, R. A. 1991. Do plumes stir Earth's entire mantle? *Science*, v. 252, p. 1068-1069 (May 24th).

*Kerr, R. A. 1997. Deep-sinking slabs stir the mantle. *Science*, v. 275, p. 613-615 (Jan. 31st).

- *Kerr, R. A. 1998. The next oil crisis looms large—and perhaps close. *Science*, v. 281, p. 1128-1131 (Aug. 21st).
- *Laporte, L. F. 1982. *The Fossil Record and Evolution*. W. H. Freeman and Co., San Francisco, 225 p. (PB - contains Newell and Glaessner articles)
- Levin, H. L. 2002 (2003). *The Earth through Time (7th Ed.)*. John Wiley & Sons, Inc., Hoboken, NJ, 614 p.
- *Martinez, J. D. 1991. Salt domes. *American Scientist*, v. 79, no. 5, p. 420-431 (Sep-Oct).
- Mathez, E. A. (Ed.). 2001. *Earth: Inside and Out*. The New Press (AMNH Book), New York, 238 p. (Many thumbnail sketches of 20th Century geologists)
- *McAlester, A. L. 1977. *The History of Life (2nd Ed.)*. Prentice-Hall Inc., Englewood Cliffs, N.J., 167 p. (PB)
- *Newell, N. D. 1963. Crises in the history of life. *Scientific American*, Offprint 867, 15 p.
- *Newton, C. R. and Laporte, L. F. 1989. *Ancient Environments (3rd Ed.)*. Prentice-Hall Inc., Englewood Cliffs, N.J., 178 p. (PB)
- *Padian, K. and Chiappe, L. M. 1998. The origin of birds and their flight. *Scientific American*, v. 278, no. 2, p. 38-47 (February).
- Peters, E. K. 1996. *No Stone Unturned*. W. H. Freeman & Co., New York, 237 p. (PB)
- *Rogers, J. J. W. and Santosh, M. 2002. *Configuration of Columbia, a Mesoproterozoic supercontinent*. Oxford University Press, New York, 289 p.
- *Skinner, B.J. (Ed.). 1980. *Earth's History, Structure, and Materials*. William Kauffman, Inc., Los Altos, Calif., 179 p. (PB - contains Bambach, Scotese, and Ziegler article)
- *Stanley, S. M. 1993. *Exploring Earth and Space through Time*. W. H. Freeman and Co., New York, 538 p. (PB)
- *Stokes, W. L. 1982. *Essentials of Earth History (4th Ed.)*. Prentice-Hall, Inc., Englewood Cliffs, N.J., 577 p.
- Sullivan, W. 1974. *Continents in Motion*. McGraw-Hill Book Co., New York, 399 p.
- *Tyson, N. de G. 1999. Goldilocks and the three planets. *Natural History*, v. 108, no. 5, p. 92-95 (May).
- Ward, P. D. and Brownlee, D. 2004. *Rare Earth*. Copernicus Books, New York, 335 p. (PB)
- *Wilson, J. T. (Ed.). 1976. *Continents Adrift and Continents Aground*. W. H. Freeman and Co., San Francisco, 230 p. (PB - contains Dietz, Dietz and Holden, and Hallam articles)
- Young, E. D. (Ed.). 1999. *Innovations in Earth Sciences*. ABC-CLIO, Santa Barbara, Calif., 342 p.
- Zimmer, C. 1997. In times of Ur. *Discover*, v. 18, no. 1, p. 18-19 (January).

GEO 404C COURSE GOALS & OBJECTIVES

GEO 404C Course Goals - The course is set up as a survey of soft-rock geology using the "paradigm" of plate tectonics as a starting point. By the end of this course, you should better understand how geologic processes on the surface and interior of the Earth work and be able to interpret the geologic history of the Earth's crust and the preserved history of its life. The course should give you some feeling for how geologists develop new theories about the Earth and its history, and what kind of research work they normally do. This survey of Earth history should also help you decide whether you want to become a Geology Major, and if you do, will better prepare you for later courses that take a particular topic (such as minerals, sedimentary rocks, fossils, or structural deformation) and build a semester's course around it.

GEO 404C Course Objectives -

First lecture - You should memorize the geologic time scale (front page), including the eons, eras, periods, and epochs, their spelling and order, and the dates for the different era boundaries.

Next 3 lectures (Crustal Units) - You should learn the layers in the Earth's interior (inner & outer core, mantle, crust), how isostasy works, how brittle, plastic, and elastic deformation differ, how continents differ from oceans, why these areas have different persistence and histories, the different parts of a continent, what geosynclines are and where they are located, how the geosyncline cycle works, and what happens during a geosyncline's intermediate or terminal orogeny.

Next 5 lectures (Plate Tectonics) - You should learn the history of ideas about drifting continents, what plates are, what happens at plate boundaries, how an "ideal plate" moves, the history of plate movements during the Phanerozoic (formation and breakup of Pangaea) and earlier in the Proterozoic (formation and breakup of Columbia and then Rodinia), what terranes are, how plate tectonics affects the distribution and diversity of fossil organisms, and how the super-continent cycle may control plate tectonics movements.

Next 5 lectures (Sedimentary Rocks) - You should learn how sediments are formed and transported, how and where sediments are deposited, the time involved in forming beds and bedding planes, the different sedimentary structures and what they imply, how sediments change to rock by diagenesis, what sedimentary facies are and how they move through time to form transgressions and regressions, Walther's Law and the vertical stacking of adjacent facies, the preservability of different depositional environments as a "time bias" in the sedimentary record, the different types of unconformities and what they tell about the history of a region, and how sedimentary units are mapped.

Next 4 lectures (Measuring Geologic Time) - You should learn how relative and absolute dating differ, what features are used to do correlation and relative age dating on geologic units, what cross-cutting relationships are, how the relative time scale was set up and who did this, how time, time-rock, and rock units differ, what facies and index fossils are used for, what features a "good geologic clock" should have, what half life is and why a closed system is important for

radiometric age dating, and how to graphically calculate a rock's geologic age using the measured ratio between parent and daughter isotopes (P/D), the known half-life constant (H), and a half-life decay curve.

Next 3 lectures (Fossils and Evolution) - You should learn what fossils are, what they tell about organisms in the past, what major biases affect the fossil record, how organisms are named and classified, how phenetic, cladistic, and evolutionary classification philosophies differ, what were the components of Darwin's theory of evolution by natural selection and what later problems did it face, what are the two major theories about speciation (gradualism vs. punctuation), and what major evolutionary and extinction patterns are present in the fossil record.

Next 7 lectures (Crustal History of southern Africa and North America [Laurentia]) - You should learn how the Earth's crust originated and how it has grown in volume, why the Earth has a moderate climate vs. other planets in the solar system, how the oceans and atmosphere have changed through geologic time, what the long Precambrian record in southern Africa tells us about events in the Archean and Proterozoic, when, where, and why orogenies occurred during the Phanerozoic in North American geosynclines, what happened during the Phanerozoic on the stable North American craton, what cyclothems are and how coal was formed in them, how evaporites and salt domes originated, how coastal plains and fault basins were formed, when have we had ice-house vs. greenhouse conditions in the past, the possibility of a runaway "Snowball Earth" in the Late Proterozoic, and how Milankovitch orbital factors may have caused the observed glacial-interglacial alternations during the recent Pleistocene glaciation.

Next 4 lectures (Origin of Life & Evolution of Microorganisms and Invertebrates) - You should learn about how life may have originated here on Earth, how bedded cherts and stromatolites preserve Precambrian microorganisms, possible causes for the sudden appearance of metazoans in the Ediacaran Fauna and slightly later in the "Cambrian Explosion" near the beginning of the Phanerozoic, the different diversity patterns shown by Phanerozoic invertebrate groups and how they can be grouped into evolutionary faunas, and where mass extinctions are located during the Phanerozoic and what may have caused each of them.

Next 5 lectures (Evolution of Plants and Vertebrates) - You should learn what features plants developed before they could colonize the land, what the fossil record of vascular plants is like with its sequential radiations of seedless plants, gymnosperms, and angiosperms, how vertebrates may have originated and their possible ancestors, the patterns of evolution in fish and early amphibians (1st tetrapods on land), how the major radiation of early reptiles is divided up into lineages using skull designs, why dinosaurs were able to outcompete early mammals during the Mesozoic and delay their expansion, and how mammals and birds then radiated to dominate the Cenozoic.

Last 2 lectures (Evolution of Humans & their Place in Nature) - You should learn how humans evolved from primate ancestors, how human migrations may have caused the extinction of many mammals and birds at the end of the Pleistocene, why human population growth is now causing major problems for the world's ecosystem and resource base and possible ways to ease these problems, and what is the outlook for future employment in the geosciences.