1-2014

GEO 582.02: Tectonic Geomorphology

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Geosciences 582: Tectonic Geomorphology
Spring 2014
University of Montana
3 credits
MW 1:10 – 2 PM, CHCB 333

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Tectonic Geomorphology will be a graduate seminar focused on reading, discussion, and analysis of journal papers. The course will focus on topics related to the broad themes of interactions among tectonics, geomorphology, and climate.

Goals : As a result of your experiences in GEO 582, you will have the opportunity to:

- gain understanding of feedbacks between surface processes and tectonic processes, current research in landscape evolution, and crustal mechanics and dynamics in the context of landscape evolution
- improve your skills in critically reading and interpreting journal papers
- communicate an understanding of the interrelationships among geomorphic and tectonic concepts and theories to peers and others
- develop your oral communication skills, including gaining confidence in speaking up with your ideas (and learning to hold back and let others contribute)

Prerequisites: Graduate standing or the consent of the instructor are prerequisites. Some background in calculus, physics, geomorphology and tectonics is expected.

Readings: We will read 2-4 papers each week; pdf's will be posted on Moodle. Background material will come from the textbook.

Discussion responsibilities: Students are expected to carefully and critically read assigned papers; come to class prepared to discuss and demonstrate comprehension of the papers; and participate in discussions
The following is a list of potential discussion questions and things to think about as you read each paper.

- What are a few key points / take-home messages from the paper?
- What was the major contribution of paper; why was it published?
- What were the objectives of the paper?
- Key hypotheses?
- What were the weaknesses of the paper?
- What methods were used, and were they appropriate for addressing the research objectives or hypotheses?
- Were the conclusions justified?
- Connections- how can we think about material in one paper based on what we've learned elsewhere (another paper / class / other experience)?
- Muddiest points- did you find any aspects of the paper unclear or confusing?

We also strongly recommend maintaining a cumulative annotated bibliography of notes on the papers as the semester goes along that you can refer back to in the future.

Grading: Grades will be based on class discussions (50%), a field trip related exercise (25%), and a final paper (25%).

Field trip: A field trip in Western Montana and project related to the field area will be included in the course.

Housekeeping notes

1. *Academic Integrity*: All students need to be familiar with and abide by the Student Conduct Code and its definitions of academic misconduct. The Code is available for review online at http://life.umt.edu/vpsa/student_conduct.php
2. *Equal Access*: The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students (DSS). If you think you may have a disability adversely affecting your academic performance, and you have not already registered with DSS, please contact DSS in Lommasson 154. I will work with you and DSS to provide an appropriate accommodation.
3. *Course website*: This course will use Moodle (https://moodle.umt.edu/). Please check the course website regularly, especially before class, for announcements, notes, readings, assignments, and schedule updates.

Textbook

We will use a textbook to help provide background on course content, in lieu of lecturing.
Burbank, D.W. and R.S. Anderson. 2012. *Tectonic Geomorphology*. Wiley-Blackwell. 2nd edition. 454 p.

You should purchase this book online; please be sure to get the 2nd edition.

Schedule

January 27: Introduction and background concepts

January 29: Feedbacks and stability analysis
reading: handout + watch http://video.mit.edu/watch/lecture-26-feedback-example-the-inverted-pendulum-1292/

February 3: Feedbacks and stability analysis paper
reading: Roe, G. (2009), Feedbacks, timescales, and seeing red, Annual Review of Earth and Planetary Sciences, 37, 93-115.

February 5: Basic signals and interpretations 1
readings: Burbank and Anderson, Chapter 1

England, P., and P. Molnar (1990), Surface uplift, uplift of rocks, and exhumation of rocks, Geology, 18, 1173-1177.

February 10: Basic signals and interpretations 2
readings: Molnar, P., and England, P., 1990, Late Cenozoic uplift of mountain ranges and global climate change: Chicken or egg?: *Nature*, v. 346, p. 29–34, doi: 10.1038/346029a0.

Herman, F., D. Seward, P. G. Valla, A. Carter, B. Kohn, S. D. Willett, and T. A. Ehlers (2013), Worldwide acceleration of mountain erosion under a cooling climate, Nature, 504(7480), 423-426, doi: 10.1038/nature12877

Egholm, D. L. (2013), Earth science: Erosion by cooling, Nature, 504(7480), 380-381, doi: 10.1038/504380a.

February 12: higher T geochronology
reading: Burbank and Anderson Chapter 3

February 19: higher T geochronology
reading: Ehlers, T.A., and Farley, K.A. 2003. Apatite (U–Th)/He thermochronometry: methods and applications to problems in tectonic and surface processes. Earth and Planetary Science Letters 206(1): 1-14

February 24: cosmogenics and low T techniques

reading: Portenga, E. W., and P. R. Bierman (2011), Understanding Earth's eroding surface with 10 Be, GSA Today, 21(8), 4-10.

Kirchner, J.W. 2002. Subtleties of sand reveal how mountains crumble. Science 295: 256-258.

February 26: cosmogenics and low T techniques

*reading*s: Densmore, A. L., R. Hetzel, S. Ivy-Ochs, W. C. Krugh, N. Dawers, and P. Kubik (2009), Spatial variations in catchment-averaged denudation rates from normal fault footwalls, Geology, 37(12), 1139-1142, doi: 10.1130/g30164a.1.

Willenbring, J. K., A. T. Codilean, and B. McElroy (2013), Earth is (mostly) flat: Apportionment of the flux of continental sediment over millennial time scales, Geology, 41(3), 343-346, doi: 10.1130/g33918.1.

Kirchner, J. W., and K. L. Ferrier (2013), Earth science: Mainly in the plain, Nature, 495(7441), 318-319.

March 3: terraces and other geomorphic features

reading: Burbank and Anderson Chapter 2

March 5: terraces and other geomorphic features

reading: Merritts, D. J., K. R. Vincent, and E. E. Wohl (1994), Long River Profiles, Tectonism, and Eustasy: A Guide to Interpreting Fluvial Terraces, Journal of Geophysical Research, 99(B7), 14031-14050.

March 10: river networks, knickpoints, and evolution of relief

reading: Burbank and Anderson Chapter 8

Stream power derivation (handout)

March 12: river networks, knickpoints, and evolution of relief

readings: Crosby, B. and K. Whipple (2006) Knickpoint initiation and distribuion within fluvial networks: 236 waterfalls in the Waipaoa River, North Island, New Zealand, Geomorphology 82, 16-38.

Snyder, N. P., K. X. Whipple, G. E. Tucker, and D. J. Merritts (2000), Landscape response to tectonic forcing: Digital elevation model analysis of stream profiles in the Mendocino triple junction region, northern California, Geological Society of America Bulletin, 112(8), 1250-1263, doi: 10.1130/0016-7606(2000)112<1250:lrttfd>2.0.co;2.

assignment: River profile lab

March 17: bedrock incision

reading: Whipple, K. X. (2004), Bedrock rivers and the geomorphology of active orogens, Annual Review of Earth and Planetary Sciences, 32, 151-185.

March 19: bedrock incision

readings: Burbank, D.W., 1996. Bedrock incision, rock uplift and threshold hillslopes in the northwestern Himalaya. Nature, 379: 505-510.

Ferrier, K.L., Huppert, K.L., and Perron, J.T. 2013. Climatic control of bedrock river incision. Nature 496(7444): 206-209

Finnegan, N. J., R. Schumer, and S. Finnegan (2014), A signature of transience in bedrock river incision rates over timescales of 104-107 years, Nature, 505(7483), 391-394, doi:

10.1038/nature12913
http://www.nature.com/nature/journal/v505/n7483/abs/nature12913.html#supplementary-information.

DiBiase, R. A. (2014), Earth science: River incision revisited, Nature, 505(7483), 294-295, doi: 10.1038/505294a.

March 24: landscape evolution & glacial buzzsaws(Brian Yanites)
reading: Yanites, B. J., and T. A. Ehlers (2012), Global climate and tectonic controls on the denudation of glaciated mountains, Earth and Planetary Science Letters, 325–326(0), 63-75, doi: http://dx.doi.org/10.1016/j.epsl.2012.01.030.

March 26: landscape evolution & glacial buzzsaws
readings: Egholm, D.L., Nielsen, S.B., Pedersen, V.K. and Lesemann, J.E., 2009. Glacial effects limiting mountain height. *Nature*, 460(7257): 884-887.

Whipple, K.X., Kirby, E. and Brocklehurst, S.H., 1999. Geomorphic limits to climate-induced increases in topographic relief. *Nature*, 401: 39-43.

Whipple, K.X., 2009. The influence of climate on the tectonic evolution of mountain belts. *Nature Geosci.*, 2: 97-104.

April 7: Bitterroot morphology lab

April 9: Bitterroot morphology
readings: Coney, P. J., and T. A. Harms (1984), Cordilleran metamorphic core complexes: Cenozoic extensional relics of Mesozoic compression, Geology, 12(9), 550-554.

Naylor, S., and E. J. Gabet (2007), Valley asymmetry and glacial versus nonglacial erosion in the Bitterroot Range, Montana, USA, Geology, 35(4), 375-378.

April 12: field trip

April 14: geophysical observations: geodesy, moment release, paleoseismology
reading: Burbank and Anderson Chapter 5

April 16: geophysical observations: geodesy, moment release, paleoseismology
readings: Grandin, R., Doin, M.-P., Bollinger, L., Pinel-Puyssegur, B., Ducret, G., Jolivet, R., and Sapkota, S. (2012) Long-term growth of the Himalaya inferred from interseismic InSAR measurement, Geology 40, 1059-1062.

Flesch, L. and Bendick, R. (2013) The relationship between surface kinematics and deformation of the whole lithosphere, Geology doi:10.1130/G33269.1.

April 21& 23: case study: Himalaya
Readings TBD

April 28: steady state orogens
readings: Willett, S.D. 1999. Orogeny and orography: The effects of erosion on the structure of mountain belts. Journal of Geophysical Research: Solid Earth (1978–2012) 104(B12): 28957-28981.

Willett, S.D., and Brandon, M.T. 2002. On steady states in mountain belts. Geology 30(2): 175-178.

April 30: steady state orogens

readings: Roe, G. H., K. X. Whipple, and J. K. Fletcher (2008), Feedbacks among climate, erosion, and tectonics in a critical wedge orogen, American Journal of Science, 308(7), 815-842.

Pratt-Sitaula, B., D. W. Burbank, A. Heimsath, and T. Ojha (2004), Landscape disequilibrium on 1000–10,000 year scales Marsyandi River, Nepal, central Himalaya, Geomorphology, 58(1), 223-241.

May 5: other numerical simulations

reading: Jamieson, R. A., and C. Beaumont (2013), On the origin of orogens, Geological Society of America Bulletin, doi: 10.1130/b30855.1.

May 7: other numerical simulations

readings: Koons, P., Zeitler, P., and Hallet, B. (2013) Tectonic aneurysms and mountain building, in Shroder, J. and Owen, L., Treatise on Geomorphology, Academic Press, San Diego, CA, vol. 5.

Pedersen, V. K., and D. L. Egholm (2013), Glaciations in response to climate variations preconditioned by evolving topography, *Nature*, *493*(7431), 206-210, doi: http://www.nature.com/nature/journal/v493/n7431/abs/nature11786.html#supplementary-information.