ENVIRONMENTAL CHANGE INSTITUTE  ILLINOIS

student sustainability committee

2010 Course Development and Enhancement Cover Page

Instructor Name and Title

Stephen Marshak (Professor of Geology; Director of the School of Earth Society & Environment

Department/Unit

School of Earth Society and Environment

Course Title

ESE 445: Earth's Resources and Sustainability

Co-Instructors Names (if applicable) and title

Co-Instructors Department/Unit

ECI Domain(s) included in the project (check all that apply)

___ Food Systems and Food Security
__X__ Energy and Natural Resources
___ Policy, and Social and Economic Well-being
___ Biodiversity and Ecosystem Health

$Amount Requested

$5,000

Brief Course Description (250 word maxium, 12 points)

The proposed course (ESE 445: *Earth's Resources and Sustainability*) is designed to provide juniors, seniors, and beginning graduate students from a broad range of backgrounds with a foundational knowledge of our planet's physical resources, and the environmental and sustainability that pertain to their use. (Thus, this course addresses the "sustainability focus" of the RFP.) The underlying concept of this course is that informed citizens will better be able to make choices about issues relating to resources, and about the challenges of sustainability, if they understand the following: the origin of resources in a geoscience context; the nature and distribution of reserves; the ways in which resources are extracted, transported, and used; the manner in which the waste from extraction and use can be managed; and why some resources are non-renewable. With this goal in mind, ESE 445 will introduce students to energy resources (fossil fuels; hydro; nuclear; geothermal; wind; etc.), mineral resources (ores; non-metallic minerals), soils, and coastal sediments. For each topic, we will address the geological context (how they formed and why they exist where they do), the nature of reserves, the impact of their use on the environment, and the issues that must be considered to determine if their use is sustainable. The course will not require prior technical knowledge, so it should serve a broad cross section of students from many departments. It will be one of the core advanced-hours requirements in the ESE major, but will also be of use to students in NRES, engineering, HDES, and other programs. This is a completely new course, so the funding offered by ECI is urgently needed to support a grad-student RA during the summer of 2010. The RA's job will be to collect and organize information, illustrations, and other materials that Prof. Marshak needs for course development, and to work with Prof. Marshak to develop the course's projects.

A Proposal to Develop: Earth, Society, and Environment (ESE) 445
— Earth's Resources and Sustainability —

Course Narrative

Our proposed new course on *Earth's Resources and Sustainability* will be designed to provide juniors, seniors, and potentially beginning grad students from a broad range of backgrounds (humanities, social science, and science) with an opportunity to develop a foundational understanding of our planet's physical (non-biologic) resources. We will discuss the origin and character of resources, how resource extraction and consumption impacts the environment, and whether resource consumption at present rates can be sustained. Participants in the course will develop a knowledge base from which they can make informed judgments about issues and policies that pertain to resources. ESE 445 will be a 3-hour course, consisting of a mix of lecture and discussion, a set of independent projects, and a field trip. The course proposal has passed the curriculum committee review in SESE, and is now undergoing review by LAS. We anticipate that it will be formally listed in time for its initial offering during the Spring term of 2011, and thus we are seeking funds to be used for development of the course during the summer of 2010.

ESE 445 will be designed to be accessible to students without specific technical backgrounds, so it can serve several academic programs, including SESE, NRES, the Energy and Sustainability Program in the College of Engineering, and the Human Dimensions of Environmental Systems program. In addition, the course will provide a key component of the "Environment and Sustainability" on-line certificate program, now under development. Considering agendas of ECI, the Provost's Office, and the Office of Sustainability to nurture sustainability education, we anticipate that the course will have a sizable audience (at least 50 to 150 students per offering).

Earth's Resources and Sustainability will consist of two parts. Part I focuses on energy resources. The starting point for this discussion will be the geologic context of energy resources, for unless students have solid understanding of how resources form in the first place, it will be hard to grasp why some resources are renewable, while others are not. Students in ESE 445 will learn about the origin of fossil-fuel (oil; coal; natural gas; tar sand; oil shale; methane hydrates), the specifics of the environments in which reserves can be retained over geologic time, the reason that these environments only occur in certain locations, and the means used to explore for and recover reserves. With this background, students will then consider the nature of combustion, the ways in which fossil fuels are used for transportation and the energy grid, and the environmental consequences of burning fossil fuels. We will discuss, in particular, the science and technology of CO_2 capture and sequestration, considering its potential importance for Illinois. We will conclude our discussion of fossil fuel by considering sustainability issues. With the substantive background on fossil fuels that students will have gained, they will be able to comprehend the meaning of Hubbert's curve (delimiting the "age of oil") and its implications as regards the need to develop alternative energy resources in the near future.

After completing our discussion of fossil fuels, the class will examine other physical energy resources (nuclear; hydro; geothermal; tides; wind; and hydroelectric). In each case, we will start by addressing the geologic context of these resources, so that students understand where the resources come from, and the factors that control resource distribution. Then, we will address

the environmental and sustainability issues associated with them. For example, in the case of nuclear energy, we will focus on the problem of nuclear waste storage, and solutions under consideration to deal with the problem. To provide a basis for this discussion, students will be introduced to basic isotope geochemistry, and to the factors that determine whether material will or won't contaminate groundwater at a location. We will consider the Yucca Mountain project as a case study. As regards geothermal energy, we will look at the factors that determine on where it can be produced, both from the standpoint of plate tectonics theory, and from the standpoint of groundwater supplies. As regards wind power, we will consider air circulation patterns and try to understand the factors that must be taken into account when building wind farms. Part I of ESE 445 will end with consideration of alternatives to Earth's physical resources (biofuels, solar, and fuel cells); these topics will not be covered in depth as they are the focus of other courses.

Part II of ESE 445 will focus on mineral ~~resources, br~~oadly defined. Under this banner, we will consider economic minerals (metallic and non-metallic), soils, and coastal sediments. Again, we start each topic with an introduction to the relevant geologic context. For example, students will have the opportunity to learn how economic mineral deposits form, where they occur, how are they discovered, and how are they mined or quarried. With this foundation, we will address environment and sustainability issues, so that students will understand the hazards of mining, the origin of acid mine waste, and the contaminants produced by smelting. We will also consider the nature and distribution of mineral reserves, how reserves are calculated, and the factors that go into determining whether a particular reserve is economic. We will have a special focus on strategic minerals (the source of rare earth elements), because of their importance for future sustainable energy technologies, and because most supplies occur in politically unstable regions. If there is time, we will discuss "extreme" mining on the deep-sea floor and in polar regions, and its implications.

The final section of Part II addresses soils and coastal sediments. While soils are covered in depth by courses in ACES, it is our expectation that students taking ESE 445 will not be planning to take whole-semester courses in soils, so ESE 445 may be the only chance they have to learn about soils. We will begin by considering the formation, structure, and classification of soils. Then, we will consider the global problem of soil erosion, fertilization, and degradation. Finally, we will address the sustainability of coastlines, for these are, in a broad sense, a physical resource too. The discussion will focus on the challenges facing coastal areas due to diminished sediment supply (because of dams and shrinking glaciers), subsidence resulting from subsurface fluid extraction, rising sea level, reefs, wetlands, and warming ocean water. The course will have a special focus on the Mississippi delta. We will not be discussing water resources in ESE 445, because that subject is covered thoroughly by ESE 320 (*Water Planet - Water Crises*).

While parts of ESE 445 overlap with other courses on campus (e.g., there is some coverage of energy resources in both Nuclear Engineering and Geology; some coverage of mineral resources in Geology; and some coverage of soils in NRES) there is no single course at UIUC that provides a synthesis of all these topics coupled with a consideration of sustainability. We argue that the lack of such a course is a significant "hole" in this university's curriculum, for debate about physical resource issues is increasingly central to domestic and international affairs. Considering student schedules, a single course that exposes students to all these topics, their interconnections, and their geoscience context will fulfill a important campus need.

A Proposal to Develop: Earth, Society, and Environment (ESE) 445
— Budget and Budget Justification —

Requested funding is needed for course development and purchase of initial course materials. Funding is not needed to teach the course, for that will be provided by SESE. SESE does not have funds to support RAs.

Graduate Research Assistant (Stephanie Mager) for Summer, 2010

• 2.5 months of 50%-time summer salary @ 1,735 per month	$4,337.50

Course Supplies

• reference book for development	$300.00
• maps and samples for student exercises	$300.00
• university vehicle rental to plan the field trip	$93.50
TOTAL	**$5,000.00**

Justification

The proposed instructor for this course (Prof. Stephen Marshak), has not taught an equivalent to ESE 445 previously, and thus will need to develop the course from scratch. To do this realistically, considering Prof. Marshak's administrative responsibilities as director of SESE as well as his research obligations, the services of a graduate research assistant are essential. The research assistant will gather materials needed to flesh out the subjects on lecture outlines that Prof. Marshak will prepare, will identify and obtain appropriate illustrations, will assist in developing the materials for the practical exercises, and will seek permissions for use of figures.

Prof. Marshak has contacted Ms. Stephanie Mager, currently a first-year Ph.D. student in Geology, and she has indicated enthusiasm in participating in course development. Prior to joining the program at Illinois, Ms. Mager obtained an M.S. in geology, worked as an environmental geologist, and served as a middle school science/math teacher. Ms. Mager, therefore, has the necessary technical knowledge and teaching knowledge, to be a productive research assistant for course development. Her CV is attached.

The other sums requested for this course are for supplies needed to develop the course. Funds for books, maps, and samples are estimates (based on experience in obtaining such materials for comparable purposes). The vehicle is needed to plan a road log for the proposed field trip accompanying the course. The areas under consideration are south of Champaign-Urbana.

ESES 445 — EARTH RESOURCE SUSTAINABILITY
Prof. Stephen Marshak — School of Earth, Society, and Environment

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PURPOSE: *Earth Resource Sustainability* introduces students to the physical (energy, mineral, and soil) resources of this planet, to the environmental consequences of producing and using resources, to the controls on resource supplies, and to alternatives to traditional supplies. The course focuses on the geological origin and context of resources, means of resource exploration and production, the history of production, and sustainability and political issues related to resource consumption and depletion.

FORMAT: This course involves in-class lecture and discussion, two Saturday field trips; and independent study of specimens and maps. The instructor will present the background and context of topics via formal lectures. These will alternate with discussions during which students utilize their background to interpret real-world examples and address real-world problems.

MEETING TIME: Tuesday/Thursday, 2:00 - 3:30 (Spring Term: 2010)

MEETING PLACE: TBA

GRADING: Exam I (20%); Exam I (20%); Final Exam (40%); Projects (4% each): 20%

INSTRUCTOR: Prof. Stephen Marshak (*Office:* Rm 245 Natural History Building)

TEXT: Craig, J.R., Vaughn, D.J., and Skinner, B.J., 2001, *Resources of the Earth: Origin, Use, and Environmental Impact (3rd ed.)*, 520 p.

LECTURE/DISCUSSION TOPICS

PART I — Energy Resources

WEEK 1
Lec 1: Context of energy-related earth materials (sediment formation and deposition).
Lec 2: Context of energy-related earth materials (lithification and diagenesis).

WEEK 2
Lec 3: History of the oil industry (1859 - present)
Lec 4: Exploration methodology (mapping; seismic reflection; well-log interpretation)

WEEK 3
Lec 5: Transportation and production of hydrocarbons (including distillation and cracking)
Lec 6: The "Age of Oil" — Reserves, production/discovery ratios, and Hubbert's curve.
Proj 1: Identification of minerals and sedimentary rocks identification - DUE.

WEEK 4
Lec 7: Utilization of hydrocarbons, and environmental consequences.
Lec 8: Hydrocarbons of the future? (tar sands, oil shale, and gas hydrates).

WEEK 5
Lec 9: The "Age of Oil" — Reserves, production/discovery ratios, and Hubbert's curve.
Lec 10: The geology of coal (depositional setting; paleogeography; coalification and rank).
Proj 3: Reading seismic profiles, and well logs. Identification of oil traps. Calculation of reserves.

WEEK 6

Lec 11: Coal production, transport, and utilization, and their environmental consequences.
Lec 12: Carbon sequestration (approaches and challenges).
Proj 2 Topographic maps; mine and quarry engineering. - *DUE*

WEEK 7

Lec 13: Coal reserves and coal alternatives (gasification; coal-bed methane; Futuregen).
Lec 14: The geology of uranium — from the origin of the Earth to the formation of a reserve.

WEEK 8

Lec 15: Nuclear power (reactor design; the geology of waste disposal; Yucca Mt. history)
Lec 16: Alternative energy 1 (solar, hydroelectric, and geothermal)

WEEK 9

Lec 17: Alternative energy 2 (wind and fuel cells).
Lec 18: **EXAM I**

PART II — Non-Energy Resources

WEEK 10

Lec 19: Controls on the distribution of elements in the Earth; essentials of mineralogy.
Lec 20: Geology of ore deposits (magmatic; porphyry; massive sulfide; supergene; placer)

WEEK 11

Lec 21: Methods of mineral exploration (gravity; magnetics; trace-element; geochemistry)
Lec 22: The story of the great Canadian diamond find.
Proj 3: Hand-specimen identification of ore minerals. -*DUE*

WEEK 12

Lec 23: Production (smelting) and utilization of metals; environmental consequences (e.g. acid).
Lec 24: The global distribution of mineral reserves, and its implications; strategic minerals.

WEEK 13

Lec 25: Geology, production, and utilization of non-metallic minerals.
Lec 26: The process of soil formation; soil horizons.

WEEK 14

Lec 27: **EXAM II**
Lec 28: Soil classification; factors controlling soil character and thickness.
Proj 4: Reading geologic maps and cross sections. - *DUE*

WEEK 15

Lec 29: Geology of coasts and coastal sediments — threats to coastal environments.
Lec 30: Opportunities for coastal preservation.
Proj 5: Geotours to coastal environments, using *Google Earth™*. - *DUE*

ADDITIONAL COMPONENTS

Field trip: Saturday trip to a cement and crushed-stone quarry.
Final Exam: To be held during finals week.

STEPHEN MARSHAK

Business Address

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phone: (217) 333-7705 *fax:* (217) 244-4996 *e-mail:* smarshak@illinois.edu

Education

Ph.D. (Columbia University, 1983); M.S. (University of Arizona, 1979); A.B. (Cornell University, 1976)

Professional

2008 -	Director, School of Earth, Society, and Environment (University of Illinois)
2008	Visiting Professor, University of Naples, Italy (sabbatical)
2008	Visitor, University of Lausanne, Switzerland (sabbatical)
2007	Visitor, US Geological Survey, Woods Hole MA (sabbatical)
1999 - 2008	Head, Department of Geology, University of Illinois
1999	Honorary Visiting Fellow, University of Leicester, UK (sabbatical)
1997 -	Professor (structure, tectonics, field geology), University of Illinois
1989 - 1997	Associate Professor, University of Illinois
1992	Visiting Research Academic, University of Adelaide, Australia (sabbatical)
1991	Visiting Research Associate, Lamont-Doherty Geological Observatory, Columbia University
1990 -	Instructional Staff, Wasatch-Uinta Geological Field Camp, Utah (summer)
1985 - 1996	Visiting Professor (geotectonics), Federal University of Ouro Preto, Brazil
1983 - 1989	Assistant Professor, University of Illinois

Selected Services (past and present)

Chair, NSF EarthScope Workshop on the central Midcontinent
Member, National Science Foundation Panel for the Continental Dynamics Program
Advisory Board, National Science Foundation Spatial Intelligence and Learning Center (SILC)
Chair, Division of Structural Geology and Tectonics, Geological Society of America
Lead Convener, GSA Penrose Conference on Continental Interior Tectonics
Associate Editor: *GEOLOGY*; *Tectonophysics*; *Glossary of Geology*
External Assessor: Kuwait University; Univ. of São Paulo (Brazil); Indiana University; St. Louis University
University of Illinois: Council on Undergraduate Education; Council on General Education

Memberships

Geological Society of America (Fellow); American Geophysical Union

Courses Taught (past and present)

100 Planet Earth (large lecture course); **104** Geology of National Parks; **411** Structural Geology and Tectonics; **415/515** Regional USA Geology & field course to Arizona/California; **417** Field geology in the Rocky Mountains; **511** AdvancedStructural Geology; **512** Geotectonics; **497** Carbon Sequestration.

Awards

2006 College of Liberal Arts & Sciences Distinguished Teaching Award
1996 Stilwell Medal (shared; Australian Journal of Earth Science) for a research publication on Australia
1994 Luckman Undergraduate Distinguished Teaching Award, University of Illinois (campus-wide)
1994 Prokasy Award for Distinguished Teaching, College of Liberal Arts & Sciences
1991 Amoco Foundation Award for Innovation in Instruction at the University of Illinois

Geological Travel Experience:

Appalachians; Antarctica; North American Cordillera; Egypt; Italy; Brazil; Tunisia; Scotland; Midcontinent USA; Caribbean; Hawaii; Alaska; Alps; Canadian Shield; southern Andes.

Research Publications

Peer-Reviewed Research Articles: 60 / Research Abstracts: 110 / Field Guides and Maps: 23

Books

Marshak, S., 2009, *Essentials of Geology, 3rd edition,* W.W. Norton., NY: 536 pp.
Marshak, S., 2008, *Earth: Portrait of a Planet, 3rd edition,* W.W. Norton, NY, 832 pp.
Wilkerson, M.S., and Marshak, S., 2008, *Geotour Exercises, Using Google Earth:* W.W. Norton, NY, 150 p.
Ludman, A., & Marshak, S., 2010, *Lab Manual in Introductory Geology, 1st ed.,* W.W. Norton, NY, 400 pp.
van der Pluijm, B., and Marshak, S., 2004, *Earth Structure — An Introduction to Structural Geology and Tectonics, 2nd edition:* W.W. Norton & Co., New York: 520 p.
Marshak, S., and Mitra, G., 1988, *Basic Methods of Structural Geology,* Prentice-Hall, New Jersey, 448 p.

STEPHANIE M. MAGER

Business Address

Dept. of Geology, University of Illinois, 1301 W. Green St., Urbana, IL 61801 mager2@illinois.edu

Education

• Ph.D. (in progress)	geology	University of Illinois at Urbana-Champaign.
• M.S. (2005)	geology	Auburn University, Auburn AL
• B.S. (2000)	geology & math	College of William and Mary, Williamsburg VA

Experience

- Teaching laboratory classes for structural geology at the University of Illinois.
- Field work, data collection, and reporting for environmental consulting firm.
- Taught laboratory classes for introductory, historical, and structural geology classes at Auburn University.
- Taught math and/or earth science at the middle school level for three years.
- Tutored middle school students in after school programs through the College of William and Mary.
- Collected field data and rock samples for mapping and structural and lithologic analysis in North Norway.
- Assisted in collecting geophysical data, including electrical resistivity, seismic and electromagnetic surveys.
- Collected field data and rock samples for mapping and structural and lithologic analysis of the Madison County, VA, 7.5' quadrangle; published 2003.
- Collected and analyzed field data of brittle fractures in Madison County, VA.
- Completed field courses focusing on the geology of the Colorado Plateau and surrounding provinces and the Virginia Valley and Ridge Province.

Positions Held

2009 - present	Graduate Teaching Assistant, University of Illinois, Urbana-Champaign, IL (Planning, teaching, and supervising undergraduate laboratory classes for structural geology)
2007 - 2009	Middle School Teacher, Sweetwater Middle School, Lawrenceville, GA (6th, 7th, and 8th grade Remedial Math; 6th grade math and science teacher; 6th grade science and language arts teacher)
2006 -	Staff Geologist, Mactec Engineering, Inc., Kennesaw, GA (Collecting soil samples, water samples, and field data, analyzing lab results, writing reports, installing monitoring wells, planning and executing field data collection)
2000 - 2003	Graduate Teaching Assistant, Auburn University, AL (Planning, teaching and supervising undergraduate laboratory classes for Physical Geology, Historical Geology, and Structural Geology)

Publications/Thesis/Papers

Mager, Stephanie M., 2005, The Late- to Post-Caledonian Extensional History of Northwest Hinnøy, North Norway, M. S. Thesis, Auburn University, 100 p.

Bailey, Christopher M., Berquist, Peter J., Mager, Stephanie M., Knight, Brian D., Shotwell, Nathan J., and Gilmer, Amy K., 2003, Bedrock Geology of the Madison Quadrangle, Virginia: Virginia Division of Mineral Resources Publication 157, Charlottesville, VA, Commonwealth of Virginia Dept. of Mines, Minerals and Energy, 22 p.

Mager, Stephanie M., 2000, Vorticity, Strain, and Volume Change Analysis of a High Strain Zone: unpublished B. S. research paper, College of William and Mary, 12 p.

Mager, Stephanie M., and Bailey, Christopher M., 2000, Fracture analysis in the Blue Ridge Province, Madison County, Virginia: The Geological Society of America Abstracts with Programs, v. 32, no. 2, pg 59.

Rehnström, E.F., Steltenpohl, M.G., Kassos, G., Mager, S., and Andresen, A., 2005, Dating the Lofoten island eclogites: Norges Geologisk Forening, Vinterkonferansen Abstracts and Proceedings, no. 1, p 98-99.

Kassos, G., Steltenpohl, M.G., Rehnstrøm, Emma, Mager, S., and Andresen, A., 2004, Structural and isotopic studies of eclogite-facies shear zones and associated pseudotachylites in lower-crustal continental basement, Lofoten Islands, Norway: Deep-crustal seismic faults(?): Geological Society of America Abstracts with Programs, v. 36, no. 5, p. 430.

Mager, S., Kassos, G., Steltenpohl, M.G., Hames, W.E., and Andresen, A., 2004, Our understanding of temporal and structural evolution of lower-crustal continental basement of Lofoten-Vesteralen, north Norway: A work in progress: Geological Society of America Abstracts with Programs, v. 36, no. 2, p. 139.

Andresen, A., Moore, B., Mager, S.M., and Steltenpohl, M.G., 2001, Structural and metamorphic observations across a Caledonian shear zone – implications for growth and collapse of the East Greenland Caledonides: Geological Society of America Abstracts with Programs, v. 33, no. 2, p. A-4.

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March 8, 2010

Dr. Wesley Jarrell
Director
Environment Change Institute
Campus

Dear Dr. Jarrell,

As the Head of the Department of Geology, I write in support of a proposal, submitted by Professor Stephen Marshak, to develop a new course entitled "Earth's Resources and Sustainability". This is a particularly timely proposal as we are facing the confluence of dwindling resources, rising concerns about the environment, and increasing threats of natural disasters.

Professor Marshak has a long, outstanding record of being a highly successful instructor and he has authored and edited several popular textbooks. As such, I am confident that his proposal will lead to a high quality course that attracts students from many corners of the campus. The proposed course, under the rubric of ESE 445, will be anchored at the newly formed School of Earth, Society, and Environment of which our Department is a part. Since the formation of the School two-and-half years ago, it has attracted about 150 new majors and served as one of the focal points for developing and delivering new courses in sustainability and environmental studies.

I strongly endorse this proposal and hope that you can give it your most favorable consideration.

Sincerely,

Wang-Ping Chen
Professor of Geophysics and Head