Earth and Planetary Science 101/271:
Field Geology and Digital Mapping

Instructors: **Professor**: George Brimhall, 391 McCone

Office Hours: Fridays 1:00-4:00 and by appointment by email: brimhall@eps.berkeley.edu

Course content: Geological mapping, field observation and geological reasoning leading to interpretation of geological processes and history from stratigraphic and structural investigations. Integration of the Berkeley Hills into California geology as a whole through extensive reading of key research papers. The tectonic evolution of California is emphasized. The field methods start by skills development by mapping using traditional topographic base maps and then evolves into complete paperless mapping using pen tablet PC's supported by GPS units and digital base maps and ortho-photos for digital mapping.

History of this Course: This class is a direct descendent of the first systematic mapping-based field geology course taught in the US by Professor Andrew Lawson in 1892 in the Berkeley Hills which remain to this day a natural field laboratory.

Undergraduate and Graduate Components: EPS 101 and 271 have the same basic lectures and field experiences. However, graduate students enrolled in EPS 271, have 2 additional lectures on advanced topics in digital mapping using precision GPS and lasers. The field report for graduate students will also contain an additional section on proposed applications of digital mapping to their research area or future teaching experience. Undergraduates in EPS 101 are welcome to attend these lectures if interested.

Prerequisites: EPS 50, Geology 50 or equivalent introduction to general geology ***Required*** or by consent of Instructor.

Letter grade only. **No** Pass/Not Pass (P/NP) option

Reading: (1) **Field Geology and Digital Mapping** by George Brimhall (draft in Reader)

(2) Published research articles in your class reader given in **Reading List**

Class hours: Mondays and Wednesdays: Lectures 1:00-2:00 and Field 2:00-5:30 p.m. **Note 5:30 +/- 20 minutes**

Goal: To begin your study of the geology of California **and study of the earth as a natural laboratory** by developing your powers of field observation through **first-hand experience**, intensive **training** and then systematically ***mapping*** key regions. While mapping technique is taught, this course stresses mapping as the most basic and realistic means of **comprehending the earth's architecture** necessary for **interpreting geological history** of internal and external **processes**. Ultimately a **synthesis** of discrete bits of information provide a comprehensive basis for interpreting the **geological history of California**. There are two key processes in field geology: (1) **mapping** and (2) **interpreting** already-made maps.

What is a geological map ? A geological map is very different from a **photograph**. Maps invariably show many important features of the earth which are completely invisible on photos or satellite images. These special features found only by mapping include **rock type identification, rock origin, age relationships and interpretation of the nature and sequence of many types of geological processes**. Photographs, especially large scale aerial photographs and satellite images do offer their own unique advantages. You will also learn to use air photographs. One of the reasons why maps show so much more than photographs is that maps are made by piecing together close up observations of the earth rather than rely on perspectives taken at a distant point in space. **Spatial intimacy provides details and ground truth**. **Proximity** also has its **limitations**. From one point on the earth, larger patterns cannot be perceived and must be pieced together by progressive observations which provide enough perspective to reveal a large-scale pattern. Making geological maps is hard, time-consuming work but it has many rewards including the fact that it can be very exciting.

Strategy: Since no one has the time to cover every inch of a field area, mapping is a matter of making intelligent choices about how to spend your time in the field: where to go, what to observe, how long to take, where to go next, and most of all, knowing **why** you are in a certain place. Field geology requires **exercising scientific discipline** similar to laboratory investigations and requires the same attention to proper application of the scientific method. **Mapping is not just covering a piece of paper with color nor is it a fishing expedition hoping to "catch" something**. One feature of the scientific method requires that relevant observations be accurate enough to be reproducible and also serve to help you in choosing what to do next**. Time management makes a huge difference to your success when we reach the part of the class where you work independently.** Therefore **you will learn a sequence of field activities** which ensure that relevant data of sufficient accuracy are collected and recorded on your map in a timely fashion. Typically, **as you map, a pattern emerges** which helps guide your subsequent work and **shows the most efficient steps to take next**. **This guidance you map provides is critical to effective mapping**. The sequence involves planning, accuracy, decision making. The **steps** are: 1.) locate yourself on topographic base map

2.) inspect the **whole** outcrop, 3.) determine lithology (rock type), 4.) measure stratigraphic and structural attitudes, 5.) plot information, 6.) draw in contacts with uncertainties indicated, 6.) record salient observations in your field book ***if necessary***, 7.) decide what to do next and later 8.) ink map information in order that it become a permanent record and not be lost if map becomes wet or abraded. **We will progress through a training sequence designed to build skills, efficiency and confidence which equips you ultimately to work independently**. Towards that end we will first work as a **group** with daily instruction and close supervision and then encourage more **independent work in small groups**. Near the end of the course you again can select working groups.

Verbalization and articulation of geological reasoning is essential to your learning so engage in discussion.

Function of the course: this class is essential to all other required and elective geology courses as it is in the field that you will first personally confront geological reality and start to comprehend the complexity and enormity of geological processes in nature. You will (1) learn **how to map** and (2) **how to use published maps**. You will acquire a deeper appreciation of the **geological time scale** and a better sense of the physical **scale, nature and variety** of geological processes. You will also become more aware of the **succession** and **superimposition** of events evident in observable features of rocks and their structures and will learn ways to unravel their history into understandable chapters of earth history. ***Observing*** geology is very different from ***listening*** in a lecture of laboratory classroom environment or just reading a published map. Rocks often provide only an **imperfect**, **scant record** of earth history. A single rock may be complex and may contain evidence of **multiple processes** which must be **unraveled**. To assist the intellectual **growth** required to be able to unravel the rock and structural record, we will **learn in stages**. We will **break up** the complexities into manageable pieces; gain skills, learn through lectures and reading, and ultimately, students completing this sequence will gradually find that they are in fact working independently on important field problems. There is a distinct **learning curve** which reflects this progressive growth over the 15 week class.

Role of geological mapping: Rigorous geological mapping of **real exposures and their intrinsic limitations** is the basic tool of field work. The constraints and controls that mapping places on understanding processes is vital to all other types of earth science study: petrology, geochemistry, geophysics, geomorphology, mineral resources, tectonics and planetology.

Approach: The course offers **basic geological understanding for students in other fields including engineering, anthropology, soil sciences, geography, environmental and ecological sciences**. However, this is a ***science*** class and

the work of all students is expected to be scientific in nature and the final report must be a **scientific document** if a student expects a passing grade.

Scientific tools: The physical tools are very simple. We use a **topographic base map** (scale 1" = 600 feet with a 20 foot contour interval) on which to locate ourselves and to record data on one, two and three-dimensional geological features surveyed and measured using a **Compass**, a protractor to measure angles and distances to the scale of the map and **colored pencils** to represent different mapable units: rock formations, faults, and contacts. You will also need a **rock hammer** and **hand lens**, also a fine point pen for inking in your mapping so as to not lose lines and detail. Additional notes will be taken in waterproof **field book**. Later in the course you will have an introduction to mapping on **stereographic** (3-dimensional) **colored air photographs**. **Inexpensive rain gear** will make it possible for you to map effectively even in the rain when it is necessary so that we do not lose valuable time.

Expectations and hazards: As this is an **interactive *progressive* class**, participation in group discussion is expected as the instructors stimulate dialogue to help illustrate geological features and to obtain feedback to gauge comprehension. It is essential also to keep up with the daily **field work and reading** for timely progress. Reading cannot be put off. **Quizzes**: will be given every week in order to see where students are in their understanding. Occasionally, a student will not meet the **minimum standards required** and will be **asked to drop the class** so that the progress of the class as a whole is not impeded**. Missing more than 2 days of class make sit impossible to keep up unless a special circumstance is brought to the attention of the instructor**

The instructor expects that all students will **work safely** being particularly careful with (1) use of rock hammers and (2) in hiking on **steep slopes where you could fall or cause others to fall**. Common **courtesy and respect**, constant awareness and concern for others is essential to **the safety of the group** and is essential to the learning process itself as we work in unusually close proximity to one another under adverse outdoor circumstances very different than classrooms. **Safety while driving and while in the field is essential. Safety training is a theme in this course. One of your text books is on field safety.** For example, we often walk on narrow trails Disrespect of *any kind* is not tolerated including other people's time which is taken to be very valuable. When we are walking between outcrops, conversation *about geology* is encouraged. However, constant dialogue about topics *other than geology* can be so disruptive that the educational experience is compromised of other students who are striving to learn by hearing what is being said concerning geology.

The **vehicles** must be respected too and the back seat entered only after folding down both of the side seats, not jumping over them. The vehicles must also be kept **clean. Always wear a pair of street shoes to class and change into field boots in the field**. When back in the vehicles, put your muddy boots in a box or plastic bag. **No muddy boots are allowed in McCone Hall and especially not in 325 or 345. Please make certain to dry out your Brunton compass each night after using it during a rainy day. The body of the compass is plastic so do put it too near extreme heat.**

Poison oak abounds in the Berkeley Hills and is the major threat to your well-being. We will try to avoid it whenever possible, but **long pants, a long sleeved shirt and a cap are a must** in order to minimize unavoidable exposure to it. Every effort should be made not to rub your eyes with hands bearing oil from the leaves or stems. After each field day, **a shower using repeated scrubbing with strong soap and a thorough washing of clothes** are necessary. **Poison oak cremes** (**Technu**) are also available which you may wish to try. See **http://www.life-assist.com/a100.html**

Lyme disease has been found to accompany some ticks bites. If a red ring appears around a tick bite, go to the Tang center and tell them you were bitten by a tick and need **antibiotics**.

We have seen one **mountain lion** in a remote area we map. Please be alert at all times and always work in a group.

Be sure to lock all **valuables** in the security boxes in one of the vehicles while we are out. University insurance does not cover any personal items.

Digital equipment: For each student or group of students, a pen computer will be provided if they accept financial responsibility for its care and repair if necessary. Each student is expected to pick up and return it to charge mode in a specified locker in Room 345 McCone after each days mapping. **Great care with these units at all times is expected *even while driving*. Do not put these computers in the back of the trucks. Hold them in your laps safely. Each computer has a replacement cost of $ 3500. Typical repairs cost in the range of $ 350 to 500. If a computer assigned to you is damaged, you will be expected to pay for the total cost of repair by the end of class.**

Some students may not wish to accept financial responsibility for digital equipment and prefer to use only the lower cost conventional gear. However, they still have to pay the cost of replacing it if lost or stolen.

Geological Report: Is the main basis of grading in the course. It involves 1.) completion of a geological map of the Berkeley Hills in two parts **paper and colored pencil** and a final **digital map**, 2.) construction of a stratigraphic column of the formations mapped, 3.) using the stratigraphic column,

construct one cross section along predetermined section lines and show your projections to depth of the major geological structures, 4.) write a formal typed geological report ending with an interpretive history of the region based upon your own field work.

Emphasis of the report: The main goal of the report on the **Berkeley Hills** is for you to use your own mapping and field observations to construct and present in a formal report the geological history of the Berkeley Hills in the context of California geology and **neo-tectonic processes**. The focus is on the **nature of sequential geological processes, their change with time and an evaluation of the most likely explanation**. This is **not intended** to be a term paper written using only published material but instead it involves original data collection though mapping, synthesis and interpretation of an extensive data base constructed piece by piece from disciplined scientific observations of your own and ***critical*** use of the readings. Much weight is placed on separating factual data, that is observation from inference and interpretation. Interpretations may vary and evolve in time with reconsideration of the available facts or further, especially more detailed mapping, but the data should withstand the test of time. Although reading is required, the emphasis in this report is on your own observations and deductions.

Honor Code: No student shall use in ***any way whatsoever*** reports written by students in previous years nor seek outside comments and reviews of their papers. All such reports and advice are off limits to Geology 101 students. This is a **discovery-oriented** course and use of work by previous students or those not on the teaching staff defeats the intrinsic purpose of the course. All reports will be submitted as a computer file which is archived and cross routinely checked making it even more ill-advised to use work (text, maps, sections) by previous students.

Grading: **Quizzes** 30 %, **Term Report** 70 %

Grading is done on the basis of **mastery** of the subject using quantitative Uniform measures in scoring the final paper.

In general a course grade of:

A means that a student has mastered skills and knowledge at the level of the course and can make and interpret geological maps at an acceptable level.

B means that they have a good working knowledge and can make and interpret geological maps at an acceptable level with supervision

C means that they have some knowledge of the field but are unlikely to be able to make and interpret geological maps at an acceptable level.

D and **F** mean that the student does not have a working knowledge of field methods and mapping.

It is necessary to **read and study** all material in the reader on a regular basis. So that you can listen and interact with the instructors, bring the **reader to class each day** as most illustrations in the lectures are contained in it.