GEOS496e, “PREPARATION FOR GEOLOGY FIELD CAMP” (3 units)
~EVERY OTHER FRIDAY, 8-5
George H. Davis, Regents Professor Emeritus
Prerequisites: GEOS 302 AND GEOS 304
Spring Term, 2015

Instructional Team

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Background of the Course and Its Purpose

Field camp is, of course, a rigorous, demanding capstone experience required or strongly encouraged by virtually all geology departments in the United States. Field camp courses challenge students to apply classroom learning in a practical manner. The main activity is comprehensive geological mapping aimed at creating a basis for students to discern the geological history of an area and of regions. Most U.S. field camps, but by no means all, are taught in summer in the West. They typically range in length from 5 to 8 weeks. Though UofA undergraduate geoscience majors are typically introduced to geological mapping in some of the core courses before the summer of the junior year, our Geosciences Department, prior to 2013, never offered a course designed to help prepare our students for field camp. However, in fall semester, 2012, our undergraduate majors expressed their desire to gain more formalized preparation for field camp. Based on this request, I (G. Davis) created GEOS 496e and taught it for the first time during spring term of 2013.

The purpose of GEOS496e is to introduce UofA undergraduate students to geological mapping, especially emphasizing field experience in describing, mapping, and interpreting outcrops and geologic contacts in areas marked by moderately challenging to very challenging geological history. Particularly critical in this ‘prep’ course is gaining skill in tracking and mapping geological contacts across field areas marked by a relatively large number and diversity of rock types and rock formations. A major constraint for us – compared to a true 5-8-week-long field camp immersion experience – is the need to approach things particularly efficiently, for field days are limited. I steer away from huge field areas for this course, because of the need to gather together during the day as a whole class from time to time for instructional purposes and for comparing and contrasting what we are experiencing. This cannot happen if we are ‘scattered to the four winds’. Consequently, I have chosen map areas of a modest size (several km²) and topographic relief (500m). Even so, there will still be a physical (hiking) element to the mapping, and this will be another helpful component of preparation for field camp. You are on your own for building additional physical stamina prior to field camp. Some of our majors, grad students, and faculty take advantage of the Gould-Simpson staircases as training grounds.
What to Expect

Based on what I learned in teaching this course the first time, and now equipped with input from a number of our majors who took field camp at a variety of field camps during the summer of 2014, I have framed the upcoming experience in terms of just two mapping projects. The first will be carried out in 4 mapping days, and the other in 5. Moreover, there will be a 1-day mapping project separating the 2 main efforts. What is learned during this 1-day project will be relevant to interpreting the geology exposed in the third and final map area. The base maps I have prepared for each project are topographic maps superimposed on aerial photography. The scale of mapping will be ~1:5000. Our work will be carried out all day approximately every other Friday. The map areas are located within an hour of campus, and thus we will maximize time in the field.

One of the benefits to be derived from these particular projects is learning how to ‘size up’ outcrop relationships and to decide 1/ what needs to be mapped, measured, recorded, sketched, and photographed; 2/ how to go about these activities; 3/ and how to go about interpreting the geologic significance of key relationships. The heart of the field mapping and interpretation, as well as the physical and intellectual demands of same, lie in tracking, mapping, and interpreting geologic contacts (such as faults, shear zones, unconformities, igneous intrusive contacts, and ordinary depositional contacts). The nature of contacts provides the basic foundation for interpreting geologic history.

Once the mapping of a given area is completed, you will construct geological cross sections. Proof of accurate visualization of mapped relationship will be evident, or not, in the quality and character of these cross sections. Throughout each mapping project I will emphasize the importance of sketching preliminary geological cross sections in your field notebooks, as an aid in helping each of you to identify what you grasp versus what remains illusive. Drawing preliminary cross sections in the field helps focus decisions on exactly what next should be mapped and measured.

The Mapping Itself

Throughout the course, each of you will maintain a field notebook within which you professionally record rock descriptions, structures, data, and interpretations, as well as sketches, e.g., outcrops, interrelations of landscape and bedrock expression, and things that particularly capture your attention and may have special significance. I will prescribe some ways for you to organize your field notebooks such that you separate raw data and description from ideas and interpretations. Photographs will be an important part of your record of inquiry and accomplishment, and it is essential to note these in your field notebooks.

I have arranged for special 2-hour value-added indoor sessions, one on the art of sketching, and one on the art of photography. Chuck Albanese (artist and former Dean of UofA’s College of Architecture) will share his best advice on sketching landscapes and bedrock, and will give us a clear idea of techniques and how to ‘see’. Pete Kresan (photographer and former faculty in Geosciences) will lay out for us some valuable insight on photographing landscape and outcrops. Chuck and Pete are two very special and talented people, and we will learn a lot from them. I have invited them to join us on a field trip so that each can ‘look over our shoulders’ as we carry out our work, and so that they can enjoy, on their own, seeing some dramatic landscape and geology.

Rock descriptions and the identification of rock formations will incrementally lead each of you to ‘build’ a proper stratigraphic and/or Geological Column, complete with formation names, ages, and brief descriptions. Similarly, the exploration of individual
outcrops and map relations will lead you to build an *Explanation* of symbols for elements such as bedding, cleavage, foliation, and geological structures, particularly faults, folds, and shear zones. All cultural features (e.g., roads, fence lines, drainages, houses, etc.) will also be shown as symbols in the *Explanation*.

While you are maintaining a field notebook, describing rock types, measuring structures, building a *Geological Column*, building an *Explanation* of all symbols, etc., you will be preparing your geological map. The map is not to be created late in the day, or back in the office, based on notebook information. Rather, throughout each mapping day your main effort will be directed toward denoting each geological unit, complete with contacts and color, and plotting orientation information along the trace of each geologic contact and within each geologic formation. *It is this need to carry out several different kinds of operations simultaneously, - while juggling notebooks, compasses, clipboards, protractors, and pencils – and while covering robust chunks of map area, which tends to make geological mapping particularly challenging.* I cannot adequately emphasize that each particular activity during mapping (writing, recording, photographing, sketching, measuring, drawing lines, coloring, determining location, tracing contacts, walking, scrambling, etc) will seem like *mapping takes forever*, and hour-by-hour progress will feel quite inadequate. The pressures that issue from this psychology can result in temptations to cut corners, when instead the goal should be to carry out all of these essential activities while making good judgments and adjustments regarding scale and spacing of coverage. All I can say is that each and every field day is a scarce resource, and to countermand the reality of the inevitable *snails pace* you must discipline and push yourself to be busy and actively engaged *throughout* the day, never at rest. Only then, on the ride home, will you sense that you actually accomplished something. Keep in mind that this sense of time pressure is slightly elevated in GEOS496e because we are carrying out geological mapping in a semester course and with practical limitations on field time. Mapping as a central activity in graduate research is generally carried out within a time frame of months, not days.

I speculate that field camp directors spend 20% of their time in the field emphasizing and reemphasizing that it is not acceptable to simply record data in the field notebook, and leave the mapping to later. Instead, mapping, including coloring of formations and plotting of orientation data and adding symbols to the Explanation must be an ongoing activity from the first outcrop to the last. Just so you know, I collect maps and notebooks at the end of each field day, and I expect that the mapping carried out each day is expressed in color and inked contacts and symbols. Part of the payoff for you comes on your first day of mapping at field camp, for from the start you will carry out your mapping the way it should be done.

Richard Lisle (2011, p. 146) expresses my emphasis this way: “*Geological mapping is like solving a jigsaw puzzle. It is more difficult in the early stages when very little of the puzzle has been completed, but gets progressively easier as parts of the picture start emerging. The field map is used to visually display the data collected to date, as well as to show the interpretations made of those data. It depicts the partly completed puzzle and therefore is an essential aid to planning the next stage of the work and eventually to completing the map. Data recorded in the field notebook is not going to be of much use to the mapper; because the spatial relationship of the already gathered data will not be obvious. For this reason it is important to plot information on the field map as soon as you collect it.*"
Tips on What to Wear in the Field

For typical spring-term southern Arizona weather, clothing choices should be driven by the reality of hot weather and grimly thorny vegetation. For sun protection, you really cannot go wrong in wearing a wide-brimmed hat, for this will provide maximum protection from the sun's intensity. Caps provide some relief from sun and glare but offer no protection for the back of the neck. If you prefer to wear a cap, consider wearing a neckerchief as well to protect the neck. Short-sleeved shirts are tempting, but learn from the cowboys: long sleeved shirts help protect the arms from sun and spines. I frankly never map in shorts, except perhaps in the bare slickrock country in southern Utah. In southern Arizona, the historic overgrazing by cattle has produced thorny landscapes. Long pants reduce the damage and create the opportunity for greater ease and speed in moving across thorny landscape. Jeans provide reasonable protection, but they tend to be binding and somewhat stiff. In making choices of what to wear, nothing is as important as having proper field boots and socks. Ankle support is essential. Good traction on rubbly slopes is also essential. To all of this I would add sunglasses (for when you really need them) and sunscreen.

During most of the semester we will find the early mornings and some late afternoons cool. For this reason I always bring a fleece, sweatshirt, or jacket. I hope that it rains a lot during our semester of mapping, but not on Fridays. We will map rain or shine, but will prudently retreat if there is lightning. On rainy days we each must bring water resistant or waterproof jackets, and perhaps water resistant pants as well.

Tips on What Stuff to Bring to the Field

If your experience is typical, it may take some time to determine what kind of ‘kit’ to bring and how to arrange and carry your equipment during mapping. The main thing is to have what you need, and more gradually develop a system for how to best carry and access what you have. When I took field camp I enjoyed going as light as possible. I have strayed considerably and have learned that I must carry with me my ‘research laboratory”, even if it tends to get bulky. For example, I carry more camera equipment than most geologists would prefer, but photography is hugely important to my professional life. I will typically have a daypack containing an extra layer of clothing, my water, my lunch, sunscreen, rain gear (if anticipated), and some of my camera equipment. These are items that I need to access infrequently. I resist mapping in a manner where I am constantly taking my day pack off and on. In addition I tend to carry my leather ‘man purse’, which is nothing more than a big pocket. Because of its open top (no flap), I have easy access to my map board (though I often simply carry this), pencils, protractors, camera, etc. Among the things I like about my leather bag (which I designed and made in 1977) is that I can slip it off my shoulder in a flash at a given outcrop, so that I am, for the moment, free and clear of any additional weight or complexity. If my daypack is snug, I do not notice its weight at all; it is part of me.

We will not be taking rock hammers into the field, for I have managed gaining access permission to our amazing map areas with the understanding with officials that we will not be beating up the outcrops. Our collecting will be done photographically.

I will always bring a hand lens (10X) with me to the field. For the most part it simply helps make me look more like a geologist. But at times, it comes in quite handy for mineral or fossil identification. My most important tool is my Brunton Compass, for my ‘bread-and-butter’ over the years has been geometric and kinematic analysis. I confess to going overboard in capturing and plotting orientations of rocks and structures. Never enough! The plotted measurements bring life to my geologic maps.
I like to have with me more than one protractor-scale (10-20), for they are easy to lose or break. The optimum pencil hardness is 3H. I have more luck with old fashion pencils and separate erasers; my mechanical pencils have had short half-lives. I have discovered that my permanent-ink preference is the Sharpie Pen, which I think first came on the market a year or two ago. They are available in the ASUA Bookstore. These pens are inexpensive and surprisingly dependable. You will also need an assortment of color pencils, perhaps 10 or 12.

I always take with me to the field a 3-m measuring tape, for it helps me estimate sizes and spacings of things, and can provide a useful scale for photographs. It also helps me ‘see’ in metric, for I was ‘schooled’ on inches and feet and these units are embedded in my DNA.

One of the things you will enjoy about this southern-Arizona-based course is encountering a VERY wide range of messed up rocks, and this presents for you an opportunity to begin or add to your archive of geology photographs. I can give you tips on photography, so that you are more likely to end up with effective, meaningful images. However, the important requirements of photography are 1/ framing the image at just the right cropping and scale, 2/ being a brutal editor of your photos, 3/ creating a system for organizing your photos, and 4/ thoroughly encrypting key information into your digital catalog of photos in a timely manner. When you look at your GEOS496e photographs in 2035, will you recall date, location, rock unit, and interpretations?

Safety

There are risks and hazards in geological mapping, and most are intimately associated with the ‘particulars’ of a given map area. Normally, however, the overriding risk/hazard is the possibility of a car crash on the way to or returning from the field. Student and/or instructor drivers of UofA vehicles will be individuals who have taken HOV training and are on the approved list. Staying within the speed limits, resisting making quick last-minute turns, buckling up, etc., all contribute to the primary objective of a day in the field: coming home safe and sound; staying out of harm’s way. Alcohol and drugs are anathema to risk and safety, and are totally prohibited on these trips. Because of the frequency and intensity of wildfires in southern Arizona in the past decade, smoking in the field is not only a health hazard but a wildfire hazard. The last thing I want to do is to call up my contacts with the offices of the Arizona State Trust Land, Coronado National Forest, Pima County Natural Resources Office, and Saguaro National Park to tell them I have set their land on fire. We all know, don’t we, there are folks in prison whose carelessness resulted in enormous wildfires!

There are other hazards and risks as well, and each day in the field I will review them so that this knowledge will help us in meeting my goal of being accident free. As we get to know one another, I wish to learn if anyone in the class has paramedic or first aid training. Encounters with cacti are usually relatively benign, but can be very serious. Cacti and catclaw will be a nuisance (or more) no matter where we will be mapping this semester. I recommend that you add tweezers and a comb (to remove cholla balls) to your equipment list, to be used for ‘surgical’ removals of cholla and spines. I sometimes bring needle-nose pliers, and there have been times where I have regretted not bringing them.

On all trips we will bring a large First Aid Kit, and position it as accessibly as possible relative to a given day’s objectives. Moreover, we are fortunate for many reasons to have Ryan Leary as a GTA, for he is also a current Wilderness First Responder.
The Challenge of Individual Mapping Versus Group Mapping

If hazards and safety were not an issue, I might be tempted to urge everyone to map completely alone and independently. But in fact the added safety of working with one or two others and the team-learning that is advanced when working together are extremely valuable. However, such virtual academic value deteriorates when ‘permanent’ partnerships or teams begin to form and I see you walking in ‘lock-step’ with the same folks, all day, all semester. This defeats the purpose of this course in multiple ways, including the inevitable development of reliance on the thinking of others, and the absence of intellectual diversity of thinking and experience that would be derived from connecting with many peers during the course of a day and over the course of a project.

At a given outcrop (station) the conversations I overhear in a class like this have the following character? “Where do you think we are located? What’s this rock? What’s the strike and dip? Is this really a fault? How have you drawn-in the contact?” I have a very simple expectation for each of you in engaging in such conversations: **Do not ask the question until you have made up your own mind.** So, if it is a question of ‘where are we located?’, you earn the right to ask (or answer) the question ONLY after you have penciled your inferred location on your map. Then you compare with the decision/judgment made by someone else, who has plotted her/his location. If it is a question of rock type, you have earned the right to ask (or answer) a question of ‘what’s this rock’ ONLY after you have described in your notebook what you are seeing, and have written down your name for the rock type. In this way you experience working independently but at the same time properly benefit from interaction with others.

In every project I will, at some point, block out a time and small parcel of ground within which you will be carrying out strictly independent mapping alone, and in silence, and for a grade. Think of it as field quiz. Indiana University’s field camp has embedded this requirement into their program for decades. Such field quizzes will seize your complete attention and surge your adrenalin, but largely I want the quizzes to feel no different than business as usual, which within reason will be the case if you have developed the confidence and skill that derives from largely independent geological mapping.

Available Geological Mapping, Pertinent to our Projects

In selecting map areas for this course, I not only have relied on my own personal familiarity with the geology of southern Arizona, but also have consulted published geologic maps. Published geologic maps prepared by the Arizona Geological Survey and the U.S. Geological Survey tend to be at scales of 1:62,500 or 1:24,000. These are ‘small-scale maps’ compared to the ‘large-scale mapping’ (1:6000) we will carry out. As a consequence, the level of detail that we will achieve in our mapping will be much greater than that achieved on the smaller-scale maps. Seeing the small-scale maps in advance undoubtedly would be helpful, but I will make these available to you only after the completion and grading of each of our mapping projects. You will find this to be quite illuminating, for in a glance you will see the limitations and strengths of carrying out geological mapping at different scales.

In the meantime, keep in mind that geology field camp programs are carried out as if the students were dropped down to earth from Mars, with the requirement of mapping areas without any consultation with products of earlier mapping. I expect you **not** to consult any published maps. On the other hand, I will make available to you, and we will discuss, the published geological columns (of rock units and stratigraphy) for each of the areas of mapping. This approach conforms to most geology field camps,
where prior to the start of a given project the students are introduced to local stratigraphy.

Getting Back to the Question: Where Are We Located On The Base Map?

Field camps, for the most part, have not yet come around to permitting students to use GPS to pin down location. There is a good reason for this: the challenges of ‘reading’ topography and imagery calls upon 3D visualization in profound ways and forces a continuous inspection of the landscape expressions of rocks and structures. Pushing a button is no substitute. Thus most field camp directors expect students to determine location via topographic contours, cultural features, aerial photographic imagery, and even dead reckoning. This is how we will begin the course. There will be no turning to GPS devices to ‘nail’ location. I anticipate softening this mandate before the end of the course, perhaps creating a hybrid approach. The timing of ‘softening’ will relate in part to the results of early field quizzes. And yes, the same constraints apply to taking strike-and-dip orientations and constructing stereographic projections. We will not, at least at first, substitute digital approaches for these methods.

Evaluation and Grading

For each project the basis for grading will be the quality of the field notebook, geological map, and geological cross section each of you prepares for each of the three map areas. There are two additional grading components as well, and these derive from your performance on field quizzes and the quality of your summaries of the geologic history of each of the map areas. For the specifics, see “Grading”, another important module on our GEOS496e D2L site.

One of the benefits you will receive in this course is evaluative feedback on your progress. Field camp projects can be a day-after-day blur for both faculty and students, and not uncommonly the only comprehensive feedback descends at the end of the project, after the final work is handed in and graded. In contrast Ryan and I intend to collect field notebooks and field maps at the end of each mapping day, and provide to you comprehensive feedback prior to the next mapping day in the field.

Closing Thoughts

The practical short-term objective of this course is to provide you with meaningful preparatory experience for geology field camp. The career-long goal is to give you more grounding in experience, which in turn will stimulate greater efficiencies and competencies in your deciphering challenging geological relationships and histories. Even if the last geological mapping you carry out is in field camp, or as a part of graduate research, the knowledge and discipline you gain from geological mapping will be applicable to most aspects of empirical geological inquiry, no matter whether the data sources are outcrops, geologic maps, cross sections, thin sections, seismic reflection profiles, or well data. I believe this to be true.

George H. Davis
January, 2015
FIELD SCHEDULE FOR GEOS496e

Field Day 1, 01/23/15: Davidson Canyon: geological mapping
Field Day 2, 02/06/15: Davidson Canyon: geological mapping
Field Day 3, 02/20/15: Davidson Canyon: geological mapping
Field Day 4, 02/27/15: Davidson Canyon: geological mapping
Field Day 5, 03/13/15: Rincon Valley: Geological Mapping
Field Day 6: 03/27/15: Pistol Hill: geological mapping
Field Day 7: 04/03/15: Pistol Hill: geological mapping
Field Day 8: 04/17/15: Pistol Hill Road: geological mapping
Field Day 9: 04/24/15: Pistol Hill: geological mapping
Field Day 10: 05/01/15: Pistol Hill Road: geological mapping

GS201 CLASSROOM MEETING SCHEDULE FOR GEOS496e

Friday, 01/16: Organizational Meeting, GS 201, 10AM-11AM.
Friday, 01/30: Sketching/Drawing, Chuck Albanese, GS201, 10AM-12 Noon
Friday, 2/13: Photography, Pete Kresan, GS201, 10AM-12 Noon
Perhaps other sessions, TBD.

OFFICE HOURS FOR GEORGE DAVIS (RM 326)

Tuesday, 1:30-2:30
Thursday, 9:30-10:30
Or by appointment

OFFICE HOURS FOR RYAN LEARY (RM 307)

Wednesday, 10:00-12:00
Non-field day Fridays, 10:00-12:00
Assignments and Grading, GEOS496e

The required performance products are geologic maps, field notebooks, geological cross sections, field quizzes, and write-ups of geological history interpreted from the rock record.

Attendance and participation are expected on each of the field days. The finalized field schedule will be firmed up during the first day of class. Every attempt will be made to schedule the map days on Fridays that meet everyone’s semester calendars. When the schedule is finalized, each registered student must decide whether he/she can meet the participation requirements of the course. When emergencies or illness interfere with participation, we instructors will try to make reasonable efforts for a make-up day, but this in no way can be assured in advance.

A component of overall grading is attendance/participation. Even one day of unexcused absences from fieldwork could drop 25 points from the total grade. This reflects the fact that learning opportunities are forfeited on missed field days. If a student is impacted by unavoidable schedule conflicts deemed critically important by the student and the instructor, or becomes physically unable to participate in the fieldwork, then I will urge the student to drop the course (Passing). Extending an Incomplete in a course such as this is not a practical reality.

Here is the ‘breakout’ of points.

**Davidson Canyon (400 possible points):**
- Attendance/Participation: 25 possible points
- Geological Map: 200 possible points
- Field Notebook: 50 possible points
- Geological Cross sections: 50 possible points
- Field Quizzes: 50 possible points
- Write-Up of Geological History: 25 possible points

**Rincon Valley (100 possible points):**
- Geological Map: 60 possible points
- Field Notebook: 10 possible points
- Geological Cross sections: 20 possible points
- Write-Up of Geological History: 10 points

**Pistol Hill (500 possible points):**
- Attendance/Participation: 25 possible points
- Geological Map: 300 possible points
- Field Notebook: 50 possible points
- Geological Cross sections: 50 possible points
- Field Quizzes: 50 possible points
- Write-Up of Geological History: 25 possible points

Thus there are 1000 possible points. Cutoffs for A, B, C, and D are 90%, 80%, 70%, and 60%, respectively.
UA and Geosciences Academic Policies

**Attendance:** Students are expected to be regular and punctual in class attendance. The University believes that students themselves are primarily responsible for attendance. Instructors will provide students with written statements of their policies with respect to absences. Excessive or extended absence from class is sufficient reason for the instructor to recommend that the student be administratively dropped from the course. Administrative drop is an instructor’s option, not an obligation. Instructors are not required to drop students who fail to attend class. Any student who intends to drop or withdraw from a course must do so following drop and withdrawal instructions. Students who are enrolled in a course but fail to attend class will receive an E grade in the course.

**Cheating and Plagiarism:** Cheating is any attempt to represent someone else's work as your own. Cheating can result in a failing grade for this course and expulsion from the University (see UA Code of Academic Integrity in the Schedule of Classes). Do not plagiarize (see [http://dos.web.arizona.edu/uapolicies](http://dos.web.arizona.edu/uapolicies)). The Department of Geosciences has a zero tolerance policy about cheating.

**Caveat:** Information contained in this course syllabus, other than the grade policy, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor. This is particularly true of a field course, where circumstances of land access and weather can impact scheduling.