SYLLABUS
GEO 660A & B – FIELD GEOLOGY
SUMMER 2018

DESCRIPTION: The capstone six-week summer field course for undergraduate geoscience majors in several Jackson School degree options. Taught annually outdoors at sites in west Texas, New Mexico, Colorado, Wyoming, Montana, Idaho and Utah by up to ten faculty/research scientists. The course consists of ~ 15 single or multi-day projects that focus on aspect of field description and interpretation. Products generated include measured sections, reports, photopan interpretations, cross sections, maps and stereonets. Geo660A and Geo660B are two separate three week courses; students may enroll for one or both.

INSTRUCTORS: Field Camp Director: Dr. Mark Helper, JGB 4.112
helper@mail.utexas.edu
Phone: Office - 471-1009
Cell – 512-924-2526
Other Instructors & Assistant Instructors: See attached.

TEACHING ASSISTANTS: See attached.

GRADING: Field Projects, Field Tests, Presentations………………………. 100%

Project scores are weighted by the number of days in the field. The number of projects varies by instructor, locality, weather and year. Single day individual exercises (field tests) are weighted double. See the attached course schedule and calendar for details.

This course carries the Independent Inquiry flag. Independent Inquiry courses are designed to engage you in the process of inquiry over the course of a semester, providing you with the opportunity for independent investigation of a question, problem, or project. You should therefore expect a substantial portion of your grade to come from the independent investigation and presentation of your work.

PREREQUISITES: A grade of C or better in Geo. 420K and Geo. 428, or permission of field camp director.

OTHER ITEMS: **Announcements and course information will be posted on the 660 website at** http://www.geo.utexas.edu/courses/660/default.htm**. *Check it often* prior to departure for updated information about the travel schedule, lodging addresses, a calendar of projects, sign-up details, etc.**

Academic dishonesty will not be tolerated. Anyone in violation of University policy (see Student Handbook) will receive a failing grade and is subject to additional punitive measures, which may include expulsion from the University. Expectations during group work will be clearly stated by all instructors prior to commencement of projects. If you are unclear about what constitutes dishonesty or unsanctioned collaboration, ASK. Do not assume that one instructor’s rule apply to all projects.

REQUIRED ITEMS: See attached list.

Course Objectives

Why a class in geological field methods? Geology is first and foremost a field science. Field geology and field geologists provide literally the ground truth for geologic concepts and theories of how the earth works. *The degree to which we, as geologists, are successful observers and interpreters of rocks in the field depends in large measure on what we are prepared to see and record.* The old adage "I wouldn't have believed it if I hadn't seen it" is, in the case of field geology, more truthfully "I wouldn't have seen it if I hadn't believed it". We explore. We discover. Unfortunately, without sufficient experience and preparation we can't attach meaning to (and thus frequently ignore) what we don't recognized or understand. Discovery is, in part, "…seeing what everybody has seen, and thinking what nobody has thought." (A. Szent-Györgyi). From our vantage point, this requires a perspective acquired largely from field experiences.

Paradoxically, *we must also learn what to ignore*; "Wisdom is learning what to overlook..." (W. James). There is rarely, if ever, sufficient time for exhaustive field data collecting. As time permits, we thus typically focus on a relatively few key aspects at a field site, paying less or no attention to the rest. Anthropologists term this ability to recognize and sort the significant from the insignificant "professional vision". It is a crucial field skill that comes mostly from practical experience. You will begin to develop your professional vision in this class.

Field proficiency has long been a distinguishing characteristic of our science. As a geoscientist, you are expected to be a proficient scientific observer and recorder. Your unique skills and training in this area separate you from lawyers, engineers, chemists and other professionals with whom you might one day work. Without proper preparation, including a strong grounding in field methods, we would be little better than rock hounds out for a day of casual collecting. Field geology is not merely collecting data and samples; it is about making sense of the geology around you, about making geologic interpretations. Landscapes are histories, with time marked by boundaries in the rocks, soil and sediment. A geologic map or a measured section is the articulation of that history, with each line marking a before and after, a hiatus that might last a second or a billion years. Through our maps and graphical logs, we represent time as space. *The ability to create, read and interpret such product is best developed from training and practice in a field setting*. It all begins by making and recording observations. An accurate record in the form of a map, measured section, photograph, sketch, a carefully documented sample, field notes, etc. provides a permanent, solid basis upon which to develop testable ideas and interpretations – the plot of the story. Without such evidence, interpretations are fanciful fables; there is no scientific basis to objectively evaluate them.

Successful field work depends greatly on how well we can formulate and test ideas while in the field. Geology is rooted in the scientific method. The process of formulating and testing multiple working hypotheses during field work is a distinctive, unique, vital aspect of our profession, one that can only be taught and practiced while in the field.

Like all sciences, geology has its own vocabulary. There is no better way to learn a language than to be immersed in it. This course can provide that immersion.

It is often said "The best geologist is the one who has seen the most rocks" and there is much truth to it. Six weeks of field work at some of THE classic geologic localities in the western US provides a strong introduction, the beginnings of a mental catalog of rocks and field relationships that can provide a framework to build upon in future classes, later field work and a future career in the geosciences.

660 STAFF, 2018

Faculty	Expertise/Interests
[1] Dr. David Mohrig	Sedimentology, depositional systems
[1] Dr. Charles Kerans	Carbonate depositional systems
[1] Dr. Rowan Martindale	Paleontology, earth history
[1] Dr. James Gardner	Volcanology
[1] Dr. Peter Hennings	Structural geology, tectonics
[1, 2] Dr. Mark Helper	Cordilleran geology, geology of crystalline rocks
[1, 2] Dr. Brian Horton	Basin analysis, tectonics
[2] Dr. Danny Stockli	Structural geology, petrology, geochronology
[2] Dr. Jamie Barnes	Stable isotopes, convergent margins
[2] Dr. Daniel Breeker	Stable isotopes, soils

Assistant Instructors (Faculty Advisor)

[1, 2] Tomas Capaldi, Ph.D. Candidate — Basin Analysis (Horton; 3 year 660 experience)

Teaching Assistants (Faculty Advisor)

[1] Margo Odlum, Ph.D. Candidate	Basin analysis, tectonics (Stockli; 1 year 660 experience)
[1] Sarah George, Ph.D. Candidate	Andean tectonics (Horton; 1 year 660 experience)
[1] Ben Smith, Ph.D. Candidate	Carbonate depositional systems (Kerans; 1 year 660 experience)
[2] Jake Makis, M.S. Candidate	Ore deposits (Cloos; 1 year 660 experience)
[2] Cullen Kortyna, Ph.D. Candidate	Tectonics, basin analysis (Stockli)
[2] Eunsil Jung, Ph.D. Candidate	Clastic Sedimentology (Steel)

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[1] Teaches all or part of 660A

[2] Teaches all or part of 660B

EQUIPMENT LIST - GEO 660

Required Materials:

- ☐ Field notebook (e.g., engineer's field book)
- ☐ Clipboard (8 1/2 x 11 size) **with cover**
- ☐ Geologic hammer
- ☐ Hand lens (10x)
- ☐ Small squirt bottle of dilute (approx. 10%) HCl
- ☐ Grain size card
- ☐ Six-inch ruler (best is the Post ruler with protractor on it)
- ☐ Protractor (bring spare rulers & protractors; many students lose several)
- ☐ Pencils and erasers (again, the number depends on how many you lose)
- ☐ 2 or 3 drafting (mechanical) pencils (recommend Pentel or equivalent 0.5 mm or 0.3 mm lead, hardness F or 3H) and spare leads
- ☐ Colored pencil set that will keep a point (at least 10 colors); pencils with hard, water-fast lead are preferred
- ☐ Pencil sharpener or pointer, and/or sandpaper – for colored pencils
- ☐ Technical pens with fine-line points and black ink (Sizes 00, 0, 1, are desirable)
- ☐ Tablet of 8 1/2 x 11" tracing paper
- ☐ Tablet of 10 square to the inch of 8 1/2 x 11" graph paper
- ☐ Liquid paper (optional)
- ☐ The textbooks and lab manual from GEO 420K and GEO 428
- ☐ Calculator
- ☐ Watch
- ☐ Carrying bag (shoulder bag or daypack)
- ☐ Proper field clothes, long pants, long-sleeve shirts, jacket (see note on gear)
- ☐ Sun screen/block lotion
- ☐ Hat, wide brim
- ☐ Hiking boots, broken in (avoid non-lace boots; see note on gear)
- ☐ Rainwear (it will rain; see note on gear)
- ☐ Canteen (2 or 3, one-quart water bottles, a Camel-Back or some other water storage container)
- ☐ Warm sleeping bag and pad** (see note on gear)
- ☐ Towels, washcloth
- ☐ Flashlight and/or headlamp
- ☐ Plate, cup, silverware

Desirable Materials:

- ☐ Digital Camera
- ☐ Masking tape
- ☐ Scotch tape
- ☐ Tweezers (important for run-ins with cactus)
- ☐ Insect repellent
- ☐ Minor first aid kit for bug bites, thorns, blisters (moleskin), etc.
- ☐ Small pair of binoculars
- ☐ Whistle (if you are prone to getting lost and have a weak voice)
- ☐ Safety goggles or other eye protection
  (see field course policy handout regarding this and hard hats)
- ☐ Sharpie markers to label rocks

Prohibited Items:

Firearms
Consumption of alcohol in UT vehicles
Illegal drugs

Gear for Geo. 660

The equipment list for Geo. 660 contains items that many of you may not own that can be relatively expensive.   Below are some ideas on adequate equipment at reasonable prices. A little searching on the web can yield tremendous dividends.

<u>Boots</u>

Footwear is the single most important item for a field course. Good boots provide traction, protection and support for your feet. Tennis or basketball shoes are not adequate for the latter two reasons, nor are cowboy boots for the former. A wide variety of boot styles are available, from those with low-or high-top nylon/leather uppers, to all-leather boots. Leather boots provide maximum protection, support and, with the proper soles, excellent traction. Most today are designed with backpacking in mind, which requires relatively rigid uppers and maximum padding to provide comfort and support for carrying heavy loads. Once broken-in, a well-made boot of this type is unsurpassed for field use. They are the best at keeping feet dry, provide an important measure of protection from cactus and other thorny plants, and will usually (but not always) outlast a softer boot.

The major disadvantage of leather boots is price; a decent pair now costs over $150, with many in the $180-$250 range. Do you need leather boots at this price for 6 weeks of fieldwork? No. A well-made, cheaper pair of “soft” boots can be adequate if: 1) you’re relatively agile and light on your feet; 2) you’re field pack doesn’t weigh more than about 30 lbs.; 3) you’re not prone to kicking cactus.   I worked in soft boots for many years and, although they lasted little more than one season, I’ve was very happy with the lowest-priced models of Merrill, Vasque and Asolo boots, which can often be found on sale (or on the web) for less than $100/pair. Well-made pairs by major manufacturers sell at list prices of $70 - $200. Less well made varieties tend to lack side support (foot tends to roll sideways when walking across slopes) and can quickly come apart (soles detach, front rand comes off) after limited use. High-top boots provide ankle support and will keep scree and dirt out when moving down-slope on loose ground.

Regardless of the boots you select, you will be much more comfortable if you use well-padded socks with a clean pair of thin sock liners. Sock liners wick moisture from your feet and are easy to wash/rinse at the end of a day.

<u>Rain gear</u>

A good, well-fitting, waterproof coat is a necessity, not a luxury. We have never experienced a summer where it didn’t rain. Two summers were exceedingly wet, raining nearly every day and for several days on end. We camp and cook outdoors and are in the field every day, rain or shine. Strong winds and colder temperatures often accompany rain in the mountains.

Adequate rain gear need not cost 100’s of dollars, but a $5 plastic poncho, which is only marginally better than a plastic trash bag, won’t work in such conditions, nor will a thin nylon shell sprayed with Scotchguard. Lower-priced ($20-50) raincoats and rain pants, which are usually made of plastic- or coated nylon, are adequate and widely available in a variety of styles. The best of the least expensive brands is probably Frogg Toggs. Medium-priced coats (typically $50-100) can be somewhat lighter-weight, usually better ventilated, may have an attached hood and are thus more comfortable to work in. They are, however, no more water repellent than lower-priced varieties, sometimes less so. High-priced rainwear is general constructed of one or more “miracle” fabrics; lightweight materials that are touted to “breathe” while also being waterproof. In my opinion (based on several coats, boots, mittens, and a few other items) these fabrics are vastly overrated for the price. Nonetheless, such coats are generally ruggedly constructed, fit well, and typically have many desirable features (multiple pockets, armpit zippers, internal drawstrings, ancillary ventilation, etc.). Again, they are no more waterproof than much lower priced models. Ponchos and umbrellas don’t work well in windy weather.

Regardless of what you type of coat you choose be sure it’s large enough to allow for insulating layers underneath. Have a pair of rain pants.

Sleeping Bags and Pads

This summer, you will spend 28 nights sleeping on the ground in a tent. Nighttime temperatures can be as low as 30^o in June and are commonly 40^o-50^o. Blankets are only marginally adequate in such conditions; a sleeping bag provides better heat retention and insulation. The enormous price range for sleeping bags reflects differences in insulating materials, weight and construction. At the high end are extremely light, down-filled bags made of waterproof, breathable fabrics that have a comfort range that extends to -30^o F. These bags are uncomfortably warm for all but the coldest conditions. At the low end are cotton bags with natural or synthetic fiber insulation, some of questionable construction, which may or may not keep you warm at temperatures below 50^o. In between is a very large spectrum of nylon shell, down- or synthetic fiber-filled bags that are more than adequate for summer camping in the US Rockies. Fiber-filled bags are light, dry quickly, are easy to clean, are nearly as warm as down, and pack to a small volume. Like wool, they provide warmth even when wet. Down bags are typically more expensive, slow to dry and nonfunctional when wet. If you are concerned about your sleeping bag keeping you warm, bring a pair of long underwear to sleep in and make sure you have a good sleeping pad. I also use a sleeping bag liner to extend the temperature range of my bag.

A sleeping pad or foam mattress provides insulation from cold ground and a measure of comfort. A closed-cell foam or inflatable pad provides the best insulation. A blanket beneath you sleeping bag is better than nothing.

Tents

The Department no longer supplies tents. Tent prices have come down in recent years and very well made, 2- or 3- person tents are available for $200 or less. In evaluating a tent for this summer, ask yourself the following: Will the tent withstand windy (30-40 mph) conditions? If it has fiberglass poles the answer is no. Is it waterproof (or can it be made waterproof) in a sustained, heavy downpour? If the tent fly does not extend most of the way to the ground the answer is no. Do I have all the parts? A waterproof ground cloth (a sheet of heavy mil plastic will do) keeps the floor of your tent from absorbing water and protects against punctures.

Clothing

You should have clothing that will allow you to live and work comfortably in both cold (40^o) and hot (100^o+) weather. Cold is best dealt with by wearing layers that can be donned and shed as needed. For maximum comfort your outermost layer should be windproof; rain coats/pants are adequate. Beneath this, a layer that will trap air (sweater, sweat shirt, fleece jacket, down vest, etc.) comes next, underlain by one or more thin layers (T-shirt, long sleeved shirt) that provide additional warmth and wick perspiration from your skin. As much as 70% of your body's heat loss occurs through your head; if you're cold put a hat on.

A wide brim hat, bandanna, and sunblock are essential for working in the deserts of western US. Finally, you will be traveling or working outdoors nearly every day of the 6 weeks. You will load and unload your gear, along with ice chests, cook boxes, tarps, etc., many, many times along the way. It is to your and everyone else's benefit to travel light. Examine every piece of clothing you pack critically; do you really need it? Keep in mind that there will be opportunities to do laundry at most places we visit and we will not be anywhere that requires anything but field clothing.

Jackson School of Geosciences Department of Geological Sciences
Field Trip and Field Course Policies

The Department of Geological Sciences conducts numerous field activities (field trips, field geology courses, and field research). Because students are exposed to a variety of situations and experiences that are different from those found in the classroom, special rules of conduct are necessary. Traveling and field work involves hazards and risks, so each person must exercise care to avoid personal injury to others. Examples of dangers specific to field work are the use of geologic picks, poisonous snakes, tick bites, toxic plants, falling, and slippery rocks encountered when hiking on steep slopes or crossing streams. Other dangers, as well as damage to property, may be created by carelessness. The Department has access to certain private properties and use of private facilities whose future availability will depend upon proper consideration for these resources by everyone. Students who abuse University or personal property during a field trip, or who jeopardize the health and safety of other people, will be required to leave the field trip immediately. These persons will be subject to appropriate academic evaluation and possible disciplinary action by the Office of the Dean of Students.

The Department has the following rules and recommendations which apply to field activities.

1. **Liability and Waiver.** The University requires all students to sign a liability release form (accompanying form). This form must be signed and returned before a student is allowed to participate in field activities.
2. **Medical Care**. A medical form must be filled out by all students. Any student who has medical problems (e.g. asthma, diabetes, metabolic disorders, allergies, trick knees) should inform the field trip leader or supervising professor. If you require special medications, it is your responsibility to insure that they are available when needed. Field activities are sometimes in very remote areas, and immediate medical assistance is not possible.
3. **Health Insurance**. Every student taking a *field course* must have medical insurance. Student health insurance is available at minimal cost through the Student Health Center (471-4955). Students taking field trips as part of normal classes who do not have health insurance will be provided with insurance for the field trips only.
4. **Clothing and protective cover**. Wear suitable clothes. We recommend wearing a hat, long pants, and good hiking boots in some areas. These help prevent sunstroke, insect bites, and bad encounters with cacti or thorny shrubs. You may want to bring insect repellent, and we also suggest the use of sunscreen. Consider significant possibilities of rain or cold weather.
5. **General field hazards**. Insects, poisonous snakes, and toxic plants may be found on any field trip or course. Wearing suitable clothing and boots helps reduce these hazards. Remember to check yourself for ticks which can transmit diseases such as Rocky Mountain spotted fever, Lyme disease, etc. Ticks should be removed immediately; be sure to remove the body with head intact. Do not use a match to kill the tick first. Watch for, don't play with, and avoid snakes. Five students on Department trips have been bitten by rattlers since World War II; try not to be the sixth. If you are allergic to such things as bee stings, you must bring appropriate medication. A few other common sense rules: stay out of the water if you can't swim; stay out of thunderstorms, particularly at high elevations, and out of flashflood-prone areas in any rain. Some field areas have steep cliffs that you are not required to and should not climb; use common sense and follow your instructor's advice in such areas.
6. **Head and eye protection**. We recommend eye protection when using, or around someone using, a geologic pick, hammer, or other tools. Hard hats should be used in mines, quarries, steep road cuts, or other areas where rock falls or blows to the head could occur; some sites may require these protective devices. Safety glasses and hard hats can be checked out from the Department storeroom.
7. **Firearms**. Possession of firearms or facsimiles at any time during any field course or field trip is forbidden.
8. **Drugs and alcohol**. Use or possession of illegal drugs at any time is forbidden. Alcoholic beverages may NOT be consumed at any time while traveling in a University vehicle.
9. **Department equipment**. Take care of Department property. Our equipment normally gets hard use and current budgets are tight, so treat it as you would your own.

You have previously read and agreed by signature to follow the Field Trip/Field Course Policies for departmental field activities given above. Please keep them in mind this summer.

2018 Class Rosters (on 4/22/18)

Last	**First**	**email**	**660 course(s)**
Aguilar	Edgar	eaguilar14@utexas.edu	Both
Anderson	Hannah	handerson@utexas.edu	Both
Barcelo	Francis	francisbarcelo@aol.com	Both
Barnett	Corey	corey.barnett@utexas.edu	Both
Benavides	Juan	juanbenavid@hotmail.com	Both
Bezucha	Blake	blakebezucha@utexas.edu	Both
Bos Orent	Eytan	ebo1122@gmail.com	Both
Bunting	Christine	christinebunting@utexas.edu	Both
Cadena	Tyler	tjcadena@utexas.edu	Both
Collins	Cara	cara.collins@utexas.edu	Both
Florez	Darien	dflorez@utexas.edu	Both
Franey	John	johnfraney@utexas.edu	B
Fussee-Durham	Preston	prestondurham@utexas.edu	A
Garcia	Victor	victorgarcia5@utexas.edu	Both
Gearon	Jake	jake.gearon@gmail.com	Both
Hauglum	Anthony	anthonyhauglum@utexas.edu	Both
Hirtz	Jaime	jaimehirtz@utexas.edu	Both
Hoffman	Mary	maryhoffman97@gmail.com	Both
Kacur	Sean	smkacur@gmail.com	Both
Kopecky	Brooke	brooke.kopecky@utexas.edu	Both
Nix	Matthew	mattnix4@utexas.edu	Both
Nixon	Emily	emily_mixon@utexas.edu	Both
Ransom	Reid	rransom95@utexas.edu	A
Rasmussen	Matthew	mattewrasmussen181@gmail.com	Both
Ravzi	Sofia	sofiaravzi@gmail.com	Both
Roberts	Mitchell	mitchroberts1996@gmail.com	Both
Ruangsirikulchai	Arisa	arisa_ruang@utexas.edu	Both
Russell	Aaron	aaron.russell1@utexas.edu	Both
Varona	Gabrielle	gabrielle.varona@utexas.edu	Both
Wageman	Caroline	cgwageman@gmail.com	Both
Wagner	Ryan	wagner95@utexas.edu	Both

SCHEDULE FOR GEO 660A&B, SUMMER 2018

May 24	Travel to Carlsbad, NM; **Drs. Kerans, Mohrig & Martindale** (Stevens Inn)
May 25-26 AM	Guadalupe Mts. projects; **Drs. Kerans, Mohrig & Martindale** (Stevens Inn)
May 26 PM	Travel to Alamogordo (Holiday Inn Express)
May 27 AM	White Sands N.M. project; **Drs. Kerans, Mohrig & Martindale**
PM	Travel Ghost Ranch (camping, Ghost Ranch Conference Center)
May 28-29	Ghost Ranch project; **Drs. Kerans, Mohrig & Martindale** (camping, Ghost Ranch Conference Center)
May 30 AM	Ghost Ranch project; **Drs. Kerans, Mohrig & Martindale** (camping, Ghost Ranch Conference Center)
PM	Travel to Los Alamos; Intro. to Valles Caldera; **Drs. Helper & Gardner** (Hampton Inn, White Rock)
May 31-June 2	Valles Caldera projects; **Drs. Helper & Gardner** (camping, Bandelier N.M.)
June 3	Travel to Casper, WY; **Dr. Helper** (Super 8 Motel)
June 4-7	Alcova, WY Mapping Projects; **Drs. Helper and Hennings** (camping, Bear Trap Meadows)
June 8	Travel to Cody, WY; Big Horn Basin structure; **Drs. Helper and Hennings** (Buffalo Bill's Antlers Inn)
June 9	Travel to Sun River, Sawtooth Mts., MT; Basin structure; **Drs. Helper, Horton & Hennings** (camping)
June 10-13	Sun River Cross Section project; **Drs. Horton & Hennings** (camping, Sun Canyon Lodge)
	END 660A
June 14	Travel to Helena, MT, shop, set camp; **Dr. Horton** (camping, Kim's Marina)
June 15-21	Big Belt Mts. mapping projects; **Dr. Horton** (camping, Kim's Marina) – Day Off June 18
June 22	Field Test; **Dr. Helper & Horton** (camping, Kim's Marina)
June 23	Travel to Butte, MT (Berkeley Pit) and Hecla, MT; **Dr. Helper** (primitive camping)
June 24-27	Hecla project; **Drs. Helper and Stockli** (primitive camping)
June 28	Travel to Rock Springs, WY; **Dr. Helper** (dorms, Western Wyoming Community College)
June 29-July 2	Rock Springs clastic sed./strat. projects ; **Drs. Helper, Barnes & Breeker** (dorms, WWCC)
July 3	Travel to Dalhart, TX; **Dr. Helper** (Super 8 Motel)
June 4 or 5	Travel to Austin; **Dr. Helper**

MONEY FOR MEALS

- *All meals while camping and all lunches, except on some travel days*, will be provided.

- All hotels during the trip will provide at least a continental breakfast (bread, pastry, juice, coffee) and some may have hot food. If you eat a hardy breakfast you may want to purchase addition breakfast food – it will not otherwise be provided.

- Y*ou will need money to purchase lunch and dinner during some hotel stays*. These days are May 24, 25, 26, 30; June 3, 8; July 3 (7 total days).

Ice chest/refrigerators will be available to store food/medicine during hotel stays. You will be able to make a lunch from food we purchase for this purpose before going into the field, *provided you are leave yourself time to do so before departure. All lunch food is put away at 7:45 AM*.

Geo660A&B Trip Addresses, Summer 2018

660A: May 24-June 13

May 24&25
Best Western Stevens Inn
1829 S Canal Street
Carlsbad, NM 88220
575-887-2851

May 26
Holiday Inn Express
100 Kerry Ave
Alamogordo, NM 88310
no phone or mailing address
(575) 434-9773

May 27-29
Ghost Ranch Conference Center
no phone or mailing address
HC 77, Box 11, Abiquiu, NM 85710-9601
EMERGENCY Contact:
Phone messages: (505) 685-4333, ext. 152

May 30
Hampton Inn
124 State Highway 4
Los Alamos, NM 87544
505-672-3828

May 31-June 2
Group Campsite
Bandelier National Monument
Los Alamos, NM
No phone or mailing address
Emergency Calls - 505-672-3861

June 3
Super 8
3838 C Y Avenue
Casper, WY 82609
(307) 266-3480

June 4-7
Bear Trap Meadows Campground
Natrona County, WY

June 8
Buffalo Bill's Antlers Inn
1213 17th St.
Cody, WY 82414
307-587-2084

June 9-13
Sun Canyon Lodge
8571 Sun Canyon Lodge Rd
P.O. Box 327
Augusta, MT 59410
(888) 749-3654

660B: June 14-July 4

June 14-22
Campground
Kim's Marina and Resort
8015 Canyon Ferry Rd.
Helena, MT 59602
(406) 475-3723

June 23 -27
Beaverhead National Forest,
Dillon Ranger District
Primitive camping at Hecla,
Pioneer Mts., near Melrose, MT
No phone or cell service

June 28-July 2
Western Wyoming Community College
2500 College Dr.
Rock Springs, WY 82902
(307) 382-1600

July 3
Super 8
403 Tanglewood Rd
Dalhart, TX 79022-1325
806-249-8526

3/27/2018
M. Helper

COURSE DESCRIPTION, GEO 660A&B, SUMMER 2018

WEEK 1 – Drs. Mohrig, Kerans and Martindale – See Figure 2 and 3
(May 24-30 AM)
Introduction to Guadalupe Mountains and Permian Basin Stratigraphic Setting/
Permian Reef Geology Trail, McKittrick Canyon

There is perhaps no more famous setting to begin your exploration of the field observation and interpretation of depositional processes than the Guadalupe Mountains. Tertiary faulting and uplift has caused the exposure of a shelf-to-basin setting that contains both carbonate and terrigenous sediments. Dramatic 2000-3000 ft high walls of carbonate and clastic shelf, slope and basin deposits are laid out in spectacular vistas. We will present the stratigraphic setting, and then sketch and interpret several of these major walls in terms of stratal geometric relationships and depositional processes.

An all-day hike on Day 2 up the 2000 vertical feet of the Permian Reef Geology Trail reveals the depositional facies and stratal geometries of a major reef-rimmed carbonate platform. We will use the Permian Reef Geology Trail guide as background material but will formulate our own model of a representative depositional profile from observations made along the trail.

Sacramento Mts. and White Sands National Monument, near Alamogordo, NM (May 27 AM)

The Sacramento Mountains, together with the Guadalupe and Franklin Mountains, comprise the outcrop trilogy used by industry and academic groups since the 60's to illustrate different styles of carbonate facies and reef styles. Exceptional exposures of unique Pennsylvanian phylloid algal mounds in Dry Canyon illustrate both a unique style of carbonate deposition and the distinct depositional patterns of an icehouse system, with repeated large amplitude swings in sea-level. These exposures, plus the Mississippian buildups of the Lake Valley Group provide a broad spectrum of carbonate and mixed systems. Reconstruction of environmental conditions associated with deposition of the Holder Formation, a Virgilian (Upper Pennsylvanian) mixed siliciclastic–carbonate sequence is a theme here. The White Sands gypsum dune field nearby also provides an ideal setting for examining dune geometries and aeolian processes that are a modern analog for our next project.

Travel to Abiquiu, NM (May 27 PM)

The drive north to Abiquiu and the Ghost Ranch Conference Center takes us across a young lava flow (the Carrizzo flow) and up the axis of the Rio Grande Rift (Fig. 3), the site of Tertiary crustal extension. Proceed north and northwest within the rift, we skirt Santa Fe and the giant Valles Caldera (our focus during week 2) along the western edge of the Espanola Basin, one of rift's central valleys. Following the Chama River, we drive up and out of the rift onto the eastern edge of the Colorado Plateau near Abiquiu, NM. Flat lying Triassic and Jurassic strata of the Plateau at Ghost Ranch (Fig. 3) are the next topic of study.

Aeolinites and evaporites – sedimentology and stratigraphy of the Jurassic Morrison, Todilto and Entrada Formations (May 28-30)

Here we measure, describe and interpret the stratigraphic and depositional contrasts between aeolian dune sandstone of the Entrada Formation and overlying gypsum and carbonate beds of the Todilto Formation, as exposed in the walls of the canyons surrounding our campground.

Week Two – Drs. Gardner, Helper and Hennings – see Figure 3
(May 30 PM-June 6)
Geology and volcanology of a supervolcano – the Valles Caldera, Jemez Mountains, New Mexico – Drs. Gardner and Helper (May 30 PM – June 2)
Following a short drive south to Los Alamos, NM (Fig. 3), we begin our study of the Valles Caldera. The Valles Caldera of the Jemez Mountains is *the* classic locality for understanding the nature of large-volume caldera eruptions. Exception preservation and outstanding exposures of Pleistocene eruptive products (ash flow and air fall tuffs, lava flows, lava domes) provide an unparalleled opportunity to examine, map and describe the hallmarks of these gigantic eruptions. A field trip our first afternoon examines the caldera proper and its youngest products. The main eruptive rocks and their precursors are studied the following day.

Days 2-4 are devoted to learning to recognize, interpret and map the intrusive and eruptive products of calderas through a mapping exercise that examine the geometry and sequence of volcanic deposits.

Travel to Casper, WY (June 3) – Dr. Helper
Leaving Los Alamos we travel a long day's drive north to Casper, Wyoming. North of Los Alamos we reenter the Espanola Basin of the Rio Grande Rift, then soon pass into the northern-most rift valley (a half graben) of the rift, the San Luis Basin (Fig. 3). As recently as 500 Ka, the northern San Luis Basin in Colorado was a closed basin that hosted a giant pluvial lake, Lake Alamosa. Southward draining of the lake is thought to have created the northern segment of the Rio Grande River in New Mexico (Fig. 3), helping integrate a vast drainage catchment that by 200 Ka resembled the modern Rio Grande watershed. We leave the Rio Grande Rift near Fort Garland, Colorado, cross the Front Ranges of the Rockies (here the Sangre de Christo Mountains) and emerge onto the high plains at Walsenburg, Colorado. Skirting Denver, we follow I-25 north along the Front Range into Wyoming (Fig. 4), where we enter the Wyoming Laramide Province of Precambrian-cored uplifts and intervening basins. These are our next topic of study.

Mapping a basement-rooted Laramide anticline, Alcova Reservoir, central Wyoming – Drs. Hennings and Helper (June 3-7)
With topographic maps and aerial photos, we will map the structural and stratigraphic relationships and interpret the subsurface geology of a small anticline with the aid of a stereonet and cross section. You will also visit the spectacular regional geology of the Alcova area and become familiar with the complexity of natural fractures. This relatively simple mapping and cross section exercise is a prelude to later, more complex mapping and subsurface interpretation.

Week 3 - Drs. Hennings, Helper and Horton – See Figure 5
(June 6-13)
Big Horn Mountains and Big Horn Basin Transect – Drs. Henning, Helper and Horton (June 8)
After finishing the Alcova project, we travel north and west to Cody, Wyoming (Fig. 5). From Sheridan to Cody, your job is to observe Laramide fold and fault geometries and speculate on their subsurface continuations. This information will inform your ~E-W regional cross section of the Big Horn Mountains and Basin at the latitude of Cody, which you will complete before day's end. Spectacular vistas in the Big Horns and westward across the Big Horn Basin, and Dr. Henning's guidance, will allow you to do so!

Clark's Fork Canyon and Travel to Sawtooth Mountains – Drs. Henning, Helper and Horton (June 9)
Departing Cody, we travel a short distance north to the mouth of Clark's Fork Canyon at the eastern end of the Beartooth Mountains (Fig. 5), another Laramide basement uplift. Here Big Horn Basin folded and faulted stratigraphy is brought above ground to observe and record. Proceeding north and westward, we cross the leading edge of the Createaceous Sevier fold-thrust belt near Bozeman and later Helena, MT (Fig. 5), and travel along its leading edge to our destination in the Sawtooth Range (Sun Canyon Lodge) near Augusta,

MT. Along the way we enter the country explored by Lewis and Clark, with spectacular Big Sky vistas of isolated, snow-capped mountain ranges.

Leading Edge of the Sevier Belt, Sawtooth Range, Montana – Drs. Henning and Horton (June 10-13)
From a camp near the Sun River in the Sawtooth Range, we examine, measure and map in cross section the geology and geometry of the leading edge of the Sevier belt. The spectacular Sevier Fold and Thrust Belt is a Late Cretaceous to Early Paleogene belt of thin-skinned deformation that extends the length of the Rocky Mountains. The end result of our field work in the Sun River area is a cross section constrained by surface observation, map data, and a seismic reflection profile. You will learn how practicing structural geologists make use of a combination of tools and techniques to arrive at a constrained subsurface interpretation in a structural complex setting.

This ends the first 3 week class, GEO660A

Week 4 - Dr. Horton – See Figure 5
(June 14-20)

Travel to Helena and Canyon Ferry, MT – Dr. Horton (June 14)
As we turn our vehicles south for the second half of the class, a short drive takes us back to Helena, the state capitol, last seen five days earlier on our trip north. Here we meet new TAs (and say so long to old ones), grocery shop and set up camp nearby along the northern edge of Canyon Ferry Reservoir, the largest of a series of reservoirs along the upper Missouri River.

Structural geology of a fold-dominated portion of the Sevier Belt – Dr. Horton (June 15-22)
Working from our camp at Kim's Marina (Fig. 5) on the southern edge of the Big Belt Mountains, you will learn how to map, measure and describe the geology of this fold-dominated salient of the Sevier Belt. This is accomplished during two 3-day projects, a day off, and a field mapping test. Each of the projects share common components:

- **Day 1**: Introduction to setting and stratigraphy
    - Compile a stratigraphic column of map units, recon. the field area, begin mapping
- **Day 2**: Continued mapping
    - Begin constructing cross section and stereonets
- **Day 3**: Finish mapping
    - Turn in map, cross section and stereonets

Evening lectures provide information on stereonets, cross-section construction and the geology of the Sevier and Laramide Orogenies.

Week 5 – Drs. Horton, Helper and Stockli (June 21-27) – See Figure 6

Travel and ore deposits introduction: Field trip to Butte, Montana; travel to Hecla, near Melrose, MT - Drs. Helper and Stockli (June 23)
After completing your work in the Big Belts with Dr. Horton, we travel southwest to Butte, MT (Fig. 6) to see what remains of "the richest hill on earth". The topics this day are giant porphyry copper deposits, EPA superfund sites and mining in the west. After buying supplies, we drive south into the Pioneer Mountains, where we establish a camp near the ghost towns of Lion City and Hecla, once the center of the richest silver mining district in Montana. Here we spend four days documenting and unraveling field relationships among deformation, plutonism, contact metamorphism and mineralization within facies equivalents of the same rocks mapped in the previous two projects.

Hecla Project: Ore deposit geology and geologic processes - Drs. Helper and Stockli (June 24-27)
This project integrates different geological disciplines to unravel the geological history of this late-1800's silver-zinc mining district. Field data will be collected over four days to understand the sedimentary, structural, metamorphic, magmatic and hydrothermal history of this area and to produce a concise report that synthesizes this information. In addition to introducing concepts in metamorphic and ore geology, this exercise offers a unique chance to integrate different types of data to understand the geological history of an area – a common exercise for any earth scientist.

Week 6 - Drs. Helper, Barnes and Breeker – See Figures 6 and 4
(June 28 – July 4)
Travel Southeast to Rock Springs, Wyoming – (Dr. Helper June 28)
A long day's drive out of the mountains, into the mountains, out of the mountains… traversing Pliocene flood basalts of the Snake River Plain (our lunch stop), the southern end of the Teton Range, the continental divide, the Green River Basin (Fig. 6) to finally arrive at Rock Springs, WY on the northern edge of the Laramide Rock Springs Uplift (Fig. 4). Stay awake and you'll see some of the best that the northern Rockies has to offer.

Clastic stratigraphy and sedimentology, Cretaceous Interior Seaway deposits near Rock Springs – Drs. Helper, Barnes and Breeker (June 29-July 2)
Here we examine, document and interpret the development of a tectonically-generated clastic wedge that built out into the Late Cretaceous Western Interior Seaway during 12 million years. This part of the course involves photo interpretation of sedimentary architectures, logging and interpretation of sedimentary strata, facies analysis and paleogeographic reconstruction. Emphasis is on high-frequency regression and transgression of shorelines during the construction of the large-scale clastic wedge.

Travel to Austin - Dr. Helper (July 3, 5)
The first day of this 2-day drive takes us across the Great Divide Basin of southern Wyoming, down of the front ranges of the Rockies (Fig. 4), across the Raton Basin and onto the high plains of the Texas panhandle (Figs. 3 and 1), where we spend the night in Dalhart. Our last day begins on the Llano Estacado and ends on the Edwards Plateau (Fig. 2), a largely featureless drive across a vast portion of this great state. It's been 6600 miles of geologic immersion, with experiences to last a lifetime - what a class, what a trip!

Figure 1. Geological Route Map, Summer 2012

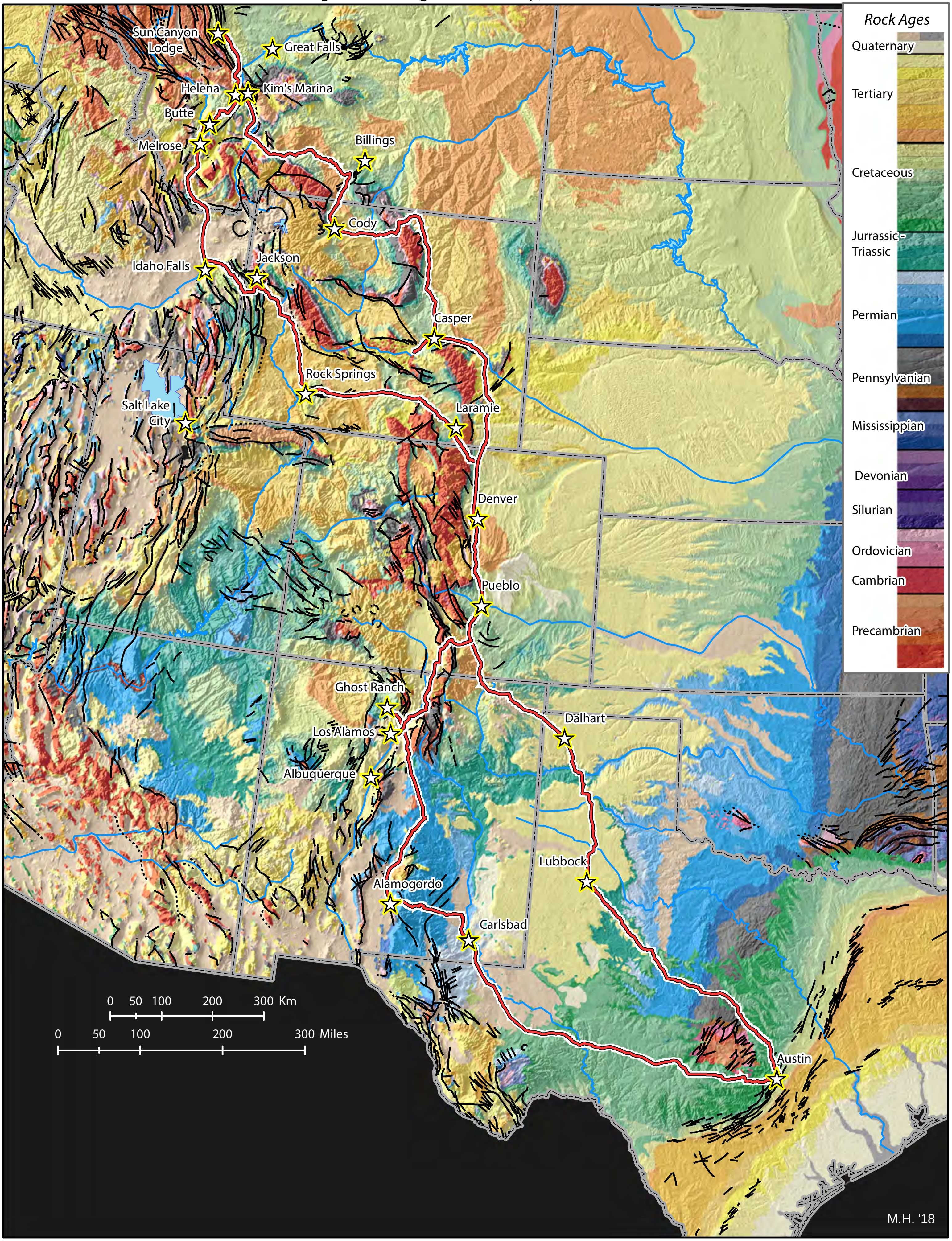


Figure 2. Route Map 2 – Austin, Texas to Albuquerque, New Mexico

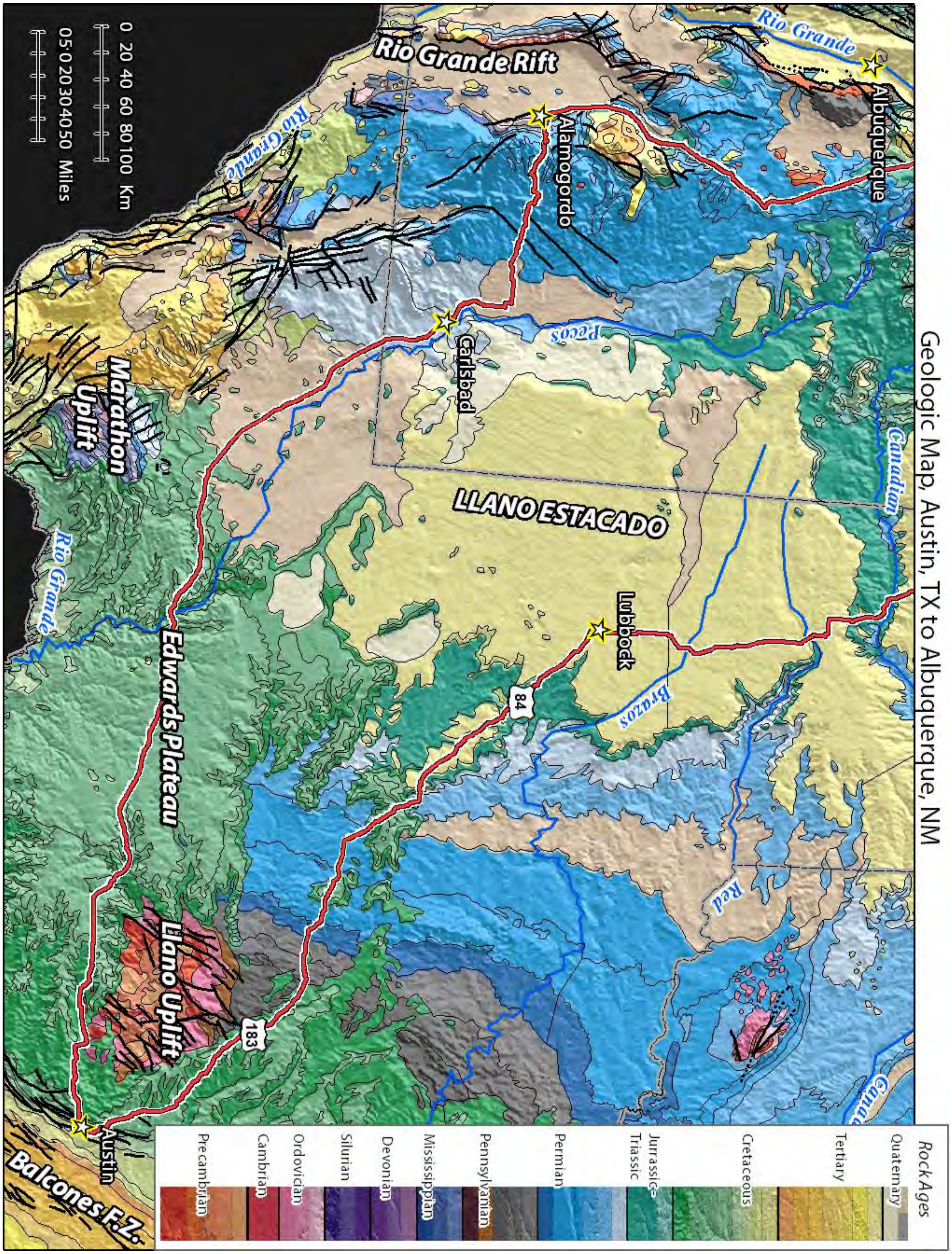


Figure 3. Route Map 3 – Albuquerque, New Mexico to Denver, Colorado

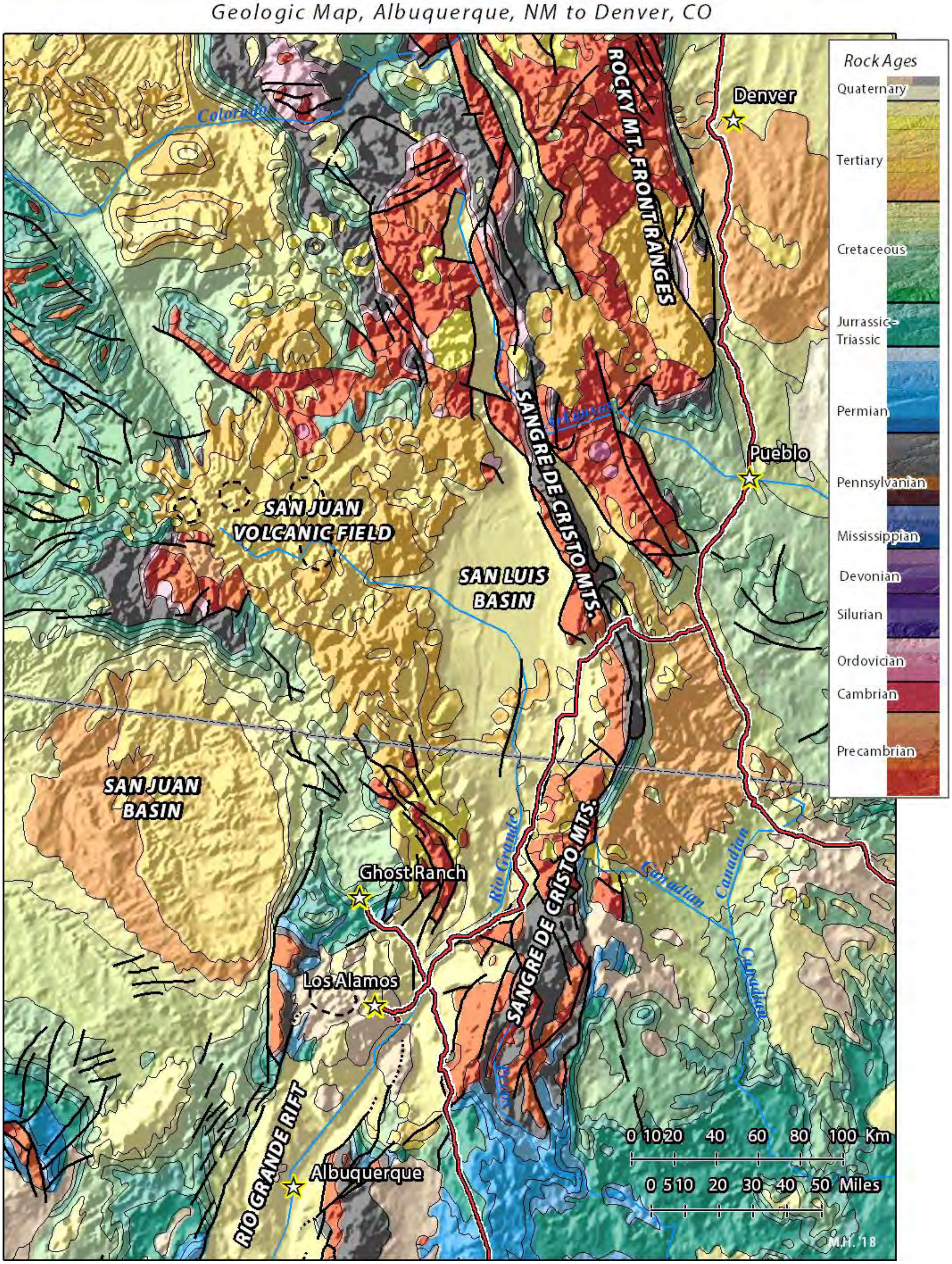


Figure 4. Route Map 4 – Denver, Colorado to Rock Springs, Wyoming

Figure 5. Route Map 5 – Casper, Wyoming to Great Falls, Montana

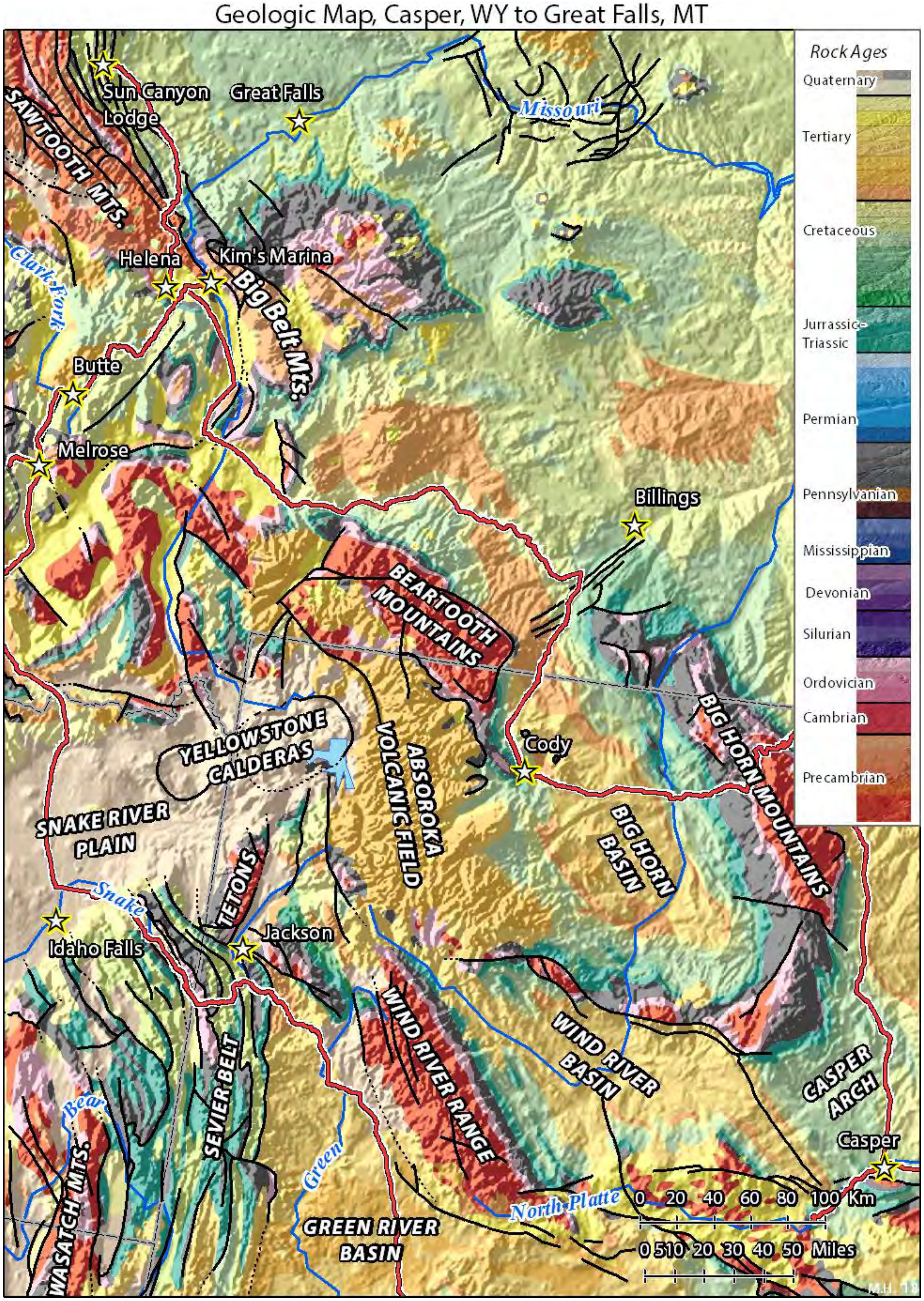
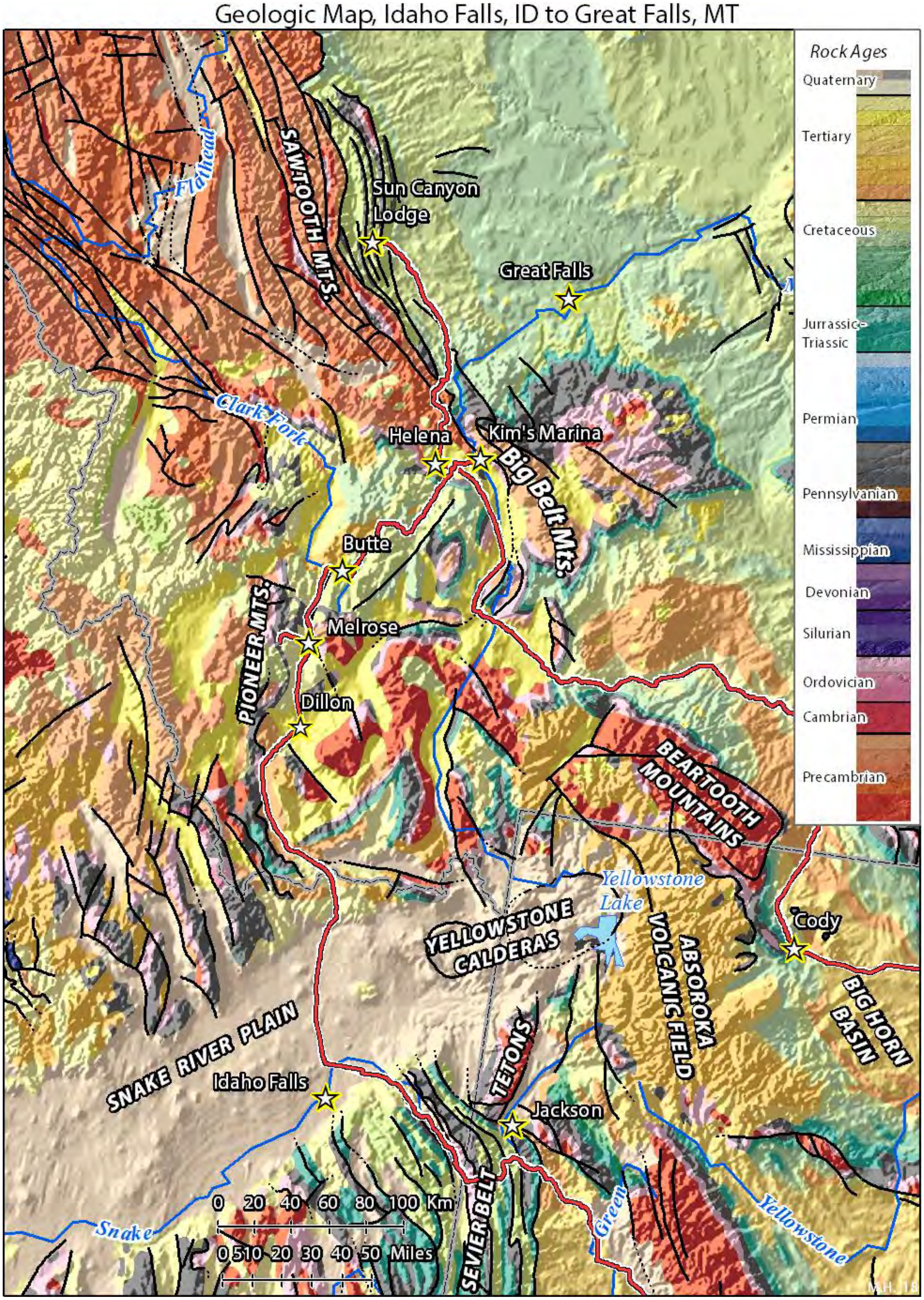


Figure 6. Geological Route Map – Idaho Falls, Idaho to Great Falls, Montana



Being Academically Prepared

Sedimentary Geology

Below are listed some general aspects of sedimentary geology that you will be expected to have mastered by the time you leave for Geo 660. All of this material was covered in Geo 416M and Geo 420K. The best sources for your review are your notes, the text, and the web sites for these courses.

1. **Classification of rocks and sediment by texture**

You must be able to classify terrigenous sediments and rocks by texture (e.g., poorly sorted, immature, fine-grained sandstone). This means that you must be able to identify the mean grain size, estimate the grain sorting, recognize the four stages of textural maturity, and recognize grain shape and roundness. You should be able to tell if the sorting reflects a unimodal, bimodal or polymodal grain distribution. Impact scars on pebbles and larger grains are important to identify. Rock color also reflects important aspects of the rock. You must have an understanding of the factors that control these sediment/rock characteristics. For sandstones and conglomerates be able to estimate the abundance of framework grains, matrix, cement, and porosity using your hand lens.

You must be able to distinguish those rock aspects that are depositional in nature from those that result from weathering. For example, weathering commonly results in the oxidation of pyrite and other ferrous minerals, differential dissolution of minerals, hydration, oxidation, and case-hardening of joints. Precipitation of travertine crusts and soluble white salt crusts (efflorescence), as well as Liesegang bands, are post-depositional products. In addition, it is usually possible on outcrop to recognize basic lithology (e.g., sandstone, limestone, shale) by weathering habit.

Be able to classify carbonate rocks according to the Dunham classification, including identification of major grain types. Know the major taxonomic groups of invertebrate fossils and their environmental significance. Know the marine evaporite mineral sequence.

2. **Classification of rocks and sediment by mineralogy**

Be able to classify sediment and rocks by mineralogy (e.g., arkose). For sandstones be able to estimate the type of common cements (quartz, calcite, dolomite, siderite, iron oxides, kaolinite), the abundance of QFR components, and clan name using the Folk classification. Understand the relationship between mineralogy, source area, and other controls such as climate, tectonism and nature of transport.

3. **Sedimentary structures**

You must be able to identify sedimentary structures and understand under what conditions they form. Be able to identify common fossils, know their age ranges, and environmental significance. Below are listed some common sedimentary structures and other features of sedimentary rocks. You should be able to recognize these, understand how they form, and interpret their genetic significance.

Laminations
Wind-ripple laminations
Trough cross-strata
Tabular cross-strata
Current ripple and climbing ripple cross-strata
Wave ripple cross-strata
Hummocky cross-strata
Textural mottled bedding
Structureless (massive) bedding
Graded and reverse graded bedding
Contorted bedding
Nodular bedding
Flaser and lenticular bedding
Herringbone cross-strata
Scour-and-fill structures
Channel walls and channel-fills
Cryptalgal laminations, stromatolites (laterally linked and stacked hemispheres)
Bouma sequence
Wave and current ripple marks
Trace fossils: burrows, tracks, and trails
Flute casts, groove casts, load casts
Parting lineation
Mud cracks
Stylolites
Liesegang bands
Chert and other nodules, calcite-cemented concretions (and other types)
Cone-in-cone structure
Adhesion structures

Breccia
Paleokarst
Evaporite molds
Inter vs. intraparticle porosity
Boundstone
Geopetals
Fenestral fabric

4. **Depositional and diagenetic environments and processes**

You must be able to make a basic interpretation of environment of deposition (e.g., deep-sea turbidite sequences, meandering fluvial channel). You should be able to determine whether the seafloor was well oxygenated, suboxic, anoxic. Clues are TOC (reflected in rock color), presence of absence of trace fossils, abundance of pyrite, etc. Most information is derived from the larger-scale geometry of the strata. You should always scan an outcrop for the continuity of beds, the overall strata arrangement, faults, channel structures, and vertical trends before studying the rock up close.

For carbonate and evaporite environments, review the shelf-to-basin facies tract, the environmental factors important for carbonate/evaporite production, the different styles of carbonate shelf architecture as a function of changes in sea level, climate, time in geologic history. Review the principal mechanisms proposed for (1) changing sea level, (2) dolomitization, (3) subaerial and subaqueous evaporite deposition, (4) cyclic sediment deposition.

5. **Field methods**

You must be able to perform basic field procedures including (1) measuring a section with a staff and Brunton compass or similar instrument, (2) identifying textures and mineralogies with a hand lens, and (3) using a Brunton compass or similar instrument to measure bedding and foreset orientations, (4) operate a hand-held GPS instrument.

6. **Data presentation**

You must be able to display geological information in various formats including (1) vertical sections, (2) scaled field sketches, (3) cross-sections, (4) neatly drafted maps, (5) stereonets.

7. **Basin-scale processes**

You must have a basic understanding of (1) tectonic basin types, (2) the types of environments associated with these, and (3) the types of sediments characteristic of the different types of basins and source areas.

8. **Global-scale processes**

You must have a basic understanding of the depositional architectures and their scales as a function of cycles of sea level, climate and tectonism. Know the general history of Earth change (e.g., greenhouse/icehouse periods, first-order sea-level curve), and the basics of higher order processes such as orbital forcing of Earth's climate.

Structural Geology & Mapping

The topics and the skills outlined below were covered in GEO428, 426P, 420K, 416K and 401/303, particularly in labs and/or field trip exercises. Notes, texts, old labs and web sites for these courses are particular valuable resources for review.

1) Be able to read a topographic map, construct a topographic profile along a line of section, and have the ability to accurately locate yourself with a topographic map.

2) Have a good understanding of strike lines (structure contours), 3-point problems, the rule of V's, and how these are manifest on geologic maps by unit contacts, fault traces, fold axial traces.

3) Be able to correctly use a Brunton compass to measure the attitudes of linear and planar features.

4) Be able to construct stereographic projections of the attitudes of lines and planes, and determine a fold axis from attitude measurements of folded layers.

5) Be able to appropriately label maps and cross sections (and where these items belong on a finished product): title, author, date, north arrow, scale bar, contour interval, stratigraphic symbols, explanation of symbols, location of cross section; endpoints of cross section, orientation of cross section, vertical scale, and vertical exaggeration.

6) Be able to draw a structural cross section; know how to project data from a map into the plane of a cross section.

7) Know fold terminology and map symbols: fold axis, axial surface, hinge line, axial trace, plunge, fold limbs, cylindrical, overturned vs. upright, parallel vs. non-parallel, angular vs. curved.

8) Know fault terminology and map symbols: thrust, normal, strike slip, footwall, hanging wall, displacement, dip and strike separation, fault tip, fault ramp, detachment, listric, thin-skinned vs. thick-skinned, releasing and restraining bends.

9) Be able to interpret a geologic map, including relative ages from superpositional or cross-cutting relationships, dip directions from map patterns, anticlines vs. synclines and directions of plunge, axial trace symbols, up vs. down sides of faults from map patterns.

Igneous Geology

1) Know how to classify igneous rocks using compositional criteria (intrusive rocks: granite, granodiorite, gabbro, peridotite; extrusive rocks: rhyolite, andesite, dacite, basalt) and textural criteria (tuff, welded tuff, vitrophyre, etc.), and apply appropriate adjectives (porphyritic, aphanitic, phaneritic, etc.).

2) Be able to identify common minerals in igneous rocks with a hand lens. These include, but are not limited to, quartz, plagioclase, k-feldspar, biotite, muscovite, clinopyroxene, amphibole (hornblende) and olivine.

3) Have an appreciation for the geological settings in which different igneous rocks might be found.

Metamorphic Geology

1) Know how to classify metamorphic rocks (slate, phyllite, schist, gneiss, hornfels) and apply appropriate adjectives (granoblastic, porphyroblastic, foliated, etc.).

2) Be able to identify common metamorphic minerals with a hand lens. These include, but are not limited to: i) minerals common to most metamorphic rocks: quartz, plagioclase, k-feldspar, biotite, muscovite, chlorite, ii) pelites: garnet, aluminosilicates (andalusite, kyanite, sillimanite), staurolite, iii) metabasites: clinopyroxene, orthopyroxene, amphibole (hornblende, tremolite/actinolite), and iv) metacalcsilicates/metacarbonates: calcite, dolomite, talc, tremolite, wollastonite, diopside.
3) Have an understanding of the concepts of metamorphic facies, P-T and T-X grids and isograds, including an appreciation of the dependence of mineral assemblages on rock composition, temperature, pressure and fluid composition/availability.

4) Understand the relationship of fabrics defined by metamorphic minerals to minor and major folds and faults/shear zones.

5) Know metamorphic index minerals for pelitic and mafic rocks.