Graduate Student Field Trip Proposal

Department of Earth & Planetary Sciences

Northwestern Wyoming and Southwestern Montana
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View of Twin Lakes from the Beartooth Highway, Beartooth Ranges, Montana-Wyoming border

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Introduction

The region of northwestern Wyoming and south-central Montana offers a wide variety of geology and earth science related attractions. This proposal outlines a nine-day field trip for graduate students and faculty to explore sites in this region of the American West and to share expertise in both field techniques and conceptual background for a wide range of topics, broadly: structural geology, tectonics, volcanism, geomicrobiology, igneous petrology, economic geology, paleontology, sedimentology and stratigraphy, fluvial and glacial geomorphology, and more.

Such field trips have been particularly valuable for incoming G1 students in the past, as well as returning graduate students, as both an intellectual experience and a social introduction to our department. This region of the American West in particular offers the opportunity for students from a wide range of disciplines to be exposed to spectacular real-life examples of geologic phenomena outside their area of specialty, or with which they are familiar but have not had previous opportunities to experience first-hand. In addition, visiting some of the greatest wilderness regions of the lower 48 states will give unique opportunities for reflection and discussion on past and future treatment of natural resources and conservation.

As with past field trips, each participant will be asked to prepare a short written description of a topic or site that will be covered during the trip, and to present this background information during an appropriate illustrative stop in the field. Essays will be collated to create field guides available to participants before departure. This approach was particularly valuable during the 2007 Arizona field trip, as at least one participant could be looked to as an "expert" for each of our stops, and the written field guide proved to be a unique and effective source of information for all stops on our group itinerary.

Proposed field destinations

There are a limitless number of localities in western Wyoming that are of diverse geologic interest. The following field destinations were selected for their broad academic appeal. They include aspects of volcanology, structural geology, tectonics, glacial and fluvial geomorphology, igneous petrology, stratigraphy, hazards monitoring, active tectonics, and economic geology. The schedule has been constructed to provide a breadth of academically relevant stops as well as opportunities for social interaction. The primary field destinations are the western Bighorn basin, the Beartooth Mountains, Yellowstone, and the Teton Range.

Western Bighorn Basin

The western Bighorn Basin has been an important petroleum region since the beginning of the 20th century. We hope to visit the Elk Creek oil field, a currently and historically producing reservoir defined by a doubly plunging anticline. We will be camping at Buffalo Bill State park, where the Shoshone River cuts through the Rattlesnake Range. This canyon is a classic example of an ancestral river. The reservoir and dam on the

Shoshoni River are also an interesting case of water management and use in the Western U.S. Additionally, while staying in Cody, we hope to enjoy some of the Old West cultural attractions, such as Old Trail Town.

Elk Creek Oil Field

Beartooth Mountains

One of the most spectacular and scenic portions of the Rocky Mountains, the Beartooth mountains are a large basement block which was uplifted during the Laramide Orogeny 60 million years ago. Precambrian basement rocks were thrust up during crustal compression, folding the overlying strata. The high mountains also bear the signs of extensive glaciation in the past two million years. Rock exposures in the Beartooths offer a special opportunity to observe outcrop-scale features such as fossil assemblages, sedimentary structures, and bed dips in a number of locales to reconstruct a geologic and tectonic history of the area for a significant portion of geologic time. While in the area, we will visit Clark's Fork Canyon, which offers outstanding exposure of a large section of the folded stratigraphy that spans the entire Paleozoic (including different fossiliferous beds), illustrating a number of depositional environments and the regional tectonics of the Beartooth uplift.

Clarks fork canyon

As we travel the Beartooth Highway, short stops will allow us to see more of these sedimentary units and interesting igneous features in the basement rock, allowing us to gain further insight into the large-scale structure of the Beartooth Uplift. We will also see the Heart mountain detachment fault, a notoriously contentious structure in the southern Beartooths, where we will discuss the phenomena of detachment faulting and the peculiarities of this specific example. Additionally, we will see many different glacial surficial features. We will also visit the Stillwater complex, a layered mafic sill that is mined for platinum and palladium. While staying in Red Lodge, we also hope to see the Pig Races at the Bear Creek Saloon, which is sure to be a memorable social experience.

Heart mountain detachment fault

Banding in the Stillwater Complex

Yellowstone

America's first national park, Yellowstone is home to a wide variety of geologic and ecologic attractions. While countless days could be spent exploring the park, we will focus our visit on a few topics and sites representing unique and varied geologic phenomena, while also allotting time for more general sightseeing, as decided by participants.

Yellowstone Caldera

Sitting atop a hot spot, Yellowstone encompasses the largest volcanic field in North America. This position sets the stage for many of the unique active geologic processes taking place within the park. Features will be considered individually and within this greater context.
(Illustration from usgs.gov, Smith and Siegel, 2000)

Volcanic features

Tuffs, basalts, and rhyolites from many generations of eruption over the last several millions of years are exposed at various sites within the park, including within the classic V-shaped Grand Canyon of the Yellowstone (River). Hydrothermal alteration of rock layers can also be observed here. In addition, parts of the caldera structure can be observed from numerous points in the park. (Photo from usgs.gov, Bob Smith, University of Utah.)

Geothermal features

Yellowstone encompasses the greatest number of geothermal features and geysers existing within a single region. *Mammoth Hot Springs* display an enormous collection of unique hydrothermal travertines and a wide variety of thermophilic microbial populations. Environmental microbial diversity, influence on landscape and ecology, and feedbacks with inorganic materials and processes (geomicrobiology) will be discussed, along with travertine formation and trace element occurrence related to hydrothermal activity.

Geysers, mudpots, and fumaroles are common features in the park – 60% of the world's geysers are located here. Upper and Lower Geyser basins contain numerous opportunities to witness the regularity of some of these explosive features. (Photos from nps.gov.)

Hazards monitoring

The Yellowstone Volcano Observatory (YVO) monitors seismic activity and surface deformation relating to risk from volcanic eruption, earthquakes, and hydrothermal events, all of which are active processes in Yellowstone. Information from this agency will provide a starting-point for broad discussion of active hazard-monitoring techniques within the park, and communication with staff may allow for a group tour of monitoring facilities.

Other Features include the Continental Divide, Precambrian schists and gneisses, the Absaroka volcanic range to the east of the park, glacial features such as ponds and erratics, and active faulting, including Hebgen Lake, site of fatal landslide in 1959, for which the landslide scar is still visible.

Wildlife/Conservation

Along with the fascinating microbial populations existing in and around the geothermal features of Yellowstone, the park is home to a remarkable and protected range of indigenous flora and fauna, such as bison, grizzly and black bears, elk, moose, mountain goat, pronghorn, bighorn sheep, mountain lion, and the recently reintroduced endangered gray wolf. While we will undoubtedly encounter wildlife, a focus of this visit will be addressing responsibility and safety in interacting with wildlife of the West, as well as challenges in balancing conservation and usage of natural resources. A student presentation will highlight these issues and describe the unique ecosystem we observe in Yellowstone, which extends to the Tetons. As per park regulations, we will take appropriate precautions with food and gear at campsites and during hikes.

Teton Range

The Tetons are a north-south trending mountain range of impressive topographic relief in Wyoming near the border with Idaho. Movement along the Teton fault began 6 to 9 million years ago associated with regional extensional tectonics in the western United States, and it continues to the present. The surface morphology of the Tetons has also been strongly shaped by glacial processes active during three ice ages in the past 2 million years. We will see the range-front fault, granites and cross-cutting basaltic dikes at Mt. Moran, and numerous glacial surficial features, including U-shaped valleys, lateral and terminal moraines, and kettle ponds. Additionally, we will see the Gros Ventre slide, a landslide that resulted from an earthquake the region in 1925.

U-shaped glacial valley below the high peaks of the Teton Range

Logistics

The budget is formulated for 20 and 25 participants. However, the cost per student is fairly constant, so a group size between 15 and 25 will work well. We will fly from Boston to Jackson, Wyoming, with a connecting flight in Denver or Chicago. In Jackson, we will rent four to six six-passenger minivans (depending on final number of participants) with unlimited mileage. Because we will be camping, participants will need to bring their own camping gear (tents, sleeping bags, hiking boots, etc.). We will borrow group gear such as cooking stoves from the department, to be supplemented by renting any additional necessary gear from an outfitter in Jackson. The day before the trip begins, 2 people will arrive in Jackson Hole, WY, rent one of the vans, buy groceries and pick up camping gear. They will camp in Jackson, WY and return to the airport the next day when the rest of the participants arrive. Groceries may additionally be purchased in Cody and Red Lodge as needed. We will camp in national forests, state parks, and national parks. Entrance fees for some of these destinations may be waived for academic groups.

While snow is not usually a limiting factor in the regions we will be visiting until mid-October, if there is unseasonable snow, the Beartooth highway may be closed. In the highly unlikely event that this does occur, we have developed an alternative itinerary in which we would travel south from Cody to Thermopolis, Shoshoni, and then along the eastern front of the Wind River Range through the Wind River Basin, and back up through the Togwotee pass back to Jackson. If this were to be necessary, modest additional costs may be incurred in order to stay at different campgrounds and possibly additional entrance fees to the Thermopolis hot springs and Wyoming Dinosaur Center.

Amanda Hughes and Hilary Close will act as trip leaders in both pre-trip planning and in the field. Before the trip, they will be responsible for reserving the necessary flights, rental vehicles, campsites, rental camping gear and group tours. Additionally, they will assemble information on where supplies can be purchased and the location and contact information for hospitals and emergency medical assistance throughout the field area. They will assemble a field guide which, in addition to scientific information, will also have the detailed itinerary and emergency phone numbers, to be distributed to each of the participants. They will also collect health and emergency contact information for each of the field participants prior to the trip. When in the field, they will be responsible for the safety and well-being of the group, ensuring that the group has adequate safety supplies and practices safe hiking and camping habits. Additionally, all participants in the field trip will be strongly encouraged to attend a pre-trip first aid training session that we will arrange for late August.

Both trip leaders will be equally prepared in terms of knowledge about the itinerary, reservations, driving routes, and details of geologic sites. If the participating group is large, this will allow us to split into two groups when necessary for practical purposes, e.g. a mine tour with 12-person maximum, or for campsite duties. Both leaders have participated in EPS fall field trips and have led other large group-field trips in the past, in addition to having backgrounds in field geology, so they are well-equipped to handle the roles involved.

Schedule

The tentative schedule of the trip is as follows:

Day 1: Arrive in Jackson Hole, WY. Drive to Cody, WY (169 miles, ~4 hours), camp at Buffalo Bill State Park.

Day 2: Field stops in the vicinity of Cody (~50 miles total). Stops include Clarks Fork Canyon, Rattlesnake Mountain and Shoshone canyon, and the Old Trail Town. Return to camp at Buffalo Bill S. P.

Day 3: Visit the Elk Creek oilfield (45 miles, 1 hr 20 min) and continue on to the Red Lodge area (32.6 miles, 1 hr 20 min) to view the frontal thrust and structure of the Beartooth range. Camp at Parkside campground in the Custer National Forest.

Day 4: Visit the Stillwater mine (55 miles, 1 ½ hours each way). Return to Bear Creek, MT to go to dinner and pig races at the Bear Creek Saloon, return to Parkside campground.

Day 5: Travel the Beartooth Highway from Red Lodge to Yellowstone (131 miles, 3 ½ hours). Several stops along the way to view igneous and sedimentary rocks, structural relationships, and glacial geomorphology. Stop at Specimen Ridge to view petrified trees. Camp in Yellowstone National Park.

Day 6 and 7: Yellowstone destinations, including Mammoth hot springs, Hebgen Lake, the Geyser trail, Yellowstone falls, and a tour of hazard monitoring facilities.

Day 8: Drive to Grand Teton National Park (94 miles, 2 ½ hours) Take Bridger Gondola to the top of Rendezvous Mountain. Option to hike here or in Cascade Canyon. See the Gros Ventre landslide, camp at Gros Ventre Campground.

Day 9: Pack and depart from Jackson Hole Airport for Boston.

Planned Destinations. Other destinations also fall along this route. A. Yellowstone Campground, B. Jackson, C. Cody, D. Clark's fork canyon, E. Elk Creek Oil Field, F. Parkside Campground, G. Bear Creek Pig Races, H. Stillwater Mine, I. Beartooth Highway, J. Specimen Ridge, K. Hebgen Lake, L. Mammoth Hot Springs, M. Geyser Basin, N. Teton Village.