

COURSE DESCRIPTION, GEO 660A&B, SUMMER 2013

Days 1-5: Permian Basin of West Texas and New Mexico

The Permian Basin of West Texas and New Mexico is one of the most famous geological sites in the world. Tertiary faulting and uplift has caused the exposure of a shelf-to-basin setting that contains both carbonate and terrigenous sediments.

Day 1: Introduction to Guadalupe Mountains and Permian Basin Stratigraphic Setting

We will leave early on the morning of Day 1 and drive more or less non-stop from Austin to the Guadalupe Mountains to begin our introduction to the field geology of stratigraphic successions. There is perhaps no more famous setting to begin your exploration of the field observation and interpretation of depositional processes. Dramatic 2-3000 ft high walls of carbonate and clastic shelf, slope and basin deposits are laid out in spectacular vistas. We will present the stratigraphic setting in this setting, and then will sketch and interpret several of these major walls in terms of stratal geometric relationships and depositional processes. Shelf margin strata of the Western Escarpment, Slope and basinal sediments of Guadalupe Canyon and the Rader Slide, and deep-water carbonates and evaporites of the Lamar Limestone and evaporites of the Castile Formation will be examined as a record of the final phases of deposition of the Permian Basin.

Day 2: Permian Reef Geology Trail, McKittrick Canyon

Day 2 is an all-day hike up the 2000 vertical ft of the Permian Reef Geology Trail to learn about 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.

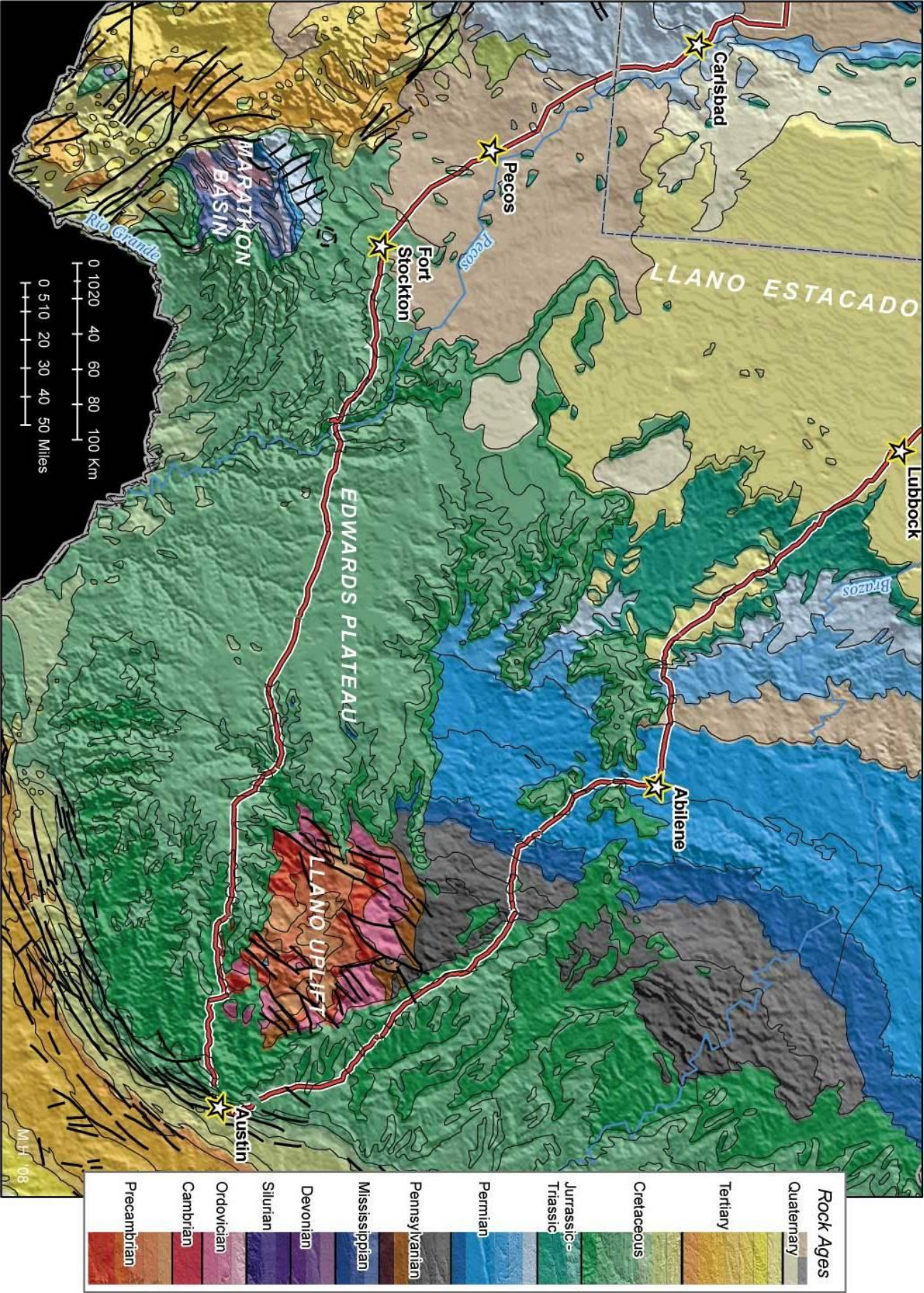
Day 3-4: Stratigraphic Analysis of the Shelf and Shelf Margin of the Tansil-Capitan-Lamar profile

Days 3 and 4 will be a focused project on one of the dip-profiles of the Capitan shelf. This will be a group exercise where we measure detailed stratigraphic sections and tie these to photomosaics of the outcrop to construct a high-resolution sequence stratigraphic model of the margin evolution.

Day 5: Carbonate ramps and ramp margins of the San Andres and Grayburg Formations

In contrast to the steep reef-rimmed margin of the Capitan-age platform, the interior of the Guadalupe Mountains is characterized by broad low-angle depositional profiles of the San Andres carbonate ramps. We will spend our last day in the Guadalupe Mountains studying this system using techniques learned during days 3 and 4. Group measured sections and mapping will allow the group to reconstruct the depositional patterns of this, the most productive hydrocarbon system in the onshore U.S.

Geo660 Route, Austin to Carlsbad



Day 6-7: Sacramento Mts. and White Sands National Monument, near Alamogordo, NM

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. Day 6 will be spent studying the unique phylloid algal mounds of the Pennsylvanian of Dry Canyon. These exceptional exposures 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, will complete our tour of carbonate and mixed systems of the desert southwest. The White Sands gypsum dune field visited on Day 7 provides an ideal setting for examining dune geometries and aeolian processes. Day 7 ends after a long drive up the Rio Grande Rift to Albuquerque and Santa Fe, NM and across the rift to the Colorado Plateau in the vicinity of Abiquiu (see map below, where we establish a camp at Ghost Ranch).

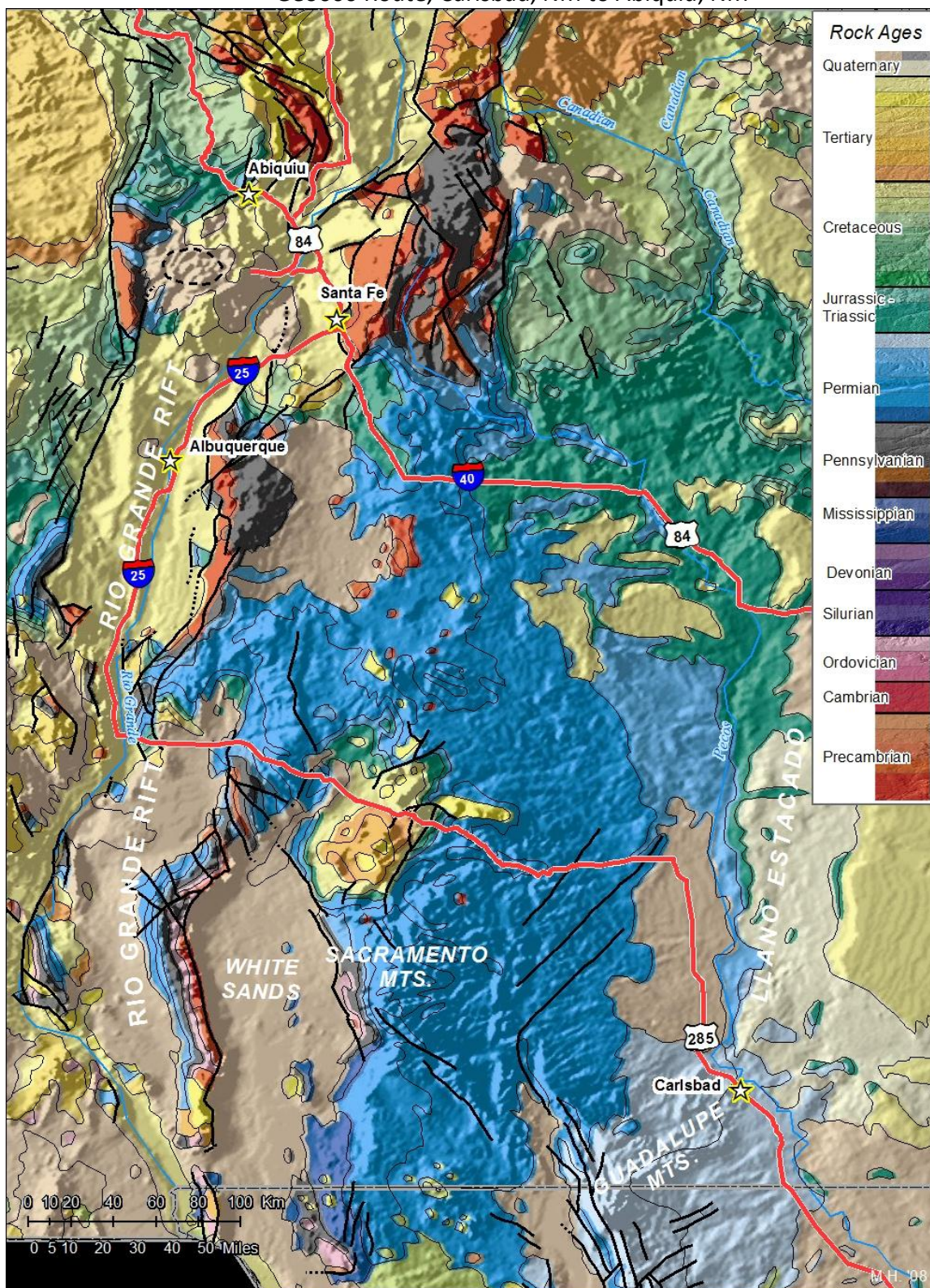
Day 8-12: Geologic Mapping in the Abiquiu embayment, NM

The Abiquiu embayment of the Rio Grande Rift contains a sedimentary and tectonic record of Mesozoic and Tertiary events related to the Laramide compression and Rio Grande rifting. This record is contained in an exceptionally well preserved and exposed sedimentary section that contains two major unconformities, folds and faults. Three days of mapping here focus on documenting and understanding this history through construction of a geologic map, cross section, stratigraphic column and stereonet. Rocks and sediments contain a record of Permian through Quaternary uplift, subsidence erosion, folding and faulting all within a small, easily accessible area.

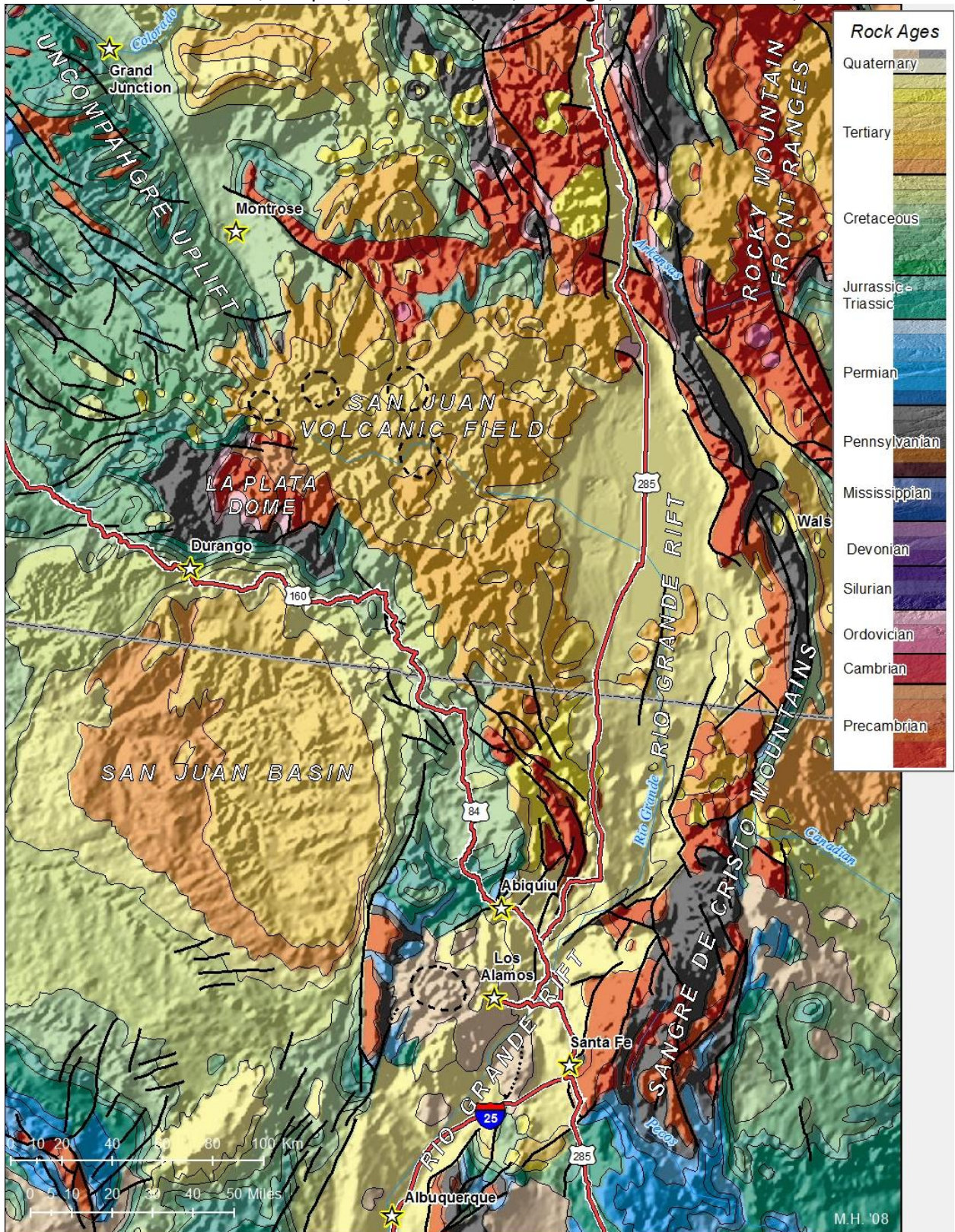
Day 13: Travel to Rock Springs, WY (see following map)

A long driving north this day takes us through the northern most and highest basin of the Rift (San Luis Basin and Taos Plateau) into southern Colorado, where we leave the rift and climb into the middle ranges of the Colorado Rockies. Crossing Tennessee pass, we drop down through Vail, Colorado and the Colorado River, then climb up into the North Park of the Rockies before descending to the Washakie Basin at the CO/WY border. Turning west on I-80, we cross the Washakie Basin and its Cretaceous and Tertiary Fill. Our destination farther west is Rock Springs, which sits on the western flank of the Rock Springs uplift. The uplift is a broad domical asymmetric anticline. Gently east dipping Cretaceous and Tertiary strata on the east limb of the dome begin to dip more steeply west near Rock Springs. These same Cretaceous strata, deposited near the eastern margin of the Cretaceous interior seaway, are the focus of study while in Rock Springs. We end the day at Western Wyoming Community College in Rock Springs, Wyoming, on the western edge of the Rock Springs Uplift in the easternmost Green River Basin.

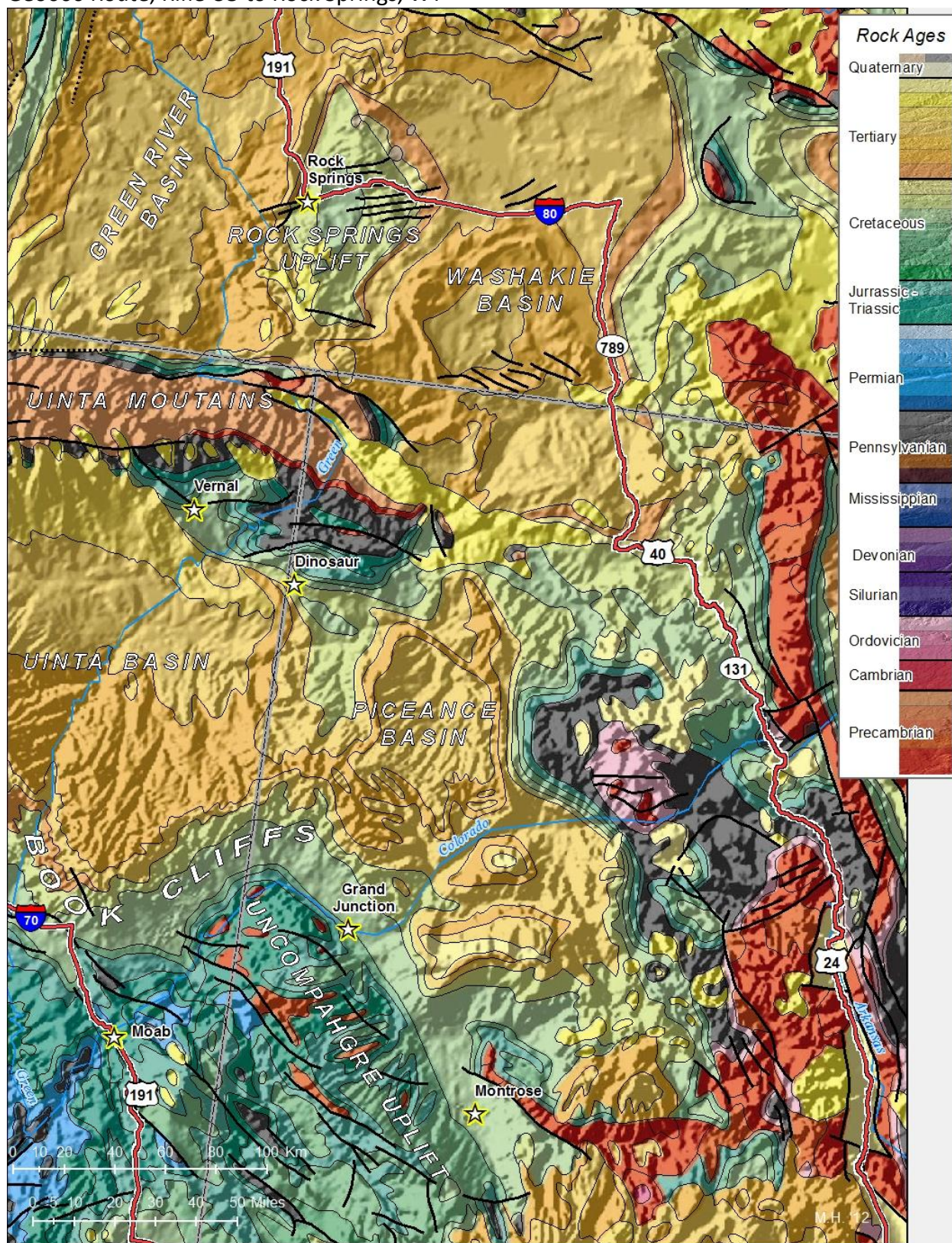
Geo660 Route, Carlsbad, NM to Abiquiu, NM



Geo660 Route, Abiquiu, NM to Rifle, CO; Durango, CO to Los Alamos, NM



Geo660 Route, Rifle CO to Rock Springs, WY



Days 14-18: LATE CRETACEOUS WESTERN INTERIOR BASINS: EVOLUTION FROM SHALLOW EPICONTINENTAL FORELAND TO DEEPWATER LARAMIDE BASINS

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, interpretation of well logs and seismic data, and paleogeographic reconstructions. There will be emphasis on high-frequency regression and transgression of shorelines during the construction of the large-scale clastic wedge.

Day 14:

- A large exercise in each of Sevier and Laramide basin types. Digest the key differences.
- Overview trip to show the stratigraphy of the Ericson-Rock Springs clastic wedge.

Day 15:

- Field exercises in Haystack Mts. Fm. near Rawlins. Practice logging in tide- and wave-influenced deltas, and in river deposits (I-80, Sinclair Road).

Day 16:

- Excursion to fluvio-estuarine Ericson Fm., Pipeline Canyon, Hwy 430. Trail, Rusty & Canyon Creek members; the core of the clastic wedge.

Day 17:

- Blair Sandstone Project (Hwy 430).

Day 18:

- Examine shelf-edge deltas that feed down into deepwater turbidites of Washakie (Laramide) Basin.

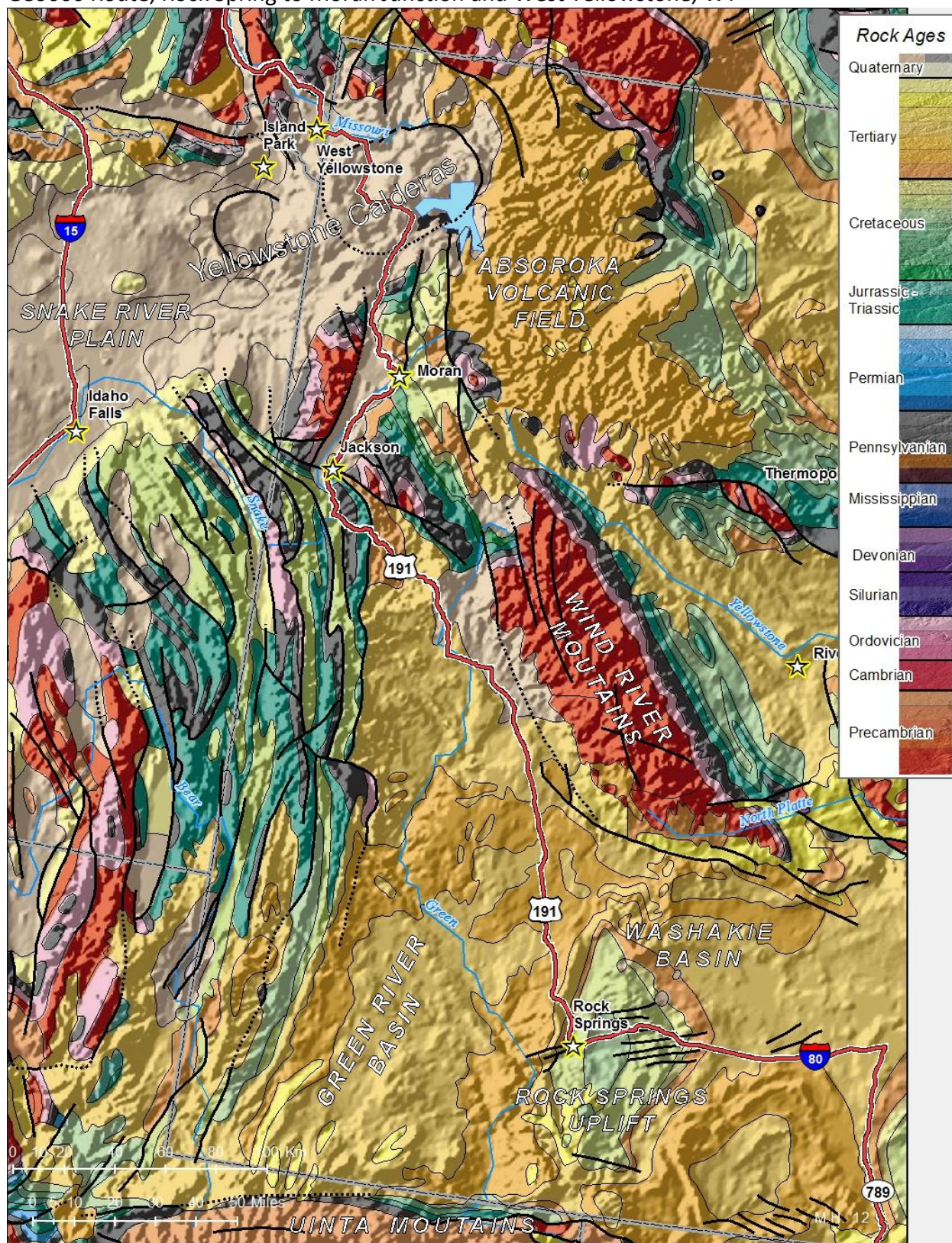
Day 19: Travel from Rocks Springs to Moran Junction, WY (see map below)

A spectacular drive this day takes us NW through the Green River Basin along the SW flank of the Wind River Mountains to Jackson, WY, which sits within the thin-skinned Sevier fold-thrust belt of western-most Wyoming. The Sevier belt here meets the younger Teton Range in Grand Teton National Park, where we will camp for two days. The drive takes us through some of the classic geology of the west. John Wesley Powell and David Love, two giants of field geology, made this region their life's work. Their fascinating and inspiring stories are detailed in the two marvelous books: Rising from the Plains (John McPhee) and The 100th Meridian (Wallace Stegner).

Day 20-21: Volcanology of the Yellowstone Hotspot; Neotectonics and Glaciation in the Yellowstone-Teton region

This part of the course examines the products and processes associated with caldera cycles, and the glacial history, seismicity and faults of the Greater Yellowstone region.

Geo660 Route, Rock Spring to Moran Junction and West Yellowstone, WY



- **Day 20: Teton Fault; Lecture on Yellowstone**

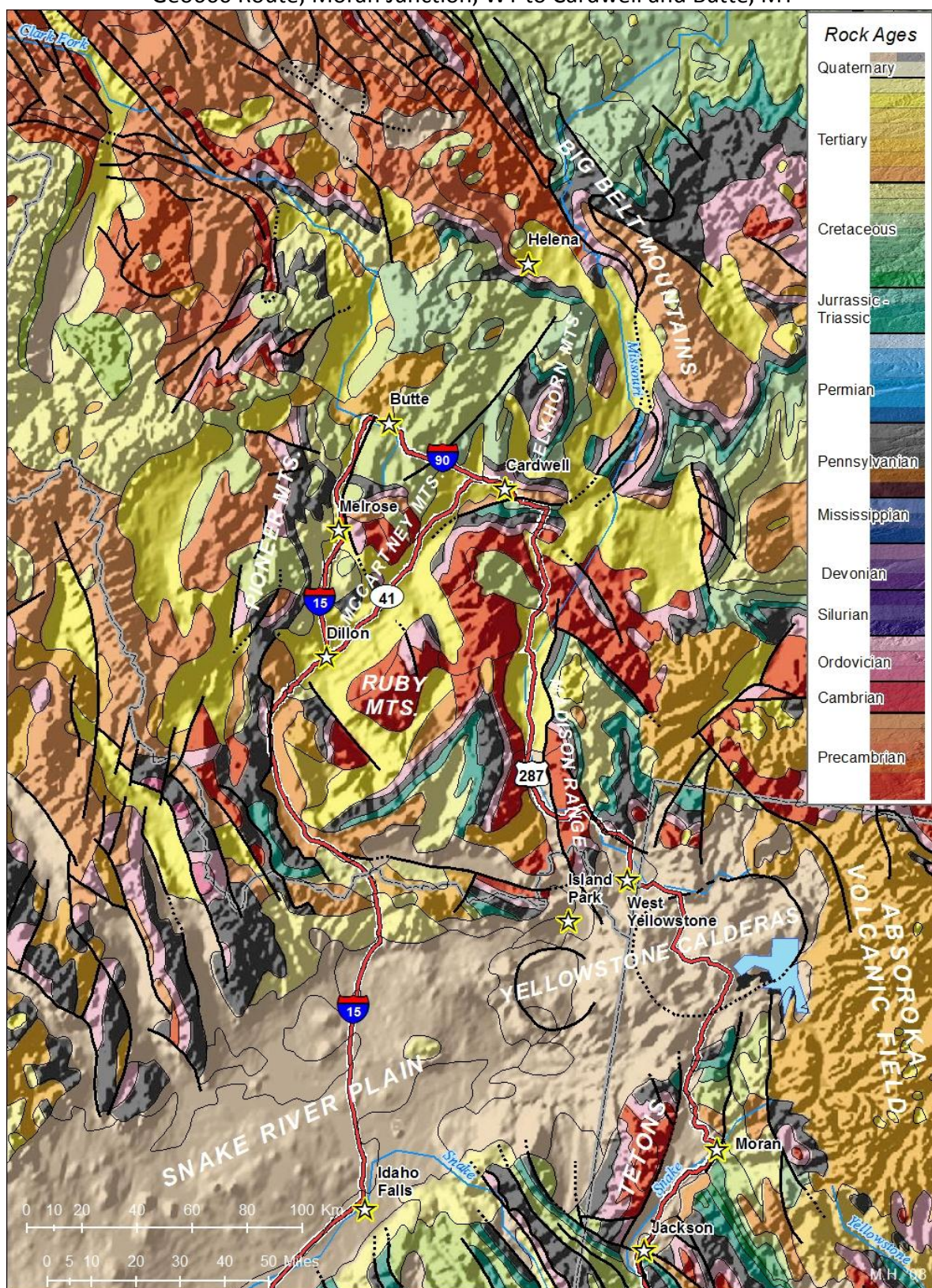
The morning is spent measuring post-glacial displacement on the Teton Fault and calculating a slip rate. In the afternoon, Dr. Helper presents background material on the Yellowstone calderas, and processes and rocks associated with explosive volcanism.

- **Day 21: Field trip through Yellowstone calderas, Yellowstone N.P., WY and drive to Cardwell, MT** (see map below)

Volcanic products and processes associated with the caldera cycle. This trip focuses on volcanic rocks, particularly tuffs and glass flows, of the Yellowstone calderas. Stops to view flow-banded vitrophyres, welded tuffs, nonwelded tuffs, and rhyolite flows. Leaving the park, we drive north, stopping to examine the Hebgin Fault scarp and Quake Lake, the site of a massive landslide initiated by an earthquake. From there we drive north through the Madison River valley, perhaps the most scenic spot in SW Montana, to Cardwell, where we camp at Lewis and Clark Caverns State Park.

This ends the first 3 week session; 660A.

Geo660 Route; Moran Junction, WY to Cardwell and Butte, MT



Day 22-25: This 3-day project and accompanying field trip allows mapping of somewhat complex fold and fault geometries near leading edge of the Sevier fold-thrust belt. The Sevier belt is a late Cretaceous belt of thin-skinned deformation that extends the length of the northern Rocky Mountains. Mapping is within a displacement transfer zone in the Elkhorn Mountains, where thrust faults become folds (or vice-versa!).

Day 22: Precambrian-lower Paleozoic stratigraphy of the Elkhorn Mountains & first day mapping.

- Describe section and define map units for this project.
- Begin mapping.

Day 23: Continue mapping

- Begin constructing cross section and stereonet.

Day 24: Finish mapping

- Turn in map, cross section and stereonet.

Day 25: Field trip through the Big Belt Mountains - see trip guidebook

Travel north toward Helena to the northern Big Belt Mountains. The Big Belts are a salient in the Montana portion of the Sevier belt. Mesoproterozoic sedimentary rocks (Belt Supergroup) here are overlain by a distinctive lower Paleozoic sedimentary sequence, both of which are exposed in folds and thrust sheets. Discuss Sevier and Laramide Orogeny, view cross section through the Big Belts as exposed in Beaver Creek Canyon, view and sketch geometries of folds and thrusts in Cambrian and Mississippian carbonate units, see folded thrusts, thrust folds, out-of-sequence thrusts, horses, and an antiformal stack.

Day 26-30: Fold-thrust belt mapping, McCartney Mts. Salient, Sevier Belt

This 3-day project and 1 day field test focuses on mapping of complex fold and fault geometries at the leading edge of a Sevier fold-thrust belt salient. Synorogenic Cretaceous sedimentary rocks, as well as Permian through Triassic strata, provide distinctive markers for mapping the thrusts and folds. A field test on the final day tests skills acquired in this and earlier mapping projects.

Day 26: Drive to Dillon, MT & Introduction to setting and stratigraphy

- Compile stratigraphic column of map units, recon. the field area, begin mapping

Day 27: Continued mapping

- Begin constructing cross section and stereonet.

Day 28: Continue mapping

- Lecture on the geometry of duplex zones and antiformal stacks.
- Continue cross section and stereonet.

Day 29: Finish mapping

- Turn in map, cross section and stereonet

Day 30: Field Test

- Individual, one-day mapping exercise.

Day 31: Field trip to Butte; travel to Hecla, near Melrose, MT

Travel north to Butte to see what remains of "the richest hill on earth". Discussions on 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 town of Hecla, once the center of the richest silver mining district in Montana. With published maps and reports already in hand, you will spend four days documenting and unraveling field relationships among deformation, plutonism, contact metamorphism and mineralization within facies equivalents of the same strata mapped in the Elkhorn Mountains.

Days 32-35: Hecla Project - Ore deposit geology and geologic processes

This project integrates different geological disciplines to unravel the geological history of this late-1800's zinc-silver mining district. Field data will be collected over a period of four days to understand the sedimentary, structural, metamorphic, igneous and fluid history of this area and produce a concise report that synthesizes this information. In addition to introducing new concepts (for 660) 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 working earth scientist.

Day 36: Travel to Price, UT

- Lunch: Flood basalts at Snake River Plain visitor's center.
- Afternoon: Great Salt Lake, Wasatch Mountains and Wasatch Mountain Fault.

Day 37: Travel from Price, UT to Los Alamos, NM

- Lunch at Arches National Monument
- Stop on western edge of Taos Plateau to view and discuss Rio Grande rift and rift volcanism

Day 38-41: Valles Caldera – Magmatism and history associated with caldera cycles

These four days in the Jemez Mts. with Dr. Gardner focus on the eruptive products and processes of caldera eruptions, as spectacularly displayed by the Valles Caldera. Projects include a 2-day mapping exercise to determine the paleotopography of the landscape beneath the Pajarito Plateau prior to the eruption of the Bandelier tuff and a field trip through the caldera that visits and examines nearly all eruptive products and their field relationships.

Day 42: Travel to Austin

After leaving the Rio Grande Rift, a long drive this day takes us across the desolate Llano Estacado of eastern New Mexico and west Texas before entering the Hill Country near Lampasas.

Geo660 Route 2012

