GEO 4510 – FIELD GEOLOGY (SUMMER FIELD CAMP), 2014 – Project 1

GEOLOGY OF PAROWAN GAP, UTAH

INTRODUCTION

Jurassic to Quaternary sedimentary and volcanic rocks are superbly exposed in Parowan Gap, a late Tertiary antecedent stream valley that cuts through the Red Hills, a small normal-fault-bounded mountain range just east of the town of Parowan in Iron County, southwest Utah. The Red Hills lie near the eastern margin of the Basin-and-Range Province within sight of the Hurricane Cliffs (the footwall of the Hurricane fault), which mark the western boundary of the Colorado Plateau in this region. We will camp on the Plateau and drive down to map in the Red Hills each morning.

You will recall from your Field Methods project in the Nugget Sandstone (I hope), that the Early Jurassic was an arid period in Utah. The Andean-type Sierra Nevada volcanic arc in eastern California trapped most of the humid Pacific air masses, depriving regions to the east of moisture. At this time a huge erg (sand sea) covered most of Utah. The oldest stratigraphic unit exposed in the Parowan Gap is the Navajo Sandstone, equivalent to the Nugget and Aztec Formations. In Middle Jurassic time, marine waters (the Sundance Sea) inundated central Utah from the northwest, recorded by nearshore and supratidal limestones of the Carmel Formation in the Parowan area.

Cretaceous to early Tertiary time in this region was marked by compressional deformation and foreland basin deposition associated with the Sevier Orogeny. A brief information sheet on this important regional tectonic event is attached. The eastward limit of Sevier folding and thrusting coincides roughly with the Wasatch Front and with the western boundary of the Colorado Plateau along much of its length in Utah. You will see and define its effects in the Parowan Gap area, both in the tectonic structures and in the nature and composition of related sedimentary deposits.

Widespread plutonism and pyroclastic volcanism occurred in the western Cordillera in Late Eocene through Oligocene time, followed shortly by the onset of east-west subhorizontal extension that has resulted in the north-south-trending mountain ranges and basins characteristic of the Basin-and-Range Province. Extensional deformation and associated basaltic volcanism continue to the present, with most activity focused along the eastern and western margins of the Great Basin.

Your primary tasks in this project are to map and describe Jurassic to Quaternary sedimentary and volcanigenic strata for a mile or so both north and south of the Parowan Gap. You will use your map and observations to ascertain the geologic evolution of the map area and present your results in a professional geologic report in the standard format that you repeatedly employed last semester in Field Methods. In addition to a carefully reasoned, logically organized write-up, your report will include a location map of the study area, a geologic map redrafted from your field map, a geologic cross section, stratigraphic section, and possibly stereoplots and rose diagrams depicting paleocurrent and structural measurements in several formations. It will also contain sketches and photographs of key sedimentary and structural relationships to illustrate and substantiate your interpretations of depositional environments and tectonic events.

FIELD PROCEDURES, PROJECT MANAGEMENT, AND COURSE GOALS

I will lead a reconnaissance trip through Parowan Gap the afternoon we arrive to introduce the formations and structures you will map, and on several mornings we'll all work together for two or three hours as we encounter new or particularly challenging map problems. Other than that, you'll be mostly on your own to organize and complete the project with your map group, employing the skills you have learned throughout your geologic studies, and honed in Field Methods. I suggest you start in the relatively simple eastern part of the study area to become well acquainted with the stratigraphy and "get your field legs" before moving west into more structurally complex areas, but your strategy is up to you. Instructors will periodically circulate among groups to assist your efforts, check progress, and answer questions, but we will *not* lead you by the hand through this project. Your central goal in this course should be to acquire experience and confidence in independent problem solving and project management. Rather than listening to lectures or reading texts, you will learn from the rocks themselves the stories they have to tell. You are ready for this!

Draw geologic contacts and plot your bedding and structural attitudes on your map *while you are in the field*. Do not try to do this from memory back in camp, or rely on copying later from your field partners. The process of mapping should be an *active* one, in which you continually apply the scientific method throughout your field day. *Use* your observations at each outcrop to generate hypotheses about their geologic significance. Then *test* those hypotheses at the next outcrop, building up elements of the geologic history as you go.

Every evening you should ink and color your map, read through your observations, and check both for completeness and internal consistency. Sketch partial cross sections to be sure that you understand the structural implications of your mapping, and that the lines you've drawn make sense geometrically and geologically. Note what important information is missing from your map and notes and plan your next day's work accordingly. Discuss gaps and problems and strategies with other students and with the instructors. Look at samples you have collected and read articles from the field library that may help you with your observations and interpretations.

ROCK UNITS (Tentative; may need to be refined based on our observations)		MAP COLORS
Qal	Undivided alluvium and other surface deposits (Quaternary)	Yellow
Qfa	Active colluvial fans (Quaternary)	Yellow
Qt	Talus	Yellow
Qls	Landslides	Tan
Qfo	Inactive colluvial fans (Quaternary)	Flesh
Qcv	Volcanic conglomerate	Dark yellow
Qb	Quaternary basalt flows	Purple
Ti	Oligocene Isom welded tuff (Indian Peak caldera; crystal-poor trachydacite)	Lavender
Tnw	Wah Wah Springs tuff (Indian Peak caldera; pink, crystal-rich dacite)	Pink
Tbh	Oligocene-Eocene Brian Head tuffaceous sandstone and tuff breccia	Purple
Tc	Claron Formation (Paleocene?-Eocene?)	Red
Kgc	Grand Castle Conglomerate (Paleocene?)	Orange
Kpg	Conglomerate of Parowan Gap (Late K? Paleocene?)	Violet
Kis	Iron Springs Formation (Late Cretaceous)	Green
Ksc	Straight Cliffs Formation (Late Cretaceous)	Brown
Jc	Carmel Formation (Middle Jurassic)	Light blue
Jn	Navajo Sandstone (Lower Jurassic)	Gray

Mapping Groups – Parowan Project

Group A:
Group B:
Group C:
Group D:
Group E:
Group F:
Group G:
Group H:

CAMP LOGISTICS

• A positive attitude and willingness to pitch in with camp chores is essential for the success of the course and to assure an enjoyable and productive field experience. The camp manager(s) can't take care of everything, so please be prepared to help whenever necessary. 10% of your grade (enough to raise or lower your grade by one full letter) will be awarded for **professionalism in the field**, including attitude, participation, doing your share of the work in camp, and **being on time**.

• Cooking and cleanup will be done by designated groups of 3-4 students (see below). Each group will be responsible for preparing and cleaning up after dinner on the dates listed below, and doing the same at breakfast, as well as laying out lunch makings, the following morning. The next group in line will take over the following evening and so on. You'll clean your own personal dishes after every meal. **Breakfast is at 7:15 A.M.**, and you will make yourself a bag lunch after breakfast each morning to eat in the field. **We leave camp for the field area promptly at 8:00 A.M.** Instructor(s) will pitch in with meals and cleanup as time allows; however, their primary responsibilities in the evening will be to check maps, discuss progress and problems, and help students prepare for the next day's fieldwork.

Cooking/clean-up groups - Both projects

Group 1:
Group 2:
Group 3:
Group 4:
Group 5:
Group 6:

Cooking/cleanup schedule (dinner on the day listed; breakfast the following morning):

Wednesday, May 7	Group 1
Thursday, May 8	Group 2
Friday, May 9	Group 3
Saturday, May 10	Group 4
Sunday, May 11	Group 5
Monday, May 12	Group 6
Tuesday, May 13	Group 1
Wednesday, May 14	Group 2
Thursday, May 15	Group 3
Friday, May 16	Group 4
Saturday, May 17	Group 5

SHOWERS AND TRIPS TO TOWN

We will camp only about 5 miles from the town of Parowan, so trips to town for showers at the TA truck stop, phone calls, and purchasing snacks and beverages will be plausible and permitted, as long as they do not disrupt or delay camp activities. There are two main factors to consider:

• First, if it is your cooking/cleanup night you are responsible to be in camp helping your group with these activities for as long as they take, from beginning to end.

• Second, you will want to work on your maps and notes each evening and read some journal articles on the field area, so please do not make a habit of disappearing into town *every* night after dinner. (This won't be an issue in Project 2 in the Raft Rivers, as there *is* no town.)

GEO 4510 - Field Geology; Summer, 2014

PROJECT 1 REPORT, ESSENTIAL ELEMENTS AND FORMAT

GEOLOGY OF PAROWAN GAP, UTAH

Your maps of the Parowan Gap are very good from what I've seen – much better than the USGS attempt. They are geometrically and geologically viable and reasonable, and they depict a coherent, internally consistent story of the geologic history of the area from Jurassic time to the present. Your task now is to tell that story in a professional quality geologic report, which should contain the following elements:

• **Geologic map**. A neatly drafted copy of your final map, with all attitudes and contacts inked and stratigraphic units colored *and* labeled with their unit symbols (e.g., Jn, Kis, Qal).

Please remember: *Every* geologic map requires: A north arrow, scale, latitude and longitude ticks (at least 2 each), a figure number and caption, and a legend, explaining contour interval, symbols used, and units mapped. Use different symbols for high-angle normal faults and the low-angle gravity slide. The map units section of the legend should consist of a stack of small boxes, one for each unit mapped, oldest on the bottom and youngest on top. The interior of each box should be labelled with the unit symbol (e.g., Jn) and colored to correspond with the map and cross section.

ROCK UNIT NAMES AND AGES for Parowan Gap:		MAP COLORS
Qal	Alluvium (modern stream and floodplain deposits)	Yellow
Qfa	Active alluvial fans	Yellow
Qt	Talus	Yellow
Qls	Landslides	Tan
Qfo	Inactive alluvial fans	Flesh
Q(?)cv	Volcanic conglomerate. This is an unconsolidated volcanic boulder conglomerate that lies depositionally upon the Claron Formation just outside of the map area to the north. If you map it, use this symbol.	Dark yellow
Ti	Oligocene (~26-27 Ma) Isom Formation (Indian Peak caldera)	Lavender
Tnw	Oligocene (~30 Ma) Wah Wah Springs tuff (Indian Peak caldera; dacite)	Pink
Tbh	Oligocene-Eocene (30-36 Ma) Brian Head tuffaceous sandstone and tuff breccia	Purple
Tc	Claron Formation (Paleocene?-Eocene?)	Red
Kgc	Grand Castle Conglomerate (Late Cretaceous? Paleocene?)	Orange
Kpg	Parowan Gap Conglomerate (Late Cretaceous? Paleocene? Older than K?gc)	Violet
Kis	Iron Springs Formation (Late Cretaceous)	Green
Ksc	Straight Cliffs Formation (Late? Cretaceous)	Brown
Jc	Carmel Formation (Middle Jurassic)	Light blue
Jn	Navajo Sandstone (Lower Jurassic)	Gray

• **1:1 geologic cross section** (no vertical exaggeration) on cross-section (graph) paper, colored and labelled to correspond exactly to the geologic map. *Draw your cross section before you write your report*. Be sure to include:

—> Thin lines showing the orientation of bedding in each unit profiled, if known,

—> Horizontal and vertical scales,

—> Labels at top left and right indicating orientation of cross section (e.g., NW, SE),

—> A figure caption (number, title, and explanation of the figure, which should include a reference to the figure showing the cross section's location, i.e., your geologic map, and also a statement that the legend for the geologic map also applies to the cross section.)

—> An abbreviated legend showing any additional symbols used on the cross section that you did not use on the geologic map. For instance, your up and down symbols on the various faults will be different on the cross section.

• **Stratigraphic column** in standard format.

—> At least two columns at left of figure should show *vertical scale* (thickness in meters and/or feet) and *ages* of each unit mapped.

—> The column itself should show a schematic weathering profile at right and symbolic depictions of bedding and sedimentary structures, fossils, etc. in the interior. Color each unit to correspond to the geologic map. Be sure to use appropriate symbols to indicate the nature of contacts between units (depositional vs. faulted, conformable vs. nonconformable).

—> Depict parts of units that were *not exposed* in the map area with blank spaces in the column. For instance, we did not see the stratigraphic bases or tops of Units Jn, Jc, or Kil, the base of Kiu, and some middle parts of Tcl. In most cases you don't know *how much* of the thickness of faulted units is missing, so note this in your descriptive column to the right of the symbolic column.

—> To the right of symbolic column, write abbreviated descriptions of each unit that clearly note any observed vertical lithological variations.

—> A legend for the column should include explanations of all symbols used.

—> Be sure to include a figure number and complete caption.

• **Location map** showing the area of your geologic map in southwestern Utah. This could be shown, for instance, as a box on a map depicting the general position of Sevier thrusts in the area. Also include a small inset showing the area of the location map in the state of Utah. Remember that every map figure must have a scale, latitude/longitude marks, and a figure number and caption.

• **Written report** on your results. (Each item above will be a numbered figure in this report).

REPORT FORMAT

A professional geological report should be clear, complete, concise, well reasoned, and well organized. State the evidence and reasoning for any conclusions you make! Don't make the reader guess at your logic. Also, publishable reports on geologic field research follow a fairly standard format. Professional journals or consulting companies are unlikely to accept your reports unless they conform approximately to the following organization scheme:

Title. A concise, informative label of the subject of your report.
Author block. Your name, professional affililation(s), and the date of submission.

Abstract. A brief synopsis of the *actual results* of your study. It should summarize your most important field observations and interpretations of depositional environments and tectonic events/structures, with reasoning clearly stated. **Write this section last**, when you have settled on what your conclusions are. This section is *not* meant to introduce your study.

Introduction. Include:

—> A *clear* statement of the problem addressed in your study,
—> Its scientific, educational, and/or practical (applied) significance,
—> The approach you have taken to solving the problem,
—> Methodology used (e.g., geologic field mapping at 1:12,000), and
—> Source and title of the geologic base map used.

• Do not include any *results* of your study in this section.

Geologic setting. Provide in this section the regional spatial and temporal geologic context of your map area, e.g., near the eastern limit of the Sevier orogenic belt, proximal margin of the Sevier foredeep basin, later the eastern margin of the Basin-and-Range province, western margin of the Colorado Plateau. This section will be mostly based on *pertinent* literature you have read and lectures or personal communications that bear on your study. Format is the same as you used in Field Methods! Use the Blakey paleogeographic maps and Sevier and Basin-and-Range structural maps and tables. *Be sure to properly (and formally!) cite and reference your sources*. See reference section below.

Rock unit descriptions. Complete, systematic lithologic descriptions of each unit that appears on your geologic map in order of decreasing geologic age (oldest unit first). Refer to figures you have

drawn (e.g., map, stratigraphic column, cross section, sketches) and any photos you have that illustrate the character of the units.
Be sure to include:

—> Clast and matrix compositions and rounding and sorting characteristics (be quantitative),

—> Sedimentary and pyroclastic structures and textures (bedding type and range of thickness, cross bedding, oncolites, cut-and-fill, flow laminations, fiammi, etc.)

—> Stratigraphic thicknesses (measured from your map and cross sections, so complete these before you do your writing),

—> Vertical and/or horizontal variations in composition, lithology, and sedimentary structures,

—> ***Descriptions of the contacts*** between units.

Depositional environments. Interpret the deposition environment(s) of each map unit based on your lithologic and sedimentary textural observations in the previous section. *Clearly* state your evidence and reasoning for each interpretation. For instance, you interpreted the existence of a regressive (or progradational) nearshore/beach sequence within the Straight Cliffs Formation on the basis of a distinctive *succession* of sandstone facies (outer rough, outer planar laminations, inner rough, inner planar). Describe the textural evidence that the volcanic unit is entirely pyroclastic. Cite references to texts and journals articles as necessary and appropriate.

Structural descriptions and timing relationships. Describe the structures you mapped (faults and/or folds), how you recognized them (tilted bedding, stratigraphic offsets, fault gouge, etc.), offsets on them as measured from your map and cross sections, whether they are brittle (upper crustal) or ductile (mid- to lower crustal) structures, and all evidence you have on *timing constraints*. This will include the ages of units affected by the structure and the ages of units or other structures that truncate or crosscut the structure in question. Clearly delineate the *sequence* of structural events to the extent that your data constrain it and cite your evidence. For instance, do you know whether the high-angle normal faults are older or younger than the Coal Canyon thrust, whether the Coal Canyon thrust is older or younger than the Carmel/Straight Cliffs thrust, when the volcanic low-angle normal fault/gravity slide fits into the local deformational sequence?

Do *not* interpret the relationship of structures to regional tectonic events (e.g., the Sevier or Laramide orogenies, Basin-and-Range extension) here. Save that for the Geologic History section.

Geologic History and Discussion. Interpret the succession of geologic events recorded by the rocks and structures in your map area, ordered chronologically from oldest to youngest, and including both depositional and tectonic events. You do not need to restate detailed depositional environments, but this *is* the section where you will want to discuss such issues as the tectonic origin of the sedimentary basins in which the various units were deposited (e.g., Sevier flexural foredeep, etc.) and the *sources* of matrix and clasts in the Grand Castle and Claron conglomerates. Discuss the relationship between tectonic events and sedimentation and volcanism. Interpret the origin and possible age of the Parowan Gap antecedent stream (it is related to uplift of the Colorado Plateau, just like the Grand Canyon is.) References to published work in this and nearby areas is typically included, and sketches may be useful. Clearly distinguish interpretations that are based *solely* on your own observations from broader interpretations that rely on previous work.

Conclusions. A summary of your principal results, their scientific and/or practical (applied) significance, and how they support, extend, or contradict previous work. Organization of this section is similar to that of the abstract, except that you can assume the reader has read the entire report before getting to this section, so it doesn't have to be a completely “stand-alone” section.

Acknowledgments. Thanking your field partners and others instrumental to your study.

References. A list of the literature to which you have referred, in standard bibliographic format. See any of the papers in the field library for acceptable reference formats. Your interpretations (and report) will be vastly improved by a background knowledge of the regional geology, which you can only obtain through reading the literature.

Figures. Your maps, cross sections, stratigraphic columns, graphs, line drawings, photographs, etc., numbered consecutively, and with complete, descriptive captions.

Grade Sheet: 2014 UU Geology Field Camp, Project 1

Parowan Gap, Utah

Mapper: ____

1. Geologic map (25 total)

- Coverage and completeness (area, sufficient attitudes, etc.) ______/07
- Accuracy (contact locations, unit thicknesses, fault offsets, etc.) ______/12
- Legend (unit and symbol explanations, scale bar, lat/long, etc.) ______/03
- Presentation (neatness, professionalism) ______/03

Subtotal: /25

2. Cross section (15 total)

- Accuracy (dips, thicknesses) and consistency with map ______/05
- Interpretation; geologic and geometric viability ______/05
- Topography, scales, unit labels, legend, etc. ______/03
- Presentation (neatness, professionalism) ______/02

Subtotal: /15

3. Stratigraphic section (10 total)

- Descriptions (accuracy and completeness) ______/05
- Required elements (ages, unit names, thicknesses, graphics) ______/03
- Presentation (neatness, professionalism) ______/02

Subtotal: /10

4. Report (50 total)

- Abstract and conclusions (completeness, accuracy) ______/05
- Introduction (statement of problem) ______/04
- Geologic setting ______/05
- Rock descriptions and depositional environments ______/10
- Structural descriptions, interpretations, and timing of events ______/08
- Discussion and geologic history ______/08
- Figures (quality, utility, appropriateness) ______/05
- Language usage and required elements (refs., fig. captions, etc.) ______/05

Subtotal: /50

Project total: __________/100