Geology and Natural Hazards of the Island Park Area, Idaho

2007 Idaho Earth Science Teachers Field Workshop
July 8-14, 2007

Material Compiled by William M. Phillips

Idaho Geological Survey
Morrill Hall, Third Floor
University of Idaho
Moscow, Idaho 83844-3014

Schedule of Events

All events held at Buttermilk Campground Group Site unless otherwise noted.

Sunday, July 8

- 1 pm – 4 pm. Registration and campsite assignment.
- 5 pm – 5:30 pm. Welcome, introductions and important announcements.
- 5:30 pm – 7 pm. IESTA/NEF/IMA Ice-Breaker Barbecue
- 7 pm – 8 pm. "Geology and Natural Hazards of the Yellowstone Area" *Hank Heasler* (Yellowstone National Park).

Monday, July 9

- 8 am – 5 pm. Field trip to Yellowstone National Park. Trip leaves from Buttermilk Campground Group Site at 8 am sharp. *Cheryl Jaworowski and Hank Heasler* (Yellowstone National Park).
- 7:45 pm – 9:45 pm. Supervolcano (movie)

Tuesday, July 10

- 8 am – 5 pm. Field trip to Hebgen Lake Earthquake area. Trip leaves from Buttermilk Campground Group Site at 8 am sharp. *Bill Phillips and Roy Breckenridge (IGS)*
- 7 pm - 8 pm. Out of the Rock. *Judy Walling (NEF/IMA)*

Wednesday, July 11

- 8 am – 10 am. "Natural Hazard Mitigation" *Dave Jackson and Mark Stephensen* (Idaho Bureau of Homeland Security)
- 10 am – 5 pm. Field Trip to Big Springs-Mesa Falls-Big Bend Ridge. *Bill Phillips and Roy Breckenridge (IGS)*
- 6 pm – 9 pm. IESTA/NEF/IMA workshop barbecue, Rock Raffle, IESTA Annual Business Meeting. *Mike Emory* (IESTA President).

Thursday, July 12

- 8 am – 10 am. "Incorporating natural hazards in your teaching" *Jim Cash* (Moscow School District)
- 10 am – 11 am. Effective workshop projects. *Bill Phillips* (IGS) and *Jim Cash* (Moscow School District)
- 11 am – 5 pm. Project Development. Participants work on projects. Staff available for help with equipment, transportation to field sites, and advice.
- 7:30 pm – 9 pm. Project work, continued (attendance optional). Staff available for consultation.

Friday, July 13

- 7:30 am – 8 am. Workshop evaluation by participants.
- 8 am – noon. Presentation of projects.
- Noon. Workshop closes. All campsites must be vacated.

Buttermilk Campground Information

Campground Rules

- Quiet hours are between 10:00 p.m. and 6:00 a.m. Please be considerate of others.
- All garbage and litter must either be deposited in containers provided, or taken with you when you leave.
- Obey any restrictions on fires.
- Fires may be limited or prohibited at certain times.
- Within campgrounds and other recreation areas, fires may only be built in fire rings, stoves, grills, or fireplaces provided for that purpose.
- Be sure your fire is completely extinguished before leaving. Do not leave your fire unattended. You are responsible for keeping fires under control.
- Drivers must obey all traffic signs and operate their vehicles in accordance with posted regulations, and applicable Federal, State and local laws.
- Vehicles must be parked in designated areas only.
- Use of vehicles within campgrounds and other recreation areas is limited to entering or leaving those areas.
- Pets must be restrained or on a leash at all times while in developed recreation areas.
- Pets (except guide dogs) are not allowed in swimming areas or sanitary facilities.
- Use of fireworks or other explosives within campgrounds and other recreation areas is prohibited.
- Do not carve, chop, cut and damage any live trees.

Recycling

- Containers will be provided for recycling glass, aluminum, plastic beverage bottles, office paper, and cardboard. Please help make the workshop a sustainable activity by recycling.

Electrical Power

Electrical power for running a laptop computer, printer, data projector, and overhead projector will be provided from a portable generator. Power will be available for workshop activities only.

Driving Directions to the Summer Field Workshop

1. Proceed to Ashton, Idaho, 54 miles north of Idaho Falls.

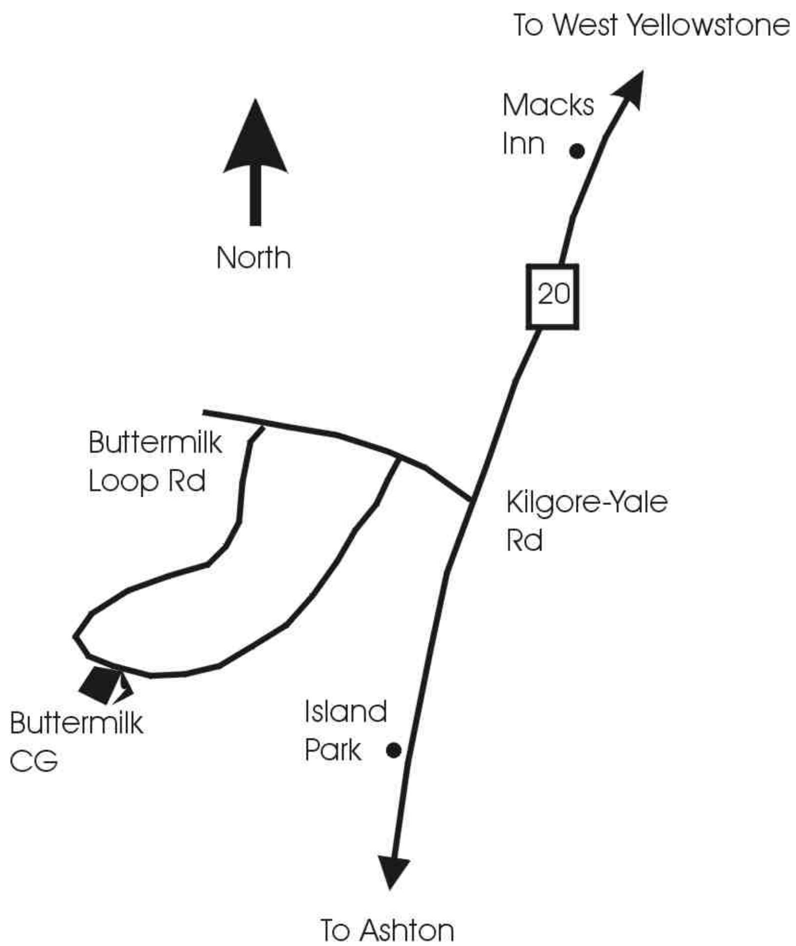
2. From Ashton, drive 27 miles north on US Highway 20 to Island Park.

3. Proceed 2.2 miles north on Highway 20 to the junction with the Kilgore-Yale Road (across from the Elk Creek Gas Station).

4. Turn west (left) on the Kilgore-Yale Road and drive 1.9 miles to the junction with the Buttermilk Loop Road.

5. Turn south (left) on this paved road and drive 2.8 miles to the entrance of Buttermilk Campground.

6. Follow signs to the Group Site. It is next to the boat launch.



Safety Information

Hazards

Field work can be dangerous. Below are some of the hazards you may face when performing field work at the workshop.

1. Automobile accident or pedestrian-automobile accident
2. Slipping on steep, loose or uneven ground
3. Low temperatures and wet conditions leading to hypothermia
4. High temperatures leading to heat exhaustion and/or heat stroke
5. Rockfall
6. Drowning
7. Getting lost
8. Insect stings/poison ivy

Making Field Work Safe

The risk of serious injury from all of the above hazards can be eliminated or greatly reduced by planning ahead.

1. On roadside outcrops, be aware of traffic hazards. Avoid standing in groups on the road and be extra careful in limited sight conditions near curves or hills.

2. Wear good quality, comfortable hiking boots. Do not attempt to climb steep slopes, especially those composed of gravel or other loose materials.

3. Keep an eye on weather conditions. Always take a raincoat, sweater, warm hat, and some extra food in your field pack in case the weather turns foul.

4. Always take a sun hat and plenty of extra water in your field pack. Sunburn is dangerous. Use sun screen and wear sunglasses. Wear long sleeve shirts and long trousers to reduce exposure.

5. Avoid working at the base of cliffs.

6. Do not enter rapidly flowing water. You may be knocked off your feet and suffer head injuries. Be cautious about swimming long distances in lakes.

7. Inform workshop organizers of your plans and do not alter them. Stay aware of your position by frequently consulting your map and compass. If lost, make yourself comfortable and stay in one place so that searchers can find you more rapidly. Carry a whistle in your field pack to signal rescuers.

8. Wear a long sleeve shirt, trousers and a floppy hat to reduce the amount of skin available to stinging insects. Gloves and insect repellent also help. Know how to recognize poison ivy or poison oak and avoid them.

Academic Requirements

Workshop Objectives

The workshop seeks to reduce losses from natural hazards by training K12 teachers in hazard recognition and mitigation. Teachers are provided information and support to help them develop natural hazard educational activities for their local classrooms. The workshop also promotes high quality teaching of the earth sciences in Idaho schools by providing instruction on important geological concepts and Idaho's unique geologic history. This year, the workshop will focus on the following subjects:

- the Yellowstone Hot Spot Hypothesis and its relationship to the natural hazards of Idaho
- natural hazard recognition and mitigation, particularly those caused by earthquakes, volcanic eruptions, and hydrothermal features
- geology and geomorphology of the Island Park-Yellowstone area
- techniques of teaching natural hazards and earth science

University Credit

Participants may elect to take the workshop for two academic credits through the University of Idaho. University credit is assigned by the workshop coordinator, Bill Phillips, on a Pass/Fail basis. Due to the workshop format, incompletes cannot be given except in case of illness or family emergency.

The requirements for receiving academic credit for the workshop from the University of Idaho are:

1. Attend all field trips, lectures, and other instructional activities noted in the Schedule of Events.
2. Develop a workshop project. This project may consist of a lesson plan, a research project, or other educational activity. Consult with Bill Phillips regarding suitable projects. Participants may work in groups, but the group size may not exceed three.
3. Present an oral project summary or demonstration in the Friday morning seminar. Group presentations (limited to three participants) are fine. A one page outline of the project is also required. The outline may be hand-written. A laptop computer, printer, overhead projector, projection screen and data projector will be available for participants.

Day 1: Field Trip to Yellowstone Park

Trip Leaders: *Cheryl Jaworowski and Hank Heasler* (Yellowstone National Park)

Buttermilk Campground-West Yellowstone. Leave Buttermilk Campground and drive north to junction with Kilgore-Yale Road. Turn right (east) and proceed to junction with Highway 20. Turn left (north) and proceed to junction with Highway 87. Continue right (north) on Highway 20 over Targhee Pass to West Yellowstone and entrance to Yellowstone National Park.

West Yellowstone-Madison. Proceed east along Madison River to junction with road to Old Faithful. Turn right (south) on the Old Faithful road.

Madision-Midway Geyser Basin. Proceed to Midway Geyser Basin and the Grand Prismatic Spring pullout for field trip activities focusing on earthquake, mass wasting, volcanic and hydrothermal hazards.

Return to West Yellowstone. Drive westward through town on Highway 20.

OPTIONAL STOP 1-1. Park at edge of town where views to west and south are available. The highway to west crosses the obsidian-sand plain. This surface slopes very gently westward, showing that it was sourced from glacial outwash streams lying to the east. Due west is the Madison Range. The higheast peak is 10,180 ft Bald Peak, with Lionhead (another prominent peak) to the east. To the southwest are Henrys Lake Mountains, a southern extension of the Madison Range separated from the main range at Targhee Pass by the east-west Centennial Fault. To the south, the margin of the post-caldera West Yellowstone Flow forms Madison Plateau on the skyline.

Continue west on Highway 20 to Denny Creek Road.

OPTIONAL STOP 1-2. Park in chain-up area. Subdued ridges on right is Bull Lake-age moraine. The ice sheet that deposited this moraine extending from the Yellowstone Plateau to Madison Range. It occurred before the emplacement of the West Yellowstone rhyolite flow, dated at xxx ka by xxx. To the east (from north to south), there are views of Yellowstone Plateau with north-dipping Lava Creek Tuff, Mt Jackson, gap breached by canyon of the Madison River, and Madison Plateau. To the west, the peak on skyline is Lionhead Peak composed of Paleozoic limestones. Lower ridge to right (north) of Targhee Pass is composed of east-dipping Huckleberry Ridge Tuff.

Continue west and south on Highway 20, over Targhee Pass, to junction with Highway 87.

OPTIONAL STOP 1-3. Park in large turnout opposite truck stop. Good views of the east-west Centennial Range with Sawtell Peak at east end (with aviation radar dome). This range is a south-tilted normal-fault block. The Centennial Fault has Holocene displacement across glaciated canyons north of Sawtell Peak. These appear continuous with scarp that blocks drainage to form Henrys Lake. To east, fault continues across Targhee Pass.

Retrace route on Highway 20 south to Buttermilk Campground.

The following figures are taken from R.L. Christiansen, J.B. Lowenstern, R.B. Smith, H. Heasler and others, 2007, Preliminary volcanic and hydrothermal hazards in Yellowstone National Park and vicinity: USGS Open-File Report 2007-1017.

[available at http://pubs.usgs.gov/of/2007/1071/]

SUGGESTED ACTIVITY

Title: Time String for Geology of Yellowstone National Park
Objective: Clarify abstract concept of geologic time by substitution of length for time; examine geologic record for signs of cycles or clusters; aid in memorizing of stratigraphic nomenclature, radiometric dates, and other geologic data.
Materials: 5 m long string or rope; colored yarn or flagging (at least 5 colors); marking pen; strips of paper; transparent tape; metric scale or tape measure
Target audience: elementary through adult

Summary of Activity:
1. Let 1 meter of string = 1 million years (10^6 a = 10^3 mm or 1 a = 10^3 a / 1 mm; a = annum; ka = kilo-annum = 10^3 a; Ma = mega-annum = 10^6 a)

2. Mark the 0 a (present) end of string and the 5 Ma end of string.

3. Measure distances corresponding to the 3 major caldera-forming episodes (Lava Creek Tuff, Mesa Falls Tuff, Huckleberry Ridge Tuff). Color-code the markers and use these colors on maps, diagrams, and drawings. Option: write the radiometric age determinations for the units on the markers.

4. Measure distances corresponding to duration of last glaciation (Pinedale Glaciation) and penultimate glaciation (Bull Lake Glaciation)

5. Measure distance corresponding to beginning of Christian Era.

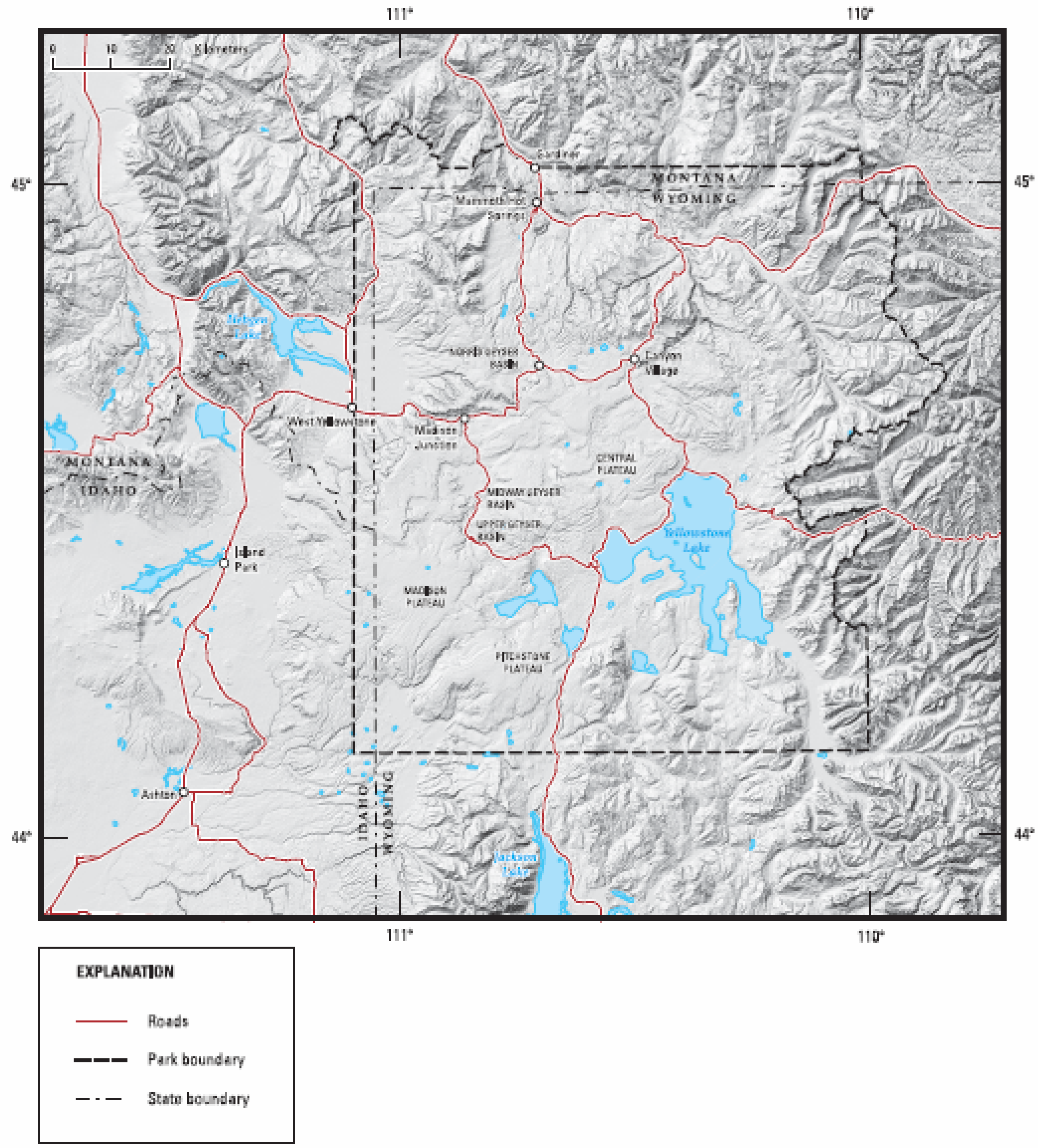


Figure 1. Map of Yellowstone National Park and vicinity showing the area considered in this report, its physiography, major roads (red lines), and selected place names.

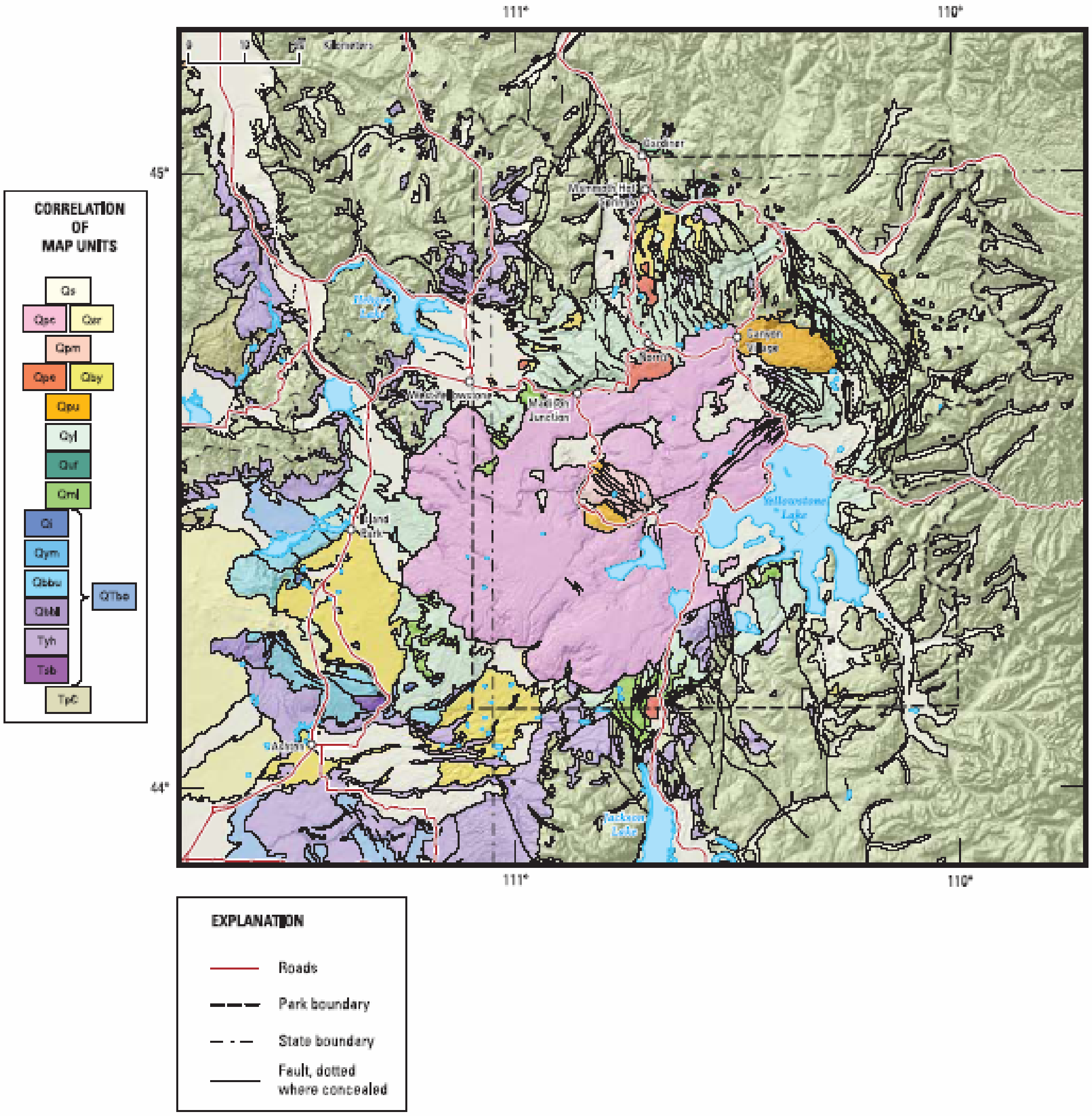


Figure 2. Geologic map of Yellowstone National Park and vicinity showing units associated with the Yellowstone Plateau volcanic field. Unit symbols: Qs, surficial deposits; Qpc, Plateau Rhyolite, Central Plateau Member; Qsr, basalts of Snake River Group; Qpm, Plateau Rhyolite, Mallard Lake Member; Qpe, extracaldera rhyolites; Qby, young extracaldera basalts; Qpu, Plateau Rhyolite, Upper Basin Member; Qyl, Lava Creek Tuff; Quf, Undine Falls Basalt; Qml, Mount Jackson and Lewis Canyon Rhyolites; Qi, Island Park Rhyolite; Qym, Mesa Falls Tuff; Qbbu, upper lavas of Big Ridge Rhyolite; Qbbl, lower lavas of Big Bend Ridge Rhyolite; Tyh, Huckleberry Ridge Tuff; Tsb, rhyolite of Snake River Butte; QTbo, older basalts; Tp€, rocks predating the Yellowstone Plateau volcanic field. After Christiansen (2001).

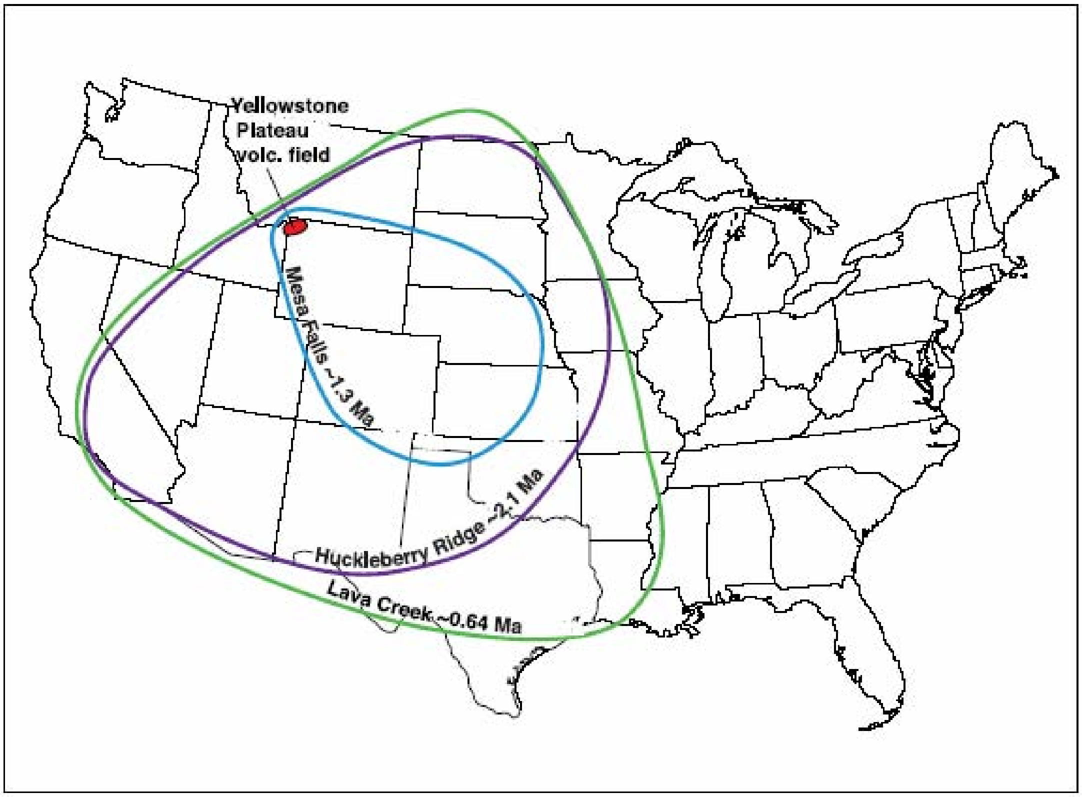


Figure 3. Map of the United States showing inferred distribution of airborne ash deposits erupted in the three major caldera-forming eruptive episodes of the Yellowstone Plateau volcanic field. Symbols: purple line, recognized extent of Huckleberry Ridge ash bed (~2.1 Ma); blue line, recognized extent of Mesa Falls ash bed (~1.3 Ma); green line, recognized extent of Lava Creek ash bed (~0.64 Ma). After Izett and Wilcox (1982).

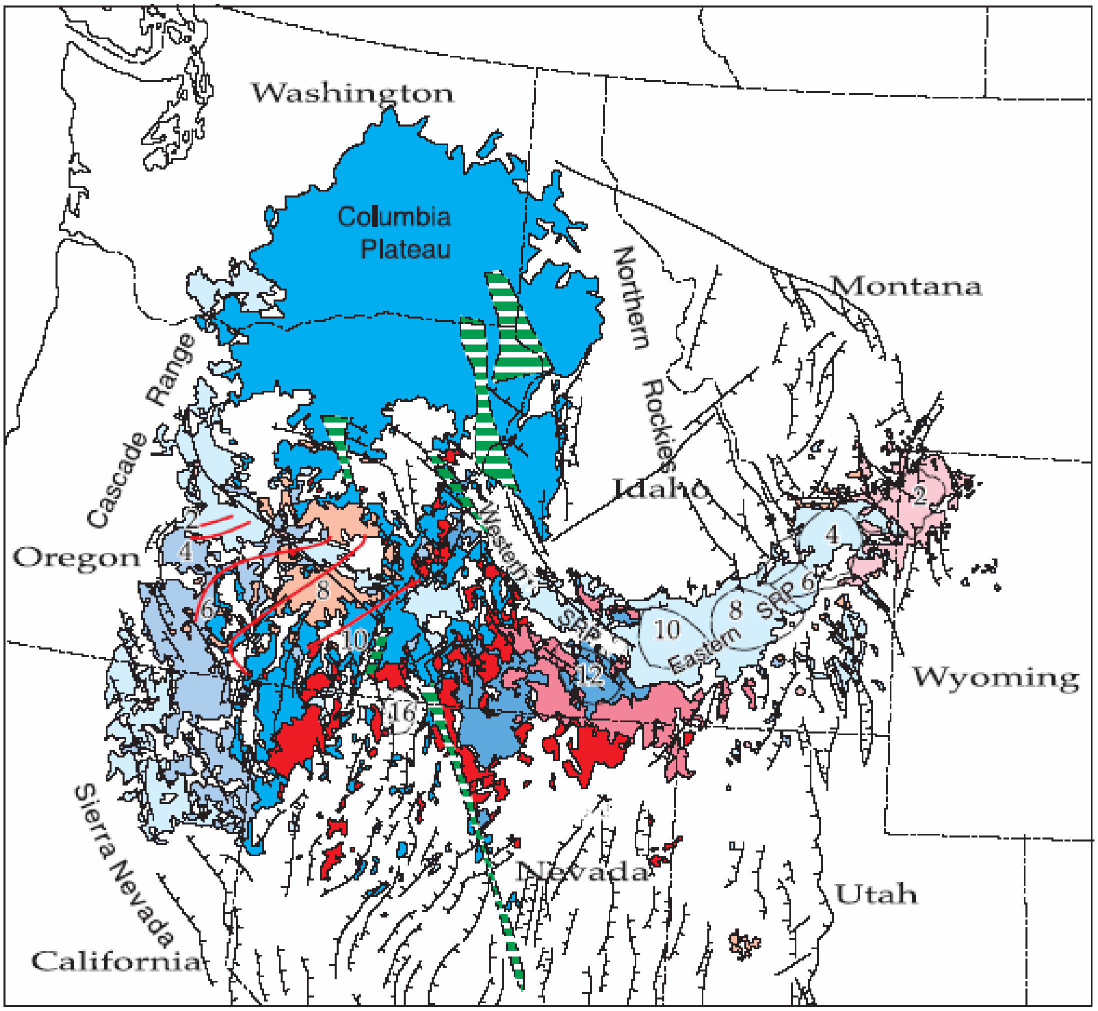


Figure 4. Map of the Northwestern United States showing major tectonic and volcanic features of 17 Ma and younger. Rhyolites shown in shades of red; basalts shown in shades of blue; lighter shades for younger ages. Major rhyolitic centers of the Eastern Snake River Plain (covered by basalts) indicated by their ages of initiation (~12, 10, 8, 6, 4, and 2 Ma) and approximate locations of calderas, after Pierce and Morgan (1992). Partly contemporaneous trend of oppositely propagating rhyolitic centers in eastern Oregon shown by age contours, after MacLeod and others (1976). Green-and-white-striped bands, vent zones for 17- to 14-Ma basalts of the Columbia River Group. Hachured lines, basin-range faults. Map after Christiansen and others (2002)

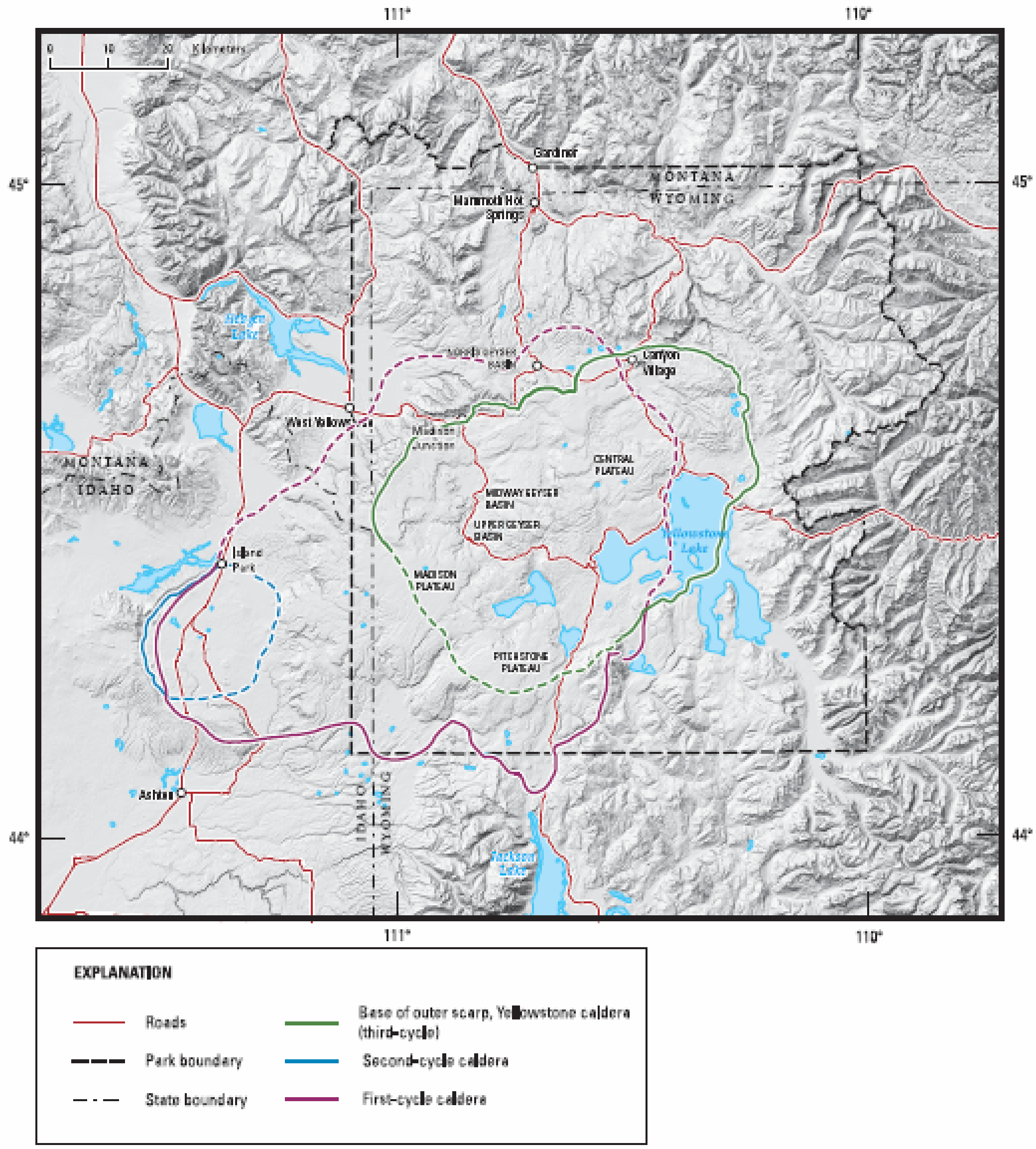


Figure 5. Map of Yellowstone National Park and vicinity showing structural caldera outlines (dashed where inferred) for each of the three large caldera-forming cycles of rhyolitic volcanism (after Christiansen, 2001) and locations of the major geyser basins.

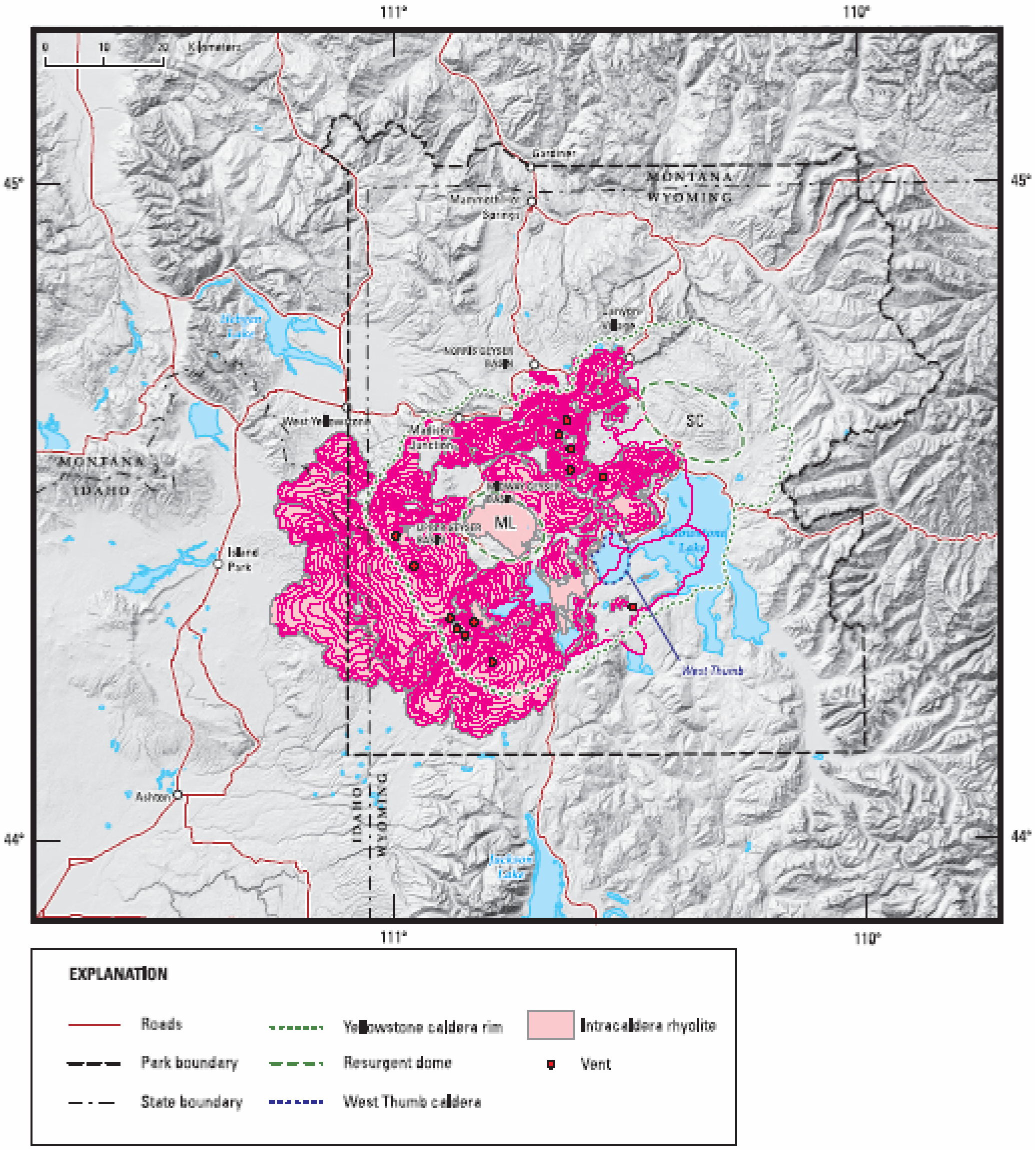


Figure 8. Map of Yellowstone National Park and vicinity showing the Yellowstone caldera, resurgent domes, and late postcaldera rhyolitic lavas. Vents for the lava flows form two linear zones across the caldera along the northwest-trending axes of the Pitchstone-Madison and Central Plateaus, respectively. ML, Mallard Lake resurgent dome; SC, Sour Creek resurgent dome. After Christiansen (2001); flow boundaries in Yellowstone Lake modified from Morgan and others (in press-b).

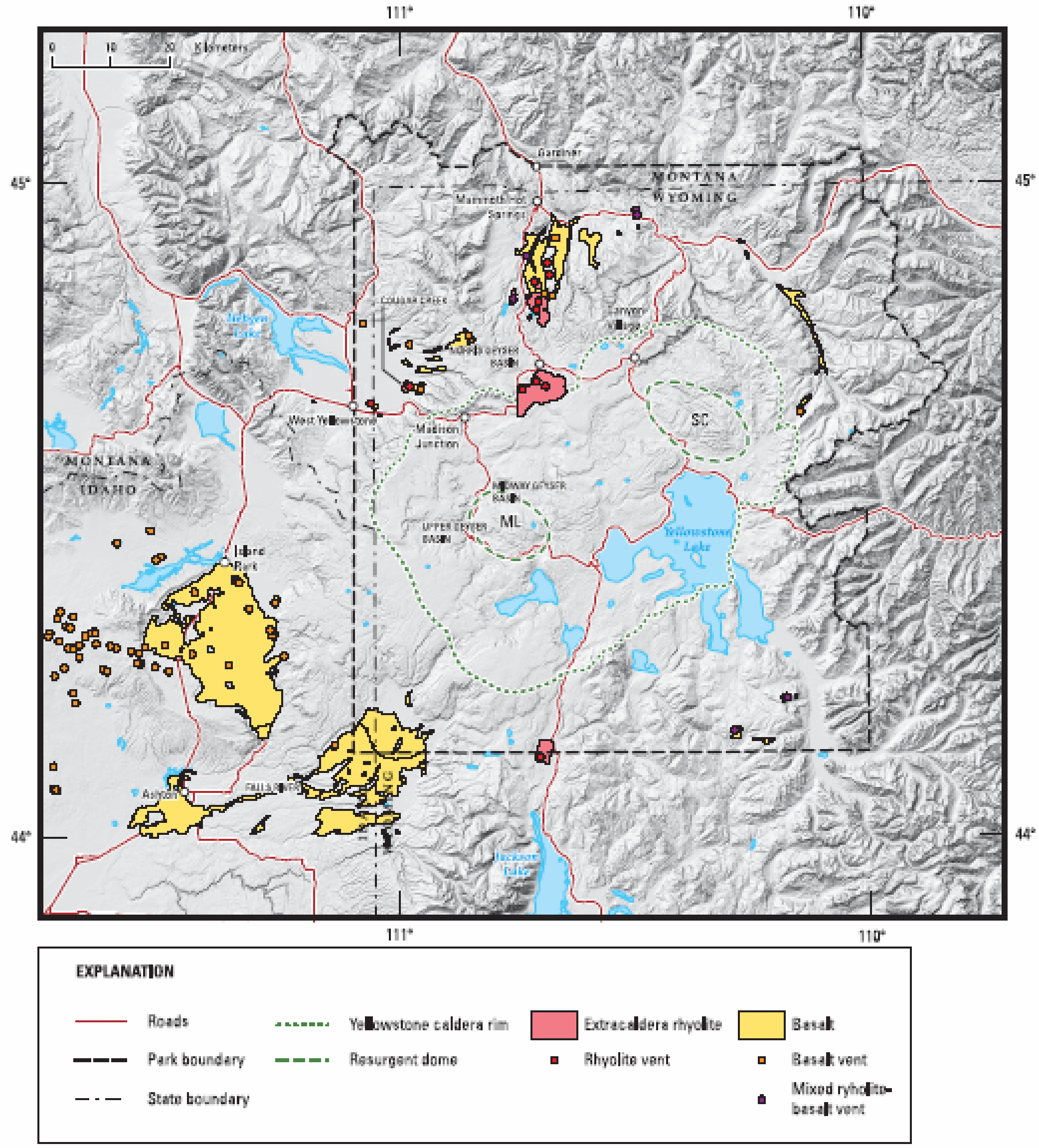


Figure 10. Map of Yellowstone National Park and vicinity showing extracaldera rhyolitic and basaltic lavas that postdate the Yellowstone caldera. ML, Mallard Lake resurgent dome; SC, Sour Creek resurgent dome. After Christiansen (2001).

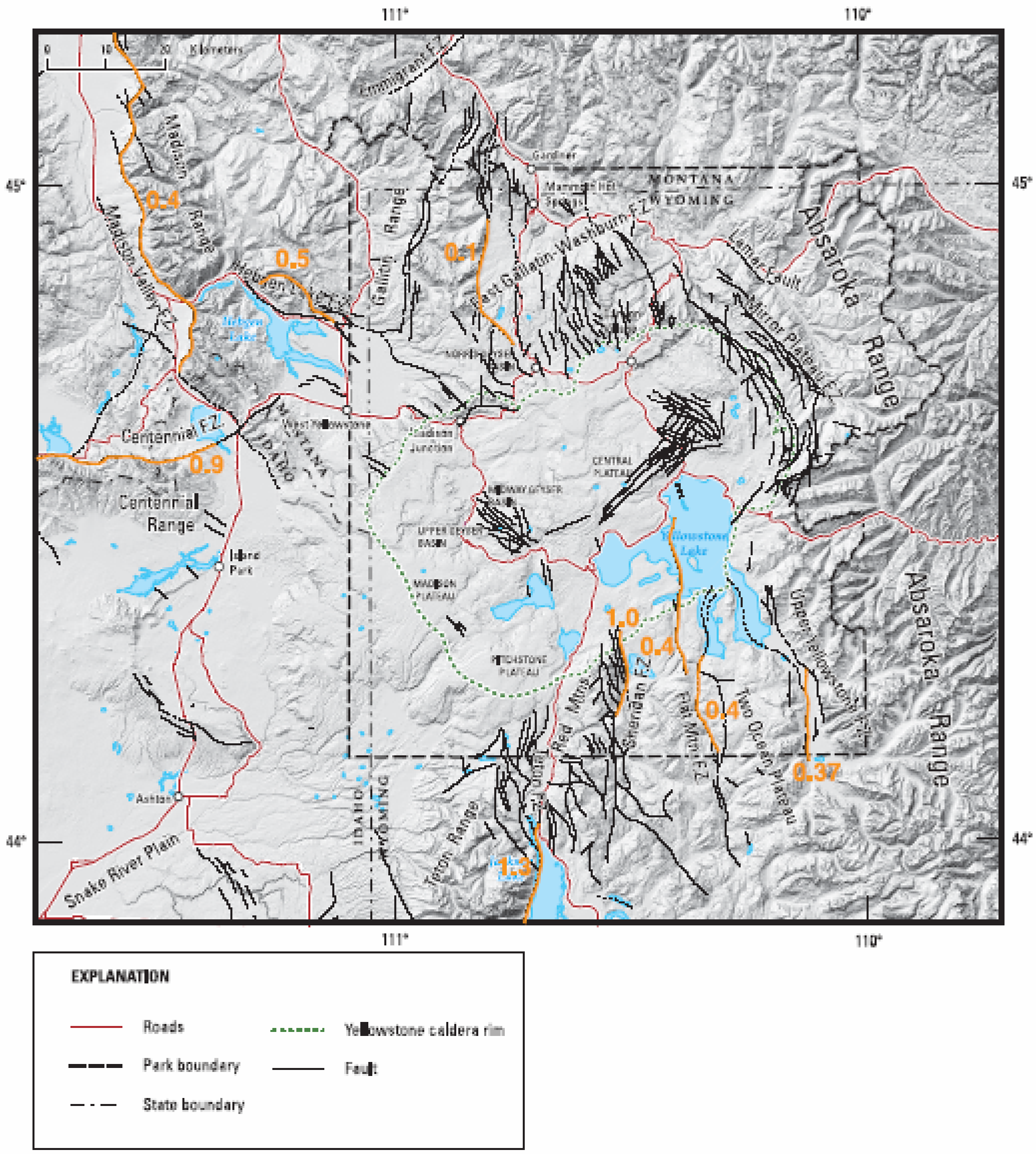


Figure 11. Map of Yellowstone National Park and vicinity showing major faults. All faults shown are normal faults having at least some Quaternary displacement . After Christiansen (2001). Faults in Yellowstone Lake from Morgan and others (in press-b). Faults in orange are those with the largest Quaternary slip rates, as indicated by adjacent numbers in mm/y (after White, 2006)

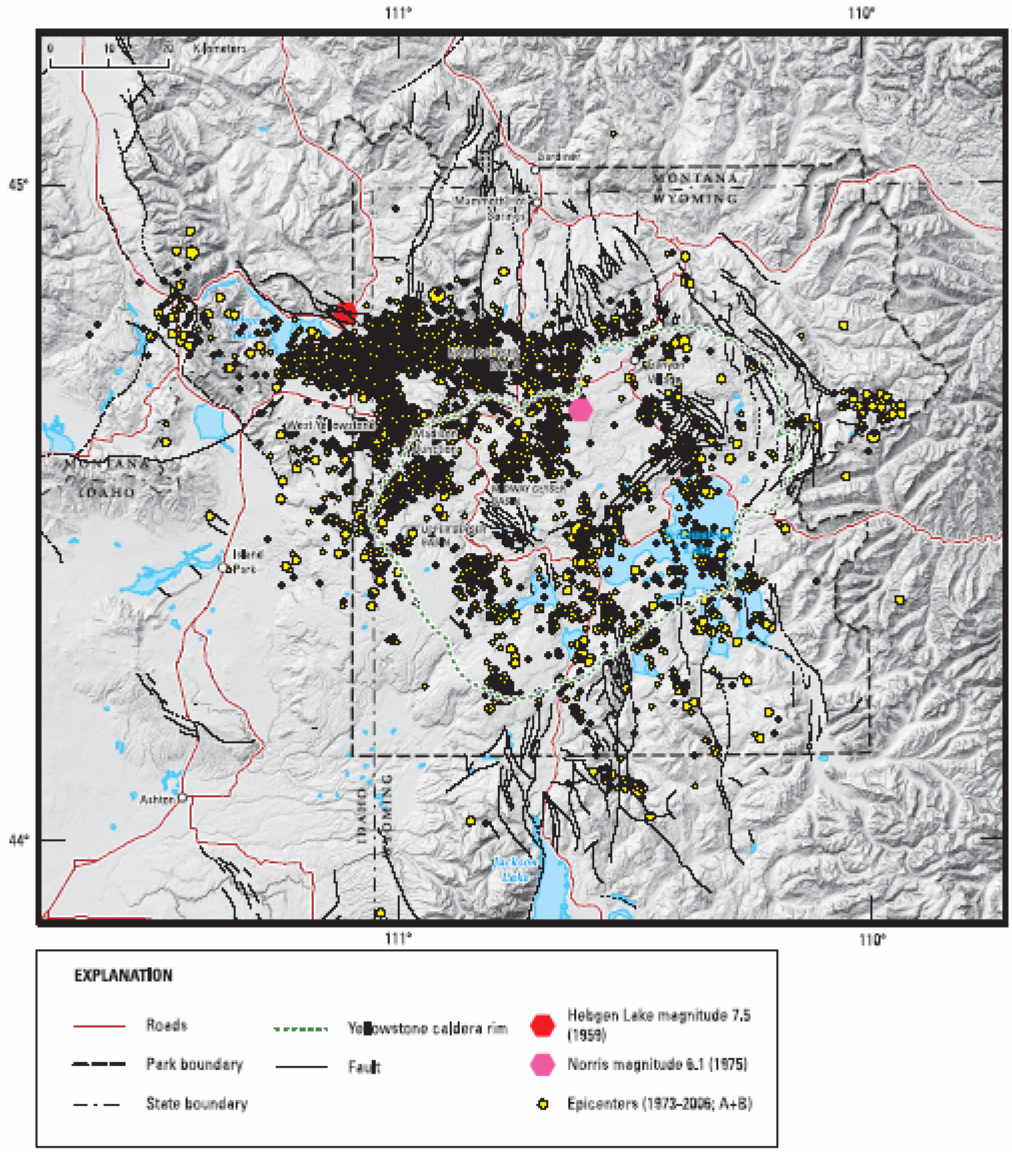
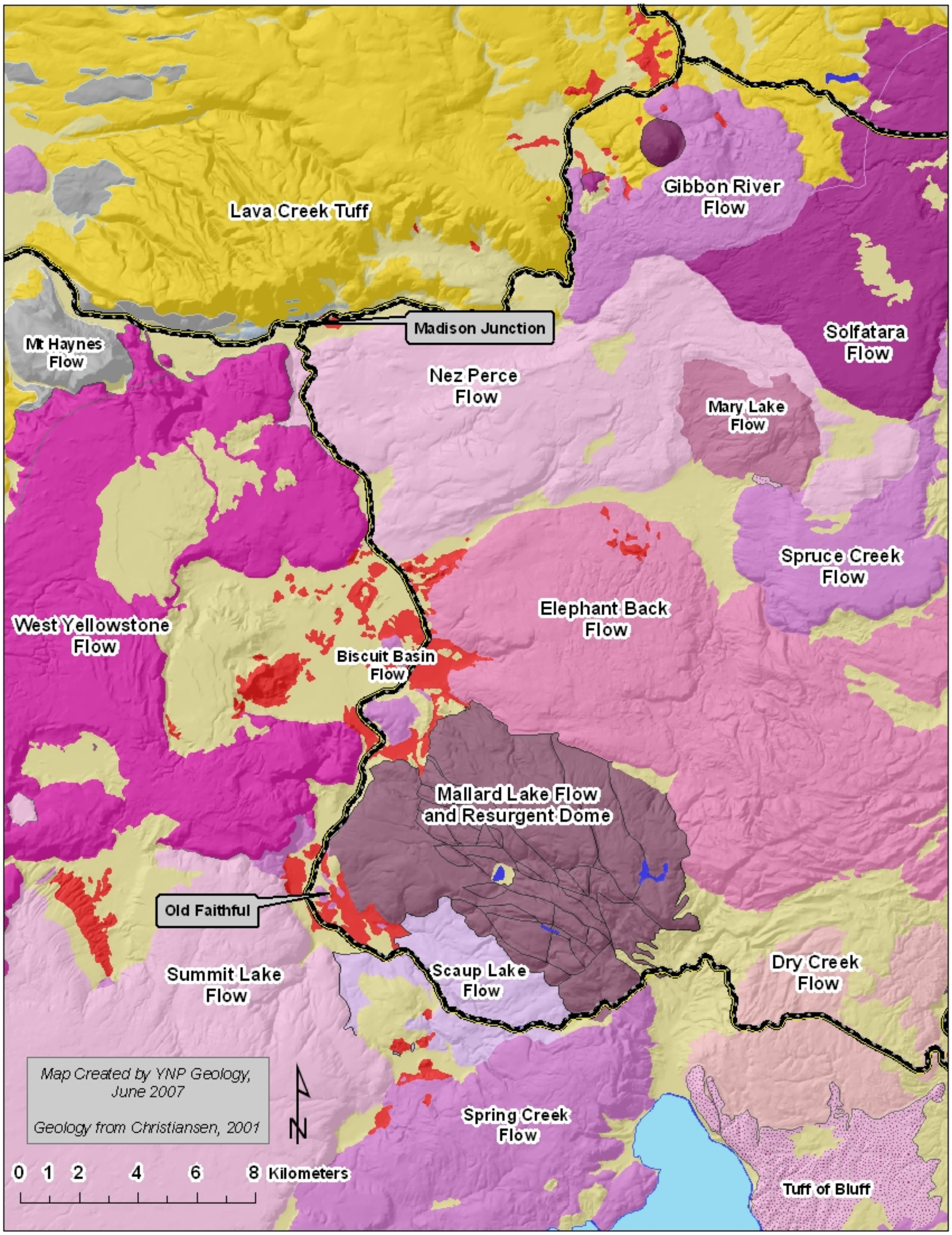


Figure 13. Map of Yellowstone National Park and vicinity showing seismicity between 1973 and 2002 (yellow dots, sizes scaled to relative magnitudes) and major faults having Quaternary displacements. Epicenters of the two largest historic earthquakes in the area are shown by colored hexagons. Data from Yellowstone Volcano Observatory, updated by J. Farrell, University of Utah Seismographic Stations. Only epicenters of classes A and B of Husen and Smith (2004) are shown.

Figure 20. Indian Pond, just north of Yellowstone Lake, is about 500 meters in maximum diameter and was formed about 3000 years ago by a hydrothermal explosion (Morgan and others, in review). Photo by Jim Peaco, 2001 (NPS stock photo).

<u>Outline of Yellowstone's Cenozoic Geologic History</u>

- 55 to 45 Ma- Absaroka (=Challis in Idaho) Volcanism
- 17 Ma to Present- Formation of Yellowstone "hot spot" and progressive eastward movement of volcanism; formation of Snake River Plain
- 2.1 Ma eruption- Huckleberry Ridge Tuff
- 1.3 Ma-eruption Mesa Falls Tuff
- 640 ka-eruption Lava Creek Tuff
- 188-128 ka (MIS 6) Bull Lake Glaciation
- 162 ka- Formation of West Thumb/Tuff of Bluff
- 160 ka-Buffalo Lake rhyolite flow
- 114 ka-West Yellowstone rhyolite flow
- 30? to 17 ka- Pinedale Maximum
- 14 to 13 ka- End of Pinedale Glaciation
- Begin forming current Yellowstone Lake and River
- 13 ka-Formation of Mary Bay
- ~ 8 ka-Formation of Turbid Lake
- ~ 4-6 ka Duck Lake
- ~3 ka-Formation of Indian Pond



Lava Creek Tuff
Gibbon River Flow
Solfatara Flow
Madison Junction
Mt Haynes Flow
Nez Perce Flow
Mary Lake Flow
Spruce Creek Flow
Elephant Back Flow
West Yellowstone Flow
Biscuit Basin Flow
Mallard Lake Flow and Resurgent Dome
Old Faithful
Summit Lake Flow
Scaup Lake Flow
Dry Creek Flow
Spring Creek Flow
Tuff of Bluff
Map Created by YNP Geology, June 2007
Geology from Christiansen, 2001
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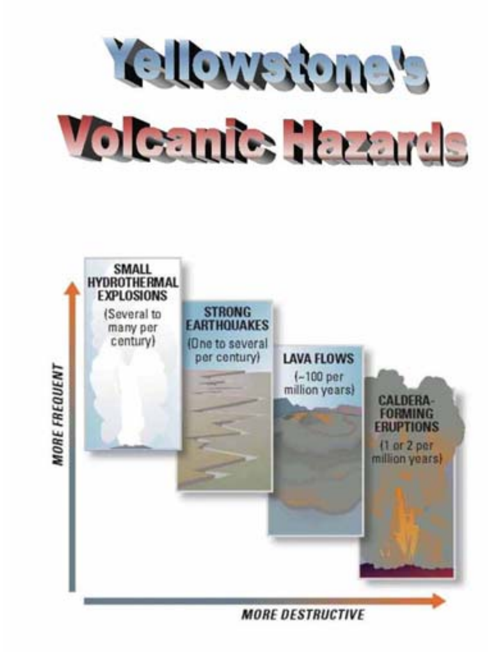
0 1 2 4 6 8 Kilometers



How to predict a volcanic eruption

Earthquakes

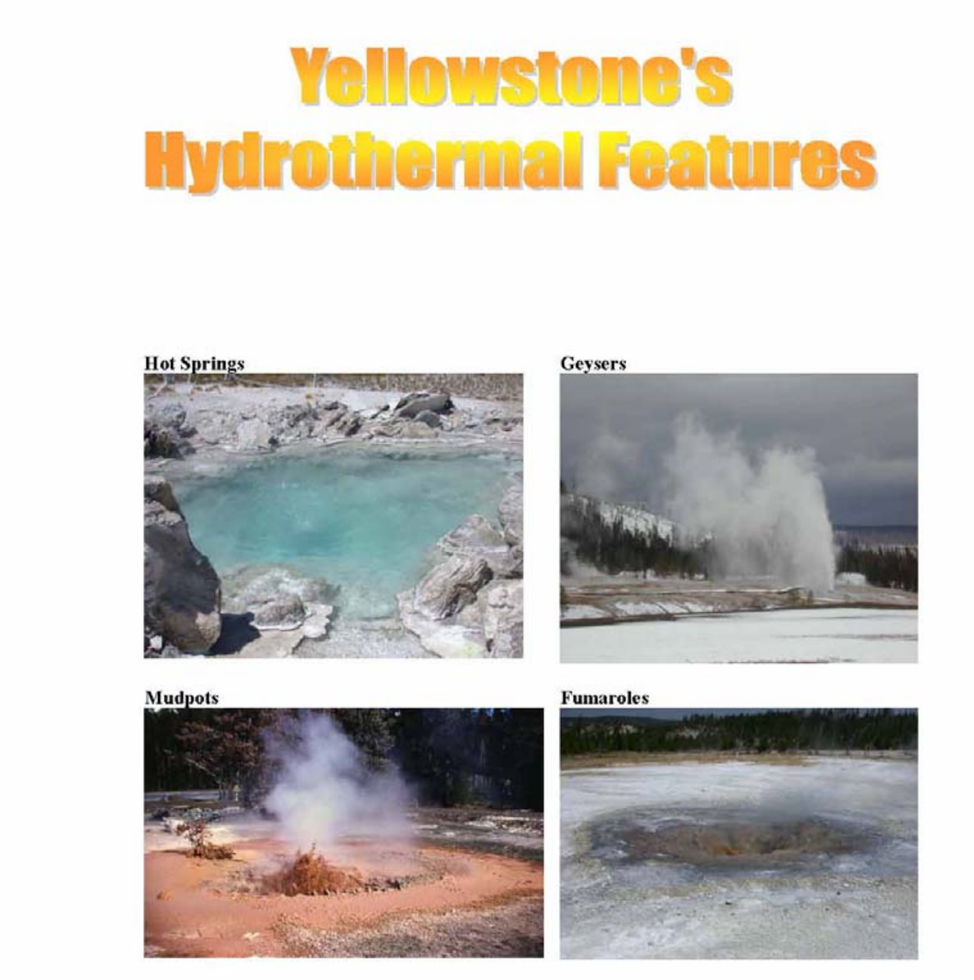
- Swarms (100's-1000's) with some magnitudes >4
- Quakes get shallower over time
- Ground deformation in same place as quakes

Ground Deformation

- Sensed by Global Positioning Satellite (GPS) network
- Deformation >1 m at caldera like Yellowstone
- Radar interferometry, tiltmeters, and strain gauages used to confirm GPS data

Gas and Hydrothermal Areas

- CO_2 emissions should increase
- H_2S replaced by SO_2 as system dries out
- Hydrothermal explosions as magma nears surface
- Hydrothermal areas may become hotter, heat and water flux may change



Yellowstone National Park's Geothermal Monitoring Program

Purpose

- Visitor safety (Hydrothermal explosions, Boardwalk and trail placement, Closures)
- Geothermal Resource Protection
    - External (Island Park Known Geothermal Resource Area, Montana Compact, Oil and Gas Development, Vandalism)
    - Internal (Roads, Infrastructure, Housing
    - Education

Monitoring Strategy (What are we trying to measure)

- Global-Greater Yellowstone (Chloride flux program, Remote Sensing)
- Local (Well monitoring, Thermal feature geochemistry and extent
-

Other Natural Hazards at Yellowstone

Rock fall on Golden Gate Road, Yellowstone National Park following August 17, 1959 Hebgen Lake Earthquake

Debris flow on Gibbon River.

Day 2: Field Trip to Hebgen Lake Earthquake Area

Field Trip Leaders: *Bill Phillips and Roy Breckenridge (IGS)*

Begin: **Buttermilk Campground-Missouri Flats**

Leave campground and proceed north on paved road to junction with Kilgore-Yale Road. Turn east (right) on Kilgore-Yale Road and proceed to junction with Highway 20. Turn north (left) on Highway 20. Proceed to junction Highway 87 and 20. Turn left (northwest) on Highway 87. Centennial Range with Sawtell Peak and Henrys Lake on left (southwest); Madison Range on right (northeast). Cross the Continental Divide at Raynolds Pass and proceed down into the Madison River drainage. Make a quick stop at any position with good view of Missouri Flats. Note large flat area with several terraces (Missouri Flats), the canyon immediately upstream, and linear mountain fronts of Madison Range (geomorphic evidence for normal faulting). Continue to river access parking lot on south-side of Madison River

Stop 2-1. Missouri Flats Terraces. Conduct **Terrace Mapping Activity**.

Proceed across Madison River to junction highways 87 and 287. Turn right (east) on Highway 287 and proceed to Hebgen Lake Earthquake Visitor Center.

Stop 2-2. Hebgen Lake Earthquake Visitor Center. View US Forest Service movie on August 17, 1959 Hebgen Lake Earthquake. Proceed in vans to Memorial Boulder parking lot. Discuss 1959 landslide, landslide-dammed lakes, controls on slope stability. Conduct **Rock Collection Activity**.

Continue east on Highway 287 to sign pointing to Cabin Creek Fault Scarp. Turn left (north) into parking lot.

Stop 2-3. Cabin Creek Fault Scarp. Discuss fluvial v fault scarps; 1959 scarp; dating of fault scarps; earthquake slip rates. Perform **Radiometric Dating Activity.**

Continue east on Highway 287 to Hebgen Lake Dam. Turn into boat ramp parking lot.

Stop 2-4. Hebgen Lake Dam. Discuss 1959 earthquake-generated seiche; damage to dam; dam hazard reduction programs.

Continue east on Highway 287 to sign directing access to Earthquake Building and Road Damage. Turn right (south) and park in lot.

Stop 2-5a: Road damage. Walk to end of former road. Discuss events of August 17, 1959. Return to vans, this time paying close attention to orientation and spacing of cracks in roadway.

Stop 2-5b: Damaged Buildings. Drive to lower parking lot then walk to edge of water to view damaged buildings. Discuss events of August 17, 1959, how earthquakes damage buildings and how construction procedures that can limit damage.

Return to Highway 287 and continue right (east). Pass The Narrows of Hebgen Lake and continue along north side of Grayling Arm to sign and parking lot noting Red Canyon Fault Scarp.

Stop 2-6: Red Canyon Fault Scarp. Good view of 1959 fault scarp. Note association of faulting with spring activity and well-preserved debris flow. Discuss hydrological effects of earthquakes and debris flow hazards.

Continue east on Highway 287 and proceed to junction with Highway 197. This location is termed the Duck Creek “Y.” It is close to the epicenter of the 1959 Hebgen Lake Earthquake. Turn right (south) on Highway 287 and proceed to sign for Yellowstone Village road on the right (west) side of road. Turn onto the road and proceed west. The road divides. Continue on the left (south) branch. The road becomes a gravel road that may be difficult in bad weather. Proceed to the Horse Butte Lookout (steep climb to lookout).

Stop 2-7: Horse Butte Lookout. Conduct **Geological Mapping Activity**.

Retrace route back to Highway 287. Proceed south toward West Yellowstone. Just before crossing Madison River, note sign on left (east) side of road for “Transfer Station.” Turn east (left) onto this paved road, proceed few 100 feet, then turn south (right) along unpaved telephone-power line road. Park where road has good view of Madison River.

Stop 2-8: Obsidian Sand Plain. Examine obsidian sand. Debate origin. Review evidence for glaciation of Yellowstone Plateau. Discuss Quaternary timescales, global climate change.

Retrace route to Highway 287. Continue south to West Yellowstone. Follow signs to Highway 20 and return to Buttermilk Campground (route described in Day 1 Field Trip).

Day 3: Field Trip to Island Park Area

Field Trip Leaders: *Bill Phillips and Roy Breckenridge (IGS)*

Leave Buttermilk Campground and proceed north to Kilgore-Yale Road. Turn right (east) and proceed to junction of Kilgore-Yale Road with Highway 20. Turn left (north) on Highway 20. Cross Henrys Fork and drive by Macks Inn Resort. Turn right (east) on road to Big Springs. Follow road to end, park in large lot.

Stop 3-1: Big Springs. View large spring discharge from beneath rhyolite flow of Buffalo Lake. Discuss post-caldera “Central Plateau” volcanism. Examine flow material. Discuss water resources of the upper Snake River Plain.

Retrace route to Highway 20. Turn left (south) and proceed past Island Park and Last Chance to vicinity of Harriman State Park. Turn left (southeast) onto Highway 47 and park at information center.

Stop 3-2: Island Park Caldera. Examine shaded relief map and identify key geomorphic features of the caldera. These include Thurman Ridge (west) and Central Plateau rhyolites (east), hummocky surface of caldera floor, and “bumpy” post-caldera vents.

Continue south on Highway 47 to near Osborne Springs Campground.

Stop 3-3: Post-Caldera Gerrit Basalts. Examine outcrop of olivine basalts that comprise floor of Island Park Caldera. **Continue Rock Collection Activity**.

Proceed south on Highway 47 to Hatchery Butte Road. Turn left (east) on this unpaved road. Park after few 100 yards at point where Butte can be viewed. Cross old barb-wire fence and walk uphill few 100 yards to outcrops of Osborne Butte rhyolite.

Stop 3-4: Post-Caldera Island Park Rhyolite of Osborne Butte. Examine rhyolite and Continue **Rock Collection Activity**.

Return to Highway 47 and continue south to sign marking Upper Mesa Falls. Park vans at top of grade leading down to the Falls.

Stop 3-5: Upper Mesa Falls. Conduct **River Incision Activity**.

After viewing Falls and historic structure, return to Highway 47. Proceed south to sign marking viewpoint of Lower Mesa Falls. Turn into viewpoint parking lot.

Stop 3-6: Lower Mesa Falls. Finish **River Incision Activity** at viewpoint.

Continue south on Highway 47 to Ashton. At junction with Highway 20, turn right (north) on Highway 20. Proceed north on Highway 20 until reaching Henrys Fork. Cross the river then turn left (west) on road to new houses. Follow the road that leads uphill until it crosses a roadcut. Park at top of roadcut.

Stop 3-7. Mesa Falls Tuff. Excellent exposure of pumice-crystal tuff overlying crystal-concentrate (air-fall?) of sanadine and quartz. Discuss age and emplacement tuff. Continue **Rock Collection Activity.**

Return to Highway 20 and turn left (north). Huckleberry Ridge tuff on right (east) side of road and Mesa Falls Tuff on left in roadcut (unsafe to stop with large group). Proceed up the flank of Big Bend Ridge and drop into the Island Park Caldera. Note distinctive erosional forms of Big Bend Ridge developed in homogeneous tuff. Cross hummocky valley floor underlain by Gerrit Basalt flows.

Continue north on Highway 20, past Last Chance and Island Park, until reaching Kilgore-Yale Road. Retrace route to Buttermilk Campground.

2007 Staff

Roy Breckenridge

Roy is the Idaho State Geologist. He came to IGS from the Wyoming Geological Survey in 1978. Roy's PhD and M.S. are in geology from the University of Wyoming. His areas of expertise are geomorphology, Quaternary geology, and field mapping. Roy enjoys all disciplines of geology and has worked in many diverse geologic terranes. He is currently working on the glacial geology of northern Idaho and the Long Valley area near McCall.

Jim Cash

Jim Cash taught earth science at Moscow High School between 1982 and 2007. Jim has presented research on earth science teaching at both state and national conferences, and was actively involved in creating curriculums and course assessments for the teaching of earth science in Idaho. Jim also worked with Idaho State University and the Idaho Geological Survey to develop the geology portion of the Idaho Digital Atlas. He has been active in the Idaho Earth Science Teachers Association for many years, particularly with the annual "rock raffle."

Hank Heasler

Henry P. (Hank) Heasler's research interests are in geothermal systems and terrestrial heat transport. He has published over 30 referred articles, including 13 papers on Wyoming geothermal resources and modeling of thermal processes in Wyoming. In 2002, Dr. Heasler became the Park Geologist for Yellowstone National Park. Since his appointment, he has worked with scientists to improve monitoring of the Yellowstone volcano. In 2005, Yellowstone National Park received $646,000 from Congress to implement a scientifically-reviewed geothermal monitoring plan for the Park.

Cheryl Jaworowski

Cheryl is a geologist at Yellowstone National Park. She earned her doctorate in geology from the University of Wyoming and specializes in Quaternary geology as well as applying remote sensing to mapping Yellowstone's active geology. Before working as a geologist at Yellowstone National Park, Cheryl taught introductory geology, physical geography and geographic information system classes at Laramie County Community College. Professional interests include Rocky Mountain glaciations, Yellowstone's volcanic ashes, remote sensing of Yellowstone's thermal areas, debris flows, mapping active Quaternary faults, paleodrainages, and science education.

Bill Phillips

Bill is a research geologist with the IGS. A Pocatello native, Bill joined the IGS in 2004 after many years living away from Idaho. He has taught university courses in geomorphology, field methods, hydrology, and introductory geology & geography, most recently at the University of Edinburgh and Colorado College. For a decade, Bill worked at the Washington Division of Geology and Earth Resources in Olympia where he conducted geological mapping in the Cascades. Bill has a Ph.D. in geology from the University of Arizona. His current research focuses on dating glacial deposits and lava flows with cosmogenic nuclides, and the Quaternary geology of the Idaho Falls-Blackfoot area in southeastern Idaho.