Field Trip Guide to the
Natural Hazards of the Boise Area, Idaho

William M. Phillips

Staff Report 07-1
January 2007

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

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Field Trip Guide to the Natural Hazards of the Boise Area, Idaho

William M. Phillips[1]

ABSTRACT

This report provides field trip stops illustrating the natural hazards of the Boise area. The field trip was developed for the 2005 Western States Seismic Policy Council annual meeting.

INTRODUCTION

The Boise area, home to about 23% of Idaho's population, is subject to a variety of natural hazards including earthquakes, flooding, and wildfires. This field trip examines the interaction of these natural hazards with the dynamics of rapid population growth and development. Most of the trip is devoted to examining evidence for active faulting and the historical record of flooding. Examples of recent development in sensitive areas such as floodplains are also viewed.

GEOLOGICAL SETTING

Wood and Clemens (2002) provide a comprehensive account of the geological setting of the Boise region from which this discussion is largely taken. Boise is located on the margins of the Western Snake River Plain (WSRP), an intracontinental rift basin about 70 km wide and 300 km long (Fig. 1). The WSRP is bounded and internally faulted by northwest-trending normal faults. Major faulting and basin development began about 11 million years ago (Ma) and was largely finished by 9 Ma. Maximum offset along the bounding faults exceeds 4 km in places and a maximum of 2-3 km of sedimentary and volcanic rocks fill the basin.

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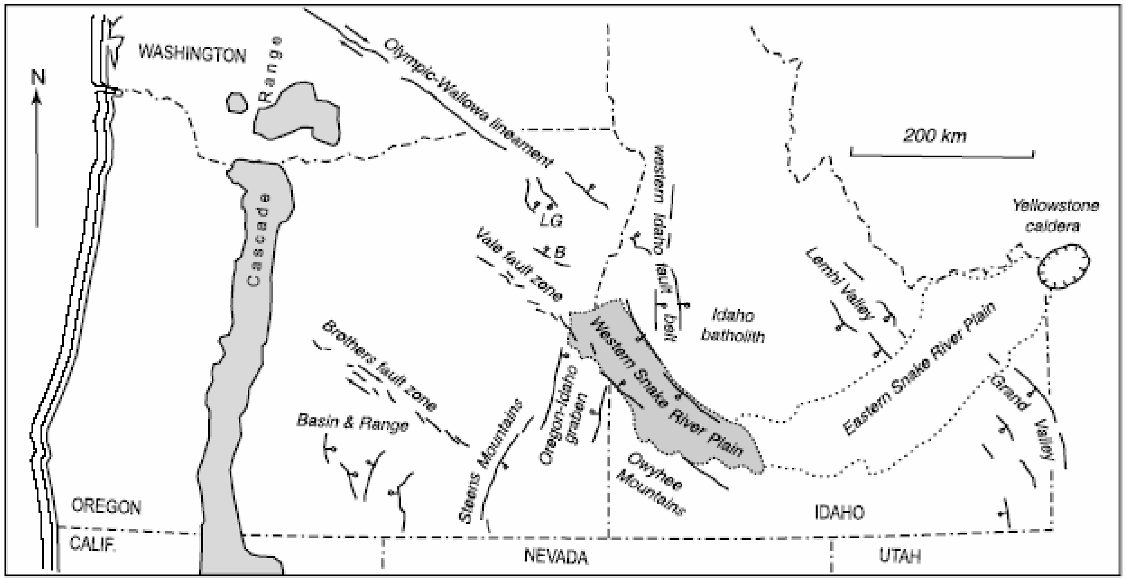

Figure 1. Major Cenozoic tectonic features of the northwestern United States (from Wood and Clemens, 2002)

Causes of rifting in the WSRP remain a topic of research. The Yellowstone Hotspot passed to the south of the WSRP about 11 Ma and may have softened the lithosphere, triggering extension and basin formation. Silicic volcanic rocks (rhyolite flows, domes, and tuffs) were erupted about 11.5-8 Ma to the south of the area and are locally present in the Boise Foothills (Fig. 2). Most volcanic rocks within the WSRP are basaltic lavas, beginning with eruptions 10-7 Ma and continuing as recently as about 400,000 years ago in the Boise area (Othberg, 1994; Othberg and others, 1995). Basalt eruptions are characterized by subaerial lava flows forming shield volcanoes, thick canyon fills, and thin flows spreading over alluvial valleys. The WSRP truncates granitic rocks of the Idaho batholith that were intruded at about 90 to 60 Ma (Fig. 2). Granodiorite is found in the mountains just north of Boise on Boise Ridge and also in the Owyhee Mountains to the south. Geophysical data indicate that the crust beneath the WSRP is not faulted granite, however, but is of mafic composition all the way to the mantle, about 42 km beneath the plain.

North-trending normal faults similar to those of the Basin and Range Province in Oregon and Nevada also occur in southwestern Idaho (Figs. 1 and 2). Basin and Range faults produce the seismic hazard in much of the western United States including Borah Peak in east-central Idaho and along the Wasatch Front in Utah. North of Boise and the WSRP, Basin and Range-style normal faults produce much of the seismic risk for the Boise area.

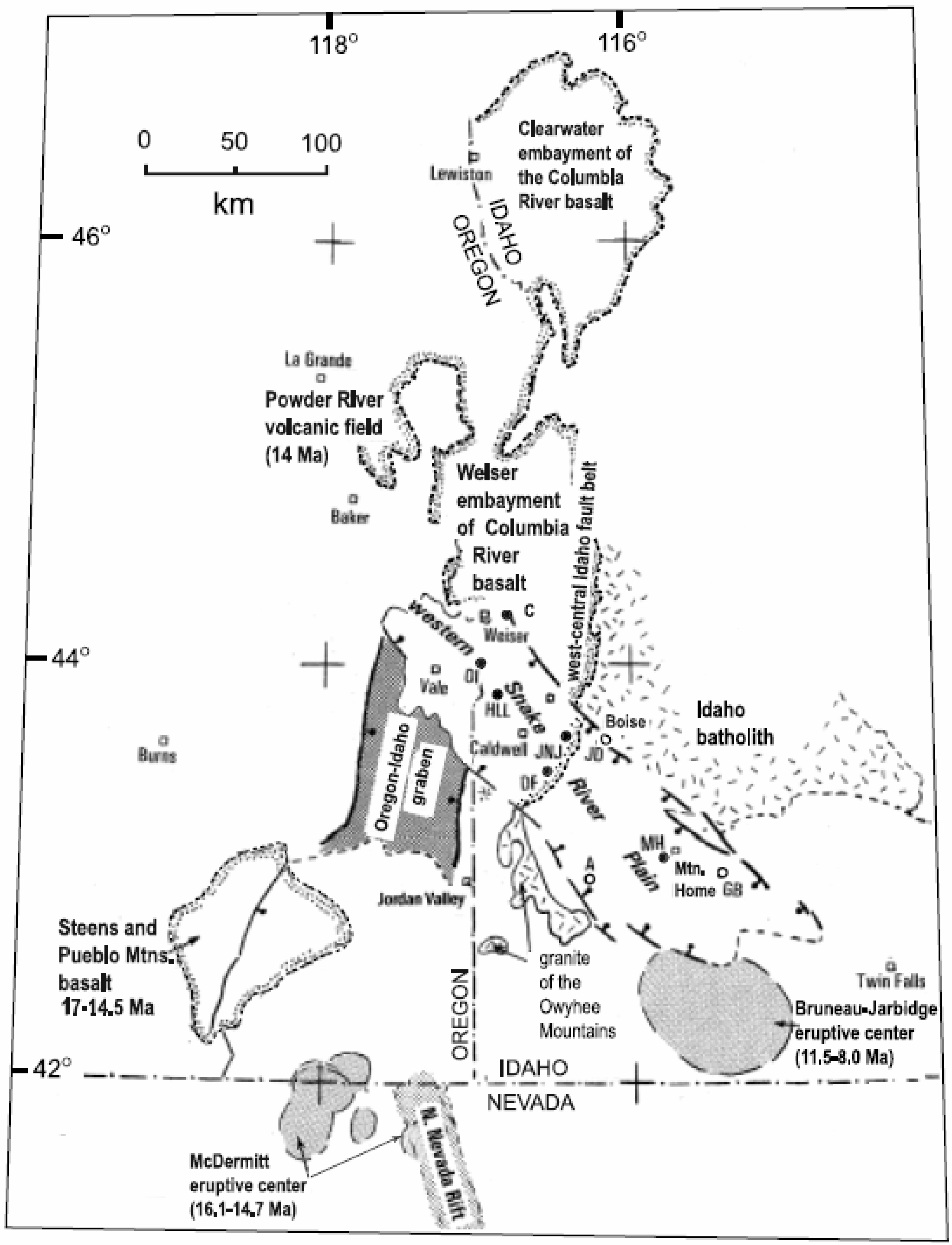

Figure 2. Major tectonic features of the western Snake River Plain and adjoining areas (from Wood and Clemens, 2002)

In response to normal faulting and basalt eruptions, drainages were disrupted in the developing WSRP rift basin, causing lakes to occupy much of it. Fluvial, deltaic, and lake sediments interbedded with lava flows accumulated during this time. The last of the large lakes to occupy the WSRP is commonly known as Lake Idaho. This lake rose to its highest elevation of about 1100 m (3600 ft) over a period of a few million years sometime between 6.4 and 1.7 Ma. At that level, Lake Idaho overtopped a threshold and spilled into the ancestral Salmon River-Columbia drainage, ultimately cutting Hells Canyon. This caused a progressive and long-standing drop in base level in the western Snake River Plain. As a result, rift basin sediments and volcanics are incised hundreds of meters by streams. These sediments can be seen in the Boise Foothills and also along the field trip route between Horseshoe Bend and Emmett.

Dropping base levels of streams continued into the Quaternary. During the glacial periods of the Pleistocene, episodic downcutting of the basin fill was followed by deposition of thick river gravels. This produced a series of stream terraces along the Boise River (Fig. 3; Othberg, 1994). Several lava flows are interbedded with these terraces to form the "benches" that much of Boise is built upon.

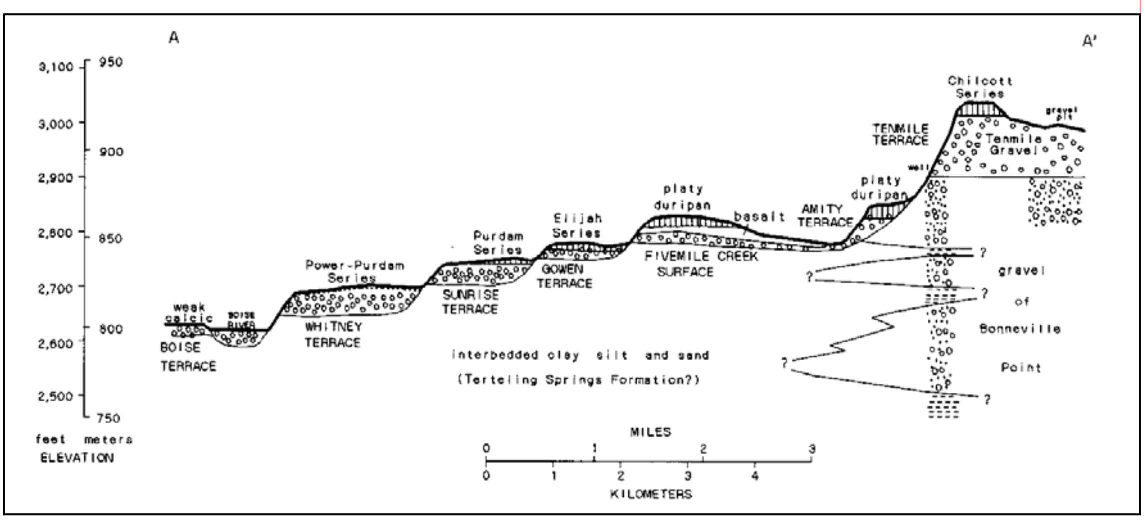

Figure 3. Diagrammatic profile and cross section of the eastern Boise Valley showing soil series on terraces (from Othberg, 1994).

A cross-section of the WSRP basin based upon wells and geophysical data shows a complexly faulted basin with a basalt basement that is filled with sediments interbedded with basalt lava flows (Fig. 4). Note that faults are present along both basin margins and within the basin.

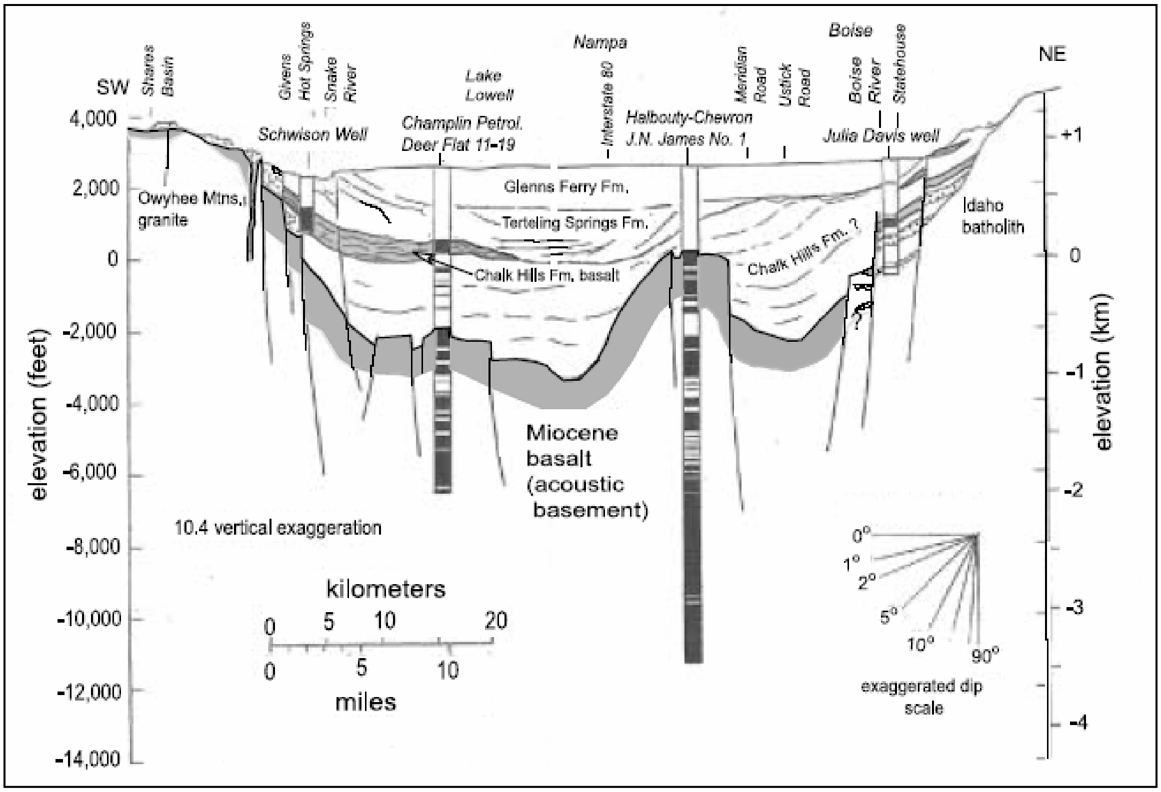

Figure 4. Cross section of the western Snake River Plain from seismic reflection and well data showing basalt (dark pattern) and sedimentary fill (from Wood and Clemens, 2002)

EARTHQUAKE HAZARDS

Boise is situated between two fault zones with evidence of Quaternary activity (Fig. 5). The Western Snake River Plain Fault System consists of numerous northwest-trending normal faults with little surface expression that offset older Quaternary deposits. To the north of the city is the Western Idaho Fault System, a group of north-trending normal faults that appear to be a continuation of the Basin and Range. The latest movement on this system was along the Squaw Creek Fault, near Emmett, Idaho, sometime after 7700 years ago (Gilbert and others, 1983). The field trip visits the Squaw Creek area and the nearby Black Canyon Dam. Most structures in the region were built without consideration of seismic hazards. The field trip views examples of housing stock in the Boise area and discusses the vulnerability of these structures to earthquakes.

HISTORICAL SEISMICITY

Based on a historical record extending from about 1872 to the present, the Boise area has not experienced any seriously damaging earthquakes. Three distant earthquakes produced intensities of VI in Boise that were strong enough to cause light nonstructural damage. These were the 1983 Borah Peak (east-central Idaho, magnitude 7.0), the 1959 Hebgen Lake (western Wyoming; magnitude 7.5), and an earthquake in 1947 with an

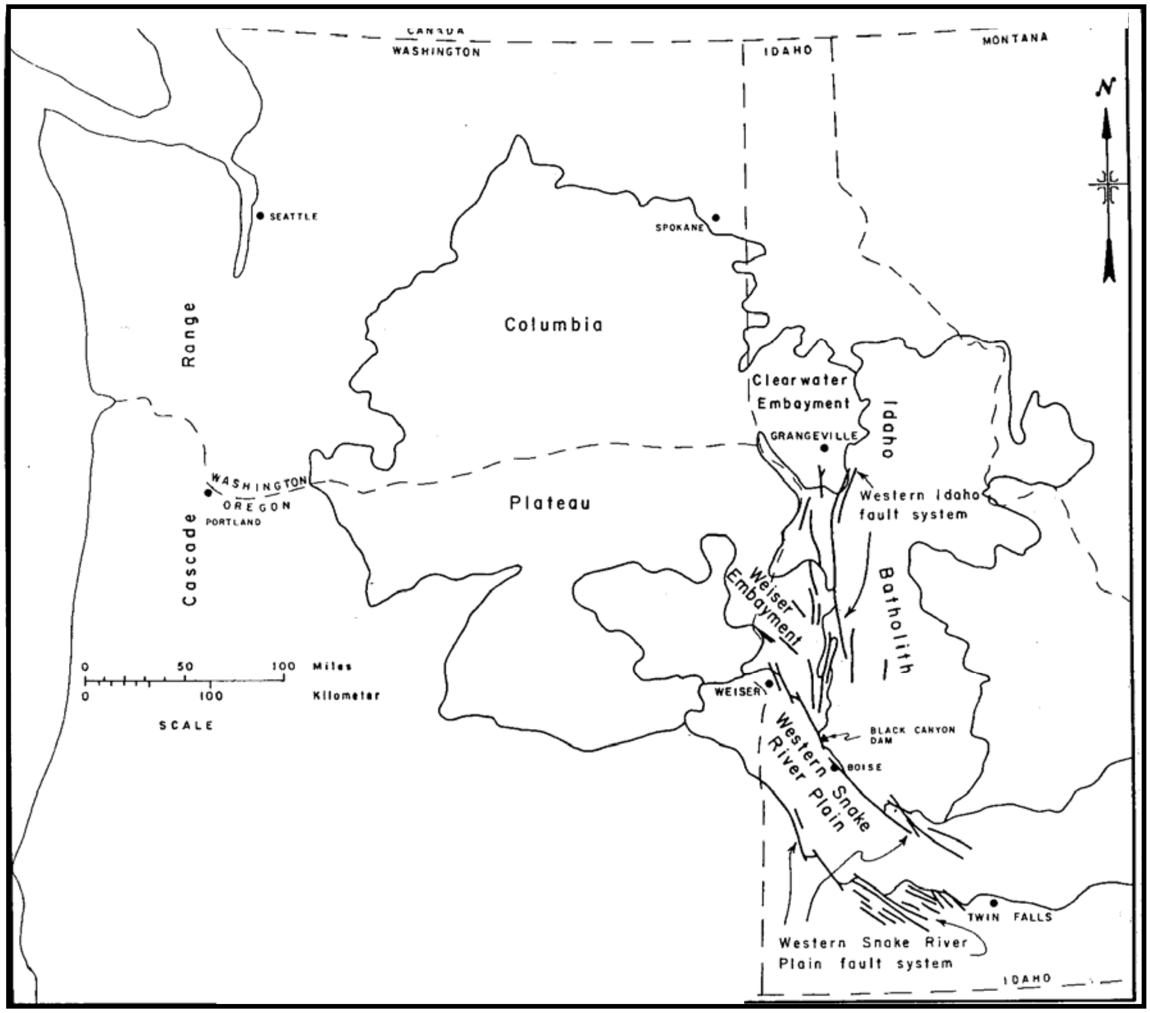

Figure 5. Physiographic map of the Pacific Northwest showing faults of the Western Idaho Fault System and the Western Snake River Plain Fault System (from Gilbert and others, 1983)

epicenter in Idaho's Salmon River mountains northeast of Boise. Regional seismic networks indicate that low magnitude earthquakes do not generally occur directly beneath Boise, and that microseismicity does not outline active faults. (Zollweg, 2001).

QUATERNARY FAULTS

A large number of faults exist in the Boise region. Most consist of structures related to rift basin development with no evidence for movement over the past 1.8-2 Ma (Quaternary period). However, few detailed studies of faults have been performed and additional active structures may be present (Zollweg, 2001, 2005). Several studies have concluded that the closest active faults to Boise are located in the Western Idaho Fault

System to the north of the city. The most important of these is the Squaw Creek fault, about 40 km from Boise (see Field Trip Stop 5 and 7). Last movement on the Squaw Creek fault was post-7700 years (Gilbert and others, 1983). This fault is assigned a maximum credible earthquake (MCE) of magnitude 7.0 at an epicentral distance of 5 km and a focal depth of 7 km (Gilbert and others, 1983). An intensity of VIII is expected in Boise from this MCE (Zollweg, 2005).

A group of northwest-trending faults assigned to the Western Snake River Plain Fault System occur in and near Boise (Fig. 6). These faults offset Pliocene-Pleistocene deposits and form topographic linears consisting of asymmetric ridges up to 30 meters high. Quaternary deposits are locally deformed by these faults (Othberg, Stanford, Burnham, 1990; Burnham and Wood, 1992). Along the southwestern margin of the WSRP Fault System between the Owyhee Mountains and the Snake River Plain, active structures have been identified in the Owyhee Mountains Fault System.

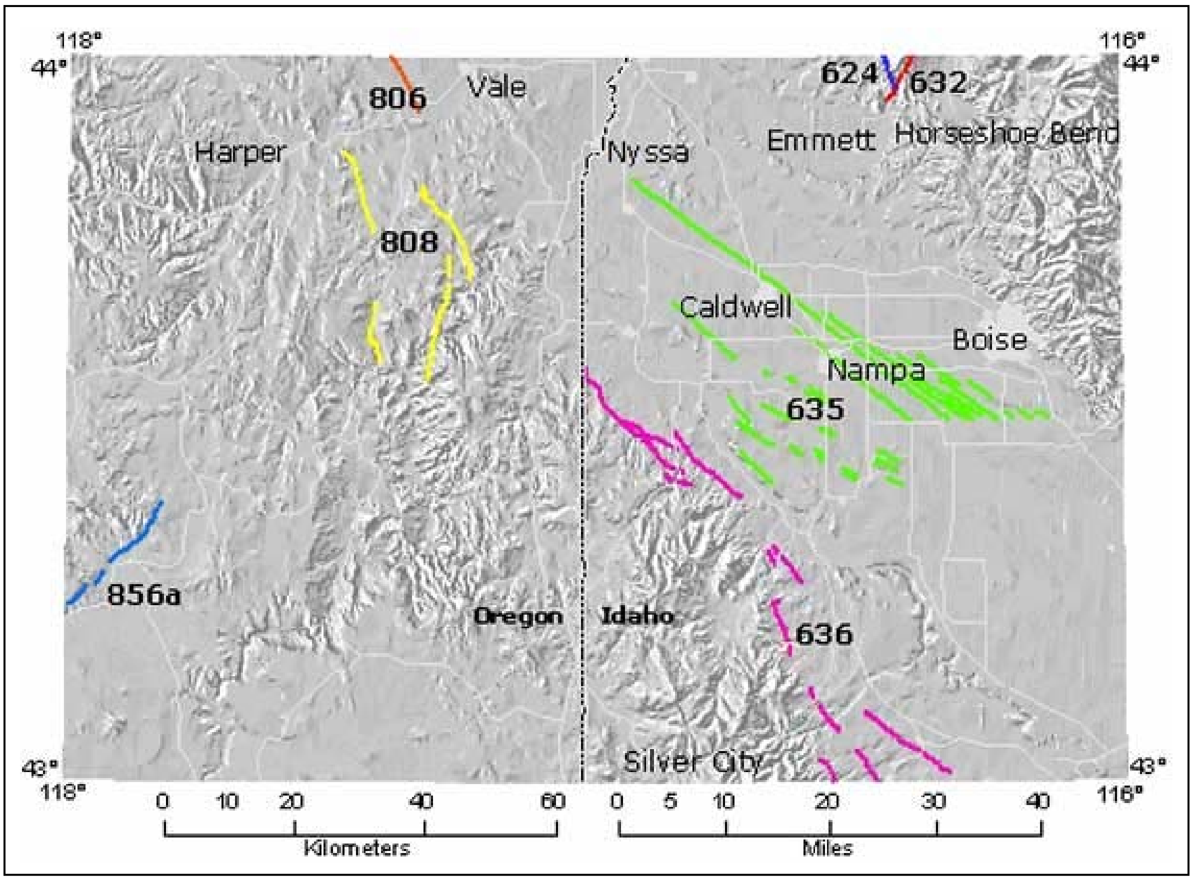

Figure 6. Quaternary faults of the Western Snake River Fault System (green and labeled 635). Faults of the Owyhee Mountains Fault System (red and labeled 636). Figure from http://earthquake.usgs.gov/qfaults/or/boi.html accessed 9/2/05. See also Personius and Lewis (2003).

Beukelman (1997) trenched the Water Tank fault in the Owyhee Mountains and found evidence for five events since 26±8 ka, and an age of the youngest event of about 3 ka.

In the Boise area, the most prominent potentially active structure is the Boise Front fault zone. This zone consists of en echelon northwest-trending faults in the Boise Foothills and as far out in the Snake River Plain as the Boise airport. In general, these structures do not clearly offset Quaternary deposits or have surface manifestations. However, minor faulting of Pleistocene terrace deposits has been reported from the Boise area (Othberg, Stanford, and Burnham, 1990; Burnham and Wood, 1992; see Field Trip Stop 1). Zollweg (2001, 2005) argues that the Boise Front fault zone is potentially capable of producing a MCE of magnitude 6.5, with an expected intensity in Boise of VIII.

FLOODING HAZARDS

Flooding is an important hazard along the Boise River and its tributaries. Flooding and irrigation practices could contribute to seismic hazards by increasing liquefaction potential for structures built in the floodplain. Despite upstream regulation by three large dams (Fig. 7), the river reaches a bankful stage of 6,500 ft3/s (cfs) at Boise most years, and in June of 1983 had a flow of 9840 cfs. High stream flows occur when greater than average mountain snow pack is melted quickly by high temperatures and/or heavy rains. Since the reservoirs are managed to conserve water for use by summer irrigators, dam managers may be forced by unexpected weather conditions to quickly release large volumes of water. Property damage and inconvenience occur under these conditions (Stacy, 1993). Encroachment and development in the river floodway is aggravating this situation (see Field Trip Stop 2 and 3).

FOOTHILLS FLOODING AND DEBRIS FLOWS

Foothills flooding occurs on small, steep catchments draining the Boise front range. Based on historic flood events, four drainages have the highest risk: Stuart Gulch, Crane Gulch, Hulls Gulch and Cottonwood Creek. The City of Boise operates flood control structures on several of these drainages. These structures improve flood protection but will not completely protect property in an extreme flooding event.

Foothills floods are caused by summer thunderstorms or heavy rain on snow during the winter. Thunderstorms generally occur in June to September while late December to February is the worst time for rain on snow events. One of the largest foothill floods occurred in the “Mudbath Floods” of September 1959 when about 0.3 inches of rain fell in five minutes in northeast Boise. Peak flow on Cottonwood Creek was estimated at 3000 cfs. Debris flows were generated by the flooding, and were probably made worse by rangeland fires the previous year. About 500 houses were damaged by mud up to 10 feet deep and over 160 acres were covered by silt and debris flows.

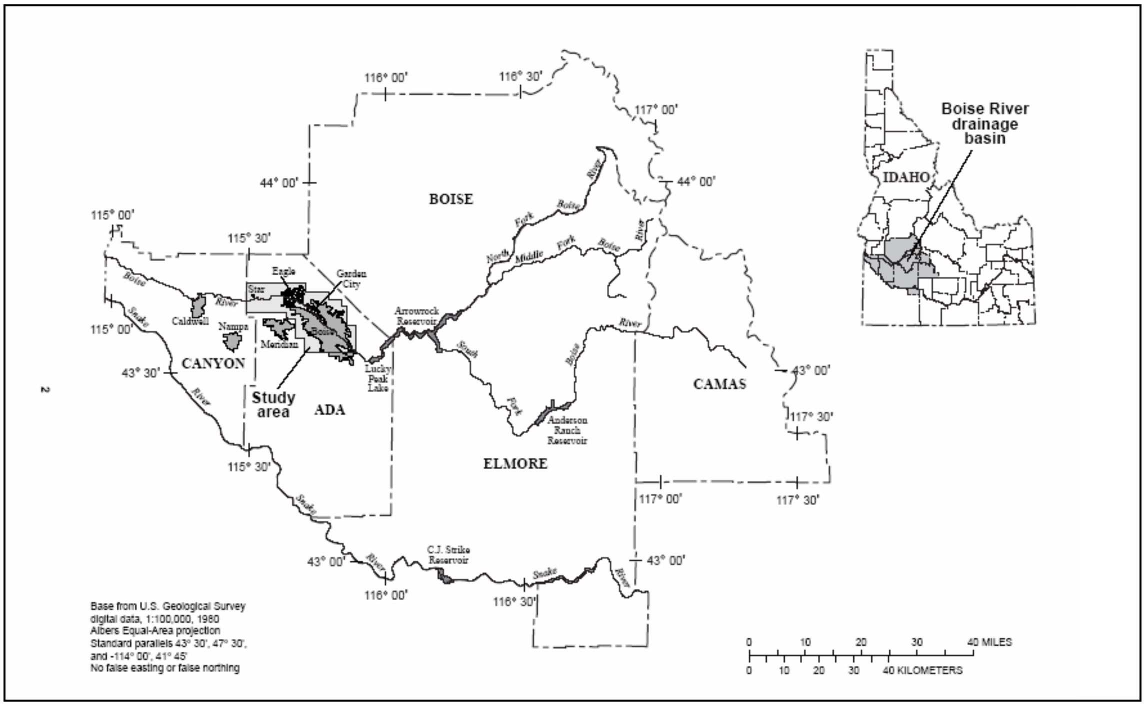

Figure 7. Location of the Boise River drainage basin showing location of Anderson Ranch, Arrowrock and Lucky Peak dams.

WILDFIRES

Wildfires occur many summers in the Boise foothills. The 1992 Foothills Fire destroyed 257,000 acres of range and forest land. In August of 1996, 15,300 acres of the Boise Foothills were burned by a wildfire. The latest foothill fire occurred July 27, 2005 when 800 acres burnt (Idaho Statesman, 7/25/05 edition). Besides being a significant hazard to structures and recreational users, the fires greatly increase the potential for damaging flooding and debris flows. Most wildfires in the Boise area are generated by lightening during summer thunderstorms. Vulnerability to wildfires is increasing as more dwellings are constructed in the Boise foothills adjacent to range and timber lands.

FIELD TRIP ROAD LOG

Distance between stops in miles begin at the Grove Hotel, 245 Capitol Boulevard in Boise. The field trip route is shown in the Fig. 8. Locations of field stops are given in UTM coordinates, zone 11T.

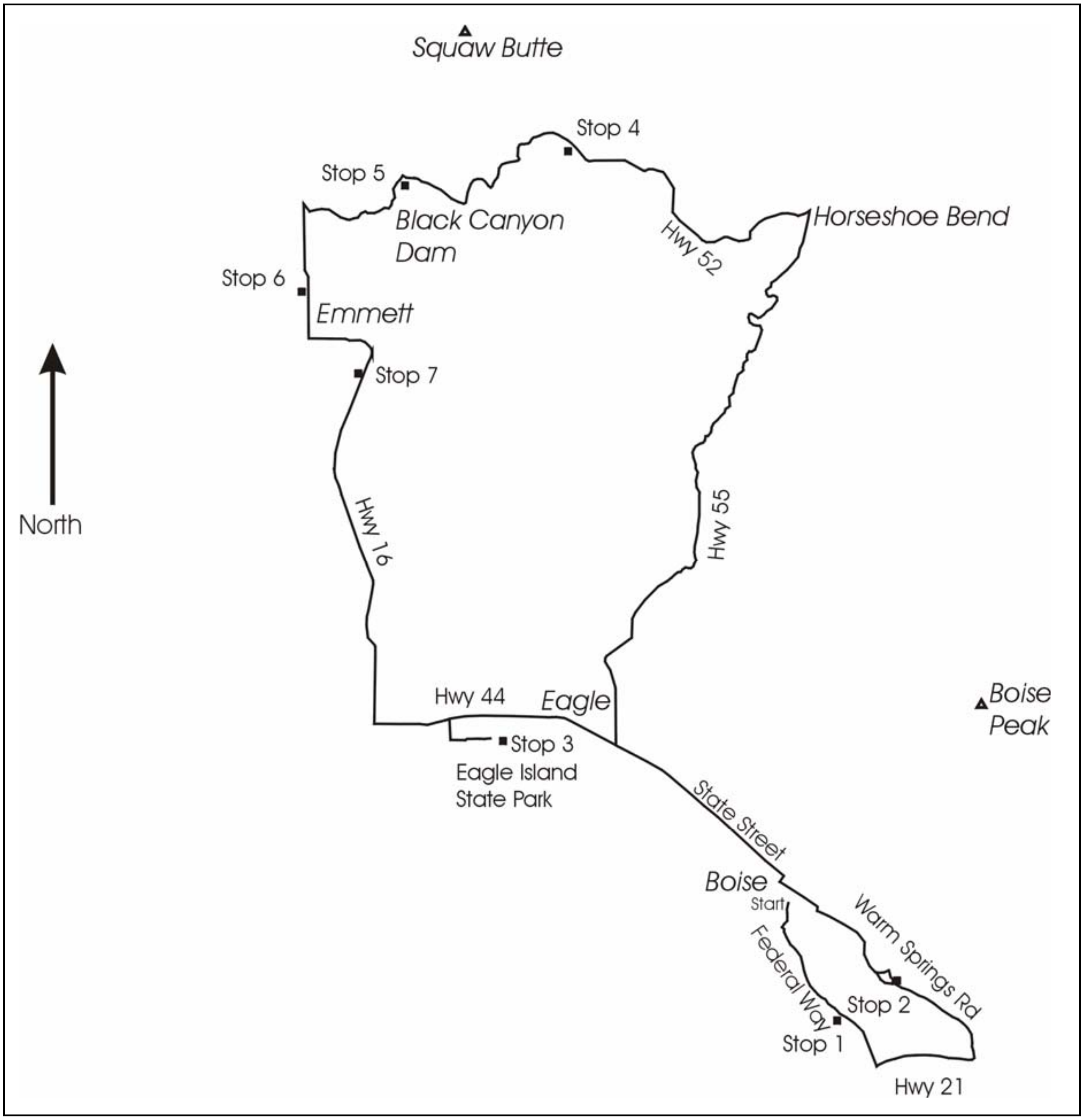

Figure 8. Location map of the field trip.

Begin Field Trip Log

Mileage	Segment	
0.0	0.0	Proceed to 9th Street and travel south. 9th Street becomes Federal Way shortly after crossing the Boise River. Continue south and east on Federal Way.
1.0	1.0	Union Pacific Railroad Depot on right is built on Whitney stream terrace.
1.1	3.1	Cross New York Canal. Climb onto Sunrise terrace.
5.4	0.3	Junction of Federal Way and Apple Street. Turn right (south) at intersection, then immediately right again into vacant lot. Park.

STOP 1. Overview of Boise foothills and the Boise Front fault zone (566821 mE 4823517 mN)

This viewpoint offers good views to the north of the Boise foothills and the floodplain of the Boise River. Mountains on the skyline are part of Boise Ridge and are underlain by Cretaceous granodiorite of the Idaho batholith. Boise Peak has an elevation of 6525 ft (1989 m) while much of Boise lies between 2700 and 2800 ft (823 and 853 m). North of Boise Peak, the Boise Ridge fault with probable Quaternary activity is present (Wood, 2004).

The foothills consist of faulted Miocene to Pliocene sedimentary and volcanic rocks, part of the rift basin fill of the western Snake River Plain. Numerous northwest-trending en echelon normal faults are present in the foothills and beneath downtown Boise (Fig. 6). These faults are collectively known at the Boise Front fault zone (Zollweg, 2001, 2005). Surface evidence of faulting in the Boise basin is seldom visible but subsurface evidence, including drill logs and geophysical data, shows many of the structures.

Below the foothills, a flight of river terraces is partly visible. We cross many of the terrace surfaces and are presently standing on the Sunrise terrace. In Boise, the terrace surfaces are called “benches.” Othberg (1994) mapped four major terrace surfaces and associated basalt lava flows (Fig. 3). The terraces can be approximately dated with K-Ar and $^{40}Ar/^{39}Ar$ ages on the basalts (Othberg and others, 1995). These ages range from 0.11 to 1.58 Ma.

The terraces are deformed by tectonic movements in the Boise area, creating steeper gradients for older surfaces (Fig. 9; Othberg, 1994). The Sunrise terrace is offset by a normal fault in a gravel pit where it overlies a fault in Idaho Group sediments (Fig. 10; Burnham and Wood, 1992). The fault strikes N35ºW and dips southwest at 70º. The age of the Sunrise terrace is between 0.1 and 0.57 Ma. NW-trending linear topographic features suggest faulted surfaces in the Gowen terrace (3rd bench up from the river) and Amity terrace (4th bench up from the river) (Othberg, Stanford, and Burnham, 1990). A gravel pit exposure in the Gowen terrace (S. 30, T. 3 N., R 2 E.) also shows fault offset. The age of the Gowen terrace is about 0.57 Ma. Normal fault exposures are also present in gravel pits and roadcuts of the Tenmile Gravel (highest eroded terrace surface). The age of the Tenmile Gravel is Pliocene.

6.2 0.8 Return to Federal Way and proceed right (southeast). Drive onto the Gowen Bench.

6.9 0.7 Drive up Fivemile Creek Bench. Note the Fivemile Creek lava flow dated at 0.974 ± 0.098 Ma.

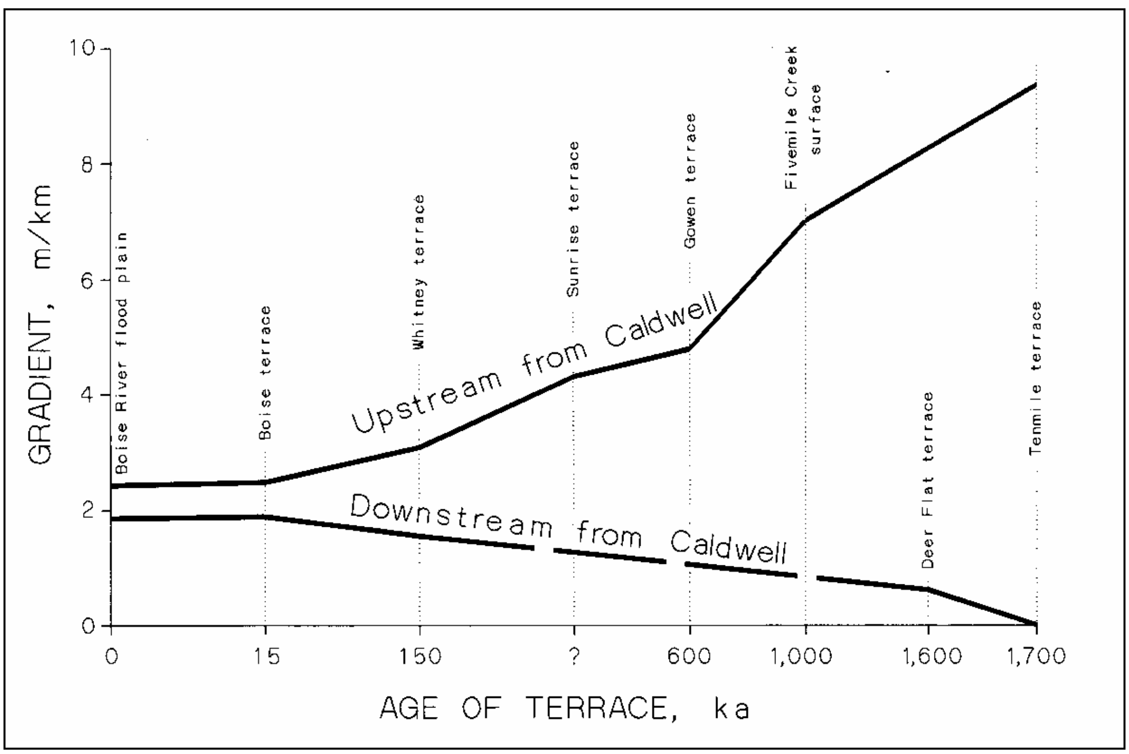

Figure 9. Longitudinal gradient versus ages for the Boise Valley terraces and floodplain (from Othberg, 1994).

7.3 0.4 Junction Highway 21 with Federal Way. Turn left (east) on Highway 21. We are now traveling on the Fivemile Creek Bench. Note roadsigns for

Micron Technology. Many factories associated with Boise's high tech boom are located on this surface east of town.

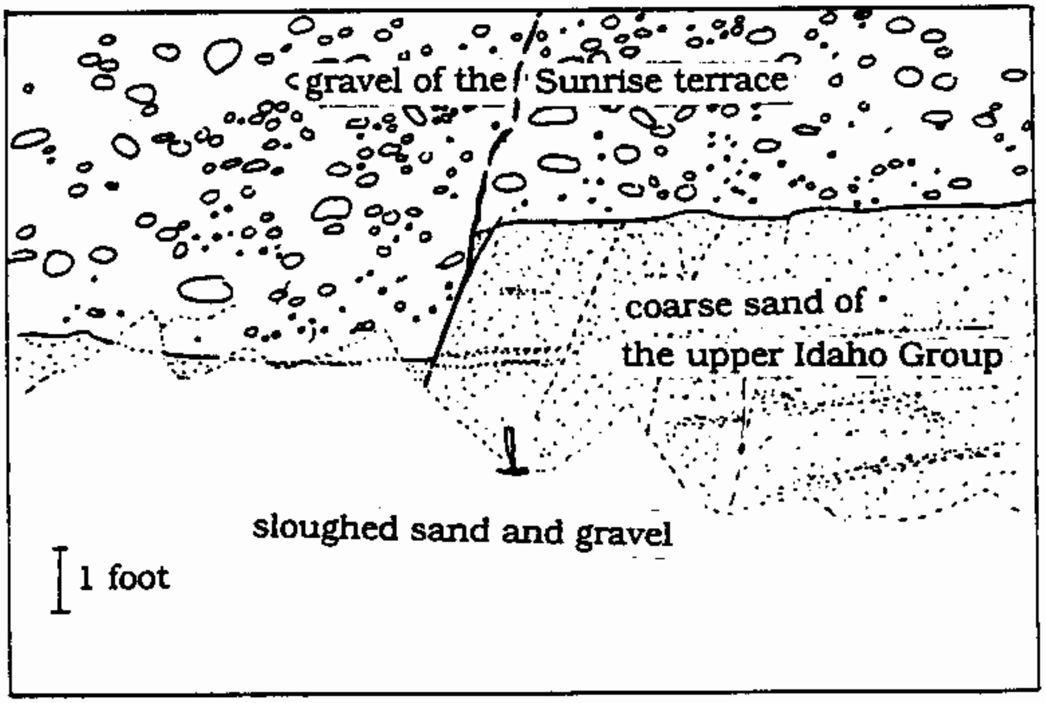

Figure 10. Tracing from photo of fault in Sunrise terrace gravels. The locality in NW/4 S. 19 R. 2 E., T. 3 N. has been back-filled and is no longer exposed (from Burnham and Wood, 1992).

8.8 1.5 Lava of Fivemile Creek exposed as we drop down to the Gowen bench.

9.5 0.7 Lava flow of Gowen dated at 0.572±0.210 Ma exposed as we drop down to Whitney bench and then to the flood plain of the Boise River.

10.4 0.9 Junction of Warm Springs Road and Highway 21. Turn left (north) on Warm Springs Road. Cross the Boise River. Note diversion dam for New York Canal visible upstream.

11.1 0.7 Historical signs commemorating the Oregon Trail on left.

12.4 1.3 Entering Harris Ranch. Controversial development on the Boise River floodplain occurred in this area and more is in progress.

14.6 2.2 Junction of Windsong Drive and Warm Spring Road. Turn right (north) on Windsong Drive.

15.9 1.3 Drive by fake rocks made of grouting covering roadcut. Proceed uphill to Hard Rock Drive. Turn right on Hard Rock Drive and continue to junction with Scyene Way. Turn right on Scyene Way. Continue through intersection with Stonepoint Drive to junction with Ridgepoint Way. Turn right on Ridgepoint Way and continue to junction with Latina Street. Turn left on Latina Sreet to junction with Starview Drive. Turn left on Starview Drive and continue to junction with Starlite Lane. Park on right side of road at junction of Starview Drive and Starlite Lane.

STOP 2. Boise River Floodplain, Faulting of Stream Terraces, and Landslides (568919 mE 4825433 mN)

This stop provides good views of the Boise River and terraces rising up out of the floodplain (Fig. 11). The Boise River has headwaters in the Sawtooth Mountains and Smokey Mountains northeast of Boise (Fig. 7). Flow is regulated by three dams: Anderson Ranch (completed 1950); Arrowrock (completed 1915); and Lucky Peak (completed 1955). The New York, Ridenbaugh and eight smaller canals also divert water upstream of Boise. Stream gage records from 1982-2004 show that discharges of >1000 cfs occur nearly every spring or early summer in response to the melting of mountain snowpack (Fig. 12). Drought years in which peak annual stream flow in the Boise River is <2000 cfs occur frequently (10 out of 23 years in the stream gage record). Droughts may extend for 3 or 4 years and induce a false sense of security in the public about flooding hazards.

Figure 11. View southeast from Stop 2 of the Boise River floodplain and terraces.

The largest historical flood of the Boise River in June 1896 had an estimated (ungaged) flow of about 35,500 cfs. The flood of April 20, 1943 had an estimated (ungaged) discharge of about 21,000 cfs at Glenwood Bridge, located in the floodplain near this stop. Since regulation by Luck Peak reservoir, the maximum discharge at

Glenwood Bridge was 9,840 cfs on June 13, 1983. The Army Corps of Engineers defines a 10-year flood as 7,200 cfs; 50-year flood as 11,000 cfs; 100-year flood as 16,600 cfs, and 500-year flood as 34,800 cfs (all discharges gaged at Glenwood Bridge).
Despite regulation by the three dams, some flooding still occurs along the Boise River. The flooding and property damage is caused by three factors: sudden melting of heavy snowpack; management of dams for summer irrigation purposes; and, floodplain encroachment by development. Stacy (1993) provides a detailed analysis of these issues. The Boise River reaches bankful at 6,500 cfs and some property is flooded with flows as low as 7,000 cfs.

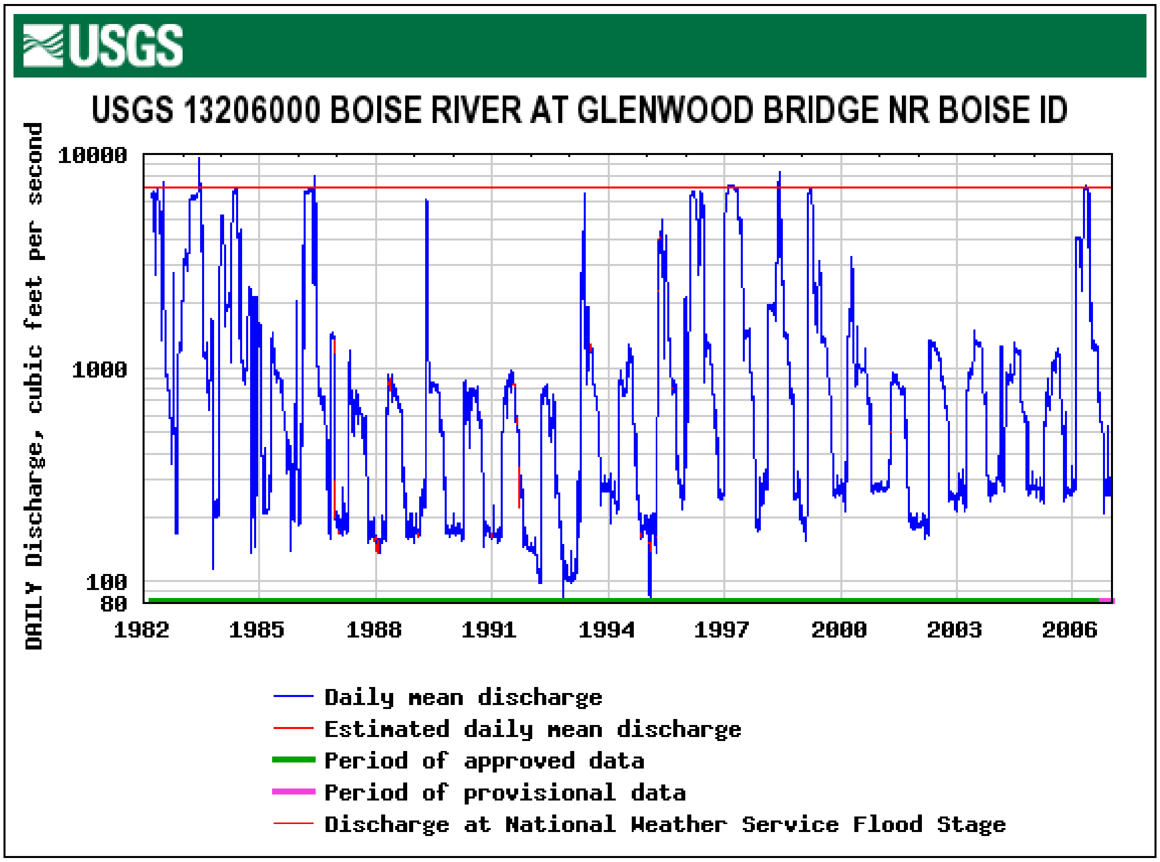

Figure 12. Daily mean streamflow 1982-2004 at Glenwood Bridge on the Boise River (Source: http://nwis.waterdata.usgs.gov/nwis/dv?site_no=13206000 accessed 1/3/07).

The flood of 1983 provides a case study of Boise River flooding (Stacey, 1993). In the spring of 1983, the mountains near Boise were loaded with snow, much of which fell in April and May. On May 27, temperatures in Boise reached a record 94ºF. By June 6th, Anderson Ranch Reservoir was full, Arrowrock was 97% full, and Lucky Peak was 78% full. Over the next week, temperatures remained high and snowmelt flowed into reservoirs much faster than water was being released. The dams were full or nearly full because of long-standing policy to operate the facilities primarily for the benefit of summer irrigators. As a result, the dam operators (Army Corps of Engineers) were required to release flows of over 9000 cfs, much larger than the ~7000 cfs to which Boise had become accustomed. Fortunately, temperatures moderated on June 10th and by June 12th inflow diminished to 16,500 cfs from a peak of 24,294 cfs. The peak flow was later determined to represent a ~50-year flood event. The Army Corps continued releases at 9500 cfs for a week but the crisis was over. Downstream of the dams, considerable property damage occurred, largely because of floodway encroachment leading to reduced conveyance of floodwaters. Figure 13 shows the hydrograph for 1982-1983.

Faulted gravel deposits are visible on the southeastern horizon from this viewpoint. The sediments are the Pliocene Bonneville Point gravels. They were deposited by the ancestral Boise River over rift basin faults parallel to the present-day Boise Front. Continued faulting along northwest-trends with down-to-the south displacement has created the prominent steps visible on the skyline.

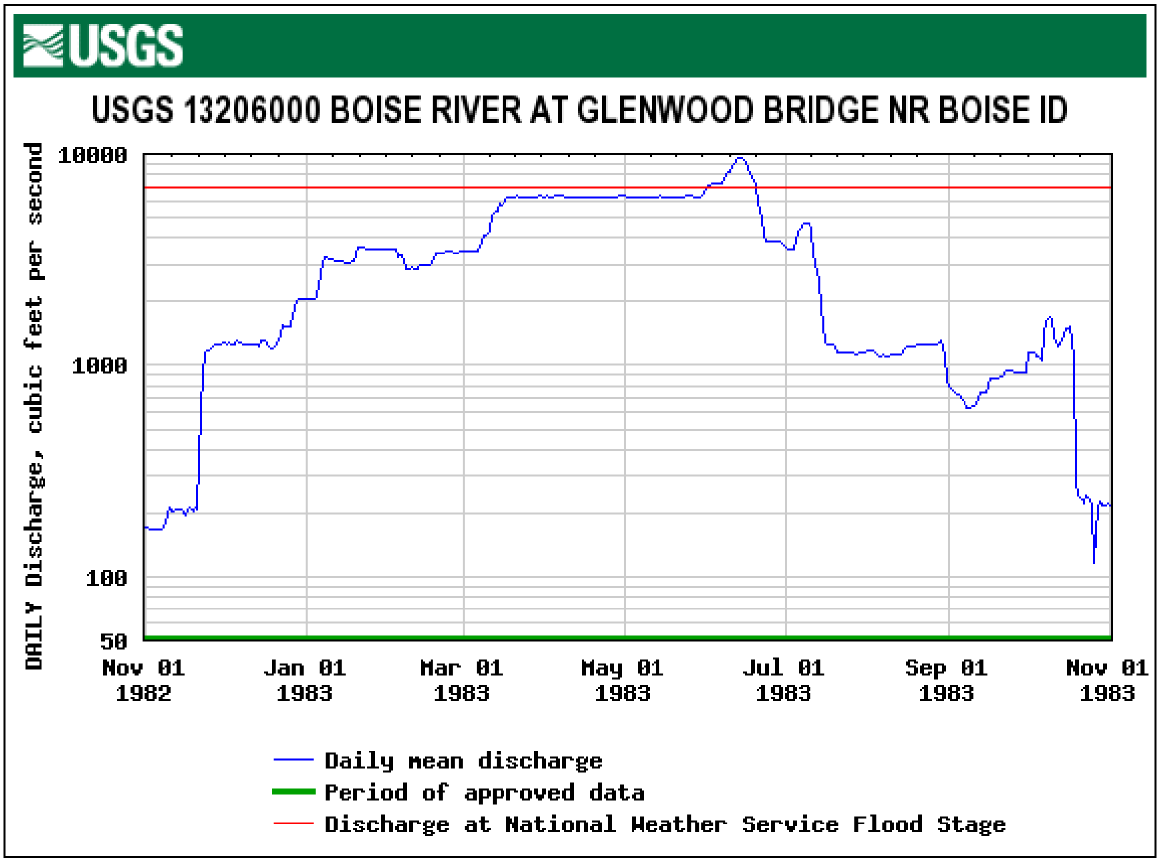

Figure 13. Daily mean streamflow for 1982-1983 at Glenwood Bridge on the Boise River (Source: http://nwis.waterdata.usgs.gov/nwis/dv?site_no=13206000 accessed 1/3/07)

The Warm Springs Mesa development we drove through to get to this site traverses an ancient landslide (Fig. 14). The ancient landslide deposits can be recognized

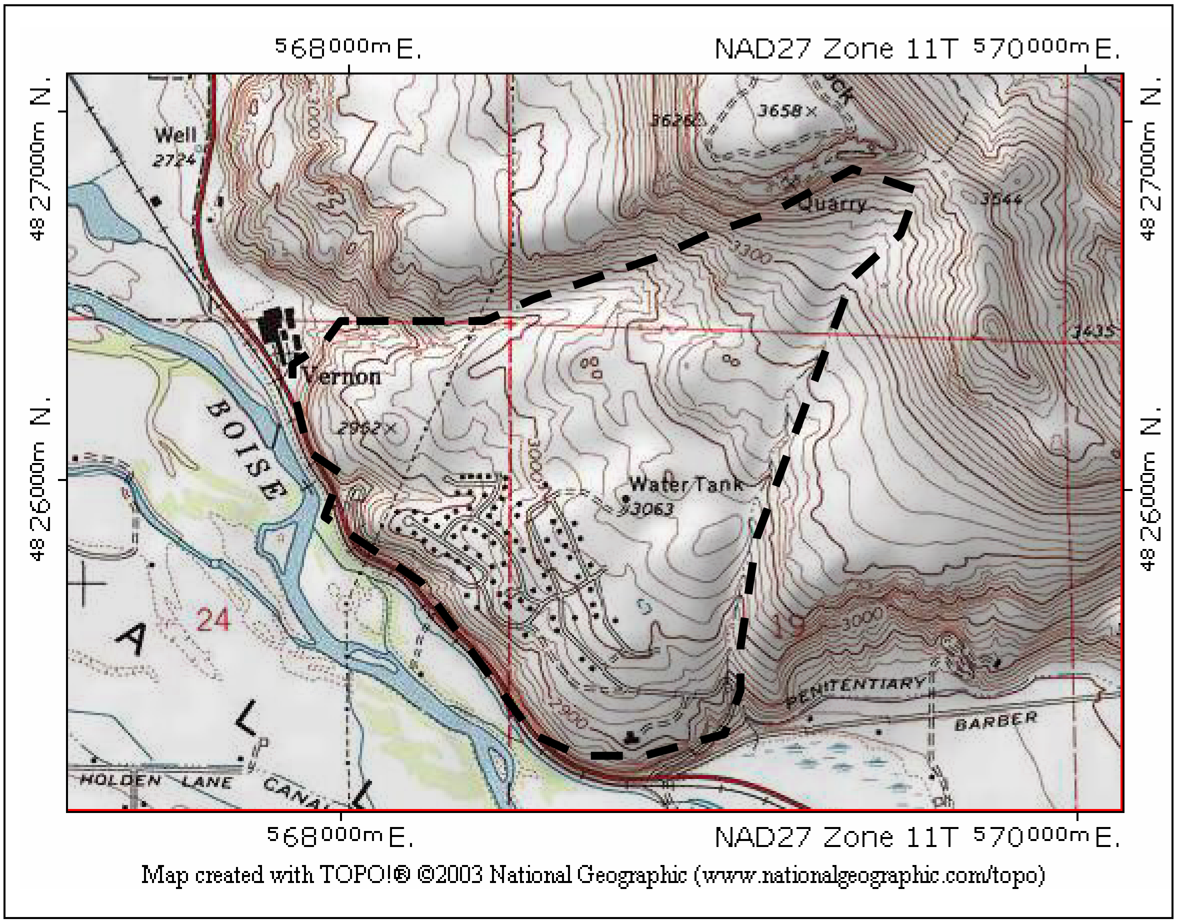

Figure 14. Sketch map of the Warm Springs landslide. The approximate location of the ancient landslide is shown by dashed black line.

as large sandstone boulders scattered throughout the yards of many homes, and the hummocky nature of the landscape. Construction of Warm Springs Avenue along the toe of the landslide created an oversteepened slope that caused reactiviation of a small portion of the slide. Additional ground water derived from the new residential uses uphill of the slide may have also contributed to destabilizing the area.

19.6 3.7 Continue downhill and east to junction with Warm Springs Road. Turn right (west) onto Warm Springs Road. Proceed past Old Penitentiary and Warm Springs historic district. This part of Boise is heated with geothermal water. At junction of Warm Spring Ave with Avenue B, turn onto Idaho Street.

20.7 1.1 Proceed on Idaho to junction with 15th Street. Note unreinforced masonry used in historic buildings in the historic district, and the mix of building types of various ages and materials. Veterans Hospital and Fort Boise are to the north of this area (not visible from bus). Cottonwood Creek enters Boise Valley near here (Fig. 8) and is routed beneath the city to Boise River after entering a flood water/sediment retention structure. Foothill floods, including the infamous "Mudbath" of September 1959 have caused damage in this part of Boise.

34.3 13.6 Turn right (north) on 15th Street and continue 3 blocks to junction with State Street. Turn left (west) on State Street. Proceed 11.7 miles on State to junction of State (now called Highway 44) and Linder Road. Note extensive development in and near the Boise River floodplain and in the foothills. Turn left on Linder Road, following signs to Eagle Island State Park. Continue 0.7 mi to Hatchery Road. Turn left (east) on Hatchery Road. Note what appear to be levees built around homes. Proceed 0.5 mile to Eagle Island State Park. Continue through entrance gate to second parking lot near volleyball courts. Park.

STOP 3. Eagle Island State Park. Land use planning and building code enforcement (548170 mE 4837031 mN)

In this peaceful location on the Boise River floodplain, we discuss differences between municipal and county land use planning and building code enforcement. Restrooms available. The Eagle Island State Park site was originally purchased and developed in 1929 by the State of Idaho to serve as a prison farm. In 1946, inmates built the first of several levees to protect the farm from flooding. Efforts for the farm to be self-supporting in terms of agricultural products failed because of the gravelly soil, and the farm was a controversial "white elephant" throughout its operation. The prison farm was transferred to the state park system in 1977. Most of the park is within the Boise River's 100 year floodplain. Natural flooding has been greatly reduced by upstream regulation of flow by three dams. During normal precipitation years, stream flow to the Eagle Island area is maintained between early April and mid-October at about 1100 cfs for irrigation purposes. (Eagle Island State Park Master Plan, 2000; http://www.idahoparks.org/ Data_Center /PDF/Park_Plans /eagle_island_chp3.pdf; accessed 9/2/05).

40.8 6.5 Return to State Street (Highway 44). Turn right (east) on State and proceed to junction with Highway 55. Turn left (north) on Highway 55, following signs to Horseshoe Bend and McCall.

58.9 18.1 Proceed north on Highway 55 toward Horseshoe Bend. Our route climbs out of the Boise River drainage, crosses a low range composed of Miocene-Pliocene sediments, and then drops down the Payette River drainage. The sediments were deposited on top of granites of the Cretaceous Idaho batholith prior to development of a through-going Snake River drainage. As the Snake River cut through Hells Canyon and became integrated with the Salmon and Columbia Rivers, base level dropped and the sediments were incised. The sediments are mostly sandstones and siltstones deposited in deltaic and fluvial environments. The sediments are prone to landslides. Prior to building the modern highway, numerous landslides occurred along the old road.

59.7 0.8 Entering Horseshoe Bend. Continue to junction of Highway 55 and Highway 52. Note crossing of Payette River and the Horseshoe Bend high school partially on floodplain. The Payette River is partially diverted at Horseshoe Bend and dropped to a power plant downstream.

70.2 10.9 Turn left (west) on Highway 52, following signs to Emmett. Proceed 7.3 miles to junction of Highway 52 with the Montour/Ola road. Continue 0.1 mi on Highway 52. Turn left on Westridge Lane at sign saying “Westridge Ranch.” Proceed 0.3 mile uphill past road cut and park at junction of unpaved road and Westridge Lane.

STOP 4. Faulted Sediments Near Minotour (552563 mE 4866825 mN)

Inclined and faulted sediments and volcanic rocks of probable Pliocene (2-5 Ma) age are exposed at this site in a new road cut (Fig. 15). Vesicular basalts, pillow basalts, and basaltic breccia are interbedded with siltstone and fine-grained sandstone. The presence of basaltic pillow structures indicates that the lava flows entered water, probably a lake. Displacement is difficult to determine because of the lack of clearly traceable horizons. There is no apparent surface expression of these faults, suggesting that recent movement has not occurred. To the north is Squaw Butte, composed of faulted Columbia River Basalts (Fig. 16). The steep, east-facing escarpment and gentle west-dipping slope of the butte is typical of structures in the Western Idaho Fault System. To the south of the Payette River, incised and eroded sediments of the Western Snake River Plain rift basin have a distinctive outcrop pattern. The Payette River follows the approximate contact between the two structural domains.

77.2 7.0 Return to Highway 52. Turn left (west) toward Emmett. Drive along the Black Canyon Reservoir to the Black Canyon Dam. Turn left 0.1 mile past the dam into Wildrose Park.

STOP 5. Wildrose Park at Black Canyon Dam (545009 mE 4864212 mN)

Black Canyon Dam is located on the Payette River about 40 km (25 mi) northwest of Boise and about 8 km (5 mi) northeast of Emmett. The dam is a concrete gravity diversion structure completed in 1924. The dam is 56 m (184 ft) high and has a crest length of 317 m (1040 ft). The crest elevation is 762 m (2500 ft) and the normal pool elevation of Black Canyon reservoir is 761 m (2497 ft). The original reservoir capacity was 5.51 x 107 m3 but siltation reduced the capacity about 40% to 3.33 x 107 m3 in 1983. The dam was designed primarily to provide irrigation water. Power is also generated.

Figure 15. Faulted sediments and basalt at Stop 4.

The foundation of the Black Canyon dam is Weiser Basalt together with lesser sandstone and conglomerate. The rocks strike parallel to the dam axis and dip about 15º downstream (Gilbert and others, 1983). Weiser Basalt is similar to Columbia River Basalt but was erupted later, toward the end of the Miocene.

Flood inundation maps show that failure of the Black Canyon Dam would cause extensive property damage and possibly loss of life in the Emmett area. Accordingly, a seismic hazard assessment of the structure was completed in 1983 (Gilbert and others, 1983). Their report found that, among the many regional faults present, three faults within the Western Idaho Fault System were specific sources for future surface faulting events. These faults are: 1) the Squaw Creek fault; 2) the Big Flat-Jakes Creek fault; and 3) the Long Valley fault (Fig. 17).

The Squaw Creek fault is 50 to 55 km long and trends ~north-south. Average displacement rate over past 17 million years is estimated at 0.05 to 0.12 mm/yr. Topographic expression of the structure consists of a steep, east-facing scarp rising 610 to 760 m (2000 to 2500 feet) above the Ola Valley. The footwall is tilted to the west, forming Squaw Butte. Discordant dips on the Imnaha Basalt of the Miocene Columbia River Basalt group are apparent. Hanging wall dips are near horizontal while the tilted footwall dips ~25º west. There are also aligned drainages and divides, and conspicuous vegetation lineaments visible for about 14 km. An 80-m long, 3 m deep trench was excavated by Gilbert and others (1983) across the Squaw Creek structure at Sucker Creek near the Ola Valley. The trench crosses a 2.4 m scarp in alluvial fan deposits. Two

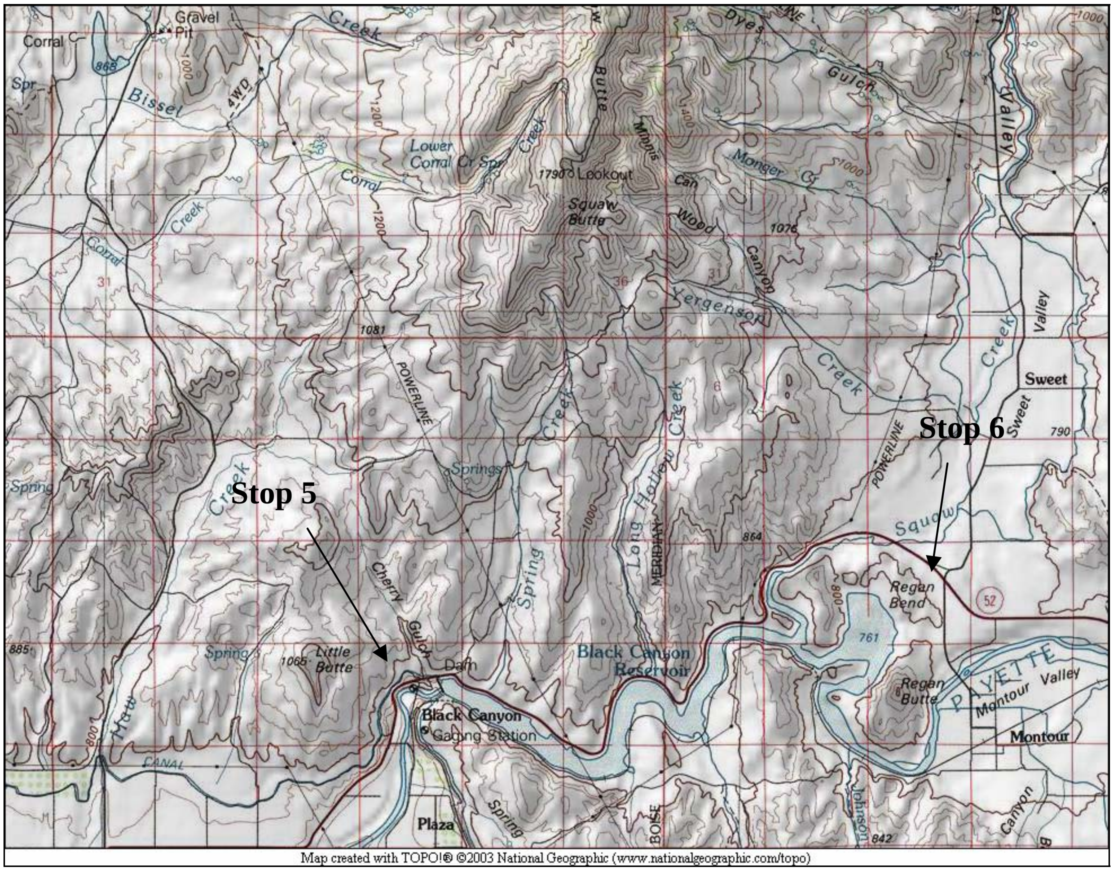

Figure 16. Topographic map of the Squaw Butte area.

episodes of faulting were recognized. The first episode has a displacement of about 1.5 m and occurred prior to 6700 years ago. The age estimate is based on the presence of Mazama Ash in deposits over the fault. Mazama Ash was erupted 7700 years ago from Crater Lake in Oregon. The second episode of faulting occurred shortly after deposition of Mazama Ash and produced a displacement of 0.6-0.8 m.

The Big Flat fault is about 32 km long with a post-Miocene displacement of between 300 to 600 m and an average displacement rate of 0.02 to 0.03 mm/yr. The structure is topographically expressed by a prominent east-facing scarp on a gently west-tilted block mountain range. Height of the range front is 180 to 245 m (590 to 800 feet). Shallow mudflow-type landslides cover most parts of the fault. The deposits may have been created by co-seismic liquifaction. Conspicuous vegetation and bedrock linears also occur along the fault trace. A trench was excavated by Gilbert and others (1983) across the Jakes Creek fault, a nearby structure interpreted to be conjugate to the Big Flat fault. The trench was 30 m long and 2 to 3 m deep. It crossed a 3.6 to 5 m scarp developed on the fault. A minimum displacement of 0.3 to 0.4 m was found. No directly datable materials were located. Based on soil development and degree of dissection, surface faulting was estimated to be latest Pleistocene or early Holocene (circa 10,000 years).

The Long Valley fault is located near Cascade, Idaho and is about 76 km long. Based on displacement of Columbia River Basalt Group flows, it has 4600 to 7000 m of down-to-the-east displacement, indicating an average displacement rate of 0.27 to 0.41 mm/yr over the past 17 million years. No scarps were observed in Quaternary materials along this fault and no trenches were excavated by Gilbert and others (1983). They assume that the Long Valley fault is capable of generating large magnitude surface rupturing events for the purposes of the Black Canyon dam study.

Maximum credible earthquakes (MCE) have been assigned to the Squaw Creek and Big Flat fault (Gilbert and others, 1983). The Squaw Creek fault has an MCE of magnitude 7 at an epicentral distance of 5 km, with a focal depth of 7 km. The MCE for the Big Flat fault is magnitude 6.75 at an epicentral distance of 14 km and a focal depth of 7 km.

No significant faults were found beneath Black Canyon Dam although many minor faults were located. The probability of movement of these faults during the lifetime of Black Canyon Dam was judged to be extremely low by Gilbert and others (1983). Because the foundation of Black Canyon dam is competent basalt, conglomerate and sandstone, foundation liquefaction was judged to be unimportant.

83.2 6.0 Return to Highway 52 and turn left (west) toward Emmett. Our route proceeds along the Payette River floodplain, then at 2.1 miles, climbs onto a broad alluvial fan surface. At stop sign, continue left on Highway 52 toward Emmett. Enter Emmett, cross the Payette River, then turn immediately right on Carson Street, right on Commercial Street, and right on Oxley Road. Park near the levee.

STOP 6. Flooding hazards of the Payette River at Emmett (540165 mE 4858644 mN)

This site is convenient to discuss flooding hazards and floodplain development issues along the Payette River. Emmett (pop. 5752) is the county seat and only incorporated town in Gem County. The population of Gem County increased 28% between 1990 and 2000 with most growth in the Emmett area. Emmett is partially protected from Payette River flooding by the Black Canyon Dam and the levee system seen at this site. Recent high stream flows include the New Year's Day storm of January 1-5, 1997. Warm temperatures combined with a rainfall 4-6 times the average amount melted mountain snowpacks. Floods, mudslides and avalanches damaged communities and infrastructure throughout Idaho. Gem County was declared a state and federal disaster area along with a number of other southwestern Idaho counties. The Payette River at the Black Canyon Dam crested at 39,000 cfs, more than twice flood stage. Gem County declared a state of emergency along the Payette River January 1, and ordered over 250 people in Emmett to evacuate. A gas line underneath the Payette River broke,

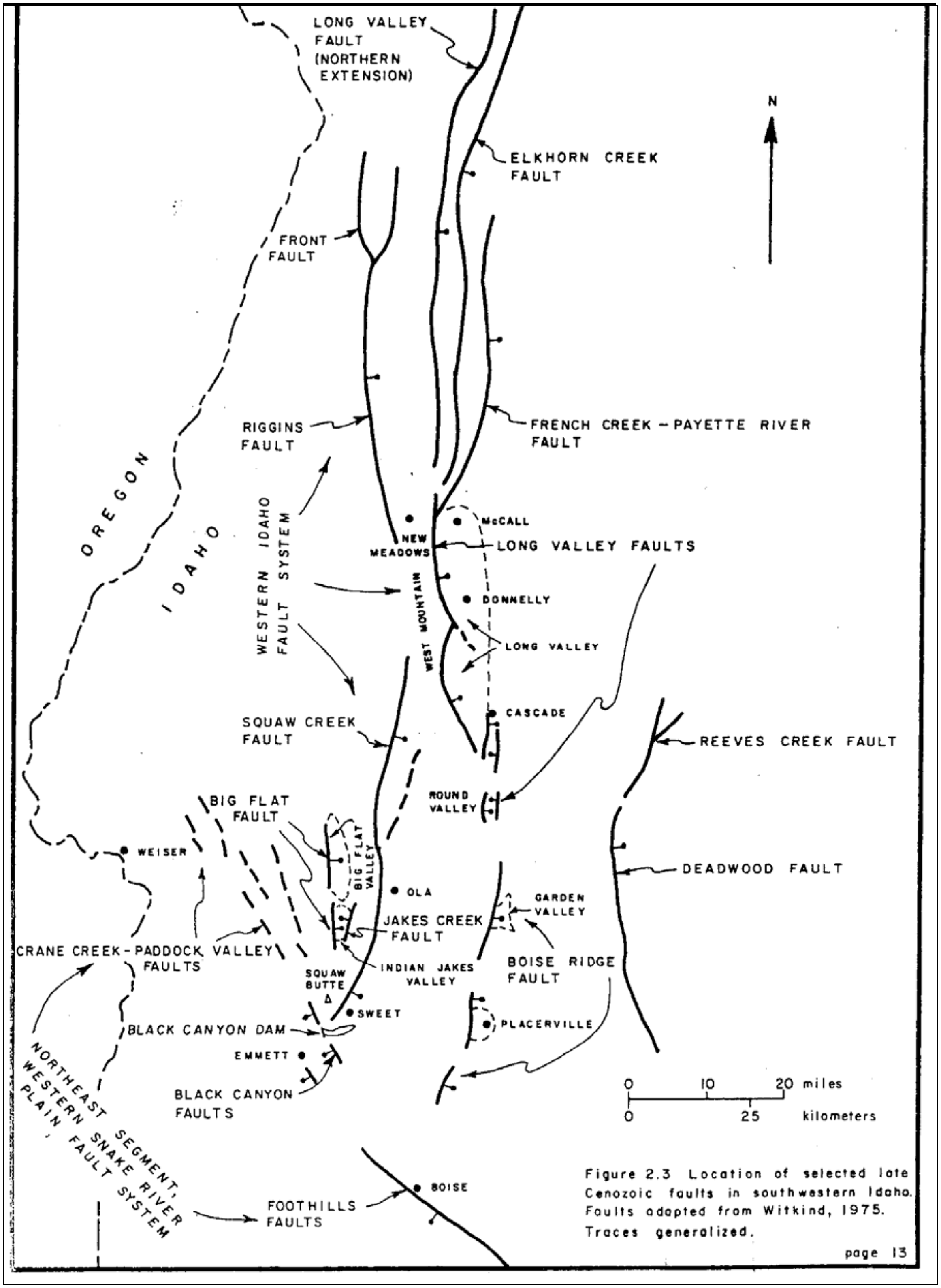

Figure 17. Location of Cenozoic faults in southwestern Idaho (from Gilbert and others, 1983).

leaving 150 people in Emmett without service. (Idaho Bureau of Homeland Security website http://www.bhs.idaho.gov/ local/counties/gem.htm, accessed 8/31/05; Idaho Statesman Jan 2-4, 1997).

88.0 4.8 Return to Highway 52 and drive through Emmett. At Main Street, note unreinforced masonry structures. Continue to junction Highway 16 and Highway 52. Turn left on Highway 16, following signs to Boise. Proceed to Freezeout Hill Memorial.

STOP 7. Freezeout Hill Memorial (542860 mE 4854502 mN)

This stop provides excellent views of the Payette River valley, Emmett, and Squaw Butte. The east-facing footwall scarp of Squaw Butte is visible to the north. The road cut exposes brilliant white sandstone of the Idaho Group, part of the western Snake River Plain rift basin fill.

At nearby Freezeout Hill, a fault is exposed in a Highway 16 road cut (Gilbert and others, 1983). The fault strikes N40ºW, dips 80ºSW, and displaces sandstone of the Pliocene Idaho Group about 20 m to the southwest. There is no surface expression of this fault and its length is not known. Unfaulted terrace deposits estimated to be between 24,000 and 15,000 years old cross the projection of the fault about 6 km northeast of Freezeout Hill. Based on its orientation, the fault is believed to be part of the Western Snake River Plain Fault System.

98.9 10.9 Continue on Highway 16 to junction with Highway 44. Along this route further exposures of the same Miocene-Pliocene sediments seen between Eagle and Horseshoe Bend are crossed. End of road log. Turn left (east) on Highway 44 (State Street). Return to the Grove Hotel by following State Street into Boise.

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