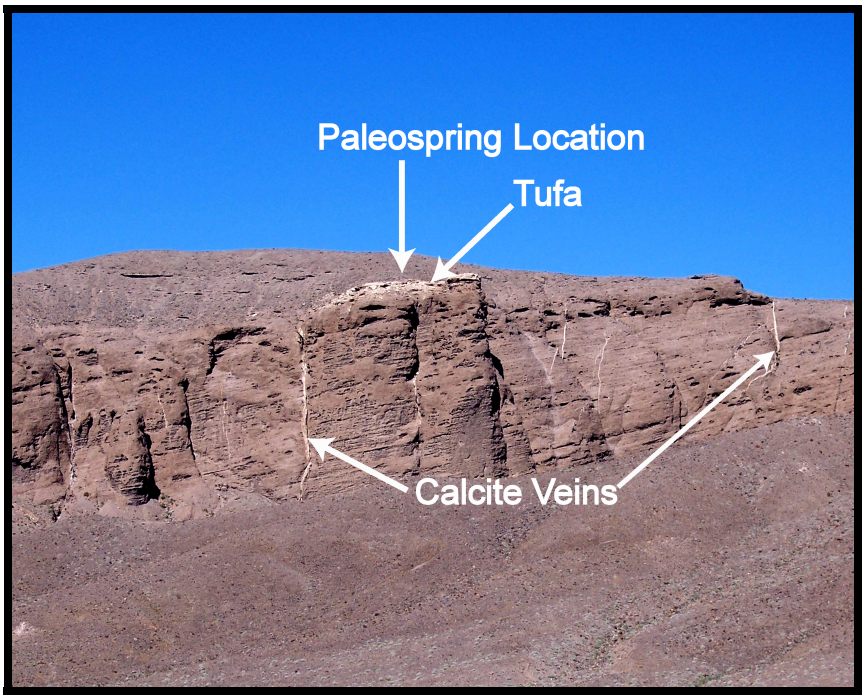


Figure 3-10. Travertine Point. Vertical rising water, now indicated by the veins, was the source of water for the paleosprings.

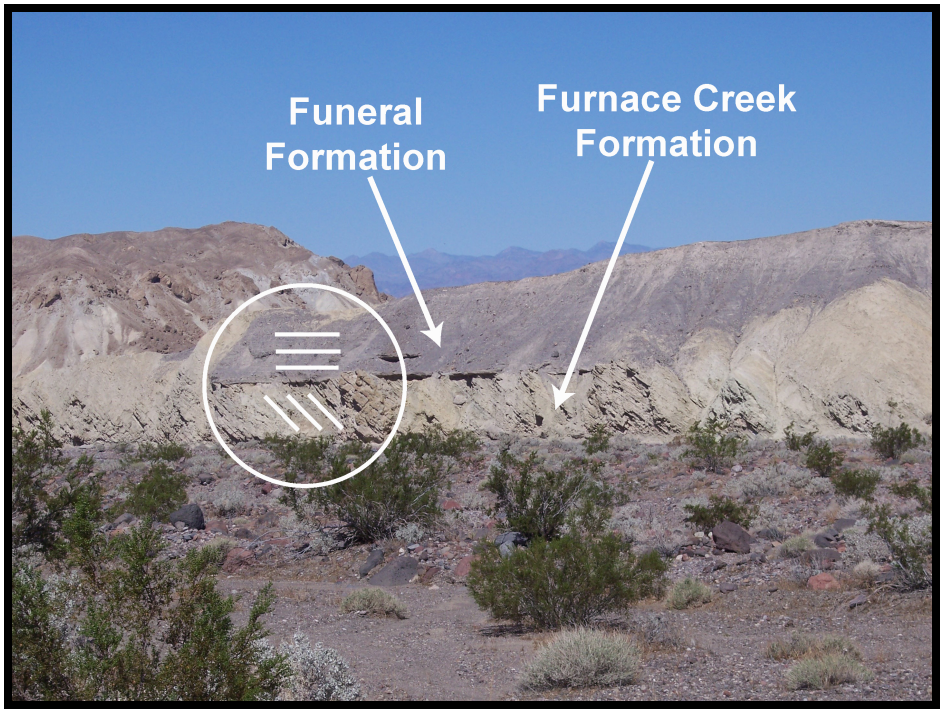


Figure 3-11. Angular unconformity along Furnace Creek Wash. This scene suggests that the Furnace Creek Formation was deposited, cemented, tilted, uplifted, eroded flat, and inundated by funeral formation sediments with the final step being erosion and deposition in the modern stream channel.

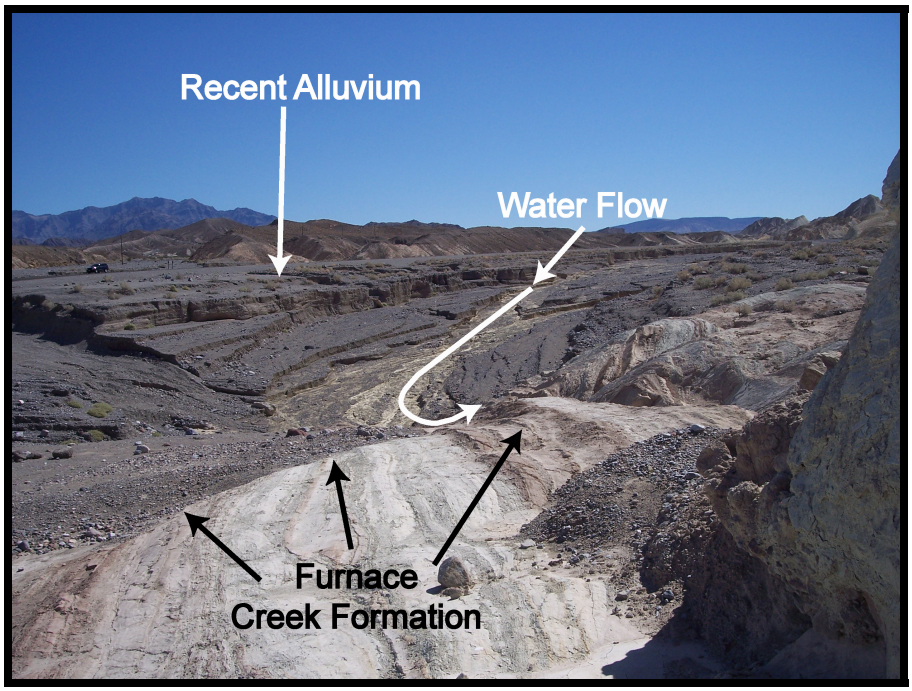


Figure 3-12. Erosion at Zabriskie Point resulting from diversion of Furnace Creek Wash to right into Gower Gulch. The modern ephemeral stream incised into the older alluvium forming terraces as gradient increased after diversion into the topographically lower Gower Gulch. The alluvium is in angular unconformity relationship with the underlying, deformed Pliocene Furnace Creek formation.

1.6/31.3 Stop 3-7: Texas Springs Campground (36° 27' 32.02" N; 116° 50' 27.7915" W)

Texas Springs is one of six springs in this part of Death Valley. The groundwater recharge that supplies water to these springs is thought to originate principally in the area north of Yucca Mountain (Bredehoeft, et al., 2005). This suggests the flow path is south through the Regional Carbonate Aquifer beneath Yucca Mountain and the Amargosa Valley, then through the Funeral Mountains to these springs (see Stop 3-1). The flow at this spring is estimated to be 0.03 m^3/sec [1.0 ft^3/sec] (Bredehoeft, et al., 2005). It is estimated that local recharge accounts for only 10 percent of the total flow.

The area surrounding this stop is in a transition zone between the northern end of the Black Mountain fault zone and the southern end of the northern Death Valley fault zone. In this transition zone the rocks have been folded, resulting in structures like the Texas Spring syncline east of this stop.

Return to CA 190. Turn right to Furnace Creek Ranch.

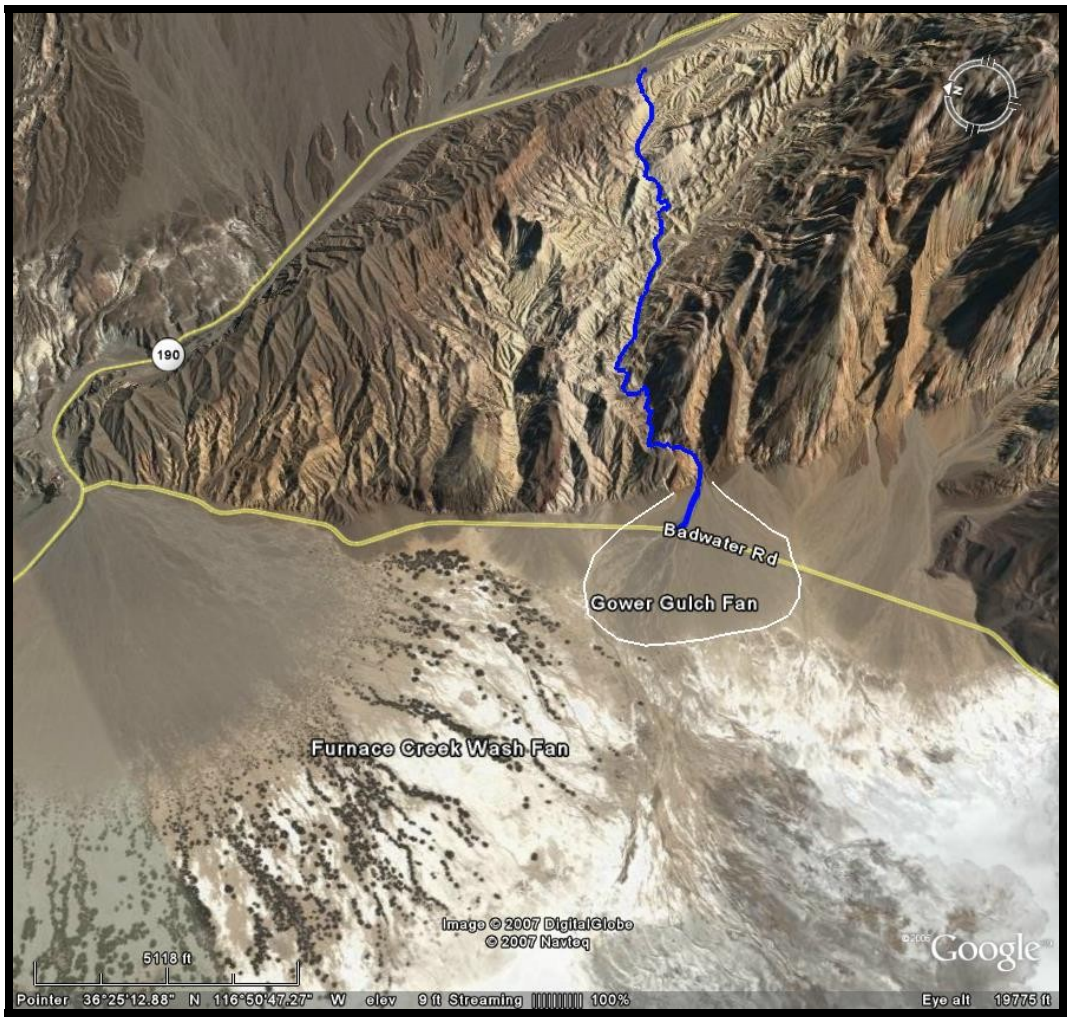


Figure 3-13. The path of the diversion of Furnace Creek Wash down Gower Gulch is shown by the blue line from Stop 3-6. Notice how much larger the Furnace Creek Wash Fan is than the Gower Gulch Fan, outlined in white, reflecting millions of years of sediment moving down Furnace Creek Wash before the diversion.

LUNCH

After lunch, go back about 1.6 km [1 mi] to the junction of CA 190 and Badwater Road.

Reset odometer to 0.0.

0.0/0.0 Furnace Creek Wash.

The Furnace Creek Wash alluvial fan's apex is at 7:00, where the wash exits the narrow canyon to the right (southwest) of Furnace Creek Inn. The fan (Figure 3-13) was built up over millions of years but has experienced little growth since diversion of Furnace Creek at Zabriskie Point in 1941. Proceeding south, we are traveling along the axis of the fan toward the distal end. This is a very large fan.

1.0/1.0 At 2:00, note phreatophyte vegetation on the Furnace Creek fan, indicating shallow groundwater beneath fan surface.

1.5/2.5 Gower Gulch.

At about this point, the road starts to cross the newer alluvial fan resulting from the diversion of Furnace Creek Wash (Figure 3-13). This fan is actually covering up some portions of the older Furnace Creek fan, as well as the fan to the south. As a result of the increased surface water flow in Gower Gulch, this portion of the road periodically gets washed out.

2.5/5.0 Low scarp on left side of road is a splay of the Artist's Drive Fault (Figure 3-14).

Figure 3-14. Fault in alluvium. Offset of surface by small scarp is evidence of active faulting. Actual fault is probably near the base of scarp.

1.0/6.0 Distal end of Furnace Creek fan to right.

From 2:00 to 4:00 are the Panamint Mountains. The highest peak is Telescope Peak at 3,368 m [11,049 ft]. Holm and Wernicke (1990) proposed that the Panamint Mountains are the overlying and younger rocks that were above the older rocks in the Black Mountains. They were displaced to the current position by faulting when Death Valley was opened up. The Black Mountains will be more visible as we drive south toward the stop at Badwater.

1.3/7.3 Black Mountains at 11:00.

2.2/9.5 Outlet for Artist's Drive. This drive is one way.

3.7/13.2 Artist's Drive entrance.

8.4/21.6 Stop 3-8: Badwater, California (36° 13' 50.55" N; 116° 46' 03.12" W; Elevation−280 ft)

Badwater, California, is the lowest point in the United States, at 86 m [282 ft] below sea level (note indicator on cliff across the road). This stop is along the Black Mountain fault zone (Figure 3-7). The Black Mountain fault zone is an active normal fault with a small component of right lateral movement (Machette, et al., 2008). The fault extends from near the Furnace Creek Inn south to Ashford Mill (near Stop 3-10) a distance of about 64 km [40 mi]. Figure 3-15 shows the alluvial fan south of the Badwater stop. In the figure, several faults offset the fan surface, indicating active faulting. This is considered to mark the location of the fault beneath the fan.

Notice the contrast in morphology of the fans on the east and west sides of Death Valley. On this side of Death Valley (similar to the southern fans in Crater Flat at Stop 1-10), the fans extend only a relatively short distance into the valley (Figure 3-16) and their surface slopes are steep. Across the valley, the fans extend much farther into the valley and their slopes are not as steep (similar to the fans north of Stop 1-10). This is believed to indicate the subsidence on the east side of the valley is more dynamic than on the west side, resulting in a half graben structural basin similar to one proposed for Crater Flat, perhaps the Black Mountain fault is an analog to the Bare Mountain fault (11–12 mya). See discussion of alluvial fans at Stop 1-10.

The Badwater **Turtleback** occurs just north of this stop (Figure 3-17). The convex surface and its covering is believed to be the remnant of the actual Black Mountain fault surface along which the east side of Death Valley subsided. Geologically, this surface is the fault plane or surface along which the movement took place. The rocks comprising the Black Mountains consist of Precambrian metamorphic rocks and an 11 mya **gabbro**. Geochemical data indicate this gabbro originated at a depth of 15 km [10 mi] and was subsequently brought to the Earth's surface 11 mya. The Black Mountain fault zone is still considered active as evidenced by the fault scarps in the alluvial fan to the south indicating the youngest alluvial deposits in front of Black Mountain are part of the syn-basin-range sequence, not the post-basin-range sequence.

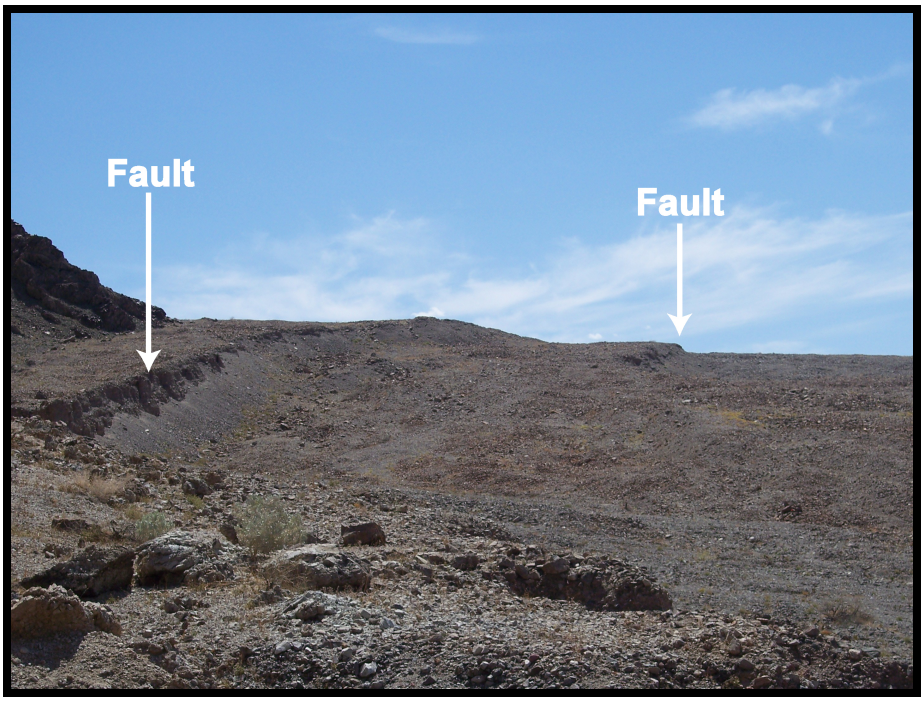


Figure 3-15. Faults offsetting very young alluvial fan surfaces at Badwater, California, indicating active faulting.

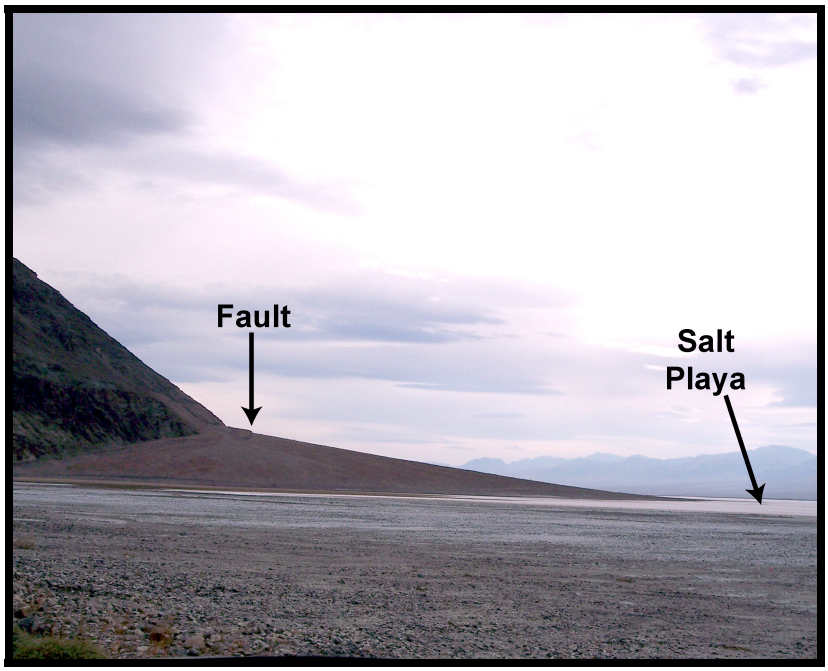


Figure 3-16. Close-up from several miles north of Stop 3-8. View to south. Notice extent of fan into the valley. See Figure 3-15.

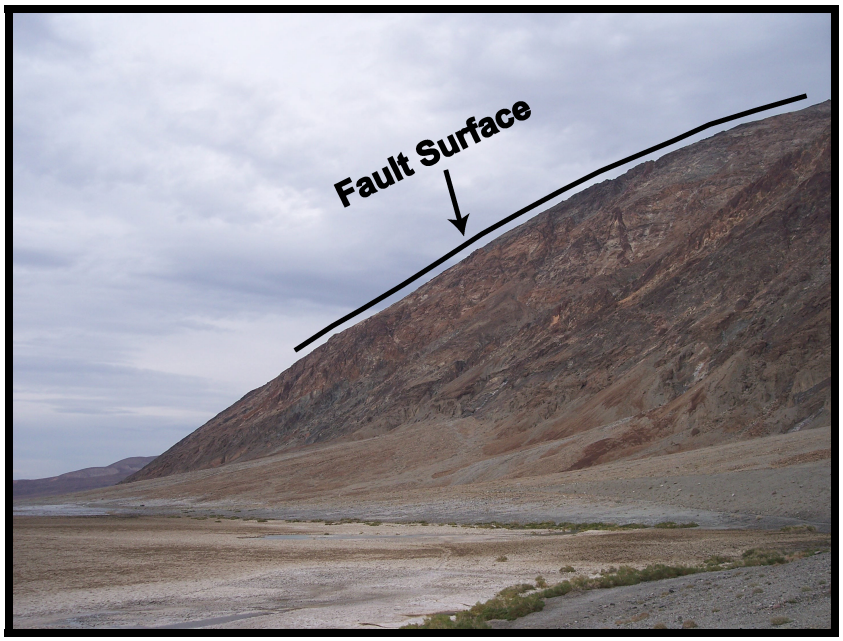


Figure 3-17. Badwater Turtleback looking north from Badwater Pulloff

ALTERNATE RETURN ROUTES FOR DAY 3

Two alternate return routes from Stop 3-8 to Las Vegas, Nevada, follow.

Option A is to return to Las Vegas, Nevada, via Furnace Creek, Death Valley Junction, California, and Pahrump, Nevada. From this stop, Option A is the fastest way to return to Las Vegas, Nevada. Otherwise, proceed south from Badwater and return to Las Vegas, Nevada, via Shoshone, California, and Pahrump, Nevada. Much of this route must be traveled at much slower speeds.

Day 3—Option A

0.0/0.0 Badwater, California (Stop 3-8). Return north on the Badwater Highway.

7.9/7.9 Turn right onto Artist's Drive. (Note: Although the road is one way, some turns are tight with very short lines of sight, so be careful.)

14.6/12.2 Stop 3A-1: Artist's Palette (36° 21' 48.35" N; 116° 48' 13.75" W)

Turn right into Artist's Palette parking area. Exposed here are rocks of the Miocene Artist's Drive Formation (Figure 3-18) (also seen at Stop 3-6); their color is a result of oxidation of minerals in volcanic tuffs and fine sediments similar to the alteration in the Calico Hills (Day 2, mileage 23.9, first half of day).

Return to Death Valley Junction via Furnace Creek and CA 190.

Figure 3-18. Artist's palette.

NOTE: From Death Valley Junction, it is quicker and easier to return to the north side of Las Vegas by going north on CA 127 to US Highway 95 and going east from there.

Reset odometer at Death Valley Junction.

0.0/0.0 Death Valley Junction, California, at the junction of CA 190 and CA 127. Turn right.

0.2/0.2 Turn left onto State Line road.

14.8/15.0 Turn right into Stewart Valley and go to Stop 3-12 at the intersection of Stewart Valley Road and NV 372.

NOTE: If you elect not to stop at Stop 3-12 (Chicago Valley Thrust), proceed straight ahead 17.9 km [11.1 mi] to the intersection with NV 160 in Pahrump, Nevada. Turn right. From this junction to the intersection with IH-15 south of Las Vegas, Nevada, is approximately 92 km [57 mi].

0.0/0.0 Badwater, California. Proceed south along Badwater Highway.

24.2/24.2 Stop 3-9: Split Cone (35° 56' 57.29" N; 116° 42' 57.82" W)

Split Cone is a 300,000-year-old cinder cone (U.S. Geological Survey, 2004) that intruded along a north-northwest-trending branch of the southern Death Valley fault zone. Subsequent right lateral strike-slip movements along the fault split the cone into two parts and moved the southwest side of the cinder cone approximately 150 m [500 ft] northwest relative to the northeast side of the cone (Figure 3-19).

1.7/25.9 Stop 3-10: Shoreline Butte (35° 55' 54.02" N; 116° 41' 46.54" W)

Lake Manley was a Pleistocene lake that filled Death Valley to an estimated maximum depth of 245 m [800 ft]. The horizontal terraces on Shoreline Butte represent past lake levels (Figure 3-20). One of the major rivers flowing into Death Valley in the Pleistocene Epoch was the Amargosa River from the south. A second river flowed in through Wingate Wash on the west side of Death Valley from Panamint Lake, one of a series of five lakes that existed between Death Valley and Owens Valley to the west in the Pleistocene time (Table 0-1). Shoreline deposits of Lake Manly are also found in northern Death Valley.

2.7/28.6 At 2:00 are the Confidence Hills.

They are Plio-Pleistocene (2.5–.5 my) in age and composed of over 200 m [656 ft] of playa, lacustrine, **evaporite**, alluvium, and fluvial deposits, with interbedded volcanic ash deposits (Gomez, et al., 1992). The east and west branches of the southern Death Valley fault zone pass on either side of the hills. Compression between the fault strands has resulted in folding and uplifting into a series of anticlines and synclines.

0.5/29.1 Road turns east to exit Death Valley. The dirt road that continues south follows the course of the Amargosa River out of Death Valley.

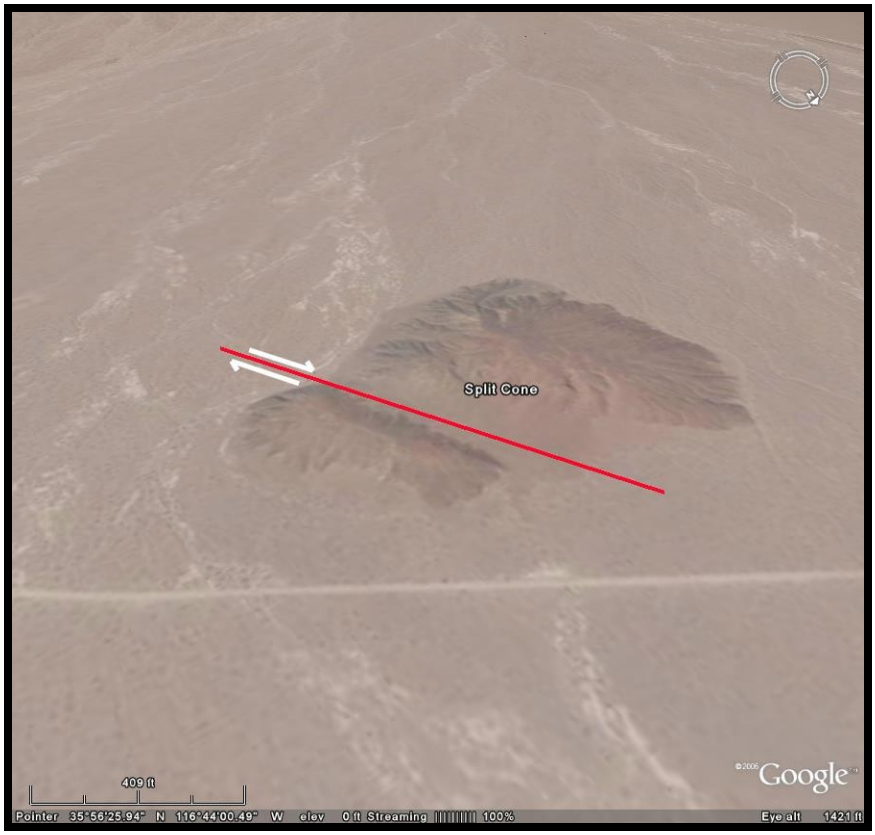


Figure 3-19. Split cone in southern Death Valley. Arrows show relative direction of fault movement. Oblique view north is to the right.

Figure 3-20. Shoreline Butte. Horizontal lines are wave-cut terraces formed when Lake Manley stood at different levels.

23.0/52.1 Lake Tecopa shoreline.

1.9/54.0 Junction with CA 127. Turn right.

1.0/55.0 Shoshone, California.

0.7/55.7 Junction with CA 178. Turn left.

1.0/56.7 At this point in the trip, we are crossing the Lake Tecopa lake beds.

Lake Tecopa, like Lake Manley (Stop 3-10), existed between 2.5 and 0.186 mya (Morrison, 1991) and was fed by local springs and inflow from the south-flowing Amargosa River. The lake basin was closed (i.e., no outlet) until approximately 186,000 years ago when an outlet developed in the Sperry Hills at the southern end of the lake. The outlet drained the lake, perhaps quite rapidly.

The lake beds are composed predominantly of mudstones with conglomerates, sandstones, and siltstones occurring around the lake margin (Sheppard and Gude, 1968). Tufa deposits indicate the occurrence of springs along or near the margin of the lake. At least six air fall tuffs are interbedded with the clastic lake beds. These tuffs have been identified as originating from the Yellowstone, Wyoming, and Long Valley, California, calderas 1,050 km [650 mi] and 300 km [190 mi] away, respectively (Hillhouse, 1987). Three diagenetic **facies** have been recognized in the tuffs that are characterized by fresh glass, zeolite, and potassium feldspar (Sheppard and Gude, 1968) (Figure 3-21). The concentric facies were controlled by the chemistry of the lake water. The glass facies occurs at the north end of the lake and around the margin of the lake where the fresh water entered the lake. In the interior portions of the lake, the zeolitic facies surrounds the central potassium feldspar facies. The juxtaposition of facies has been related to changes in the alkalinity and salinity of the lake water relative to the influx of fresh water.

2.0/58.7 Stop 3-11: Resting Spring Pass Tuff (35° 59' 44.46" N; 116° 13' 04.40" W)

The Resting Spring Pass tuff (Figure 3-22) is a locally derived, small 9.0-m^2 [3.5-mi^2] area rhyolitic tuff (Heydari, 1986) dated at 9.5 mya (Hillhouse, 1987). Because the tuff was deposited on irregular topography, its thickness ranges from 61–245 m [200–800 ft]. Although the Resting Spring tuff is a relatively small ash flow, it has all the classical features of larger and more extensive ash flow tuffs, including welding zonation, pumice and glass shards, incipient devitrification, textural zonation, and evidence of multiple flows. Five welded/nonwelded zones are present. The lowermost is a nonwelded zone that is 3–6 m [10–20 ft] thick. The overlying zone is a 3 to 6-m [10 to 20-ft]-thick partially welded zone. Above that is a 30 to 150-m [100 to 500-ft]-thick densely welded zone, marked at its base by the vitrophyre seen in the road cut (Figure 3-22). The overlying upper partially welded zone is up to 46 m [150 ft] thick. The upper nonwelded zone is, as is quite common, eroded from the top of the welded zone and present only in a few locations. Offsetting beds in the Chicago Valley formation, below the ash flow and to the right in the road cut, are a number of northwest- and southeast-dipping normal faults (Heydari, 1986).

The fault seen in the lower right corner is a normal fault. A less obvious fault occurs to the left of it.

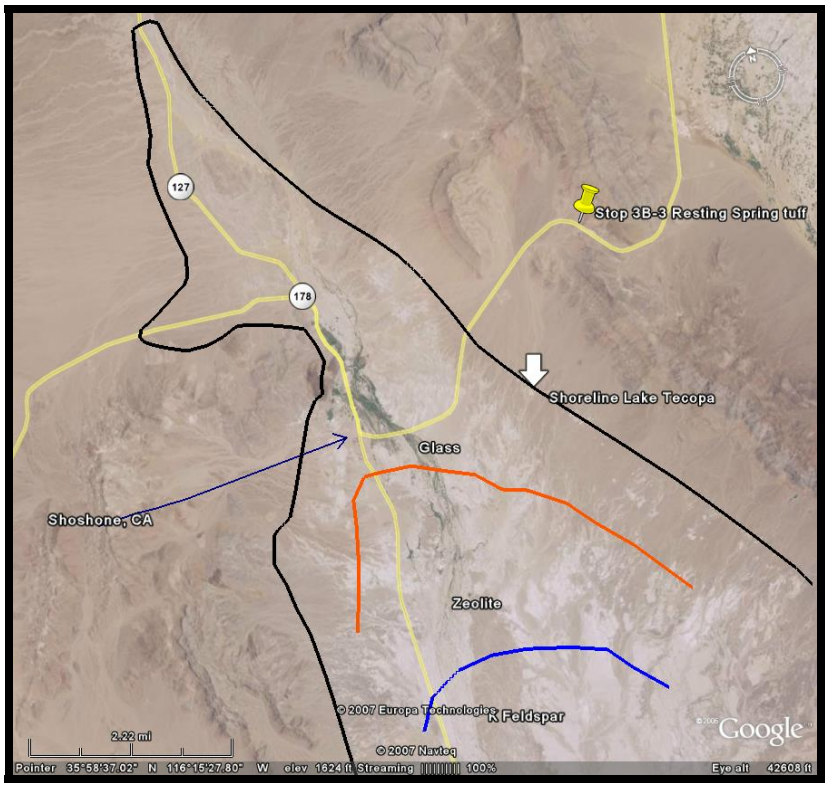


Figure 3-21. Lake Tecopa area near Shoshone, California, showing distribution of three dominant zones of altered tuffs within the Tecopa lake beds.

Figure 3-22. Outcrop of Resting Spring Pass tuff. Black Band is a vitrophyre, although it has incorrectly been referred to as a coal seam. View is to the north.

Proceed east on CA 178.

15.9/74.6 Stop 3-12: Chicago Pass Thrust (36° 10' 09.53 N; 116° 05.86" W)

The Chicago Pass thrust is visible on the north end of the Nopah Range. The jagged topography on the south (left) is underlain by various overturned units of Cambrian to Mississippian carbonate rocks. The jagged topography gives way abruptly to the north (right) to the smooth, brown, weathered Precambrian and Cambrian clastic rocks of the Chicago Pass thrust plate (Figure 3-23). The thrust dips gently to the north. This is believed by some to be a western extension of the Wheeler Peak–Gass Peak thrust system seen the first day (Stop 1-2) (Wernicke, et al., 1989). The Stateline–Pahrump Fault is projected to pass near this stop. A large normal fault has been mapped on the east side of the Nopah Range.

Proceed east on NV 372 to Pahrump, Nevada.

7.5/82.1 Junction NV 372 and NV 160. From this junction to the intersection with IH-15 south of Las Vegas, Nevada, is approximately 85 km [53 mi].

Figure 3-23. Chicago Pass thrust at north end of Nopah Range. View is westward.

END OF FIELD TRIP.

GLOSSARY

aa – Basalt lava flow characterized by a blocky rough surface (Stop 1-7).

accessible environment – The atmosphere, land surface, surface water, and the portion of the lithosphere (crust) that is outside the postclosure controlled area (10 CFR 60.2).

active fault – See **fault**.

alcove – A work area or excavation off the main ESF tunnel that is ventilated. See **niche**.

alluvium – Continental deposits of unconsolidated sediment, such as clay, silt, sand, gravel, or boulders, deposited by running water, in a river bed, flood plain, alluvial fan, or at the base of a mountain slope. The latter is sometimes referred to as colluvium.

alluvial fan – An outward-spreading, gently sloping mass of rock fragments deposited by a stream. Fans originate at areas where a stream issues from a confined channel and suddenly loses the capacity to carry coarser clastic material. An example is seen in the middle of Figure 1-9.

aquifer – A body of rock that contains sufficient saturated conductivity to allow groundwater to move to a point of lower hydrologic potential and yields sufficient water from a spring or well to be beneficially used.

aquitard – A body of rock that contains low saturated conductivity that minimizes movement and acts as a barrier to prevent the flow of groundwater.

argillite – A fine-grained sedimentary rock derived from mud, clay, or silt that is more compact than shale and generally lacks the fissility (property of splitting along layers) of shale. See also **mudstone**.

ash – Fine {<2 mm [<0.08 in]} particles erupted into the atmosphere from an active volcano.

ash fall – Airborne volcanic ash that falls downwind following an eruption. After the ash deposit becomes lithified (becomes rock), it is described as either an ash fall or bedded tuff (Stop 1-8).

ash flow – A hot mixture of volcanic ash and gases that, following a volcanic eruption, travels across the land surface because its density is greater than air. After an ash flow solidifies, it is described as a nonwelded, welded tuff, or an ignimbrite (Stops 1-8, 2-1, and 3-11).

atmospheric tests – Nuclear explosive tests, conducted at or aboveground from 1945 to 1963; replaced by underground nuclear testing in the middle 1960s. See **underground testing**.

aureole – Zone of metamorphic (altered) rock surrounding an igneous intrusion caused by heat, fluid flow, and geochemical reactions initiated by the igneous intrusion.

basalt – A dark-colored, fine-grained basic volcanic rock. See also **igneous rock** (Stop 1-7).

basement – The oldest rocks in a given area; usually applies to an undifferentiated complex of metamorphic and igneous rocks that underlies younger sedimentary deposits. Commonly basement rocks are Precambrian or early Paleozoic in age.

basin – This term has multiple uses in both geology and hydrology at a variety of scales. It generally means a depressed feature or one where the defining characteristic (e.g., water table, top of a rock unit) is lower at an interior point than at the edge. Often circular or elliptical.

basin and range – Landscape characterized by tilted fault blocks forming longitudinal ridges or mountains and intervening, flat-floored valleys; exemplified by the Basin and Range physiographic province of southwestern United States (Figure 1-1).

bed (pl. beds)/stratum (pl. strata) – A tabular or sheetlike body or layer of sedimentary or volcanic rock (see Figure 1-26).

bedded tuff – A nonwelded tuff that may originate from an ash fall or ash flow (nonwelded) or by reworking of preexisting nonwelded volcanic material. Generally light colored compared to welded units, bedded tuffs commonly occur at the base of welded tuffs, separating an older welded tuff from a younger welded tuff unit (Stop 1-8).

bedding – The stratification or layering that is characteristic of rocks formed by the deposition or accumulation of material (see Figure 1-26).

biotite – Rock-forming mineral that is a generally black, dark brown, or dark green mica; a hydrous ferromagnesian potassium alumino-silicate with characteristic platy cleavage; useful for potassium-argon (K-Ar) method of age determination.

blind fault – A fault that does not intersect the Earth's surface.

breccia – A coarse-grained, clastic rock composed of angular fragments or clasts. Varieties of breccia include

> **breccia pipe** – Rock composed of angular (not rounded) rock fragments occurring in a vertical, tube-shaped space in sharp contact with the surrounding rocks; attributed to fluid under high-pressure hydrofracturing through bedrock.
>
> **mega-breccia** – Sedimentary deposit of boulder to house-sized angular rock masses such as whole hillslopes broken from the main mass and transported by gravity or tectonically induced stresses.

calcite – Rock-forming mineral that is calcium carbonate ($CaCO_3$), is characteristically white, has rhomboidal cleavage, effervesces in acid, and is scratchable by a steel point. See **carbonate**. Main component of limestone.

caldera – A large volcanic depression, often used synonymously for a large silicic volcano or complex of closely spaced volcanic vents (see Figure 0-1).

caliche (syn. calcrete) – Used in southwestern United States to describe a weakly to strongly cemented layer of clasts (sand, gravel, cobbles) that forms on or near the Earth's surface due to the formation of secondary calcite cement. Term is also applied to the secondary calcite cementing material.

carbonate – A general term for a sedimentary rock composed chiefly of carbonate minerals {i.e., calcite ($CaCO_3$) and/or dolomite [$CaMg(CO_3)_2$]}.

channel – Part of the bed of a stream or wash containing the main current; abandoned or buried watercourse represented by alluvium (Stop 1-6; Figures 1-21 and 3-8).

cinder cone – A volcanic edifice built up by the accumulation of ash, cinders, and volcanic bombs around a volcanic vent. The Lathrop Wells volcano (Figure 1-24) is a cinder cone.

clast – An individual grain or rock fragment in a rock or sediment. In Figure 3-7, dark rock fragments are clasts in the conglomerate. In Figure 3-8, boulders in Furnace Creek Wash are clasts.

clastic – Refers to sediment or sedimentary rock composed of fragments of preexisting rocks.

clay – Sediment with >67 percent clay-sized or colloidal particles. If uncemented, it is clay; if cemented, it is claystone; if cemented and laminated or fissile, it is shale (cf., argillite). Clay (size) is any naturally occurring material that passes a U.S. standard #200 sieve (about 0.074 mm); a term used to describe a group of hydrous aluminum silicate minerals characterized by a layered internal structure.

cleavage – Fine, closely spaced parallel planar fractures along which a rock may split or break.

clinoptilolite – See **zeolite**.

colluvium – Unconsolidated loose material, rock, and soil on or at the base of a slope. Transported downslope by gravity and often aided by water (i.e., sheet wash). See **alluvium**.

compressional – See **deformation**.

conglomerate – A sedimentary rock composed of rounded clasts larger than 2 mm [0.08 in] in diameter (see Figure 3-7).

continental – Sedimentary and volcanic rocks or a basin formed on land as opposed to formed in the ocean. See **marine**.

continental crust – The lower density Earth crust beneath the continents as opposed to the higher density oceanic crust beneath ocean basins.

continental margin – That portion of the continental crust between the shoreline and the oceanic crust. Also known as continental shelf and continental slope.

craton – The stable interior portion of a continent.

creosote bush – A common desert shrub with waxy bright-green leaves (when flowering, petals are yellow), up to 2 m [6.5 ft] in height, locally dominant, in Yucca Mountain vicinity; odor of crushed leaves is that of the aromatic hydrocarbon creosote. The creosote bush may be cultivated for creosote oil. See Appendix C, page 15 for additional information.

cross bedding – A feature within sedimentary rocks that form during the deposition of sediment by water or wind. The feature is characterized by the occurrence of inclined beds between parallel beds that were originally horizontal.

cuesta – A low ridge with a steep slope on one side and a gentle slope on the other (Stop 2-2). Yucca Mountain is a cuesta.

deformation – A general term for process(es) that change the shape and position of rocks in the Earth's crust.

> **extensional/extended terrain** – Deformation that lengthens and thins the Earth's crust (Stops 1-10 and 1-13).
>
> **compressional** – Deformation that shortens and thickens the Earth's crust (Stop 1-4).
>
> **transtensional** – Deformation that causes transposition of the Earth's crust on either side of a vertical fault (Stop 1-2). The Furnace Creek Fault is an example of a strike-slip fault resulting from shear deformation.

demographic/demography – The science of vital and social statistics of populations.

deposition – The process through which sediment is accumulated.

desert pavement – Natural residual concentration of wind-polished, closely packed pebbles and boulders that mantles a desert surface, often cemented by calcite in Yucca Mountain region.

desert varnish – See **rock varnish**.

detachment – A subhorizontal (shallowly dipping) fault or shear zone of large displacement (km to tens of km); faults and folds above a decollement typically do not extend across it.

detritus – A mixture of particles of rocks and minerals resulting from weathering and erosion of preexisting rocks.

devitrified – A volcanic rock that has changed from a glassy (vitric) to crystalline state (i.e., it contains small crystals of minerals).

diatomaceous/diatomite – Containing numerous diatoms (siliceous single-celled aquatic plants); light-colored siliceous sedimentary rock composed mainly of opaline skeletons of diatoms; high surface area of the microscopic organisms makes the rock useful for such things as chemical filters, paint, and plastic extenders.

digital elevation map (DEM) – A digital representation of the elevation of an area; also a digital elevation model.

dike – A tabular, planar intrusive igneous body, commonly vertical, that cuts across older rocks and surrounding structures. May have been pathway for upward movement of magma for an erupting volcano.

dip (dipping) – The angle at which the plane (i.e., bed or fault) is inclined from the horizontal. Dip is measured perpendicular to the strike (Stop 1-3, Figure 1-14).

displacement – The relative movement of the two sides of a fault (or shear fracture) in a specified direction (also called slip, dislocation); the amount of such movement.

dissolution – The chemical process whereby a liquid dissociates a solid forming a homogeneous solution, such as acidic water dissolving calcite (i.e., limestone).

distal – Describes sediments at the greatest distance from their point of origin, as opposed to "proximal," which means relatively close to its source. Frequently used to describe regions on an alluvial fan (Stop 1-1).

distributary – A stream that diverges from the main stream (or channel or wash) and does not return to it, as opposed to "tributary." See Figure 1-21.

dolomite – Refers to a mineral, similar to calcite, but containing about equal amounts of calcium (Ca) and magnesium (Mg) [CaMg (CO_3)]. Also refers to a rock composed chiefly of the mineral. See **dolostone**.

dolostone – See **dolomite**. The sedimentary rock composed mainly of the mineral dolomite.

drill and blast – Method of making headway in a mine or tunnel or of excavating a quarry face by detonating an explosive in drilled holes in the rock to be broken.

drift – A nearly horizontal underground tunnel, frequently with only one opening.

earthquake – Shaking at the Earth's surface as a result of movement along a fault plane.

earthquake activity – See **seismicity**.

effusive – See **extrusive**.

electrical survey – A geophysical method of surveying buried rocks, soils, and groundwater bodies by measuring electrical conductivities at different depths using electrode arrays. Some methods induce an electric current into the ground, while others detect and measure the natural conductivity, usually mapping lines of equal electrical potential.

emplacement drift – For Yucca Mountain project, it is the designated underground tunnel(s) for the long-term disposal of waste packages.

endemic – Native or characteristic of a particular geographic area or environment.

eolian – Refers to processes and features resulting from action of wind. Included are wind transportation and deposition (sand dunes) and wind erosion (deflation or removal of fine-grained particles by winds; a source area for sandstorms).

epicenter – The point on the Earth's surface directly above an earthquake. See **hypocenter**.

erosion – The process of wearing away the land by the action of water, wind, ice, and gravity.

ESF – See **Exploratory Studies Facility**.

evaporite – A sedimentary rock composed of water soluble minerals that results from the evaporation of a standing body of water (e.g., rock salts).

Exploratory Studies Facility (ESF) – DOE's underground complex at Yucca Mountain that has been used for sample collection, tests, experiments, and measurements to understand and characterize the Yucca Mountain site. The facility consists of a 7.9-km [4.9-mi]-long, 7.6-m [25-ft]-diameter tunnel; the Enhanced Characterization of the Repository Block cross drift; alcoves; and boreholes where rocks, air, moisture, and underground conditions are measured, sampled, monitored, and analyzed and tests are conducted; often used to refer to the main tunnel.

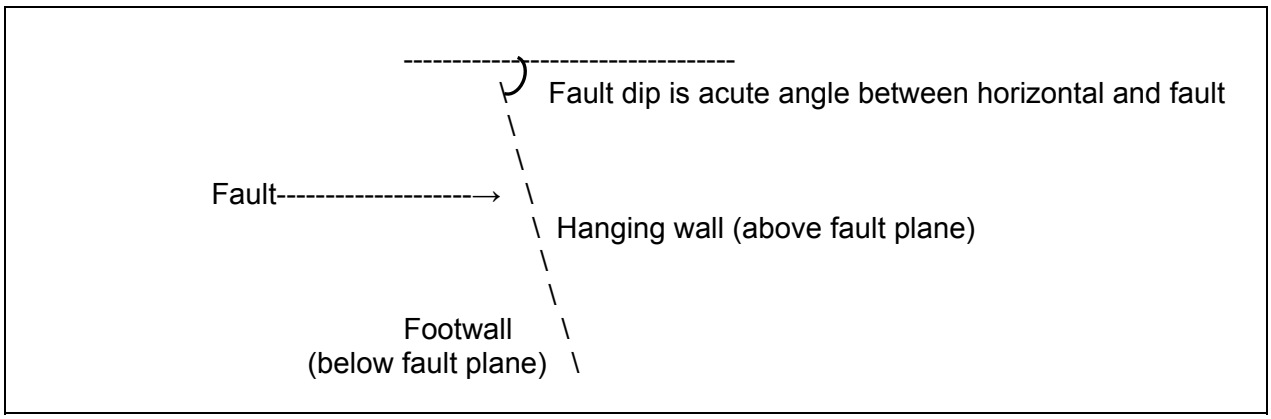
> **Enhanced Characterization of the Repository Block** (ECRB) – A 2.8-km [1.7-mi]-long, 5.0-m [16-ft]-diameter cross drift off the ESF, accessible by rail spur; used for the same purposes as ESF; includes test chambers air-sealed from main tunnel; and terminates in the Solitario Canyon fault zone.

facies – A rock unit with specific attributes (e.g., grain size, grain shape, composition of minerals/rock particles/matrix, presence/absence of fossils), usually reflecting conditions of origin that distinguish that unit from adjacent or associated units. Often a vertical succession that reflects a changing, laterally migrating sedimentary environment. For example, a subsiding costal environment where marine-type rocks gradually cover shore terrestrial sand deposits with increasing subsidence.

fanhead – The portion of an alluvial fan at its emergence from a mountain front or similarly constricted area.

fault – A rupture or series of closely spaced ruptures through rock along which opposite walls have moved past each other. The differential movement is parallel to the rupture surface. There are a number of different kinds of faults (Stop 1-3).

> **active fault** – A fault on which slip recently occurred and is likely to occur in the next few thousands of years or sooner.
> **fault system** – Two or more interconnected or geometrically related faults.
> **fault zone** – A fault expressed by a damaged region (zone) parallel to its imaginary fault-slip plane; damage may be small fractures, breccia, or gouge.
> **footwall** – The block of rock directly below the fault (see accompanying diagram).
> **hanging wall** – The block of rock directly above the fault (see accompanying diagram).
> **listric fault** – A fault with a dip that shallows with depth (see Figure 1-9).
> **master fault** – The major or controlling fault in a system of related faults.
> **normal fault** – A fault in which the hanging wall moved downward along the fault. Such faults indicate crustal thinning and lengthening by extensional deformation. A listric normal fault is concave upward with the fault plane dip becoming shallower with increasing depth.
> **strike-slip fault** – A vertical fault along which the movement is horizontal and parallel to the fault plane. A strike-slip fault is characterized as right or left lateral if the block across the fault plane moves right or left, respectively.
> **thrust fault** – A fault similar to a reverse fault but with the dip of the fault plane less than 45°. Thrusts indicate great crustal thickening by horizontal compression.



fault line scarp – The elongated slope or cliff where a fault that intersects the surface has been exhumed and eroded; the foot of the scarp is not coincident with the fault trace (see Figure 3-13).

faulting – The process of forming a fault.

feldspar – Mineral commonly found in igneous, metamorphic, and sedimentary rocks estimated to make up 60 percent of Earth's crust.

fissure – Long narrow crack in the Earth's surface.

flat – In western United States, this term is often applied to broad, flat valleys between mountain ranges (e.g., Crater Flat).

flux(es) – In hydrology, the amount (volume or mass) of transfer of water or solutes passing a unit area per unit time.

fold – An arch or trough in layered rocks, generally as a result of compressional deformation. A bent or deformed planar surface (i.e., bedding) (see Figure 1-20).

> **anticline** – Beds are deformed to form an arch with the limbs (sides) dipping away (anti) from each other.
> **overturned fold** – A fold or limb of a fold that has been tilted beyond 90° (see Figure 1-20).
> **syncline** – Beds are deformed to form a trough with the limbs dipping toward (syn) each other.

fold axis – An imaginary linear feature marking the crest of an anticline or trough of a syncline on a folded bed.

footwall – See **fault**.

formation – A persistent rock unit that can be easily identified and mapped in the field and included on a geologic map.

fracture/fractured – General term for any surface within a rock across which there is no cohesion; it includes crack, joint, fault, irregular, and conchoidal breaks in rocks.

gabbro – A dark, coarse-grained basic plutonic rock. See **igneous rock**.

geodesy – The science concerned with determination of the size and shape of Earth and precise location of points on Earth's surface; requires knowledge of gravitational field, temporal variations [such as Earth tides, motion of poles (e.g., precession)], and rotation of Earth.

geologic repository – A system that is intended to be used for, or may be used for, the disposal of radioactive wastes in excavated geologic media. A geologic repository includes the engineered barrier system and the portion of the geologic setting that provides isolation of the radioactive waste (10 CFR 63.2).

geology – Broadly, the science concerned with the origin, evolution, and potential future condition of the Earth; consists of branches studying the solid, liquid, gaseous, and biotic components and their interrelationships and applying methods and concepts from physics, chemistry, biology, astronomy, probability, and statistics.

global positioning system (GPS) – A satellite-based radio navigation system used for surveying, navigating, tracking, and collecting field data; a radio wave receiver (10–20 GHz range) that precisely calculates the time, latitude, longitude, height of itself by travel-time versus distance triangulation. In addition to determining location, GPS monitors the movement (i.e., both horizontal and vertical motion) of specific stations (locations) to determine the orientation and magnitude of strain in an area. This requires repeated measurements at the same location over an extended period of time. The results can be accurate to less than a millimeter.

graben – An elongated downdropped block between two parallel normal faults. A half-graben has only one bounding normal fault.

graded bedding – A feature within sedimentary rocks that forms during deposition of sediments. The feature is characterized by the larger grains at the base of the bed with increasingly finer grains in the upward direction (Stop 1-4). This is interpreted as indicating a decreasing energy in the transporting medium with time.

granite/granitic – Broadly, any completely crystalline, quartz-bearing plutonic igneous rock in which the potassium (K)-feldspar predominates over the calcium-sodium (Ca-Na)-feldspar. See **igneous rocks**, **granodiorite**, and **quartz monzonite**.

granodiorite – Broadly, a granitic rock in which the calcium-sodium feldspar predominates over the potassium feldspar. See **granite** and **quartz monzonite**.

gravity data – Measurements of minute changes in the Earth's gravitational strength at numerous places on the ground in an area such as Yucca Mountain, corrected for elevation and topographic effects (among others) and plotted on a map; the maps indicate places where there are gradual and abrupt changes in gravity. Such gravity anomalies are analyzed for their geologic causes, which are due to buried rocks of different densities and buried faults—clues to understanding subsurface geologic structures; computerized solutions to the causes of gravitational potential variations lead to alternative conceptual models of the subsurface.

groundwater – Water in the pores and fractures of rocks below the water table. See **water**.

half-graben – See **graben**.

hanging wall – The rock immediately above an inclined fault or vein. See **fault**.

head frame – Mining term for the raised structure above a shaft used to lower and raise men and supplies into an underground mine. Stop 2-6 is at the head frame used to transport men and equipment, but not spent fuel, into the spent fuel test-climax experiment site.

high-level waste – "The highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; irradiated reactor fuel; and other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation" (10 CFR 63.2); high-level waste is primarily in the form of spent fuel discharged from commercial nuclear power reactors; it also includes some reprocessed high-level waste from defense activities and a small quantity of reprocessed commercial high-level waste.

horizon – In geology, any defined position or level in a stratigraphic column; in soil science (pedology), a defined layer in a soil sequence, such as the "a-horizon." See **Repository Host Horizon**.

hydraulic gradient – The difference in hydraulic head between two points along a flow path divided by the distance between the points.

hydrologic – Pertaining to the properties, distribution, and circulation of water on, or beneath, the ground surface and in the atmosphere.

hydrology – The study of the surface and subsurface distribution, movement, and quality of water.

hydrothermal – Hot water or the associated action (alteration) derived from either the heating of groundwater or evolved from the crystallizing magma.

hypocenter – The focus or initial point of earthquake rupture. See **epicenter**.

igneous rock – Rock formed from the solidification of molten, or partially molten, rock (magma). The term igneous is also used to identify processes and activities related to formation and movement of magma on and beneath the Earth's surface. A very simple classification of igneous rocks follows.

COLOR ⇒		Light (Silicic)	Dark (Basic)
ORIGIN ⇓	**Grain Size of Minerals in Rock**		
Volcanic (extrusive)	fine grained	Rhyolite Quartz Latite	Basalt
Plutonic (intrusive)	coarse grained	Granite Quartz Monzonite Granodirite	Gabbro

incised exposure/incised stream – A channel that has been down cut, entrenched, or eroded into the underlying strata (e.g., Fortymile Wash at well J-12; the Colorado River at the Grand Canyon; Figure 1-5).

interfluves – The relatively undissected upland or ridge between streams or rivers.

intrusion – The process of emplacement of magma into preexisting rock; the igneous rock mass resulting from the intrusion process (e.g., a dike is a tabular-shaped intrusion caused by the solidification of magma intruded into a fracture or fault).

isotope – Different types of atoms of the same chemical element. For example, the isotopes of the element hydrogen are protium (most common), deuterium, and tritium.

karst – Terrain or landforms that developed through the dissolution of rocks by groundwater. Common in areas with humid climate underlain by carbonate rocks. Caves and sinkholes are common karst features. Devils Hole, Stop 3-2, is an example of a sinkhole.

lacustrine – Refers to formation in a lake (e.g., lacustrine limestone).

landslide – General term for the movement of large masses of soil, rocks, and combinations of materials that creep or slide downslope by gravitational potential energy converting to kinetic energy and are deposited at lower elevations; deposits are landforms that take the same names (e.g., mudslide, rockslide, debris flow, earthflow, rockfall, mega-breccia slide, avalanche, slump block); depends on dominant earth material, block size, and velocity; creep may occur before and after high-velocity displacement.

lava/lava flow – The flow of magma on the Earth's surface; the lateral outpouring of lava from a vent or fissure and the rock that results from the solidification of the lava flow. Stop 1-7 is at the front of a lava flow from the Lathrop Wells volcano.

level-line survey – A method for determining the elevation of a point on the Earth's surface relative to a point of known elevation. Surveys are performed with a telescope that swivels in a horizontal plane sighting on a graduated hand-held pole that is moved and located at known distances and azimuths from the instrument; level-line surveys have been used to measure vertical changes in elevation by subsequently reoccupying the earlier sites years later.

limestone – A sedimentary rock composed chiefly (>50 percent) of calcite ($CaCO_3$) (Stop 1-3).

listric fault – See **fault**.

lithic tuff – A tuff containing rock fragments derived from rocks surrounding volcanic vent (Stop 3-11).

lithologic/lithology – The description of rocks ("lithos" means rock) especially in hand specimens and at outcrops; a general term meaning the study of rock types; petrography is synonymous, but includes study of rocks in thin sections under a microscope.

lithophysae/lithophysal – A volcanic-gas bubble in rhyolitic tuff, now degassed and preserved by solidification and possibly filled with air (void), lined with minerals, or completely filled by mineralization from groundwater precipitation; often occurs in zones parallel to original layering of ash flow tuff; ovoid shaped with long-axes bedding-plane parallel, ranges in size from microscopic to a few meters (Stop 2-1).

lithostatic pressure – The vertical pressure caused by the weight of the overlying rocks.

low-level waste – "Radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in Section 11e.(2) of the Atomic Energy Act (U or Th tailings and waste)" (10 CFR 61.2); includes low-level waste containing source, special nuclear, or byproduct material that is acceptable for disposal in a land disposal facility.

magma – Molten rock. Commonly referred to as lava when it reaches the Earth's surface.

magnetic survey

> ***aeromagnetic survey*** – Magnetic measurements made above the surface of the Earth from an airplane or helicopter.
> ***surface magnetic survey*** – Magnetic measurements made at the Earth's surface.

magnetic anomaly – Variations in the Earth's magnetic field resulting from the magnetic properties of rocks at and below the Earth's surface. These anomalies can be interpreted, generally by modeling, to indicate the occurrence of and distribution of rock type in the subsurface.

magnitude – A logarithmic scale used to measure the energy released by an earthquake. A magnitude 6 earthquake releases 30 times more energy than a magnitude 5 earthquake (see **Richter scale**).

marble – A metamorphic rock consisting chiefly of recrystallized calcite or dolomite.

marine – A general term for things relating to the sea or ocean.

marl – A rock composed of fine-grained calcite and clay in variable proportions (i.e., a clay-rich limestone).

master fault – The major or dominant fault in an area or system of temporal or spatially related faults.

megabreccia – See **breccia**.

metamorphic rock – A preexisting rock that has been altered in the solid state by changes in its thermal, pressure, stress, and chemical environments, generally at great depths in the Earth's crust.

metamorphism – The processes by which existing rocks are chemically, mineralogically, and physically (mechanically) altered significantly by changing conditions of tectonic or lithostatic stress, thermal or geochemical gradients, or combinations; usually occurs in lower crust or upper mantle and adjacent to igneous intrusions; results are called metamorphic rocks [e.g., slate or schist from shale, marble from limestone and gneiss from granitic, granodioritic (femic) and basaltic (mafic) igneous rocks]. The degree (amount of alteration) is often indicated by metamorphic grade. The amount of change in the rock increases from low to high grade metamorphic rocks.

metasedimentary – Metamorphosed sedimentary rocks.

mineral – A naturally occurring, inorganic, crystalline solid of fixed chemical composition; minerals are the building blocks of rocks.

mudflow – A mass movement of predominantly mud-rich debris and resulting landform. See also **landslide**.

mudstone – The same as argillite; a coherent mud (consists of both clay and silt-size particles) having the texture and composition of shale, but lacking its fine lamination or fissility.

niche – A small work area or excavation of the main ESF tunnel that is not ventilated. See **alcove**.

neotectonics – The study of recent and ongoing deformation of Earth's crust and seismic-volcanic-tectonic hazards since the late Miocene Period, about 5.3 million years ago.

nonwelded tuff – See **tuff**.

obsidian – A rock that is composed of dense black volcanic glass, usually rhyolitic in composition (Stop 3-11). See **vitrophyre**.

oceanic crust – Crust of Earth underlying deep oceans. Because of basaltic composition, it has higher density than continental crust.

ore/ore body – Minerals in sediment (e.g., gold nuggets), soil (e.g., bauxite), and rocks (e.g., copper, uranium, sulphur) from which metals or individual elements can be extracted at a profit under existing economic conditions; a concentration of ore generally in rocks.

orogeny – The process of mountain building generally resulting from shortening of the Earth's crust by folding and faulting.

paleosol – A buried soil layer.

paleospring – Rock deposit formed by a formerly active spring (Stops 3-4 and 3-5).

passive continental margin – A continental boundary formed by rifting and continental rupture and without substantial plate-boundary tectonism (e.g., the submerged continental shelf and slope off the eastern U.S. coast).

perched aquifer – An aquifer that lies above the regional aquifer as a result of a small underlying area of low permeability.

permeability – The intrinsic ability of a rock or alluvium to transmit water through pores and fractures expressed in units of area (e.g., cm^2).

playa – A vegetation-free, dry lake bed at the lowest part of an undrained basin evidenced by stratified light-colored clay, silt, or sand and commonly containing soluble evaporite salts; also, sabkha, kavir, takir, vloer, salar, salada, or saline pan.

plunge – The angle between a linear feature and the horizontal.

plutonic – An igneous rock formed below the Earth's surface at great depths (Stop 2-6).

proximal – Describes sediments closest to their point of origin. See **distal**.

pull-apart basin – A basin formed between two strike-slip faults that are connected by normal fault. Fault parallel extension along the strike-slip faults causes extensional stress across the normal fault, resulting in creation of a basin on the hanging wall side of the normal fault.

pumice – A light-colored rock formed from the solidification of a frothy silicic magma. Pumice fragments are a component in many ash flow tuffs, although with thick overlying deposits, the frothy nature is decreased. With extreme compression, they may be compacted to lenticular glassy lenses (Stop 1-8).

quartz – One of the most common minerals in the crust of the Earth composed of silicon dioxide (SiO_2).

quartz latite – A volcanic rock (lava and ashflow tuff) with silicon dioxide (SiO_2) content, slightly less than rhyolite as seen at Stop 1-8. See **igneous rock**.

quartz monzonite – Granitic igneous rock in which potassium (K)-feldspar and calcium-sodium (Ca-Na)-feldspar are in about equal abundance. The host rock for the Spent Fuel Test Climax Experiment (Stop 2-6). See also **granite** and **granodiorite**.

quartzite – A metamorphic (metaquartzite) or sedimentary (orthoquartzite) rock consisting mainly of quartz. When fractured, the rock breaks across quartz grains (Stop 1-4), as opposed to breaking around the quartz grains like a sandstone.

radioactive – A substance that spontaneously emits radioactivity, the energetic particles or energy from its nucleus—alpha, beta, and/or gamma rays.

ramp structures – A sloping or faulted surface that connects the ends of two parallel offset and overlapping normal faults. Ramp structures allow the fault displacements to be carried between the faults.

Reasonably Maximally Exposed Individual (RMEI) – "The RMEI is a hypothetical person who meets these criteria: (a) lives in accessible environment above the highest concentration of radionuclides in the plume of contamination; (b) has a diet and living style representative of the people who now reside in the Town of Amargosa Valley, Nevada; (c) uses well water with average concentrations of radionuclides based on an annual water demand of 3,000 acre-feet; (d) drinks 2 liters of water per day from wells drilled into the ground water at the location

specified in (a); and (e) is an adult with metabolic and physiological considerations consistent with present knowledge of adults" (10 CFR 63.312).

recharge – The process by which groundwater is replenished. A recharge area is where water from rain or snow is transmitted down to the water table.

repository – See **geologic repository**.

Repository Host Horizon – The zone in the Topopah Spring member of the Paintbrush Tuff at Yucca Mountain designated by DOE to potentially house waste packages. It consists of four submembers, in ascending order: the lower non-lithophysal unit {Tptpln, 13–31 m [42.7–101.7 ft] thick}, lower lithophysal unit {Tptpll, 10–17 m [32.8–55.8 ft] thick}, middle non-lithophysal unit {Tptpmn, 16–20 m [52.5–65.6 ft] thick}, and the upper lithophysal unit {Tptul, up to about 11 m [36.1 ft] thick}. Stop 2-1 is in the middle non-lithophysal unit.

rhyolite – A volcanic rock (lava and ash-flow tuff), light to medium colored, with a silicon dioxide (SiO_2) content greater than 65 percent. Many of the ash flows in the Yucca Mountain region are described as rhyolitic ash flows because of their color and SiO_2 content (Stop 1-8). See also **igneous rock**.

rift – A long fault zone along which the entire crust is ruptured by extensional deformation.

ring fault – A circular fault bounding a caldera.

rock – An aggregate of one or more minerals.

rock varnish – A thin, dark, shiny rind on rock fragments usually on desert pavements composed of iron oxide accompanied by traces of organic matter (e.g., bacteria, fungi), manganese oxide, and silicon dioxide; caused by transport of pore water from within and deposition by evaporation on the surface; early studies on the thickness and quantity of laminations were erroneously used to determine the exposure age of the fragments. Later studies based on the chemistry of microlayers appear to be more reliable.

Rhodinia – (Russian for motherland) a super continent that existed between 1,100 and 750 mya and is thought to have contained most of the Earth's land mass at that time.

sand ramp – Landform composed of eolian sand piled against the side of a hill (see Busted Butte in Figure 2-1).

sandstone – A sedimentary rock that is composed of sand-sized grains {0.625 to 2 mm [0.002 to 0.079 in]}. Commonly, quartz constitutes >65 percent of the grains. A mature sandstone consists of a high percentage (>90 percent) of well-rounded quartz grains, indicating a long transport time. An immature sandstone consists of less quartz (75 percent), while the remainder of the grains can be rock fragments, feldspars, and mafic minerals, indicating rapid transport. When fractured, a sandstone breaks around the individual grains, rather than across the grains. See **quartzite**.

scarp – A cliff or alignment of cliffs produced by faulting or erosion; short for escarpment.

schist – A metamorphic rock with a strong foliation that readily breaks into tabular slabs.

sediment – An accumulation of unconsolidated fragmental material (i.e., clasts) that has been transported and deposited by mechanical processes such as wind, water, and gravity; may be either marine or continental (see Figure 3-8).

sedimentary rock – A rock formed by (i) consolidation of loose fragments (clasts), (ii) chemical precipitation, or (iii) accumulation of plant or animal remains. Commonly forms in thin to thick layers.

sedimentation – See **deposition**.

seismic/seismicity – Pertains to an earthquake or vibratory ground motion, including those produced by artificial means; earthquake events or activity prehistoric or historically recorded in a given area.

seismic monitoring station – A permanent or temporary location of instrumentation (seismometers) to detect and record earthquakes by placing seismometers on or in the ground (a monitoring station) to continuously record and measure vibratory ground motion. Data from remote stations are often recorded digitally and transmitted by radio waves.

seismic refraction/seismic reflection – Two seismic surveying methods used to generate and record vibratory ground motion (acoustic waves). Analyses of the waves are commonly used to develop models of the shallow to deep geologic structures locally and/or regionally.

shale – A sedimentary rock composed of clay-sized minerals.

shear/shear zone – See **deformation**.

sheet wash – The downslope surface runoff from a rainstorm that is not concentrated into channels.

silicic – A term used to refer to igneous rocks or magma with a silicon dioxide (SiO_2) greater than 65 percent. Commonly light colored. Examples are rhyolite (Stop 1-8) and granite (Stop 2-6). See **igneous rock** (basic).

silt – Granular material with a grain size between sand and clay.

siltstone – A rock composed of silt.

sinkhole – A landform (generally shaped like an inverted cone) caused by the collapse of rocks into a void; common feature of karst landscapes; also applied to mine cave-in reaching surface. At Stop 3-2, Devils Hole is a sinkhole (see Figure 3-4).

slip – See **displacement**.

spent fuel – Nuclear fuel removed from a nuclear reactor because it can no longer sustain power production at economic level, among other reasons. In 2005 about 52,000 metric tons were being stored among reactor sites in pools of cooling water and in dry casks on surface pads.

spring – In hydrology, a place where groundwater flows from a rock or soil onto the land surface or into a body of water (i.e., an underwater spring) (Stop 3-7).

stemming in the hole – Using loose rock fragments or sand (stemming) to backfill an emplacement hole containing an explosive. This prevents release of unwanted radioactivity after a nuclear test.

stock – A plutonic intrusion with a surface exposure area of less than 104 km^2 [40 mi^2].

stone stripe – A landform on a sloping hillside consisting of an elongated deposit of coarse rock debris occurring between wider bands of finer grained debris or otherwise distinguishable from surrounding surface material; in Yucca Mountain area, distinguishable by its rock varnish (see Figure 1-29).

strata – See **beds**.

stratigraphic – Pertaining to the chronological arrangement of layered rocks.

> ***stratigraphic column*** – A composite illustration in a single column of the sequence of geologic units (sedimentary, igneous, and metamorphic rocks; sediments; soils) at a given locality, generally oldest at the bottom, layers adjusted to the horizontal, showing various attributes, such as cross-cutting relationships, type of contact, resistance to weathering, rock textures; also called geologic column or geologic section.
>
> ***stratigraphic unit*** – A single bed (stratum), group of layers (strata), a rock body (e.g., lava flow, dike) that possesses attribute(s) useful for distinguishing the units for a particular purpose of investigation. Rocks may be classified stratigraphically on the basis of lithology (lithostratigraphic units), fossil content (biostratigraphic units), age (chronostratigraphic units), or physical characteristics (e.g., seismic velocity or degree of welding of tuffs, lithophysae content, or other categories for which formal nomenclature is lacking).

stratigraphy – The study of layered rocks.

surface water – See **water**.

syncline – See **fold**.

tectonic – Pertaining to the large-scale deformation of the Earth's crust.

temporal clustering – Earthquakes occuring during a relatively well-defined time period.

throw – The vertical displacement of a fault.

thrust fault – See **fault**.

topography – A general term referring to the shape of the Earth's surface resulting from hills, mountains, valleys, etc.

total dissolved solids – The portion of organic and inorganic solids (i.e., ions, molecules, and colloids) that can pass through a 2-micron filter. Expressed in units of mass per unit volume (e.g., mg/L). Often abbreviated as TDS.

transmissivity – The rate at which water is transmitted through a unit thickness of an aquifer; expressed in units of length squared per time.

transtensional – See **deformation**.

travertine – A light-colored, white to tan, dense, finely crystalline, massive to banded calcite (carbonate) deposit formed by the precipitation and evaporation of calcium-rich water often indicative of a paleospring (Stop 3-4). See **tufa**.

tufa – A spongy mineral deposit around a spring (Stop 1-9).

tuff – Rock formed by consolidation or lithofication of volcanic ash. Tuffs are generally described by their degree of consolidation or welding, which can relate to their position within an ash flow. If the minerals have crystallized in the ash, the rock is described as devitrified tuff. Nonwelded tuffs form because they cool too quickly for the individual ash fragments to fuse together. Bedded or reworked tuffs show bedding that may result from erosion and redeposition of nonwelded ash or accumulation of ash fall material. When they contain fragments of wall rock, they are described as a lithic tuff. A generalized sequence of tuff units within an individual ash flow follows.

Tuff (Ash Flow) Nomenclature

---------- < Top of ash flow
Nonwelded tuff – Ash particles not cemented together.

Partially welded tuff – Ash fragments are slightly fused together.

Densely welded tuff – Ash fragments are fused together.

Vitrophyre – Ash particles are completely fused together. Rock is glassy.

Densely welded tuff

Partially welded tuff

Nonwelded tuff
---------- < Prior ground surface

tunnel boring machine (TBM) – Used to construct the ESF tunnel. A self-propelled, electrical-powered rail train with a rotating 7.62-m [25-ft]-diameter bit mounted at the front of the machine and the drive shaft parallel to the axis of the machine. The muck (broken rock) was conveyed to the rear of the train as it bored forward. A flatbed car served as a platform for geologic sampling and mapping of the tunnel walls and roof as the train was slowly moving forward. Tunnel walls and roof support (ground support) systems were emplaced as needed, ahead of the mappers, for safety. These ground-supported stretches were not readily mapped. The tunnel boring machine was custom designed and built in the United States at a cost of $12.8 million for this job. It is viewable at the south portal of the ESF. It took the tunnel boring machine, also known as the Yucca Mucker, about 2.5 years to construct the main ESF tunnel. A TBM with a 5-m [15-ft] diameter is parked at the distal end of the ECRB.

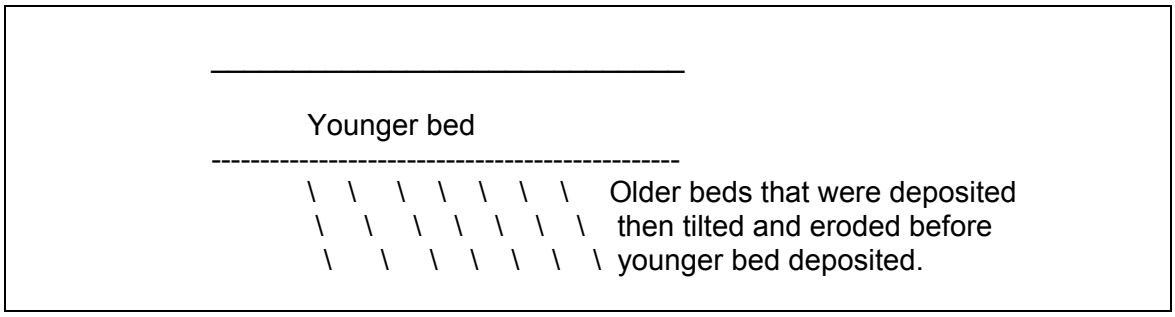
turtleback – Extensive smooth concave topographic surfaces in the Death Valley region that resemble the carapace of a turtle. They may represent the fault surface of a curved normal fault. Turtlebacks are well developed at Stop 3-8 (Figure 3-16).

type locality – An area where a rock unit was first described or where the most representative example of that rock unit is found.

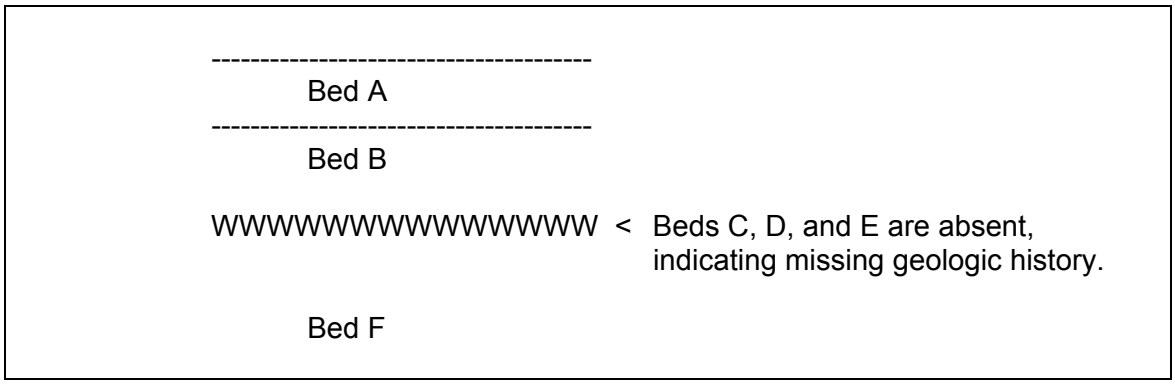
unconformable – Beds that do not conform to the known stratigraphic sequence because of the absence of an underlying bed due to erosion or lack of deposition.

unconformity – A break or gap in a continuous geologic record where a rock unit is overlain by another that is not next in the stratigraphic succession.

angular unconformity – Evidence of structural deformation taking place between the deposition of two different strata. The beds above and below the unconformity are not parallel (Figure 3-10). Several are visible along CA 190 between Stop 3-6 and Furnace Creek Inn.



disconformity – The beds A and B are parallel to bed F; however, beds C, D, and E are missing. Beds A, B, and F are unconformable, and the break between them indicated by the wavy line is a disconformity.



underground testing – Nuclear explosive testing conducted in vertical drill holes, shafts, and tunnels underground at Nevada Test Site to prevent the unwanted release of radioactivity into the atmosphere.

unsaturated zone – See **water**.

U.S. Atomic Energy Commission – Federal agency established by Atomic Energy Act of 1954 and assigned functions for military, promotional, and regulatory purposes regarding nuclear materials, safety, safeguards, and energy production; reorganized by Energy Reorganization Act of 1974, which authorized creation of the U.S. Nuclear Regulatory Commission (to handle the regulatory responsibilities) and the Energy Research and Development Agency (later to become the U.S. Department of Energy).

vadose zone – See **unsaturated zone**.

vein – A mineral or ore body, tabular shaped or in thin sheets, filling a fault or fracture (see Figure 3-9); veins in Yucca Mountain vicinity typically are filled with calcite and opal; when veins contain ore, they are called lodes.

vent – The opening in the Earth's crust through which molten lava and volcanic gases escape onto the Earth's surface or into the atmosphere.

vitric – Composed of glass.

vitrophyre – A densely welded tuff with a glassy appearance (Stop 3-11; Figure 3-21).

volcanic/volcanism – Pertaining to activity, structures, or rock types of a volcano; the process by which magma and associated gases rise into the crust and are extruded onto the Earth's surface and into the atmosphere.

volcano – Term refers to (i) the opening (vent) in the Earth's crust through which magma and gases are erupted onto the Earth's surface or into the atmosphere and (ii) the constructional landform produced by accumulation of erupted material around the vent (Stop 1-7).

wash – A normally dry bed or channel of an intermittent stream; term used in southwestern United States and arid and semi-arid environments elsewhere (see Figures 1-21 and 3-8).

water – Includes

> ***groundwater*** – That part of the subsurface water in the saturated zone.
> ***saturated zone*** – Subsurface volume where virtually all pores and fractures are filled with water under pressure greater than atmospheric; also called phreatic zone. Saturated zone commonly lies beneath the water table; however, saturated zones can exist locally above a regional water table as perched saturated zones.
> ***surface water*** – Any water on the surface of the Earth, including fresh and salt, ice and snow.
> ***unsaturated zone*** – The volume of the Earth's crust between the surface and the water table. Within this zone, pores and fractures in the rock or sediment are only partially filled with water. A variable percentage of pores or fractures contain gas (i.e., they are not 100 percent filled with water). Also referred to as **vadose zone**.
> ***water potential*** – Tendency of water in soils to move from one place to another as a result of differences in pressure and solute potentials.
> ***water table*** – The surface in a groundwater system, separating the unsaturated zone from the saturated zone, at which the water pressure is equal to atmospheric measure.

weathering/weathering surface – Collective chemical, biochemical, and physical processes under atmospheric conditions of changing temperature, humidity, air, and water chemistry, and barometric pressure acting on rocks and minerals causing their dissolution, chemical alteration, or comminution *in-situ* (analogous to uniform corrosion and stress corrosion cracking of metals); some weathering rinds protect vulnerable interiors until breached (analogous to passive surface films and pitting corrosion of metals).

welded tuff – See **tuff**.

zeolite/zeolitized – General term for group of hydrous aluminum silicate minerals with a particular molecular structure that results in an open crystal lattice that renders them useful as filters, absorbents, and drying agents; usually colorless, white, light green, pink, or yellow; presence suggests prior contact with warm or hydrothermal pore water. For additional information, see Appendix C.

> ***clinoptilolite*** – A zeolite mineral that is a hydrous calcium, sodium, or potassium alumino silicate; at Yucca Mountain, found concentrated in zeolitized zones of nonwelded tuffs, such as Calico Hill member of Topopah Spring tuff; also found in saline lake beds (Stop 3-3).

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